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Time-of-night variations in the story-like organization of dream experience developed during rapid eye movement sleep

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SUMMARY

This study aimed to investigate the cycles (2nd/4th) and duration-related (5/10 min) variations in the story-like organization of dream experience elaborated during rapid eye movement (REM) sleep. Dream reports were analysed using story grammar rules. Reports were provided by those subjects (14 of 22) capable of reporting a dream after each of the four awakenings provoked in 2 consecutive nights during REM sleep of the 2nd and 4th cycles, after periods of either 5 or 10 min, counterbalanced across the nights. Two researchers who were blind as to the sleep condition scored the dream reports independently. The values of the indicators of report length (measured as value of total word count) and of story-like organization of dream reports were matched taking time-of-night (2nd and 4th cycles) and REM duration (5 versus 10 min) as factors. Two-way analyses of variance showed that report length increased significantly in 4th-cycle REM sleep and nearly significantly for longer REM duration, whereas the number of dream-stories per report did not vary. The indices of sequential (number of statements describing the event structure developed in the story) and hierarchical (number of episodes per story) organization increased significantly only in dream-stories reported after 10 min of 4th-cycle REM sleep. These findings indicate that the characteristics of structural organization of dream-stories vary along with time of night, and suggest that the elaboration of a long and complex dream-story requires a fairly long time and the availability of a great amount of cognitive resources to maintain its continuity and coherence.

INTRODUCTION

Dream experience, as reported after provoked awakening [mainly in rapid eye movement (REM) sleep], is perceptually vivid, sometimes bizarre in content and organized in a relatively lengthy and coherent sequence of quite plausible and complex events (Snyder, 1970). Within the storyline of these events, individuals can recognize that concerns, characters and objects of recent or remote waking-life events (so-called 'memory sources' of dream content; Nielsen and Stenstrom, 2005) are combined in a much more novel manner than simple collages (Pace-Schott, 2013). The fact that episodic memories, i.e. recent and remote events, are rarely reproduced integrally in reported dreams (in fewer than 2%; Fosse *et al.*, 2003; Malinowski and Horton, 2014) implies that the story-like structure of dream experience is constructed during sleep. Accordingly, the multi-level view of dreaming (Foulkes, 1982, 1985) postulates that the characteristics of story-like structure reflect the functioning of high-level cognitive processes involved in dream production, specifically providing for the coherence of dream experience as narrative.

The relationships between the story-like characteristics of reported dreams and the putative functioning of the processes involved as a system in dream production have been investigated by assessing dream reports with tools derived

from story grammar, script analysis or less formalized approaches. This investigation has shown that story-like organization is more marked in reports collected after REM sleep than after Stage 2 of non-REM (NREM) sleep (Nielsen *et al.*, 1983) and its complexity increases in dream reports collected after a period of REM sleep in the second compared with the first half of the night (Cipolli *et al.*, 1998). The latter finding appears to complement the evidence that dream reports become longer, more dramatic and more emotionally charged after awakening from REM (Dement and Kleitman, 1957; Snyder, 1970) and NREM sleep during the late night (Pivik and Foulkes, 1968).

Several characteristics of REM sleep also change during the late night, with an increase in REM duration, higher values of REM density and higher neurophysiological indices of brain activation which are supposedly related to the functioning of cognitive processes (Mukai *et al.*, 2003; Wamsley and Antrobus, 2007; Yordanova *et al.*, 2008). This makes it plausible that not only the perceptual and emotional characteristics, but also the structural characteristics of dream experience change in REM sleep of the late night. The putative better functioning of the cognitive processes, in particular, should lead to an enhanced length and complexity of the stories present in dream reports (hereinafter, dream-stories) collected after a long compared with a short period of REM sleep of the same cycle. Some indirect support for this hypothesis may be found in the relationship between report length (measured as number of words: total word count, TWC) and REM duration of up to 15 min of sleep (Dement and Kleitman, 1957; Stickgold *et al.*, 2001). Stronger and more direct support may be gathered by assessing whether REM duration, in interaction with time of night, is actually associated with an increased story-like organization of dream reports, namely with longer and more complex stories rather than with a larger number of dream-stories per report.

We present here the findings of a comparison of story-like characteristics of reports collected after 5 and 10 min of REM sleep of the 2nd and 4th cycles in a previous study (Rosenlicht *et al.*, 1994), the design of which appeared suitable for the above aim. The story-like characteristics of these reports were assessed by applying the rules of Mandler and Johnson's (1977) story grammar. This tool proved to be suitable for the evaluation of both the comprehension and recall of stories in waking (Mandler and Goodman, 1982) and the persistence of story-like organization in reports of the same dream experience collected just after awakening from REM sleep and the next morning (Cipolli and Poli, 1992).

METHODS

Subjects

In the original study (carried out at the Sleep Laboratory of the University of California at Davis, USA; Rosenlicht *et al.*, 1994) 22 subjects (native English-speaking college student volunteers: male/female, 12/10; 22.8 $\pm$ 2.54 years) who were free from sleep problems, substance abuse and emotional or physical illness were recorded, after an adaptation night, for two consecutive experimental nights, with bedtime and wake-up time approximating subjects' customary sleep habits.

During each experimental night subjects were awakened three times: at sleep onset (data not reported in the original study) and during REM sleep of the 2nd and 4th cycles. Subjects were awakened either 5 or 10 min after the first non-ambiguous eye movement in REM sleep of the 2nd and 4th cycles in a counterbalanced manner during the 2 nights. Awakening was provoked by calling the subject's name over an intercom, and the dream report was elicited using the non-directive Foulkes' instructions (Foulkes, 1962). This 'spontaneous' report, as resulting from free recall of previous dream experience, can be considered representative of what the subject would have recalled if he/she had been woken up in the same sleep stage at home (Schredl *et al.*, 2003; Windt, 2013).

Dream reports were recorded on audiotape and then transcribed verbatim. The study protocol was approved by the Institutional Review Board of the University of California at Davis. Informed written consent was obtained from each participant.

PROCEDURE

Experimental design

The database for this study was constituted by the transcripts of dream reports of the subjects who provided a contentful report (i.e. with at least one sentence describing contents of previous dream experience; Cohen, 1972) for each of the four REM awakenings. The demographic data of this subsample were fully comparable to those of the entire sample (seven males and seven females, mean age = 22.09 $\pm$ 2.17).

The authors of the original study (IF and NR) were requested by CC to select the transcripts of dream reports of the subjects (n = 14) fulfilling the above criteria and then sent them without any information regarding the sleep cycle and REM duration after which they were collected. This precautionary measure allowed us to carry out the analysis of dream reports using story grammar rules in a double-blind condition, given that not only were the scorers (see below) unaware of cycle and REM duration, but the researchers who collected the reports had also been unaware of the aim and tools for report analysis of the present study.

At the conclusion of the report analysis (see below) the data were transmitted to IF and NR, who disclosed both the experimental condition corresponding to each report and the value of report length (as measured previously in terms of TWC; Rosenlicht *et al.*, 1994).

Structural analysis of dream reports

Two investigators (CC and LP) preliminarily pruned the transcript of each dream report of (a) all clauses not related to

dream contents (e.g. 'I'm not sure, but I think…'), (b) repetitions of contents already encoded in that report and (c) digressions regarding waking-life events and environments to which some contents were related or detailed descriptions of post-awakening associations related to perceptual features of characters, objects and places. Pruned reports were then submitted to two researchers unaware of the REM cycle and duration of report collection (CB and MM), who scored reports independently by applying the rules of Mandler and Johnson's (1977, 1984) story grammar. These rules allow for the description of dream reports in terms of constituents (conceptual, and not linguistic, in nature) of a story and temporal/causal relationships between these constituents (i.e. the structural organization of the story). As described extensively elsewhere (Cipolli and Poli, 1992), the outcome of story-grammar analysis can be represented as a tree structure going from the top constituent (story, namely one or more events linked by the same setting and characters) to the basic (or terminal) nodes (statements). Each statement represents either a state or an event, and is expressed typically as a sentence or part of a sentence describing its meaning. A state may be internal (i.e. an emotion or state of mind) or external (i.e. a current condition of the world). An event is any occurrence or happening and may also be internal (i.e. thoughts, plans) or external (i.e. actions of characters or changes of state in the world). In its simplest form, a story consists of a setting (which identifies the protagonist and/or one or more characters, and the time and place of the event to be narrated) and an event structure (i.e. the development of the event). The event structure may consist of one or more episodes; each episode includes a beginning, in which some initial event happens to the protagonist, a development that describes the protagonist's internal and external response to the beginning, and an ending, which often emphasizes long-range consequences of the development. The development is the most complex constituent in a simple episode: most frequently it takes the form of a complex reaction followed by a goal path. The complex reaction includes both a simple reaction (the protagonist's thoughts or feelings about the beginning) and a goal. The goal path includes one or more attempts to achieve the goal (i.e. actions) and the outcome of those attempts.

The organization of more complex stories is accounted for by rules for connecting and embedding constituents. For example, an attempt can include an embedded development in which the protagonist (or another character) pursues a subordinate goal. The complete tree of a story goes from the top constituent (story) to the terminal nodes (states and events). In this study, as well as in previous studies, we applied the rule that a report is to be treated as a single story as long as its episodes involve the same goal and at least one of the same characters is in any two consecutive episodes, while the setting may change.

The procedures for subdividing (i.e. parsing) a story into episodes, constituents and statements are exemplified in Fig. 1.

Interscorer agreement was higher than 96% in parsing statements and classifying statements into constituents (or basic nodes), 98% in classifying such constituents into

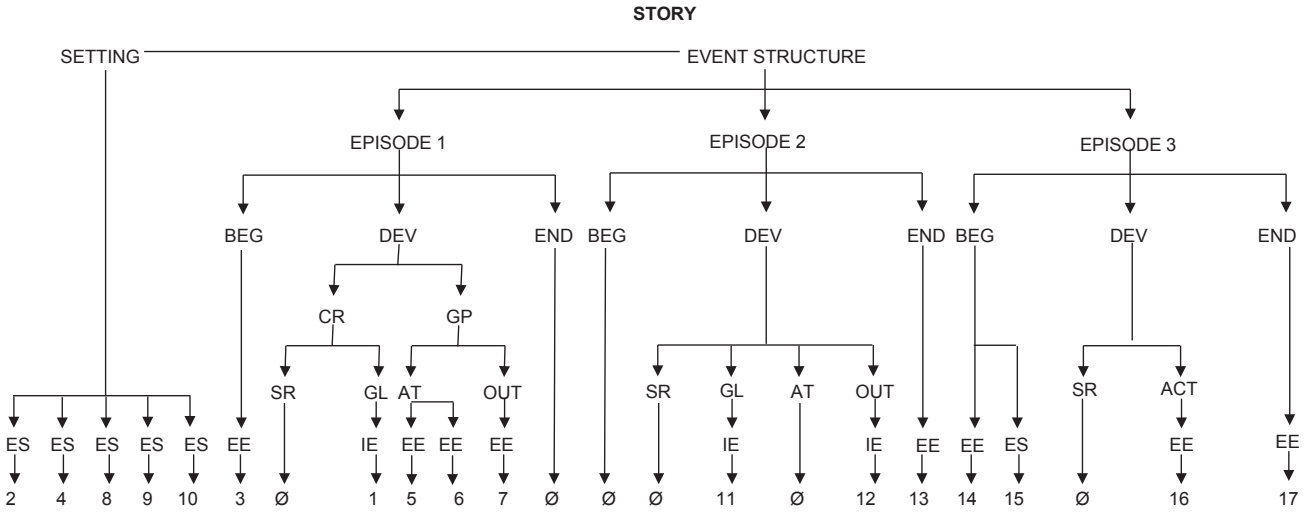

Figure 1. IE S1. I was getting ready to baby-sit a little kid. ES S2. (first) I was outside. EE S3. (then) I went into a living room. ES S4. where I was sitting on a couch. EE S5. My roommate Anne was asking me some questions. EE S6. like how long I was going to be watching this little kid. EE S7. (and then) I pinned him up onto the refrigerator, with a magnet. ES S8. I lived in a totally separate house from the people I was with. ES S9. (but) it was two doors down. ES S10. it was like they were rooms, not houses. EE S11. I just had to watch the baby there for the night. EE S12. (so) I walked out of the back door to the first house in the second row of houses. EE S13 (when) I walked back into the original house. ES S14. I still had the baby. ES S15. (because) my roommate Anne was there. EE S16. and she asked me if I had to watch him for one night. EE S17. and I said that he would need to be watched for more than that, as he had been neglected. BEG, beginning; DEV, development; END, ending; CR, complex reaction; GP, goal path; SR, simple reaction; GL, goal; AT, attempt; OUT, outcome; ACT, action; ES, external state; EE, external event; IE, internal event; Ø, constituent not realized in report structure.

episodes and 100% in classifying episodes into stories. The few cases of disagreement were resolved through discussion between the two scorers and their reconciled version was taken into account.

The researchers who did not score reports (CC and LP) calculated the number of stories per report and three indicators of story-like (i.e. structural) organization for each story, namely: (a) the number of statements per story describing the setting. This indicates the context organization, i.e. the time and place where the narrated actions occur; (b) the number of statements per story realizing the event structure, as indicative of the sequential (i.e. temporal) development of the actions of the story; and (c) the number of episodes per story, as indicative of the hierarchical (i.e. causal) organization of the actions of the story.

The length of a story (which was not considered here as a further indicator) corresponds to the sum of the numbers of the statements in setting and event structure.

In the interpretation of the findings obtained, the context organization was considered as representative mainly of the effectiveness of recall (assessed in terms of number of statements in which the setting of a story is described: the more accurate the recall, the higher the number of statements). Moreover, the indicators of sequential and hierarchical organization, being measures of the temporal development and hierarchical structuring of the story (i.e. the coherence of various episodes within a single frame or plot), were considered representative of the effectiveness of the cognitive processes involved in generating the story-like structure of dream experience (Cipolli *et al.*, 1998).

Statistical analysis

Two-way analyses of variance (ANOVAs) were carried out on the length of reports (the TWC value), the number of stories per report and the values of structural (contextual, sequential and hierarchical) organization of stories present in dream reports (see above), taking 'cycle' (2nd versus 4th) and 'REM duration' (5 versus 10 min) as within-subject factors. *Post-hoc* Scheffé's test ($P < 0.05$) was applied in the case of significant interaction. The effect size was estimated by calculating the partial eta-squared (η^2_p; Richardson, 2011).

RESULTS

The means and standard deviations of TWC value, number of stories per report and indicators of contextual, sequential and structural organization of dream-stories are shown in Table 1.

1. A two-way ANOVA, taking cycle (2nd versus 4th) and REM duration (5 versus 10 min) as factors, was carried out on the values of TWC per report. This analysis showed a significant effect for cycle ($F_{1,13} = 5.573$, $P < 0.05$; $\eta^2_p = 0.300$) and a near-to-significance effect for REM duration ($F_{1,13} = 4.143$, $P = 0.06$; $\eta^2_p = 0.242$), whereas the cycle × REM duration interaction did not approach significance.
2. Identical two-way ANOVAs were then carried out on the indicators of story-like organization. They showed that:
   (a) The number of dream-stories per report did not vary significantly with respect to cycle, REM duration and their interaction;
   (b) The number of statements in the setting (indicative of contextual organization) did not vary significantly with respect to cycle, REM duration and their interaction;
   (c) The number of statements in the event structure (indicative of sequential organization) varied significantly with respect to the cycle ($F_{1,13} = 4.767$, $P < 0.05$; $\eta^2_p = 0.268$) and the cycle × REM duration interaction ($F_{1,13} = 5.590$, $P < 0.05$; $\eta^2_p = 0.301$), but not with respect to REM duration. Subsequent *post-hoc* comparisons (Scheffé's test, $P < 0.05$) carried out on the interaction effect showed that the number of statements in event structure was significantly different in 10-min 4th REM reports compared to all other reports (Table 1); and
   (d) The number of episodes per story (indicative of hierarchical organization) varied significantly for the cycle × REM duration interaction ($F_{1,13} = 4.620$, $P = 0.05$; $\eta^2_p = 0.262$), almost significantly for REM duration ($F_{1,13} = 4.082$, $P = 0.064$; $\eta^2_p = 0.239$), but not for cycle. Subsequent *post-hoc* comparisons (Scheffé's test, $P < 0.05$) carried out on the interaction effect showed that the number of episodes per story varied

Table 1 Mean and standard deviations of report length (measured as total word count, TWC) and indices of structural organization of dream reports

Experimental condition	*Report length (as TWC value)*	*No. of stories per report*	*Contextual organization of story (no. of statements in setting)*	*Sequential organization of story (no. of statements in event structure)*	*Hierarchical organization of story (no. of episodes in story)*
(a) REM II 5 min	300.64 ± 325.44	1.07 ± 0.27	1.96 ± 1.22	6.21 ± 4.39$^{\neq d}$	1.82 ± 1.38$^{\neq d}$
(b) REM II 10 min	388.86 ± 469.42	1.00 ± 0.00	1.78 ± 2.04	5.64 ± 5.53$^{\neq d}$	1.71 ± 1.32$^{\neq d}$
(c) REM IV 5 min	473.86 ± 707.65	1.07 ± 0.27	2.93 ± 2.09	5.28 ± 6.26$^{\neq d}$	1.57 ± 1.16$^{\neq d}$
(d) REM IV 10 min	629.28 ± 538.82	1.28 ± 0.61	2.98 ± 2.40	10.68 ± 6.68$^{\neq a,b,c}$	2.67 ± 1.35$^{\neq a,b,c}$

Significant differences at *post-hoc* comparisons (Sheffé's test, $P < 0.05$) carried out on significant cycle × rapid eye movement duration interactions are indicated by the superscript letters next to the mean values.

significantly only in 10-min 4th REM reports in comparison with all other reports (Table 1).

The differential values of the indicators of structural organization for the four experimental conditions are presented in Fig. 2.

DISCUSSION

To ascertain whether the complexity of story-like organization of dream experience increases along with duration of REM sleep in the late night, we analysed dream reports collected after awakenings provoked alternately after 5 and 10 min of REM sleep in the 2nd and 4th sleep cycles during the two experimental nights of a previous study (Rosenlicht *et al.*, 1994).

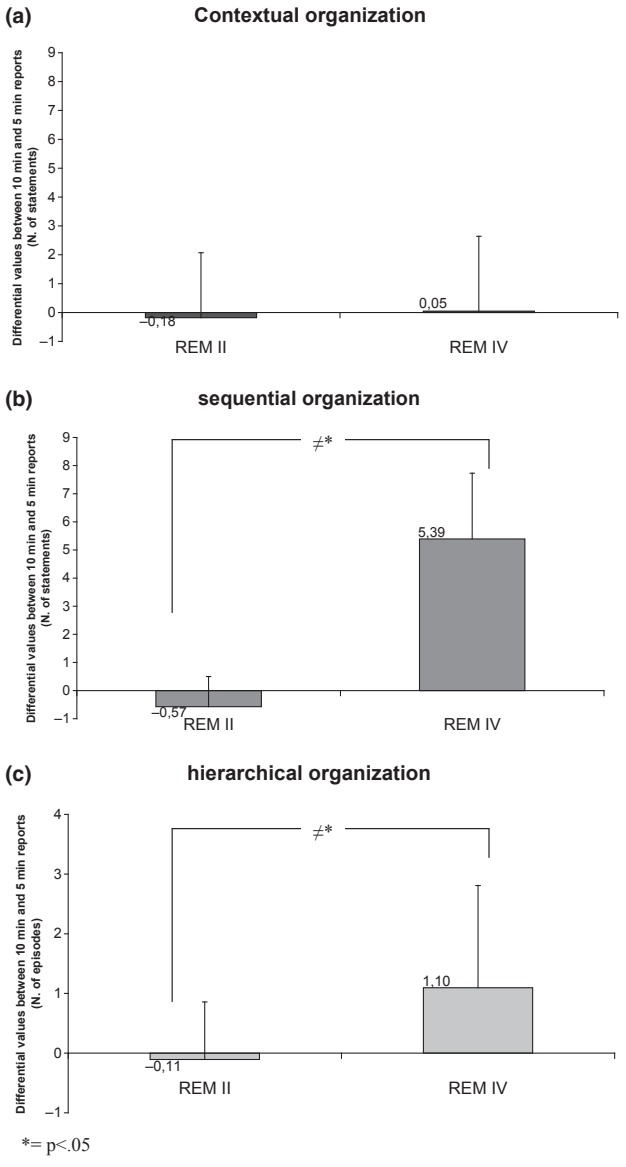

Figure 2. Differential values between 10 min and 5 min reports for the three indices of structural organization are reported. The significant comparisons (p<.05) are indicated by an asterisk.

We first established that report length (measured in terms of TWC) increased significantly in the second half of the night (the 4th compared to the 2nd sleep cycles) and almost significantly with REM duration (10 compared to 5 min), without a significant interaction between the two factors. This picture, as largely replicating that of the original study, strengthened the presupposition that the indications obtained from the data of the present sample can be generalized as well as those drawn from findings of the original sample.

Taken as a whole, the three main findings of story-grammar analysis indicate that the length of reports increases in the late night because dream-stories are not more numerous, but longer (with a higher number of statements in event structure) and more complex (with a higher number of episodes per story) in reports collected after 10 min of 4th REM sleep compared with the other three conditions. This picture suggests that the development of an articulated and complex dream-story (i.e. with several connected episodes) requires both a fairly long period of REM sleep (more than 5 min) and an increase in the cognitive resources available during sleep to maintain the coherence of the dream-story. This suggestion—which is fully compatible with previous indications that the perceptual vividness, bizarreness and drama of dream experience reach their highest levels in the second half of the night (Foulkes and Schmidt, 1983; Snyder, 1970)—is also made plausible by some further experimental findings. In particular, the processing of masked stimuli (Verleger *et al.*, 2008) and the access to weakly related items of semantic information in memory (as measured with a priming task during the period of sleep inertia; Mazzetti *et al.*, 2006; Stickgold *et al.*, 1999) are more effective during REM sleep of the late night. Moreover, the length and complexity of dream-stories reported by patients with Parkinson's disease after awakening from REM sleep are correlated with the psychometric indices of global cognitive functioning, as estimated in waking (Cipolli *et al.*, 1992). However, to definitively support the view that the time-of-night variations in the story-like organization of dream experience depend upon those in the functioning of the cognitive processes involved in dreaming, more direct evidence is required regarding the effectiveness of specific processes and their polisomnographic correlates in REM sleep of different cycles.

Pertinent items of evidence may be expected from investigation regarding (a) the circadian variations of working memory (necessary to maintain the coherence of a dream-story, i.e. the event structure: see Fig. 1) during REM sleep (where it remains fairly effective for the processing of externally delivered verbal stimuli; Daltrozzo *et al.*, 2012) and (b) the relationships between the story-like organization of REM dreams and the level of cortical activation. These relationships (which have been shown for such content features as emotional intensity and bizarreness; Wamsley *et al.*, 2007) could be assessed by using techniques such as multi-channel sleep electroencephalography (EEG) and fast-Fourier transform analyses for the quantitative

evaluation of spatio–temporal dynamics of EEG power. Indeed, these techniques have shown that dream recall can be predicted by a high theta oscillatory activity in the frontal area upon awakening from REM sleep (Marzano *et al*., 2011).

It also seems worth stressing that neither the value of TWC per report nor the value of contextual organization of dream-stories (i.e. the number of statements describing the setting) showed a significant interaction between cycle and REM duration. These seemingly convergent findings, however, disclose two distinct phenomena. The former finding indicates that dream recall is actually more accurate during the late night, while the latter indicates that the variations in story-like organization are intrinsic to dream experience and not dependent upon the accuracy of recall. Indeed, TWC data, being merely linguistic, are more sensitive to the variations in the arousal level at the moment of reporting, which lead to more accurate retrieval and description of perceptual and emotional features of dream experience in the late night (where arousal is higher; Rosenlicht *et al*., 1994; Wamsley and Antrobus, 2007). Conversely, story-grammar data, being conceptual in nature, are sensitive mainly to variations in the structural characteristics of dream experience as developed and stored in memory during sleep. Indeed, psycholinguistic studies have shown that the characteristics of story-like organization (in particular, the number of episodes and their relationships; Habermas and Diel, 2013) of a text processed during waking influences its delayed recall (Kintsch *et al*., 1977; Yussen *et al*., 1988). Moreover, studies comparing immediate (after night awakening) and delayed reports (the next morning) of REM dreams (Cipolli and Poli, 1992) and REM dreams and short films (Montangero *et al*., 2003) have shown that also during sleep the greater the story-like complexity of a text, the more accurate its encoding in memory and the subsequent recall of its structural characteristics (which, unlike the details, remain stable across reports). Consistently with this explanation, the shorter length of dream-stories developed during 10 min of the 2nd cycle of REM sleep compared with those developed during 10 min of the 4th cycle could be attributed to a lower consolidation in memory during sleep because of a poorer story-like organization.

CONCLUSIONS

The complexity of story-like organization of dream experience elaborated during REM sleep appears to reach its highest level in the second half of the night; more complex dream-stories (i.e. with more connected episodes) are developed during a fairly long period of REM sleep (10 min compared with 5 min) only in the late night.

Multiple-night studies could throw light on the relationships between the story-like organization of dream experience and the underlying cognitive processes and specific parameters of REM sleep by examining how they covary with sleep stage and cycle and from night to night.

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AUTHOR CONTRIBUTIONS

IF and NR collected the original data; CC and MG planned the new experimental design; CB and LP scored dream reports; MM ran new data analysis; CC and IF wrote the first draft. And all the authors contributed to the final version of the manuscript.

CONFLICT OF INTEREST

No conflicts of interest declared.

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