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RESEARCH ARTICLE

Morning naps architecture and mentation recall complexity

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Summary

Mentation reports were collected after spontaneous awakenings from morning naps in 18 healthy participants, and associations between sleep stages duration and complexity of recalled mentation were investigated. Participants were continuously recorded with polysomnography and allowed to sleep for a maximum of 2 hr. Mentation reports were classified according to both their complexity (1–6 scale) and their perceived timing of occurrence (Recent or Previous Mentation with respect to the final awakening). The results showed a good level of mentation recall, including different types of mentation with lab-related stimuli. N1 + N2 duration was positively related to the complexity of Previous Mentation recall, while rapid eye movement sleep duration was negatively related. This suggests that the recall of complex mentation, such as dreaming with a plot, occurring far from awakening may depend on the length of N1 + N2. However, the duration of sleep stages did not predict the complexity of Recent Mentation recall. Nevertheless, 80% of participants who recalled Recent Mentation had a rapid eye movement sleep episode. Half of the participants reported incorporating lab-related stimuli in their mentation, which positively correlated with both N1 + N2 and rapid eye movement duration. In conclusion, nap sleep architecture is informative about the complexity of dreams perceived as having occurred early during the sleep episode, but not about those perceived as recent.

KEYWORDS
hypnogram, lab-related incorporations, mentation complexity, morning nap

1 | INTRODUCTION

Previous research investigated the association between sleep architecture (i.e. sleep stages) and dream recall. Despite earlier studies proposing an ideal correspondence between rapid eye movement (REM) sleep and dream generation—a sort of "REM sleep = dreaming" equation (Aserinsky & Kleitman, 1953; Dement & Kleitman 1957; for a review, see Nielsen, 2000)—several more recent lines of evidence have demonstrated that dreaming is far from being exclusively confined to REM sleep. In fact, dreams can be reported also when subjects are awakened from non-rapid eye movement (NREM) sleep, but clear differences in mentation content are present between REM and NREM (for a review, see Nielsen, 2000; and Hobson et al., 2000). Studies about neural correlates of dreaming both in NREM and REM sleep (Chellappa et al., 2012; Esposito et al., 2004; Marzano et al., 2011; Nielsen et al., 2017; Scarpelli et al., 2015; Scarpelli et al., 2017; Siclari et al., 2017; Takeuchi et al. 2003; Zhang & Wamsley, 2019) verified the alternative hypotheses of one "covert" REM sleep dream generator for all sleep stages (Nielsen, 2000), or two distinct generators—NREM and REM sleep.

Mentation recall has been investigated not only during night sleep but also after day naps. Rates of reported dreams upon awakening from naps are consistently higher as compared with typical recall rates upon night-time sleep awakenings (Carr and Nielsen, 2015). Moreover, a circadian modulation in the ability to recall dreams following naps has emerged from the application of morning versus afternoon napping protocols (Carr and Nielsen, 2015).

The study of Palagini et al. (2004) on dream recall after afternoon naps confirmed that both awakenings from REM and NREM sleep were associated with dream reports. REM sleep dreams, however, were longer than NREM sleep dreams, thus suggesting a greater complexity of mentation during REM than NREM sleep. Similarly, Suzuki et al. (2004), by applying a paradigm of repeated 20-min naps separated by 40-min periods of forced wakefulness, found that dream reports after awakening from NREM sleep were fewer, less vivid and with less emotional content than the reports after awakening from REM sleeps, and that they were obtained more frequently during the morning hours, which suggested the involvement of a specific subcortical activation occurring more likely in the morning.

Chellappa et al. (2009) implemented a 40-hr protocol consisting of multiple 75-min naps separated by 150 min of wakefulness, and found that dream recall was higher and with a greater emotional content after REM than NREM sleep and that it was influenced by the circadian cycle.

Kussé et al. (2012) investigated the hypnagogic hallucinations reported by subjects during a 90-min afternoon nap, following or preceding practice of a computer game. Participants were repetitively awakened at different times after sleep onset, and hypnagogic hallucinations were mostly observed when participants were awakened during N1.

The nap condition has also been exploited to see whether electroencephalographic (EEG) patterns were related to dream recall. For instance, Chellappa et al. (2011) investigated NREM and REM sleep EEG power density associated with and without dream recall during a 40-hr multiple nap protocol, and found that specific changes in EEG frequency and topography underpinned the differences between dream recall and no recall after both NREM and REM sleep. On the other hand, Scarpelli et al. (2015) suggested that dream recall depends on the physiological state related to the sleep stage from which the subject awakes rather than on a stable individual EEG pattern.

A recent research line investigating the incorporation of fragments related to participant's lab experience (i.e. the lab setting and people) in sleep mentation (lab incorporation dreams [LIDs]) revealed a high frequency of lab-related elements in dreams occurring during overnight REM sleep and morning naps (Picard-Deland et al., 2021). Because sleep timing predicted the occurrence and richness of LIDs (i.e. higher frequency of LIDs during morning naps and, in overnight studies, in dreams from later awakenings), circadian factors as well as time-dependent factors involved in memory processing during sleep have been suggested to be involved in this phenomenon (Picard-Deland et al., 2021).

Grounded on the evidence of a chronobiological process modulating dreams recall, the aims of our study were to explore: (i) the complexity of recalled mentation (images, fragments, dreams with a plot); (ii) the presence of LIDs; and (iii) the association of sleep architecture with the complexity of recalled mentation and LIDs occurrence, in subjects spontaneously awakening from morning naps.

2 | MATERIALS AND METHODS

2.1 | Participants and procedure

Data collection and analysis were performed according to the criteria approved by the Committee on Bioethics of the University of Pisa (Review No. 2/2019).

Eighteen students of Pisa University (12 females and six males), aged between 19 and 22 years (mean ± SD, 20.55 ± 1.04 years) participated voluntarily in the experiment and signed an informed consent.

Exclusion criteria were the anamnesis positive for medical, neurological and psychiatric disorders, psychoactive drugs intake over the past 6 months. We also excluded subjects reporting sleep disturbances or self-describing as non-dreamers. None of the participants received any specific training on how to report mentation content.

After a night of normal sleep, subjects came to the sleep laboratory at about 09:00 hours. After polysomnographic recording montage, the participants were invited to lie down on a bed, to relax and spontaneously fall asleep for a maximum time window of 2 hr. The mean lights-off time was 09:25 hours ± 0.04 hours. All participants were allowed to conclude their sleep episode spontaneously. In fact, the recording ended when the participant woke up and said that his/her nap was definitely over within the predefined 2-hr limit.

2.2 | Polygraphic recordings and sleep-stage scoring

The recordings included 12 standard EEG leads (F3 F4 C3 C4 T3 T4 T5 T6 P3 P4 O1 O2), together with two bipolar electrooculogram, one submentalis bipolar electromyogram channel and one bipolar electrocardiogram traces. The sampling frequency was 512 Hz. The high-pass and low-pass cut-off frequencies of the acquisition filters were 0.15 and 100 Hz. The Micromed Morpheus portable device was used for the polysomnographic acquisition and recording.

The sleep-stage scoring was visually performed by a trained technician (Marco di Galante) according to the American Academy of Sleep Medicine Scoring Manual Updates for 2017 (Version 2.4; Berry et al., 2017).

Epoch-by-epoch scoring was done on 30-s-long segments (Alice Sleepware software), and each epoch was assigned to N1, N2, N3, REM sleep stage or to intra-sleep wakefulness (wakefulness after sleep onset [WASO]).

2.3 | Mentation report classification

Verbal mentation report was collected by one experimenter (Umberto Barcaro [UB]) immediately upon awakening. The experimenter asked

the participant if he/she had dreamed (Did you dream?) and, if so, to describe it (What did you dream about?). Participants, spontaneously, specified whether their mentation consisted of an image or a dream with a plot, or a fragment of it. Sometimes subjects reported that they had the feeling to have dreamed but could not grasp and report the content of the mentation. When participants reported an image, the experimenter asked whether it was part of a dream with a plot or isolated. Almost all participants spontaneously assigned their mentation to sleep periods either preceding the final awakening (Recent Mentation [RM]) or an intermediate awakening (Previous Mentation [PM]). Whenever participants did not indicate this information, the experimenter asked to specify when the mentation had occurred (When did you dream?).

This approach, unlike a more structured questionnaire, was preferred to replicate a more naturalistic approach to the investigation of nap mentation. The participants were also asked to briefly provide episodic associations with the mentation items that emerged as most significant (for details of the association method, see Barcaro et al., 2016). The results of these memory associations are not reported here.

Mentation was classified according to six categories that reflect a plausible criterion of increasing complexity, and a number between 1 and 6 was assigned to each category. We thus obtained the following categories.

1. No Recollection (NR): the participant did not remember any dreams, fragments or images.
2. Forgotten Images (FI): the participant was sure of having had one or more images but was unable to recollect them.
3. Recollected Image(s) (RI): the images were reported as isolated, not as parts of a dream.
4. Forgotten Dream(s) (FD): the participant was sure of having had one dream, or more than one dream, with a plot, but was unable to recollect the contents.
5. Recollected Fragment(s) (RF): the participant was sure of having had a dream with a plot but was only able to recollect a detailed fragment/image, which he/she assessed as part of the dream.
6. Recollected Dream(s) (RD): the participant reported the detailed plot of a dream or more than one.

As in several cases there were fluid boundaries between dream recalls, we decided to consider the highest degree of complexity for scoring purposes.

Each reported mentation item was assigned to a single category. Reported mentation was also distinguished between RM, perceived as having occurred right before the final awakening, and PM that was assigned by the participant to the beginning of the nap or to a sleep episode preceding a period of intermediate wake, which the participant was aware of.

The assignment of each reported mentation to its corresponding category (1-6) was independently evaluated by two scorers (UB, Laura Sebastiani [LS]). Inter-scorer concordance, calculated as Cohen's kappa coefficient, was high for both PM (0.855) and RM (0.841). No discrepancy between the two scorers occurred for the classification of mentation as Previous or Recent. Because kappa estimates were high, for further analysis we applied the scores of one scorer only (UB).

A representative summary of the complexity level of reported mentation and the corresponding classification is given in Table 1, in which four actual mentation recalls are reported, translated in English.

2.4 | Mentation content: LID

The occurrence of LIDs was evaluated by using the Scoring of LIDs (SoLID) criteria proposed by Picard-Deland et al. (2021). These are designed to describe the features of the reported mentation related to the sleep lab environment. They include direct and indirect references to the lab, subjective sensations, and feelings of self-consciousness and sleep performance anxiety. SoLID consists of 14 categories grouped in Lab Elements (people, place, task, objects, sleep activities), Lab Themes (sleep performance, way finding, sensory, meta-dreaming, object of observation, family/friends in lab) and Temporal Orientation (past, immediate future, near future). A binary 0/1 scoring, with 0 indicating the feature's absence and 1 the feature's presence, was used. A global category evaluating the richness of lab incorporation (Likert Scale 1–7: 1 = only indirect reference to the lab experience; 7 = extensive incorporation of many aspects of the lab experience) was also included.

2.5 | Relationship between type of mentation and sleep architecture

For the analysis of the relationship between the category of reported mentation and hypnographic properties, we visually scored and classified sleep into N1, N2, N3 and REM sleep.

A multiple linear regression model was used to analyse whether the duration of N1, N2, N3, REM and intra-nap wake (WASO) were predictive of the complexity of both RM and PM.

2.6 | Relationship between occurrence of LIDs and sleep architecture

Spearman correlation analysis was carried out to study the association between the duration of N1 + N2, N3, REM and WASO, and the scores of the LIDs categories (Elements, Themes). The correlation between LID richness and the duration of sleep stages and WASO was also studied.

For statistical analysis, the IBM SPSS Statistics 20 and Matlab tools were employed. Significance was set at $p < 0.05$.

TABLE 1 Examples of different types and complexity of recollected mentation

Type of mentation	Complexity category	Recollected mentation
Images	3	I saw images of my past life, when I was about 12–14 years old: me running on a road, me playing a volleyball game. My dream was not a story but consists of isolated images. I dreamed at the end of the nap, just before I woke up.
Fragments of a dream (with LIDs)	5	I knew that you (the experimenter) wanted me and M (the lab technician) to steal oxygen cylinders to rob a bank. The colour was dark purple, gloomy. There was a sedan where M and I loaded oxygen cylinders, which were thin, long, did not weigh, and were cold metallic. I had this dream after an intermediate awakening.
Dream with a plot	6	I woke up three times. I remember only the dream I had before the first awakening. Before the second awakening I dreamed but I forgot about what. Before the last awakening I did not dream at all. I was with three friends of mine (two males and a female) and we knew that we had to go to a business meeting. We walked outside of a building. We crossed a small square in front of it, opened a sliding door, and entered the building. We took a tiny elevator. I pressed the keypad, I guess I pressed on the 41st floor button. It was the last floor. We entered the meeting room. There were about 10 people and they talked about economics, business plans.
Dream with a plot (with LIDs)	6	I woke up once but then I fell asleep again. I do not remember the dream before the awakening. I remember what I dreamed before the last awakening. In the dream I had the feeling that I woke up, and you two (the experimenter and the technician) entered the room with other people. You were talking but I did not understand what you were saying. Within the dream I had the feeling that I did not dream. I got dressed and moved away but, since I had forgotten some things, I got back to retrieve them. There were students graduating, they all passed except one girl who was crying. I was looking for you. I wanted to ask you some questions but I did not find you. There was a student of yours to whom I asked questions but he was not prepared: he told me that the sleep phases were 10 while you had talked of phase N1, 2, 3 and REM. I went out with everything I had to take. There was my father picking me up with the car.

Abbreviation: LID, lab incorporation dreams; REM, rapid eye movement.

TABLE 2 Sleep stages duration

	Duration (min)		
Sleep stages and variables	Mean	SD	% of SPT
N1	8.37	4.87	10.94
N2	41.18	14.22	51.55
N3	8.22	11.15	9.89
REM	8.28	8.56	8.61
WASO	15.88	10.36	19.11
SPT	81.93	26.30	
SOL	21.78	6.74	
	Mean	SD	
Number of awakenings	10.5	6.8	

Abbreviation: REM, rapid eye movement; SOL, sleep-onset latency; SPT, sleep period time; WASO, wakefulness after sleep onset.

3 | RESULTS

3.1 | Hypnograms

Table 2 reports the mean duration of each sleep stage and of sleep period time (SPT). The duration of sleep stages was expressed as both absolute length (min) and percentage of SPT. The mean sleep-onset latency (SOL) and the number of awakenings were also reported.

After some latency time (average = 21.78 min, minimum =11 min, maximum = 36.5 min), all subjects fell asleep. The average length of the recordings, which included initial wakefulness, nap and final wakefulness, was 122.35 min. On average, SPT, which was calculated as the interval between the last epoch spent awake and the one of the final awakening, was 82 min (mean ± SD, 81.93 ± 26.3 min). None of the naps lasted more than 2 hr (highest SPT = 115.5 min).

As witnessed by the high values of the time spent in WASO (Table 2), naps were generally characterized by a high degree of fragmentation. Four examples of naps with different degrees of fragmentation are shown in Figure 1.

The number of awakenings was on average about 10 (mean ± SD, 10.5 ± 6.8). For all of the participants, the N2 stage was the most prevalent in time (51.5% ± 12.7% of the SPT). At least two separate N2 epochs were always observed, one in the first half of the nap, and the other in the second half. The occurrence of REM sleep was observed in 12 of the participants (average duration 12.91% ± 5.96% of the SPT). In six cases, this sleep stage lasted more than 10 min. All of the REM epochs occurred during the second half of the nap. Eight participants showed N3 epochs, which occurred either in the central part of the naps or in the final part (average duration 22.25% + 16.06% of the SPT). Five of these participants also displayed REM epochs. Finally, three out of the 18 participants did not show either REM or N3 epoch.

In 14 participants the prevalent sleep stage over the last 5 min preceding awakening was N2. As for the remaining participants, one awoke from N1, one from REM and two from N3.

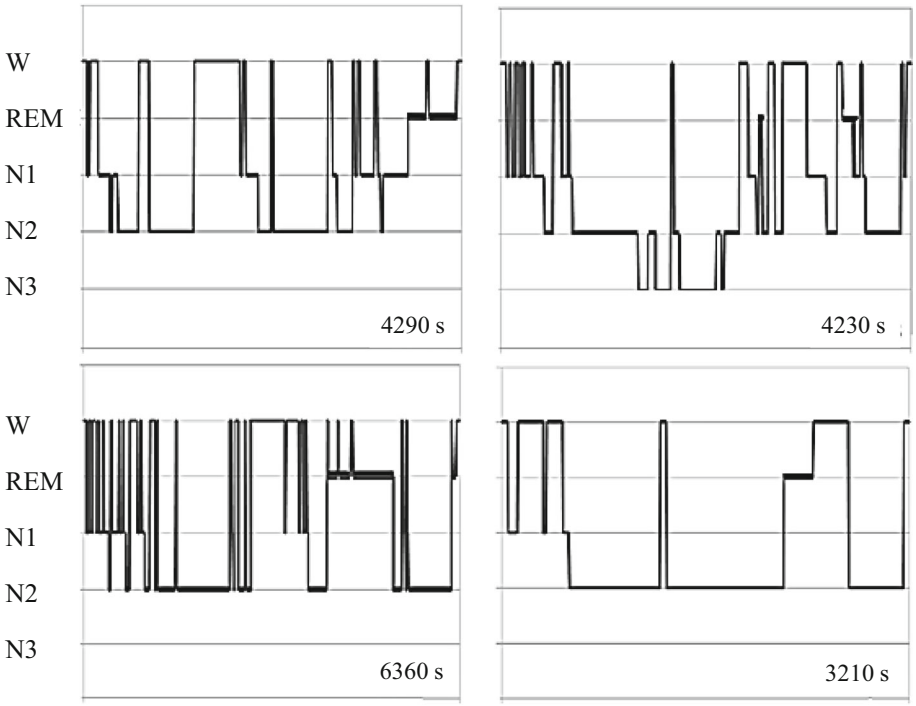

FIGURE 1 Hypnograms. Four examples of hypnograms with different degrees of fragmentation are presented. Upper left: the hypnogram shows no N3 epochs and one rapid eye movement (REM) epoch before the final W. A rather long W epoch occurred during the first half of the nap. Upper right: N3 is present in the central part of the nap; a short REM epoch, followed by N2, shortly preceded the final awakening; frequent transitions between light sleep and W were present in the second half of the nap. Lower left: frequent transitions between W and light sleep are present throughout the nap; no N3 and a fairly long REM epoch, followed by N2, is present in the final part. Lower right: long and stable N2 epochs are present during the whole nap; one REM epoch followed by a fairly long W was present in the second half of the nap; no N3 was present

Analysis of correlation (Spearman) between the various sleep stages yielded a significant positive association between N1 + N2 and REM duration (rho = 0.730, $p = 0.001$).

3.2 | Mentation

All 18 participants reported substantial mentation. The categories assigned by the scorer to each participant's mentation are shown in the Supplementary material (Table S1). For each nap time window (either previous or recent), some participants reported more than one mentation item. For instance, within a complex RD, a participant could insist during the recall on a single rather isolated image. Nevertheless, when the episode was reported with continuity within the same nap time window, we decided to assign the score including the highest degree of complexity.

Previous Mentation was reported by 13 of the participants, while only one participant did not report any RM. The number of participants who were able to recollect a dream plot (RD) was 12 out of 18 (67%). Specifically, eight participants assigned the reported dream to RM, two participants to PM, and two participants recollected both a previous and a recent dream.

Nine out of 10 participants who assigned the RD to RM displayed N2 for at least 5 min before the awakening from the nap; the remaining one awoke from N3. Five out of eight participants who did not recall recent dreams displayed N2 before awakening. The remaining three awoke, respectively, from N1, N3 and REM. N2 duration of participants who recalled a recent dream was similar to that of participants who did not (Mann–Whitney, $z = -1.56$, $p = 0.12$).

The number of mentation reports belonging to each mentation category is shown in Table 3.

3.3 | Relationship between mentation and sleep architecture

Scatterplots representing the association of sleep stages and WASO durations as a function of the complexity of reported PM are shown in Figure 2(a).

The results of multiple regression analyses concerning the relationship between the complexity of reported PM and the duration of sleep stages are shown in Table 4. The duration of N1, N2 and REM sleep were, respectively, positively and negatively correlated to the complexity of reported PM, with coefficients of similar size (N1, $\beta = 0.0039$, $t = 2.362$, $p = 0.0359$; N2, $\beta = 0.0024$, $t = 2.965$, $p = 0.0118$; REM, $\beta = -0.0033$, $t = -2.552$, $p = 0.0253$).

On the basis of these results, we investigated the possible association between the complexity of reported PM and the difference between the more superficial sleep stages (N1 + N2) and REM sleep duration ((N1 + N2) − REM) by means of correlation analysis

(Pearson). As shown in Figure 2(b), there is a positive correlation between the two variables ($r = 0.66$, $p = 0.0029$), such that the greater the difference the higher the complexity of the reported PM.

Multiple regression analysis did not reveal any significant association between the complexity of reported RM and the duration of sleep stages.

3.4 | Lab incorporation dreams

The LIDs occurred in nine out of 18 participants (50%). Four episodes were assigned to RM while five were assigned to PM. As for the mentation type, three LIDs consisted of RI, two of RF and four of RD. The frequencies of the different LIDs categories are reported in Table 5. Most LIDs included people of the lab (66.7%), the lab place (66.7%), the experimental task (44.4%), and referred to the immediate future (66.7%). Dreaming of awakening was also frequent (55.6%).

None of the reported mentation including LIDs was a true replay of what had really happened in the lab before the nap.

TABLE 3 Mentation reports

Mentation report classification	PM *N*	RM *N*
1. No Recollection (NR)	5	1
2. Forgotten Images (FI)	0	1
3. Recollected Images (RI)	5	2
4. Forgotten Dreams (FD)	2	2
5. Recollected Fragments (RF)	2	2
6. Recollected Dreams (RD)	4	10

Abbreviation: PM, Previous Mentation; RM, Recent Mentation.

3.5 | Relationship between LIDs and sleep architecture

Correlation analysis between the duration of the different sleep stages/WASO and the LIDs categories scores revealed that N1 + N2 duration was significantly correlated with Lab Elements (rho = 0.566, $p = 0.014$) and Lab Themes scores ($\rho = 0.548$, $p = 0.018$), while REM duration was positively correlated with Lab Elements scores ($\rho = 0.573$, $p = 0.013$) but not with Lab Themes ($\rho = 0.448$, $p = 0.062$). Neither N3 nor WASO was significantly correlated with Lab Elements (N3, $\rho = 0.155$, $p = 0.538$; WASO, $\rho = 0.099$, $p = 0.696$) or Lab Themes (N3, $\rho = 0.072$, $p = 0.766$; W, $\rho = 0.210$, $p = 0.403$).

The comparison between sleep stages duration of participants reporting ($n = 9$) and not reporting ($n = 9$) LIDS (Mann–Whitney) further corroborated this finding by showing a significant difference between the two groups for N1 + N2 duration ($z = -2.474$, $p = 0.013$), with longer mean duration in the group with LIDS (mean ± SD, 57.83 ± 10.55 min) than in the other group (41.26 ± 12.61 min). A near-significant difference ($z = -1.935$, $p \leq 0.053$) was found for REM duration (LIDs group, 12.16 ± 9.36 min; no LIDs group, 4.39 ± 5.83 min).

No significant differences between the two groups were found for N3 ($z = -0.436$, $p = 0.6639$) and W ($z = -0.839$, $p = 0.401$).

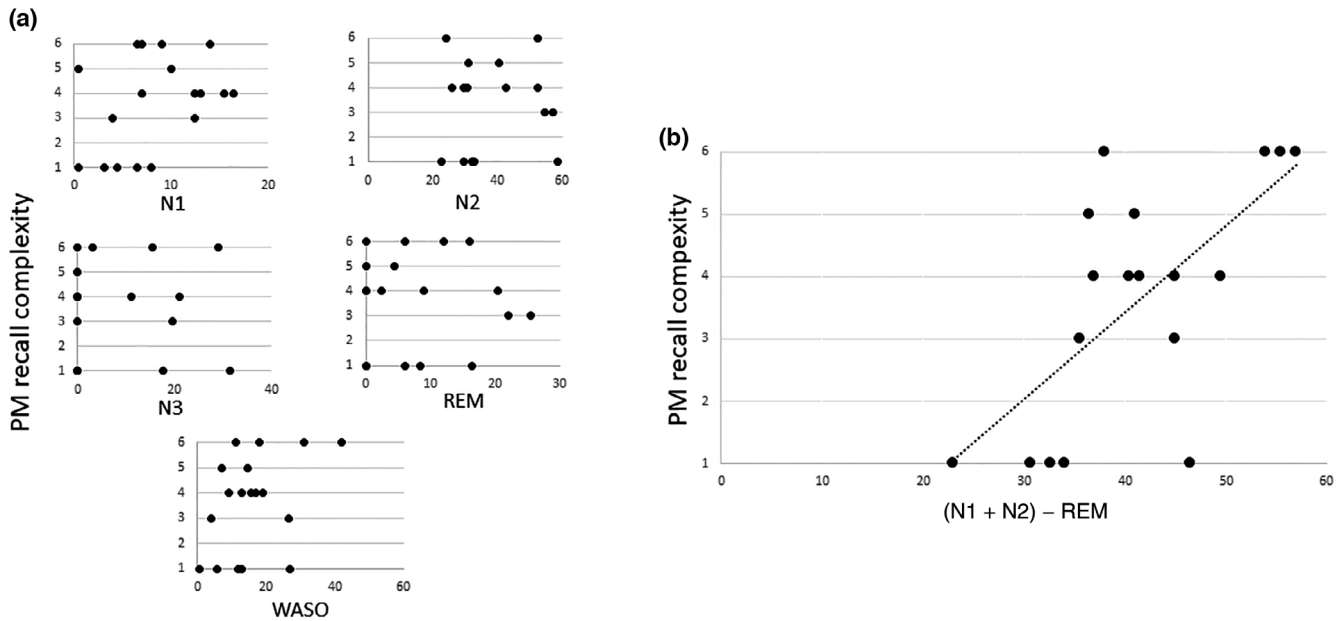

FIGURE 2 Association between sleep stages and Previous Mentation (PM) recall complexity. The scatterplot shows the complexity (1-) of PM reported by each participant as a function of sleep stages and wake after sleep onset (WASO) duration (a), and of the difference between the duration of N1 + N2 and rapid eye movement (REM) sleep (b). The six-point scale reflects increasing complexity of recall. Sleep stages duration is expressed in minutes. Each point refers to a single participant. The trend line (dotted line) is shown for significant associations

TABLE 4 Association between complexity of PM recall and the duration of sleep stages: summary of the linear regression model

Model	**$R^2 = 0.540$**	**Adj $R^2 = 0.349$**	**Residual SE = 1.544**	
F-statistic	$F_{5,12} = 2.823$, $p = 0.065$			
Coefficients	***B***	**SE**	***t***	***p*-value**
Intercept	−2.883	1.908	−1.511	0.157
N1	0.0039	0.00165	2.362	0.0359*
N2	0.0024	0.00082	2.965	0.0118*
N3	0.0003	0.00058	0.565	0.582
REM	−0.0033	0.00127	−2.552	0.0253*
WASO	0.00001	0.00074	0.0205	0.984

Note: Predictors: N1, N2, N3, REM, WASO.
Abbreviation: REM, rapid eye movement; WASO, wakefulness after sleep onset.
*$p < 0.05$.

TABLE 5 Frequencies of LIDs

LIDs categories	***N***	**%**
LID elements		
People	6	66.7
Place	6	66.7
Task	4	44.4
Objects	3	33.3
Sleep-related activities	0	0.0
LID themes		
Sleep performance	3	33.3
Way finding	3	33.3
Sensory	4	44.4
Meta-dreaming	5	55.6
Friends/family lab	2	22.2
Object of observation	0	0.0
Temporal orientation		
Past	2	22.2
Immediate future	6	66.7
Near future	1	11.1

Abbreviation: LID, lab incorporation dreams.

Consistently, when comparing the recalls of those subjects experiencing REM with those that did not enter REM sleep, there was a statistically significant difference in terms of laboratory elements integration (Table S2).

No significant correlations were found between LIDs richness and the duration of sleep stages and intra-nap wake (N1 + N2, $\rho = 0.339$, $p = 0.372$; N3, $\rho = 0.044$, $p = 0.910$; REM, $\rho = 0.525$, $p = 0.146$; WASO, $\rho = 0.077$, $p = 0.845$).

4 | DISCUSSION

The aim of our study was to explore mentation contents and their association with sleep structure in individuals awakening from morning naps, by investigating mentation reports after spontaneous awakening. The condition of morning naps is easy to implement in the sleep lab and is comfortable for the participants. Although all subjects could successfully fall asleep, the quality and relative duration of sleep stages during naps showed a high degree of variability. We took advantage of such variability in the attempt to find associations between sleep and subsequent mentation.

The present data indicate that naps offer a condition for the creation and recollection of significantly structured mentation. In fact, it was observed that: (a) all the participants reported some mentation, either images, fragments or dream with a plot; (b) the level of recalled mentation was generally good and sometimes high; in fact, 67% of the participants were able to report a dream with a plot; (c) the participants assigned items of mentation to nap periods close to the final wakefulness but also to the beginning of the nap or to a sleep episode preceding a period of intermediate awakening; (d) the presence of REM sleep, as revealed by standard sleep-staging techniques, was not a necessary prerequisite to recall mentation, as either images, fragments or dreams with a plot were also reported by participants who displayed only NREM sleep.

The fact that, upon awakening, participants reported mentation, irrespective of the presence of REM sleep, is in line with recent studies that suggest that dreams report can be obtained from every stage of NREM sleep, even though less often (Siclari et al., 2017). In fact, our data show that complex mentation (dream with a plot), which mainly occurred in participants that displayed REM sleep, was also reported by two participants who displayed N3 but not REM, and by one participant that displayed neither N3 nor REM.

Analysis of the relationship between the complexity of reported mentation and the duration of sleep stages revealed that the durations of N1, N2 and REM sleep were, respectively, positively and negatively related to the complexity of the reported PM. This finding suggests that the capability to remember mentation with high levels of complexity (e.g. dream with a plot) that occurred at the beginning of the nap or anyway far from the final awakening could depend on the length of the more superficial sleep stages. The opposite happens for REM, whose duration seems to contrast the ability to recall

previous complex mentation. These findings are also supported by the linear positive association between the difference between light and REM sleep and PM complexity. These apparently paradoxical results should be read in light of the modulation of recall ability of mentation rather than mentation occurrence itself. In parallel, sleep inertia, which is most likely higher for longer naps, could play a role in modulating the complexity of recalled mentation.

Interestingly, the duration of sleep stages does not appear to influence the capability to recall RM. In fact, neither the durations of N1, N2 or REM sleep length were predictive of the complexity of RM. However, 80% of participants (eight out of 10) who recalled recent dreams also displayed REM sleep in contrast with 50% of participants (four out of eight) who did not, thus suggesting that this stage basically contributes to complex mentation during naps.

Focusing on sleep stages immediately preceding the awakening, rather than the entire nap duration, no difference between mentation reports and the lack of thereof could be identified. This is most likely due to the large predominance of N2 in both awakenings associated with mentation reports or without. The high occurrence of lab-related incorporations is in line with previous literature that describes high rates of LIDs in morning naps (Picard-Deland et al., 2021). The incorporation of experiences related to the subject's waking life, either referred to some days before (dream-lag effect) or to the previous day (day-residue effect), has been previously investigated (Nielsen & Powell, 1992). In the case of the present experimental design, waking life preceding morning naps consists of the time interval between waking up from night sleep and the nap itself (at about 09:00 hours). Thus, it is not surprising that, owing to the scheduling of our experimental protocol, the day-residue effect could have favoured the reactivation of lab-related memory sources. However, despite the large presence of LIDs (e.g. persons and elements of the lab, sleep experiment), our results show that the reported mentation did not consist of a true replay of what had really happened in the lab before the nap. This finding is in accord with previous literature, which indicates that a true "re-experiencing" of episodic memory in a dream occurs only rarely (Baird et al., 2022; Mallett, 2020). This notion has been proposed as the expression of a typical processing mode of episodic memories during sleep that involves their decomposition and recombination into a novel construct, and not a mere replay of previous experience (Tuominen et al., 2019).

Our findings show a positive association between LID themes and/or elements scores and the length of N1 + N2 and REM sleep. Because N2 is the prevalent stage in terms of presence (all participants displayed N2) and duration (mean ± SD, 41.18 ± 14.28 min), we can assume a crucial role of this stage both for the occurrence and amount of lab incorporations. As N2 represented the most common sleep stage from which the awakening occurred (in 14 out of 18 subjects woke up from N2), an intrusion of LIDs element during the recall process cannot be excluded. Interestingly, LIDs occurrence is comparable in PM versus RM, thus suggesting that this phenomenon is independent of the time of occurrence of the dream, either early or late during the napping episode, further suggesting that the duration of sleep preceding the awakening correlates with LIDs, regardless of the timing attributed during the recall. It might be of note that, in this experiment, the duration of naps was relatively short. It would be of interest to replicate this paradigm in whole-night experiments, to expand the time window of sleep mentation relative to the recall.

The positive association between REM duration and LID themes could mask the real association between N1 + N2 and LID themes incorporation, as the longer the subjects slept the more likely they were to reach REM sleep. In fact, also in our sample, N1 + N2 and REM duration were positively correlated. Another possible explanation of the association between REM duration and LIDs themes scores (e.g. sleep performance) could rely on the role REM sleep plays in memory consolidation of novel experiences (for a review, see Rasch & Born, 2013). This stage could facilitate the consolidation of memories related to the partaking of the experiment, i.e. a novel, and thus salient, experience for most participants.

Beyond the hypothesized role of REM in memory consolidation, another well-described phenomenon is the so-called "first-night effect" (Curcio et al., 2004): lab incorporations are more frequent during a first night in the laboratory than during the following ones (Browman & Cartwright, 1980; Dement et al., 1965). In fact, even if we cannot strictly define it a "first-night effect", our experimental protocol consisted of a single nap session, such that participants had never visited the lab before and, moreover, it was the first time they took part in a sleep/nap experiment. Thus, the experimental setting and the nap were a new experience for them. We cannot exclude that, mirroring the dissipation of the "first-night effect" during whole-night experiments, a similar reduction in LIDs could occur after adaptation to the laboratory environment.

Our studies carry some limitations and caveats. The sample size is rather small. Despite the significance of the reported results, a larger and more heterogeneous sample would certainly benefit this study and possibly make the conclusions more generalizable. Moreover, particularly in the investigation of LIDs, the novelty of the experience could have driven the reported observations. To prevent this confounder, a more elaborate experimental paradigm, including an adaption time window, should be considered for future studies.

4.1 | Conclusions

The obtained results support the idea that naps provide a feasible investigation window into sleep mentation, as they are less invasive for the subjects undergoing the experiment as compared with all-night studies. In parallel, this approach offers a high yield of dream recall.

The finding of an association between sleep stages and the degree of complexity of recalled mentation during morning naps suggests that further insight into the terms of this complexity is a necessary development of current research. Specifically, the method so far applied to data analysis should be extended in two directions. First, the possible correspondence should be studied between the various kinds of mentation and specific EEG patterns. These patterns are related to both topography and oscillation frequency (Esposito

et al., 2004; Nir & Tononi, 2011; Scarpelli et al., 2017; Siclari et al., 2017), and are modulated by chronobiological processes (Nielsen et al., 2004). Second, the results of RM versus PM of dream content seem to depend on light sleep duration across the nap, possibly affecting mentation recall rather than mentation occurrence. A specific experimental paradigm capable of disentangling dream recall and dream occurrence could be implemented in the attempt to clarify this association, taking advantage of recently implemented neuroimaging approaches (Horikawa et al, 2013). In conclusion, the present nap protocol has revealed significant associations between sleep stages duration and mentation recall, in particular with its complexity and recalled timing of occurrence.

AUTHOR CONTRIBUTIONS

Laura Sebastiani: Conceptualization; formal analysis; funding acquisition; supervision; writing – original draft; writing – review and editing. **Umberto Barcaro:** Conceptualization; formal analysis; investigation; methodology; writing – original draft; writing – review and editing. **Paolo Paradisi:** Conceptualization; writing – review and editing. **Paolo Frumento:** Formal analysis; writing – review and editing. **Ugo Faraguna:** Data curation; formal analysis; funding acquisition; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

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