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RESEARCH ARTICLE

Evaluating a practical approach to targeted memory reactivation by Vedic Chants and Indian Classical Music during daytime nap

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ABSTRACT

Background: Among the multiple functions of sleep, its role in the establishment of memories seems to be particularly important. Spontaneous memory reactivation during sleep can promote consolidation and thus shape the memory storehouse that each individual possesses. Targeted memory reactivation (TMR) is a method whereby cues associated with previous learning are used to externally reactivate aspects of learning. **Aims and Objectives:** The aim of this study was to evaluate the effect of TMR by Indian classical music and Vedic Chants during daytime nap on consolidation of newly learnt material and to evaluate effect of time spent in various stages of sleep during TMR on consolidation of newly learnt material. **Materials and Methods:** The study was conducted on 45 participants who were divided into three groups. Memory was assessed with the help of digit span (working memory) and paired associate task (long-term memory) before and after the nap. During 1 h daytime nap, sleep was monitored by polysomnograph. Sound cues were played both during learning of word pairs and during sleep. Results: Participants listening to Vedic Chant performed better in digit span after nap ($P = 0.001$). When evaluated for subjects of all groups significant positive correlation was found between improvements in digit span score after nap and sleep efficiency, time spent in N3, and percentage of N3 in total recording time and had negative correlation with awake time. No significant change in score of paired associate task after nap was seen. **Conclusion:** This result paves way for usage of Vedic Chants as a background sound during daytime nap to improve working memory. The result also suggests that a daytime nap with good sleep efficiency and presence of N3 stage of sleep can increase the work efficiency of individuals after nap. Improvement in score of paired associate task in Vedic Chants group though not statistically significant demands for further research in the effect of Vedic Chants on long-term memory.

KEY WORDS: Daytime Nap; Memory; Targeted Memory Reactivation; Vedic Chant; Indian Classical Music

INTRODUCTION

Alteration in human behavior in response to the change in environment is brought by learning and memory. Among the multiple functions of sleep, its role in the establishment of memories seems to be particularly important. Sleep promotes primarily the consolidation of memory, whereas memory encoding and retrieval take place most effectively during waking. In the landmark study by Plihal and Born[1] recall of word pairs, a declarative memory task was assessed after retention interval of early sleep dominated by slow wave sleep (SWS). Recall of word pairs improved significantly after the sleep. Tucker *et al*.[2] also found that daytime nap containing only non-rapid eye movement sleep also enhances memory for word pairs. Schabus *et al*.[3] studied word-pair association performance using a cued recall procedure, before and after

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a 60-min nap. Results indicated that only those nappers with SWS in their sleep showed an improvement at the declarative memory task after the nap.

Targeted memory reactivation (TMR) is a method whereby cues associated with the previous learning are used to externally reactivate aspects of this learning. Rudoy *et al*.[4] used auditory cues to demonstrate that memory processing during sleep could be highly specific. Participants recalled locations more accurately for objects cued during sleep than for objects not cued during sleep. This TMR demonstration shows that reminders during sleep can be used to target the reactivation and strengthening of individual memories. Similar experiment was conducted by Oudiette *et al*.[5] and Van Dongen *et al*.[6] who also studied TMR by sound. Reactivation with sound cues during sleep improved memory of learned material. In another study by Donohue and Spencer,[7] contextual cuing by environmental sounds was done. Sleeping with sound however had no impact on recall.

Vedic chanting is a meditative practice from the rich tradition of Indian spiritual practices. Vedic chanting in a traditional way is used as one of the powerful means as any other yogic practices such as meditation for enhancing memory and in effective improvement of attention. Ghaligi *et al*.[8] studied the effect of Vedic chanting on memory and sustained attention and observed that chanting group showed better verbal and spatial scoring as compared to non-chanting group.

Earlier it has been observed that listening to classical music, particularly Mozart, enhances performance on cognitive tests (The Mozart effect).[9] The benefit of background classical music was also shown in study done by Silor[10] where classical music was used as background in reading story through the use of video presentation. Results showed higher scores in classical music group as compared to control group. On this background, our present study was aimed to evaluate the effect of Vedic Chants and Indian classical music as a cue for TMR during a daytime nap on consolidation of descriptive memory.

MATERIALS AND METHODS

Permission from Ethical Committee of Indira Gandhi Medical College, Shimla, was taken for conducting this study. Recruitment of subjects was done on the basis of inclusion and exclusion criteria. Subjects gave informed consent after understanding the purpose of study and interventional procedure. Subjects were then allotted the group by lottery method.

Three days before the day of study subjects received the pre-test instructions to abstain from alcohol and caffeine 24 h before test day and were asked to complete the sleep log that recorded bed time, wake time, and total sleep of 3 days before the day of study.

On the day of study, on arrival at 1:30 pm subjects were familiarized with the sleep chamber and the nature of the study.

The subjects then went to the testing area of the sleep lab. The tests were digit span immediately followed by learning phase of paired associate task. The score of digit span was considered as pre-nap digit span score.

Headphones were kept for each subject before the initiation of learning phase of paired associate task and it was removed after the learning period. During learning of paired associate task subject of Vedic Chants group was listening to Vedic Chants (Purusha Suktam), subjects of Indian classical music group were listening to Indian classical music (Santoor) and subjects of control group were listening to white noise.

Following a 10 min break subjects were tested for the recall of learned material. This was considered the pre-nap paired associate task score.

After completion of pre-nap test, subjects were taken to a sound attenuated sleep chamber for nap. Electrodes necessary for recording of sleep were then applied.

Headphone was kept before initiation of sleep recording and cues were played throughout the recording period during which Vedic Chants group were presented with Vedic Chants, Indian classical music group with Indian classical music and control group with white noise. These sounds were also present during learning and were now being used as a contextual cue for TMR of learned material.

All subjects were given opportunity to sleep at 2 pm (light off time in polysomnogram) to keep circadian influences constant.

Total bed-time of 60 min was given for each participant. The subjects were monitored with digital electroencephalograph (EEG) acquisition software (Allenger SL-PSG) during this period.

After the sleep session, the electrodes and headphone were removed and subject stayed in the laboratory until the post-nap test session which initiated after a period of 20 min provided to overcome sleep inertia.

Post-nap tests were done which included digit span and paired associate task. Scores were compared to pre-nap scores for evaluation of consolidation of memory of learned material and improvement in working memory during sleep.

Instruments and Tools

- Digit span test for immediate memory
- Paired associate task for intermediate long-term memory

- Allenger SL-PSG polysomnogram for recording sleep
- American Board of Sleep Medicine criteria for sleep scoring.

Statistical Analysis

Statistical software SPSS windows version 20 was used for data analysis. Paired t-test and Pearson correlation tests were used for categorical values.

RESULTS

In the present study, total 45 individuals were selected. The mean age of subjects in Vedic Chant group was 20.6 years (SD ± 2.89), in Indian classical music group was 20.7 (SD ± 3.10) and in control group was 20.7 (SD ± 3.10). The difference of age among groups was statistically not significant ($P = 0.998$).

Digit Span Test (Working Memory)

Digit span test pre-nap score and post-nap score in Vedic Chant group were 7.46 (SD ± 1.18) and 8.80 (SD ± 1.32), in Indian classical music group was 7.73 min (SD ± 1.22) and 8.20 min (SD ± 1.20), and in control group was 8.06 (SD ± 1.29) and 9.06 (SD ± 1.38), respectively. Statistically significant difference was found between the two scores in case of Vedic Chant group with $P = 0.001$ whereas no statistically significant difference was found in score of digit span in Indian classical music group ($P = 0.089$) and control group ($P = 0.220$) [Figure 1].

Paired Associate Task (Long-term Memory)

Paired associate task pre-nap score and post-nap score in Vedic Chant group were 29.66 (SD ± 7.59) and 29.9333 (SD ± 7.71), in Indian classical music group was 27.0000 (SD ± 7.10) and 26.6667 (SD ± 7.24) and in control group was 30.1333 (SD ± 8.45) and 29.4667 (SD ± 8.94), respectively. Although there was increase in score of Vedic Chant group, after nap no statistically significant change in score of paired associate task after TMR during nap was seen in any group [Figure 2].

Sleep

Sleep parameters taken for all groups were total recording time, awake time, total sleep time, sleep efficiency, time spent in N1, N2, N3, and R in minutes and its percentage to total recording time. Time period of each sleep parameters is elaborated in Table 1. No statistically significant difference among group was present in awake time ($P = 0.486$), total sleep time ($P = 0.972$), and sleep efficiency ($P = 0.566$), N1 min ($P = 0.902$), N1% ($P = 0.942$), N2 min ($P = 0.951$), N2% ($P = 0.680$), and N3 ($P = 0.414$), N3% ($P = 0.368$).

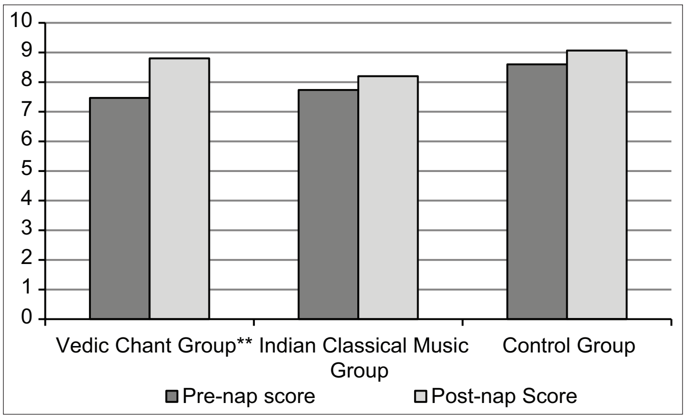

Figure 1: Comparison of Digit span pre-nap and post-nap score in subjects of all groups. (**$P < 0.01$)

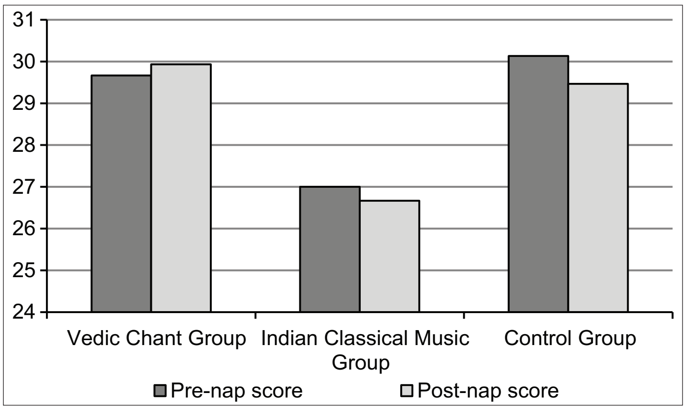

Figure 2: Comparison of paired associate task pre-nap and post-nap score in subjects of all groups

Correlation between Change in Digit Span Score after Nap and Sleep Parameters

There was negative correlation between change in digit span score after nap and awake time ($r = -0.318$), ($P = 0.033$). There was positive correlation between change in digit span score after nap and sleep efficiency ($r = 0.320$), ($P = 0.032$).

There was positive correlation between change in digit span score after nap and time spent in N3 in minutes ($r = 0.382$), ($P = 0.010$), and N3% ($r = 0.402$), ($P = 0.006$).

Correlation between Change in Paired Associate Task Score after Nap and Sleep Parameters

No statistically significant correlation was present between change in score of paired associate task after TMR during nap and sleep parameters.

DISCUSSION

The numbers of behavioural and physiological evidence in favour of the view that memory consolidation is supported by sleep are growing rapidly. Sleep does not only protect memories from the interference posed by wakefulness,

Table 1: Sleep parameters in subjects of all groups

Variables	Vedic chant group (*n*=15)	Indian classical music group (*n*=15)	Control group (*n*=15)
Total recording time (in min)	54.30 (SD±6.62)	59.13 (SD±2.57)	57.93 (SD±4.03)
Awake time (in min)	28.03 (SD±14.88)	33.13 (SD±10.16)	32.86 (SD±13.43)
Total sleep time (in min)	26.13 (SD±13.22)	25.76 (SD±11.44)	25.03 (SD±13.75)
Sleep efficiency in %	50.60 (SD±24.95)	43.18 (SD±18.43)	42.96 (SD±22.61)
N1 (in min)	15.16 (SD±7.29)	16.00 (SD±8.98)	14.70 (SD±7.43)
N1 %	68.38 (SD±30.47)	65.40 (SD±31.64)	69.06 (SD±30.39)
N2 (in min)	8.23 (SD±9.08)	9.33 (SD±8.14)	8.76 (SD±11.11)
N2 %	24.69 (SD±24.07)	33.28 (SD±30.61)	27.66 (SD±26.17)
N3 (in min)	2.23 (SD±3.96)	0.43 (SD±1.67)	1.56 (SD±4.78)
N3 %	5.63 (SD±9.62)	1.31 (SD±5.08)	3.26 (SD±9.32)
R (in min)	0.00	0.00	0.00
R %	0.00	0.00	0.00

sleeping brain actively facilitates memory processing and impart qualitative changes to memory encoded throughout the preceding day.[11,12]

Effect of Nap on Working Memory

When the pre- and post-nap digit span test scores were compared, we found statistically significant difference between the two scores in case of Vedic Chant group. Statistically significant correlation was found between change in digit span score after nap and awake time, sleep efficiency, time spent in N3 in minutes, and in N3% of total sleep time (TST). On analyzing the correlations, we found that participants who were awake for more time during the total recording time had significant negative effect on the score of digit span or the working memory. The participants who had better sleep efficiency during nap improved significantly on digit span score. The participants who spent more time on N3 stage of sleep also significantly improved on digit span.

Mednick *et al*.[13] studied the effect of nap on visual texture discrimination task. Results showed that napping significantly affected subsequent performance. Short naps prevented the normal deterioration and long naps reversed the deterioration seen in earlier session. They also found that the long nap group spent significantly more time in SWS on the test day. This large increase in SWS in test day naps (31% over baseline) suggested that SWS is crucial for post-nap performance, perhaps through stabilizing, and consolidating plastic neuronal changes from earlier in the day. Similar results were obtained in our study as well. The improvement was seen in digit span test which was significantly correlated with the time spent in SWS ($P = 0.010$).

Brooks and Lack[14] compared the benefits of different length naps relative to no nap and analyzed the electroencephalographic elements that may account for the benefits. Subjects with delta onset in the nap condition showed trends of greater benefit relative to those with no delta onset. It was proposed that the beneficial effects of napping in the conditions of that study may be due to the onset of delta-wave activity or the accumulation of a fixed, relatively brief, duration of stage 2 sleep, or total sleep which was also seen in our study by positive correlation between change in digit span score after nap and sleep efficiency ($r = 0.320$), ($P = 0.032$).

In another study by Hayashi *et al*.,[15] recuperative power of a short daytime nap with or without stage 2 sleep was tested. They showed that a daytime short nap containing 3 min of stage 2 sleep has recuperative effects, whereas these effects are limited following only stage 1 sleep. In our study, there was also a positive but not statistically significant correlation between improvement in digit span and time spent in N1 and N2 stages of sleep.

From various studies done on effect of nap on working memory, it is still unclear that whether it is the length of nap time, initiation of N1, N2, or N3 stage of sleep or as such the complete sleep architecture that is responsible for the beneficial effect of nap. Our present study suggests that the N3 stage of sleep and sleep efficiency has significant correlation with the improvement in attention after nap. Our study also suggests that listening to Vedic Chants in background during sleep contributes to improvement in attention as compared to listening to Indian classical music or white noise without affecting the sleep architecture.

Effect of Nap on Long-term Memory

Although there was increase in score of Vedic Chant group, after nap no statistically significant change in score of paired associate task after TMR during nap was seen in any group. No statistically significant correlation was present between change in score of paired associate task after TMR during nap and sleep parameters.

Time spent in SWS predicted the memory benefit of TMR. TMR initiates an augmented consolidation process during subsequent SWS.[16] Memory reactivation per se is sufficient to improve subsequent retrieval, because reactivation necessarily entails strengthening of the previous storage. In this case, the longer one sleeps, the more memory reactivation takes place, and so memory benefits are greater. This idea is consistent with results showing equivalent memory benefits of a 40-min sleep period with odor TMR and a 90-min sleep period without TMR, because only in the second condition was the memory benefit correlated with time spent in SWS.[17] This study suggests that SWS duration and amount of memory reactivation are critical factors for memory consolidation.

Similar to the findings of Donohue and Spencer,[7] no statistically significant improvement in memory was seen and no statistically significant correlation was present between change in score of paired associate task after TMR during nap and sleep parameters. This null result may reflect one or more restrictions that may limit the benefits of TMR during daytime nap.

The daytime nap which does not have SWS can limit the benefit of TMR. The mean time spent in SWS by subjects in our study was 1.41 ± 3.70 min which is very less as compared to 22.43 ± 4.60 min in study by Tucker *et al*.[2] which has shown an improvement in memory after daytime nap (P = 0.05). Their study also showed positive, though non-significant, relationships between percentage of SWS in the nap and improvement on the paired associates task (P = 0.12). In study by Rasch *et al*.,[18] all participants reached SWS averaging 15.5 ± 4.1 min. Less time spent in SWS by our subjects could be the reason behind no improvement in memory after nap.

The lengthy presence of the contextual cues during sleep may have allowed the participants to habituate to the sound prior to SWS. Rasch *et al*.[18] re-presented the odor selectively only during SWS and in 30 s on and off bouts to prevent habituation. Like-wise Rudoy *et al*.[4] presented brief sound (200–500 ms) once every 5 s during SWS. By presenting the sound throughout the nap participants may have habituated to this sound before the SWS, there by prohibiting the usefulness of the cue.

Limitations of this Study

Although conducted with relatively sound methodology, this study has few limitations. Due to small sample size, this study needs to be done in a large sample size to confirm its findings. Due to limited time of daytime nap (1 h) and lack of proper time spent by individuals in N3 stage of sleep, the full effect of sleep on consolidation of long-term memory could not be seen in the present study.

CONCLUSION

Score of digit span test was significantly improved after nap in subjects listening to Vedic Chants as compared to subjects listening to Indian classical music and white noise where though score improved it was not statistically significant. This improvement in short-term memory was positively correlated with sleep efficiency and time spent in N3 stage of sleep whereas it was negatively correlated with awake time. This result paves way for usage of Vedic Chants as a background sound during daytime nap to improve working memory. The result also suggests that a daytime nap with good sleep efficiency and presence of N3 stage of sleep can increase the work efficiency of individuals after nap.

Improvement in score of paired associate task in Vedic Chants group though not statistically significant demands for further research in the effect of Vedic Chants on long-term memory.

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