





Article

To Nap or to Rest? The Influence of a Sixty-Minute Intervention on Verbal and Figural Convergent and Divergent Thinking

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Abstract: Background: The relationship between sleep and creativity is a topic of much controversy. General benefits of napping have been described not only in sleep-deprived individuals and in shift workers, but also in people with sufficient night sleep. However, only few studies have investigated the relationship between nap and creativity. Methods: Forty-two native German speakers (29 females, mean age = 24 years, SD = 3.3 years) took part in two experimental sessions (i.e., baseline and intervention). In both sessions, divergent and convergent verbal and figural creativity tasks were administered at the same time of the day. While the baseline session was identical for all the participants, in the second session participants were randomized into either a sixty-minute nap or a sixty-minute rest group. Results: No significant group differences were found for neither divergent nor convergent creativity thinking tasks, suggesting that the interventions had similar effects in both groups. Interestingly, the analysis of the pooled data (i.e., pooled nap and rest groups) indicated differential effects of figural versus verbal creativity tasks, such that significant post-intervention improvements were found for the figural, but not for the verbal divergent and convergent thinking tasks. Conclusions: While further studies are needed to confirm these findings, to the best of our knowledge, such a dissociation between performance of verbal and figural creativity tasks after nap/rest interventions has not been described to date.

Keywords: sleep; creativity; nap; rest; intervention; divergent thinking; convergent thinking; EEG



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1. Introduction

The role of sleep in creativity has been discussed for many years and the relationship between sleep and creativity is a topic of much controversy. Famous scientists, such as August Kekulé or Otto Loewi, demonstrated that key insights may be gained through intuition, imagery, and dreams. Moreover, Thomas A. Edison was known for sleeping barely three hours a night, possibly compensating for his lack of night sleep by taking brief daytime naps. Salvador Dalí referred to his very short episodes of sleep, which were supposed to stimulate insight and creativity [1]. Similarly, Leonardo da Vinci is believed to have followed a special sleep schedule, also known as the “sleep of genius” or polyphasic sleep, which is a type of sleep pattern involving sleeping not more than five hours a day.

Previous studies have demonstrated the general benefits of napping on performance. Such benefits were not only described in sleep-deprived individuals (e.g., [2,3]) and in shift workers (e.g., [4,5]), but also in people with sufficient night sleep (e.g., [6,7]). It has been further shown that a nap may reduce subjective and objective sleepiness [8] and enhance short-term memory or mood [8–11]. Finally, there is evidence that sleep, in general, has an impact on cognitive functions, such as memory, learning, and emotion

regulation [12,13]. A recent systematic review and a meta-analysis analyzing 11 studies with a total of 381 participants, assessed the benefits of a short daytime nap (mean nap duration 55.4 ± 29.4 min) on cognitive performance [14]. This meta-analysis reported an improvement in cognitive performance (in particular in alertness) in the nap group, as compared to the control group. Such improvements in performance were found for up to 120 min post-nap, with conflicting results with respect to the sleep inertia period, i.e., the transition period from sleep to waking [15], which is characterized by a reduction in the ability to think and perform upon awakening due to sleep [16]. Furthermore, naps before 1.00 p.m. resulted in better cognitive performance, as compared to naps taken in the later afternoon. Finally, the benefits of napping were independent of sex and age. However, in their review Faraut et al. [17] reported a link between an increased prevalence of cerebrovascular diseases and regular and longer napping (>60 min) in elderly individuals, suggesting that a nap, per se, may not always be beneficial.

Creativity is a complex neuro–psycho–philosophical phenomenon that is difficult to define and to operationalize, and which may be influenced by personality, genetics, and social and environmental settings, as well as culture [18]. Sternberg [19] sees creativity as the ability to produce work that is both novel (i.e., original, and unexpected) and appropriate (i.e., useful). Creativity is often operationalized, according to J. P. Guilford [20], who postulated two types of creative strategies, namely convergent and divergent thinking. The concept of convergent thinking postulates a channeled and controlled problem-solving process of a clearly defined problem with only one correct solution. In general, in this process the focus is on speed, accuracy, logic, and recognizing familiar techniques, as well as applying accumulated information. In divergent thinking, the solution approaches proceed in different directions, as the problem can be solved by means of different solutions. The focus of this process is on combining unexpected connections and unanticipated transformations of information. The operationalization of divergent thinking is typically based on fluency (i.e., number of answers/solutions given), flexibility (i.e., number of distinct answers given), and originality (i.e., uniqueness of answers).

To date, multiple studies have investigated the influence of sleep on creativity (e.g., [21–23]). In this context, Drago et al. [24] studied the influence of REM and non-REM (NREM) sleep on creativity performance, as assessed by the Abbreviated Torrance Test for Adults (ATTA) [25]. They tested eight healthy young adults who underwent three consecutive nights of polysomnography, two of which were followed by the ATTA that was applied on the second and third mornings. While they found positive correlations for NREM sleep stages, especially between the N1 sleep and fluency ($r = 0.80$), as well as flexibility ($r = 0.43$), they reported a negative correlation between the REM sleep and originality ($r = -0.83$). Since NREM sleep is associated with low levels of cortical arousal, they concluded that low cortical arousal may enhance the ability of people to access the remote associations that are critical for creative innovations.

REM sleep has also been linked to creative problem-solving in the Remote Associates Test (RAT) [26], and a better performance in anagram word puzzles was found for those participants who were awakened from REM sleep [27]. Moreover, REM has been suggested to represent a brain state that is more responsive to flexible cognitive processing, as compared to NREM sleep and the wake state. In their study, Lacaux et al. [28] compared creative performance of healthy subjects with subjects diagnosed with narcolepsy. Narcolepsy causes frequent napping throughout the day, with commonly occurring direct shifts into REM. The authors considered this privileged access to REM sleep as a possible explanation for the higher scores in convergent and divergent thinking in narcoleptic subjects. A more recent study with type 1 narcolepsy patients, reported a key effect of hypnagogic hallucinations to modulate creative behavior [29]. These results highlighted the role of hypnagogic hallucinations in triggering the process of mind wandering, which led to a greater creative success.

In contrast to the literature focusing on sleep and creativity, only few studies investigated the relationship between nap and creativity. Cai et al. [26] found improvement in

creativity evaluated by the RAT in primed and retested subjects who showed REM sleep during a nap, compared to subjects who had a quiet rest. The study by Bejjani and colleagues [30] showed an increased likelihood of solving a retested problem presented in a video game after taking a nap, i.e., compared to the wake control group, the probability of solving the problem increased twice as much for subjects who napped. In contrast, Carlsson et al. [31] found no improvement in the RAT in primed subjects who showed REM sleep, compared to subjects without REM episodes, and no significant enhancement of creativity was found between the nap and the wakefulness conditions. Lacaux et al. [32] showed that the twilight zone between sleep and wakefulness (i.e., N1 sleep) might ignite creative sparks. In a large population of 103 participants, they found that spending at least 15 s in N1 sleep during a resting period tripled the chance of discovering the hidden rule of mathematical problems (i.e., 83% versus 30% when participants remained awake). Interestingly, this effect vanished if subjects reached deeper sleep stages.

Most of the studies mentioned above focused either on divergent or convergent thinking. However, the operationalization of creativity reveals that both divergent and convergent thinking are parts of the creative process. While divergent thinking seeks multiple perspectives and multiple possible answers to questions and problems, convergent thinking assumes that a question has one correct answer and that a given problem has only one single solution. In this study, we aimed to assess the effect of a sixty-minute nap and a sixty-minute rest on both convergent and divergent thinking creativity tasks in figural and verbal domains. We hypothesized that, compared to the baseline measurement, participants randomized to the nap intervention would perform better in the creativity testing following the intervention. For the rest intervention we did not expect such an improvement.

2. Materials and Methods

2.1. Participants

Forty-two German native speakers (29 females, 13 males, Mean age = 24 years, SD = 3.3 years) participated in the study. All participants were university students (recruited through the students' pool of the University of Bern) and had normal or corrected-to-normal visual acuity. Prior to participation, they were informed about the study procedure and gave their written, informed consent to participate in the study. The study was approved by the cantonal ethics committee, and it was conducted in compliance with the latest version of the Declaration of Helsinki.

2.2. Procedure

Each participant took part in two sessions (i.e., a baseline and an intervention session) separated by one week. The experiments were always administered at the same time of the day. In the baseline and in the intervention sessions, divergent and convergent thinking creativity testing (see Section 2.3) was performed. In the intervention session, depending on the randomized group assignment, participants were either subject to a nap or a rest intervention, both lasting sixty minutes. As such, following EEG preparation (see Section 2.4), in a quiet, darkened room, participants were either instructed to nap or listen to relaxation music without falling asleep. Following this 60-min procedure, that always started at 1.30 p.m., all participants were again subject to creativity testing. To account for circadian influences, the creativity testing in both experimental sessions (i.e., baseline and intervention) always started at 2.30 p.m. Prior to, and following, the nap/rest interventions, participants were asked to evaluate their subjective levels of sleepiness by means of a visual analog scale and the Stanford Sleepiness Scale (SSS) [33].

2.3. Creativity Test Battery

Creativity performance was assessed by means of two divergent and two convergent thinking tasks, which were randomized in order of presentation. All the tasks were programmed in Unity 2019.3 (Unity Software Inc., San Francisco, CA, USA) and administered

via a 15.6" Lenovo Yoga 720-15IKB convertible laptop (i7, 16 GB RAM). Whenever required, a compatible digital pen (Lenovo active pen) was provided to the participants. A portable microphone (Jabra PHS001U) was used to record oral answers.

2.3.1. Torrance Test of Creative Thinking (TTCT)

Torrance Test of Creative Thinking (TTCT, versions A and B, [33]) was conducted to assess figural divergent thinking. In brief, both versions consisted of three 10-min long subtasks, i.e., "Picture Construction", "Picture Completion", and "Lines and Circles". The outcome variables, "Fluency" and "Originality", used in this study were calculated according to the scoring manual [34].

2.3.2. Associative Fluency Task (AFT)

In this verbal divergent thinking task, participants were presented with three target words (adapted from the German translation of the Kent–Rosanoff Word Association Test [35]), appearing for three minutes on a Lenovo Yoga notebook 720-15IKB screen (15.6 Zoll, i7, 16 GB RAM), and they were instructed to tell everything that came to their minds when thinking of the word presented. Participants' verbal responses were recorded by means of an external microphone (Jabra PHS001U), and were further transcribed by the study experimenter and evaluated with the outcome variables "fluency", "flexibility", and "originality".

2.3.3. Tower of Hanoi

The Tower of Hanoi [36] task was used as a measure of figural convergent thinking. In this task, that was administered on a Lenovo Yoga notebook 720-15IKB screen (15.6 Zoll, i7, 16 GB RAM), participants were presented with a setup of three poles, where the left-most pole contained four disks of decreasing diameter. Using the digital pen, participants were tasked with stacking up the disks in the same order on the right-most pole. The disks could only be moved one at a time and smaller disks could not be placed on a larger one. The "number of correct movements" and the "number of wrong movements" were calculated.

2.3.4. Remote Associate Test (RAT)

In this verbal convergent thinking task, that was originally developed by Mednick [37], participants were presented with seemingly unrelated word triplets (e.g., "candle–cake–party") and required to produce a fourth word associated with the three test words (i.e., in the given example "birthday"). Nine-word triplets of the German RAT version by Landmann et al. [38] were presented in each session (i.e., baseline and intervention). The word triplets were presented in the center of the Lenovo Yoga notebook 720-15IKB screen (15.6 Zoll, i7, 16 GB RAM) screen, and participants were given 60 s to press a button and report the solution. The task was preceded by a practice experimental run ensuring that participants understood the test procedure. The number of correct answers provided were summed up and served as the outcome variable in this task.

2.4. EEG Recording and Sleep Scoring

EEG recordings were performed using the EGI NA400 amplifier sampling at 500 Hz, and the 256-channel EGI geodesic net (Electrical Geodesics Sensor Net for long-term monitoring, Electrical Geodesics Inc. (EGI) System, Magstim EGI, Eugene, OR, USA). The EEG net was adjusted to the participant's vertex (Cz) and the electrodes were filled with electrolyte gel (electro-gel, Electro-Cap International, Eaton, OH, USA).

Participants' EEGs were measured for 60-min under either nap or rest interventions. All the measurements were performed in a quiet, darkened room that was equipped with a bed. While in the nap intervention, participants were instructed to sleep, in the rest intervention they were instructed to sit on the bed while soft relaxation music was played to them.

The polysomnographic (PSG) setup used for subsequent sleep scoring was reduced to 14 channels. For the EEG channels, online filters were set at 0.5 Hz (high-pass) and 30 Hz (low-pass) and for the EOG channels at 0.3 Hz (high-pass) and 10 Hz (low-pass). Sleep stages were scored in 30-s epochs according to the AASM manual criteria (2020, v2.6, [39]), by selecting the sensor-net equivalents for the standard channels (i.e., REOG, LEOG, F3, F4, C3, C4, O1, and O2), and including a review of four additional channels (i.e., Fz, Pz, P3 and P4) that were referenced to the contralateral mastoid channel. Two posterior lateral electrodes, referenced to one another, served as the EMG channel for muscle tone. The 30-s epochs were visually classified, by a sleep expert and reviewed by a second expert, into the following stages: wake (W), non-rapid eye-movement sleep 1 (N1), non-rapid eye-movement sleep 2 (N2), non-rapid eye-movement sleep 3 (N3), and rapid eye-movement sleep (REM). Sleep scoring was performed in Matlab (Version R2020b), using an open-source toolbox csc-eeg-tools [40].

2.5. Data Analysis and Hypotheses

We hypothesized that, compared to the baseline measurement, participants randomized to the nap intervention would perform better in the creativity testing following the intervention. For the rest intervention we did not expect such an improvement. To this end, we calculated the difference in performance between the baseline and the intervention sessions for the four tests of the creativity test battery (i.e., verbal, and figural convergent and divergent thinking tests, see Section 2.3). Statistical analyses were performed with JASP Version 0.14.1. Between-subject ANOVAs (grouping variable intervention, i.e., nap vs. rest) or Kruskal–Wallis tests (when normal distribution was not given) with the above-mentioned outcome variables were calculated.

Given very little REM sleep and long wake periods in the nap group (Table 1), along with the lack of significant group differences (see Sections 3.1 and 3.2), the data of the nap and rest interventions were pooled in a second step and further analyzed by means of one-sample *t*-tests. Based on the results of the Shapiro–Wilk test of normality, we used either the one-sample Student *t*-test (the alternative hypothesis specifying that the mean was different from 0) or the Wilcoxon test (the alternative hypothesis specifying that the median was different from 0).

Table 1. Percentages of different sleep stages for the nap (N = 24) and rest (N = 18) groups.

| | W | | N1 | | N2 | | N3 | | REM | |
|-----------|-------------|---------|------------|--------|-------------|---------|-------------|---------|-----------|--------|
| | M | (SD) | M | (SD) | M | (SD) | M | (SD) | M | (SD) |
| Nap n | 35.9% 24 | (24.2%) | 9.2% 24 | (4.8%) | 31.8% 24 | (13.5%) | 18.3% 15 | (20.7%) | 4.8% 7 | (9.7%) |
| Rest n | 93.1% 18 | (23.2%) | 1.0% 6 | (1.8%) | 0.4% 3 | (1.0%) | 0.0% 0 | (0.0%) | 0.0% 0 | (0.0%) |

M = Mean; SD = Standard deviation. W—wake, N1—non-rapid eye-movement sleep 1, N2—non-rapid eye-movement sleep 2, N3—non-rapid eye-movement sleep 3, REM—rapid eye-movement sleep. N number of participants presenting the corresponding sleep stage.

3. Results

3.1. Analysis of Sleep Stages

The percentages of the different sleep stages for the nap and rest groups are presented in Table 1. In the nap group, the average time awake was rather high, i.e., 35.9%, and only a little REM sleep could be observed, i.e., 4.8%. On the individual level, almost half of the participants assessed (i.e., 10 out of 24), were awake for more than 40% of the entire 60-min nap time (range: 40–79%). More importantly, in the nap group, 17 out of 24 participants showed no REM sleep, and N3 sleep was observed in 15 out of 24 participants. Overall, the rest group stayed predominantly awake, showing minimal average percentages of N1

(1.0%) and N2 (0.4%) sleep. Supplementary Table S1 shows the number of participants from the nap group reaching different sleep stages.

3.2. Between Group Analysis—Nap versus Rest Groups

The results of the statistical analysis (ANOVA or Kruskal–Wallis test for non-normally distributed data) are summarized in Table 2 and the Supplementary Table S2, which present the group values. We found no statistically significant differences between the nap and rest groups.

Table 2. Results overview of the comparison between the nap and the rest groups.

| Creativity Tests | Between-Subject Factor | Statistics | <i>p</i> Value |
|------------------|-------------------------|-------------------|----------------|
| TCCT | Fluency | $F(1,40) = 0.002$ | 0.968 |
| | Originality | $F(1,40) = 0.395$ | 0.533 |
| AFT | Fluency | $F(1,40) = 3.754$ | 0.060 |
| | Flexibility | $F(1,40) = 0.003$ | 0.960 |
| | Originality | $F(1,40) = 2.99$ | 0.091 |
| Tower of Hanoi | Nb of correct movements | $F(1,40) = 0.151$ | 0.699 |
| | Nb of wrong movements | $H(1) = 1.402$ | 0.236 |
| RAT | Correct answers | $F(1,40) = 0.006$ | 0.941 |

Sleepiness—SSS and Visual-Analogue Scale

Repeated Measures ANOVAs conducted for the visual analogue scale and the SSS, indicated no significant effects, neither for the within-subject factor time point (i.e., pre and post, $F(1,39) = 0.2603$, $p = 0.61$, and $F(1,40) = 0.0696$, $p = 0.79$ respectively), nor for the between-subject factor intervention (i.e., nap and rest, $F(1,39) = 1.4368$, $p = 0.23$, and $F(1,40) = 0.0696$, $p = 0.79$ respectively).

3.3. Analysis of the Pooled Data

3.3.1. TTCT

In the TTCT, participants performed significantly better following the intervention (“Fluency” ($t(41) = 19.2087$, $p < 0.0001$, effect size Cohen’s $d = 2.9640$; and “Originality” ($t(41) = 25.1007$, $p < 0.0001$, effect size Cohen’s $d = 3.8731$, Figure 1).

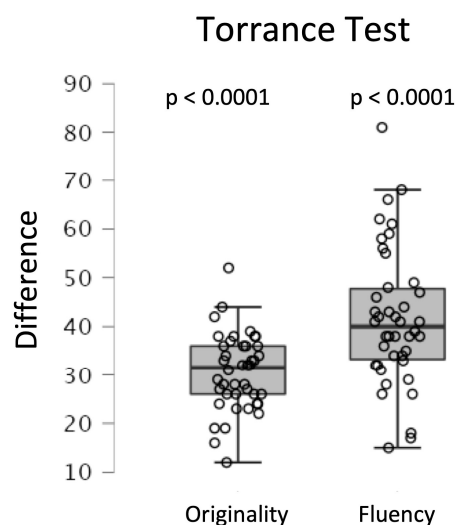


Figure 1. Box-Plots with individual values of the results of the TTCT. In this figural diverging thinking test, we found a post-intervention (i.e., nap and rest groups pooled) improvement in performance between baseline and intervention measurements for both “Originality” and “Fluency”.

3.3.2. AFT

In the AFT, no significant differences were found, neither for “Fluency” ($t(41) = 0.1903$, $p = 0.8500$), nor for “Flexibility” ($t(41) = 0.3959$, $p = 0.6942$), and “Originality” (Wilcoxon signed-rank test, $V = 544.5$, $p = 0.2474$).

3.3.3. Tower of Hanoi Task

While for the Tower of Hanoi task there was a significant difference in the percentage of wrong movements, indicating a reduction of wrong movements (Wilcoxon signed-rank test, $V = 31.000$, $p = 0.0034$, Rank-Biserial Correlation = -0.7316 , Figure 2), no significant difference was found for the “Number of correct moves” (Wilcoxon signed-rank test, $V = 553.5$, $p = 0.98$).

Tower of Hanoi

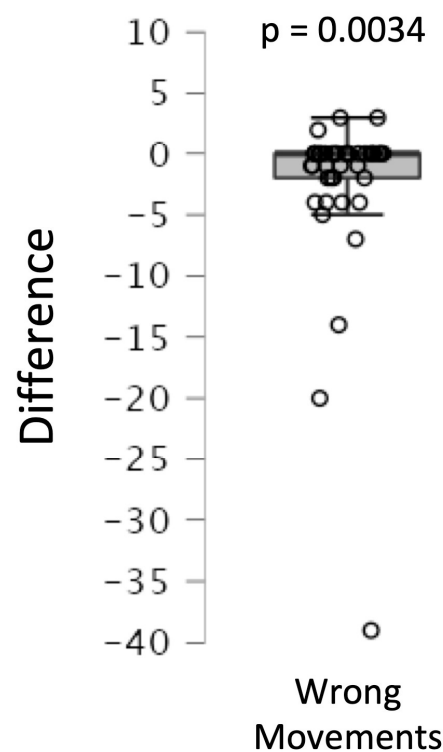


Figure 2. Box-Plot with individual values of the results of the Tower of Hanoi task. A post-intervention decrease in the number of wrong movements was found for the Tower of Hanoi test assessing figural convergent figural thinking.

3.3.4. RAT

No significance difference for the number of correct answers was found ($t(41) = 0.3951$, $p = 0.6948$).

4. Discussion

The aim of this study was to evaluate the effect of a 60-min nap on the performance in a creativity test battery including two convergent and two divergent thinking tasks. Our hypothesis was that, compared to a rest intervention (i.e., a 60-min rest during which participants were listening to relaxation music), a 60-min nap would increase creativity performance. However, this was not the case. Both nap and rest seemed to influence the creativity performance (i.e., between-subject ANOVAs revealed no significant differences

for any of the outcome variables in the four creativity tasks). Indeed, the analysis of sleep stages indicated that in the nap group barely 7 out of 24 participants had REM sleep, and only 14 out of 24 had N3 sleep. The reason why we did not find differences between the nap and the rest interventions remains speculative. One speculation may be that the length of the nap might be of particular importance. Indeed, a broad spectrum of nap durations has been reported to date (for a review, see [16]), yet most of these studies focused on behavior or cognition. In the review by Milner and Cote [16], nap durations ranging from 10 min up to 8 h were reported to be effective. Thus, an explanation as simple as the nap duration appears insufficient. May it be the percentage of REM sleep? To date, only a limited number of studies have investigated sleep architecture as a means to predict the type, and degree, of benefits gained from a nap (for a review, see [16]). Tucker et al. [41] showed that memory is dependent on the sleep architecture of the nap. Specifically, they demonstrated that a nap improved declarative memory; however, both a nap and a period of rest were equivalent in terms of procedural memory improvement. Cai and colleagues [26] examined the role of REM sleep during a nap on creative problem solving using the RAT. They found that, compared to quiet rest and non-REM sleep, REM enhanced the formation of associative networks and the integration of unassociated information. However, their results suggested that the REM sleep benefits did not result in improved memory for the primed items. Another speculation, with respect to missing differences between the nap and the rest interventions, may be that the outcomes were due to our rest condition. In our study, participants were seated in a dimmed room, and they were listening to relaxation music. As such, it cannot be ruled out that listening to relaxation music may influence creativity performance, as also previously shown in the study by Ritter and Ferguson [42]. In their study, they investigated whether listening to music, compared to a silent control condition, facilitated divergent and convergent thinking. Indeed, they found that participants listening to “happy music” were more creative, as compared to those performing the same task in silence. However, this effect was found for a convergent, but not for a divergent creativity task. Eye-closure has also been shown to influence creativity in both divergent and convergent thinking tasks, while having no effect on a working memory task [43].

In the current study, the analysis of the pooled data indicated differential effects of the pooled interventions (i.e., nap and rest) on figural versus verbal creativity tasks. As such, a figural divergent thinking task (i.e., TTCT) indicated a significant improvement between the baseline and the intervention measurements for both Originality and Fluency with very high effect sizes for both parameters. A significant effect was also found for the figural convergent thinking task (i.e., the Tower of Hanoi Task), where the number of wrong movements was significantly lower following the pooled interventions. Conversely, we found no effects for either divergent (i.e., AWT) or convergent (i.e., RAT) verbal thinking tasks. While further studies are needed to confirm these findings, to the best of our knowledge, such a dissociation between performance of verbal and figural creativity tasks after nap/rest interventions has not been described to date. Needless to say, explanations as to which are the possible mechanisms of this dissociation must remain purely speculative for the moment. One hint for a possible dissociation between verbal and figural domains may be that the effects of sleep on performance of verbal and visuospatial memory differ. Given that sleep quality has been shown to be associated with visuospatial episodic memory accuracy, but not with verbal episodic memory accuracy [44], one may speculate that such a dissociation might also exist for verbal and figural creativity domains.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/ctn7030020/s1>, Table S1: Number of participants from the nap group (total N = 24) reaching different sleep stages (expressed in percentages), Table S2: Mean difference values (i.e., baseline-intervention sessions) and the corresponding standard deviations (provided in parentheses) of the nap and the rest groups.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Kanton of Bern (protocol code 2018-01578, date of approval: 21 November 2018).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The conditions of our ethics approval do not permit public archiving of the data supporting the conclusion of this study. Readers seeking access to the data and study materials should contact the corresponding author.

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Conflicts of Interest: The authors declare no conflict of interest.

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