ORIGINAL ARTICLES

NREM Sleep Dream Recall, Dream Report Length and Cortical Activation

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This study explores the role of cortical activation for dream recall in non rapid eye movement sleep. Six healthy young females were awakened in three consecutive nights five times per night from slow wave sleep and stage 2 sleep. Spectral analysis of the EEG was performed over the 32 s preceding awakening. Power spectra of the recall categories 'dream' and 'no dream' were compared, and spectral power in specific frequency bands was correlated with dream report length. Dream recall was not associated with cortical activation. However, correlations between spectral power in the delta, sigma and beta bands and dream report length support a relationship between cortical activation and memory capacity for dreams. **(Sleep and Hypnosis 2004;6(2):43-47)**

Key words: *Dream recall, dream report length (DRL), cortical activation (CA), non rapid eye movement sleep (NREMS), rapid eye movement sleep (REMS), power spectral analysis (PSA*

INTRODUCTION

A central question for psycho-physiological dream research is whether differences between REM sleep (REMS) and non-REM sleep (NREMS) dream reports justify the assumption that different brain mechanisms (i.e., two separate generators (1)) are responsible for mentation in REMS and NREMS. Such a two-generator-model (1) would be plausible in case of qualitative differences between dream reports of REMS and NREMS (e.g., visual REM vs. thought-like NREM dream content (1)).

Quantitative differences such as dream report length (longer REMS dream reports (1)) may be explained within the framework of a one-generator model on the basis of sleep stage dependent differences in brain activation (2). Cortical activation (CA) was quantified by spectral analysis of the EEG as a decrease in spectral power below 8 Hz and an increase above 12 Hz (2). According to a one-generator model the relationship between dream recall and CA should be evident in both states, REMS and NREMS. For REMS the findings are contradictory (1-8), for NREMS two positive (9) and a non-significant finding (7) have been reported. In this study we tested whether dream recall after NREMS awakenings is associated

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with higher CA. According to the functional state-shift hypothesis (10), higher CA would be expected to occur with higher dream recall rates, as it diminishes the difference in CA between sleep and the following waking state. Assuming that differences in CA are responsible for differences in the dream report length (DRL) of REMS and NREMS dream reports (11), it can be expected that CA and DRL are correlated also within NREMS.

METHOD

Subjects and procedure

Six healthy, female students (mean age 25.0, range 22-28 years), with a self-reported pre-study dream recall frequency of at least three dreams a week participated. They reported a habitual bedtime from 23:00 h to 07:00 h, were right-handed and free of sleep disorders (as verified in a screening night in the sleep laboratory). Subjects were paid for participation and gave written informed consent.

The study protocol was approved by the local ethics committee for research on human subjects. An adaptation night without awakenings was followed by three consecutive experimental nights in the sleep laboratory (lights off at 23:00 h). Three days prior to the study subjects were instructed to refrain from drugs and cafeinated beverages and to adhere to their habitual bedtime.

During the experimental nights subjects were awakened five times, during the first and second sleep cycle after ten min of consolidated slow wave sleep (SWS), during the third and fourth cycle after ten min of stage 2 (S2), and at 07:00 h (final awakening). Awakening was initiated by calling the subject's first name via intercom. After responding, subjects were asked what was going through their mind before they heard their names. If subjects did not recall any content, they were asked whether they had not dreamt or if they dreamt but do not recall any content. Continuous polysomnographic recording included six bipolar EEG derivations (F3C3, C3P3, P3O1, F4C4, C4P4, P4O2) plus a referential derivation (C3A2) for scoring, EOG, submental EMG and ECG. The data were digitalized and stored with a frequency of 128 Hz. For recording details see Endo et al. (12).

Data analysis

The report of at least one content item of mental experience was considered as an indicator of a successful dream recall. Both, not having dreamt and being unable to recall any dream content, were considered as 'no dream'. CA was quantified by spectral analysis as defined by Wollman and Antrobus (2) (decrease in spectral power below 8Hz and increase above 12 Hz). All words contributing to the dream content, excluding comments, repetitions (also pronouns) and fills ("and", "somehow") counted for dream report length (DRL). Two of us (LW, CP) independently scored the reports (interrater reliability: r=0.96) and determined the final score by consensus.

Awakenings not preceded by at least 10 min of uninterrupted sleep were excluded from the analysis. As the spectral analyses were based on 4s-EEG-epochs, standard criteria were applied on the 32s preceding the awakening stimulus for definition of the stage of sleep of the last epoch prior to an awakening. Spectral analysis (FFT, Hanning window, mean over 4 - 8 artefact free 4s epochs) of the bipolar derivations was performed and power in specific frequency bands (δ: 0.75-4.5 Hz; θ: 4.75-8.0 Hz; α: 8.25-10.5 Hz; σ1: 10.75-12.25 Hz; σ2: 12.25-13.75 Hz; β1: 14.0-22.0 Hz; β2: 22.25-30.0 Hz, definitions according to Werth et al. (13,14)) was determined. Sixty-five (average length of 29 s) of 91 awakenings contributed to the analysis.

In each subject, mean power in the specified frequency bands was computed for the recall classes 'dream' and 'no dream' in the different sleep stages (stage 2, SWS, and both combined). Wilcoxon rank sign tests (N=6, α=0.05) were

performed one-tailed for the δ, θ, σ2, β1 and β2 band (according to the operationalisation of CA) and two-tailed for the α- and σ1-band. A two-tailed t-test was performed for the time since lights off variable contrasting awakenings with and without dream recall. Pearson correlations (α=0.05, one-tailed for all bands except for α- and σ1-band) between DRL and the power in the frequency bands were computed without distinguishing between SWS and S2 awakenings. In addition, semi-partial correlations controlling for time since lights off were computed.

RESULTS

Dream recall rates and report characteristics Thirty-three of the analysed awakenings occurred from S2 and 32 from SWS. SWS awakenings occurred earlier than those from of S2 (mean time since lights off: 134 min vs. 306 min, t=6.95, p<.001). In 39 awakenings (60%) a dream report was obtained without differences with regard to sleep stage (61% (S2) vs. 59% (SWS): χ^2=0.01, p=0.92). Recall rates of the single subjects varied between 20 and 80% in SWS and between 50 and 80% in S2. In 19 of the 26 awakenings without dream recall subjects stated having dreamt without being able to recall any content. This was more often the case in awakenings from S2 (12 times) than from SWS (7 times, χ^2=4.9, p=0.03). The answer not having dreamt at all was recorded only once in awakenings from S2, but 6 times in SWS-awakenings. Because of technical problems, transcripts could be made only for 29 of the 39 recorded dream reports. Mean report length was 18.2 words (SD 14.2; range 1-57) and did not differ between SWS (15.0 ± 8.3) and S2 (22.2 ± 18.9) (t=1.3, p=0.22, unequal variances). Almost all dream reports contained sensory features that were predominantly visual and containted activity, and occasionally bizarre events. Eleven reports (37.9%) contained at least one reference to the sleep laboratory (post-hoc estimation).

CA and dream recall

According to Koukkou and Lehmann (10) the two recall conditions are expected to differ in specific frequency bands. In none of the frequency bands did power differ between 'dream' and 'no dream'. Time since lights-off of 'dream' (228 min) and 'no dream' (219 min) awakenings did not differ either (t=0.26, p=0.80).

CA and dream report length

It was hypothesised that CA is associated with DRL (12). Correlations between power in band and report length were calculated. Correlation coefficients are shown in Table 1. The mean SD of DRL of single subjects was almost as high as the SD of the total group. Therefore single dream reports were treated as independent variables. Semi-partial correlations adjusted for time since lights off were on average smaller, only two coefficients (P3O1 / σ2: ρ=.35, p=.034; P4O2 / β1: ρ=.36, p=.031) reaching statistical significance. None of the correlations between DRL and power in the θ-, α-, and σ-1-bands exceeded 0.2 or reached significance.

Table 1. Pearson-Product-Moment-Correlations between power in different frequency bands and dream report length

Frequency band	Derivation					
	F3C3	F4C4	C3P3	C4P4	P3O1	P4O2
δ	-.29 (.061)	-.34 (.035)	-.27 (.082)	-.36 (.026)	-.28 (.074)	-.29 (.065)
θ	-.04 (.416)	-.08 (.343)	-.08 (.335)	-0.9 (.313)	.01 (.518)	-.04 (.412)
σ2	.21 (.136)	.14 (.240)	.29 (.062)	.28 (.068)	.47 (.006)	.37 (.024)
β1	.09 (.317)	.16 (.197)	.06 (.378)	.23 (.110)	.20 (.155)	.45 (.008)
β2	.21 (0.136)	.17 (.194)	.26 (.085)	.26 (.087)	.32 (.047)	.16 (.210)

For definitions of frequency bands see text; p-values for one-tailed tests of significance in parenthesis

DISCUSSION

Dream recall rates and report characteristics

The dream recall rate of 60% in awakenings from NREMS is consistent with data reported by Nielsen (1). Almost every second SWS-awakenings without dream recall led to the statement of not having dreamt at all. Contrarily, after awakening out of stage 2, subjects reported regularly the impression of having dreamt even in the absence of any concrete dream memory. Although the NREMS dream reports were short when compared to reported REMS dream reports (15) they contained visual features. Such features were postulated to be typical for REMS (1). Thus, our finding does not support the assumption of qualitative differences between NREMS and REMS dream reports as postulated by the two-generator model1.

The high percentage of dreams with laboratory references in our subjects indicates a further similarity between NREMS and REMS dream reports (16).

CA and dream recall

Our spectral data do not support a relationship between NREMS dream recall and CA as postulated by the functional state shift hypothesis (10). The following reasons may be considered: Group comparisons were performed on mean power spectra and thus statistical power was reduced (small sample size). The lack of a relationship between dream recall and CA may be related to the combination of the report classes 'no dream recall at all' and 'no content'. However, Meier Faber (4) did not observe significant differences between EEG spectra of these two recall classes after awakenings from REMS. The rare occurrence of 'no dream recall at all' after awakening from stage 2 (only one case out of 33 in our study) necessitated the combination of the two recall classes. The analysed epoch of 32 s prior to the awakening might have been too short. Previous studies applied time windows between 16 s (4) and 120 s (5). Our selection was based on the shortness of the dream reports which we assumed to reflect retrievable mental experiences of short duration. In summary, the generation of a memory trace retrievable after awakening out of NREMS may be affected by factors independent of CA as operationalized here.

CA and dream report length

Our data support a relationship between CA and DRL. A similar finding of a negative correlation between power in the δ-band and DRL has previously been reported for REMS7. The reduced correlation between CA and DRL after adjusting for time since lights off does not contradict our hypothesis, as the increase of CA in the course of the night (17) is accompanied by increased DRL. In conclusion, our findings indicate that CA is not associated with dream recall. The relationship between CA and DRL in NREMS, however, supports the assumption of a one-generator model (1). This model explains quantitative differences between NREMS and REMS dream report by corresponding differences in CA.

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