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RESEARCH ARTICLE

Gender-based variation in short-term memory in age-matched healthy male and female subjects

Priyanka Gupta, Ashish Goel, Desh Deepak

Department of Physiology, Government Doon Medical College, Dehradun, Uttarakhand, India

Correspondence to: Priyanka Gupta, E-mail: drpriyanka0502@gmail.com

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ABSTRACT

Background: Memory is the ability to process, retain, and subsequently recall information of the past learned experiences. Memory is divided into sensory memory and short-term and long-term memory depending on its processing status. Sensory memory by verbal mode undergoes encoding to form short-term memory (STM). Estrogen is thought to have a facilitating effect on verbal memory in which women typically excel. **Aim and Objective:** This study has been planned with the aim to study the effect of gender on STM in age-matched males and females. **Materials and Methods:** An observational study was carried out on 80 male and 80 female subjects after seeking their consent and sorting out inclusion and exclusion criteria, using California Verbal Learning Test II. For comparing age- and gender-wise memory status, following groups were formed of 20 subjects each: Group A: 21–30 years; Group B: 31–40 years; Group C: 41–50 years; and Group D: 51–60 years. Further groups were divided into two groups: Group I – Male subjects and Group II – Female subjects. **Results:** Statistical analysis (paired "*t*-test") showed significantly better performance in age-matched Group II for immediate free recall for all 5 trials, short-delay recall, long-delay recall, and recognition memory which decreased gradually with progression of age. **Conclusion:** Recall of memory decreases, perhaps due to decreased hormone levels in both males and females as age advances, but seen comparatively more in males. Furthermore, there is a scope of improvement in learning, if trials are increased for any activity.

KEY WORDS: Age; Gender; Short-Term Memory; Learning; Recall Memory; Sex Hormones

INTRODUCTION

Memory is the sum total of knowledge collected as information learnt by past experiences with purpose of their future use, thus giving us capability to learn and adapt from previous experiences as well as to build normal way of living life. After a sensory stimulus is perceived in the specific cortical area, it undergoes encoding to form short-term memory (STM) and further consolidation causes formation of long-term memory (LTM) that remains stored in the neuronal networks. In simple terms of physiology, memory forms by a set of processed neural connections in the brain.[1]

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Memory is divided into sensory memory, short-term/working memory, and LTM depending on its time span. Sensory memory is an ultra STM which is formed through the sensory stimuli received through the five senses (sight, smell, hearing, touch, and taste). It is the ability to retain impressions of sensory information after the original stimuli have ended. STM which interests a person undergoes encoding to form STM to remember and process information at the same time. It holds a small amount of information in a readily available form for a short period of time, from 10 to 15 s up to 1 min therefore, also known as working memory.[2]

Memory as sights, sounds, words, and emotions gets encoded in the same part of the brain that originally created it like visual cortex, motor cortex, language area, and amygdala; then, it undergoes consolidation process in hippocampus and related structures. After processing, our memory gets stored not in one particular place in the brain, but remains widely distributed in several different areas of the brain which act in conjunction with one another, thus recall of a memory reactivates the similar neural patterns generated during the original encoding. Therefore, even if part of the brain is damaged, some parts of an experience of any event can be recalled. Clinical studies have shown that verbal information is better retained on self-generation actively rather than perceived passively because self-generation involves an individual's production of verbal information based on a cue or set of cues, as opposed to hearing or reading the full phonological or orthographic form. In the clinical setting, it is also seen that application of self-generation procedures has been found to improve memory in both non-demented elderly individuals and patients with Alzheimer's disease, frontal lobe dementia, and in other neurological conditions. Hence, supporting the fact that active participation during verbal encoding engages memory mechanisms, leading to improvements in memory performance.[3]

Dementia is defined as degeneration of the brain of many cognitive processes, including memory. Obvious memory deficits occur before much earlier than any other signs of dementia; therefore, monitoring memory function can be useful for early diagnosis of dementia, which, in turn, can be helpful with diagnosing and management of the disorder, like therapeutically slowing down its progression.[4]

Since mild cognitive impairment (MCI) is widely considered a precursor phase of dementia, because individuals diagnosed with MCI usually convert to Alzheimer's disease. As cognitive complaint in MCI is an important part of the MCI diagnostic criteria and an early and predictive marker of unhealthy brain aging, therefore, understanding it is an essential part. Cross-sectional studies also suggest that poor subjective cognitive complaint in MCI is related to poorer verbal episodic memory performances.[5]

In respect of the earlier studies, the present study is planned to evaluate memory status in healthy male and female adults in Uttarakhand region which aims to know age-matched gender-based variation in memory.

MATERIALS AND METHODS

Approval from the Institutional Ethical Committee was taken. The study was carried out on 80 male and 80 female subjects. For comparing age-wise memory status, following groups were formed of 20 subjects each: Group A – 21–30 years, Group B – 31–40 years, Group C – 41–50 years, and Group D – 51–60 years. For comparing gender-wise memory status, they were further divided into two groups: Group I – Male subjects and Group II – Female subjects. All the chosen subjects were physically and mentally fit, non-smoker, non-alcoholic, and of same socioeconomic and educational status. All were free from any auditory and verbal diseases. Subjects were screened and excluded for medical conditions known to have impact on cognitive and memory functions, for example, neurological or psychiatric disorders, head injury, cardiovascular disease, hypertension, and diabetes mellitus. All the subjects were made familiar with the method prior application on them. Informed consent was taken from all subjects.

Materials

The test adopted for the above study is California Verbal Learning Test-II (CVLT-II);[6] it is a standard technique and neutral in nature, has been adopted for various neurological studies based on memory. This test consists of word lists of absolutely familiar 16 words from four different categories: (1) In List A, there are four animals, four vegetables, four ways of travelling, and four pieces of furniture. (2) In List B, there are four animals, four vegetables, four instruments, and four parts of house (distractors). (3) List C consists of eight novel distractors (categories same as List A). (4) List D consists of eight novel distractors (categories unrelated to any category A or B). Two of the four categories (animals and vegetables) are common to both lists.

Procedure of Test

CVLT-II was administered to subjects. The evaluator read a list of words (List A), and participants were asked to recall as many of the words as they could in any order (immediate recall [IR]: List A). This procedure was repeated 4 times (trials 2–5) so that there were five trials total. Each time, the examiner read the list of words, and the participant attempts to recall words in any order. Following the list learning procedure in trials (1–5), participant hears a second list of words (List B) and subsequently tries to name as many of these words as possible (IRD: List B). Then, the participant was asked again to name as many words as possible in any order from the first list (short-delay free recall: List A). Following this free recall task, participants were given a cued recall task, in which they were asked to name all the words from the first list that belonged to each of the four categories (short-delay cued recall). Following a delay of approximately of 20–30 min, they were asked to recall words from the first list (List A) that was read to them (long-delay free recall). The categories were then provided as cues (long-delay cued recall). Following this, a yes/no recognition task was given, in which participants had to respond yes or no as to whether a word had been on the List A with the help of List C and List D (long-delay yes/no recognition). After another delay of approximately 15 min, the participants were given a two choice, forced choice recognition task by pairing List A words with List C or D and then asking which one belongs to List A out of the two paired words (long-delay forced choice recognition). Data collected were subjected to paired "*t*-test" using SPSS software version 23.

RESULTS

The findings of the present study are described in Tables 1 and 2 and Figures 1 and 2. Statistical analysis (paired "*t*-test") showed that gender variation exists significantly in STM as exhibited by free recall tests and performance was seen significantly better in Group II than Group I.

DISCUSSION

Using the CVLT-II, a newly revised clinical measure of learning and memory, the present study showed that the elderly age group male as well as female performed poor in comparison to their younger healthy age groups, for there was a decreasing trend in learning, as Group D (51–60 year) recalled fewer words in the initial immediate recall trials (1–5), as depicted in Table 1 and supported by [Figures 1a-d], they also recalled fewer words from the distractors list, recalled fewer words at short- and long-delay recall, exhibited reduced semantic clustering in free recall, some of them made errors on yes/no recognition task also depicted in Figure 2. Although age groups in both genders did not differ in the following ways, the learning pattern was comparable with improved performance in the later trials, benefitted similarly from category cues, and showed comparable retention rates following long delay, and all groups performed perfectly on forced choice recognition task. Thus, it showed that they are not amnesic but had difficulty in retrieving information. Thus, the current study showed that CVLT-II was sensitive enough to detect recall and recognition deficits in different age and gender groups and also provides an indication of the type of performance to expect in older people, comparatively more in elderly males such as overall reduced learning and free recall, reduced semantic clustering, and reduced yes/no recognition, but normal forced choice recognition.

In other studies of verbal memory and age done by Vannest *et al*., it was found that there were changes in task negative ("read > generate") and default mode networks more active during the baseline reading task as well as there were widespread age-related decreases in connectivity in regions of the verbal encoding network engaged during self-generation of words. These changes occurred independently of a small,

Table 1: Immediate recalls (trials 1–5) (mean values in age-matched gender groups)

Age groups	Gender	Immediate recall trials (1–5)				
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Group A	Male	10	14.2	15.5	15.5	15.9
	Female	13.3	15.65	16	16	16
Group B	Male	8.85	13.35	15.05	15.75	16
	Female	12.35	15.55	15.95	16	16
Group C	Male	8.25	11.95	13.2	15.05	15.65
	Female	11.25	15.5	15.6	16	16
Group D	Male	6.4	9.25	12.45	13.9	15.1
	Female	11.2	13.9	15.25	15.75	15.95

Table 2: Gender-based variation in memory with significance (P<0.05)

Gender	Age group (years)	Memory tests (mean value±s.d)							
		IR	IRD	SDFR	SDCR	LDFR	LDCR	LDFY/NR	LDFCR
Group I (male)	21–30 (A)	14.22±1.84	12.3±3.32	14.8±1.57	16±0.00	15.7±0.80	16.0±0.00	48.0±0.00	16.0±0.00
	31–40 (B)	13.8±1.50	7.2±2.82	14.25±1.99	16±0.00	14.95±1.57	16.0±0.00	48.0±0.00	16.0±0.00
	41–50 (C)	12.8±2.18	8.5±4.23	12.0±3.24	15.9±0.30	14.05±2.45	16.0±0.00	47.95±0.22	16.0±0.00
	51–60 (D)	11.4±2.76	5.5±2.25	10.6±2.76	15.4±2.68	12.0±3.21	15.65±1.18	47.0±2.47	16.0±0.00
Group II (female)	21–30 (A)	15.46±0.63	13.4±1.45	15.53±0.51	16±0.00	16.0±0.00	16.0±0.00	48.0±0.00	16.0±0.00
	31–40 (B)	15.25±0.53	12.8±1.43	15.35±0.74	16±0.00	16.0±0.00	16.0±0.00	48.0±0.00	16.0±0.00
	41–50 (C)	14.84±0.66	12.65±1.78	15.3±1.30	16±0.00	15.9±0.30	16.0±0.00	47.5±1.82	15.9±0.44
	51–60 (D)	14.0±1.24	11.0±2.73	14.75±0.78	16±0.00	15.9±0.30	16.0±0.00	46.8±2.62	15.85±0.48
Paired *t*-test	P<0.05	0.004	0.014	0.032	0.15	0.05	0.195	0.112	0.09

IR: Immediate recall IRD: Immediate free recall, SDFR: Short-delay free recall, SDCR: Short-delay cued recall, LDFR: Long-delay free recall, LDCR: Long-delay cued recall, LDFY/NR: Long-delay yes/no recognition, LDFCR: Long-delay forced choice recognition

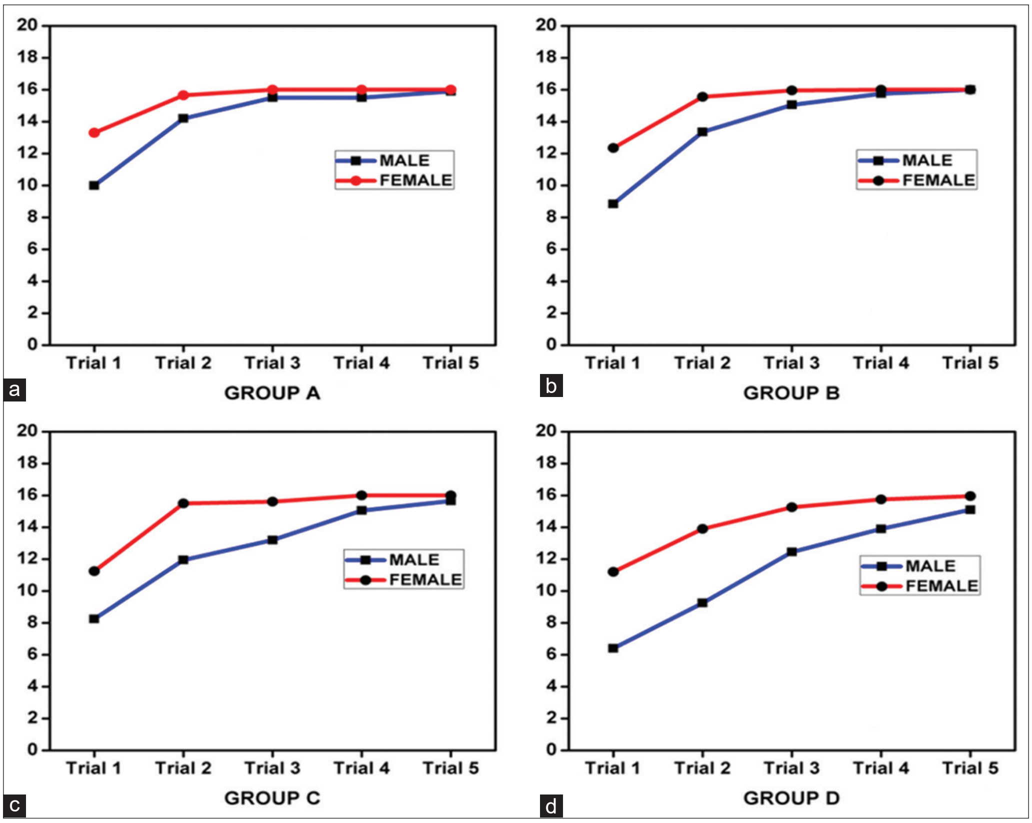

Figure 1: (a-d) Lower learning curve of words in males in all age groups which improved in the later trials

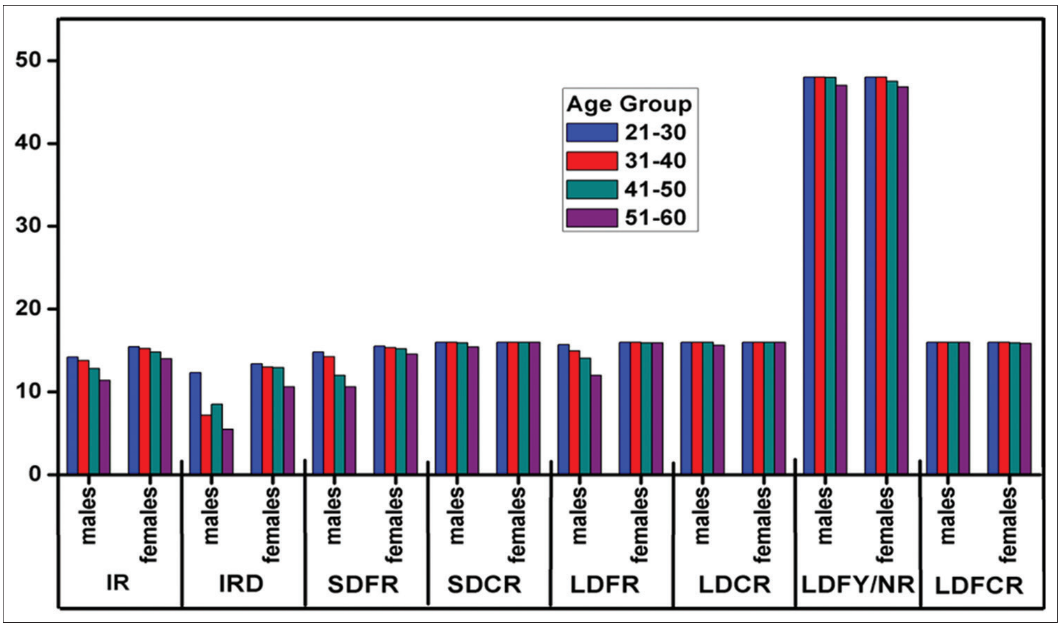

Figure 2: Gender-based variation in memory in similar age groups

but significant decrease in memory performance for generated words with age.[3] Further, the study also showed that females performed better in word recall task as compared to males which is concordant with the studies done earlier by Mittal *et al*. showed that female subjects showed better auditory memory as well as visual memory in comparison to males.[7] In support of this contention, there is an evidence which comes from the neuroimaging studies in temporal and parietal cortical areas during neuropsychological task performance in young and postmenopausal women receiving estrogen treatment which showed greater activation, increased blood perfusion and glucose metabolism in certain brain regions related with memory and other cognitive functions.[8,9] Studies have also shown that estrogen is thought to have a facilitating effect on tasks of verbal memory, articulation, speed, and coordination, therefore women typically excel, and another study by Saucier and Kimura supports role of estrogen when conducted during mid-luteal phase of menstrual cycle which showed that women perform at a higher level on these tasks, as at this time of cycle, estrogen levels are high.[10,11] Studies done in rodents document robust effects of estrogen on hippocampal synaptic plasticity, hippocampal long-term potentiation, and hippocampal-mediated cognitive behaviors, thus showing episodic memory depends on estrogen effect and the integrity of the hippocampus and adjacent medial temporal lobe structures.[12] It is well accepted by studies that serum testosterone levels decline progressively with aging in men. This decline is associated with body composition, decrease in energy, muscle strength, and physical and cognitive functioning.[13] In women, the back part of the corpus callosum is bigger than in men which is an established fact confirmed by the results of the previous studies. The study of gender-based variation in cognitive functions in adolescent subjects concluded that females excelled in visuospatial skills, language, memory, and attention subtests for cognition have been shown by Mittal *et al*.[14] In another study done earlier by Kimura, it has been shown that women tend to perform better than men on tests of perceptual speed due to varying hormonal influences on brain development and thus display different patterns of behavioral and cognitive functions. He also showed in his study that women perform better than men in both verbal memory and verbal fluency and also excel on tests that measure recall of words and on tests that challenge the person to find words that begin with a specific letter because; overall level of Intelligence Quotient does not vary much in males and females as people have different intellectual strengths and two individuals may have differing cognitive abilities within the same level of general intelligence, but the difference lies in pattern of ability.[15] Females showing better deep engraved memory and other cognitive functions such as visuospatial skills, language, memory, and attention, as compared to males further supports the association of estrogen with cognition, but since estrogen level is low in males, sex hormone-binding globulin was found to be positively associated with verbal memory in them and endogenous sex steroid levels were unassociated with cognitive composites.[16]

Strength and Limitations

Results of this observation were supported by most of the previous studies giving the impact of doing more prospective studies further to deduce any memory tasks or activity to delay the progression of memory in both genders. The limitations of the study were sample size, if more numbers of individuals were there, the results would have been much better and highly significant.

CONCLUSION

The study showed that as age advances, there is gradual decline in recollection of memories, although females performed better in word recall tasks as compared to males in corresponding age groups. The reason could be gradual cognitive impairment associated with decline in hormone levels with advancing age. Hence, hormonal estimation along with memory assessment is suggested for further research to give better correlation with age and gender and also to rule out other causes for decline in memory with age in healthy individuals, and may also help to prevent or prolong the development course of the memory deficits seen with progression of age in males and females by increasing the rehearsal or learning trials for any activity.

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