Does training increase NREM dream recall? A pilot study

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Summary. The percentages of successful dream recall vary depending on whether the participants were awakened from REM sleep (about 80% recall) or NREM sleep (about 50% recall). The question as to whether this difference is explained by less dreaming during NREM sleep or sleep state-dependent memory processes cannot be answered easily. The present pilot study was designed to test whether high recallers can increase their NREM dream recall to figures equal to those obtained from REM awakenings. The participants were awakened during NREM on three non-consecutive nights while training in dream recall by keeping a dream diary. The study's goal was not achieved but the findings support the hypothesis that dreaming is always present during NREM sleep and that reduced NREM recall percentages are explained by sleep stage-dependent recall processes. Future research should focus on these sleep stage-dependent recall processes and correlate possible inter-individual differences with their differences in dream recall.

Keywords: NREM sleep, Dream recall, Dream diary

1. Introduction

If young healthy participants are awakened from REM sleep, the percentage recalling a vivid dream is very high: 97.5% (Schredl et al., 2009) or 95.9% (Schredl & Erlacher, 2010). Reviewing the studies in the field, Nielsen (2000) computed an average of 81.9 ± 9.0% (29 studies) dream recall after awakenings from REM sleep. Researchers generally agree that REM sleep is usually accompanied by dreaming (defined as subjective experience while sleeping and recalled upon awakening), (Schredl, 2008). On the other hand, mean recall rates after awakenings out of NREM sleep are considerably lower: 43.0 ± 20.8% (33 studies; Nielsen, 2000). The studies following the discovery of REM sleep by Aserinsky and Kleitman (1953) linked dreaming almost exclusively to REM sleep (Dement, 1960), attributing recall after NREM awakenings to memories of previous REM dreams or the awakening process. Subsequent studies, however, were able to demonstrate that awakenings out of the first NREM period (without prior REM period) also yielded dream reports (Kamiya, 1962; cited in Nielsen, 2000). In addition, Foulkes (1962), pointed out that the wording of the question and the definition of dreaming is important when eliciting dreams after NREM awakenings. Using a broad definition that includes all cognitive activities led to an increase of NREM recall rates from about 20% in the pre1962 studies to about 50% in later studies (Nielsen, 2000).

The unresolved question is whether the lower dream recall rates are due to reduced dreaming activity during NREM sleep or due to recall problems (Wittmann, Palmy, & Schredl, 2004). The AIM model of Hobson et al. (2000) might implicate that reduced cortical activity and lack of cholinergic neuro-modulation might not suffice to produce dreaming throughout NREM sleep. Similarly, the theory of covert REM sleep associating REM sleep processes like PGO waves with dreaming during NREM sleep would predict that dreaming processes are not always occurring during NREM sleep.

On the other hand, several researchers hypothesize that the differences between REM and NREM dreaming rates is mainly due to differences in recall – based on the functional state-shift model proposed by Koukkou and Lehmann (1983). Their model postulated that recall of material, between two functional states of the brain, is more difficult the wider the gap in the general cortical activation between these two states is; i.e., as REM sleep is closer to waking in this respect than NREM sleep, recall of experiences that occurred during REM sleep should be remembered more easily than NREM experiences. Interestingly, this is also valid for NREM parasomnias which are often not remembered afterwards (Cartwright, 2010).

Another factor that might play an important role in the recall process is sleep inertia (Tassi & Muzet, 2000); i.e., the cognitive performance and particular memory skills directly after awakening might affect the ability to recall a dream. Differences between these processes, depending on the sleep stage, have been demonstrated by Conduit et al. (2004), showing that tones and trained eye movements are better recalled after awakenings from REM sleep when compared to awakenings from NREM sleep.

Interestingly, the ability to recall the tones and eye movements from NREM sleep awakenings was strongly related to home dream recall frequency (Conduit et al., 2004). Home dream recall also correlated with the percentage of recalled dreams after REM and NREM awakenings (Goodenough, Shapiro, Holden, & Steinschriber, 1959), a finding support-

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ing the recall hypothesis of reduced NREM dream rates.

The fact that experimenters' and participants' expectations strongly affect the percentage of NREM dream recall (Herman, Ellman, & Roffwarg, 1978) is also indicative for the recall hypothesis. Systematic studies relating NREM dream recall to sleep inertia effects, or memory processes during the awakening processes, have not yet been carried out. On the other hand, studies investigating cortical activation as a correlate of successful dream recall after NREM awakenings yielded mixed results. Wittmann et al. (2004), for example, did not find differences in EEG spectra in NREM sleep, prior to the awakening, with regard to successfully recalling, or failure to recall, content. In this line of research, imaging techniques like fMRI have not yet been used to quantify brain activation patterns and relate these to dream recall.

For home dream recall, many studies have demonstrated that simple encouragement (Halliday, 1992) or keeping a dream diary (Schredl, 2002) can increase dream recall dramatically. A similar finding was reported for dream length (Reed, 1976). The basic idea behind these studies is that focusing on dreams will enhance dream recall. The present study was designed to investigate whether NREM dream recall can be enhanced by training. As the aim was to achieve very high recall rates (close to those reported for REM awakenings) high dream recallers (home dream recall) were selected for the study. It was predicted that focusing on dreams by repeating awakening nights, and keeping a dream diary at home between the laboratory nights, will increase dream recall and also increase dream length if dreams are recalled.

2. Method

2.1. Participants

Overall, twelve healthy individuals (11 women, 1 man) participated in the study. One participant had to be excluded because of very low sleep efficiency in the awakening nights (mean sleep efficiency over the three experimental nights with awakenings of this participant was 44.0%; compared to 85.6% of the other 11 participants). The mean age of the remaining participants (all female) was 22.7 ± 2.4 years, their ages ranging from 19 to 29 years. A brief sleep history was taken to ensure that the participants had neither current sleep complaints nor an organic sleep disorder in the past. The volunteers had given written informed consent and were paid for their participation.

2.2. Dream questionnaire

In addition to socio-demographic variables like gender and age, dream recall frequency was measured by a seven-point rating scale (0 = never, 1 = less than once a month, 2 = about once a month, 3 = twice or three times a month, 4 = about once a week, 5 = several times a week and 6 = almost every morning). The retest reliability of this scale for an average interval of 55 days is r = .85 (n = 198; Schredl, 2004a).

2.3. Sleep recordings

Each participant spent four nights (adaptation, three awakening nights) in our sleep laboratory for polysomnographic recordings. Polysomnography encompassed EEG (C3-A2, C4-A1), horizontal and vertical eye movements, submental and leg electromyogram (left and right anterior tibial muscles), as well as electrocardiogram. Respiration (oral and nasal air flow, thoraco-abdominal respiratory movements, and oxygen saturation) was recorded during the first night only in order to rule out sleep-related breathing disorders and periodic limb movement disorder. All recordings were carried out from 11 pm (lights out) to 7 am (lights on). All sleep recordings were scored in 30-second epochs, according to Rechtschaffen and Kales criteria (Rechtschaffen & Kales, 1968). For the present study sleep efficiency (total sleep time/time in bed*100) was computed.

2.4. Awakening protocol

During the three experimental nights, participants were awakened out of NREM sleep 15 minutes after the end of the previous REM period. In order to minimize the amount of awakenings out of slow wave sleep, the first awakening was performed at least three hours after sleep onset. The participants were awakened by calling their first name via intercom and then asked what was going on in their minds prior to awakening. If they did not recall any specific content, the participants were asked whether they had the impression that something was going on in their minds – even if no content could be reported. The dream reports were recorded and later transcribed. Word counts ware used as the measure for dream length.

2.5. Dream diary

After the second night (the first night with NREM awakenings) the participants were asked to keep a dream diary at home – for about one week until the next experimental night in the sleep laboratory. Each morning, they were to state whether they recalled a dream explicitly, had the impression of having had dream but without recalling specific content, or no recall at all. The participants received a second dream diary after the third night (second night with NREM awakenings) which they kept until the fourth and final night of the study.

2.6. Design

The study was approved by the local ethics committee. First, the participants were contacted via telephone in order to evaluate whether they fit the inclusion criteria: a good sleeper with high dream recall. Prior to the first laboratory night, the participants signed the informed consent and completed the dream questionnaire. They spent two consecutive nights in the sleep laboratory. Night 1 served as an adaptation night and was also used to rule out sleep apnea or periodic leg movements by measuring nasal and oral airflow, chest and abdomen movements, blood oxygen saturation and anterior tibialis electromyograms from both legs. During the second night, participants were awakened out of NREM sleep after at least three hours of sleep. The third night was scheduled one week later. During this period the participants kept the dream diary. The fourth night was scheduled one week after the third night. Due to time constraints in the sleep laboratory, the mean number of nights between the nights varied slightly: Second to third night: 6.73 ± 1.10 days (range: 6 to 9 days), third to fourth night: 6.27 ± 1.49 days (range: 4 to 9 days).

Table 1. Sleep and recall parameters of the three nights with NREM awakenings (N = 11 participants)

Variable	Night 2	Night 3	Night 4	Night 2 vs. Night 3[1]	Night 3 vs. Night 4[1]
Sleep efficiency (%)	86.5 ± 4.9	85.7 ± 6.5	82.6 ± 4.2	t = -0.7 .5206	t = -1.7 .1254
Number of awakenings	2.91 ± 0.54	2.82 ± 0.60	2.55 ± 0.69	t = -0.4 .6761	t = -1.5 .1669
Number of dream reports	1.90 ± 0.99	2.13 ± 0.64	1.50 ± 0.71	t = 0.6 .6036	t = - 1.3 .2249
% NREM dream recall (with content)	59.1 ± 13.5	56.1 ± 42.3	54.6 ± 29.9	S = -0.5 .5078[3]	S = -5.0 .7149[3]
% NREM dream recall (including the impression of having dreamed)	93.9 ± 6.2	85.6 ± 30.8	75.8 ± 36.0	S = -1.5 .5938[3]	S = -6.5 .9375[3]
Word count [2]	22.9 ± 11.0	42.1 ± 30.0	26.6 ± 21.7	t = 2.7 .0184[3] (N = 7)	t = 1.0 .1675[3] (N = 9)

[1] Statistical tests: paired t-test (t =) or sign rank test (S =) and p-values, [2] Reduced sample sizes (Night 2: 10; Night 3: 8; Night 4: 10) including participants reporting at least one dream. [3] one-tailed

2.7. Statistical analysis

For each participant, dream recall parameters were determined for one night or one dream diary. Night 2 was compared with paired t-tests or sign rank tests (percentages were tested non-parametrically) to Night 3 and Night 4. Word count were aggregated over the night and tested with paired t-test. One-tailed tests were carried out because we expected a positive effect of training on dream recall and dream length. In order to account for the multiple measurements per participant, we computed mixed models (see result section). Statistical analyses were carried out with the SAS for Windows software package (Version 9.2).

3. Results

3.1. Dream recall

As shown in Table 1, the adults in the sample read more The pre-study dream recall frequencies in the present sample, measured via questionnaire, were as follows: almost every morning (N = 6), several times (N = 2), about once a week (N = 2), twice or three times a month (N = 1). Regarding the nights in the sleep laboratory, there was a slight but non-significant decline in the numbers of awakenings per night (see Table 1). A similar reduction was seen for sleep efficiency. The percentage of NREM awakenings with explicit recall remained quite stable over the study period, yielding an average of 55.7% (range: 22.2% to 100%). Two participants recalled dreams from every awakening: participant 4 seven out of seven with mean word count of 26.6 words and participant 7 ten out of ten with mean word count of 24.8 words.

If the category recall without content was added, the mean recall rate for all three nights was 85.1% (range: 50.0% to 100%). There was a drop in dream recall from the second to the third and fourth nights, but the decline was not significant. Regarding word count, there was a significant increase from the second to the third night (see Table 1) but no significant difference between Night 2 and Night 4.

3.2. Correlations between dream recall measures

The percentage of NREM dream recall in the second night correlated with the value of the third night (r = .339, p = .1537, one-tailed) and the fourth night (r = .512, p = .0536, one-tailed), respectively. The pre-study dream recall frequency was associated with the percentage of NREM dream recall in the second night/first night with awakenings (r = .561, p = .0368, one-tailed) and the percentage of dream recall in the first diary period (r = .585, p = .0294, one-tailed; all Spearman rank correlations). In addition, the mean word counts of all NREM dreams correlated with the mean word counts of all diary dreams (r = .489, p = .0364, one-tailed; Pearson correlation).

3.3. Effect of time of night on dream recall and word count

On a descriptive level, the awakenings that resulted in explicit recall (318.1 ± 101.2 minutes after midnight) were later than the awakenings with the impression of having dreamed (290.8 ± 95.4 minutes after midnight) or no dream recall at all (268.8 ± 77.1 minutes after midnight).

In order to account for the repeated measurements, generalized linear mixed models for correlated binary data was

Table 2. Dream diaries (N = 11 participants)

Variable	Period between Night 2 and Night 3	Period between Night 3 and Night 4	Period 1 vs. Period 2[1]
% Morning dream recall (with content)	71.7 ± 25.0	59.9 ± 23.7	S = -17.5 .9580 [2]
% Morning dream recall (including the impression of having dreamed)	92.9 ± 15.3	90.2 ± 14.4	S = -1.5 .6250 [2]
Word count	89.9 ± 44.8	75.1 ± 47.0	t = -0.8 .7694 [2]

[1] Statistical tests: paired t-test (t =) or sign rank test (S =) and p-values, [2] one-tailed

computed to test the effect of time of night on dream recall. The effect on dream recall with explicit recall did not reach significance ($t(89) = 1.38$, $p = .0857$, one-tailed); the effect on recall whether explicit or having the impression of having dreams was also not significant ($t(89) = 1.08$, $p = .1422$, one-tailed). A similar analysis (linear mixed model for correlated data) did not yield a significant effect of time of night on the word count ($t(45.6) = 0.53$, $p = .2991$, one-tailed). The time intervals between the last REM sleep period and the awakening did not differ with respect to recall: 16.9 ± 5.3 min. (no recall), 19.1 ± 4.8 min. (impression of having dreamed), and 16.8 ± 5.8 min (recall with content). The generalized linear mixed models for correlated binary data did not yield significant results for testing no "recall" vs. "recall/impression of having dreams" ($t(89)=-1.4$, $p = .1699$) and testing "no recall/impression of having dreamt" vs. "recall with dream content" ($t(89) = 0.0$, $p = .9986$).

Out of the 94 awakenings, the sleep stage directly preceding the awakening was most likely NREM stage 2 (N = 86 awakenings). Only seven awakenings occurred out of NREM stage 3 (slow wave sleep) and one out of NREM stage 1. Explicit dream recall was not affected by sleep stage (55.8% (Stage 2) vs. 57.2% (Stage 3), $\chi^2 = 0.0$, $p = .9457$); adding the category of the impression of having dreamed did not change the results (87.2% (Stage 2) vs. 85.7% (Stage 3), $\chi^2 = 0.0$, $p = .9097$).

4. Discussion

The NREM recall rate of the present study lies well within the range obtained by previous studies (Nielsen, 2000) and the figures, including the "having dreamed" category, are comparable with those reported for REM awakenings with explicit dream recall (Schredl, 2008). This is also indicative for the idea that lower rates in recall after NREM awakenings when compared to REM awakenings are mainly due to recall problems – as predicted by the functional state-shift model of Koukkou and Lehmann (1983).

On the other hand, training by repeating nights and keeping a dream diary as applied in this study did not increase dream recall after NREM awakenings. One exception is dream length which increased from the first to the second awakening night but decreased again in the third awakening night. The first explanation is that high dream recallers were included in the study – the potential to increase dream recall is limited, a ceiling effect. Percentages of recalling of having dreamed (with and without content) and diary dream recall even decreased during the study period, a finding which has been reported by Schredl (2002) and Schredl (2004b) for questionnaire and diary studies. This might be explained by motivation problems because high dream recallers have to invest quite some time into recording their dreams each morning.

Looking at the sleep efficiency of the three awakening nights, there is a slight trend to poorer sleep quality – even though the number of awakenings was not increased. This might be explained by stress and the pressure the participants experienced in the course of the study because they were well aware of the experimenters' expectations of increasing dream recall by training (this information was given in the informed consent).

First, it would be interesting to carry out this study with low dream recallers because they start with lower percentages of NREM dream recall (Goodenough et al., 1959) and, thus, increasing dream recall by training might be more effective. Second, the design of the study might have put too much pressure on the participants; studies applying diaries with checklists for measuring dream recall (without eliciting dream reports) indicate that dream recall frequency does not decrease – even in high dream recallers (Schredl & Fulda, 2005). Another option would be to expand the time periods between the laboratory nights to minimize the stress for the participants which can be monitored by checking the sleep efficiency of the lab nights. On the other hand, the study period might have been too short for increasing NREM dream recall; studies with more training and more awakening nights might yield positive results.

The validity of the findings is supported by the result that the time of night is positively related (statistical trend) to the probability of recalling a dream after NREM awakenings (Pivik & Foulkes, 1968). The time interval between the last REM period and the awakening was not related to recalling a dream; i.e., this finding did not support the covert REM theory of NREM dreaming proposed by Nielsen (2000) because this model predicts more NREM dreaming the closer the awakening is to REM sleep.

Even though the participants were not able to increase their NREM dream recall during the study period, two participants recalled dreams after every NREM awakening from the beginning. How can these large inter-individual differences be explained? First, NREM recall was related to home dream recall and diary recall in this study and in previous studies (Goodenough et al., 1959); i.e., dream recall is a stable trait of the participants, independent of the measurement paradigm used (cf. Schredl, 2004b). Even though research has identified a few factors explaining the inter-individual differences in dream recall, such as creativity, openness to experience, frequency of nocturnal awakenings, attitude towards dreams (Schredl, 2007), the overall explained variance is quite low – less than 10% (Schredl, Wittmann, Ciric, & Götz, 2003).

Several factors, however, which might be associated especially with the ability to recall a dream after lab awakenings, like sleep inertia (Tassi & Muzet, 2000) or specific memories of sleep events (Conduit et al., 2004), have never been investigated systematically in relation to dream recall after NREM awakenings. It seems implausible that the large inter-individual differences are explained by different brain activation patterns or the amount of covert REM sleep; nevertheless it would be interesting to study whether persons with 100% recall differ from those persons with low NREM recall percentages.

To summarize, even though the study's goal of demonstrating that NREM recall percentages can be increased by training and equal the figures obtained from REM awakenings was not achieved, two findings (high percentage of recalled of having dreamed and participants with 100% NREM dream recall over three nights) support the hypothesis that dreaming – as defined as recallable cognitive activity (see: Nielsen, 2000) – is always present during NREM sleep (Wittmann & Schredl, 2004) and that reduced NREM recall percentages are explained by sleep stage-dependent recall processes. Future research should focus on these sleep stage-dependent recall processes and correlate possible inter-individual differences with their differences in dream recall. The application of imaging techniques during sleep, for example, to study characteristics of brain networks (Spoormaker et al., 2010) might help identify factors

and explain the inter-individual differences in NREM dream recall more fully.

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