

## Assessment of Working Memory in Young Adults

Swasti Banerjee<sup>1</sup>, Tanya Das<sup>2</sup>, Soumya Mishra<sup>1</sup>, Jayanti Mishra<sup>3</sup>

<sup>1</sup>Post graduate student, Dept. of Physiology, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar.

<sup>2</sup>MBBS student, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar

<sup>3</sup>Professor, Department of Physiology, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar.

Corresponding Author: Soumya Mishra

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### ABSTRACT

**Background:** Working memory is the system that actively holds multiple pieces of transitory information in the mind, where they can be manipulated. Working memory includes subsystems that store and manipulate visual images or verbal information, as well as a central executive that coordinates the subsystems. It includes visual representation of the possible moves, and awareness of the flow of information into and out of memory, all stored for a limited amount of time. The cognitive processes needed to achieve this include the executive and attention control of short-term memory, which permit interim integration, processing, disposal, and retrieval of information.

**Methods:** 250 healthy young adults were tested in 3 sessions. 20 set of mutually exclusive words were spoken to verbally, then written words and finally 20 visual objects were shown to the subjects for 30 seconds each followed by 1 minute of discussion for distraction. Thereafter, the subjects wrote as many words as they could recall.

**Results:** The mean test scores of each session were higher in case of females as compared to males; also they scored much higher values as compared to males. Verbal word testing can be a better method of assessment of working memory.

**Conclusion:** Working memory can be a central problem for many people with Attention-Deficit/Hyperactivity Disorder (ADHD). Those with weak working memory are likely to have learning disorders, too. This can be used as a reliable indicator of such disorders.

**Keywords:** Working memory, attention deficit, learning disorders, verbal word testing, visual object testing, written word testing

### INTRODUCTION

Working memory is the ability to recall information after a short duration which is interspersed with periods of distraction. It serves as the key for several higher-order cognitive functions, such as reasoning, intelligence, problem solving, and language comprehension.<sup>[1-3]</sup> The functioning of working memory declines with advancing age,<sup>[2,4,5]</sup> and is the main

contributing factor of various cognitive impairments of old age.<sup>[6]</sup> It plays a crucial role in the process of learning as it is pivotal for the cognitive system that stores and processes information.<sup>[7]</sup> It aids in the learning process by focusing the task at hand, inhibiting irrelevant information and integrating information from several sources such as long term memory.<sup>[7]</sup> An assessment of working memory gives us an idea about

the quality of learning process and achievement of automatised knowledge.<sup>[7]</sup>

Since working memory has a great role in concentration<sup>[8]</sup> and learning, children with severe attention deficits may be those who suffer from visuo-spatial working memory deficits,<sup>[9-11]</sup> Such children had impairment in planning, inhibition, attention and spatial working memory abilities, which also had a negative influence on social interactions and academic outcomes.<sup>[12]</sup> Those children with deficits on traditional verbal short term memory tasks were seen to have reading disorders too.<sup>[13,14]</sup> Thus any defect in working memory functioning which may go unnoticed, may pose a spectrum of personality, cognitive, reading and learning disabilities. Being malleable, training sessions may bring about tremendous improvements in the working memory functioning.

As working memory deficits do not present with frank symptoms, there should be screening tests which can be applied on general population. The present study was taken up with an objective to assess the working memory status in healthy young adults and devise simple methods of testing using written words, verbal words and visual objects. Such studies are scantily documented in India, with no recorded data from Odisha.

## **MATERIALS AND METHODS**

An observational study was designed for the assessment of working memory in healthy young adults of 18-23years. There is little evidence of data on research conducted in this age population. The present study was undertaken in the Department of Physiology, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha with 250 medical and dental students of the same Institute as subjects. The subjects with known history of any cognitive or

psychiatric disorder and/or taking drugs which could affect the cognitive ability were excluded from the study. The subjects were asked to refrain from intake of tea, coffee or any cognitive stimulants one day prior to the study. After detailed explanation of the purpose and method of conducting this study to all the subjects, written consent was taken.

The study was conducted in small groups with 10 subjects so as to avoid crowding and attention to each individual. Previous studies have been done taking one subject at a time, however this study attempts at the applicability of working memory tests as a screening modality for large groups. The short term memory or working memory was evaluated in 3 sessions of verbal, visual and written words. In the first session, 20 mutually exclusive words were read out to the subjects slowly and clearly within 30 seconds. For the next 1 minute, discussion on general topics such as sports, entertainment, etc was done to provide distraction and prevent immediate recall. Then they were asked to write down as much words they could remember within 30seconds. In the second session, 20 different written words were projected to all the subjects for 30 seconds and in the third session, 20 objects were shown to the subjects for 30 seconds and the same procedure was followed for free-recall. The scores were evaluated as to how many words each subject could recollect correctly and appropriate statistical analysis was done using SPSS (SPSS Inc., Chicago, Illianos, USA) version 16.0 software. For all statistical purposes, p-value of less than 0.05 was considered as statistically significant.

## **RESULTS**

Of the 250 students (125males and 125 females) included in the study, the mean age of all the subjects was  $20.75 \pm 0.175$  years (Mean  $\pm$  Standard deviation). Table 1

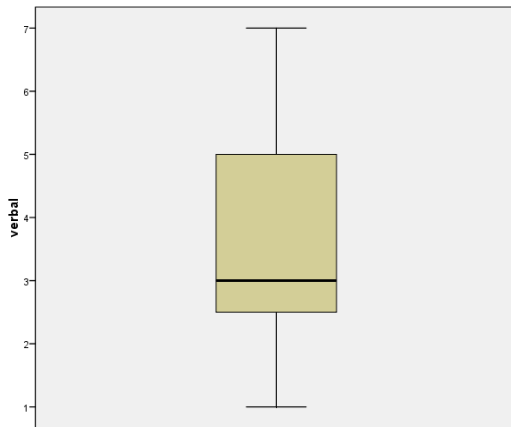
shows the mean scores obtained in each session along with the standard deviation and standard error of mean. On applying one way ANOVA, we see that there is significant difference in case of verbal words as compared to written and visual words. Even the scores were lowest for the verbal words testing of working memory.

There was not much significant difference in the scores of written and visual objects tests, but the scores for visual object was highest. Testing of verbal words for working memory can be used a better test for working memory as it showed statistically significant difference in scores as compared to the other two sessions of testing.

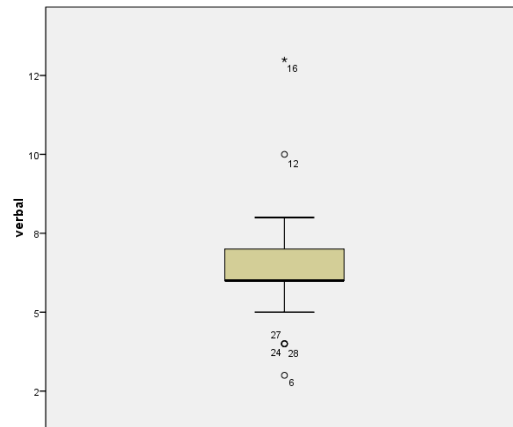
**TABLE-1 Mean values of the test scores of working memory assessment.**

	Verbal words		Written words		Visual objects	
	Male	Female	Male	Female	Male	female
Mean	3.73	6.41	5.87	7.00	7.93	10.07
Standard Deviation	1.98	1.97	2.13	2.25	3.08	2.92
Standard Error of Mean	0.51	0.36	0.55	0.41	0.79	0.54
F-value	18.19		2.59		0.34	
p-value	0.0001*		0.115 <sup>ns</sup>		0.559 <sup>ns</sup>	

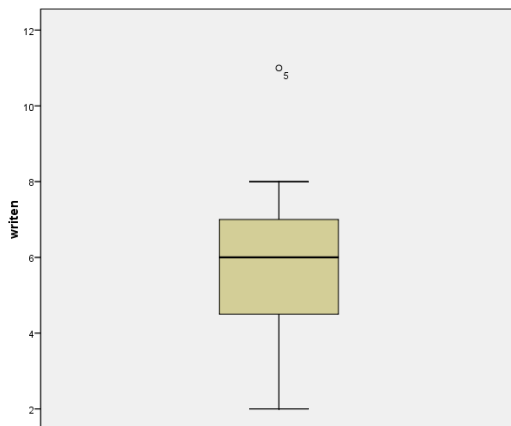
Figure 1-6 shows the minimum, maximum and mean values of the test scores of each session of memory testing in males and females. In all the tests, females have scored better than males and even they scored higher marks as compared to males.



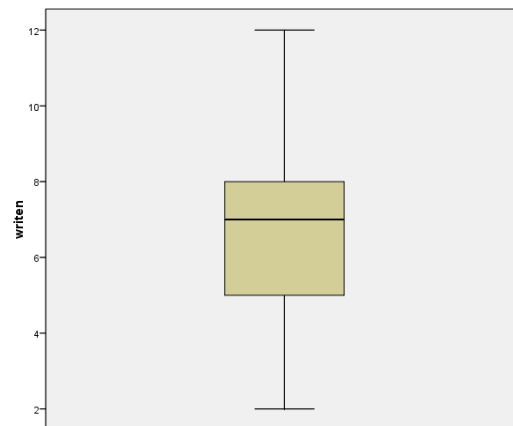
**Figure-1 Verbal test scores in males.**



**Figure-2 Verbal test scores in females.**



**Figure-3 Written words test score in males.**



**Figure-4 Written words test score in female subjects.**

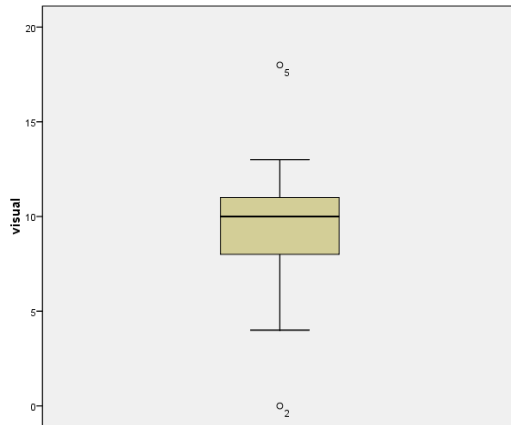


Figure-5 Visual object test scores in males.

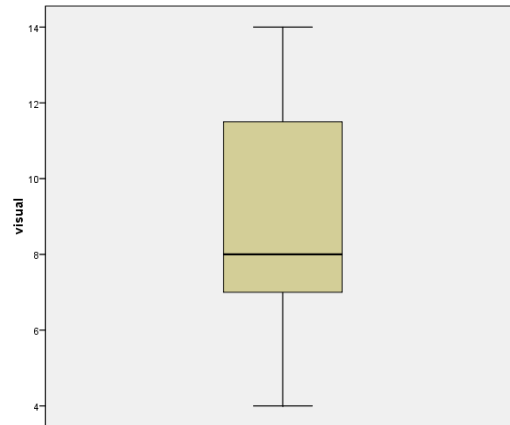


Figure-6 Visual object test scores in females.

## DISCUSSION

The present study shows significant results after conducting the test in groups indicating that the working memory tests can be used as a screening modality in larger population studies such as in testing in a class room of 20-25 students. In 250 subjects, of whom there were 125 males and 125 females, it was seen that the females scored higher than males in all the three sessions. This might be due to the fact that females had better concentration and focusing ability as compared to males who were more fickle.<sup>[15]</sup> Comparing between the three different methods of testing, most students scored poorly in the verbal word testing. This might be due to the fact that they did not get a chance to hear the words a second time and try to memorize. This can be used as a better method of assessment of working memory. In case of written words and visual objects, the subjects got a chance to revise the words over and over again within 30 seconds and thus could recall more number of words.

Habituation is a simple form of learning in which a neutral stimulus is repeated many times. The first time it is applied, it is novel and evokes a reaction; however, it evokes lesser and lesser electrical response as it is repeated till the

subject becomes habituated to the reflex. This can be the explanation why the subject performed better on the written words and visual object testing.

Different areas of the brain are responsible for different type of memory. The hippocampus is involved in spatial learning and declarative learning. Other parts responsible for memory functioning are amygdala, mamillary body, dentate gyrus, entorhinal cortex, etc. However it is not sufficient to describe memory and its counterpart learning, as solely dependent on specific brain regions. Learning and memory are attributed to changes in neuronal synapses, thought to be mediated by long term potentiation and long term depression.

Previous studies has pointed out that females are more affected with attention deficient hyperkinetic disorder (ADHD) and generally score lesser in cognitive testing.<sup>[7]</sup> This might be attributed to the fact that attention deficits in females may go unrecognized, as they seem to be less hyperactive and less inattentive compared to males, and females may not get the specific help they need in order to cope positively.<sup>[16]</sup>

Further studies including a wider age range can be taken up to test verbal word testing to test for its reproducibility and reliability. Also hormonal study can be done

in females along with the memory assessment tests to see if there is any endocrine influence on the cognitive functions.

**Conflict of Interest:** None

**Source of Funding:** None

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