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RESEARCH ARTICLE



Dreaming in patients with epilepsy: a cross-sectional cohort study

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Summary

Epilepsy impacts cognition during wakefulness. As epileptic activity is present and even augmented during sleep, epilepsy could also influence sleep-related cognitive processes. However, whether epilepsy modulates sleep-related experiences like dreaming remains poorly known. Here, we prospectively investigated the characteristics and determinants of dreaming in patients with epilepsy. Consecutive adult patients with epilepsy and no major cognitive deficit were recruited in an epilepsy outpatient clinic. They completed a questionnaire about their dreams, sleep and epilepsy over the past year. Medical data on epilepsy characteristics were gathered from the medical file. A generalised linear model was used to explore the determinants of dream recall frequency (DRF). We included 300 patients, with a mean (standard deviation [SD]) age of 40.4 (13.4) years and 51.3% female; 28.6% had more than one seizure/month, and 34.7% already had seizures during sleep. Patients recalled dreams on an average of 1.6 (1.5) days/week and 11% had one or more nightmare/week. Younger age, higher number of nocturnal awakenings, and lower seizures frequency predicted a higher DRF. In patients with focal epilepsy (65.3%), the localisation of the epileptic focus in the parieto-occipital area was negatively associated with DRF. Regarding dream content, 34.0% of patients reported having already dreamt about epilepsy. Dreams of seizures were associated with sleep-related seizures ($p = 0.034$) and dreams of epilepsy were associated with nightmare frequency ($p = 0.004$). Our results show that patients with epilepsy share several determinants of DRF (age,

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awakenings, role of the parieto-occipital area) with healthy subjects. In addition, epilepsy-related factors (seizure frequency, focus localisation) also impact DRF. Investigating dreams in patients with epilepsy can provide information on their epilepsy and their sleep.

KEYWORDS

dream content, dream recall frequency, epilepsy, nightmare, seizures, sleep

1 | INTRODUCTION

Dreaming in patients with epilepsy has been only scarcely investigated to date (de la Chapelle et al., 2021). Yet, in the same way as epilepsy impacts cognition during wakefulness, it may influence dreaming through several mechanisms.

First, epileptic activity is activated by sleep (Frauscher & Gotman, 2019) and, in turns, is associated with sleep disruption, marked by increased wake after sleep onset (WASO) (Crespel et al., 2000; Parrino et al., 2012; Peter-Derex et al., 2020), as well as delayed and reduced rapid eye movement (REM) sleep (Bazil, 2000; Kilgore-Gomez et al., 2024; Parrino et al., 2012). These sleep alterations may impact dream production and/or recall in opposite directions. In healthy individuals, awakenings from REM sleep are associated with the highest dream recall rate (Nielsen, 2000); reduced REM sleep in patients may thus lower dream recall frequency (DRF). Conversely, irrespective of the sleep stage, long intra-sleep awakenings, thought to enable the encoding of dreams into long-term memory, are associated with increased dream recall in healthy subjects (Koulack & Goodenough, 1976; Schredl et al., 2003; Vallat, Lajnef, et al., 2017; van Wyk et al., 2019). The epilepsy-related increase in WASO could therefore lead to an increased DRF in patients with epilepsy. One study evaluating dream recall with dream diaries in patients with temporal lobe epilepsy concluded to a decreased average DRF in patients (2.4 dreams/week) as compared to matched controls (5.5 dreams/week) (Bentes et al., 2011). However, in this study the measure of DRF was not the one usually used (Schredl, 2008).

In addition, seizures and interictal epileptiform discharges (IED) can transiently disrupt cortical processing (Landi et al., 2018), potentially interfering with neuronal processes involved in dream production and/or recall, especially during non-REM (NREM) sleep, which strongly activates epilepsy (Frauscher & Gotman, 2019). This disruption could lead to a global DRF decrease as awakenings from NREM N2 sleep account for a large part of DRF variability in healthy individuals (van Wyk et al., 2019). The hypothesis of epilepsy suppressing dreaming or dream recall during NREM sleep is supported by findings that DRF increases even more following awakenings from REM versus NREM sleep in patients with epilepsy than in controls (Cipolli et al., 2004). The only study directly assessing the effect of seizures (temporal lobe epilepsy only) on DRF found no association but lacked data on sleep-related seizures and interictal activity (Bentes et al., 2011). Importantly, the impact of epilepsy on dreaming may depend on the location of the epileptic network. To date, only coarse

localisation effects have been investigated and data about the influence of seizures lateralisation on DRF are inconsistent (Bonanni et al., 2002; Cipolli et al., 2004; Paiva et al., 2011). Besides, not only DRF but also dream content could be impacted by seizures or IED, as suggested by reports of seizure symptoms being incorporated into dreams, with or without demonstrated co-occurring epileptiform discharge (Epstein & Hill, 1966; Vercueil, 2005).

Another specificity of epilepsy is the common presence of underlying brain lesions. Lesions in key areas for dream production or dream memory, such as the medial prefrontal cortex or the temporo-parieto-occipital junction (Eichenlaub et al., 2014; Solms, 2011; Vallat et al., 2018), could impair dream recall and alter dream content (Joswig et al., 2022; Solms, 2011). Only one study in patients with epilepsy ($N = 61$) considered the presence/absence of a brain lesion and found no effect of this parameter on DRF (Bonanni et al., 2002). Further investigations are thus needed to explore the impact of the localisation of lesions and epileptic focus on DRF.

Lastly, epilepsy may modify the content of daily life in patients who have to adapt to the disease at possibly several levels (work, transport, social interactions, etc.). Such impact on life content could cascade onto dream content as waking life aspects (e.g., actions, thoughts, emotions) are often expressed in dreams (Vallat, Chatard, et al., 2017), as posited by the hypothesis of a thematic continuity between waking life and dreaming (Schredl & Hofmann, 2003). Epilepsy is also associated with heavy comorbidities like depression and cognitive impairment (Keezer et al., 2016), which could as well impact DRF and dream content (Barrett & Loeffler, 1992; Paiva et al., 2011) as may anti-seizure medications (ASM) and more generally psychotropic drugs (Nicolas & Ruby, 2020).

All these factors likely contribute to diverse and multiple dreaming modifications, explaining the complexity of studying the impact of epilepsy on dreaming. In addition, the variability of epilepsy-epilepsy syndrome, type and frequency of seizures, localisation of the epileptic focus, ASM, duration of evolution, etc.– highlights the need for large cohort studies. Yet, existing studies involved limited samples of patients, with specific epilepsy syndromes, and their heterogeneous designs limit the generalisability of findings on DRF and its determinants (Bentes et al., 2011; Bonanni et al., 2002; Cipolli et al., 2004; Paiva et al., 2011).

This prospective study aimed at describing the characteristics of dreaming in a large cohort of 300 patients with epilepsy, focusing on how sleep- and epilepsy-related factors modulate DRF and dream content. We hypothesised that: (1) increased intra-sleep wakefulness

in epilepsy would raise the DRF unless epileptic activity disrupts working memory at awakening; (2) sleep-related seizures would increase (if sparing working memory) or decrease (if erasing working memory content) DRF given their arousing effect, and lead to the incorporation of seizures symptoms in dream content; and (3) an epileptic focus in areas critical for dream production or recall would affect DRF and content.

2 | METHODS

2.1 | Study design and participants

The study was conducted in the Department of Functional Neurology and Epileptology of the Hospices Civils de Lyon, between February 2023 and January 2024. A total of 300 consecutive patients were prospectively recruited according to the following criteria: (1) age between 18 and 65 years, (2) definite diagnosis of epilepsy, and (3) no major cognitive deficit preventing questionnaire completion. At the end of the follow-up medical consultation, the epileptologist proposed to patients meeting these criteria to take part in the study. Patients who agreed to participate were invited complete an online questionnaire on LimeSurvey (LimeSurvey GmbH, 2019). An investigator was present to help them through the process of completing the questionnaire and to answer any questions they may have.

2.2 | Data collection

Questionnaire. The online questionnaire was designed to assess patients' dreams, sleep and epilepsy characteristics over the past year. First, two questions aimed at assessing patients' DRF. The first question asked for the usual average frequency of dream recall (less than once a month, once a month, more than once a month but less than once a week, once a week, or several times per week). A second question asked for the number of mornings with a dream recall during the past week and during the last month. The following questions asked about the frequency of nightmares and recurring dreams, as well as the precision of the recalled dreams. Further questions examined the possible intrusion of epilepsy in dream content (having a seizure in a dream, feeling symptoms of seizures, or reference to epilepsy such as the fact of being epileptic) and possible change in dreaming since epilepsy onset. Then, patients had to report about sleep quality, number of awakenings per night, comorbid sleep disorders and treatments. Finally, patients were asked to estimate the frequency of their seizures and to describe how they usually recognise that they had a seizure during sleep and during wakefulness.

Medical data. In addition, medical data were gathered from the medical file. Besides demographical data (birthdate, sex), the epilepsy characteristics were collected: age at epilepsy onset, epilepsy aetiology, type of epilepsy (focal, generalised, combined generalised and focal, unknown) and syndrome when appropriate, type of seizures (focal, generalised or unknown onset) with description of symptoms,

seizure frequency, location and lateralisation of the epileptic focus when available in case of focal epilepsy (as determined by epileptologist based on the available evaluation), past or present seizures during sleep, last electroencephalography (EEG) date and results, presence of a lesion on magnetic resonance imaging (type, topography, link with epilepsy), drug-resistance, epilepsy treatments (ASM, surgery, thermo-coagulation, vagus nerve stimulation). Psychiatric comorbidity was also collected, when available (depression, anxiety or psychosis and treatments).

2.3 | Data analyses

Data were described using standard statistical measures for quantitative variables, including the mean, standard deviation (SD), median, first-third quartiles, and minimum-maximum values. For qualitative variables, we presented the values and frequency. The quantity of missing data were also reported.

The DRF was expressed as a number of mornings per week with a dream recall as in previous studies using a similar method (e.g., $DRF = 0.25$ indicates that one dream is recalled per month) (Schredl, 2008). To increase the precision of recent DRF estimation, we used the average between last week and last month DRF. This allowed the estimation of DRF over a sufficient period of time and limit short-term fluctuations, while accounting for bias due to memory decline with time. To identify the determinants of DRF in this cohort of patients, we used a generalized linear model. We tested epilepsy-related factors (seizure frequency, types of epilepsy, present or past sleep-related seizures, number of ASM, and (1) for patients with focal/combined epilepsy: localisation of the epileptic focus, (2) for patients with ASM monotherapy: type of ASM), and factors previously identified as co-varying with DRF (age, sex, number of reported sleep awakenings per night) (Schredl, 2008; Schredl et al., 2003). These factors were chosen according to our hypotheses and based on the literature. Data were organised into categories for the following factors: focal/combined and generalised for epilepsy types, frequent seizures (>1 /month) and rare seizures (<1 /month), presence (as mentioned in the questionnaire and/or the medical file) or absence of present or past sleep-related seizures, parietal and/or occipital versus all other areas for the localisation of the epileptic focus in patients with focal or combined epilepsy; treatment with carbamazepine versus lacosamide versus lamotrigine versus levetiracetam versus sodium valproate versus other medications in patients with monotherapy to ensure groups with sufficient sample size, as these treatments were the most frequently prescribed. We chose this approach rather groups based on the mechanism of action of ASM, as the impact of ASM on sleep is rather molecule-dependant (Liguori et al., 2021).

As DRF is a positive continuous variable, the DRF model should follow either a reverse, Gaussian or gamma distribution. These three distributions combined with the three standard link functions (identity, logarithmic, or reverse), led to the generation of nine possible models for the DRF. After the exclusion of non-convergent models, the model with a gamma distribution and a logarithmic link function

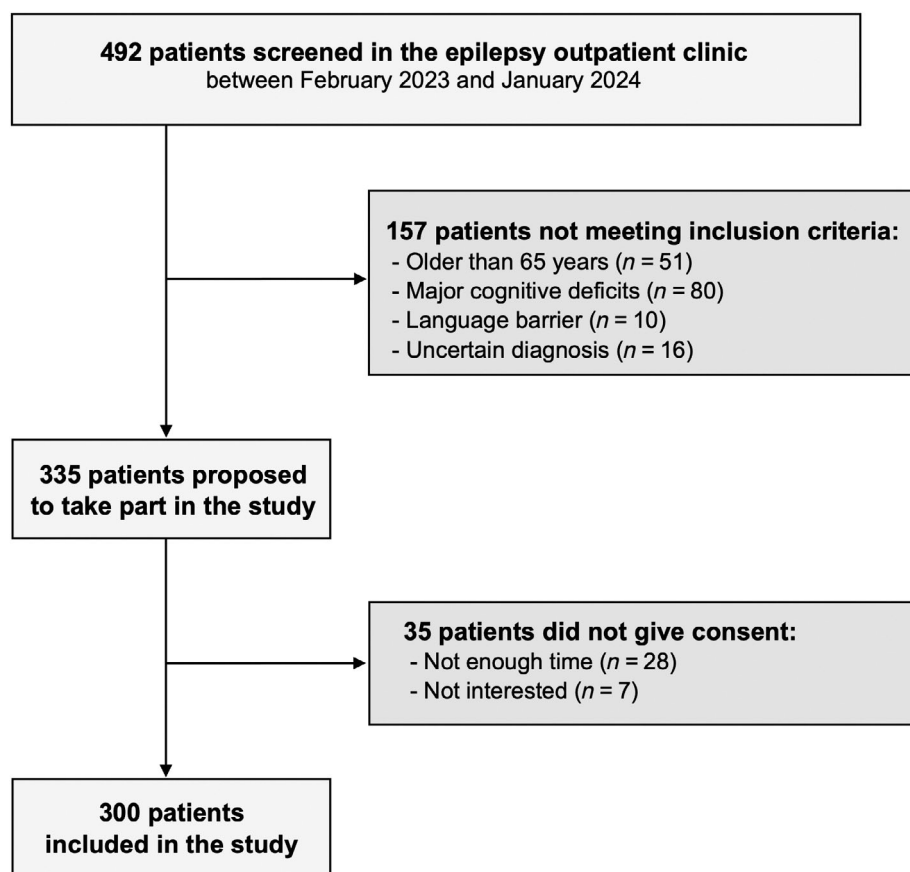


FIGURE 1 Flowchart of patient inclusion process.

was chosen based on the lowest Akaike Information Criterion (AIC). This criterion reflects the difference between the model and the data, while taking into account the number of factors in order to prevent overfitting. Then, a regressive AIC-based algorithm tested step by step the addition or removal of a factor to the model, keeping the AIC as low as possible at each iteration ('lme4' R package from Bates et al., 2015). This algorithm resulted in a simplified model, with the most relevant determinants of DRF. Finally, the model was statistically tested using a Wald type II chi-square analysis of variance ('car package', Fox & Weisberg, 2019).

Finally, comparisons between patients with versus without epilepsy-related content were conducted with Kruskal–Wallis and chi-square or Fisher's tests for DRF, frequency of nightmare recall, frequency of seizures, presence of sleep-related seizures and duration since epilepsy onset.

Statistical analyses were performed with Python (Python 3.9, 2020) and R (R 4.2.3, 2023). A $p < 0.05$ was considered as significant.

2.4 | Standard protocol approvals, registrations and patient consents

The study was performed in accordance with the principles of good clinical practice and the Declaration of Helsinki. The trial was approved by the Ethic Review Board (CPP South Mediterranean II,

N°222 C18, national Number N°2022-A02123-40). All participants provided informed consent. The trial was registered at [ClinicalTrials.gov](https://clinicaltrials.gov) (NCT NCT05561166).

3 | RESULTS

3.1 | Patients

Among the 492 patients screened by the participating investigators at the epilepsy consultation between February 2023 and January 2024, 335 patients met the inclusion criteria, and 300 patients gave consent to participate in the study (51.3% women, mean [SD] age 40.4 [13.4] years). The flow chart is presented on Figure 1. The demographic and clinical characteristics of the patients are detailed in Table 1. Of the 300 patients included in the study, 178 (59.3%) had focal epilepsy, 100 (33.3%) had generalised epilepsy, 18 (6.0%) had combined focal and generalised epilepsy, and four (1.3%) had unknown type epilepsy. Most patients had less than one seizure per month (210 [71.4%]), but 48.3% were drug-resistant as defined by the 'failure of adequate trials of two tolerated and appropriately chosen and used ASM schedules (whether as monotherapies or in combination) to achieve sustained seizure freedom' (Kwan et al., 2010). About one third of the patients had already presented at least one sleep-related seizure, based on the questionnaire and/or medical file (104 [34.7%]).

TABLE 1 Description of demographic and clinical characteristics of the patients.

Demographic characteristics	Value
Age (N = 300), years, mean (SD; range)	40.4 (13.4; 18–65)
Sex (N = 300), n (%)	
Female	154 (51.3)
Clinical characteristics	
Type of epilepsy (N = 300), n (%)	
Generalised	100 (33.3)
Focal	178 (59.3.0)
Combined focal and generalised	18 (6.0)
Unknown	4 (1.3)
Epileptic aetiology and/or syndrome(s) (N = 298, 2 missing data), n (%)	
Idiopathic generalised epilepsy	85 (28.5)
Developmental and epileptic encephalopathy	9 (3.0)
Immune epilepsy	2 (0.7)
Infectious epilepsy	6 (2.0)
Acquired structural focal epilepsy	83 (27.9)
Malformation of cortical development	39 (13.1)
Genetic focal epilepsy	1 (0.3)
Unknown aetiology	73 (24.5)
Localisation(s) of the epileptic focus ^a when focal or combined epilepsy ^b (N = 164, 32 missing data), n among the 164 patients with available data (%)	
Frontal lobe	57 (34.7)
Temporal lobe	97 (59.1)
Insula	4 (2.4)
Parietal lobe	20 (12.1)
Occipital lobe	18 (11.0)
Epilepsy duration (N = 294), years, mean (SD; range)	20.7 (14.2; 1–63)
Age at epilepsy onset (N = 294, 6 missing data), n (%)	
0–4 years	27 (9.0)
5–11 years	51 (17.0)
12–17 years	85 (28.3)
>17 years	131 (43.7)
Lesion on MRI (N = 269), n (%)	
Yes	152 (56.5)
Type of the lesion (N = 152), n (%)	
Cerebral malformation	60 (40.1)
Post-surgery sequelae: brain malformation (N = 9); tumour (N = 12); vascular malformation (N = 4); infectious/inflammatory lesion (N = 3); post-traumatic lesion (N = 1); vascular lesion (N = 2); other (N = 13)	44 (28.9)
Stroke	15 (9.7)
Post-traumatic lesion	14 (9.2)
Tumour	9 (5.9)

(Continues)

TABLE 1 (Continued)

Demographic characteristics	Value
Vascular malformation	7 (4.6)
Infectious lesion	2 (1.3)
Undetermined	1 (0.7)
Past or present sleep-related seizures (N = 300), n (%)	
Yes	104 (34.7)
Frequency of seizures (N = 294, 6 missing data), n (%)	
Less than once a month	210 (71.4)
More than once a month	84 (28.6)
Drug-resistance (N = 300), n (%)	
Yes	145 (48.3)
Epilepsy treatment(s) ^b (N = 300), n (%)	
Anti-seizure medications	
None	5 (1.7)
One	137 (45.7)
Two	109 (36.3)
Three or more	49 (16.3)
Epilepsy surgery	
Thermocoagulation/Gamma knife	10 (3.3)
Vagus nerve stimulation	18 (6.0)

Abbreviations: MRI, magnetic resonance imaging; SD, standard deviation.

^aThe determination of the localisation of the epileptic focus is based on clinical (seizure symptoms, postoperative seizure outcome in patients who underwent surgery), electrophysiological (electroencephalography [EEG] ± magnetoencephalography ± invasive EEG), and imaging (MRI ± fluorodeoxyglucose positron emission tomography) data. Note that this information was not available for all patients.

^bOne patient can be listed in more than one category.

3.2 | Sleep and dream characteristics in patients

The dreams and sleep characteristics of the patients collected from the questionnaire are detailed in Table 2. The mean (SD) DRF in patients was 1.6 (1.5) dreams recalled/week. In all, 60 (20%) patients reported that they almost never recalled dreams and had not recalled a dream during the last week, i.e., had a DRF of 0.0625. The mean (SD) self-reported number of awakenings was 1.4 (1.5) awakenings/night. One third (33%) of patients complained from poor or very poor sleep quality. Only 8.9% were treated for sleep disorders, half of them for sleep apnea.

3.3 | Determinants of DRF

To identify the variables explaining best the variability in DRF, a generalised linear model was used on the patients without missing data for the following predictors: age, sex, number of awakenings reported per night, type of epilepsy, seizure frequency, presence of sleep-related seizures, and number of ASM (N = 292). After the stepwise regression AIC-based algorithm, the resulting model identified age

TABLE 2 Dream and sleep parameters based on questionnaire responses.

Dream parameters	Value
Dream recall frequency ($N = 300$), days/week with a dream recall, mean (SD; range)	1.6 (1.5; 0.063–5.3)
Dream of having a seizure ($N = 300$), n (%)	
Never	247 (82.3)
At least once, thinking seizure was only a dream	36 (12.0)
At least once, thinking seizure was also real	17 (5.7)
Incorporation of symptoms of seizure in a dream ($N = 300$), n (%)	
Never	274 (91.3)
At least once	26 (8.7)
Dream of epilepsy in general but not of seizures ($N = 300$), n (%)	
Never	242 (80.7)
At least once	58 (19.3)
Recurrent dream frequency ($N = 300$), n (%)	
Never	163 (54.3)
Rarely	68 (22.7)
Sometimes	43 (14.3)
Often	26 (8.7)
Nightmare frequency ($N = 300$), n (%)	
Less than once a month	201 (67.0)
Once a month	38 (12.7)
More than once a month but less than once a week	28 (9.3)
Once a week	15 (5.0)
More than once a week	18 (6.0)
Sleep parameters	
Sleep quality ($N = 300$), n (%)	
Very good quality	41 (13.7)
Good quality	88 (29.3)
Medium quality	69 (23.0)
Bad quality	66 (22.0)
Very bad quality	36 (12.0)
Number of reported awakenings per night ($N = 300$), mean (SD; range)	1.4 (1.5; 0–8)
Treatments for sleep disorders ($N = 300$), n (%)	
Continuous positive airway pressure	13 (4.3)
Hypnotic/sedative medication	13 (4.3)
Wake-promoting medication	1 (0.3)
None	273 (91.1)

Abbreviation: SD, standard deviation.

($p < 0.001$), the number of awakenings/night ($p < 0.05$), and the frequency of seizures ($p < 0.05$) as the best predictors of DRF. Age and frequency of seizures were negatively correlated with DRF, whereas the number of awakenings/night correlated positively with DRF (details in Table 3).

In patients with focal or combined epilepsy with available information on epileptic focus localisation ($N = 164$), the same three predictors remained significant. In addition, the localisation of the epileptic focus in the parietal and/or occipital area (versus other localisations) was significantly associated with DRF ($p < 0.05$), with a decreased DRF when the epileptic focus was located in this area. In patients with ASM monotherapy ($N = 122$), only age and number of awakenings were identified as significant determinants of DRF, but not the frequency of seizures nor the type of ASM (levetiracetam, carbamazepine, lacosamide, lamotrigine, sodium valproate, other or none) (Table 3).

3.4 | Epilepsy-related dream content

About one third of the patients reported that they already had a dream with an epilepsy-related content (102 [34.0%], see details in Table 2 and examples of dream content in Table 4). Some patients reported having felt symptoms of seizures (26 [8.7%]) or having typical seizures (53 [17.7%]) during dreams, including 17 patients thinking that dreaming of having a seizure coincided with an actual sleep-related seizure (5.7%). Patients reported that they knew they had a seizure based on direct clues if they woke up before the seizure (e.g., auras) or after the seizure (e.g., unusual pain, headache), or indirect clues (e.g., being told by a partner that they had a seizure, blood on the pillow). In addition to seizure-related content, many patients reported having already dreamt about other aspects of epilepsy (58 [19.3%]).

The association between epilepsy-related dreams and the following factors was tested: DRF, frequency of nightmare recall, frequency of recurring dreams, frequency of seizures, presence of sleep-related seizures and duration since epilepsy onset. No significant association was found between the presence of dreams of seizures, dreams of symptoms of seizures, dreams of other aspects of epilepsy and DRF (respectively $p = 0.97$, $p = 0.81$, $p = 0.083$, Wilcoxon signed-rank test), frequency of seizures (respectively $p > 0.99$, $p > 0.99$, $p = 0.80$, Pearson's chi-square test), and duration since epilepsy onset (respectively $p = 0.47$, $p = 0.30$, $p = 0.16$, Wilcoxon signed-rank test). Dreams of epilepsy were significantly associated with recurring dreams ($p = 0.032$, Pearson's chi-square test), whereas dreams of seizures ($p = 0.59$) and dreams of seizure symptoms ($p = 0.80$) were not. Recurring dreams were not associated with sleep-related seizures ($p = 0.40$, Pearson's chi-square test). The occurrence of dreams of seizures increased in case of sleep-related seizures (Figure 2a, χ^2 [1, $N = 299$] = 4.47, $p = 0.034$) but not the occurrence of incorporation of symptoms of epilepsy ($p = 0.21$, Pearson's chi-square test) nor of other aspects of epilepsy ($p = 0.23$, Pearson's chi-square test) in dreams. Dreams of seizure (Figure 2b, χ^2 [4, $N = 298$] = 14, $p = 0.0078$) and dreams of other aspects of epilepsy (Figure 2c, χ^2 [4, $N = 300$] = 15, $p = 0.0042$) increased with the frequency of nightmares but dreams of symptoms of seizure did not ($p = 0.26$, Pearson's chi-square test). Finally, we assessed the value of the presence of dreams of seizures to predict the presence of sleep-related seizures.

Sensitivity was low (24.3%) but specificity was high (86.2%), with a negative predictive value of 68.4%. Patients who reported seizure-related dream content had two-fold more risk of having actual sleep-related seizures.

4 | DISCUSSION

In this systematic study of dreams and sleep in patients with epilepsy, we found that (1) DRF in patients is modulated by determinants shared with healthy subjects (i.e., age, nocturnal awakenings and role of the parieto-occipital region) and by epilepsy-related factors (i.e., seizure frequency and epileptic focus location), (2) epilepsy influences dream content with epilepsy-related dream content being reported in one third of patients and correlated with nightmare frequency, and dreams of seizure being associated with sleep-related seizures.

4.1 | Determinant of DRF in patients with epilepsy

We identified several factors associated with the DRF. As in healthy adult populations, age was negatively correlated with DRF (Nielsen, 2012). We did not observe any difference between women and men, possibly as the effect size of gender on DRF is small (Schredl & Reinhard, 2008). Regarding sleep-related factors, intra-sleep awakenings were positively correlated with DRF, as previously reported in healthy populations and in line with the arousal-retrieval model, which posits that awakenings are necessary to transfer the short-term dream memory into long-term memory, thus enabling subsequent dream reports (Koulack & Goodenough, 1976; Schredl et al., 2003; Vallat, Lajnef, et al., 2017). Interestingly, increased WASO is one of the most consistent disturbance in sleep parameters reported in patients with epilepsy (Crespel et al., 2000; Parrino et al., 2012; Peter-Derex et al., 2020). In our study, on average, the patient group reported more than one awakening/night. It is more than what was reported in a healthy group (Schredl et al., 1998) and could at least partly explain the increased DRF observed in our study (Vallat, Lajnef, et al., 2017). In addition to these factors, we identified several epilepsy-related determinants of DRF. Increased seizure frequency was associated with a lower DRF, while no influence of sleep-related seizures was found, thus arguing against a direct effect of seizures on DRF, possibly as seizures remain rare and short lasting events. One can hypothesise that patients with more frequent seizures have a more severe condition, with associated interictal activity and disturbances of brain functioning. In patients with available routine scalp EEG at the last consultation, we did not observe a link between epileptic spikes and DRF (data not shown as it was in a subset of patients, $N = 79$), possibly as scalp EEG remains blind to numerous epileptiform discharges. Interestingly, patients with focal seizures arising from parietal and/or occipital lobe showed a decreased DRF. This echoes previous reports on lesional cases (Solms, 2011) and studies performed in healthy individuals with EEG and functional imaging,

which highlighted the key role played by the temporo-parieto-occipital junction in dream recall (Eichenlaub et al., 2014; Siclari et al., 2017). Notably, although many ASM have an effect on sleep structure including sleep efficiency, we did not observe any effect of the type of ASM on DRF (Liguori et al., 2021). One should keep in mind that the choice of an ASM at the individual level is multifactorial, being related not only to the epilepsy syndrome and seizure type, but also to comorbidities and to individual factors (gender, contraception, pregnancy planning, compliance, possible side effects...), which may by themselves influence DRF or be associated with factors influencing DRF.

Epilepsy would thus induce both promoting (intra-sleep awakenings) and depreciating (seizure frequency, focus in the parieto-occipital area) factors on DRF. The result in the studied patients population was a mean (SD) DRF of 1.6 (1.5) days/week with a dream recall, which is twice as high as the DRF (mean [SD] 0.8 [1.6] days/week) in a representative sample of the general population (Welsh test, $p = 0.0001$) with close demographic characteristics (patients, $N = 300$: mean [SD] age of 40.4 [13.4] years, 51% of women; representative sample of the German population, $N = 937$: mean [SD] age of 47.9 [18.3] years, 53% of women) and the same methodology (retrospective self-evaluation of DRF) (Schredl, 2008). One may thus speculate that increased intra-sleep awakenings has a stronger effect on DRF than the epilepsy-induced depreciating factors in the group of patients who were investigated in our study. This finding contradicts the finding of a decreased DRF in patients with epilepsy reported in a previous study (Bentes et al., 2011) but the discrepancy may be explained by methodological differences between studies. Bentes et al. (2011) investigated dream recall in patients with temporal lobe epilepsy only and with a dream diary completed over 5 days, a method known to increase DRF in low and medium dream recallers as compared to retrospective assessment (Putois et al., 2020; Schredl, 2002). They reported a DRF of 2.4 dreams/week in patients ($N = 52$) versus 5.5 dreams/week ($N = 41$) in a group of control subjects. Importantly, their measure included the possibility of reporting multiple dreams in the same night, whereas the most common assessment of DRF considers the number of nights with one or several dreams recalled per week. The DRF measure in Bentes et al. (2011) may thus be artificially inflated by some participants (in the patients, in the controls or in both groups) recalling several dreams per night. Indeed, in studies considering the number of nights with one or multiple dream recalls per week rather than the number of dreams recalled per week, the DRF in healthy subjects keeping a dream diary (for 2 weeks, $N = 285$ participants) was 2 days/week with a dream recall (Schredl, 2002), i.e., more than twice lower than the DRF in the control group of Bentes et al. (2011).

4.2 | Dream content in patients with epilepsy

More than one third of the patients reported that they already had a dream with a content related to epilepsy. Epilepsy-related dream content could include features linked to the fact of living with epilepsy

TABLE 3 Determinants of dream recall frequency.

Predictor variable	Coefficient estimates	Z value	Chi-square	p
All patients (N = 292)				
Age	-0.027 ± 0.0059	-4.5	19.1	<0.001
Number of awakenings per night	0.14 ± 0.0623	2.2	5.5	0.019
Frequency of seizures	-0.36 ± 0.15	-2.3	4.4	0.035
Patients with focal or combined epilepsy (N = 164)				
Age	-0.021 ± 0.0072	-2.9	15.8	0.0031
Number of awakenings per night	0.14 ± 0.077	1.8	5.3	0.055
Frequency of seizures	-0.47 ± 0.19	-2.4	2.6	0.012
Epileptic focus in the parieto-occipital area	-0.51 ± 0.18	-2.9	4.7	0.034
Patients on monotherapy (N = 122)				
Age	-0.025 ± 0.0087	-2.9	8.5	0.0036
Number of awakenings per night	0.17 ± 0.090	2.0	4.9	0.026

Note: Three GLMs were used: (1) one including all patients with no missing data (N = 292) and (2) two in subgroups of patients: One testing the effect of the localisation (parietal and/or occipital versus all other areas) of the epileptic focus in patients with combined or focal epilepsy in whom this information was available (N = 164), and one testing the influence of the molecule taken as anti-seizure medication (levetiracetam, carbamazepine, lacosamide, lamotrigine, sodium valproate, other or none) in patients with a monotherapy (N = 122). For each model, the variables identified as the best predictors, the coefficient estimates, the evaluation of the reliability of these coefficients (Z value), the chi-square statistics and the evaluation of the predictors (p value) are shown.

(i.e., seizure, seizure-related social fears), especially the daily impact of the disease and concerns about treatments. Such findings are in line with the hypothesis of a continuity between waking and dreaming thematic content (Schredl & Hofmann, 2003). Interestingly, one in five patients reported that they already experienced a seizure during a dream, and some reported incorporation of seizures symptoms in the dream content. Such observations have been previously reported (Epstein & Hill, 1966; Vercueil, 2005) and might result from concomitant ictal activity, as suggested by our finding that patients who had seizure-related dreams were twice as likely to have actual sleep-related epileptic seizures. A relationship between recurring dreams and temporal lobe seizures has been reported (Epstein, 1964). In our sample, we did not identify any association between recurring dreams and seizures occurring during sleep. Only EEG recordings during night sleep would allow the elucidation of the possible direct causal role of sleep-related epileptic seizures and interictal activity on seizure-related dream content. Our results suggest nonetheless that seizure-related dreams could be considered at the clinical level as a possible indicator of sleep-related seizures.

Another aspect of dream content in the group of patients with epilepsy studied seems to be altered by epilepsy: the nightmare frequency. In all, 11% of the patients reported having nightmares at least once a week, which is approximately twice as high as in the general population (Germany, N = 2019: 2.4% [Schredl, 2010], Finland, N = 71,068: 3.4% for men and 4.8% for women [Sandman et al., 2017], Europe, N = 2202: Iceland 0.9%, Sweden 5.3%, Belgium 5.8% [Janson et al., 1995]). Our findings contrast with that of a previous study on sleep quality in epilepsy showing no nightmare frequency increase in patients compared to controls, possibly due to methodological reasons including the number of patients included, the metric used to quantify nightmare frequency, the patient population

(with more men and less patients with drug-resistant epilepsy), and the control population (hospital staff and their relatives) (Khatami et al., 2006). The high DRF in patients may at least partly explain the increased nightmare frequency that we observed in the patient group, as DRF and nightmare frequency are positively and strongly correlated (Schredl et al., 2014). In addition, nightmare frequency is increased in many clinical populations with psychopathology (Levin & Nielsen, 2007). Several factors have been identified as risk factors for nightmare frequency, the strongest being symptoms of depression and insomnia, which are frequent comorbidities in patients with epilepsy (Bergmann et al., 2021; Keezer et al., 2016); in the group of patients who participated in our study, more than one third reported bad or very bad sleep quality. Finally, the fact that nightmare frequency in patients was positively associated with epilepsy-related dreams (seizure-related or not) may suggest that when epilepsy becomes an important concern, or a cause of anxiety (inducing epilepsy-related dreams) nightmares become more frequent. This may also explain the association between recurring dreams and dreams of epilepsy.

4.3 | Limitations

Patients were consecutively included as part of their regular consultation, with very few of them declining participation, which limited recruitment bias. However, the proportion of drug-resistant patients was high (almost 50% in our study whereas a recent meta-analysis reported a prevalence of 13.7% in population/community-based populations and 36.3% in clinic-based cohorts [Sultana et al., 2021]), likely because the study was conducted in a tertiary academic centre specialised in epilepsy surgery. This may in theory limit the

TABLE 4 Dream experiences related to epilepsy, reported by the patients.

Type of dream content: epilepsy but no seizure

- *There was a time when I had a lot of job interviews. My new manager already knew about my health condition, but I had to tell my new colleagues about my illness because seizures could happen at work. This idea was stressful, so I dreamt about it a lot.* (woman, aged 46 years, focal left frontal epilepsy, unknown aetiology, focal impaired awareness seizures with hemi-body motor clonic manifestations)

Type of dream content: having a seizure

- *I am in a first person perspective, I feel the inability to move or interact with others, but I can feel persons around me speaking, without understanding what they are saying* (woman, aged 23 years, focal right temporal epilepsy, right hippocampus atrophy, focal impaired awareness seizures with a feeling of changes in soundscape, then loss of consciousness, fixed gaze, staring, and pallor, presence of sleep related-seizures)
- *I dream that I fall on the ground, have a seizure, but not at the same place or with the same people, or in the same context in each dream.* (man, aged 42 years, focal left frontal epilepsy, unknown cause, focal to bilateral tonic-clonic seizures, presence of sleep-related seizures)
- *When I dream of having a seizure, I see myself convulsing, although I don't even know what I look like when I am having a seizure!* (man, aged 25 years, focal occipital epilepsy, bi-occipital leukomalacia, focal aware seizures with visual hallucinations and focal to bilateral tonic-clonic seizures, presence of sleep-related seizures)
- *I had a nightmare in which I was driving and could not release my foot from the pedal at all. I woke up at the moment of the crash. I think it was related to my first seizure, which I had on the highway. My second seizure, I had it at the office with all my colleagues around me. I had also this dream where I was lying on the floor, and everybody would tell me to lie still.* (woman, aged 61 years, focal left parietal epilepsy, surgical sequelae of a left parietal meningioma, focal aware seizures with right hemi-body tonic motor manifestations and focal to bilateral tonic-clonic seizures, presence of sleep-related seizures. Note: this patient had her first seizure while driving)
- *I dream of having a seizure once or twice a month, and it wakes me every time. In these dreams I see myself convulsing from above my body. I never saw my seizures, but my wife described them to me.* (man, aged 49 years, right frontal epilepsy, focal frontal dysplasia-had frontal cortectomy, focal aware seizures with feeling of strangeness, tremor, possible urination, had focal to bilateral tonic-clonic seizures in the past, presence of sleep-related seizures)

Type of dream content: having a seizure and feeling that it was associated with an actual concomitant sleep-related seizure

- *I dreamt that I was walking with my daughter on a road in V... (I used to live there but my daughter never did), and suddenly it was as if the road was transforming into a river. My daughter managed to get out of the river, but I did not. When I woke up, I thought that I just had a seizure, but my wife told me I had not.* (man, aged 40 years, focal right frontal epilepsy, operated brain tumour (astrocytoma), focal aware seizures with left hemi-body hypertonia, possible focal to bilateral tonic-clonic seizures, presence of sleep-related seizures)
- *I dreamt two or three times of having a seizure, and when I woke up, I could know I had one because my body hurt, and my nose was bloody.* (woman, aged 24 years, idiopathic generalised epilepsy, generalised tonic-clonic seizures)
- *At night I know I'm having a seizure when I feel a strange atmosphere in my dream and wake up with a migraine and my vision impaired.* (woman, aged 33 years, focal left temporal epilepsy, left hippocampus hypersignal on magnetic resonance imaging, focal impaired awareness seizures with aura described as difficulties in understanding, dissociation, and an impression of dreamy state followed by a loss of consciousness, possible focal to bilateral tonic-clonic seizures, presence of sleep-related seizures)
- *I had a seizure once; I thought that I was dreaming but I was really having one. I could see myself seizing as if I was in front of a mirror, I could see me next to me.* (woman, aged 29 years, undetermined focal epilepsy, unknown cause, focal impaired awareness seizures with epigastric aura, unmotivated laughing and then a ceiling of the eyes with a loss of consciousness, possible focal to bilateral tonic-clonic seizures)

No epilepsy-related dream content because there is no dream memory or seizure memory

- *When I wake up from a seizure, I feel so disoriented that I am unable to know if I dreamt or not.* (man, aged 29 years, focal left temporo-perisylvian epilepsy, unknown cause, focal impaired awareness seizures with hot sensation, hypersalivation, gustatory symptom with unpleasant taste in the mouth followed by a loss of consciousness, possible focal to bilateral tonic-clonic seizures, presence of sleep-related seizures)
- *I never dreamt of having a seizure, but probably because I am not the one who remembers my seizures. The ones dreaming of seizures are probably my relatives, the witnesses.* (man, aged 46 years, idiopathic generalised epilepsy, myoclonic and generalised tonic-clonic seizures, presence of sleep-related seizures)

generalisation of our findings. However, although drug resistance may have modulated certain factors (seizure frequency, sleep disturbances) and therefore the DRF in our population, there is no reason to believe that the determinants of DRF in patients with drug-resistant epilepsy may differ. In addition, most epileptic syndromes and aetiologies were covered in our sample, which makes our sample quite representative of the variability of the disease. No conclusion can be drawn as to the impact of cognitive impairment on dreaming in patients with epilepsy because the most severely impaired patients were excluded and the data on cognitive function were so sparse that we were unable to study this factor. In our series, only patients with cognitive complaints or undergoing pre-surgical evaluation (i.e., 25%) had benefited from a full neuropsychological assessment, thus most of these evaluations showed impairments. Previous studies are conflicting regarding the impact of cognitive impairment on dreaming, which may depend on

the affected domain (Blain et al., 2022; Solms, 2013; Spanò et al., 2020), so further investigation with systematic neuropsychology assessment is needed. The same limit applies to psychiatric comorbidities, which were not systematically mentioned in the medical file whereas it (as well as associated psychotropic medications) could be a modulating factor (Barrett & Loeffler, 1992; Nicolas & Ruby, 2020; Paiva et al., 2011). To note, several psychological and personality factors known to be associated with DRF in healthy individuals such as attitude towards dreams, creativity, and openness to experience could not be tested in this study but may be involved in DRF in patients with epilepsy as well (Schredl et al., 2003). In addition, we did not systematically collect details of comorbid sleep disorders likely to influence DRF and dream content (Siclari et al., 2020). The prevalence of sleep apnea syndrome was low in our population, and most patients were being treated, which did not allow us to analyse this factor

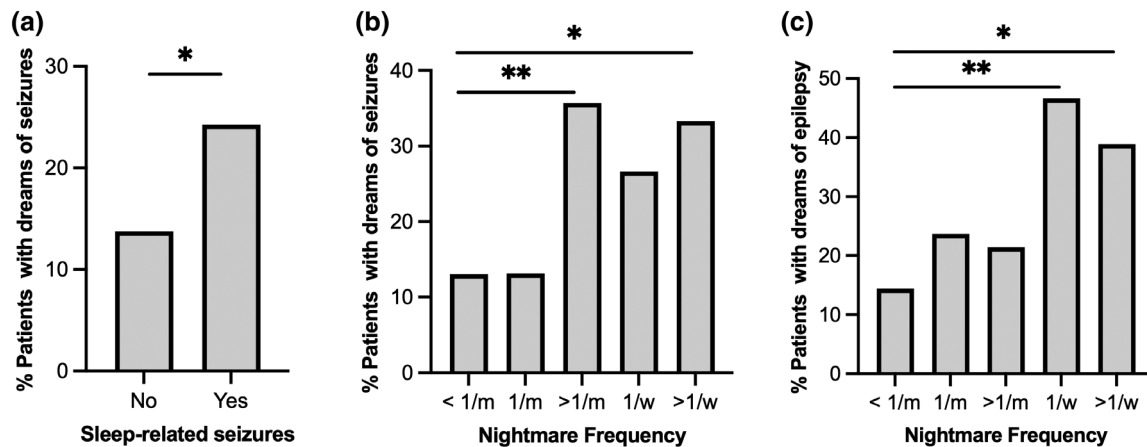


FIGURE 2 Epilepsy-related dream content, sleep-related seizures and nightmare recall frequency. (a) The proportion of patients with dreams of seizures is higher in case of sleep-related seizures (36.0% versus 13.8%, $\chi^2 [1, N = 299] = 4.5, p = 0.034$). (b) The proportion of patients with dreams of seizures is higher when nightmares are more frequent ($\chi^2 [4, N = 298] = 14, p = 0.0078$). (c) The proportion of patients with dreams of epilepsy is higher when nightmares are more frequent ($\chi^2 [4, N = 300] = 15, p = 0.0042$). Nightmare recall frequency: <1/m = less than once a month, 1/m = once a month, >1/m = more than once a month but less than once a week, 1/w = once a week, >1/w = more than once a week. Sample sizes used for percentage measures are detailed in the bottom of the bars. * $p < 0.05$; ** $p < 0.01$.

specifically. Importantly, the design of the study did not allow us to assess the precise temporal relationship between sleep-related seizures and epilepsy-related dreams, as our data were informed by retrospective memories. In addition, self-estimation of seizures by patients, in particular sleep-related seizures, has a limited reliability (Hoppe et al., 2007). This emphasises the need for prospective studies with objective quantification of seizures and interictal activity, together with dream report and sleep structure as self-reported sleep quality also has limitations. Finally, due to the design of our study, no control group could be included (it was not possible to match the conditions of questionnaire completion and motivation between patients and controls). Therefore, we compared the patients' DRF and nightmare frequency with those of healthy subjects assessed in other studies using similar methodologies. Importantly, the core findings of our study do not rely on a control group as they focus on correlations between DRF or dream content and specific disease-related parameters.

5 | CONCLUSION

Our findings suggest that epilepsy influences dreaming (DRF, and dream content including nightmare frequency). Mechanisms involved seem to be manifold and may include biographical effects, intra-sleep wakefulness, and characteristics of the epilepsy syndrome (localisation of the focus, epileptic seizures frequency) with possibly direct (on cognitive processes involved in dreaming and dream recall, for intra-sleep wakefulness and focus in the parieto-occipital region) and indirect (as a marker of disease severity for seizure frequency) effects. Asking patients with epilepsy about their dreams could provide information about their epilepsy, in particular about the presence of sleep-related seizures. On the other hand, the study of epilepsy provides insights for a better

understanding of dream physiology, especially regarding the impact of sleep structure and specific anatomical regions in dreaming.

AUTHOR CONTRIBUTIONS

Maïlis Charpentier-Hélary: Methodology; data curation; investigation; formal analysis; writing – original draft; writing – review and editing; visualization. **Aurélien de la Chapelle:** Methodology; formal analysis; writing – review and editing. **Maxime Linard:** Methodology; writing – review and editing; data curation; investigation; formal analysis. **Nathalie André-Obadia:** Investigation; writing – review and editing. **Sébastien Boulogne:** Investigation; writing – review and editing. **Hélène Catenox:** Investigation; writing – review and editing. **Julien Jung:** Investigation; writing – review and editing. **Sylvain Rheims:** Investigation; methodology; writing – review and editing; resources. **Katharina Schiller:** Writing – review and editing. **Birgit Frauscher:** Writing – review and editing. **Perrine Ruby:** Conceptualization; methodology; supervision; writing – original draft; writing – review and editing. **Laure Peter-Derex:** Conceptualization; methodology; supervision; validation; writing – original draft; writing – review and editing; project administration.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data supporting this study are available upon reasonable request to the corresponding author and in compliance with local ethical regulations.

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