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REM sleep behavior disorder: Relation between aggressiveness and emotions expressed in dream enactment and cognitive and anxiety/depression status

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ABSTRACT

Aggressiveness and negative emotions in dreams reports of patients with alfa-synucleinopathies have been associated with cognitive dysfunction. Observation of dream enactment episodes could be a more precise method to capture dream content in patients with REM sleep behavior disorder (RBD). Our objective was to assess the relation between aggressive and emotional dream enactment episodes in patients with RBD and cognition and depression/anxiety.

Motor events (ME) during REM sleep were classified by visual inspection of video-PSG files. Cognition and anxiety/depression were assessed with MoCA and the Hospital Anxiety and Depression Scale (HADS), respectively. Multivariate regression analysis was performed, with MoCA or HADS scores as predictors, age and DED as co-variates and aggressive, negative and positive ME frequency (raw values, per total and per complex indexes) as the dependent variable.

We included 15 patients with isolated RBD and 12 and 4 with RBD associated with Parkinson's disease and Dementia with Lewy Bodies, respectively. They presented a total of 873 ME. There was a significant positive association between HADS score and violent/complex and negative emotion/complex indexes. There was a significant positive association between MoCA score and violent/complex index.

A significant correlation between depression/anxiety severity and negative emotion and aggression ME frequency agrees with the dream continuity hypothesis and suggests that REM sleep acts as a regulator of emotional experience. Patients with a higher prevalence of aggressive ME had higher scores in cognitive testing, suggesting that the elaboration of these complex movements could depend on the integrity of cognitive functions.

1. Introduction

Vivid dreams and nightmares are commonly described by Parkinson's disease (PD) patients. Analysis of dream content in these patients has suggested a preponderance of physical aggression and animals, when compared with non-PD subjects matched for age and sex [1]. Cross-sectional and longitudinal studies have shown a significant correlation between the frequency of specific dream content (physical aggression, negative emotions) and cognitive dysfunction, specifically of the executive type [1,2]. It has been suggested that frontal lobe dysfunction could cause disinhibition of the limbic system during sleep, causing a higher frequency of negative emotions and fight-or-flight situations in these patients dreams. Dream content alteration could thus be an early marker of impending cognitive dysfunction in PD patients. On the other hand, an association between affective state and dream content is well known, with depression and anxiety resulting in nightmares and negatively toned dreams [3].

Most studies have accessed dream content by collecting dream reports on awakening, which comport a high dose of inaccuracy, being subject of significant recall bias and relying on a narrative reconstruction of the events [4]. Some studies have tried to circumvent these biases, by investigating dream enactment episodes in patients with REM sleep behavior disorder (RBD), a parasomnia in which patients retain muscle tone during REM sleep, enabling them to enact the content of their dreams, this is, to act out accordingly to the events occurring during oneiric experience [5]. Among the more frequent simple, distal,

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small amplitude movements [6,7], a plethora of different behaviors has been described, mostly violent or emotionally negative [8], but also including non-aggressive day-to-day activities [9]. Observing dream enactment episodes allows for deduction of dream content, without the need to awake the patients during sleep or rely on dream diaries. Previous studies using this method have successfully correlated observable motor patterns to sleep microstructure [10], eye movements [11] and emotions [12–14]. Samples have included patients with isolated RBD (iRBD) and RBD associated with PD, disorders that constitute different steps of a neuropathological continuum in which cognitive dysfunction and anxiety/depression are common [15]. However, there lacks information on weather dream content, as observed by this method, bears any correlation with patients' cognitive and affective function, as suggested by studies using dream reports. In the present study, our objectives were to characterize dream enactment episodes in patients with RBD and their relation with cognitive and affective dysfunction, two important and incapacitating symptoms in patients with alpha-synucleinopathies. Specifically, we thought to correlate the frequency of aggression and emotion related episodes with the severity of cognitive dysfunction and anxiety/depression.

2. Methods

This as a retrospective study, based in video-PSG data and clinical records review of patients attending the sleep disorders or movement disorders outpatient clinics of a tertiary referral hospital in Lisbon.

2.1. Subjects

Inclusion criteria was the presence of RBD, according to the International Classification of Sleep Disorders II: 1) repeated episodes of behavior or vocalization that are either documented by PSG to arise from REM or are presumed to arise from REM based on reports of dream enactment; 2) evidence of REM sleep without atonia (RSWA) on PSG. To define RSWA we used the criteria from the AASM scoring manual. Phasic and tonic activities indexes were calculated by dividing the number of epochs with excessive activity by the total number of REM epochs. According to the work by Frauscher et al. [16], the cut-off for excessive muscular activity was 16 % for phasic activity and 10 % for tonic excessive EMG activity in the mentalis muscle. Both iRBD, PD and Dementia with Lewy Body patients with RBD were included. We excluded patients that did not present with at least one complex motor event during REM sleep in video-PSG records (see below for definition), which we considered uninformative regarding dream enactment, and/or whose clinical records lacked objective data (i.e. rating scale scores) on cognition and anxiety/depression.

2.2. Cognitive dysfunction and anxiety/depression assessment

We collected data from cognitive and anxiety/depression rating scales applied at the time of video-PSG and included in patients' clinical files. In most cases, cognitive function had been assessed with the Montreal Cognitive Assessment scale (MoCA) and depression with the Hospital Anxiety Depression scale (HADS). Two patients had been assessed with the Mini-Mental State Examination (MMSE) and one with the Global Dementia Rating Scale (GDS). In these cases, published data [17] was used to convert these scores to MoCA.

2.3. Video-PSG protocol

All patients underwent one night of video-PSG in the sleep laboratory (8 h duration). PSG was performed with a digital polygraph (XLTEK-TREX, Natus Medical Inc., Middleton, USA) and included electrooculography, electroencephalography (six channels F1-A1, F2-A2, C4-A1, C3-A2, O1-A2, O2-A1) electrocardiography, electromyography of the mentalis, right and left tibial muscles, recording of nasal air flow, thoracic and abdominal respiratory effort, oxygen saturation, microphone, and digital EEG-synchronized videography with infrared camera. Sleep staging and REM sleep muscular tone were scored according to the American Academy of Sleep Medicine (AASM) recommendations (except for REM sleep, which we allowed to be scored in the presence of increased EMG activity in the mentalis muscle). The following sleep parameters were registered: Total sleep time, Sleep efficiency, Awakenings Index, WASO, Sleep latency, REM sleep latency, Stage N1 %, Stage N2 %, Stage N3 %, Stage R %, Apnea-Hipopnea Index, Desaturation Index, Periodic Limb Movements of Sleep index (PLMS).

2.4. Dream enactment assessment

To assess motor activity during REM sleep, we counted all REM sleep motor events (ME), defined as any movement visible in video recordings during this sleep stage. Consecutive movements were considered as separate if there was a visible pause between them, as inspected in the video-file, in slow-motion when needed. A pause was considered when there was no visible dislocation in the body segment in which the movement was occurring. We determined total number of events and duration, in seconds, of each event. ME were individually classified according to the system developed by Frauscher et al. [7] which rates motor events according to type (myoclonic vs. simple vs. stereotypes vs. scenic vs. vocalizations vs. violent), emotional tone (negative vs. positive), complexity (elementary vs. complex), body region (trunk vs. neck/head vs. upper extremity vs. lower extremity), spatial distribution (focal vs. segmental vs. multifocal vs. global), laterality (symmetric vs. asymmetric) and proximal vs. distal. As explained above, only patients with at least one complex movement were included in this study. Complex movements are defined as "apparent "acting out" of dream contents or movements different from elementary simple events in term of complexity of action". In the study, the variables of interest were positive or negative emotion related events (as defined in the cited study: "all those in which a positive or negative emotion can be recognized like laughing versus crying or shouting") and aggressive events (violent events, defined as "forceful and vehement motor events that could potentially injure a bed partner (e.g. kicking or punching").

2.5. Data analysis

Descriptive data was expressed as mean (standard deviation) for continuous variables and frequency (percentage) for categorical variables. For the effect of assessing motor event type distribution, data is both presented as the raw frequency of each type of ME per patient and as an index, calculated by diving the frequency of ME type events by the total number of ME (which accounts for the inter-individual variability of the total number of ME). To assess the relation between ME type and cognitive function or anxiety/depression, a preliminary multivariate regression analysis was performed, in which MoCA or HADS scores were entered as predictors, age and dopa-equivalent doses as co-variates and ME frequency (raw values or per total indexes) as the dependent variable. Given that to detect emotion and aggression related components requires the respective ME to be complex (i.e. involving some kind of dream enactment) we considered that using the total number of complex ME (which in theory would correspond to the total number of dream events) as denominator could be more informative than the total number ME regarding the preponderance of these elements in patients dreams. Therefore, we created two extra ME variables for each patient: violent/complex index (number of violent ME per total number of complex ME); negative emotions/complex index (number of negative emotions ME per total number of complex ME); positive emotion/complex index (number of positive emotions ME per total number of complex ME). These three variables were used as dependent variables in a multivariate regression model that also used MoCA and HADS scores as predictors and age and dopa-equivalent doses as co-variates.

$p < 0.05$ was considered as significant.

2.6. Ethics

Patients signed informed consent forms. The ethics committee of the institution approved the investigation protocol.

3. Results

A total of 31 patients met the inclusion criteria and had cognitive assessment data available (15 iRBD, 12 PD and 4 DLB). Of these, 17 had HADS score available (9 iRBD and 8 PD). These two groups were treated as separated entities regarding data analysis. Table 1 provides a general description of the sample's demographic and PSG data.

Table 2 describes the frequency of motor events. We inspected a total of 873 ME, with a frequency that was highly variable between patients. There was a predominance of elementary, simple, focal movements involving the upper limbs. Negative emotion events were more frequent than positive ones.

We found no significant relations between MoCA or HADS scores and ME type raw values and per total indexes. There was a significant positive association between HADS and violent/complex index (B = 0.028, 95 % CI 0.002 to 0.054, p = 0.034) and negative emotion/complex index (B = 0.038, 95 % CI 0.017 to 0.058, p = 0.002). There was a trend level and significant, respectively, positive association between MoCA score and negative emotion/complex index (B = 0.033, 95 % CI -0.033 to 0.069, p = 0.067) and violent/complex index (B = 0.041, 95 % CI 0.007 to 0.075, p = 0.021). None of the tests involving positive emotions showed any significant association.

4. Discussion

Regarding the relative frequency of ME type, the present study agrees with previous investigations using similar methodology [6,7,18], by showing that although dream enacting events constitute the hallmark of RBD motor manifestations, their constitute a small part of ME in REM sleep, which are more frequently elementary movements, concentrated in the hands and with no emotional content. The difference in frequency between complex and elementary movements was smaller than in previous studies, probably because we only included patients that had at least one complex ME. The predominance of negative emotion ME over positive ones is in line with previous studies using the same methodology (one of them showing a complete absence of positive emotions [18]) and with evidence showing a predominance of negative emotions in patients dream reports [19].

We found a significant positive association between higher HADS scores and the proportion of negatively toned and violent ME in complex motor events, meaning that patients with higher levels of depression/anxiety had more negative emotion and aggression contents in the dreams they enacted. Accepting that there is a direct relation between dream content and dream enacting, our study agrees with the dream continuity hypothesis, which states that dream content reflects waking activity, being influenced by the events and emotions the dreamer faces wile awake [20]. Negative or anxious views on reality, as are caused by depression and anxiety, could thus imprint themselves on dreams, giving rise to emotionally negative content and flight-or-fight scenarios. Viewed in a different perspective, our data are also in accordance with the hypothesis stating an important role of REM sleep dreams in emotional regulation, as a mechanism that allows for reenacting and thus metabolizing negative memories [21]. The predominance of negative emotions could thus be viewed as a reaction against negative

Table 1
Descriptive data: demographic, clinical and PSG variables

	Patients with MoCA scores (n = 31)	Patients with HADS score (n = 17)
Age (years)	70.3 (8.39)	67.5 (9.17)
Gender (male)	23 (74.2)	14 (82.4)
DED	273.4 (452.22)	388.8 (542.10)
MoCA	22.5 (3.85)	
HADS		8.3 (6.12)
Total sleep time (min)	331.0 (100.34)	358.9 (95.97)
Sleep efficiency (%)	61.0 (17.91)	63.9 (16.25)
Sleep latency (min)	58.5 (81.09)	49.5 (42.22)
REM sleep latency (mi)	187.3 (113.39)	175.4 (119.08)
Stage N1 (%)	38.7 (31.60)	51.1 (29.55)
Stage N2 (%)	32.7 (24.57)	25.1 (22.68)
Stage N3 (%)	16.8 (9.92)	13.6 (6.08)
Stage R (%)	15.0 (11.51)	15.8 (12.12)
AHI	16.2 (17.86)	10.9 (12.78)
PLMS index	43.6 (40.50)	54.5 (44.25)

Values are number (percentage) or mean (standard deviation). DED dopa-equivalent doses. MoCA – Montreal Cognitive Assessment test. HADS – Hospital Anxiety and Depression Scale. AHI – Apnea-Hypopnea Index. PLMS – Periodic Limb Movements of Sleep.

Table 2
Motor events subtypes

		Patients with MoCA		Patients with HADS	
		Raw frequency	Per total	Raw frequency	Per total
Total number of motor events		27.2 (27.44)		24.5 (19.45)	
Mean duration of motor events (seconds)		6.3 (4.70)		6.8 (5.41)	
Elementary		16.4 (13.55)	0.6 (0.21)	14.8 (10.53)	0.6 (0.13)
Complex		9.6 (14.85)	0.3 (0.22)	6.2 (5.84)	0.3 (0.13)
Emotion	positive	1.0 (2.18)	0.0 (0.15)	0.5 (1.51)	0.0 (0.03)
	negative	2.3 (2.65)	0.1 (0.18)	3.1 (3.01)	0.1 (0.09)
Type	myoclonic	2.7 (2.83)	0.1 (0.17)	3.1 (2.91)	0.2 (0.19)
	simple	8.6 (7.17)	0.3 (0.19)	7.9 (6.38)	0.4 (0.17)
	stereotypes	7.0 (9.87)	0.2 (0.18)	4.3 (5.32)	0.2 (0.14)
	scenic	5.3 (9.44)	0.2 (0.21)	4.2 (5.04)	0.2 (0.13)
	vocalizations	4.4 (6.54)	0.1 (0.17)	5.1 (7.06)	0.2 (0.20)
	violent	2.5 (3.32)	0.1 (0.19)	2.5 (2.40)	0.2 (0.09)
Body region	trunk	4.4 (6.92)	0.5 (0.31)	5.7 (8.22)	0.2 (0.18)
	neck/head	9.7 (16.62)	0.3 (0.28)	5.9 (6.59)	0.3 (0.26)
	upper limbs	16.8 (23.01)	0.5 (0.31)	13.8 (15.00)	0.5 (0.31)
	lower limbs	8.5 (10.04)	0.3 (0.29)	8.9 (0.59)	0.4 (0.25)
Spatial distribution	focal	9.0 (9.11)	0.4 (0.26)	7.1 (5.40)	0.4 (0.24)
	segmental	6.6 (8.86)	0.2 (0.21)	6.2 (7.01)	0.2 (0.17)
	multifocal	6.2 (9.56)	0.2 (0.13)	4.8 (6.65)	0.2 (0.14)
	global	2.9 (4.23)	0.1 (0.11)	2.9 (2.84)	0.1 (0.13)
Laterality	symmetric	12.4 (16.60)	0.4 (0.20)	9.5 (8.32)	0.4 (0.20)
	asymmetric	12.4 (13.54)	0.5 (0.24)	11.1 (10.91)	0.4 (0.22)
	Distal	18.3 (23.00)	0.7 (0.29)	14.2 (11.31)	0.6 (0.31)
	Proximal	13.5 (17.50)	0.4 (0.27)	10.5 (10.63)	0.5 (0.23)

Values are mean (standard deviation). MoCA – Montreal Cognitive Assessment test. HADS – Hospital Anxiety and Depression Scale.

feelings caused by anxiety and depression during wake experience. A reaction that could, in fact, be considered as innefective: according to theoretical models that propose normal dreaming to be the result of successful extinction of negatively charged memories and nightmares as a failure of this process [22], the relation between depression/anxiety levels and negative emotion in dreams could be viewed as a failure of dream process to metabolize the memories of negative experiences, thus contributing to the perpetuation of affective disturbance.

Contrary to our expectations, the proportion of negative emotion and aggression relation motor events contained in complex motor events was positively, and not negatively, related with cognitive function, as assessed by MoCA. This is, patients with a higher content of these features had higher scores in cognitive function assessment. This relation is opposite to what was found when using dream reports as surrogate for dream content in our previous studies [1,2]. Although there isn't a straightforward explanation for this discrepancy, we could ascribe it to differences in populations as well as in dream content ascertainment. Dream content studies were performed in PD populations, including patients with and without RBD, while our present group is composed only by RBD patients, some with PD but other with iRBD or DLB. Also, our patients had to present at least one complex ME. Aggression related content is more common in RBD patients [8] and takes a major part in dream enactment reportorial [18]. We could thus say that our population represents the end of dream content aggression spectrum, in whom there is an overrepresentation of this particular type of content. On the other hand, although there is strong indication that dream enactment can be linked to dream content during the episodes, previous data also suggests that dream enactment does not transmits the integrity of one night's dream content (i.e., not all dreams are enacted) [23]. It seems probable that to be seen as dream enactment event by an external observer, dreams must comport some degree of complexity. Some studies, performed in PD patients, have shown cognitive function to correlate with the complexity and vividness of dreams, this is, the cohesion of dream scenarios depends on the integrity of cognitive functions [24]. The relation between dream complexity and specific motor events can be inferred from studies that have proved an association between the occurrence of rapid eye movements (believed to be the equivalent of visual scanning during dreaming) or other REM sleep dreaming related phasic events and either violent or negative emotion movements [10,11] and that complex motor events causes an increase in heart rate variability (a marker of emotional activation) compared to elementary ones [25]. It also agrees with investigations that have shown a reduced frequency of ME in RBD patients with dementia (DLB patients) compared to RBD patients without overt cognitive decline (iRBD patients) [26]. If one believes dream enacting to depend on a threshold of complexity (complex dreams having a higher chance of being enacted as beahvioural events in RBD) and negative and aggression related phenomena to correlate with this complexity, then it seems plausible that there exists a significant correlation between the proportion of this type of events in dream enactment and cognitive measure scores, particularly in a sub-group of patients in which these situations are particularly frequent. We should point, however, that if one takes cognitive dysfunction as a surrogate marker of disease progression, our findings would be in discordance with those of Nepozitek et al. [18], that used the same methodology in a cohort of iRBD patients, and found the frequency and aggressiveness of ME to be directly related with DaT-scan assessed dopaminergic denervation and conversation to overt alpha-synucleinopathy. These authors did not find significant correlation between ME type and cognitive of affective disturbance, a discrepancy that deserves analysis in further studies and could be ascribed either to differences in ME frequency calculations or patient sampling (as they only included iRBD patients).

Our study presents some limitations, that should be acknowledged. PSG study included only one night. First night effect, which is known to reduce the proportion of REM sleep, could have interfered with REM sleep manifestations, in terms of dream enactment, although this problem may have been attenuated in our sample, as we only included patients with at least one complex motor event. Also, the size of the sample was smaller when compared with one of the previous video-analysis study [18], particularly regarding the number of patients who were assessed with HADS.

5. Conclusion

In summary, our data suggests a significant relation between the proportion of negative emotional type episodes in complex dream enactment episodes and the severity of anxiety/depression in patients with RBD. The results also support a relation between higher proportion of aggressive dream enactment and better performance in cognitive tests. Besides being potentially useful for a better understanding of dream phenomena, their role in affect regulation and dependence on cognitive integrity, this information could be relevant at the clinical ground, permitting the use of dream enactment episodes as surrogate markers to assist movement disorders and sleep specialists in detecting non-motor symptoms that significantly affect patients' daily activities. These interpretations, however, should be taken with care, given the methodological limitations of the present study: a relatively small and heterogeneous population in terms of diagnosis (although all groupable under the classification of alpha-synucleinopathy), the possibility that dream enactment episodes could represent only part of the spectrum of emotion and actions present in dreams and the subjectivity inherent to addressing mental events by observing exterior behavioral output. Further studies should involve larger samples, extensive neuropsychological examination and awakening protocols that could allow for confirmation of dream content during dream enacting episodes.

CRediT authorship contribution statement

Paulo Bugalho: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marta Magriço:** Writing – review & editing, Investigation. **Vítor Mendes Ferreira:** Writing – review & editing, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Bugalho P, Paiva T. Dream features in the early stages of Parkinson's disease. J Neural Transm 2011 Nov;118(11):1613–9. https://doi.org/10.1007/s00702-011-0679-5.
[2] Bugalho P, Ladeira F, Barbosa R, Marto JP, Borbinha C, Salavisa M, da Conceição L, Saraiva M, Fernandes M, Meira B. Do dreams tell the future? Dream content as a predictor of cognitive deterioration in Parkinson's disease. J Sleep Res 2021 Jun;30 (3):e13163. https://doi.org/10.1111/jsr.13163.
[3] Levin R, Nielsen TA. Disturbed dreaming, posttraumatic stress disorder, and affect distress: a review and neurocognitive model. Pych Bull 2007;133:482–528. https://doi.org/10.1037/0033-2909.133.3.482.
[4] Urbina SP. Methodological issues in the quantitative analysis of dream content. J Pers Assess 1981 Feb;45(1):71–8. https://doi.org/10.1207/s15327752jpa4501_14.
[5] Schenck CH, Bundlie SR, Ettinger MG, Mahowald MW. Chronic behavioral disorders of human REM sleep: a new category of parasomnia. Sleep 1986 Jun;9 (2):293–308. https://doi.org/10.1093/sleep/9.2.293.
[6] Bugalho P, Lampreia T, Miguel R, Mendonça M, Caetano A, Barbosa R. Characterization of motor events in REM sleep behavior disorder. J Neural Transm 2017 Oct;124(10):1183–6. https://doi.org/10.1007/s00702-017-1759-y.

[7] Frauscher B, Gschliesser V, Brandauer E, et al. Video analysis of motor events in REM sleep behavior disorder. Mov Disord 2007;22:1464–70.

[8] Fantini ML, Corona A, Clerici S, Ferini-Strambi L. Aggressive dream content without daytime aggressiveness in REM sleep behavior disorder. Neurology 2005; 65:1010–5.

[9] Oudiette D, DeCock VC, Lavault S, Leu S, Vidailhet M, Arnulf I. Nonviolent elaborate behaviors may also occur in REM sleep behavior disorder. Neurology 2009 Feb 10;72(6):551–7. https://doi.org/10.1212/01.wnl.0000341936.78678.3a.

[10] Frauscher B, Gschliesser V, Brandauer E, Ulmer H, Poewe W, Högl B. The relation between abnormal behaviors and REM sleep microstructure in patients with REM sleep behavior disorder. Sleep Med 2009 Feb;10(2):174–81. https://doi.org/10.1016/j.sleep.2008.01.003.

[11] Leclair-Visonneau L, Oudiette D, Gaymard B, Leu-Semenescu S, Arnulf I. Do the eyes scan dream images during rapid eye movement sleep? Evidence from the rapid eye movement sleep behaviour disorder model. Brain 2010;133:1737–46.

[12] Clé M, Maranci JB, Weyn Banningh S, Lanfranchi J, Vidailhet M, Arnulf I. Smiling asleep: a study of happy emotional expressions during adult sleep. J Sleep Res 2019 Aug;28(4):e12814. https://doi.org/10.1111/jsr.12814.

[13] Maranci JB, Aussel A, Vidailhet M, Arnulf I. Grumpy face during adult sleep: a clue to negative emotion during sleep? J Sleep Res 2021 Dec;30(6):e13369. https://doi.org/10.1111/jsr.13369.

[14] Masset L, Nigam M, Ladarre A, Vidailhet M, Leu-Semenescu S, Fossati P, Arnulf I, Maranci JB. The dynamics of emotional behaviors in rapid eye movement sleep. Sleep 2023 Feb 8;46(2):zsac285. https://doi.org/10.1093/sleep/zsac285.

[15] Di Folco C, Couronné R, Arnulf I, Mangone G, Leu-Semenescu S, Dodet P, Vidailhet M, Corvol JC, Lehéricy S, Durrleman S. Charting disease trajectories from isolated REM sleep behavior disorder to Parkinson's disease. Mov Disord 2024 Jan; 39(1):64–75. https://doi.org/10.1002/mds.29662.

[16] Frauscher B, Iranzo A, Gaig C, Gschliesser V, Guaita M, Raffelseder V, Ehrmann L, Sola N, Salamero M, Tolosa E, Poewe W, Santamaria J, Högl B, SINBAR (Sleep Innsbruck Barcelona) Group. Normative EMG values during REM sleep for the diagnosis of REM sleep behavior disorder. Sleep 2012 Jun 1;35(6):835–47. https://doi.org/10.5665/sleep.1886.

[17] Solomon TM, deBros GB, Budson AE, Mirkovic N, Murphy CA, Solomon PR. Correlational analysis of 5 commonly used measures of cognitive functioning and mental status: an update. Am J Alzheimers Dis Other Demen 2014 Dec;29(8): 718–22. https://doi.org/10.1177/1533317514534761.

[18] Nepozitek J, Unalp C, Dostalova S, Dusek P, Kemlink D, Prihodova I, Ibarburu Lorenzo Y, Losada V, Trnka J, Zogala D, Bezdicek O, Nikolai T, Perinova P, Dall'Antonia I, Ruzicka E, Sonka K. Systematic video-analysis of motor events during REM sleep in idiopathic REM sleep behavior disorder, follow-up and DAT-SPECT. Sleep Med 2021 Jul;83:132–44. https://doi.org/10.1016/j.sleep.2021.04.033.

[19] Merritt JM, Stickgold R, Pace-Schott E, Williams J, Hobson JA. Emotion profiles in the dreams of men and women. Conscious Cognit 1994;3:46–60. https://doi.org/10.1006/ccog.1994.1004.

[20] Schredl M. Factors affecting the continuity between waking and dreaming: emotional intensity and emotional tone of the waking-life event. Sleep Hypn 2006; 8:1–5.

[21] Scarpelli S, Bartolacci C, D'Atri A, Gorgoni M, De Gennaro L. The functional role of dreaming in emotional processes. Front Psychol 2019 Mar 15;10:459. https://doi.org/10.3389/fpsyg.2019.00459.

[22] Levin R, Nielsen T. Nightmares, bad dreams, and emotion dysregulation: a review and new neurocognitive model of dreaming. Curr Dir Psychol Sci 2009;18(2):84–8. https://doi.org/10.1111/j.1467-8721.2009.01614.x.

[23] Valli K, Frauscher B, Gschliesser V, Wolf E, Falkenstetter T, Schönwald SV, Ehrmann L, Zangerl A, Marti I, Boesch SM, Revonsuo A, Poewe W, Högl B. Can observers link dream content to behaviours in rapid eye movement sleep behaviour disorder? A cross-sectional experimental pilot study. J Sleep Res 2012 Feb;21(1): 21–9. https://doi.org/10.1111/j.1365-2869.2011.00938.x.

[24] Cipolli C, Bolzani R, Massetani R, Murri L, Muratorio A. Dream structure in Parkinson's patients. J Nerv Ment Dis 1992 Aug;180(8):516–23. https://doi.org/10.1097/00005053-199208000-00007.

[25] Bugalho P, Mendonça M. Heart rate changes according to the complexity of motor events in REM sleep behavior disorder. Clin Neurophysiol 2017 Jul;128(7):1317–8. https://doi.org/10.1016/j.clinph.2017.05.001.

[26] Bugalho P, Salavisa M, Marto JP, Borbinha C, Alves L. Polysomnographic data in Dementia with Lewy Bodies: correlation with clinical symptoms and comparison with other α-synucleinopathies. Sleep Med 2019 Mar;55:62–8. https://doi.org/10.1016/j.sleep.2018.12.006.