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RESEARCH ARTICLE

Effect of hormones on cognitive abilities and skills

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ABSTRACT

Background: Cognitive dexterity is a higher functional competence that we need to execute most of the day-to-day movements. These motor proficiency and intellectual skills are mostly influenced by the presence of estrogen and testosterone levels. The levels of these chemicals (mainly testosterone) in both males and females accord supremacy in males as compared to females in most of the dimensional intelligence. Testosterone by converting into estrogen may improve directly or indirectly cognitive function. This study is intended to find out any casual or causal relationship between this cognitive behavior and sex difference. **Aims and Objectives:** This study aims to find the difference in cognitive abilities in both the sexes. **Materials and Methods:** The study was conducted in the Department of Physiology, ESIC Medical College and Hospital, Gulbarga. We selected student volunteers of age 18–25 years for study. Cognitive function tests as visual reaction time (VRT), and go-no-go test for attention, fast counting for perception, Eriksen flanker test, and Stroop test (ST) for execution and working memory were conducted in males and in preovulatory and postovulatory phase for females. Data were compared and statistical analysis was done using SPSS software. **Results:** Cognitive functions in male were almost similar to females in the preovulatory phase. Cognitive functions only VRT and ST in male differed to females in postovulatory phase. Males performed better than females in VRT. Reading color interferences in ST were done more accurately by females than males. **Discussion:** The difference showed in results mainly focus on; emergence of sex difference developmentally and its magnitude, gender variations in spatial skills contributed by biological and environmental factors? And effect of training in minimizing this difference? Spatializing curriculum may also have role in raising level of spatial thinking in students. **Conclusion:** Different cognitive functions, depending on the tasks performed, are selectively affected by sex-related hormone modulation.

KEY WORDS: Cognitive Function Tests; Sex Hormones; Gender Variations, Spatial Skills

INTRODUCTION

Human information processing can be collectively called under the term cognition. These cognitive abilities and mental skills are attributed to components such as various executive functions, spatial and visual processing, attention, and memory, motor, and language skills.[1] It has to do more with the mechanism of how we learn, remember, recollect, and reproduce rather than with actual knowledge, for example, singing in a competition, as it involves synchronizing with music (hearing the music), decision-making (when to start singing), motor skills (holding mike), language skills (singing and understanding language), and social interactions with the audience.

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Specific neuronal circuits support some of the cognitive abilities and skills. Also memory skills are mainly concerned with working of the frontal and temporal lobe.[2] Hormones such as testosterone and estrogen accentuate and affect cognitive functions. Similar findings supported by some

studies, in which memory, verbal skills also perceptual speed, accuracy, and fine motor skills are excelled by females, whereas visual memory, mathematical, and spatial ability are outperformed by males.[3]

A good amount of research has been taken place to show the difference in tasks of mental rotation among males and females. In contrast with the performance of these tests in the laboratory their performance differ in the actual real world.[4] After a thorough research, it is found that there are some tasks in real life such as mental rotation or navigation ability in which men perform well than women. One of the important reasons behind this difference in the spatial ability can be the effect of testosterone on the development of hippocampus.

The role of female sex hormones in neuroprotection and the role of male sex hormones in cognitive functions in older men differ considerably. In literature, a number of studies have been done to find out the difference in the cognitive profile of women in estrogen and progesterone phases of menstrual cycle and difference in cognitive profile in males as per their levels of testosterone separately. Very few studies have been done comparing this difference in the cognitive profile between males and females. This study tries to reports casual or causal relationship between the effects of altered hormones levels on cognitive and brain function in younger age group in both the sexes.

MATERIALS AND METHODS

Participants for this study were undergraduate medical students, with the age ranges from 17 to 25 years. The study was presented and obtained ethical committee approval from the institution. Informed consent was taken from the entire participant. Inclusion criteria to involve the participant were to select subjects without any endocrine or metabolic disorders and also females with regular menstrual cycle without any gynecological disorders were included in the study. This is confirmed by their physical examination and noting the menstrual history of previous 2 months. Exclusion criteria applied were a subject with a previous history of head injury, cerebrovascular accidents, or on any steroidal or antidepressant treatment.

Regular menstrual cycles were confirmed by noting their previous 6 months history of reproductive cycle. Tests were conducted 2–4 days before the predicted date of ovulation and tests in the postovulatory phase were conducted within 9–11 days post-ovulation as per menstrual cycle.[5]

In both male and female, attention, perception, execution, and working memory were tested for cognitive functions. Visual reaction time (VRT) and go/no-go VRT executed for attention tasks, fast counting for perception, Eriksen flanker test (EFT), and Stroop test (ST) color interference reading for execution, and picture 2-back remembering for working memory were assessed using a cognitivefun.net program. After a proper demonstration, tests were done ones by males and twice by females; one in preovulatory and other in postovulatory phase of menstrual cycle.

Attentional Task

Visual reaction time

Out of two signals, red and green, subjects pressed space bar when green dot appears. The average reaction times were then calculated.

Go/No-Go VRT

In this test, subject pressed space bar when green dot appears and did not press when red dot appears. A total of 12 trials were given. The average reaction time then displayed.

Perceptual (Fast Count) Task

Dots from 4 to 7 were displayed and subject will press the number key corresponding to the number of dots appeared. The results were displayed after the completion of 12 trials.

Executive Task

Eriksen Flanker Test

In this, arrows from different directions will be displayed and subject has to identify and type the correct arrow mark within 1 min. Within 20 trials, congruent as well as non-congruent forms will be tested.

Both the congruent or incongruent forms were tested with 20 trials.

Stroop Test

In this test, words will be displayed describing colors but in different color. Subject has to read ink color and not the written words. Twelve trials will be given.

Working Memory Task

Ten different pictures of various objects will be displayed in sequence, and subject has to identify the sequence and has to click when the third picture is repetition of the first picture. Thirty trials will be given and results were displayed.

Statistical Analysis

The data are compared between males and females using Mann–Whitney U-test. The obtained data were expressed in median. $P < 0.05$ was considered statistically significant.

RESULTS

The findings of the study are described in Tables 1 and 2.

Table 1: Comparison of cognitive function between male and females (preovulatory phase)

Variables	Males (avg. SD)	Females	*P*-value	Significance
Visual reaction time	351.1±9.53	382.8±13.02	0.0523	NS
Go-no-go test	527.1±14.9	534.7±23.42	0.7842	NS
Perceptual (fast count) test	1213±16.42	1236±25.4	0.4443	NS
Eriksen flanker test	645.4±23.05	776.5±32.06	0.0668	NS
Stroop test	1397±42.07	1350±25.55	0.3513	NS
Item span forward	2.411±0.08693	2.685±0.1202	0.0676	NS
Item span backward	3.338±0.1261	3.311±0.1675	0.8971	NS
Working memory test	1883±114.2	2137±116.6	0.1228	NS

Table 2: Comparison of cognitive function between male and females (postovulatory phase)

Variables	Males (avg. SD)	Females	*P*-value	Significance
Visual reaction time	351.1±9.53	409.6±11.4	0.0002	***
Go-no-go test	527.1±14.9	543.4±18.55	0.4960	NS
Perceptual (fast count) test	1213±16.42	1239±22.43	0.3503	NS
Eriksen flanker test	645.4±23.05	776.5±32.06	0.0013	**
Stroop test	1397±42.07	1289±26.22	0.0326	*
Item span forward	2.411±0.08693	2.517±0.08133	0.5713	NS
Item span backward	3.338±0.1261	3.201±0.1865	0.5450	NS
Working memory test	1883±114.2	2642±140.6	<0.0001	****

DISCUSSION

Cognizance is a perplexing, multidimensional arrangement of scholarly capacities whose segment forms are subserved by particular yet interrelated mind territories. In spite of the fact that there are no subjective contrasts in psychological aptitudes between the genders, quantitative contrasts have been reliably found. Intellectual profiles of guys were discovered indistinguishable from females in the preovulatory stage yet when contrasted and postovulatory stage females were that there were noteworthy contrasts in attentional visual response times and in ST (shading correctness). The report of this examination was as per the way that the errands which require fine engine abilities, effectiveness are most astounding in the postovulatory stage in females. Hence, in ST (executive undertaking), females in the postovulatory stage had a higher precision rate than guys.[6,7] As the testosterone shows its activity through its transformation to estrogen in a considerable lot of the tissue by means of aromatase catalyst framework, so psychological profile found in females in preovulatory period of menstrual cycle (more estrogen) is relied upon to be like male subjective example.

Rather than our investigation others consider that there was no proof that exhibitions contrasted with menstrual cycle stage,[8] and furthermore, sex contrasts in utilitarian cerebral asymmetry amid mental pivot do not require hormonal changes that happen amid pubescence.[9] Hence, it is basic to connect with female youth specifically spatial exercises to close the gap between sexual orientation.[10] Two reports assessed the neural associates of mental pivot in connection to the menstrual cycle. Both the investigations report that the nearness of large amounts of estradiol reports the adjustments in cerebrum reactivity over the menstrual cycle and furthermore expanded reactivity in Brodmann's zone 39 and precise angular gyrus as angular gyrus is not just engaged with verbal handling and spatial judgment.[11,6]

These psychological working sexual contrasts are due to introduction of the fetal mind to differential dimensions of sex hormones amid prenatal life. These sexual hormonal hierarchical impacts for all time change the life structures or elements of explicit mind zones in fetal life and after pubescence, these sex hormones help to enhance the neural "hard-wiring" done prenatally under its impact.[8] To recommend this psychoendocrine hypothesis of the starting point of sex distinction in comprehension, a noteworthy measure of proof is accessible. It is verifiable truth that females amid their preovulatory stage are affected by high estrogen levels and males under testosterone levels. Barely, any investigations have demonstrated that estrogen and testosterone complement intellectual capacities along these lines according to this examination.[12] As testosterone is changed over to estrogen in numerous tissues, including the central nervous system, it could apply its impact straightforwardly or by implication through its transformation to estrogen by means of the aromatase protein.[13,14]

According to think about the estradiol levels associated adversely with mental turns and perceptual preparing,

which propose that estrogen, and not progesterone, was in charge of the progressions which were seen in cognition;[15] however, we found no huge contrasts among males and females (preovulatory or postovulatory stages) in perceptual fast count, working memory, and EFT. In spite of this examination, few investigations detailed that males indicated favorable circumstances in working memory, mathematical abilities,[16,17] and EFT.[18] This is likewise bolstered by the reality by an examination that males perform fundamentally superior to anything females on the mental rotation task and in finding a shrouded stage in the virtual Morris water task.[19]

A noteworthy cycle contrast in spatial capacity as tried by the Mental Rotation Test a high score was found amid the menstrual stage and low scores amid the midluteal stage. Because estradiol had a negative one, testosterone affected mental rotation execution.[20,21] The report of this examination says that the visual response times of females in postovulatory (progesterone) period of the cycle were more unfortunate than those of males which bolster the finding that guys outflanked females in the trial of visuospatial capacity[22] or visual response time.[23,24] Another investigation supporting these sex contrasts in intellectual profile expresses that the large amounts of gonadal steroids give qualified help to the theory that the abnormal amounts of gonadal steroids present at the luteal period of the cycle may encourage aptitudes favoring females, yet be hindering to abilities favoring males.[25]

Limitation and Further Scope of the Study

With the few limitations in this study as an assessment of cognitive profile without sex hormone estimation and reliability of ovulation time on the history of the last menstrual period, there is a further scope of the study. To make the results more conclusive and for more generalization of findings, involvement of large population along with sex hormone profile estimation in both the sexes should be included.

CONCLUSION

In finish of this investigation, the two males and females (in the preovulatory stage) psychological profiles are indistinguishable; however, men exceeded expectations in visual response time, working memory, and EFT while females exceeded expectations in ST as progesterone that favored females to appropriately segregate the various hues and furthermore ready to execute the undertakings superior to males. These findings can be explained by the observation that after an acute rise in progesterone there is also increase in sensitivity of amygdala which is supported by increased reactivity in the supplementary motor area, cerebellar vermis, inferior frontal gyri, fusiform gyrus, and amygdala.[26] In addition, as of late, it is shown that it is the connection between COMT Val58Met and estradiol level regulates the prefrontal cortex actuation in connection to working memory task.[27]

REFERENCES

1. Michelon P. What is Cognitive Ability. What are Cognitive Abilities and Skills? Available from: http://www.sharpbrains.com/blog/2006/12/18/what-arecognitive abilities. [Last accessed on 2006 Dec 18]; [Last accessed on 2012 Oct 14].
2. Michelon P. What are Cognitive Abilities and Skills, and How to Boost them? SharpBrains Virtual Summit; 2016.
3. Halpern DF. Sex Differences in Cognitive Abilities. 2nd ed. Hillsdale New Jersey: Lawrence Erlbaum Associates; 1992.
4. Kimura D. Sex, sexual orientation and sex hormones influence human cognitive function. Curr Opin Neurobiol 1996;6:259-63.
5. Upadhayay N, Paudel BH, Singh PN, Bhattarai BK, Agarwal K. Pre-and postovulatory auditory brainstem response in normal women. Indian J Otolaryngol Head Neck Surg 2011;66:133-7.
6. Maki PM, Rich JB, Rosenbaum RS. Implicit memory varies across the menstrual cycle: Estrogen effects in young women. Neuropsychologia 2002;40:518-29.
7. Rosenberg L, Park S. Verbal and spatial functions across the menstrual cycle in healthy young women. Psychoneuroendocrinology 2002;27:835-41.
8. Sherwin BB. Estrogen and cognitive functioning in women. Endocr Rev 2003;24:133-51.
9. Janowsky JS. Thinking with your gonads: Testosterone and cognition. Trends Cogn Sci 2006;10:77-82.
10. Taxel P, Stevens MC, Trahiotis M, Zimmerman J, Kaplan RF. The effect of short-term estradiol therapy on cognitive function in older men receiving hormonal suppression therapy for prostate cancer. J Am Geriatr Soc 2004;52:269-73.
11. MacLusky NJ, Walters MJ, Clark AS, Toran-Allerand CD. Aromatase in the cerebral cortex, hippocampus, and mid-brain: Ontogeny and developmental implications. Mol Cell Neurosci 1994;5:691-8.
12. Zaidi ZF. Gender differences in human brain: A review. Open Anat J 2010;2:37-55.
13. Stoet G. Sex differences in the processing of flankers. Q J Exp Psychol 2010;63:633-8.
14. Astur RS, Tropp J, Sava S, Constable RT, Markus EJ. Sex differences and correlations in a virtual Morris water task, a virtual radial arm maze, and mental rotation. Behav Brain Res 2004;151:103-15.
15. Hausmann M, Slabbekoorn D, Van Goozen SH, Cohen-Kettenis PT, Güntürkün O. Sex hormones affect spatial abilities during the menstrual cycle. Behav Neurosci 2000;114:1245-50.
16. Kozaki T, Yasukouchi A. Sex differences on components of mental rotation at different menstrual phases. Int J Neurosci 2009;119:59-67.
17. Downing K, Chan S, Downing W, Kwong T, Lam T. Measuring gender differences in cognitive functioning. Multicult Educ Technol J 2008;2:4-18.
18. Kosinski RJ. Literature Review on Reaction Time; 2012. Available from: http://www.biae.clemson.edu/Bpc/Bp/Lab/110/Reaction.Htm#Gender. [Last accessed on 2013 Jun 25].
19. Shelton J, Kumar G. Comparison between auditory and visual simple reaction times. Neurosci Med 2010;1:30-2.
20. Hampson E. Variations in sex-related cognitive abilities across the menstrual cycle. Brain Cogn 1990;14:26-43.
21. Epting LK, Overman WH. Sex-sensitive tasks in men and women: A search for performance fluctuations across the menstrual cycle. Behav Neurosci 1998;112:1304-17.

22. Hahn N, Jansen P, Heil M. Preschoolers' mental rotation: Sex differences in hemispheric asymmetry. J Cogn Neurosci 2010;22:1244-50.
23. Nazareth A, Herrera A, Pruden SM. Explaining sex differences in mental rotation: Role of spatial activity experience. Cogn Process 2013;14:201-4.
24. Dietrich T, Krings T, Neulen J, Willmes K, Erberich S, Thron A, *et al*. Effects of blood estrogen level on cortical activation patterns during cognitive activation as measured by functional MRI. Neuroimage 2001;13:425-32.
25. Schoning S, Engelien A, Kugel H, Schafer S, Schiffbauer H, Zwitserlood P, *et al*. Functional anatomy of visuo-spatial working memory during mental rotation is influenced by sex, menstrual cycle, and sex steroid hormones. Neuropsychologia 2007;45:3203-14.
26. van Wingen GA, van Broekhoven F, Verkes RJ, Petersson KM, Backstrom T, Buitelaar JK, *et al.* Progesterone selectively increases amygdala reactivity in women. Mol Psychiatry 2008;13:325-33.
27. Jacobs E, D' Esposito M. Estrogen shapes dopamine-dependent cognitive processes: Implications for women's health. J Neurosci 2011;31:5286-93.

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