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Association Of Visuospatial Memory In Different Phases Of Menstrual Cycle In Healthy Young Adult Females

Mohima Murmu[1], Dr.Vinita Ailani[2]
(PG Student, Department Of Physiology, NIMS Medical College, NIMS University)
(Professor, Department Of Physiology, NIMS Medical College, NIMS University)

Abstract :
Background*: To examine the association of visuospatial working memory in different phases of menstrual cycle in healthy young adult females.*
Materials and Methods*: A Prospective observational study was carried out in the Department of Physiology at NIMS Medical college, NIMS University, Jaipur,Rajasthan,India, over a period of 12 months. A total of 77 young adult females with a history of regular menstrual cycles were selected for the study. Vertual Corsi-block tapping test for Visuospatial working memory(https://www.memorylosstest.com/corsiblock-tapping-test/) were given three time in the same menstrual cycle: first Early follicular phase – Day 2-3, second Pre- ovulatory phase – Day 13-15, and third Mid- luteal phase – Day 19-22). Descriptive statistics such as mean, median, standard deviation, and mode were calculated.*
Results: *Across all three phases of the menstrual cycle, the reverse total scores showed relatively higher values compared to the forward total scores. The Pre-Ovulatory Phase exhibited the highest median and mean scores for both forward and reverse tasks, with a statistically significant difference compared to the Early Follicular and Mid-Luteal phases ($p < 0.05$). Conversely, the Early Follicular Phase had the lowest scores, particularly in terms of the forward total score, with a significant difference observed between this phase and the other two phases ($p < 0.05$).*
Conclusion: *The study reveals a link between menstrual cycle phases and memory performance, showing peak efficiency before ovulation. Notably, hormonal fluctuations impact cognitive abilities cyclically, highlighting the need for tailored interventions.*
Key Word: *Visuospatial working memory, Early follicular phase, Pre ovulatory phase, Mid luteal phase, Menstrual cycle*

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I. Introduction

For decades, the differences in skills noticed between men and women, particularly in the field of intellect, have piqued the interest and debate of intellectuals and researchers. The scientific community generally agrees that the functioning of working memory varies depending on whether it is processing verbal or spatial information. This long-standing disparity in cognitive capacity among individuals depending on gender has spurred a variety of studies and enquiries aiming at understanding the underlying mechanisms and consequences. It is not uncommon to discover several academic enquiries and studies investigating the complexities of how men and women differ in cognitive activities, particularly those involving memory retention and retrieval.[1]. During cognitive tasks, verbal working memory involves mostly left hemisphere regions. These regions include the inferior parietal lobe, which processes spatial and numerical information; the lateral frontal lobe, which is important for executive functions and decision-making; the supra-marginal gyrus (BA 10), which is involved in higher-order thinking and cognitive control; premotor areas, which aid in movement planning and coordination; and Broca's area, a critical centre for language production and speech articulation. When human verbal working memory is active, these several brain regions work together to encode, retain, and manipulate language information. The left hemisphere's specialisation for language activities makes it a hub of brain activity during verbal working memory demands, highlighting the complicated interplay between two crucial areas in supporting efficient communication and cognitive process[2]. Spatial working memory, the cognitive process responsible for temporarily storing and manipulating visual and spatial information, has received substantial attention in neuroscience. This sort of memory has been linked to a more distributed neuronal activation pattern throughout the brain. These regions include the inferior frontal lobe, which plays a role in executive functions and decision-making processes; the posterior parietal lobe, involved in visual attention and spatial processing; the right occipital gyrus, responsible for visual information processing; the right premotor area, contributing to motor planning and coordination; the right dorsolateral prefrontal cortex, crucial for working memory tasks and cognitive control; and the extra-striate cortex[3]. When studying the complexities of working memory, a distinction emerged between how different genders process information. It was discovered that when the idea of working memory is analysed and broken down into its essential pieces, namely spatial and verbal components, gender discrepancies emerge. The study found that males and females handle working memory tasks differently depending on whether they prefer spatial or verbal processing modules. This underscores the potential role of gender in influencing the cognitive mechanisms that underpin working memory[4]. A large amount of research has continuously demonstrated that gender differences in psychological processes are frequently linked to the complex interplay of numerous hormones within the human body. Hormonal variances, such as testosterone and oestrogen, have been linked to differences in cognitive functioning, emotional control, and behavioural patterns between men and women. These hormone changes can have a substantial impact on brain development, changing the neuronal circuits responsible for information processing, decision making, and emotion regulation. Furthermore, the role of hormones in gender-specific behaviours and tendencies has been extensively studied in neuroscience and psychology, shedding light on how biological factors can contribute to observed differences in cognitive abilities, social interactions, and emotional responses between men and women[5] . Despite evidence that gender differences exist in working memory, there is also compelling evidence that there are no performance differences, as supported by numerous research. According to the research, while some studies demonstrate differences in working memory between genders, there is a substantial body of data supporting the assumption that performance discrepancies are not always gender-related. Numerous research have revealed that characteristics such as education level, cognitive ability, and environmental cues have a greater impact on working memory performance than gender alone[6,7,8]. In a typical menstrual cycle, oestradiol and progesterone levels naturally ebb and flow, resulting in a distinct physiological rhythm marked by oestrogen and progesterone peaks. During menstruation, both hormone levels are typically low, providing a resetting phase before the cycle's advancement. Surprisingly, oestradiol spikes during the pre-ovulatory phase before falling, only to rise again to moderate levels during the mid-luteal phase. This complicated ballet of hormone variations not only coordinates the numerous stages of the menstrual cycle, but it also has implications beyond reproductive activities. It's remarkable that fluctuations in hormone levels have been linked to cognitive ability, notably visuospatial and verbal working memory tests[6,7,8].

Natural fluctuations in ovarian hormones during the menstrual cycle regulate menstruation while also providing a unique chance for non-invasive research on how oestrogen affects young women's cognitive capacities. This natural fluctuation enables researchers to investigate the potential effects of oestrogen on cognitive performance without the need of invasive techniques. Women with menstrual cycles ranging from 28 to 29 days can be divided into two phases: the luteal phase and the follicular phase. The luteal phase occurs after ovulation and is distinguished by higher levels of progesterone and lower levels of oestrogen, whereas the follicular phase occurs before ovulation and is marked by an increase in oestrogen levels[9]. The follicular or proliferative phase extends from Day 1 (the first day of menstruation) to Day 14. Low serum concentrations of both 17--estradiol, the most abundant form of estrogen, and progesterone characterize the early follicular phase. Estradiol peaks in the preovulatory surge just prior to ovulation, though progesterone levels remain low. The follicular phase ends at the time of ovulation. The luteal or secretory phase generally extends from Days 14 to 28 and is characterized by high concentrations of both estrogen and progesterone. Cycle phase can be estimated by counting backward to the first day of menstruation. Although this counting method has been used legitimately in some previous research, the approach has been associated with an error rate of 15 [34] to 50%[10].

II. Material And Methods

A Prospective observational study was carried out on 77 healthy young females of age group 18 -25 years in NIMS Medical College,NIMS University, Jaipur,Rajasthan,India. The sample size was calculated ,estimated sample size was 77 participants. A detailed medical and menstrual history of the individual participant will be taken in order to check for inclusion and exclusion criteria. Estimates of the menstrual cycle phase will be made by counting forward from the first day of the last menstrual period (Day 1) as per the calendar method for all females[11] .

Early follicular phase – Day 2-3 - (low estrogen and progesterone phases)
Pre- ovulatory phase – Day 13-15 - (estrogen peak phase)
Mid- luteal phase – Day 19-22 - (progesterone peak phase)

Visuospatial memory tests will be given to the subjects once in each phase. Participants will be subjected to the first memory test in different phases to overcome the training bias. In each phase, the participant will have to perform the Vertual Corsi block-tapping task for visuospatial working memory test.

Vertual Corsi-block tapping test for Visuospatial working memory[12]:
(https://www.memorylosstest.com/corsiblock-tapping-test/)

- Index finger will be used to click the blocks every second and the finger will be lifted straight up before moving it to the next block.
- 2 trials per level will be given, starting from 3 levels sequences , and maximum to 10 levels.
- Level above which the subject is unsuccessful in reproducing block-tapping sequence will be taken as the score.

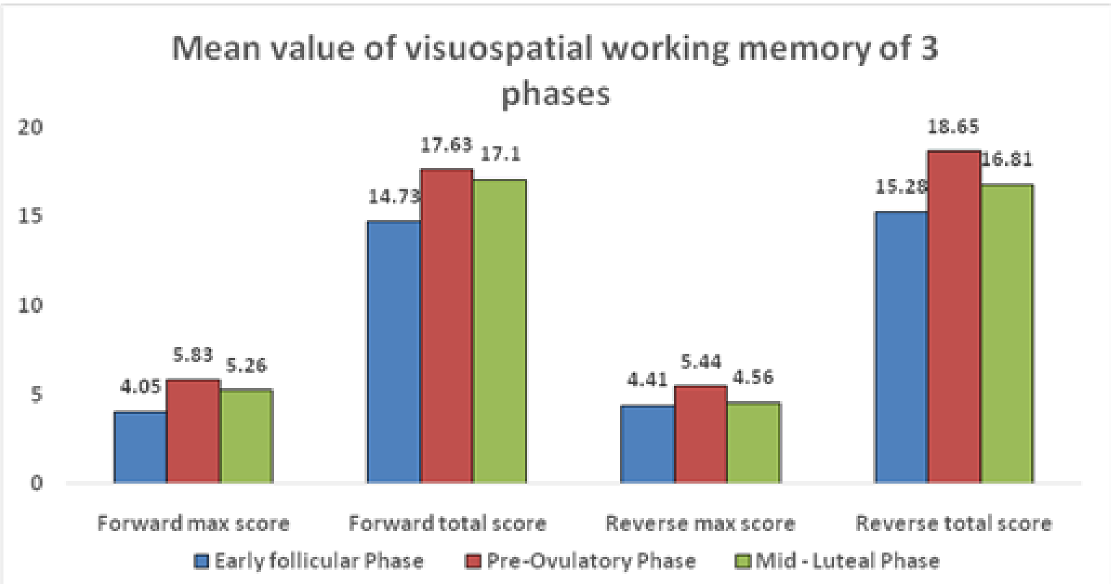
SAMPLING TECHNIQUE: sample size was calculated using the formula
n =(Z^(2)*σ^2)/d^2
n = (〖1.65〗^2* 〖1.57〗^2)/(0.35)^2
n = 77.3 ≈ 77 sample
Where,
Z = 1.65: Inverse normal value at 90% confidence interval
σ^= Standard deviation of implicit CEG total .
D = 0.35 considered

III. Results And Discussions

The table presents the descriptive statistics of visuospatial working memory across three phases of the menstrual cycle—early follicular, pre-ovulatory, and mid-luteal phases—analyzing forward and reverse tasks in terms of maximum scores and total scores. The pre-ovulatory phase exhibited the highest visuospatial working memory performance, with mean forward and reverse maximum scores of 5.83 ± 0.79 and 5.44 ± 0.50, respectively, while the early follicular phase recorded the lowest performance (4.05 ± 0.78 forward, 4.41 ± 0.50 reverse), and the mid-luteal phase showed a decline from the pre-ovulatory peak but remained higher than the early follicular phase (5.26 ± 0.63 forward, 4.56 ± 0.50 reverse), with total scores following a similar trend—highest in the pre-ovulatory phase (17.63 ± 1.94 forward, 18.65 ± 2.22 reverse), lowest in the early follicular phase (14.73 ± 3.28 forward, 15.28 ± 2.59 reverse), and moderately reduced in the mid-luteal phase (17.1 ± 2.38 forward, 16.81 ± 2.82 reverse), reinforcing that cognitive efficiency peaks in the pre-ovulatory phase and is least efficient in the early follicular phase.

Table 1: Descriptive statistics of visuospatial working memory of 3 phases

Variables			Minimum	Maximum	Median (IQR)	Mean ± SD
Early follicular Phase	**Forward**	**Maximum Score**	3	5	4 (3-5)	4.05 ± 0.78
		Total score	10	20	13 (12-18)	14.73 ± 3.28
	Reverse	**Maximum Score**	4	5	4 (4-5)	4.41 ± 0.50
		Total score	12	20	16 (12-18)	15.28 ± 2.59
Pre-Ovulatory Phase	**Forward**	**Maximum Score**	5	7	6 (5-6)	5.83 ± 0.79
		Total score	16	22	18 (16-18)	17.63 ± 1.94
	Reverse	**Maximum Score**	5	6	5 (5-6)	5.44 ± 0.50
		Total score	16	22	19 (16-20)	18.65 ± 2.22
Mid - Luteal Phase	**Forward**	**Maximum Score**	4	6	5 (5-6)	5.26 ± 0.63
		Total score	12	20	16 (16-20)	17.1 ± 2.38
	Reverse	**Maximum Score**	4	5	5 (4-5)	4.56 ± 0.50
		Total score	12	25	16 (16-20)	16.81 ± 2.82



Interpretation:

- *The peak cognitive performance in the pre-ovulatory phase aligns with the estrogen surge, which has been associated with enhanced cognitive abilities, including working memory and attention.*
- *The decline in performance in the early follicular phase may be due to low estrogen and progesterone levels, which could impact neural efficiency.*
- *The mid-luteal phase, marked by increased progesterone, shows a moderate decline in scores from the pre-ovulatory phase, suggesting that higher progesterone levels may slightly dampen cognitive function*

Table 2: Comparing visuospatial working memory score parameter between 3 phases of menstrual cycle by using analysis of variance

Variables		Early follicular Phase	Pre-Ovulatory Phase	Mid - Luteal Phase	Anova	P - Value	Significance
Forward	Maximum Score	4.05 ± 0.78	5.83 ± 0.79	5.26 ± 0.63	121.1	< 0.0001	All are significant
	Total score	14.73 ± 3.28	17.63 ± 1.94	17.1 ± 2.38	28.4	< 0.0001	
Reverse	Maximum Score	4.41 ± 0.50	5.44 ± 0.50	4.56 ± 0.50	98.9	< 0.0001	
	Total score	15.28 ± 2.59	18.65 ± 2.22	16.81 ± 2.82	34.96	< 0.0001	

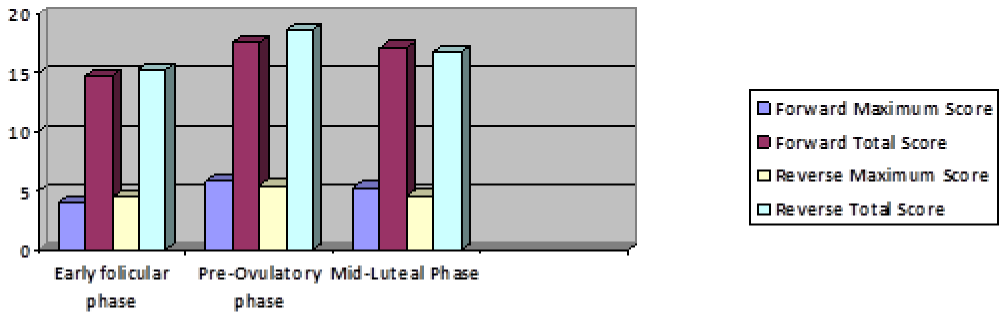


Figure 2: *Comparing visuospatial working memory score parameter between 3 phases of menstrual cycle by using analysis of variance*

This table compares visuospatial working memory across three menstrual cycle phases: Early Follicular, Pre-Ovulatory, and Mid-Luteal. It uses an ANOVA test to show significant differences (p<0.0001) for both forward and reverse memory tasks. The pre-ovulatory phase generally shows the highest scores in both maximum score and total score for both tasks. Essentially, it's highlighting how the menstrual cycle phases impact memory performance, with the pre-ovulatory phase performing the best across most measures.

Table 3: Comparing visuospatial working memory score parameter between early follicular and pre-ovulatory phase of menstrual cycle by using t-test

Variables		**Early follicular Phase**	**Pre-Ovulatory Phase**	**t-test**	**P - Value**	**Significance**
Forward	**Maximum Score**	4.05 ± 0.78	5.83 ± 0.79	-14.34	< 0.0001	All are significant
	Total score	14.73 ± 3.28	17.63 ± 1.94	-6.81	< 0.0001	
Reverse	**Maximum Score**	4.41 ± 0.50	5.44 ± 0.50	-13.03	< 0.0001	
	Total score	15.28 ± 2.59	18.65 ± 2.22	-8.84	< 0.0001	

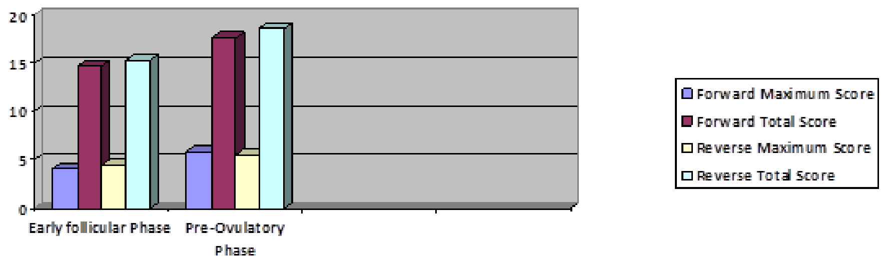


Figure 3: Comparing visuospatial working memory score parameter between early follicular and pre-ovulatory phase of menstrual cycle by using t-test

This table compares visuospatial working memory parameters between the Early Follicular and Pre-Ovulatory phases using a t-test, revealing significantly higher scores in the Pre-Ovulatory phase ($p < 0.0001$) for both forward and reverse measures (maximum and total scores).

Table 4: Comparing visuospatial working memory score parameter between early follicular and mid-luteal phase of menstrual cycle by using t-test

Variables		Early follicular Phase	Mid - Luteal Phase	t-test	P - Value	Significance
Forward	Maximum Score	4.05 ± 0.78	5.26 ± 0.63	-10.79	< 0.0001	Significant
	Total score	14.73 ± 3.28	17.1 ± 2.38	-5.23	< 0.0001	
Reverse	Maximum Score	4.41 ± 0.50	4.56 ± 0.50	-1.90	0.0596	Not significant
	Total score	15.28 ± 2.59	16.81 ± 2.82	-3.57	0.00047	Significant

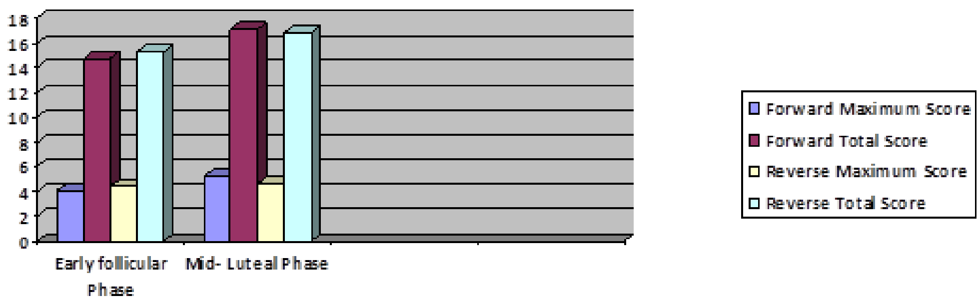


Figure 4 : Comparing visuospatial working memory score parameter between early follicular and mid-luteal phase of menstrual cycle by using t-test

This table compares visuospatial working memory parameters between the Early Follicular and Mid-Luteal phases using a t-test, revealing that the forward maximum and total scores, as well as the reverse total score, are significantly higher in the Mid-Luteal phase ($p < 0.0001$ and $p = 0.00047$, respectively), while the reverse maximum score shows no significant difference ($p = 0.0596$).

Table 5: Comparing visuospatial working memory score parameter between pre-ovulatory and mid-luteal phase of menstrual cycle by using t-test

Variables		Pre-Ovulatory Phase	Mid - Luteal Phase	t-test	P - Value	Significance
Forward	Maximum Score	5.83 ± 0.79	5.26 ± 0.63	5.05	< 0.0001	Significant
	Total score	17.63 ± 1.94	17.1 ± 2.38	1.54	0.12462	Not significant
Reverse	Maximum Score	5.44 ± 0.50	4.56 ± 0.50	11.13	< 0.0001	Significant
	Total score	18.65 ± 2.22	16.81 ± 2.82	4.59	< 0.0001	

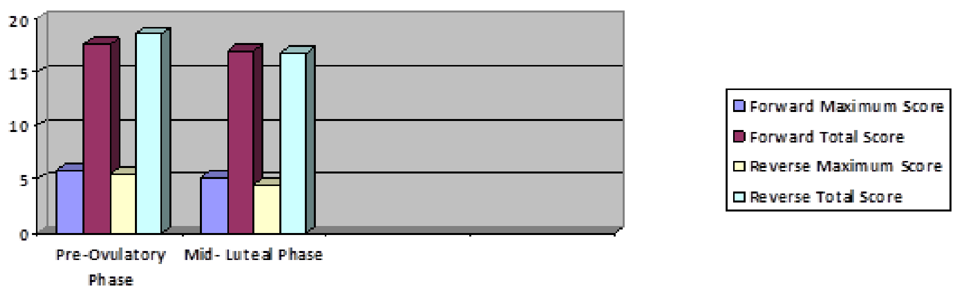


Figure 5: Comparing visuospatial working memory score parameter between pre-ovulatory and mid-luteal phase of menstrual cycle by using t-test

This table compares visuospatial working memory parameters between the pre-ovulatory and mid-luteal phases using a t-test, indicating that while the forward maximum, reverse maximum, and reverse total scores are significantly higher in the pre-ovulatory phase ($p < 0.0001$), the forward total score does not differ significantly ($p = 0.12462$).

Discussion

In this present study we observed a notable enhancement in visuospatial working memory during the pre ovulatory phase of menstrual cycle as compared to early follicular and midluteal phase.

This investigation shed light on the intricate relationship between the menstrual cycle and cognitive function, particularly regarding working memory. The comprehension of this connection could potentially offer valuable insights into the fluctuations in cognitive abilities that individuals may experience throughout different phases of the menstrual cycle. By elucidating the variations in working memory performance across menstrual phases, our study contributes to the broader understanding of how hormonal fluctuations can impact cognitive processes.

The results obtained from this research shed light on the considerable differences observed in visuospatial working memory abilities throughout various stages of the menstrual cycle. These findings serve to reinforce the theory that cognitive performance is indeed affected by the natural hormonal changes that occur during different phases of a woman's menstrual cycle. The variations in working memory capacity in relation to these hormonal fluctuations signify the intricate interplay between biology and cognition. By demonstrating the impact of the menstrual cycle on cognitive processes, this study underscores the importance of considering physiological factors when evaluating mental abilities. The presence of such fluctuations emphasizes the need for a comprehensive understanding of how hormonal shifts can influence cognitive functions, providing valuable insights into the complexities of brain-behavior relationships. Ultimately, these results contribute to a broader understanding of the intricate mechanisms underlying the influence of hormonal variations on cognitive performance, highlighting the dynamic nature of memory processes in the context of the menstrual cycle. Which is in support with study by KAJOL KUMARI TULSYAN [13].

IV. Conclusion

The study's findings revealed a substantial association between the different phases of the menstrual cycle and visuospatial working memory performance. Particularly noteworthy was the notable variation observed across phases, with peak efficiency seen during the pre-ovulatory stage. These results indicate a compelling link between hormonal levels and cognitive abilities, shedding light on the role of estrogen dominance in augmenting working memory function.

Moreover, the implications suggest a nuanced interplay between hormonal fluctuations and cognitive performance, with estrogen's influence, especially pronounced in the pre-ovulatory phase, notably enhancing cognitive processes. The enhancement in cognitive function during this phase aligns with the concept of estrogen's positive effects on neural plasticity and memory consolidation, potentially contributing to the observed peak in working memory performance.

In contrast, the findings highlight a stark contrast in working memory performance during the early follicular phase, characterized by lower hormone levels, which appeared to correspond with a decline in cognitive function. Lower estrogen levels during this phase may underlie the observed decrease in working memory efficiency, reinforcing the importance of hormonal balance in maintaining optimal cognitive abilities throughout the menstrual cycle.

Overall, these findings underscore the intricate relationship between hormonal fluctuations and cognitive performance, emphasizing the essential role of estrogen, and suggest potential implications for cognitive health and function in individuals, particularly those affected by hormonal imbalances or fluctuations.

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References

[1] Reuter-Lorenz PA, Jonides J, Smith EE, Hartley A, Miller A, Marshuetz C, Koeppe RA. Age Differences In The Frontal Lateralization Of Verbal And Spatial Working Memory Revealed By PET. J Cogn Neurosci. 2000 Jan;12(1):174-87. Doi:10.1162/089892900561814. PMID: 10769314

[2] Jonides J, Schumacher EH, Smith EE, Koeppe RA, Awh E, Reuter-Lorenz PA, Marshuetz C, Willis CR. The Role Of Parietal Cortex In Verbal Working Memory. The Journal Of Neuroscience. 1998;18:5026–5034

[3] D'Esposito M, Aguirre GK, Zarahn E, Ballard D, Shin RK, Lease J. Functional MRI Studies Of Spatial And Nonspatial Working Memory. Brain Research. Cognitive Brain Research. 1998a;7:1–13.

[4] Halpern DF, Benbow CP, Geary DC, Gur RC, Hyde JS, Gernsbacher MA. The Science Of Sex Differences In Science And Mathematics. Psychological Science. 2007;8:1–51.

[5] Hill, Ashley C "Gender Differences In Working Memory Networks: A Brainmap Meta-Analysis." Biological Psychology Vol. 102 (2014): 18-29. Doi:10.1016/J.Biopsycho.2014.06.008.

[6] Kaufman SB. Sex Differences In Mental Rotation And Spatial Visualization Ability: Can They Be Accounted For By Differences In Working Memory Capacity? Intelligence. 2007;35:211–223.

[7] Speck O, Ernst T, Braun J, Koch C, Miller E, Chang L Neuroreport. 2000 Aug 3; 11(11):2581- 5.) Gender Differences In The Functional Organization Of The Brain For Working Memory.

[8] Lejbak L, Crossley M, Vrbancic M Brain Cogn. 2011 Jun; 76(1):191-6. A Male Advantage For Spatial And Object But Not Verbal Working Memory Using The N-Back Task.

[9] Wilson JD, Foster DW, Kronenberg HM, Larsen PR. Williams Textbook Of Endocrinology, 9th Ed. Philadelphia PA: W.B. Saunders Company, 1998.

[10] Gordon HW, Corbin ED, Lee PA. Changes In Specialized Cognitive Function Following Changes In Hormone Levels. Cortex 1986;22:399–415

[11] Maki PM, Rich JB, Rosenbaum RS. Implicit Memory Varies Across The Menstrual Cycle: Estrogen Effects In Young Women. Neuropsychologia. 2002;40(5):518-29. Doi: 10.1016/S0028-3932(01)00126-9. PMID: 11749982.

[12] Mittal S, Jain N, Verma P, Garg N, Devi S, Munjal S, Gupta P, Jheetey S. Gender Preference For Auditory Versus Visual Routes For Memorization. Indian J Physiol Pharmacol. 2016 Jan-Mar;60(1):62-9. PMID: 29953195.

[13] Tulsyan, K. K., Manna, S., & Ahluwalia, H. (2023). Effects Of Menstrual Cycle On Working Memory And Its Correlation With Menstrual Distress Score: A Cross-Sectional Study. Journal Of Clinical And Diagnostic Research, 17(1), 45-52.