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Journal search and commentary

Take afternoon naps to improve perceptual learning

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1. Article reviewed

Title: Sleep-dependent learning: a nap is as good as a night.

Authors: Mednick S, Nakayama K, Stickgold R.

Journal: Nat Neurosci, 2003;6:697–698.

2. Objectives

Determine benefits of naps with and without REM sleep for performance on a perceptual learning task.

3. Study design

Between group comparisons for experimental groups assigned to different nap conditions and also for groups divided by occurrence of REM during the naps.

4. Study population

Age, gender and source of the 73 subjects were not given.

5. Methods

All subjects were trained in a standard visual texture discrimination task at 09:00 and tested at 19:00 the same day and again at 9:00 the next morning. At about 14:00 on the day of the learning the task subjects either had no nap ($n = 28$) or naps of about 60 ($n = 26$) or 90 min ($n = 19$) durations depending on the group to which they were assigned. The process for assigning subjects to groups was not specified. Data were analyzed for each nap condition and then also for nap groups divided not by length of nap but by whether or not REM sleep occurred. The amount of nocturnal sleep for the night before the test and the next night after the nap was also recorded for each subject, but the methods for this (sleep log, questionnaire the next day, activity or home recordings, polysomnogram) were not specified.

The learning task involved detection of whether diagonal bars in the lower left visual quadrant of a stimulus were in a horizontal row or vertical column in a stimulus presented and then followed by a masking stimulus of both horizontal and diagonal bars. The dependent measure of minimum inter-stimulus interval for 80% accuracy generally shows initial improvement over a few minutes of training, deterioration during the wake time and improvement after night's sleep with performance actually better the next morning than immediately after learning the task. Learning was evaluated by presenting the test stimuli in the same visual quadrant as that during the training, but as a control, the test stimuli were also presented in visual quadrants other than that for the original learning to check the retinotopic specificity of the effects on learning.

6. Results

The subjects in the nap groups all had slow wave sleep (SWS) during the naps and one-half of the 60-min nap group and all but two of the 90-min nap group also had REM sleep during the naps. The no-nap group showed the expected decrement in performance at 19:00 similar to that seen in prior studies. The nap groups showed significantly better performance at 19:00 than the no-nap group; this improvement was greater for the 90-min than the 60-min group, but both showed on average performance better than immediately after learning the task. There were no effects from napping on the task performance when the stimuli were presented to a visual quadrant other than that used for the original testing. There were no significant differences in nocturnal sleep times between the night before and that after the naps and testing (averages of 7.6 and 7.5 h, respectively) although no information was presented on the possible differences in nocturnal sleep time between nap and no-nap groups.

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When the nap groups were divided by presence of REM sleep, it was found that the 60-min nap group with REM sleep had the same degree of improved performance as the 90-min nap group, and conversely, the two subjects from the 90-min nap group with no REM sleep had performance changes about the same as the 60-min nap group without REM sleep. The subjects with naps without REM sleep showed that naps had reversed the usual decrement in learning over the day, but they did not show the enhancement of learning seen in the group with REM sleep. A step-wise regression showed that the degree of improvement in performance correlated significantly with the product of SWS and REM sleep minutes ($r = 0.37$, $P = 0.01$); results matched those for degree of similar improvement after nocturnal sleep. It was also noted that the degree of improvement for the nap compared to no-nap groups, was even greater the next morning (by 50%) after the night's sleep had enhanced the performance of all groups. Thus, there was a cumulative learning benefit from the naps and the following night's sleep. This cumulative enhancement of the performance of the group with a nap plus 1 night of sleep was equivalent to that observed for subjects in other studies after 2 nights of sleep.

7. Conclusions

A 60–90 min nap reverses the loss of perceptual learning during wakefulness, and if the nap contains REM sleep it actually enhances the performance as much as does a normal night's sleep. The occurrence of REM and not the length of the nap appears to be the critical variable for producing improvement in performance over that initially after learning the task. The benefits were retinospecific and cumulative, with that from subsequent sleep at night again similar to the learning benefits of a night's sleep. There was no indication that the afternoon naps produced a significant decrease in the length of the subsequent night's sleep or loss of the learning benefits from that night's sleep.

8. Comment

Animal studies had shown for some time that sleep improved various types of learning, and the demonstration of such effects for humans, which had been somewhat uncertain, have now been well demonstrated by the excellent recent body of work on perceptual and procedural learning, particularly that conducted by Karni et al. [1] and the research groups of Stickgold et al. [2]. It has now been well established that for a wide variety of human learning, particularly that involving perceptual skills, post-training sleep greatly enhances the learning and appears to be required to achieve any significant degree of performance improvement from the learning trials. While this had been demonstrated for nocturnal sleep, there had been little study of the effects of relatively shorter sleep occurring in daytime naps. The results from this study show a remarkable benefit for only 60–90 min of sleep in the afternoon, matching that observed for an entire night's sleep. Moreover, the naps added to rather than detracted from the learning benefits from the subsequent night's sleep. The evaluation of the type of sleep in this study also provides another possible window on the effects of different sleep stages. SWS appears to be adequate to stabilize the perceptual learning, reversing the decrement occurs during waking. REM sleep may serve to enhance the learned performance to be even better than that after immediate training. It is, however, the combination of both stages of sleep that seems most significant for producing the perceptual learning benefits.

Despite the impressive nature of these results, there are some limitations and problems. It should be noted that this type of learning involves perceptual processes; the benefits from sleep are retinotopic specific, and therefore, seem likely to involve the degree of neural plasticity in the visual cortex [3], which may in general have some dependence on or enhancement by occurrence of sleep, particularly REM sleep. A similar argument regarding neuronal activation and growth has also been advanced to explain the greater amounts of REM sleep occurring for animals with greater post-natal brain development. Thus the results in this study clearly indicate strong benefits of napping sleep for perceptual or performance learning but the generalization to more abstract cognitive learning seems uncertain.

The article has some unfortunate omissions, particularly regarding the characteristics of the subjects tested and the method for assigning them to different nap conditions. Presumably the subjects were mostly young adult students at Harvard. It would be interesting to determine if these nap benefits also occur for older adults. It deserves note that the total sleep time at night was apparently not altered by a nap during the day, suggesting possible correction of a mild chronic sleep debt or that a short period of afternoon sleep does not alter the expression of sleep at night.

Despite the limits of this study the data clearly demonstrate that naps enhance perceptual learning. Naps have been shown to provide a wide variety of benefits for alertness, mood, work performance, and now learning. Sleep medicine clinicians may, therefore, want to consider recommending afternoon naps as part of good sleep hygiene.

References

[1] Karni A, Tanne D, Rubenstein BS, Askenasy JJ, Sagi D. Dependence on REM sleep of overnight improvement of a perceptual skill. Science 1994;265(5172):679–82.

[2] Stickgold R, Whidbee D, Schirmer B, Patel V, Hobson JA. Visual discrimination task improvement: a multi-step process occurring during sleep. J Cogn Neurosci 2000;12(2):246–54.

[3] Zohary E, Celebrini S, Britten KH, Newsome WT. Neuronal plasticity that underlies improvement in perceptual performance. Science 1994; 263(5151):1289–92.