

Gender based variation in cognitive functions in adolescent subjects

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KEY WORDS

Gender
Cognition
MOCA
Prefrontal cortex
Memory

ABSTRACT

Background: Cognition can be defined as all mental activities that are involved in acquisition, processing, storage and retrieval of information. **Purpose:** There is paucity of the data related to cognitive function amongst healthy adolescent age group which limits our ability to distinguish and compare cognitive changes that occur across the adult lifespan in female and male subjects separately and can provide some help to understand dementia related conditions. **Methods:** Cognitive function was assessed in 100 healthy subjects of each sex of 17–20 years by using 'Montreal Cognition Assessment Test', a 10 minutes: 30-points test which is used in assessing a wide range of cognitive abilities on 7 subscales : 1) Visuospatial Skills, 2) Language, 3) Memory, 4) Attention, 5) Mathematical ability, 6) Abstraction, and 7) Orientation. **Results:** Overall score (Male: 25.16 ± 1.8 , Female: 25.72 ± 1.8) of cognition functions was statistically significantly higher in female adolescents ($p < 0.02$). However male subjects showed higher score in Mathematical ability. **Conclusion:** There are variations in the cognitive functions in male and female individuals and neuroanatomical and physiological differences contribute to these variations.

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Introduction

The prefrontal cortex is important for a wide range of cognitive functions. Cognition can be defined as all mental activities that are involved in acquisition, processing, storage and retrieval of information. It includes a variety of skills attention, learning, memory, verbal ability or language, visuospatial function, and a group of abilities, known as executive function i.e. reasoning, abstraction and mental flexibility.¹ There is paucity of the data related to cognitive function amongst healthy adolescent age group which limits our ability to distinguish and compare cognitive changes that occur across the adult lifespan in female and male subjects separately and can provide some help to understand dementia related conditions.

Methods

Study was carried out in the department of Physiology, SGRRIM&HS, Dehradun on 200 mentally and physically healthy volunteers (medical students) of both sexes of 17–19 years after seeking written informed consent and getting permission from the institutional ethical committee for the study. Montreal Cognition Assessment Test' (MOCA),² a 10 min: 30-points test, was undertaken to score cognitive abilities on 7 subtests i) Visuo-spatial Skills, ii) Language, iii) Memory, iv) Attention, v) Mathematical ability, vi) Abstraction, vii) Orientation.

i) Visuospatial Skills: 5 points

- Alternating trail making (1 point)
- Visuoconstruction skills (two exercise 1 and 3 points)

ii) Language: 6 points

- Naming the figures (3 points)
- Sentence repeating (2 points)
- Verbal fluency (1 point)
at least >11 words with any letter

iii) Memory: 5 points

Recalling 5 different (not related) words

iv) Attention: 3 points

- Forward digit span
- Backward digit span and
- Vigilance: tap only on saying specific letter.

v) Mathematical ability: 3 points

Serial 7s subtraction

vi) Abstraction: 2 points

Similarities in the pair of words,
eg Train-Bicycle

vii) Orientation: 6 points

- day, b) month, c) year, d) place and e) city

Interpretation: On sum of scoring points if score is < 21: Cognitive impairment.

Group A - Male adolescents

Group B - Female adolescents

Statistical Analyses

All statistical Analyses were performed using the SPSS version 17-0 programme.

- Univariate analysis of variance was done to compare any statistically significant difference in overall score of cognitive functions of both the sexes.
- One way anova was done to compare any statistically significant difference between various subtests of cognitive functions of both the sexes.

Results

Sum score of all the subtests together of '30 – point MOCA test' for Group 2 was higher (25.21) in comparison to Group1 (25.01) (Table 1). Univariate analysis of variance showed statistically significant difference in cognition functions between two groups ($F_{1,399} = 1604.29$, $p = < 0.001$) (Table 2). The mean

Table 1: 'Montreal Cognition Assessment Test' (MoCA Test) Score on 7 subscales in two groups

Descriptives		N	Mean	Std. Deviation	Std. Error
Visuospatial (5 points)	Group 1	100	3.48	0.56	0.06
	Group 2	100	4.05	0.72	0.07
	Total	200	3.765	0.70	0.05
Language (6 points)	Group 1	100	4.8	0.82	0.08
	Group 2	100	4.84	0.94	0.09
	Total	200	4.82	0.88	0.06
Memory (5 points)	Group 1	100	3.85	0.87	0.09
	Group 2	100	4.1	0.83	0.08
	Total	200	3.975	0.86	0.06
Attention (3 points)	Group 1	100	2.46	0.83	0.08
	Group 2	100	2.5	0.67	0.07
	Total	200	2.48	0.76	0.05
Mathematical (3 points)	Group 1	100	2.8	0.60	0.06
	Group 2	100	2.12	0.77	0.08
	Total	200	2.46	0.77	0.05
Abstraction (2 points)	Group 1	100	1.62	0.49	0.05
	Group 2	100	1.6	0.49	0.05
	Total	200	1.61	0.49	0.03
Orientation (6 points)	Group 1	100	6	0.00	0.00
	Group 2	100	6	0.00	0.00
	Total	200	6	0.00	0.00
Sum of all the MEAN values of 7 subtests of both groups					
Overall Score (30 points)	Group 1	700	25.01
	Group 2	700	25.21

scores of individual subtests for Group 1 and Group 2 are given in Table 1. One Way Anova test showed statistically significant difference between two groups for all the subtest of cognition functions (Table 3). It was found that Group 2 has statistically significantly higher scores in visuospatial skill and memory in comparison to that in Group 1 (visuospatial; $F_{1,199} = 39.365$, $p < 0.001$; Memory; $F_{1,199} = 4.304$, $p < 0.05$). On the other hand Group 1 has statistically significantly higher scores in mathematical ability ($F_{1,199} = 48.41$, $p < 0.001$). The values for language and attention were higher in female subjects in comparison to males but these were statistically insignificant (Language; $F_{1,199} = 0.103$, $p > 0.05$; Attention; $F_{1,199} = 0.139$, $p > 0.05$). The values for abstraction and orientation were similar in both the groups (Table 1).

Table 2: Univariate Analysis of Variance. Comparison of cognitive functions between two Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11.092 ^a	2	5.546	2.244	0.106
Intercept	3964.546	1	3964.55	1604.295	0.000
Cognitive functions	10.806	1	10.806	4.373	0.037
Groups	0.286	1	0.286	0.116	0.734
Error	3452.276	1397	2.471		
Total	21478	1400			
Corrected Total	3463.369	1399			

a. R Squared = .003 (Adjusted R Squared = .002)

Discussion

The results of the present study show statistically significantly higher overall cognitive score in female young adults in comparison to male young adults. In earlier related studies, difference in overall level of cognition amongst the two sexes was not found in the studies of Kimura D, Herlitz A, Halpern DF, Downing K & Voyer E as they proclaim that most of the standard tests have been shaped to avoid gender bias, although almost all of these gender based studies quote differences in the various components of cognitive abilities.³⁻⁷

Out of 7 subsets of Cognition test, since we obtained higher scores in 4 subtests in female subjects, 2 equal scores and 1 higher score in male subjects thus obviously raising the overall score in female subjects (fig 1). Above findings in our study may also be attributed to greater body-brain weight ratio for the female although male brain is 10% larger⁸. Further, MRI studies have revealed that the brain in female subjects contain relatively greater proportion of gray mater^{9,10}. Presently, it is an observed fact that in many medical institutes female students surpass males in the scores obtained in various levels of examination systems.

The findings of our study revealed that females excelled in visuospatial skills, language, memory, attention subtests for cognition and statistically significant results were found for visuospatial skills and memory. Earlier many studies have revealed that men performed at a sizeably higher level on most visuospatial tasks than women^{3-6,11,12} and these were correlated to the influence of sex hormone levels (testosterone). It was said that men with higher levels of endogenous testosterone were expected to perform better than men with lower levels and the cause was postulated to be linked to the presence of receptors in the certain brain areas¹³⁻¹⁶ but some investigators mentioned non-significant association to androgens.^{17,18} Further, it appears that early prenatal presence of androgens may organize the male brain to enhance certain spatial functions. Higher level of testosterone can be taken to be conclusive in affecting the spatial ability by the results of studies on females,

Table 3: ANOVA Test for the comparison of the cognitive functions of both the sexes

		Sum of Squares	df	Mean Square	F	Sig.
Visuospatial	Between Groups	16.245	1	16.245	39.365	0
	Within Groups	81.71	198	0.413		
	Total	97.955	199			
Language	Between Groups	0.08	1	0.08	0.103	0.748
	Within Groups	153.44	198	0.775		
	Total	153.52	199			
Memory	Between Groups	3.125	1	3.125	4.304	0.039
	Within Groups	143.75	198	0.726		
	Total	146.875	199			
Attention	Between Groups	0.08	1	0.08	0.139	0.71
	Within Groups	113.84	198	0.575		
	Total	113.92	199			
Mathematical	Between Groups	23.12	1	23.12	48.411	0
	Within Groups	94.56	198	0.478		
	Total	117.68	199			
Abstraction	Between Groups	0.02	1	0.02	0.083	0.773
	Within Groups	47.56	198	0.24		
	Total	47.58	199			
Orientation	Between Groups	0	1	0		
	Within Groups	0	198	0		
	Total	0	199			

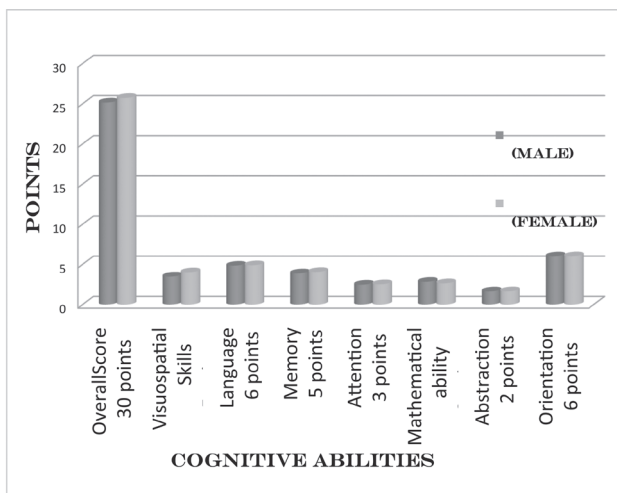


Fig. 1: Gender wise comparison of cognition

suffering from congenital adrenal hyperplasia¹⁹ showing better visuospatial skills. On the other hand estrogen was thought to have an inhibitory influence on visuospatial skills.²⁰

On the contrary, the better visuospatial skill in our study in female subjects can be explained on the basis of changing trend of the technologies, indulgence and predilection of females since very early childhood. Currently, even girls play video games, handle computers and this makes them proficient in tackling all sorts of images orientation. The female subjects included in our study were the ones having admittance to new advent of computer era since early childhood.

Our findings of better memory in females were in accordance to the earlier studies of Delis and Chipman *et al.*^{21,22} A significant finding by Kimura D also suggested that women excel on a test of 'location memory for objects.'³ Estrogen is thought to have a facilitating effect on tasks of verbal memory in which women typically excel, such as articulation, speed, and coordination. Role of estrogen can further be supported by the studies conducted during midluteal phase of the menstrual cycle and women per-

form at a higher level on these tasks, when estrogen levels are high.^{20,23} Also, in cases of Turner syndrome (XO), ovarian development occurs normally until the 4th–5th month of intrauterine life after which it prematurely undergoes involution. Inferior performance of these patients in tasks that imply attention and memory, prone to improvement with the administration of estrogens.^{24,25} In neuroimaging studies during neuropsychological task performance in temporal and parietal cortical areas in young and postmenopausal women receiving estrogen treatment, greater activation, increased blood perfusion and glucose metabolism in certain brain regions related with memory and other cognitive functions have been found.^{26,27} The results can still not be regarded conclusive due to the reduced number of studies and the differences in methods used.

However, in our opinion, the explanation could also be linked to the way the female child grows up. Usually, they sit quiet, are calm and observe things keenly. This learning due to intense observational ability influences learning and memory in women. The result of higher scores for language and attention in females, although statistically insignificant, can also be explained on the basis of the reason given above. It is generally believed that the average 20-month old young girl has twice the vocabulary skills of the average same age old boy. It is also reported that Toddler girls begin to talk sooner and more clearly than boys.²⁸ Therefore, males are much more likely to be diagnosed with stuttering and problems with handwriting.^{29,30}

On the other hand, in our study, males outshine females with statistically significant results in the mathematical ability akin to prior studies.^{4,5} The reason speculated by Gur *et al* based on fMRI showed increased white matter in males contributes towards their analytical skills and transfer of information to different regions of brain thereby, helpful in problem solving capacity.⁶

Conclusion

This study provides preliminary data to show that men are not intellectually superior to women in visuospatial skills despite bigger skull size and additional studies should be done in this direction. The handling of computers, driving, participation in outdoor activities since early childhood and rising education and job opportunities for girls have brought drastic advances in the skills. These results can further be highlighted in view of the educational status of the subjects (medical students) of the present study representing changes in lifestyles.

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