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Memory Sources of REM and NREM Dreams

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Summary: Sixteen male volunteers slept 4 nonconsecutive nights each in a sleep laboratory. They were awakened for one dream report per night. Awakenings were made, in counterbalanced order, from early-night and late-night rapid-eye-movement (REM) and non-REM (NREM) sleep. Following dream reporting, subjects were asked to identify memory sources of their dream imagery. Two independent judges reliably rated mentation reports for temporal units and categorized memory sources as autobiographical episodes, abstract self-references, or semantic knowledge. We replicated earlier findings that semantic knowledge is more frequently mentioned as a dream source for REM than for NREM reports. However, with controls for length of reports, the REM–NREM difference disappeared, indicating that the stage difference in memory sources was not independent of stage difference in report lengths. There was a significant effect of time of night on source class, but only in REM sleep: Both without and with controls for report length, more semantic sources were cited for late than for early REM dreams. **Key Words:** REM dreams—NREM dreams—Dream sources—Temporal units.

At least three aspects of the relationship between dreaming and memory can be studied: (a) how the dream experience (i.e., the dream) is stored in, and successively recalled from, memory (1); (b) what kind of effects, if any, dreaming has on the storage and retrieval of some material learned outside the dreaming condition (2); and (c) how the contents of memory influence dreaming (i.e., what kind of memories participate in the production of dream experience). The present research, which deals with the last-mentioned aspect, is part of a series of studies aiming to clarify the nature and causes of the differences between dreaming in different stages of sleep, specifically between rapid-eye-movement (REM) and non-REM (NREM) dreaming.

This difference is one of the most reliable findings of electrophysiological dream research. Typically, NREM dreams are remembered less often, and when remembered are shorter and less organized than REM dreams. The causes of these differences, however, are still unclear. Are REM and NREM dreams produced by different kinds of

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cognitive processes, or are all dreams produced by the same processes, whose frequency and level of engagement vary only across sleep stages? Recent findings (3,4) that, when length of reports is controlled, there are few, if any, "qualitative" differences in dream content between REM and NREM reports suggest that it is unnecessary to postulate different dream production systems to account for the dissimilarities. According to this view, observed REM–NREM differences have been interpreted by Antrobus (3) as the by-product of a misfunctioning of the memory processes of encoding and retrieval, which operate on the original dream experience after its occurrence. On the other hand, Foulkes and colleagues (4,5) claim that the differences originate at the time of dream production and interpret the dissimilarities between reports in terms of the amount and kind of mnemonic activity available for, or requiring synthesis by, dream generation processes.

In some previous studies (6–9) a first attempt to test Foulkes's hypothesis was made investigating the memory information involved in the production of dreams in REM and NREM sleep. Subjects had to free-associate to their sleep mentation reports immediately after these reports were collected upon experimental awakenings from different sleep stages. The major findings were the following:

1. Associations to sleep onset NREM reports are predominantly discrete episodic memories (e.g., "Yesterday I arrived at Atlanta from Italy"), while associations to REM reports are more balanced among episodic memories, abstract self-references (e.g., "I'm a very shy person"), and generalized semantic or world knowledge (e.g., "Apples are red") (6).
2. When episodic memory associations are classified in terms of their temporal references, day residues (i.e., memories of the day preceding the dream) are more frequent to sleep-onset reports than to REM reports, while memories of events occurring in the year before the dream are more frequent to REM than to sleep-onset reports (7).
3. When subjects are asked to reassociate to dreams 2 months following their original reporting, few of the original associations are retained, and sleep-stage differences in association classes (e.g., episodic memories) no longer are apparent, suggesting that sleep-stage differences in immediate associations reflect the mnemonic conditions responsible for dream reports rather than the structure of those reports themselves (8).
4. Associations to initial sleep-onset reports, to later (post–experimental-awakening) sleep-onset reports, and to regular midnight NREM reports are comparable to one another (and different from associations to REM reports) in containing a relatively high level of episodic associations and a relatively low level of semantic associations, indicating that neither prior sleep time nor time of associating can explain the earlier-described sleep onset versus REM differences (9).
5. Associations to short and long REM reports show comparable distribution into episodic memory, abstract self-reference, and semantic knowledge, while associations to short and long NREM reports do not, suggesting that different amounts and kinds of mnemonic activation underlie variable-length NREM but not REM reports (9).
6. Infrequent long NREM reports have comparable associations as do frequent long REM reports (relatively more semantic than episodic memories), while frequent short NREM reports, unlike infrequent short REM reports, have relatively more episodic than semantic associations (9).

These last two findings, although tentative, suggest a stable and continuous dreaming process in stage REM, a situation only rarely achieved during NREM sleep. They also suggest that when such a situation is achieved in NREM sleep, NREM and REM dreams differ neither in manifest form nor in mnemonic sources.

The present study was designed in order to (a) extend and replicate the previous findings of a more diffuse activation of memory sources in REM than NREM dreaming, using a slightly different technique to analyze memory contexts of dream generation (direct memory search instead of free association); and (b) examine the relationships among time of the night in which awakening is carried out (early versus late), length of the report (short versus long), and memory sources that may be involved in dream production.

METHOD

Sixteen male university student volunteers, aged 19–26 years, served as subjects in the experiment. Each subject slept in the sleep laboratory for 4 nonconsecutive nights, with standard electropolygraphic recordings (two electroencephalographic and two electrooculographic channels). He was awakened once per night in one of four awakening conditions, in counterbalanced order: NE (*N*REM *E*arly in the night, ascending stage 2 before the first REM period); NL (*N*REM *L*ate in the night, ascending stage 2 before the third REM period); RE (*R*EM *E*arly in the night, during the first REM period, 5 min after the appearance of the first REM burst); RL (*R*EM *L*ate in the night, during the third REM period, 5 min after the appearance of the first REM burst).

Awakenings were made by calling the subject's name over an intercom system until an acknowledgment was obtained. Immediately after that, an experimenter, who was unaware of the sleep stage in which the awakening had been carried out, entered the subject's room (lights off) and solicited a dream report with the standard probe: "Please tell me everything you can remember of what was going through your mind before I woke you up." Where an initial awakening in any category failed to produce a content report, awakenings were repeated at the next suitable periods until a report was obtained. Three subjects required two RE awakenings to remember a dream, while five subjects for NE and four for NL required two or more awakenings to remember a dream. Altogether, there were 64 valid dream reports: 16 NE (mean sleep time 135 min), 16 RE (149 min), 16 NL (269 min), and 16 RL (278 min).

Each dream report was tape recorded. Immediately following each dream interview, the recording was replayed to the subject. The dream report was segmented "on line" by the interviewer during the replay. Segments corresponded to short thematic units expressing an action or a concept characterized by completeness. A new thematic unit was considered to occur whenever there was a change in characters, in the prevailing activity, or in the setting. After each segment, the replay recorder was stopped, another recorder was activated, and the subject was asked to identify the immediate memory sources of his dream imagery. Memory sources were collected to segments in the order in which the subject described the segments as having occurred in the dream experience. Subjects were oriented, in each presleep period, to the task of identifying "the sources of the various images you can remember from a dream." In addition, in their first session they listened to a tape in which an experimenter, as ostensible subject, demonstrated the technique.

The 64 dream and 64 memory source reports then were submitted to two judges, one of whom had no prior knowledge of the experiment. Judges analyzed dream reports to assess their length in temporal units (4). Memory source reports were classified into the three following memory categories: (a) Strict Episode—discrete episode in the life of the dreamer, with precise spatial and/or temporal coordinates (e.g., "It reminds me of last Saturday when I went to a party at David's house"); (b) Abstract Self-reference—memories not connected to any particular spatiotemporal context, referring to the dreamer's general knowledge of himself and his own habits (e.g., "It reminds me of my fondness for pop music; this is related to the fact that Michael and I went abroad together several times"); (c) Semantic Knowledge—elements of general knowledge of the world, including episodes from the biographies of others (e.g., "It reminds me that the Chrysler Building was built in 1930; that particular color is associated with several paintings by Van Gogh").

Over the 64 dream reports, the judges showed high agreement in initial scoring of temporal units ($r = 0.95$). The judges agreed 85.2% on initial classification of 358 memory source units into Strict Episodes, Abstract Self-references, and Semantic Knowledge. Discrepancies in each analysis then were resolved, and the reconciled versions were used in data analysis.

RESULTS

Not unexpectedly, REM reports were, on average, significantly longer, in terms of temporal units, than NREM reports ($F_{1,15} = 14.07$, $p = 0.0019$). No significant effect of either time of night or stage-by-time interaction was found (see Table 1). Similarly, the mean number of dream sources identified was significantly greater in REM than in NREM ($F_{1,15} = 10.37$, $p = 0.0057$). Again, no significant effect of either time of night or stage-by-time interaction was found (see Table 2).

As far as categories of memory sources in the two conditions are concerned, we found no significant stage, time, or stage-by-time effects for either Strict Episodes or Abstract Self-references. For Semantic Knowledge, however, we found a significant REM–NREM difference (24.12 vs. 6.19, $F_{1,15} = 9.28$, $p = 0.008$), as well as significant interaction between stage and time of night ($F_{1,15} = 6.01$, $p = 0.027$). The percentage of semantic memory sources identified in RL was significantly higher than that in RE, while NE and NL did not differ from each other (see Table 3). Within NREM conditions (NE and NL), Abstract Self-references were significantly more frequent ($p < 0.05$) than Strict Episodes, which in turn were significantly ($p < 0.05$) more frequent than Semantic Knowledge. Within RE, Abstract Self-references were significantly more frequent ($p < 0.05$) than both Strict Episodes and Semantic Knowledge, which did not differ from each other. In RL, the incidences of the three memory source categories did not differ from one another. Taken together, these findings suggest a qualitative difference in the kind of memory traces activated during dream generation in REM

TABLE 1. *Mean number of Temporal Units in REM and NREM reports collected upon early and late night awakenings*

	Early	Late	Total[a]
NREM	1.88	1.56	1.72
REM	3.56	4.31	3.94
Total	2.72	2.94	—

[a] $p = 0.0019$.

TABLE 2. *Mean number of dream sources for Early and Late NREM and REM dreams*

	Early	Late	Mean[a]
NREM	4.69	3.75	4.22
REM	6.56	7.37	6.97
Mean	5.62	5.56	—

[a] $p = 0.0057$.

versus NREM sleep conditions, as well as a significant effect of time of night operating in a selective way only within REM sleep.

However, in order to control for the known correlation between sleep stage and mentation report length, memory source density (number of memory sources/number of temporal units in the report) was determined for each sleep-stage and memory category. The analysis gave the results presented in Table 4. As in the previous analysis, we found no significant stage, time, or stage-by-time effects for either Strict Episodes or Abstract Self-references. For Semantic Knowledge, we found a marginally significant interaction between stage and time of night ($F_{1,15} = 3.51$, $p = 0.08$). In particular, memory source density was significantly higher in RL than in RE, while there was no significant difference between NL and NE. Thus, these data do offer some support for the hypothesis of a selective influence of the time-of-night factor within REM sleep. However, with the control for report length, there no longer was a significant sleep-stage difference for Semantic Knowledge ($F_{1,15} = 0.85$), and thus there no longer was any indication of sleep-stage differences in dream sources.

We also tried controlling for length effects in stage-of-sleep comparisons by matching NREM and REM reports both for number of units in the dream and for number of memory-source units identified, using the criteria of Foulkes and Schmidt (4). Ten matched pairs (REM–NREM) were obtained on the temporal unit variable (only three of which were at a level greater than one temporal unit). Here only four pairs differed in the proportion of semantic units scored in memory sources, three having more such sources in REM, one in NREM. Thus, again, it did not appear that there was a strong

TABLE 3. *Mean percentages of episodic, abstract self-referred, and semantic dream sources for early and late REM and NREM reports*

	Episodic	Abstract self-referred	Semantic
NREM			
Early			
Mean	32.26	60.04	7.69
SD	30.71	33.42	12.80
Late			
Mean	37.78	57.53	4.69
SD	34.09	32.88	8.84
REM			
Early			
Mean	28.28	55.34	16.37
SD	26.62	25.30	17.09
Late			
Mean	28.41	39.73	31.86
SD	29.75	28.91	29.56

TABLE 4. *Mean memory source density for early and late NREM and REM dreams*

	Episodic	Abstract self-referred	Semantic	Mean
NREM				
Early				
Mean	1.22	1.56	0.45	1.08
SD	1.58	1.08	1.31	
Late				
Mean	0.82	1.36	0.21	0.80
SD	0.81	0.84	0.51	
MEAN	1.02	1.46	0.33	0.94
REM				
Early				
Mean	0.96	1.19	0.36	0.84
SD	1.36	0.82	0.44	
Late				
Mean	0.68	1.00	0.72	0.80
SD	0.99	1.24	0.82	
MEAN	0.82	1.10	0.54	0.82

stage-of-sleep effect on memory source category independent of stage differences in report length.

This conclusion was strengthened in matches for number of memory source units. The proportion of semantic units from REM (median = 0.11) did not differ significantly from the proportion of such units for NREM (median = 0.09). Twelve matches were possible here: five showed no stage difference, four showed more semantic memory sources proportionately in NREM than in REM, and three more semantic memory sources proportionately in REM than in NREM. Thus, the apparent REM superiority in the relative incidence of Semantic Knowledge is not independent of the number of memory sources identified.

DISCUSSION

Our results replicate the finding of a greater proportion of semantic memory sources in REM than NREM reports obtained in previous studies (6,9). The replication is significant given that there were some differences in data collection and data analysis procedures in this study, as compared to the previous ones. One concerned the way in which subjects were interviewed to obtain memory sources of their dream reports. In the earlier studies, subjects were asked to free-associate. Here they were asked to identify manifest sources of dream imagery. Another difference concerned the criteria used by judges to classify memory sources. In the previous studies, judges were asked to determine the conceptual background of an association to decide whether knowledge was abstract self-related or generic. Here they followed the literal phrasing of the subject's description of memory sources. This difference in memory source scoring seems to have affected only the amount of abstract self-referred sources (which is higher in the present study) but not the interstage differences. The original finding of relatively more semantic/generic than self-related (episodic or abstract) associations to REM than NREM reports is therefore robust.

With controls for length (using REM and NREM scores prorated to dream length in temporal units; matching REM and NREM reports for report length or for number of memory source units), however, there were no significant differences in memory sources between REM and NREM dreams. This suggests that recent demonstrations of no qualitative differences, with control for report length, in dream content between REM and NREM dreaming, now may be extended to dream sources, when similar controls are observed. However, variably activated across sleep stages, the same system seems to be responsible for dreaming whether it occurs in or outside REM sleep. While this conclusion is based on acceptance of the null hypothesis in relatively small samples, these are samples of a magnitude that elsewhere has produced REM-versus-NREM content differences without control for report length and that here did produce a time-of-night effect, even with control for report length. Thus, we conclude that any stage differences in memory sources when length of report is factored out must, at best, be relatively minor ones, the main observation being that most of the apparent source-class difference between stages is length-dependent.

The time-of-night factor influenced, only in REM, the amount of semantic memory material identified as a dream source. This result seems to suggest that the further from waking the REM dream generation process takes place, the wider is the spectrum of mnemonic information currently activated; i.e., memory sources become relatively more abstract and less self-referred.

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