

VARIATION OF COGNITIVE SKILL ON AGE AND SEX OF PRIMARY SCHOOL CHILDREN OF WEST BENGAL.

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ABSTRACT

The cognitive growth of the children is an important phenomenon along with the physical growth. The purpose of the present study was to investigate the influence of age and sex on visuospatial function and the ability of learning and memory among 5-10 years school going boys and girls. A cross-sectional study was conducted on 905 school going children of which 445 was boys and 460 was girls from different districts of West Bengal state, India. Visuospatial ability of the children were evaluated by Picture completion test (PCT). The Learning ability of the participants was evaluated by Ray's auditory verbal learning test (RAVLT). The result showed that performances of visuospatial skill increases with the advancement of age in both sexes but the performances of boys were significantly ($p < 0.001$) greater than that of the girls. The results of RAVLT revealed that the 5 years old boys and girls recalled significantly lesser words on each of the learning trials and showed significantly lower learning score compared to that of older boys. It was also found that performances of girls were significantly greater than that of the boys. Age was significantly ($P < 0.001$) and positively correlated with verbal learning and memory, and visuospatial scores of both boys and girls. Multiple regression analysis demonstrated that even after controlling the effect of the height, weight, BMI and socioeconomic status the age had strong significant impact on visuospatial skill (PCT) learning of trials (LOT) and recognition (REC).

Key words: Age, Sex, Cross sectional study, Visuospatial function, Learning abilities.

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INTRODUCTION

Cognitive development of a person means perception, thinking and understanding the world through the interaction of genetic and learned factors. Different areas of cognitive development are information processing, reasoning, intelligence, language development, and memory. Brain development is an organized and highly dynamic multistep process, which is genetically determined, epigenetically directed and environmentally influenced (Tau and Peterson, 2010). This process continues both through childhood and adolescence, the developmental period during which the body and brain emerge from an immature state to adulthood (Spear, 2000., Steinberg, and Morris, 2001). Although total brain size is approximately 90% of its adult size by age six, it is now well known that the gray and white matter subcomponents of the brain continue to undergo dynamic changes throughout adolescence (Giedd et al., 1999., Paus, 2005).

The Rey Auditory Verbal Learning Test (RAVLT) was a commonly used measure of a person's ability to encode, consolidate, store, and retrieve verbal information (Schmidt, 1999). While the RAVLT has been found to be a sensitive test of verbal learning and memory (Tuokko., Kristjansson, and Miller, 1995., Petersen et al., 1999) performance has also been found to be affected by age, education, intelligence, and, albeit inconsistently, by gender (Schmidt, 1996). The declines in performance of RAVLT with age are well documented (Bolla-Wilson and Bleecker, 1986; Crossen and Wiens, 1994). The effect of education, IQ, and gender on RAVLT performance has

been mixed, but it was generally accepted education and IQ affect performance and, when there is a difference, women perform slightly better than men (Schmidt 1996; Uchiyama et al., 1995).

Gender differences in cognitive abilities have been widely analyzed in the psychological and neuropsychological literature (Halpern, 1992., Hedge and Nowell, 1995., Kimura, 1999., Weis et al., 2003). Three major differences in cognitive abilities between men and women have generally been reported: (a) higher verbal abilities, favouring women; (b) higher spatial abilities, favouring men; and (c) higher arithmetical abilities, also favouring men. However, differences in calculation abilities have, at times, been interpreted as a result of men's superior spatial abilities (Geary, 1996); hence, these three differences could be reduced to just two. Nonetheless, gender differences in children's cognitive abilities remain an area of controversy. Whereas some studies have found such differences, others have not been able to isolate them. There is no question that additional analyses of the potential gender differences in cognitive development are needed. These analyses should include a large sample with an ample age range, which may help to clarify the interaction between gender and age in relation to cognition. The aim of the present study was to analyze gender differences in verbal learning and memory, and visuospatial function of the primary school children as well as to study the pattern of growth of cognitive

characteristics with the advancement of age .

Methods and Materials:

Sites and Subjects:

A cross-sectional study was conducted on 905 school children of which 445 were boys and 460 were girls. They were selected within the age group of 5-10 years from different districts of West Bengal state, India. The eligibility of criteria for recruitment of the participants for the present study were boys having age 5 to 10 years, apparently healthy, and not suffering from any kinds of psychiatric or neurological disturbances. Participants with background of acute or chronic diseases were excluded from the study. For more precision, those participants who were taking psychotropic medication for at least last three weeks were excluded in the present study. The protocol of the present study was explained verbally in local language (Bengali) and informed consent was obtained from the parents. Ethical approval and prior permission were obtained from the institutional Ethics Committee before commencement of the study and the study was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration.

Ray's Auditory Verbal learning Test (RAVLT)

The RAVLT (Bleecker et al.1988) is a neuropsychological test of verbal learning and episodic declarative memory. The RAVLT was used to produce scores that measured short-term auditory verbal memory, rate of learning, learning

strategies, retroactive, and proactive interference, presence of confabulation of confusion in memory processes, retention of information, and differences between learning and retrieval. In this experiment a list of 15 words (list A) was read loudly to the subject for consecutive 5 times. Each of the attempts was consisted of test of spontaneous retrieval. After the completion of fifth attempt, a list of interference, also consisted of 15 words (list B), was read to the subject and after reading of the words the students were asked for its retrieval (attempt B1). After attempt B1, the examiner instructed the individual student to recall the words which was belonged to list A, without reading the list again the individual student was instructed to recall it again (attempt A6). For the evaluation of learning curve of the words during attempts A1 to A5, the learning rate during the attempts –learning of trials (LOT) was calculated by the following formula:

$$\text{Sum of A1 to A5} - (5 \times A1)$$

After an interval of 20-minutes, the examiner again asked the individual to remember the words that were belonged to list A, without reading the list (attempt A7). After the attempt A7, the individual was asked to attend for the test of memory recognition, in which a list that consists of 15 words from list A, 15 words from list B along with 20 distracting words (similar to the words in list A and B in phonological or semantic terms) were read to the individual. Then each of the word read aloud, the individual was asked to indicate if the word belongs to list A, or not. The total time for application of the RAVLT ranged from 35 to 40 minutes. The total sum of attempts, from 01 to 05, and the rates of proactive

interference were calculated by $(B1/A1)$; retroactive interference was calculated by $(A6/A5)$ and forgetting speed was calculated by $(A7/A6)$. The result of the memory recognition test was calculated by adding the correct answers (when the individual correctly identified that the word belonged /did not belong to list A) – 35 (total of distracting words). This same procedure, used in recognition memory tests, allowed to evaluate not only identification of targets (words in list A), but also took into account the effect of false positives (identification of distracting words) and false negatives (unidentified words in list A).

Picture completion test:

It is a measure of visuoconceptual ability, visual organization and visuo-conceptual reasoning. It consists of 20 cards with pictures of different objects with a missing feature. The participants are required to name or point out to the missing feature. Number of correct responses comprises the score (Malin.1969).

Statistical analysis:

Descriptive statistics, including means and standard deviations, were calculated for all the variables. To test the significant difference of the variables, the t- test was performed. Pearson's correlation coefficient (r) was computed to test the association of all the variables. One-way analyses (Scheffe's procedure) were carried out to test for differences in Rey's auditory verbal learning test (RAVLT)

and picture completion test performances across the different age groups. To address the potential for confounding, regression analyses was undertaken. Age of the participants was entered into the model as independent variables. Age was included in the model as independent variables against RAVLT performances (LOT and REC) and visuospatial performances (PCT) as dependent variables after adjusting the effect of age. P-value set at <0.05 level. Statistical analyses were performed using the statistical software IBM SPSS version 20.

Results

The performance of cognitive skills of the primary school going children has been presented in Table 1 according to the age of the subjects. From the results it was revealed that there were significant variations ($p<0.001$) of simple scores of cognitive ability among the children of different ages. There was general tendency of increasing the scores of most of the variables with advancement of age.

The results of Bonferroni post hoc analysis showed that the boys and girls of lower age group (5 years) performed significantly lesser ($p<0.001$) score on each of the cognitive task and showed significantly lesser ($p<0.001$) visuospatial function (PCT) and verbal learning and memory (LOT,REC) compared to that of the boys and girls of 6 to 10 years. On the other hand, the 10 years old boys and girls performed significantly greater score ($p<0.001$) than that of other age groups.

Table 1: Scores (Mean ±SD) of different cognitive parameters of boys and girls of the age groups 5 -10 yrs

Age(yrs)			PCT		REC		LOT	
	Boys (n)	Girls (n)	Boy	Girl	Boy	Girl	Boy	Girl
5	67	75	3.38±0.98	2.45±1.04	5±1.41	5.84±1.98	6.37±2.63	6.90±2.57
6	76	80	3.68±1.15	2.68±1.19	6.90±2.66	7.27±2.50	7.26±2.88	7.91±3.28
7	79	72	3.78±1.00	2.87±1.05	6.94±1.83	8.62±1.95	8.35±2.80	9.15±3.20
8	83	80	3.90±1.15	2.95±1.11	7.29±2.96	8.78±2.15	9.45±4.45	9.56±3.62
9	74	70	4.13±0.96	3.10±1.35	7.97±3.00	10.44±2.18	9.48±3.75	10.40±3.18
10	66	83	4.25±1.33	3.31±1.27	9.28±4.48	11.26±3.03	10±4.00	11.03±3.51
F ratio			5.46***	5.15***	16.07***	55.56***	11.55***	17.28***

*p<0.05, **p<0.01, ***p<0.001. [PCT- picture completion test. REC- recognition LOT-learning of trials]

Correlation coefficient of cognitive parameters with age has been presented in Table 2. Correlation analysis demonstrated that age of boys and girls was significantly (P<0.001) and positively

correlated with all the scores of cognitive task such as picture completion test (PCT) and recognition (REC) and learning of trials (LOT).

Table 2: Correlation coefficient of cognitive parameters of studied participants with age

Cognitive parameter	Boy	Girls
PCT	0.240***	0.230***
REC	0.371***	0.608***
LOT	0.330***	0.396***

*p<0.05, **p<0.01, ***p<0.001 [CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test.. REC- recognition, LOT-learning of trials]

From the linear regression analysis of age with different cognitive parameters such as picture completion test (PCT) and verbal learning and memory test (LOT, REC) it was revealed that the age had significant association with different cognitive parameters (Table 3,4). Multiple regression analysis demonstrated that

even after controlling for the effect of the height, weight, BMI, and socioeconomic status the age showed strong significant impact on all the cognitive parameters. Therefore, the age might be the best account for the variability of the cognitive performances.

Table 3 : Regression analysis of cognitive parameters with age (Boys)

Variables	Unadjusted						Adjusted #			
	B	SeB	B	R ² change	F change	T	B	SeB	B	T
PCT Vs. Age	0.165	0.032	0.240	0.058	26.88	10.756***	0.074	0.042	0.108	1.785
REC Vs. Age	0.669	0.083	0.372	0.138	70.37	8.38***	0.323	0.123	0.172	2.63*
LOT Vs. Age	0.745	0.101	0.331	0.110	53.99	7.34**	0.336	0.148	0.149	2.26*

*p<0.05, **p<0.01, ***p<0.001 [PCT -picture completion test ; REC- recognition ; LOT-learning of trials] #adjusted Height, Weight, BMI, & Socioeconomic Status

Table 4 : Regression analysis of cognitive parameters with age (female)

Variables	Unadjusted						Adjusted#			
	B	SeB	B	R ² change	F change	T	B	SeB	B	T
PCT Vs. Age	0.161	0.032	0.230	0.053	25.66	5.066**	0.221	0.0057	0.315	3.86***
REC Vs. Age	1.048	0.064	0.608	0.370	268.75	16.39**	0.708	0.102	0.411	6.92***
LOT Vs. Age	0.813	0.088	0.396	0.157	85.22	9.23**	0.641	0.160	0.312	3.99**

*p<0.05, **p<0.01, ***p<0.001 [PCT -picture completion test ; REC- recognition ; LOT-learning of trials] # adjusted Height, Weight, BMI, & Socioeconomic Status

Gender variation of cognitive skill has been presented in Table 5. The result showed that girls out performed boys in verbal learning and memory tests (Fig 2 and 3). It was found that performances of girls in verbal learning and memory was

significantly greater (p<0.001) than that of the boys. On the contrary, the visuospatial function of the boys, which was presented by PCT (Fig-1), was significantly greater (p<0.001) than that of the girls.

Table 5 : Comparison of different cognitive parameters between boys and girls

Cognitive parameters	Boys	Girls
PCT	3.85*** ±1.13	2.89±1.20
REC	7.21±3.09	8.71*** ±2.97
LOT	8.50±3.70	9.17** ±3.53

* p<0.05, **p<0.01, ***p<0.001 [PCT- picture completion test. REC- recognition , LOT-learning of trials]

The growth curve of the picture cancellation test (PCT) showed that the scores of the test were gradually increased with the age of the children (Fig. 1) representing better visuospatial fuction of

the boys and girls with the advancement of the age. The boys showed higher growth of this characteristic than that of girls.

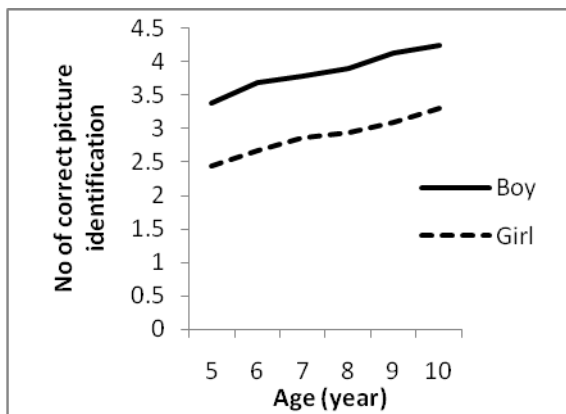


Figure-1: variation of visuospatial function (PCT) in relation to age and sex of the children.

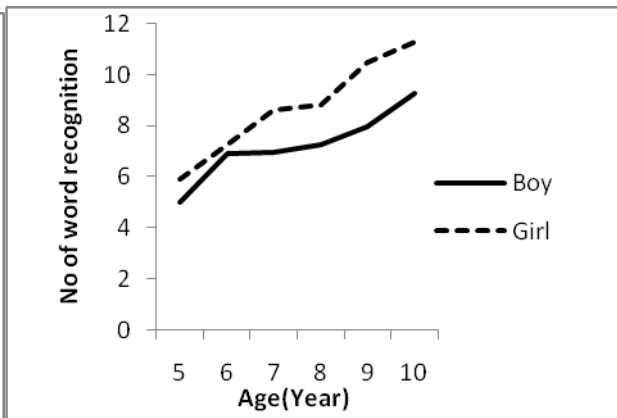


Figure-2: Variation of verbal memory (REC) in relation to age and sex of the children.

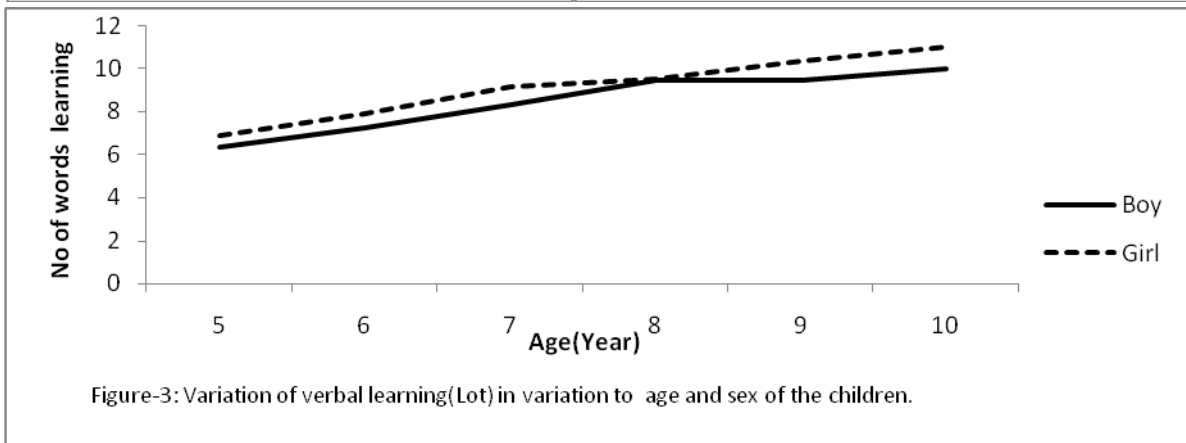


Figure-3: Variation of verbal learning (Lot) in variation to age and sex of the children.

From the Figs. 2 and 3 it was observed that the growth curves of the scores of learning of trials (LOT) and recognition (REC) showed upward shift with the increment of the age of the children. The pattern of the growth curve showed age related betterment in the ability of verbal learning and verbal recognition in boys and girls. In both the cases girls had better growth in those cognitive characteristics than that of the boys.

DISCUSSION

From the results it was noted that visuospatial ability, verbal learning and memory was gradually increased in both boys and girls from 5 years to 10 years of age. The articulatory process was the key component for gradual increase of verbal learning and memory and it was reported the said process was gradually activated

by means of articulatory loop with the advanced of age (Baddeley.2000., Manna et al. 2016). It was also pointed out that the better cognitive performance of young children was due to the activity of the two main components, viz, articulatory loop and episodic buffer (Baddeley.2000). The key function of the episodic buffer was to integrate the information from the articulatory and visuo-spatial loop along long-term memory material (Query and Berger.1980). Toga et al.(2000) confirmed in his studies that myelination of some part of the brain continued well into adolescence, whilst myelination occurred earlier in other parts of the brain that coordinated more primary function. Investigator had reported that grey matter reached asymptote by the age of 7-11 in different regions of the brain and growth of the white matter started to develop at earlier age and became matured at the

age of 20 years of age (Giedd et al.2010). Studies also reported that maturation of brain area during childhood was associated with reading, learning and memory (Nagy et al. 2004., Deutsch et al. 2005). It had long been recognized that males and females exhibit differential performance on various cognitive tasks, including tests of visuo-spatial and verbal domains (Kimura.1996). Moreover, males and females experience different propensities for the development of neuropsychiatric disorders, may report different symptom profiles clinically, and present with altered levels of functioning and co-morbidity (Wilkinson and Robertson. 2006). These differences may reflect innate functional brain differences between the genders.

From the test of visuospatial ability (picture completion test) it was found that boys outperformed girls and from the tests of verbal learning and verbal memory girls outperformed the boys . The findings of this study was similar to that of the findings of other studies, where it was suggested that boys outperformed girls in visuospatial ability (Halpern et al.2007.,Moreno-Briseno et al. 2010) From the results (Table 5) it was also noted that performances of verbal learning and verbal memory in girls was better than that of boys. This findings was supported by other studies (Kimura. 1996) which also suggested that females performed better than males in tasks of verbal learning and memory.

Li et al. (2004) demonstrated that functional asymmetry, cerebral metabolic rate and cerebral blood flow in females was higher than that of males using the techniques of PET and SPCT. More recently, functional imaging studies and functional magnetic resonance imaging (fMRI) studies were conducted to

investigate gender influence upon regional brain activity changes and the changes of regional cerebral blood flow occurred during stimulus presentation and it was reported that there were significant patterns of differential activation in between the sexes in tasks of visuospatial function and verbal learning and memory (Fischer et al. 2004.,Lee et al.2005). Gender specific alterations in brain activation was observed in insular and thalamic regions, frontal region (Lee et al. 2005) , occipital and cingulate regions (Fischer et al. 2004) , parietal regions (Weiss et al. 2003) and temporal regions (Ragland et al. 2000). An altered lateralization between the hemispheres was also reported (Ragland et al. 2000). It was suggested that females have greater bilateral activation during a phonological language task (Lee et al. 2002., Georgopoulos et al. 2001). Additionally, females had more frontal activation, compared to more parietal activation in males, during a verbal learning and verbal memory tasks (Weiss et al. 2003). Males had greater bias towards right hemisphere activation (and females to left hemisphere activation) during a task requiring a judgement of a whole object from its parts (Georgopoulos. 2001). The female had a greater bilateral regional cerebral blood flow in temporal regions during performance of memory recall or verbal learning and memory (Ragland et al. 2000).

Studies had suggested that males perform better than females on tests of visuospatial functioning (Kimura.1996). However, the difference in performance between these groups was not accompanied by significant alterations in functional activation. Greater parietal activation in males and greater frontal activation in females was reported (Weiss et al.2003).

Previous studies suggested that males performed better than women in cognitive measures of visuospatial ability. In the present study it was found that in general girls performed better than males in tests of verbal function (Kimura, 1996). However, in other studies Bell et al. (2005) reported that significantly increased in activation of the regions that involved in carrying out a verbal fluency task in males compared to females. A regional analysis revealed that a greater BOLD signal magnitude was observed in males compared to females in several brain regions (Bell et al. 2006). Structural brain differences and brain composition differences influence the BOLD signal, as well as regional cerebral blood flow, blood volume, and cerebral metabolic rate of oxygen was reported. (Vogt et al. 1992). Visual stimulation in males and females contain a greater number of undetectable BOLD signals were present in males than in females were established (Marcar et al. 2004). In a similar investigation, reported that decreased BOLD signal response in females during binocular visual stimulation, compared to males (Levin et al. 1998), that might be reason for lower visuospatial function of girls compared to that of boys.

Conclusion

The neuro-cognitive development was found to be directly related to age and sex of the children. The cognitive parameters, viz., visuospatial and verbal learning and memory, were found to be increased with the advancement of age of the boys and girls. The visuospatial skill was greater in boys than that of girls but the ability of learning and memory was higher in girls than that of boys.

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