Correlation of task-related dream content with memory performance of a film task – A pilot study

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Summary. Dreams could reflect memory consolidation processes during sleep. The present pilot study examined whether the incorporation of a film sequence shows a relationship to task performance. Twenty-two participants (17 women, 5 men) were exposed to a late-night paradigm in which they were shown a film sequence prior to the second sleep-onset. REM dreams and morning dreams have been collected. Compared with those of a control group the incorporation of film elements in the study group dreams was only higher for morning dream reports on one of two scales. The incorporation rate in morning dreams correlated on one scale with increased memory task performance. Due to the consolidation of declarative tasks, mainly during NREM, and procedural tasks during REM sleep, dream reports should be collected in the respective sleep stage in which the learning task is consolidated. Furthermore, tasks with high incorporation rates should be selected to show the relationship to task performance consistently.

Keywords: Dream content, dream incorporation, sleep-dependent memory consolidation

1. Introduction

Memory tasks have been shown to be enhanced by sleeping thereby supporting the idea that human beings consolidate memory during sleep (overviews: Born, Rasch, & Gais, 2006; Diekelmann & Born, 2010; Ellenbogen, Hulbert, Stickgold, Dinges, & Thompson-Schill, 2006; Stickgold, 2005). For such studies, different paradigms such as diary studies, nap studies or overnight studies have been used and have shown inhomogeneous results (Wamsley, 2018).

De Koninck, Prevost, and Lortie-Lussier (1996) let participants wear googles which change the angle of vision; incorporators (persons who incorporated vision changes in their dreams) performed better in 2 of 3 adaptation tests. A different paradigm used by De Koninck, Christ, Hebert, and Rinfret (1990) showing that participants who made significant progress in an intensive 6-week language learning course incorporated the language in their dreams earlier and had more verbal communication in this language during dreaming than persons with less progress. Fiss, Kremer, and Litchman (1977) presented a story to participants before their sleep onset; combined dream incorporation and number of reported dream episodes together explained 88% of the variance of memory performance. Pantoja et al. (2009) showed that the amount of game-related elements incorporated into dreams correlated with performance gains. Schoch, Cordi, Schredl, and Rasch (2019) used a word-picture association learning task and could predict memory performance in the morning by an incorporation score for NREM dreams but not in REM dreams obtained by awakenings in the night. Performance in a maze task correlated with incorporation of the maze topic into dreams obtained from daytime naps as well as after whole nights of sleep independent of sleep stage (Wamsley & Stickgold, 2018; Wamsley, Tucker, Payne, Benavides, & Stickgold, 2010). In both samples, however, dream incorporators had worse baseline performance than non-incorporators. After Wamsley and Stickgold (2018) controlled for baseline performance they did not find a relationship between dream incorporation and task performance.

It has been suggested that the baseline performance level mediates sleep consolidation (Tucker & Fishbein, 2008; Wilhelm, Metzkow-Mészàros, Knapp, & Born, 2012). However, Wamsley, Hamilton, Graveline, Manceor, and Parr (2016) and Stamm et al. (2014) used the same maze task and could not replicate the finding of a relationship between dream incorporation and task performance. Dream incorporation did not show a significant effect on overnight improvement for a mirror tracing task used by Schredl and Erlacher (2010). A video game related balance task has not shown a significant overnight improvement for participants with respect to balance-related topics being included in their dreams (Nefjodov, Winkler, & Erlacher, 2016).

Different explanations for these inhomogeneous results have been proposed: A small incorporation rate has been seen in the studies by Nefjodov et al. (2016) and Schredl and Erlacher (2010), i.e., the consolidation of these types of tasks might not be reflected in dreams. Furthermore, task improvement could be mediated by anxiety (De Koninck et al., 1990) which is supported by results showing that bizarre, long, and intense dreams were associated with a decreased amount of errors (Schredl & Erlacher, 2010), i.e., anxious persons worked harder to improve their performance in the retest in the morning. Different learning paradigms could have an influence; the suggestion is that tasks that are closer to daily life, e.g. learning a language

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(De Koninck et al., 1990) or listening to a story (Fiss et al., 1977) compared to mazes (Wamsley et al., 2010) or mirror tracing tasks (Schredl & Erlacher, 2010) could show a larger incorporation rate and a larger effect of dream incorporation on task performance.

In the present study, dream incorporation effects on a memory task of watching a film sequence have been studied. Incorporators were expected to show better memory task results than non-incorporators. Watching a film sequence has been used because it is similar to dreaming (Cook, 2011).

2. Method

2.1. Participants

The sample consisted of 22 participants, 17 women and 5 men. The mean age of the participants was 23.09 ± 2.35 (range 20 – 28). All participants were students. The average age of participants of the experimental group who gave a REM-dream report (16 females and 5 males) was 23.10 ± 2.41 years. Control group dream reports collected during the night via awakenings, dreams from Schredl et al. (2012), Schredl and Erlacher (2010) and one dream provided by Daniel Erlacher stemming from an unpublished pilot study have been used. The control group had an average age of 23.48 ± 2.70 years and was not significantly different in age ($t = -0.5$, $p = .6316$) from the experimental group. The gender contributions of both groups were equal. The 12 women and 3 men of the experimental condition who gave morning dream reports had an average age of 23.53 ± 2.47 years. The control group for morning dream reports consisted of participants from different studies (Domhoff, Meyer-Gomes, & Schredl, 2005-2006; Schilling et al., 2018; Schredl et al., 2012) and had an average age of 23.53 ± 2.53 years. When both groups were compared, age was not significantly different ($t = 0.0$, $p = 1.00$).

2.2. Research Instruments

2.2.1 Sleep recordings

Each participant spent two consecutive nights in a sleep laboratory for polysomnographic recordings. Polysomnography procedures, consisting of EEGs (C3-A2, C4-A1), horizontal and vertical eye movements, electrocardiograms and the submental electromyograms, have been measured. Leg (left and right anterior tibial muscles) and respiration (oral and nasal air flow, thoraco-abdominal respiratory movements and oxygen saturation) were recorded only during the first night. All sleep recordings were scored in 30-second epochs, according to Rechtschaffen and Kales (1968). For each REM period the number of NREM and awaken epochs was added and divided by the total number of REM period epochs in order to derive a rough measure for REM sleep continuity.

The following sleep parameters were determined: total time in bed (in minutes); sleep onset latency (in minutes); sleep efficiency (total sleep time/time in bed*100); REM sleep latency (time between sleep onset and first REM sleep epoch); percentage wakefulness after sleep onset (time spent awake between sleep onset and final end of sleep); percentages of NREM1, NREM2, slow wave sleep (defined as stages NREM3 and NREM4) and REM sleep of the total sleep time.

2.2.2 Film material

An edited sequence of the film “four rooms” of Allison Anders, Alexandre Rockwell, Robert Rodriguez and Quentin Tarantino was used without sound. The 5-minutes and 6 seconds sequence showed first a concierge who telephones. Then an Iberian appearing male and an Asian appearing female comb their children’s hair in a hotel room. The parents leave the room and the children start to watch TV. Shortly afterwards, they start to throw their shoes and socks. They fight for the TV remote control and use a lipstick to draw a target on a painting. Then, the children take a syringe, which they found in the bedside table, to throw it at the target. The sequence ends with the syringe thrown by the boy landing directly in the middle of the target.

2.2.3 Film content analysis

After awakening during the night and watching the film, participants had to answer four open-ended questions: 1) How many people were present in the film; 2) What did the family do at the beginning of the film sequence; 3) Which series have been shown on the television set within the sequence; 4) What did the girl do in the end. The number of correct answers was evaluated. In the morning, participants had to write down everything they were able to remember from the film. It was mentioned in the instructions that the chronological order has to be followed and that they should also mention specific details. Participants were told to write down sentences. For this task participants regularly had 15 minutes to complete the task but were given an additional 5 minutes if they could not finish in time. The sequence has been coded by two independent raters. The film sequence has been divided into 62 small action parts and evaluated as to which ones occurred in the written reports. The number of recalled scenes has been summed up; a higher quantity of remembered film sequences meant better film memory. The interrater reliability for 50 film reports showed a high correlation of $r = .958$ (Schredl, Wittmann, Ciric, & Götz, 2003).

2.2.4 Dream content analysis

Dream content of the REM and the morning awakenings has been coded for the occurrence of a couple, siblings and hotel employees. General actions of the film scene: to telephone, to do body care, to prepare to go out, to hit or kick someone, to watch TV, to wave, to rant, to play, to undress, to dance, to smell, to shoot and to argue could be coded. Furthermore, items such as socks, a tongue, hotel utensils, computers, bath room utensils and books could also be coded. The sum score of the occurrences of persons, actions and items has been used for further analysis. The film-dream similarity scale was designed to measure the similarities between dream and film content on a five-point scale (0 – not at all, 1 – somewhat; 2 – moderate; 3 – strong; 4 – very strong).

2.3. Procedure

Participants were screened to exclude sleeping disorders. They slept two consecutive nights in the laboratory setting both of which were monitored by polysomnography. After the first night it was possible to exclude sleep-related disorders. Lights-off time for both nights was at 11 pm. After three and half hours, they were awakened and had to sit down on a chair outside the bed to watch a five minute sequence of the "Four rooms" film without sound. After viewing, they answered the four brief questions about the film and went back to sleep. After five minutes into the first REM sleep period, they were awakened via an intercom system and had to report orally everything they had had in mind before awakening. They were asked three times if they could remember more. Afterwards, participants could sleep until light-on time at 7 am. After waking up in the morning, they were asked to write down all the dreams they could remember (except for the already reported REM dream). Finally, participants gave a free recall of the film sequence as detailed as possible in written form.

Control dreams were selected from two studies (Schredl & Erlacher, 2010; Schredl et al., 2012) carried out in the same sleep laboratory using the exact same protocol for obtaining the dream reports. The major difference is that these studies were full-night studies starting with awakenings from the second REM period. Therefore, it was not possible to control for time of night that the dream reports were obtained but – as a proxy – dream reports were matched regarding word count (in addition to matching for age and gender). Only one dream report was provided by a colleague who also used the same procedures for obtaining dream reports but that study was carried out in another sleep lab. The morning dream reports were also matched for gender and age of the dreamer and word count of the dream report. These reports (with one exception) were also collected after – in this case uninterrupted second night – in the sleep laboratory (again the same sleep laboratory where the present study was carried out). I.e., the conditions regarding how the morning dream reports were collected had been very similar.

The REM dream accounts were transcribed. Afterwards, the REM dream reports and the morning dream reports were coded in a randomized order along the scale described in the dream content analysis section by two independent raters who saw the film sequence beforehand. The answers of both raters were correlated to compute interrater reliabilities. For the further analysis, ratings of the first rater have been used.

2.4. Statistical Analysis

Statistical analyses have been carried out with the SAS 9.4 software package for Windows. A within-design between the adaptation night and the experimental night has been used in the experimental group. Dream content of the experimental group has been compared to dream content of sex- and age-matched controls to study the effect of the film on the dream. In addition, they were also matched for word count. To determine significant differences, t-tests and Mann-Whitney-U-tests have been applied for the different data types.

Spearman correlations were used to show the relationship between incorporation of the film content in the dreams on the two scales and memory performance in the night as well as in the morning. For the film test in the night, two-tailed spearman correlations and for the test in the morning one-tailed spearman correlations have been used.

3. Results

Table 1 shows the different variables of the polysomnographic measurements. The change in REM-latency can be seen when comparing REM-latency before with the significantly lower one after being awakened in the second night ($t = 6.2$, $p < .0001$, $d = 1.31$). All other variables were comparable to the adaptation night when part one and part two of the experimental night were merged.

In the test directly after the film, the mean number of correct answers was 2.82 ± 0.59 of four answers. For the memory test in the morning, participants used 286.00 ± 30.66 words to describe the film content. An average of 21.41 ± 4.11 scenes were remembered. Correlations of word count ($r = .293$; $p = .084$, one-tailed) and number of scenes ($r = .186$; $p = .352$, one-tailed) with the nightly film test showed no significant results.

Interrater reliability for the incorporated scenes in the dream was high ($r = .71$). The film-dream similarity scale showed a smaller correlation ($r = .545$) and the ratings of the first rater have been used for the following analysis.

After being awakened in the night, 95.45% (N = 21) and in the morning, 68.18% (N = 15) of the participants could recall a dream. In the morning 7 participants awoke from NREM and 8 awoke out of REM sleep. REM-latency was not significantly correlated with the film-dream-similarity scale ($r = .052$, $p = .824$). In addition to age and gender, the control group has been matched for word count and t-tests did not show significant differences for word count between the two groups. As shown in Table 2, no significant differences could be shown between the experimental and the control group for the incorporated film content in REM-dreams, neither for the film elements nor for the film-dream-similarity scale. In the morning, the film-dream similarity scale was significantly higher for the experimental group than for the control group.

Table 1. Polysomnographic variables (N = 22 participants)

Variable	Adaptation night M ± SD	Awakening night – Part 1 M ± SD	Awakening night – Part 2 M ± SD
Bedtime (min)	466.70 ± 17.93	233.07 ± 17.46	226.7 ± 18.37
Sleep onset latency (min)	27.57 ± 29.86	23.02 ± 13.38	27.52 ± 13.41
Sleep efficiency (%)	83.07 ± 9.72	83.37 ± 6.17	72.95 ± 11.73
REM latency (min)	143.02 ± 66.78	103.07 ± 41.18	46.11 ± 14.19
Stage wakefulness (%)	11.29 ± 7.01	7.69 ± 4.56	17.08 ± 9.48
Stage NREM1 (%)	6.42 ± 2.98	5.32 ± 4.19	7.64 ± 4.81
Stage NREM2 (%)	52.88 ± 8.04	47.71 ± 9.37	49.44 ± 10.52
Stage slow wave sleep (%)	18.04 ± 8.56	29.55 ± 12.62	4.84 ± 5.13
Stage REM (%)	11.38 ± 3.70	9.72 ± 6.07	21.02 ± 8.63

Table 2. Film memory test scales for REM-dream reports and morning dream reports of experimental group in comparison with control group

Variable		Experimental Group	Control Group	Statistical test	
		M ± SD	M ± SD		p
REM dream reports (N = 21)	Word count	105.10 ± 62.16	106.38 ± 63.83	t = -0.1	.948
	Incorporated film elements	0.19 ± 0.40	0.86 ± 0.73	z = -3.2[1]	.999
	Film-dream similarity scale	0.71 ± 1.06	0.57 ± 0.98	z = 0.4[1]	.345
Morning dream reports (N = 15)	Word count	163.1 ± 209.2	166.7 ± 227.1	t = -0.1	.964
	Incorporated film elements	2.67 ± 1.76	2.53 ± 1.68	z = 0.4[1]	.350
	Film-dream similarity scale	1.13 ± 1.19	0.40 ± 0.63	z = 1.9[1]	.026*

*p ≤.05; [1]one-tailed Mann-Whitney-U-Test

As shown in Table 3, spearman correlations did not show significant results for the REM-dream reports and the morning memory test. Furthermore, a significant correlation between the film-dream similarity scale and morning film recall could be shown. The number of remembered scenes and the number incorporated film elements did not show a significant correlation. The word count of dreams did show a small but non-significant correlation with the number of remembered scenes. A correlation between the film-dream similarity scale and the film memory task controlled by word count of the dream reports still reached significance (r = .636, p = .007, one-tailed). The scatter plot for this correlation is depicted in Figure 1; four of the participants who showed similarities performed well in the free recall test in the morning. In the same table, it is shown that there are no significant relationships between the mentioned variables and the nightly film test.

Dream examples

(including the coding of the film-dream similarity scale)

„… There is food and the family of the film, son, daughter, mother, father, and I are sitting at a long table. The length of the table is several meters, on my right, the son is sitting, and in front of me on the other side of the table, the daughter. (coding: 4)“

„The setting was a flat shared by several persons including a room with shoes. I took a closer look at the shoes, there were no other things. I also watched TV in this room. (coding: 3)”

„Someone painted manually a point with circles around it. Then, to increase accuracy everything was measured with a ruler and the point was moved so it was dead center within the circles. (Coding: 3)”

4. Discussion

In the present pilot study the idea that dream incorporation enhances memory task performance could only be partially confirmed by showing a relationship of performance in a film memory task to one of two scales. It could be shown that the performance is not explained by better film memory directly after the presentation. The film-dream similarity scale of the given morning dream reports, was significantly higher for an experimental group than for a control group. Shorter REM-Latency did not seem to be correlated with film incorporation in dreams.

When comparing the second night to data by Plihal and Born (1997) the percentages of the stages were similar: In the second half of the night an increased amount of REM sleep occurred and less slow wave sleep. Plihal and Born (1997) indicate that the different amounts of slow wave and REM sleep could reflect the different forms of learning because declarative forms of learning improved more in the first night half and procedural learning in the second night half. The present late night paradigm reflects REM sleep consolidation. The number of remembered scenes in the film report was lower than in a study by Schredl (2004); 457 participants reported their memory of the film sequence directly afterwards and used about 50 words more and remembered around 7 scenes more than in the present study which is explained by the longer retention interval of the present study. Research could investigate if the memory performance of the sleeping group for this film task was better than a group which stayed awake for an equal duration. Interrater reliability has been accepted as sufficient in

Table 3. Correlations between film memory test scales and dream content related items

Variable		Film Recall Morning		Film test following film presentation	
		r	p	r	p
REM dream reports (N = 21)	Word count	-.023	.922	-.191	.386
	Incorporated film elements	-.091[1]	.653	.031	.891
	Film-dream similarity scale	.238[1]	.149	-.052	.823
Morning dream reports (N = 15)	Word count	.399	.141	-.023	.935
	Incorporated film elements	-.042[1]	.560	.454	.089
	Film-dream similarity scale	.531[1]	.021*	-.212	.449

*p ≤.05; [1]one-tailed

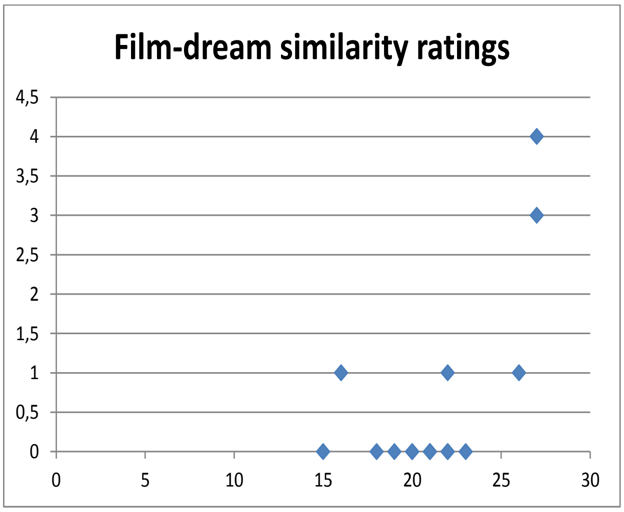

Figure 1. Correlation between film test performance in the morning and film-dream similarity ratings of the morning dream reports (N = 15)
(please not that three data points (null axis) represent two participants with identical values for both variables)

the present study but might be improved in further studies, e.g. by training of raters or by adapting the scales (Schredl, Burchert, & Grabatin, 2004). In this study we chose to select the ratings of one judge (and not using means of both raters) as we are mainly interested in the correlations with performance – adding the findings might increase error variance if there had been systematic differences in coding between the raters. To solve this issue, it would have been necessary to train the raters with different dream material and instruct them to discuss the dreams they did not agree on. For this study, this was not possible as the raters did not work at the sleep lab at the same time. Longer periods of learning (in this study the five-minutes sequence was shown once), e.g. language learning (lasting days or weeks) would give the possibility to elicit more dreams in the course of the learning process and therefore it would be possible to study the effects of dreams on task performance more closely. Another methodological issue is that testing the memory directly after the film with four brief questions was different from the free recall task in the morning. This procedure was chosen to avoid consolidation processes by writing down a lengthy report of the film; the disadvantage is that it is a very crude measure with low reliability and, thus, correlation coefficients might be underestimated.

It has to be stated that the study started out with a different rationale; according to the mathematical model of the continuity hypothesis (Schredl, 2003), it was expected that shorter time intervals between day-time experience and dream would increase the probability of this experience to be incorporated in the dream. Therefore, an emotionally involving film was chosen (a documentary about possibly unjustified death sentences in the USA) but after three participants (not included in this analysis), the original aim was dropped as the participants had major difficulties falling asleep again after seeing such a film in the midst of the night. So, we switched films and, interestingly, obtained no effect between REM latency and incorporation – very likely due to the fact that this "softer" film did not affect the REM dreams as much as more intense films would have.

Diekelmann and Born (2010) showed that declarative memory is consolidated during slow wave sleep and procedural memory is more closely related to REM sleep. Furthermore, emotional stimuli are consolidated during REM-sleep (Rasch & Born, 2013). Wagner, Gais, and Born (2001) indicated that emotional stimuli are better learnt during the second night half when more REM sleep occurs. Episodic memories are consolidated during REM sleep (Rauchs et al., 2004). The film reflects episodic memory and possibly elicits emotions, fitting with the present finding that task performance is partly associated with morning dream incorporation. But the REM dreams did not show this relationship. It is possible that longer time in REM sleep is needed to be able to see incorporation of the film content. I.e., it would be interesting to extend the design of the present study to include REM awakenings from later REM periods. Furthermore, morning dreams consisted of REM and NREM dream reports; this could indicate that the task is consolidated during NREM sleep. Participants of the present study were awakened only twice and it is not therefore possible to get insight into ongoing processes in the rest of the night. So it could improve the results if NREM dreams were collected.

Alternative explanations were excluded by the control for confounding variables. The length of the film recall was not significantly correlated with the number of remembered scenes and with the number of right answers in the night. The effect in the morning cannot be explained by better memory in the night. Furthermore, the result for the relationship between the film-dream similarity scale and the memory task could not be explained by the lengths of the dream reports. This leads to the assumption that the improvement in relation to incorporation is not explained by a trait as suggested by Schredl (2017) in answer to the study of Wamsley et al. (2010) in which incorporators had worse baselines than non-incorporators.

Based on the continuity hypothesis which suggests that dreams continue waking-life content (Schredl & Hofmann, 2003) it was expected that the film content would be incorporated into the dreams. The number of incorporated film elements and the film-dream similarity scale was not higher for the experimental group than for a control group when having a look at the REM dreams. A significantly higher number of general film item incorporations in dream content could only be shown for the morning dreams. These inconsistent findings have similarly been seen in previous research which examined film incorporation into dreams (Davidson, Hart, & Haines, 2005; de Jong & Visser, 1983; De Koninck & Koulack, 1975; Foulkes & Rechtschaffen, 1964; Goodenough, Witkin, Koulack, & Cohen, 1975; Powell, Nielsen, & Cheung, 1993).

Humans regularly experience new situations and therefore sleep-dependent memory consolidation processes happen every-night (Stickgold & Walker, 2005). If dreams are connected with the consolidation process, everyday dream content should reflect those processes. For example, social activities are incorporated into dreams quite often (Schredl, 2018) which supports the social simulation theory (Tuominen, Revonsuo, & Valli, 2019), highlighting the importance of learning social skills. Therefore, experimental studies should choose tasks that are related to typical dream contents as they reflect everyday life experiences. This is still a puzzle to be solved, as dreams typically reflect declarative memory such as episodic memories (Schredl, 2018) and declarative memory is typically consolidated during NREM sleep (Diekelmann & Born, 2010). This would favor theories (Buzsaki, 1998) that propose that NREM and REM sleep are important for memory consolidation irrespective of the memory type. For example, Schredl, Hoffmann, Sommer, and Stuck (2014) found evidence of target memory reactivation of a declarative task in REM dreams. Within this context, it would be very interesting to study the relationship between NREM dreaming and memory consolidation in a more detailed way.

Additionally, tasks that are more often incorporated into dreams could show the effect of dreams on task performance more consistently. Eichenlaub, Cash, and Blagrove (2017) have shown that salient or intense waking events are more easily incorporated into dreams. Mirror tracing is rarely incorporated into dreams (Schredl & Erlacher, 2010) whereas language learning is more often incorporated (De Koninck et al., 1990). Participants of a study by Schoch et al. (2019) incorporated a word-picture association learning task successfully into dreams. The incorporation of the film sequence has only been significant for morning awakenings. Therefore further research could use a longer or more emotional film sequence in order to have a higher impact on dream content.

Depending on which type of learning, the paradigms for the used studies should be adapted to the task. Declarative memory is mostly consolidated during NREM sleep, procedural memory is closer related to REM sleep (Diekelmann & Born, 2010). In the word-picture association learning task which is a classic declarative memory task incorporation into NREM dreams predicted task memory performance the next morning (Schoch et al., 2019). Vocabulary learning (De Koninck et al., 1990) or story reading and retelling (Fiss et al., 1977) would be other declarative tasks which benefit from consolidation during NREM sleep and should therefore either use a first night half paradigm or awaken participants during NREM sleep to find incorporation and possible relationships with improved task performance. Performance in procedural tasks, such as a maze task (Wamsley et al., 2010), a video-game related balance task (Nefjodov et al., 2016) or a mirror tracing task (Schredl & Erlacher, 2010) would benefit from REM sleep and therefore should use second night half paradigms or REM dreams. However, the maze navigation task (Wamsley et al., 2010) are probably not best described as procedural, as this form of spatial memory can be explicit and relies critically on the hippocampus, indicating that the differentiation between procedural and declarative memory tasks and their consolidation into REM sleep or NREM sleep is more or less problematic. Another factor that might affect the sleep-dependent memory consolidation and underlying processes in different sleep stages is task difficulty, since novel, difficult procedural tasks might rely on REM sleep whereas further improvements of already trained tasks depend on NREM sleep (Smith, Aubrey, & Peters, 2004). It has also to be mentioned that the conflicting results so far may be partly explained by the low statistical power (small number of participants per study, e.g., N = 22 in the present study) to detect small or medium effect sizes; on the other hand, sleep laboratory studies with large numbers are labor-intensive and expensive.

To summarize, a relationship between the film incorporation and the morning memory task performance could be found for the film-dream similarity scale but not for the number of film elements. More film content has been incorporated into dreams for the morning awakenings than for the nightly awakenings. This supports the idea that dreams reflect the consolidation process during sleep. Further research should pay attention to the learning type which the used task represents and adapt the paradigm to the task dependent consolidation process. Furthermore, tasks which are often incorporated into dreams should be used to show the relationship to task performance consistently.

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