

A STUDY ON THE IMPACT OF DAYTIME NAP ON DECLARATIVE MEMORY IN YOUNG ADULTS

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ABSTRACT

Objective: To evaluate the impact of the daytime nap on declarative memory assessed by performance of memory tasks in young adults.

Methods: The study was carried out among 30 subjects, 15 males and 15 females divided into daytime napping group and control group. These subjects were allowed for 60 minutes retention interval. Later the subjects in daytime nap group were put to bed in a sound attenuated sleep chambers to enable napping while control group was kept awake. Performance of declarative memory was evaluated both pre and post intervention for all subjects by three tests namely, unrelated paired associates, maze learning, and the Rey-Osterrieth complex figure.

Results: Statistical analysis revealed that independent t-value was significant between napping and awake group on memory task performance conducted before and after 60 minutes retention interval ($p < 0.001$). Sleep parameters analysis in napping group show sleep onset latency time of 10.6 minutes, which was dominated by Stage I sleep with sleep efficiency of 56.35%. Total sleep time was 51.46 minutes in napping group. Improvement in memory task was statistically significant as the results of unrelated word pair's associates the performance of nap group was 97.2% when compared with the control group with 90% performance. Rey-Osterrieth complex figure test results show the average time taken by nap group was 45 seconds, and that of awake group was 63 seconds. In the case of maze learning task, the time taken by nap group was 27.33 seconds and by awake group was 38.2 seconds ($p < 0.001$).

Conclusion: From the results it is evident that non declarative memory is well enhanced by daytime napping shown by improved performance tests. This might be brought about by memory consolidation process triggered during sleep onset latency.

Keywords: Daytime nap, Non-rapid eye movement sleep, Memory consolidation, Declarative memory task.

INTRODUCTION

Sleep is a naturally recurring state characterized by reduced consciousness, relatively suspended sensory activity, and inactivity of nearly all voluntary muscles. It is distinguished from quiet wakefulness by a decreased ability to react to stimuli and is more easily reversible [1].

Memory is the process by which information is encoded, stored, and retrieved. Encoding processes information received in the form of chemical and physical stimulus. Storage is the second stage in memory process by which we retain information over a period. The third process is the retrieval of information that we have stored [2]. There are several memory systems in the brain among them, hippocampus is the key brain structure responsible for storing declarative (explicit) memories. Memories are not static; they weaken or strengthen depending on a variety of influences [3].

Substantial numbers of studies have shown a relationship between sleep and improvement on memory typically focused on declarative memory tasks like syllables, word lists, and paired associate lists [4]. Recent researches have also established sleep-related memory facilitation for a variety of perceptual and motor skills, and even for complex cognitive tasks. Few more procedural learning paradigms that have shown performance improvement with sleep include visuo-motor learning [5]. Studies have shown that non-rapid eye movement (NREM) sleep, a period of suppressed long-term potentiation, facilitates declarative memory compared with wakefulness and REM sleep. Studies report that the performance increases after an hour of nap compared with the same period of waking, implicating a slow, and offline process during NREM sleep that strengthens and improves the memory tasks [6]. Daytime naps have been shown to impact a

number of performance variables beneficially. This finding is proved by documented evidence on sleep influenced retino topically-specific learning enhancement with primary visual areas recording increased functional magnetic resonance imaging blood-oxygen-level-dependent signals after nap [7].

Given the relative robustness of the night sleep effect on declarative memory and the widespread presence of polyphasic sleep cycles, it might be speculated that a sleep-related memory enhancement also applies to short episodes of napping which usually consist mainly of Stage 1 (NREM sleep), but of only little or no REM sleep as compared with a regular night sleep period [8].

So, in order to address the deficiency, present study employs a daytime nap design that specifically analyses the benefits of daytime napping (60 minutes) on memory consolidations and association of NREM (Stage 1) and total sleep time (TST) with improved memory task performance.

Aim

1. To assess the performance of declarative memory task in young adults in the age group of 18-25 years
2. To compare the pre and post-test memory task in the young adults with daytime napping with the control group who are awake.

METHODS

The present study is a comparative analytical study of 6 months approved by the Institutional ethical committee. Polysomnogram (SLEEP CARE) in the Department of Physiology, SRM Medical College and Research Centre was used to assess the memory performance. 30 adult of age 18-25 years comprising 15 males, 15 females were

recruited for the study based on the following criteria. Written consent was obtained for the study after explaining the protocol of the study to the subjects.

Inclusion criteria

Professional college students of age between 18 and 25 years who are non-smokers, non-alcoholics.

Exclusion criteria

1. Subjects with neurological, endocrine disorders
2. Subjects on antipsychotic drugs and sedatives.

To assess the declarative memory benefits of NREM sleep obtained during a daytime nap, these subjects were trained on three well-known declarative (hippocampus-dependent) memory tasks aided by a computer in sound-attenuated room. After the training session, they were evaluated on three memory tasks (pre-test). These subjects were allowed for 60 minutes retention interval during which they were divided into daytime napping group and control group. During retention interval, EEG activities were monitored using polysomnography. The subjects in daytime nap group were put to bed in a sound attenuated sleep chambers to enable napping. Electrodes for standard polysomnography were applied to record the sleep pattern. After 60 minutes, the subjects were awakened. The electrodes had been removed, and recall (post-test) performed. Participants of control group were made to lie in the bed, electrodes were applied on them to record electrical activity of brain, and these subjects were kept awake by engaging them in simple computer games of non-verbal nature. After 60 minutes retention interval when electrodes had been removed, they were tested for recall (post-test).

Memory tasks

Semantically unrelated paired associates

Thirty word pairs were created. Subjects had 2 minutes time to read all the words and memorize carefully as many as possible. They were also instructed to recall the correct word pair for scoring. During testing, they were presented the stimulus (first) word in each of word pairs printed in the paper and were asked to write the associated pair word. After completion of the 30 tested word pairs, subjects viewed all 30 word pairs once more. After the 60 minutes of retention interval, recall test (post-test) was performed. The second task was the Rey-Osterrieth complex figure test (ROCFT); a measure of visuospatial declarative memory [9] and the third test was a maze learning task adapted from the task used by Brenda Milner on a large sample of hippocampal lesion patients [10].

Statistical analysis

The data collected were entered in the MS excel sheet. Paired correlation was generated, and statistical analysis was done using SPSS_16 software of IBM. A significance level of $p < 0.05$ was considered for the Student's "t" value and for correlation analysis the significance level of $p < 0.01$ is considered.

RESULTS

Statistical analysis of the study results shown significant improvement between napping and awake group on memory task performance conducted before and after 60 minutes retention interval, with independent t-value being ($p < 0.001$). Results of unrelated word pair's associates the performance of pre-test was 82.2% when compared with the post-test (97.2%) ($p < 0.001$). ROCFT results show, the average time taken in pre-test was 76.6 seconds, and that of post-test was 45 seconds ($p < 0.001$). Maze learning task results indicate the time taken for pre-test was 47.6 seconds when compared with the post-test 27.33 seconds ($p < 0.001$). Sleep parameters were analyzed in napping group show, sleep onset time 10.6 minutes, sleep was dominated by Sleep I, sleep efficiency was 56.35%. TST was 51.46 minutes in the napping group (Tables 1 and 2 and Figs. 1 and 2).

Table 1: Correlation between pre and post-test nap

| | Paired samples correlations | | |
|----------------------|-----------------------------|-------------|-------------|
| | n | Correlation | Significant |
| Pair 1 | | | |
| Pre I and post I | 15 | 0.750 | 0.001 |
| Pair 2 | | | |
| Pre II and post II | 15 | 0.814 | 0.000 |
| Pair 3 | | | |
| Pre III and post III | 15 | 0.874 | 0.000 |

Table 2: Sleep statistics of polysomnographic study between nap group and no nap group

| Parameters | Nap group | Control group (no nap) | t-value | p-value |
|------------|------------|------------------------|---------|---------|
| SL | 10.6±1.72 | 2.46±11.3 | -2.7 | 0.01 |
| SI | 19.8±13.6 | 4.4±5.03 | 4.0 | 0.00 |
| SII | 4.6±6.7 | 0 | 2.6 | 0.013 |
| SE | 56.35±15.2 | 6.6±7.3 | 11.3 | 0.00 |
| TST | 51.46±5.7 | 4.7±4.04 | 25.7 | 0.00 |

SL: Sleep latency, SI: Sleep impairment, SII: Sleep impairment index, SE: Sleep efficiency, TST: Total sleep time

DISCUSSION

Results of our study confirm the beneficial effect of the daytime nap on memory, which is evident by the positive correlation between memory performance and TST. The results show that brief NREM sleep state improves all the three memory tasks (paired associates words, Rey-Osterrieth complex figure, maze learning) in nap subjects. The results are consistent with earlier studies done by Fischer *et al.* [11].

It is a known fact that the molecular mechanisms underlying the induction and maintenance of memory are very dynamic and comprise distinct phases covering a time window from seconds to days together. People can construct their memories when they encode them and recall the information later. Memory is enhanced by certain stages of sleep, but the neurophysiological mechanisms of sleep-dependent memory enhancement are not fully understood [12].

Theories of sleep-related memory consolidation clearly suggest that the electrophysiological and biochemical brain state produced while NREM sleep should be an optimal time for non-declarative memory consolidation. Few researchers contradict our findings, such as Fennk *et al.*, Nusbaumbaum *et al.*, who suggest that a "hippocampo-neocortical dialog" occurs primarily during slow wave sleep (SWS) to strengthen the memory trace [13]. They found that the nap and no nap group performed similarly on the non-verbal declarative memory tasks, which was unexpected given the fact that declarative memory tasks have been shown consistently to benefit more after periods of NREM sleep compared to equivalent periods of wakefulness. In Mednick *et al.*, study improvement of declarative tasks has been correlated with SWS related hippocampal activity [14].

Although, the results of the present study are correlative with other studies done on similar concepts, there are limitations in this study. These include a variety of non-declarative tasks like prose passage, spatial task, forming sentences are to be studied, to confirm and extend our knowledge about napping and memory [15]. Optimal duration of a nap should be evaluated for memory consolidation, and these parameters have to be included in future research.

CONCLUSION

It is clearly revealed that napping enhances memory task performance as shown in paired sample correlation between napping and awake group. Significant improvement in memory tasks performance in nap

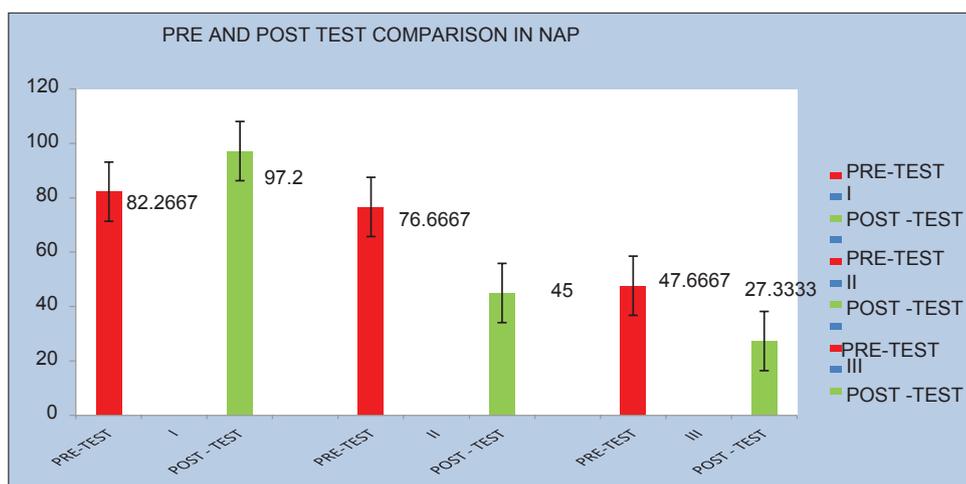


Fig. 1: Pre and post-test comparison in nap

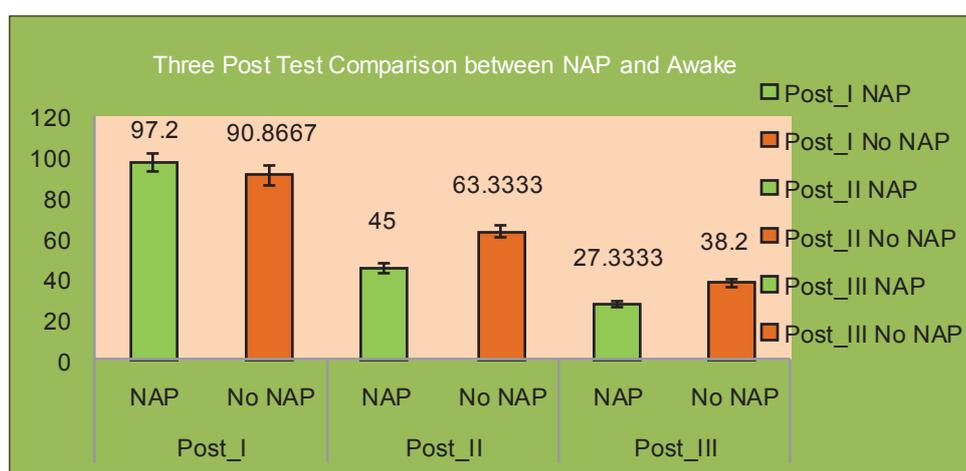


Fig. 2: Post-test comparison between nap and awake

group is associated with memory consolidation of declarative tasks performance of post-test memory tasks was enhanced in napping group which states that sleep-dependent performance task improvement is well appreciated in napping because memory consolidation process is triggered during sleep onset latency.

Based on our research findings, we could recommend teaching professionals to utilize this concept in preschools and challenged children to enhance their performance.

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