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Research Paper

Visuospatial working memory: does sleep quality correlate with it?

Chhanda Karmaker[1]*, Papry Akter[2]

ABSTRACT

Sleep difficulty is a common problem nowadays and it produces impairments in our cognitive functioning. A number of studies suggests that an adequate sleep quality is essential for working memory. However, knowledge regarding the effect of sleep quality on visuospatial components of working memory is scant. Therefore, the aims of this study were to investigate the relationship between sleep quality and visuospatial working memory and also to explore whether sleeping pattern as a significant predictor of visuospatial working memory performance among the young adults. 100 undergraduate students were selected as participants from different departments of Dhaka University by using convenience sampling technique. Pittsburgh sleep quality index and Dual n back test were used to meet the objectives of this study. The results revealed that poor sleep quality was significantly negatively associated with visuospatial working memory and a significant predictor of it (β =0.439, p<0.05). Adjusted R^2 also indicated that the model explained 18.4% of the variance in visuospatial working memory.

Keywords: *Sleep Quality, Working Memory, Visuospatial Working Memory*

Sleep is one of the most significant components of our healthy life and wellbeing. It can be defined as a naturally recurring state of mind and body where consciousness and awareness to environmental stimuli is absent. Sleep quality is the key factor of sleep which is associated with integrating aspects of sleeping initiation, the quantity of sleep, sleep maintenance and feelings of refreshment after awakening. A good quality of sleep is very vital because it helps us to restore our energy as well as gives a face-lift so that we can prepare ourselves for another day. People who sleep well at night can perform their daily activities in an optimal way. On the other hand, when they experience sleep deprivation due to their academic study, works or other activities their physical and mental fitness may be affected (Bonnet & Arand, 1995). Poor sleep quality causes our physiological and cognitive changes that also affect our mood, spirit and concentration levels and make difficulties to stay awake and function properly during the daytime.

[1]Assistant Professor, Department of Psychology, University of Dhaka, Dhaka, Bangladesh
[2]Former Student, Department of Psychology, University of Dhaka, Dhaka, Bangladesh
*Responding Author

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Several studies reported that a wide range of variables has been affected by poor sleep pattern like emotion regulation (Gruber et al., 2012), executive function (Sadeh. et al., 2002), academic attainment (Wolfson & Carskadon, 1998). Sleep is also important in case of forming new learning and memory pathways in the brain (Huber et al., 2004). Our brain shapes connections to proceed and recollect additional information during sleep. Inadequate sleep pattern has a detrimental impact on both our short term memory and long term memory. So, sleeping is the most significant time for our memory shaping and maintaining the connections among events, feelings and experiences.

Human memory keeps information overtime and so that it can be used for an appropriate action when needed. Generally we thought our memory is a single process but actually it is broken into three systems- sensory memory, short-term memory and long-term memory. Working memory is a cognitive function having limited capacity and also an essential part of our short-term memory (Miyake & Shah, 1999). It accumulates task-linked information over a few seconds while the other mental activities are at service (Cowan, 2001; Luck and Vogel, 1997). It works as a bridge between sensory and long-term memory (Baddeley, 2000) and is very important to process information that lead to decision making, reasoning, learning and guidance of behaviour (Diamond, 2013). According to some theoretical models, working memory consists of a wide variety of components within a complex system, such as the encoding of stimulus-driven attention, the rehearsal and maintenance of information, and the encoding to and retrieval from episodic memory (Arnett et al., 1999). There are three functional components of working memory like central executive, visuospatial sketchpad and phonological loop, and episodic buffer. The central executive component helps us to assign cognitive resources, focus attention and control cognitive interference. The phonological loop retains auditory information active in consciousness and the visual sketchpad lets individuals keep visual metaphors and spatial information active to solve the problem immediately. Episodic buffer is like a backup store that maintains connections with both the components of working memory and long term memory (Baddeley, 2012; Baddeley, Eysenck & Anderson, 2009). An evidence was found regarding the influence of visuospatial working memory on school children's mathematics and linguistic ability (Gathercole, Pickering, Knight and Stegman, 2004) and a moderate relationship was found between this component and cognitive functioning (Ackerman, Beier and Boyle, 2005). According to Ashkenazi et al., (2003), visuospatial working memory is a significant basis of area for arithmetic cognition, specifying that it functions as a mechanism in the brain to support learning in a wide ranging of areas. So, visuospatial working memory has been acknowledged as a fundamental cognitive function and deficiencies in this memory can have major impacts on decision-making, reasoning and problem solving skills as well as on reading, doing arithmetic, and even keeping track in the conversation (Bermudez and Souza, 2017). So, visuospatial working memory has a significant contribution in our day to day functioning.

In recent years, a growing body of research has provided evidence that sleep deprivation impairs our attention (Dinges, Pack, Williams and others, 1997) and executive functions (Sadeh et al., 2002) as well as working memory functions (Blasiman and Was, 2008). Our neurotransmitter receptors of the brain area related to memory are destroyed due to poor sleep quality (Pierard et al., 2011). Currently, the majority of the population suffers sleep difficulties and young generation recognized as a population group who are affected by poor sleep quality. Most of them maintain an improper sleep habit and totally ignore and unaware about its negative impacts. Those who regularly sleep late at night and having poor sleep quality face difficulties in giving concentration and functioning at daytime properly.

Although many are exposed or experienced chronic sleep deprivation, its effects on cognitive processes are not known well or little known. Some studies have established that sleep deprivation decreases the performance of verbal working memory (Jiang, Vandyke, Zhang & others, 2011) while other researches didn't find any differences (LO et al., 2012). On the other hand, there are few studies conducting the effects of sleep on visuospatial working memory where some papers failed to establish its effect (Alhol et al., 2007) and others found five days of sleep deprivation decreased the performance of visuospatial task of working memory (Angel et al., 2015). Due to these conflicting results, the researchers of this study aimed to examine the relation of sleep quality with visuospatial working memory as well as to explore whether sleeping pattern as a significant predictor of visuospatial working memory among the young adults.

METHODOLOGY

Participants

A total of 100 undergraduate students from different departments of Dhaka University were taken as participants in this study by using convenience sampling technique. All of them were 19 to 22 years of age and had no any previous training in memory skill. None of them were under medical treatment and consumed drugs that may alter the functions of their nervous system.

Materials

The following instruments were used for data collection of the current study:

Demographic and personal information form

This form includes information about the participants' age, gender, educational qualification, medical history and socioeconomic status.

Pittsburgh Sleep Quality Index (PSQI):

For assessing the sleep quality of the participants over last month, the researchers used Pittsburgh sleep quality index in the current study. This scale was originally developed by Buysse, Reynolds, Monk, Berman and Kupffer (1989). It was a self-report questionnaire having 19 individual items that generate 7 components (i.e. subjective sleep quality, habitual sleep efficiency, sleep disturbances, sleep duration, sleep latency, use of sleeping medication and daytime dysfunction). The overall internal consistency of this index was .83. Most of the items were 4 point Likert type items. The scores of seven component were added to get a total score which ranged from 0-21 points. Here "0" means no struggling in sleep and "21" specifies acute difficulty. That means higher scores specify poorer sleep quality.

The Number-Back Test (n-back):

The researchers used n-back test in this current study to measure visuospatial working memory which was introduced by Kirchner, W. (1958). This test is a continuous performance test where participants are instructed to notice a series of stimuli attentively and to match the present stimulus with the one presented *n* trials previously. In each turn of the visual *n*-back test one item appears in various locations on the screen. This test has different versions like 0 back test, 1 back test, 2 back test and so on. In 0 back test, the task of the participants is to remember the position of the visual stimulus presented at the beginning of the section. The tasks of 1 back test and 2 back test are similar to 0 back test but here participants have to match the positions of the stimuli with those presented 1 event prior and 2 events prior respectively. We, the researchers used dual 2 back test where a series of visual stimuli (shapes) were presented in a certain location on the computer screen. In this test the

participants had to match the current shape and the position of the stimulus shown on the screen with those presented two turns back.

Procedure

Students who were willing to participate and having no training background in memory as well as having no medical history were taken as participants. After getting consent participants were approached individually and a few minutes of conversation was carried out with each of them to establish rapport. After providing proper written and oral instruction the dual 2 back visual working memory test was given to the participants on computer screen. The participants were provided necessary assistance and clarification whenever they faced problem to perform the test. After finishing the test they were given the Pittsburgh sleep quality index and encouraged to answer all the items by telling that there was no right or wrong answer of any item. Both the test and the questionnaires were administered in one sitting and the average time for completing these two was about 30 minutes. The participants were assured about the confidentiality of their personal information. After completion, all the participants were thanked for their participation and cooperation in this study.

RESULTS

To explore the relation of sleep quality with visuospatial working memory among the young adults and to examine whether it was a significant predictor of visuospatial working memory, Pearson product moment correlation analysis and simple regression analysis were conducted.

Table 1 Descriptive Statistics

Variables	*Mean*	*Std. Deviation*	*N*
Sleep Quality	6.23	9.637	100
Visuospatial Working Memory	32.15	3.576	100

Table 2 Correlation of Sleep quality with Visuospatial Working memory

Sleep Quality	**Visuospatial Working**	**Memory**
Sleep Quality	**–**	**-.439****
Visuospatial Working Memory	**-.439****	**–**

*Note: **p<0.01*

Table 2 indicates that sleep quality has significant negative correlation with visuospatial working memory (*r*= -.439). That means, the participants who have sleep difficulties also face problem in performing visuospatial working memory tasks.

Table: 3 Regression of sleep quality on visuospatial working memory

Predictor Variables	**Unstandardized coefficients**		**Standardized coefficients**	***t***	***P***
	B	**SE**	***β***		
(Constant)	39.516	1.755		22.512	.001
Sleep Quality	-1.182	.245	-.439	-4.832	.001

Adjusted R^2 = 0.184 ($F_{1, 98}$ = 23.350, p<0.05)

Standardized beta value in Table 3 shows that sleep quality (β=.439, p<.05) was a significant predictor of young adults' visuospatial working memory. Adjusted R^2 also indicates that the model can explain 18.4% of the variance in their performance of visuospatial working memory.

DISCUSSION

Visuospatial working memory is considered as an important factor in our life. It helps us to perceive, analyze, manipulate and transform visual images and/or spatial information over a brief period of time. This memory increases our reading and arithmetic ability, accelerates our performance in tasks that require sustained attention as well as helps us to keep track of relevant information and the position of moving objects. The bulk of research reports that a good sleep pattern enhances our cognitive processes like learning, attention, memory, and reasoning as well as improves our physical and mental health and also our level of wellbeing. However, relatively less is known regarding the influence of sleep pattern on visuospatial working memory among the young adults. Therefore, the present study has tried to address this knowledge gap and highlighted whether sleep quality was a significant predictor of visuospatial working memory performance.

The result of the study showed that poor sleep quality was negatively associated with visuospatial working memory (r=-.439). Standardized beta value also expressed that sleep quality (β=.439, p<.05) was a significant predictor of this type of working memory. That means a change of 1 standard deviation in the sleep quality explained a change of 0.439 in the visuospatial working memory of young adults. Furthermore, Adjusted R^2 indicated that the model can explain 18.4% of the variance in visuospatial performance of working memory. This result was consistent with a number of prior studies where it has been found that sleep deprivation poses a wide range of difficulties in cognitive functions (Durmer & Dinges, 2005) as well as decreases the performance of tasks that require constant attention and recalling ability (Alhola & Polo-Kantola, 2007). All these research findings expressed that sleep quality has a significant role on visuospatial components of working memory.

Poor sleep pattern is a common phenomenon currently and assumes as a serious problem for everyday cognitive functioning. It impedes our mnemonic and attentional abilities that are the core characteristics of visuospatial working memory. People having less capacity of visuospatial working memory face difficulties to process images, to identify the position of the objects, to solve the problems that require spatial analysis as well as to acquire new knowledge. So, it is no doubt that an adequate and proper sleep at night is one of the most important factors for our cognitive processes. It permits our brain to take rest and recharge itself so that we can get ready for the next day's activities. People should maintain a good sleeping habit and require 7 to 9 hours of sleep at night without any interruption. But unfortunately, nowadays it is frequently observed that most of the young generation do not maintain this schedule of sleep rather sleep late at night due to their study, work, social media or other activities and even the use of electronic devices. Irregular sleeping style and sleep deprivation may lead to sleepiness, tiredness, mood swings and disrupts the concentration and working memory ability which also interfere with their academic performance or other work activities. They think that they can just balance the lost sleep over the weakened. Some of them use caffeine and other stimulants to re-energize themselves for better performance. However, these stimulants are not recommended due to having negative impacts on both physical and mental health. In conclusion, it can be said that there is no alternative for regular and healthy sleep pattern and a good sleep quality must be essential to maintain our optimal visuospatial working memory.

Although the present study tried to maintain a sound methodology and analysis of data to meet the research objectives, it is not free from certain drawbacks and limitations. An in depth analysis of the various sub scales of sleep quality questionnaire, larger and more rigorous sampling method implementation, analyzing various factors affecting visuospatial working memory should have been given consideration and these things could be studied in future.

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Conflict of Interest

The author declared no conflict of interest.

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