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Handedness and Gender Differences in Spatial Abilities

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INTRODUCTION

Handedness is the hand preference patterns that are regarded as an index of individual differences in the cognitive performance. Earlier it was thought that hand preference has been regarded as the gross correlate possibly more informative patterns of neural organization. But recently attention has been focused on the studies of cerebral lateralisation of cognitive functions. The familial left-handedness has been recognized as important variable, but very little effort has been devoted to examine the dimensions of manual and cognitive functioning that might transmit from one generation to next. Sex - related differences have been reported in some of the studies of handedness in families.

The relationships among handedness, sex and cognitive processes have generated the results of high incidence of males and left handedness or mixed - handedness in Clinical groups of children with reading and learning disabilities (Cashdan et al., 1970; Critchley, 1970), Social - Cognitive disorders such as autism (Colby and Parkinson, 1977) and speech problems (Bloodsteni, 1969); males and females may have different pattern of hemispheric specialization for cognitive function and that their pattern may be related to handedness (Lake and Bryden, 1976; Levy and Reid, 1976).Till now hand preference was considered as dichotomy (left - handed versus right handed), but now it is on tracheotomy (ambidexterity). People do differ in the extent to which their right or left hand dominates in manual activities, however, and there is an increasing tendency to classify individuals along a continuous dimension of hand preference for various tasks, subjects are usually asked to fill out a questionnaire in which they indicate the direction. For various activities writing, throwing, drawing, sewing, tooths brushing, opening a lid, or dealing cards (Annett, 1967; Oldfield, 1971), several investigations have reported the assessment of strength, speed, dexterity or sensitivity of the hands on a variety of tasks in order to get performance information. Some activities have been assessed i.e. finger tapping (Kimura and Archibald, 1974; Wolf and Hurwitz. 1976), dowel balancing (Hicks, 1975), mirror tracing (Long, 1977), tactile perception (Varney and Benton, 1975; Witelson, 1977). These studies reveal that the preferred hand for writing is of the not superior to other activities. The non-writing hand has been found to be superior for tasks such as mirror tracing (Long, 1977) and tactile perception (Varney and Benton, 1975). The right - hand (RH) superiority in speed and accuracy for sequential finger tapping is thought to reflect left- hemispheric superiority for the control of the sequential activities (Wolff and Hurwitz, 1976). The manual performance has been used to assess the asymmetries of hemispheric function (Hicks, 1975; Kimura, 1976; Kinsbowene and Cook, 1971; Levy and Reid, 1976, 1978).

The *sex- related* or *gender* differences in the cognitive functions are fairly well established and documented as well at least in three different areas viz. Mathematical, verbal skill and spatial visualization (Maccoby and Jacklin, 1974). Precisely, the research on cognitive abilities of men and women has a long history. But it does not imply that there is well-documented literature, on the similarities and differences, have not yet agreed on the extent and origin of these differences rather than on the theoretical origins of presumed differences (McGuiness, 1989). Therefore, after reviewing the literature on human handedness, spatial abilities and gender differences in the cognitive functioning, several *hypothesizes* have emerged out and it has been tried to make an attempt to test some of them. The sex differences in spatial abilities began with adolescence and exhibit the consistent mean differences between sexes for spatial ability (Maccoby and Jacklin, 1974). Males perform better than females on test of non-analytic spatial ability in 8 of 10 studies with subjects 13 year and above. Further studies of analytic spatial ability show males scoring higher in 22 of 43 studies while females score higher only is one.

Several other studies also support of the results of Maccoby and Jacklin (1974) (Hydeetal., 1975; McGlone and Devidson, 1973; Mitchemore, 1974; Sherman, 1974; Yen, 1975). These all studies have revealed a significantly higher male performance in non-analytic spatial ability which one exhibits significant differences in only two of four school studies (Fennema and Sherman, 1977).

Present study was an attempt to understand the human handedness, spatial ability and gender differences in the cognitive functioning with following broad aims. The aims of the study were to find out the effect of sex and handedness on the perceptual judgment, if any; to find out the effect of sex and handedness on the value judgment and orientation of a level and to find out the effect of handedness and gender on the performance on the spatial ability. The study has been conducted on the college going students of the CCS University, Merrut, U P. Most of them were studying for undergraduate and postgraduate courses, while others for research degrees. Therefore, the universe of the study is comprised of the college students both female and male. A questionnaire was used to administer certain questions as well as to draw certain diagram or figures related to a set of questions. Here the subjects were asked for the required task and questions were directed to determine the handedness e.g. whether a subject is right or left-handed. These questions form a set of *self-reported handedness* (SRH). Handedness, right or left was not observed, but the subjects themselves reported it and it was practically difficult to observe for various tasks. Lastly, it was very difficult to identify the person with left-handedness however the right-handed persons are easily available. Therefore, the sample size is not very large i.e. 200 subject including 100 males and 100 female (Rani, 2001).

MATERIAL AND METHOD

The data of 200 subjects were collected from the college going students of the University. Every one of 200 subjects has participated in following tests and their data were recorded systematically.

1. Mental Rotation Task (MRT)
2. Line Bisection Task (LBT): without cue, with cue either on left or right side of a horizontal line.
3. Angle drawing of 30 on right and left side on a horizontal line.
4. Angle drawing of 60
5. Water Level Task (WLT) in titled container
6. Drawing an angle in WLT.

The aims, set forth, were to understand the human handedness, spatial ability and gender differences in the cognitive function. There were some limitations in the study. *First,* the study includes only the college going students and not the general population. *Second,* a set of questionnaire was used to determine the self reported handedness (SRH) in which each subject him/herself reported himself or herself either as Right handed or Left handed. The handedness was self-reported by the subject which again has left those who were amphidextrous, a mixed category of two extremes. There was no specific test used to determine handedness. *Third*, the left-handed subjects were very difficult to identify and the therefore the data are not very large. *Fourth,* in some cases age or caste was not recorded; hence, the effect of age or caste/community could not be studied in the study.

All the data were systematically coded and subjected to SPSS package, for Anova (F-ratios) and these were converted into t-values. Following tests and the precise results are summarized as follows:

RESULTS AND DISCUSSION

The precise results and their interpretation are summarized under the headings of Mental Rotation Task (*MRT*), Line Bisection Task (*LBT*), Angle drawing of 30 and 60; Water Level Task(*WLT*) and Drawing an angle in WLT.

i) Mental Rotation Task (MRT): It is observed that *F* and *t* values reveal significant differences in MRT for both the sexes as well as for Handedness of both the sexes. Though the interaction between the sex and handedness does not shows any effect on MRT and this interaction is non-significant. The main values for MRT vary much for sex and for right-handed male (21.01) and females (25.96). Whereas left handed male and female do not very much in their mean values for MRT. (Table 1)

ii) Line Bisection Task (LBT): As *F*-ratios and *t*

Table 1: ANOVA of correct responses in MRT for Handedness (SRH) and Sex of 200 subjects.

Source of Variation	*Sum of squares*	*D.F.*	*Mean*	*t*	*F*	*Significance of F*
Sex	222.605	1	222.60	3.34*	11.15*	0.00
SRH	1225.125	1	1225.12	7.84*	61.39**	0.00
Sex X SRH	6.845	1	6.84	0.58	0.34	0.55

values indicate that there is non-significant differences in LBT for both sex and handedness. Further, the presence of cue either on left or right side of horizontal line does not show any significant effect for both the sexes and handedness. Beside the interaction of sex, handedness and cue is not significant for the Line Bisection Task without cue (WOC), with cue on Right side WCR and with cue on left side (WICL). The mean values though apparently vary much but these difference seems to be non-significant (Table 2 and 3).

iii) Angle Drawing of 30' on Left side: Both *F* and *t* values do not show any significant effect of sex and handedness in angle drawing of 30' on left side of a horizontal line. Interaction between sex and handedness is not effective. Mean values for both angle drawing are negative for both the sexes and for both he handedness (Tables 4).

iv) Angle Drawing of 30' on Right Side: Similar results are observed as given above in (iii) for angle drawing of 30' on left side (Table 5).

v) Error in Drawing 60' Angle: The *F* and *t*-values reveal no significant effect of sex as well as of handedness. However, the interaction effect is significant e.g. the sex effect the handedness of a persons in drawing a 60' angle. The mean values vary much for both sexes and differences seems to be significant. Mean values for left

Table 2: ANOVA and t-values for Line Bisection Task (LBT) with cue interaction between Sex and Cue; between handedness (SRH) and cue; and between sex, handedness and cue

Source of variation	*Sum of squares*	*D.F.*	*Mean*	*t*	*F*	*Significance of F*
Cue	0.07	2	0.04	0.26	0.51	0.76
Sex x cue	0.82	2	0.41	2.89	0.70	0.05
SRH x cue	0.17	2	0.09	0.61	0.70	0.54
Sex x SRH x Cue	0.95	2	0.48	3.35	1.83	0.03

Table 3: ANOVA and t-values for sex, SRH and interaction of sex and SRH for line bisection task (LBT).

Source of variation	*Sum of squares*	*D.F.*	*Mean*	*t*	*F*	*Significance of F*
Sex	0.02	1	0.02	0.11	0.33	0.74
SRH	0.31	1	0.31	2.00	1.41	0.15
Sex x SRH	0.15	1	0.15	1.00	1.00	0.31

Table 4: ANOVA and t-values for the Error in drawing 30 degree left side on a horizontal line (30 L) for handedness (SRH) and sex.

Source of variation	*Sum of squares*	*D.F.*	*Mean*	*t*	*F of F*	*Significance*
Sex	4.80	1	4.80	0.15	0.38	0.69
SRH	0.00	1	0.00	0.00	0.00	0.99
Sex x SRH	49.00	1	49.00	1.53	1.24	0.21
Explain	53.81	3	17.93	0.56	0.75	0.56

and right handed subject for the same task also exhibit the apparent variations. But despite of latter, the right handed mean values of male (0.28) and of female (4.26) subject seem to exhibit a significant differences and these differences are not much for left handed male and female subjects (Table-6).

vi) Water Level Task (WLT) in the Titled Container: Both F and t values were used to assess the accuracy in WLT of both the sexes and both the handedness (Table-7). These values do not reveal any significant effect either of sex or handedness on the WLT. The interaction between sex and handedness in WLT is also not significant. Mean values of accuracy in WLT are more or less similar for both the sexes and both the handedness. Similarly, the mean value of accuracy in WLT of right handed and left handed subjects is also very close to each other.

vii) Drawing an Angle in Water Level Task (WLT): The F-ratio and t values reveal non-significant differences in sex and handedness for drawing an angle in WLT. The interaction of both is also non-significant. Mean values of this task for both sex and handedness are very close to each other. So, these are not much effective in the task. Similarly, the mean values of right handed subject vary much for angle drawing in WLT and it is 16.665 for male while 22.04 for female and t test could only attribute this difference to non-significance. The left handed subject do not very much in mean values for the task.(Table 8).

The results of the present study have clearly shown that handedness and gender differences

Table 5: ANOVA and t-values for the errors in drawing 30 degree right side on a horizontal line (30 R for sex and handedness (SRH).

Source of variation	*Sum of squares*	*D.F.*	*Mean*	*t*	*F*	*Significance of F*
Sex	0.72	1	0.72	0.23	0.15	0.87
SRH	24.500	1	24.50	0.78	0.89	0.37
Sex x SRH	1.280	1	1.28	1.042	0.20	0.83

Table 6: ANOVA and t-values for the Errors in drawing 60 degree for sex and handedness (SRH).

Source of variation	*Sum of*	*D.F. squares*	*Mean*	*t*	*F*	*Significance of F*
Sex	94.82	1	94.82	2.13	1.46	1.14
SRH	6.42	1	6.42	0.14	0.38	0.70
Sex x SRH	339.56	1	339.56	7.64	2.77	0.00
Error	8658.23	195	44.40	-	-	-

Table 7: ANOVA and t-values in Accuracy in water level task for sex and handedness.

Source of variation	*Sum of squares*	*D.F.*	*Mean*	*t*	*F*	*Significance of F*
Sex	6.00	1	3.00	0.00	0.3	0.97
SRH	6.84	1	6.84	1.22	1.11	0.27
Sex x SRH	8.40	1	8.40	1.50	1.23	0.22
Explained	15.22	3	5.08	0.91	0.95	0.43

Table 8: Anova and t-values in angle of water level task (WLT) for sex and handedness (SRH).

Source of variation	*Sum of squares*	*D.F.*	*Mean*	*t*	*F*	*Significance of F*
Sex	0.320	1	0.32	0.00	0.32	0.98
SRH	62.720	1	62.72	0.13	0.36	0.71
Sex x SRH	1404.500	1	1404.50	2.90	1.71	0.90
Explained	1467.540	3	4890.18	1.01	1.01	0.38

do not directly affect the spatial ability as a whole except for MRT. This significance may be due to right hemispheric laterisation in males as it has been reported in different studies. Further it has also been observed that functional asymmetry among male is greater than female. In case of the *Line bisection Task (LBT)*, the result reveals that sex and handedness alone are not important in this task, but the presence of cue make vital differences in this task. Whereas in case of the angle drawing – 30/60 degree, all the subjects have under estimated the degree of angle. It appears that LBT is not enough to distinguish among the handedness. In case of the WLT it seems, from the result that the task was not well designed so it could establish, in some cases, the difference among the sex and handedness. Why these differences are not significant and why are they significant in some other cases? It requires a detailed explanation which has its roots in the history of gender research, methods currently being used, selection of sample, how old was the subject, how and what constitute to determine the handedness of a person etc. The explanation of all is not possible in the present text, however, it is tried to make an attempt to review the current literature pertaining to psychology of gender research before reaching to the conclusion of the study (Rani, 2001).

If we see the results then it appears, it was conducted on the subject who were above 18 years and studying in the university and clearly, they may be well versed in the present changing climate. Therefore, their thinking and analytical skills, might be well developed, so most of the tests did not reveal the significance in gender differences in spatial ability except mental rotation task (*MRT*) for sex and handedness. Sex differences indicate the significant differences in mental rotation task and similarly Handedness also exhibit the similar differences. But the interaction between two variables is non-significant. In mathematical task, to draw an angle of 60', only the interaction between Sex and Handedness reveal significant effect. Precisely, there are Gender and Handedness differences in spatial ability as well as in drawing the 60' angle for right-handed subject. The other task somehow was not so sensitive to pick up the differences.

Now, alternatively can we assume the gender differences are disappearing in the changing-ecological and political climate? We cannot say that they are entirely disappearing but becoming minimum gradually. On other hand we may further say that in our present study we have tried to use some tests which might not be sensitive to pick up sex or handedness difference (e.g. Angle drawing). It might be that spatial ability and its relation with sex and handedness is task dependent. In order to find precise relationship we further need more controlled experiment and also need various other tasks of spatial and non-spatial ability. Moreover, we may revise or modify the methodologies according to changing environment, subjects, age specific, degree of urbanization etc. all these factors influence these differences. Hence all of us would agree that if we remind of Halpern (1992) who laid more stress to know other's ethic, cultural values, social structures etc. we will come to an understanding that the gender differences are partly controlled by biological and socio-cultural processes. Thus it would be safer to say that as far as present study is concerned, the gender differences are not significant in maximum tasks, which may be due to changing atmosphere where men and women are equally participating in different walks of life, influencing in many ways: their thinking, skills, rational vision, intellectual aspects etc. besides the political aspects of famine movements for more power in social structure are equally responsible for minimizing the gender differences. At last, we may conclude that answers to all these are interwoven in the web of *bio- socio-cultural fabric* of the society.

KEY WORDS Handedness; gender differences; spatial ability.

ABSTRACT The sex- related differences in the cognitive functions are fairly well established and documented as well at least in three different areas viz. Mathematical, verbal skill and spatial visualization (Maccoby and Jacklin, 1974). Precisely, the research on cognitive abilities of men and women has a long history. But it does not imply that there is well documented literature, on the similarities and differences, have not yet agreed on the extent and origin of these differences rather than on the theoretical origins of presumed differences (McGuiness, 1989). After reviewing the literature on human handedness, spatial abilities and gender differences in the cognitive functioning, the various ***hypothesizes*** have emerged out and it has been tried to make an attempt to test some of them. So with this view, the present study was conducted on the college going students of the CCS

University, Merrut, U P. Present study is an attempt to understand the human handedness, spatial ability and gender differences in the cognitive functioning. Most of the tests did not reveal the significance in gender differences in spatial ability except mental rotation task (MRT) for sex and handedness. Sex differences indicate the significant differences in mental rotation task. Similarly Handedness also exhibits the similar differences. But the interaction between two variables (Sex and Handedness) is non-significant. In mathematical task, to draw an angle of 60', only the interaction between Sex and Handedness reveal significant effect. Precisely, there are Gender and Handedness differences in spatial ability in drawing the 60' angle for right-handed subjects and Mental Rotation Task (*MRT*), whereas the other task somehow were not so sensitive to pick up the differences.

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