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SLEEP DURATION OF AN INDIVIDUAL HAS ADVERSE INFLUENCE ON AUDITORY EPISODIC MEMORY

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Abstract : The present study evaluated the influence of habitual sleep duration on episodic memory in a wakeful state. Episodic memory was assessed for auditory and visual processing pathways. A total of 96 medical students (53 male and 43 female, between the age group 18–23 years) accustomed to different sleep durations volunteered in the tests. The tests included auditory free recall of 10 common words, pictorial free recall of 10 pictures and recognition of 10 miniature animal replicas with 10 distracters. There was no gender-related difference in the visual and the auditory memory scores. The visual episodic memory scores were similar in persons sleeping longer or shorter duration. On the other hand auditory memory scores were significantly lower in persons accustomed to > 10 h sleep. The results indicate the importance of sleep duration on episodic memory processing of learned material even during wakeful state specially which involves auditory system.

Key words : auditory memory, cognition, free-recall tests, episodic memory, visual memory, pictorial memory

INTRODUCTION

With better understanding of memory processing, human memory is no longer a "unitary system". The most commonly used memory classification is the declarative and the non-declarative memory system (1). Declarative memory is associated with the conscious recollection of fact-based information (i.e. knowing "what"). Non-declarative memory, a reflexive memory, includes procedural memory (i.e. knowing "how") and does not involve consciousness (2, 3). Declarative memory system has subcategories, including the semantic and the episodic memory (4). Semantic memory is a memory of general knowledge and vocabulary, while episodic memory is a memory about the events of particular places at particular time (4–7). Episodic memory is the only memory system that at the time of retrieval travels back in time (6, 7). It encompasses the pathways of information processing including auditory, visual and

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other pathways that are concerned with the ideas such as self, subjective time and autoneotic consciousness (7).

All forms of memory undergo processing in sequential stages. These include encoding, stabilization, enhancement, retrieval, and reconsolidation. Consolidation phase comprises of stabilization and enhancement that occurs largely during wake cycles (8, 9) and sleep cycles, respectively (1). Besides, additional post encoding stages like association, translocation and active erasure play a significant role in memory processing (1).

There are several studies to understand the memory processing, especially in terms of role of sleep on learning and memory consolidation, using behavioral, molecular and cellular approaches, both in humans and animals (1, 10). Similarly, studies have been done to understand the other aspects of sleep and memory like the effects of sleep preceding the learning of a task (1) and the importance of types of sleep (REM and NREM sleep) in memory processing (11, 12). All these studies have shown the beneficial role of sleep on memory (1, 10–12). However, there are no studies yet available to understand the significance of habitual sleep duration on memory performance, though the importance of habitual sleep duration in other health related issues like hypertension (13), cardiovascular diseases (14, 15), carcinoma breast (16), and mortality (17–19) has been reported. Therefore, we examined the role of habitual sleep duration of an individual on the episodic memory performance in wakeful state by conducting the test 5–7 h after the subject woke up. Further, the study evaluated the memory performance involving two important sensory inputs viz. auditory and visual systems.

MATERIALS AND METHODS

Subjects

A total of 96 medical school students (53 boys and 43 girls, of age group 18–23 years) participated in the study. Informed consent was obtained from the volunteers as per the guidelines given by the ethical committee of Institute of Medical Sciences for conducting the human studies. The subjects with a history of hearing impairment, psychiatric, neurological or any other chronic diseases were excluded. Similarly, subjects under the influence of any medication/drug that may alter concentration/alertness were not included. Also, it was made sure that participants had no anxiety, fatigue or mental tiredness at the time of tests. Tests were conducted between 11 AM and 1 PM i.e. at least 5–7 hours after subject woke up to eliminate the effects of immediate sleep on memory performance (1, 20).

Prior to the tests, participants had to fill a questionnaire citing the information on age, sex, sleep duration (4–6, 6–8, 8–10 and 10–12 h per day) and any family history of dementic disorders. Regarding the sleep duration, subjects were specifically instructed to furnish the natural average sleep duration ignoring the occasional deviations.

Experimental tests

Participants were tested for the auditory free recall, pictorial free recall and recognition test.

Auditory free recall test

Ten words of commonly known unrelated objects (mirror, rice, fan, car, parrot, padlock, table, flute, egg and coin) were recorded in an audiotape in local language (Hindi), pausing equally. Subjects were asked to listen to the audio using an earphone. Following this, they were given a mind distracting task, where the subject had to arrange the numbers in a magic cube or to assemble a pyramid from the cut pieces. This prevented the continuous memorization of the learned materials. At the end of 5 min, they were asked to recall the words within 2 min and for each correct answer one point was given. Test duration lasted for about 8 min in each subject.

Pictorial free recall test

Ten pictures of commonly known unrelated objects (shirt, mango, bed, clock, shoes, tortoise, elephant, carrot, mobile-phone, percussion instrument) were used. The pictures chosen here were not from the words used in the auditory test. All pictures were of same size (13.5 cm × 9.5 cm) with similar background colour. Subject was shown each picture for 4 s in sequence, following this, a mind distracting task was given as earlier. At the end of 5 min, subject was asked to recall the objects shown earlier within a period of 2 min and for each correct answer one point was awarded. Test duration lasted for about 8 min in each subject.

Recognition test

Twenty small dummies of various animals (e.g. polar bear, camel, mouse, cow, elephant, tiger, leopard, lion etc.), were used for the test. Ten of these were test animals and remaining ten were used as distracters. Test animals were shown for 4 s each, in a random order. Following this, a mind distraction task was given. At the end of 5 min all the animals including the distracters were shown randomly and the subjects were asked to respond 'yes', if shown earlier or 'no', if not shown. For each correct response 0.5 score was given. This test lasted for about 9 min.

Data analysis

The scores for individual tests were pooled separately to obtain the mean ± standard error (SE) values of a given group. The significant difference was evaluated by using one way ANOVA followed by Dunn's test for multiple comparisons. Student's t-test was also used wherever required. $P<0.05$ was considered significant.

RESULTS

Episodic memory performance in male and female

The auditory and visual episodic memory data of male and female are presented in Fig. 1. The auditory memory, pictorial memory and recognition memory in male were not different from the female ($P>0.1$, Student's t-test for unpaired observation). Hence, the corresponding data of male and female were pooled together for further evaluation.

Effect of habitual sleep duration on episodic memory

The auditory and visual episodic memory

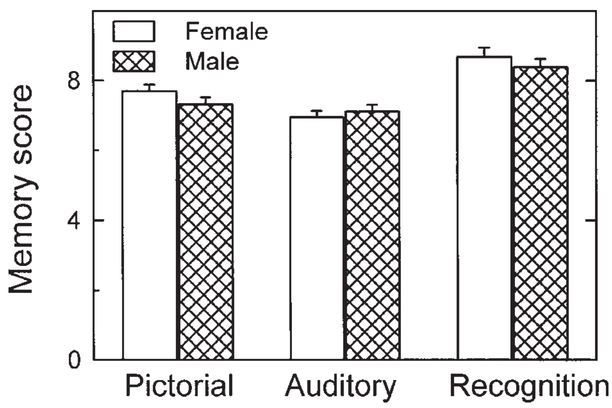

Fig. 1 : Comparision of episodic memory profile in male vs. female. No differences were observed in auditory free recall, pictorial free recall, and recognition memory (P>0.1, Student's t-test).

data in relation to habitual sleep duration are presented in Fig. 2. The scores were higher in recognition, followed by pictorial and auditory memory, respectively. Pictorial and recognition memory scores were not influenced by the sleep duration (P>0.1, one way ANOVA). However, auditory memory

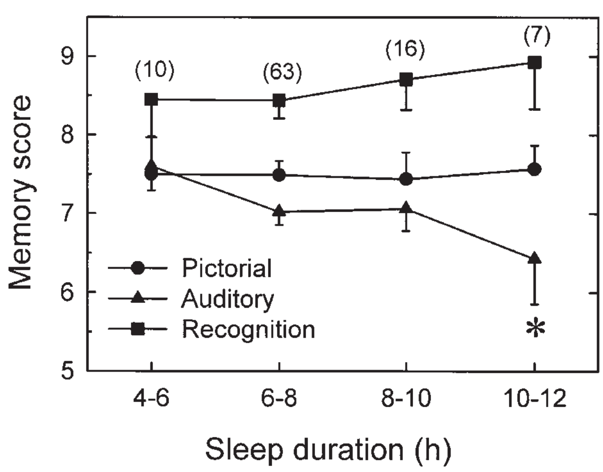

Fig. 2 : Episodic memory pattern in relation to the habitual sleep duration. The mean ± SE values are from number of subjects mentioned in the parenthesis. Auditory memory scores declined significantly with increasing sleep duration. (P<0.05, one way ANOVA). An asterisk (*) indicates P<0.05 as compared to 4-6 hr (Dunn's test).

performance declined with the increasing sleep duration (Fig. 2; P<0.05, one way ANOVA). The subjects with > 10 h sleep duration had significantly lower auditory score (P<0.05, Dunn's test).

DISCUSSION

The present study for the first time looked into the effects of sleep duration on the episodic memory performance in individuals accustomed to different sleep duration. The results indicate that prolonged habitual sleep has adverse effect on the auditory episodic memory performance while pictorial and recognition memories remain unaffected.

The tests used in this study assessed the episodic memory but not the working memory or the semantic memory. Working memory operates fully at a conscious level (6) to keep the incoming information transiently available for < 30 s (21). Therefore, in contrast to a study elsewhere (22) where the recall tests were performed immediately, in the present study, 5 min time was allowed before the retrieval/recognition so that the working memory is erased by this time. Further, a mind-distracting task (given in the study) prevented the continuous memorization process. Hence, the tests did not assess the working memory. Likewise, semantic memory component was not assessed by the recognition tests used; the test materials used had the advantage of selectively assessing the episodic component (recollection/remembering) and not the semantic component (familiarity/knowing) of recognition. Remember/know paradigm (11, 23) and process dissociation procedure (24) have been used to discriminate the two components of recognition. However in our study, the miniature replicas of animals were used to ensure recognition of the study materials as recollection and not mere familiarity. In such experimental design, as used in the present study, an individual gets a 3D image of animals along with strong emotions and feelings unlike the face/word recognition. Besides, precautions were also taken in selecting the animals where the distracters resembled the test animals excepting the colour. Consequently, during recognition mere familiarity of the animal or the colour might not lead to the correct answer unless the subject consciously recalled the animal of a particular colour. Moreover, since every correct "no" response to distracters was an evidence of remembering the test animal vividly, score was provided for all the correct answers. Thus, the precautions taken in the present experimental design helped to assess the episodic memory specifically.

This study looked into memory performance of a learned task in wakeful state. The neural components of memory include encoding, stabilization, enhancement, retrieval, and reconsolidation (1). The encoding, stabilization, and retrieval were only involved in these test conducted in wakeful state. The enhancement and reconsolidation of memory were not assessed by these tests because enhancement occurs during sleep and reconsolidation assessment requires a second sitting of retrieval test (1).

The results reveal that pictorial free recall task showed no variation in memory performance with increase in habitual sleep duration. Similar findings were also seen for recognition memory. Unlike both of these visual based memory systems, auditory free recall performance was decreased with greater sleep duration (Fig. 2). The decreased auditory free recall performance of an individual with prolonged habitual sleep duration is a novel finding.

The importance of sleep and memory has been studied elsewhere showing its beneficial role in memory processing (1, 10, 11). Most of these studies were performed on sleep deprivation states (1, 11). However, it remained to be explored whether the pre-learning status of cortical pathways is a function of habitual sleep duration especially in terms of subsequent learning and memory performance. Our study provides evidence for such effects as depicted by the differential performance of auditory and visual episodic memory (Fig. 2).

The effects of prolonged sleep duration on memory must be because of either the confounders (sleep quality, mental depression, hypoxic states) or the true mediators (e.g., shortened photoperiod, limited sensory challenges, REM/NREM variations) associated with such sleep habit (25). However, the results are perhaps not due to the confounders because, in such situation, the auditory as well as visual memory processing are expected to be influenced equally. Therefore, it is most probable that the findings of the study have been due to the influence of true mediators of prolonged sleep.

Yet, at present, the exact mechanisms underlying such differential memory performance as a function of habitual sleep duration can only be speculated. The differential effect of habitual prolonged sleep is likely to involve the encoding, stabilization or retrieval stages of visual and auditory memory. Additional information present in the visual inputs may have helped its encoding and stabilization and, further aided as cues during retrieval. Likewise absence of such additional cues in auditory system may have lead to impaired stabilization or retrieval. The impaired encoding or stabilization of auditory memory may also be perhaps because of relatively smaller cortical representation for auditory system. Thus, the present study certainly points towards the possibility of the neuronal plasticity operating at encoding or stabilization or retrieval stages of memory processing in different pathways during prolonged sleep. In support to our hypothesis, recently, fMRI study results demonstrated that memory processing occurs at occipital and temporal areas differentially, during overnight sleep; where the greater activity was seen in occipital lobe and decreasing signals in temporal lobe (1). The present study thus, imparts the need on future works to understand the memory processing at various areas associated with habitual prolonged sleep.

In conclusion, the present results demonstrate that the individual with longer sleep duration have decreased auditory episodic memory than visual episodic memory. Further, it also indicates the presence of differential pattern of visual and auditory memory processing in habitual prolonged sleep.

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