METHODOLOGY
Chapter - III

METHODOLOGY

This chapter deals with the methodology of the present study elaborating the design, sample, instruments, procedure and the proposed techniques of statistical analysis.

I. DESIGN:

Keeping the objectives of the study in mind a 2 x 3 factorial design with unequal cell frequencies was used. Table 4.1 shows the design of the study.

Table 4.1 - Design of the Study

<table>
<thead>
<tr>
<th>Handedness groups B →</th>
<th>Sex A ↓</th>
<th>rs --</th>
<th>rs +</th>
<th>rs ++</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females (a₁)</td>
<td>a₁b₁</td>
<td>a₁b₂</td>
<td>a₁b₃</td>
<td></td>
</tr>
<tr>
<td>Males (a₂)</td>
<td>a₂b₁</td>
<td>a₂b₂</td>
<td>a₂b₃</td>
<td></td>
</tr>
</tbody>
</table>

The above putative genotypic groups were formed on the basis of the scores on hand preference and laterality index. Sex and handedness groups were the independent variables of the study. Sex (A) had two levels: females (a₁) and males (a₂). Handedness groups (B) had three levels: rs --
(b₁), rs + − (b₂) and rs ++ (b₃). These groups were tested on a number of cognitive ability measures viz., intelligence and creativity.

II. SAMPLE

Determination of the size of the sample is always a difficult problem. Of course, the sample should be based on some technical and statistical considerations. Studies conducted earlier in the Western countries, have recommended that studies of asymmetry should be conducted on diverse populations.

Though, according to Burroughs (1971), the exact size of a sample should be decided on statistical considerations, number of Ss in the present study, however is based on practical rather than statistical considerations.

First Stage Sampling:

The sample of the study was selected following multistage sampling. Initially, 2645 subjects (1465 males and 1180 females) with a mean age of 15.28 years (S.D. = 4.80) ranging from 5 to 60 years were selected. These subjects completed the Handedness Inventory (Sharma, 1986) translated in Hindi by the investigator (Appendix - A). This inventory with 17 items was given to the literate subjects who were from various schools and colleges (including students & staff members) in Rohtak and Bhiwani Districts. Ss easily accessible from various localities of Rohtak and Bhiwani cities were also included. Thus, the subjects were from both rural and urban areas. Figures 4.1, 4.2 and 4.3 show the distributions
of total subjects, males and females respectively on the basis of hand preference scores. All the three distributions are J-shaped with a strong peak at the right most extreme, a less pronounced peak at the left most extreme and relatively few individuals clustered around the neutral points. The proportion of females (0.77) was slightly higher than that of males (0.71) among the right-handers.

The primary objective of this sampling was to select a representative sample of right, mixed and left handed subjects from both the sexes. Ultimately, 240 subjects (80 in each handedness group) were selected on the basis of hand preference using the sum score of 17 items of the handedness inventory (Hindi). For each item there were five categories describing the degree of hand preference always right (scoring +2), mostly right (+1), left and right hand equal (0), mostly left (−1), always left (−2). The sum score of the 17 items, indicating degree of hand preference, can vary from +34 for scoring right handers to -34 scoring for left handers.

A large number of subjects obtained a score +34 on handedness inventory. Of these 80 subjects were randomly selected in the right-handed group. There was a small number of left handed subjects who obtained a hand preference score of −34. So, it was decided to select subjects in left-handed group who scored between −34 to −30 on handedness inventory. A score of 10 left and right from zero is defined as mixed-hander. The subjects scoring zero or near zero equally prefer both hands. Keeping the %age of left-handers in mind (8% in general population, Sneddon & McManus, 1991), it
Fig. 4.1: Distribution of hand preference scores (N=2645)

Skewness = -2.41
Kurtosis = 4.88
SE = 0.34
SD = 1.729
Mean = 25.03
Hand Preference Scores

Fig. 4.2: Distribution of hand preference scores for Males (N=1465)

- Skewness = -2.01
- Kurtosis = 0.271
- SE = 0.54
- SD = 19.66
- Mean = 23.02

Preference scores (N=1465)
Fig. 4.3 : Distribution of hand preference scores Females (N=1180)

- Skewness: -3.13
- Kurtosis: 10.30
- SE: 3.89
- SD: 13.40
- Mean: 27.53

Hand Preference Scores
Laterality Index (L.I) = 100 x (R-L)/(R+L) of Dotting Circles, Copying Alphabets & Tapping Alternatively (N=240)

Fig. 4.4: Distribution of averaged L.I. of Right-handers vs Left-handers

Fig. 4.4: Distribution of averaged L.I.
was decided to include subjects scoring between -10 to +10 in the mixed-handed group.

On the basis of above criteria a sample of 240 subjects (80 in each group) viz., left-handed (mean age = 16.14 years; S.D. = 6.13 years), mixed-handed (mean age = 17.94 years; S.D. = 7.50 years) and right-handed (mean age = 16.94 years; S.D. = 2.32 years) were selected. Sample characteristics (N=240) are presented in Table 4.2 & 4.3.

Table 4.2 :- Domicile and Hand Preference wise number of subjects in each group.

<table>
<thead>
<tr>
<th>Domicile</th>
<th>Left-Handers</th>
<th></th>
<th>Mixed-Handers</th>
<th></th>
<th>Right-Handers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>M</td>
<td></td>
<td>F</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>13</td>
<td>38</td>
<td>2</td>
<td>26</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>Urban</td>
<td>12</td>
<td>17</td>
<td>26</td>
<td>26</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>55</td>
<td>28</td>
<td>52</td>
<td>44</td>
<td>36</td>
</tr>
<tr>
<td>G.Total</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>
Table 4.3 :- Educational Qualifications and Hand-Preference wise number of subjects in each group.

<table>
<thead>
<tr>
<th>Educational Qualifications</th>
<th>Left-Handers</th>
<th>Mixed-Handers</th>
<th>Right-Handers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>Low (Level I)</td>
<td>5</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>Medium (Level 2)</td>
<td>19</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>High (Level 3)</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Very High (Level 4)</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>55</td>
<td>28</td>
</tr>
<tr>
<td>G.Total</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

Note :- Level 1 - 6th to 8th class, Level 2 - 9th to 12th class.
Level 3 - B.A. I to B.A. III, Level 4 - M.A. & Above

Second Stage Sampling:

The main objective in this stage of sampling was to divide the subjects into three putative genotypic groups viz., rs – –; rs + – and rs ++ as left handers, mixed handers and right handers respectively on the basis of laterality index (L.I.). It was ensured that all the subjects who participated in this stage of sampling were physically and mentally fit.

For dividing the subjects into different handedness groups (rs – –, rs +–, rs ++) on the basis of laterality index (L.I.) a Hand Proficiency Task Battery (HPTB) was prepared by the investigator (details given ahead). The 240 subjects selected in the 1st stage were administered HPTB and measures of intelligence and creativity. The HPTB consisted of 11 tasks viz., Dotting Circles (DC), Tracing Stars (TS), Copying Alphabets (CA), Cutting Marked Paper (CMP); Thread Pegging (TP), Pegging Holes (PH),
Screwing Holes (SH), Grip Power Holding (GPH), Grip Power Counting (GPC), Tapping Both Hands (TBH); and Tapping Alternatively (TA) from left to right and right to left. In addition to HPTB, handedness inventory, was again administered on these 240 subjects to check the retest reliability of the inventory.

To form the tripartite genotypic groups viz., rs —, rs + — and rs + +, genotypes were estimated on the basis of behavioural phenotypes. Though hand preference is also a phenotypic expression of genotype, yet it is influenced by societal and cultural factors (Connoly and Bishop, 1992, Corballis, 1991). Therefore, in addition to hand preference, it was decided to test the subjects on Hand Proficiency Task Battery (HPTB) to calculate the laterality index (L.I.). The L.I. gives an estimation as to which hand the subject is more proficient. This method of dividing the subjects in different genotype groups has been used by various researchers (Annett, 1985; McManus et.al., 1993; Palmer and Corballis, 1996; and Resch et. al., 1997).

For dividing the subjects into three different genotype groups viz., r− −, r + − and r + +, the laterality index (L.I.) was calculated for all the 11 HPTB tests. The L.I. for each test was $100 \times \frac{(R-L)}{(R+L)}$, where ‘R’ means score for the right hand and ‘L’ the score for left hand. The range of L.I. was −100 to +100 for the HPTB tests. To remove the negative values a constant of 100 was added. Thus, the range became 0 to 200.

Coefficients of correlation between the L.I. and hand preference scores (HS-I, score + 50 as constant) were calculated. (Table 4.4). All the
inter-correlations are significant (beyond .01 level of significance) lowest being 0.29 between tapping alternatively (TA) and screwing holes (SH). This shows the validity of the selection of HPTB tests. The inter-correlation matrix was factor analysed. Factor analysis (unrotated, Principal Component Analysis) yielded one factor with Eigen value > 1 accounting for 51.9% of the variance (Table 4.5). The varimax rotation was carried out and the obtained rotated factor matrix is given in Table 4.6. The factor loadings declined but the order remained the same as in the unrotated factor matrix.
Table 4.4: Intercorrelations Matrix

<table>
<thead>
<tr>
<th></th>
<th>CA</th>
<th>CM P</th>
<th>DC</th>
<th>GPC</th>
<th>GPH</th>
<th>HS-I</th>
<th>PH</th>
<th>SH</th>
<th>TA</th>
<th>TBH</th>
<th>TP</th>
<th>TS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>1.00</td>
<td>.59</td>
<td>.74</td>
<td>.50</td>
<td>.41</td>
<td>.74</td>
<td>.41</td>
<td>.44</td>
<td>.59</td>
<td>.45</td>
<td>.46</td>
<td>.60</td>
</tr>
<tr>
<td>CMP</td>
<td>1.00</td>
<td>.56</td>
<td>.43</td>
<td>.40</td>
<td>.67</td>
<td>.39</td>
<td>.43</td>
<td>.43</td>
<td>.40</td>
<td>.41</td>
<td>.39</td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>1.00</td>
<td>.46</td>
<td>.40</td>
<td>.74</td>
<td>.42</td>
<td>.43</td>
<td>.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPC</td>
<td>1.00</td>
<td>.54</td>
<td>.61</td>
<td>.35</td>
<td>.39</td>
<td>.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPH</td>
<td>1.00</td>
<td>.64</td>
<td>.36</td>
<td>.41</td>
<td>.39</td>
<td>.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HS-I</td>
<td>1.00</td>
<td>.57</td>
<td>.58</td>
<td>.69</td>
<td>.58</td>
<td>.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>1.00</td>
<td>.49</td>
<td>.49</td>
<td>.42</td>
<td>.38</td>
<td>.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH</td>
<td>1.00</td>
<td>.40</td>
<td>.29</td>
<td>.41</td>
<td>.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA</td>
<td>1.00</td>
<td>.51</td>
<td>.39</td>
<td>.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBH</td>
<td>1.00</td>
<td>.34</td>
<td>.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP</td>
<td>1.00</td>
<td>.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All coefficients of correlation are significant at .01 level

CA - Copying Alphabets
CMP - Cutting Marked Paper
DC - Dotting Circles
GPC - Grip Power Counting
GPH - Grip Power Holding
HS I - Hand Preference Scores (I)
PH - Pegging Holes
SH - Screwing Holes
TA - Tapping Alternatively
TBH - Tapping Both Hands
TP - Thread Pegging
TS - Tracing Stars
## Table 4.5: Unrotated, Principal Component Factors

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor</th>
<th>Commu nality</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>.82</td>
<td>.67</td>
</tr>
<tr>
<td>CMP</td>
<td>.71</td>
<td>.51</td>
</tr>
<tr>
<td>DC</td>
<td>.79</td>
<td>.62</td>
</tr>
<tr>
<td>GPC</td>
<td>.66</td>
<td>.44</td>
</tr>
<tr>
<td>GPH</td>
<td>.66</td>
<td>.44</td>
</tr>
<tr>
<td>HS-I</td>
<td>.94</td>
<td>.88</td>
</tr>
<tr>
<td>PH</td>
<td>.65</td>
<td>.42</td>
</tr>
<tr>
<td>SH</td>
<td>.65</td>
<td>.42</td>
</tr>
<tr>
<td>TA</td>
<td>.74</td>
<td>.45</td>
</tr>
<tr>
<td>TBH</td>
<td>.63</td>
<td>.40</td>
</tr>
<tr>
<td>TP</td>
<td>.64</td>
<td>.40</td>
</tr>
<tr>
<td>TS</td>
<td>.69</td>
<td>.48</td>
</tr>
<tr>
<td>Eigen Value</td>
<td>6.23</td>
<td></td>
</tr>
<tr>
<td>% of variance accounted</td>
<td>51.90</td>
<td></td>
</tr>
</tbody>
</table>
From Table 4.5, it is clear that all the HPTB measures loaded significantly lowest being 0.63 on the 1st factor. Therefore, it was decided to take up the laterality indices (L.I.) of copying alphabets (CA), dotting circles (DC) and tapping alternatively (TA) because these were having the highest factor loadings. These three laterality indices were summed up and average was taken as the final laterality index.

Fig. 4.4 shows the distribution of averaged laterality indices (N=240). The distribution is bimodal as reported in studies of Borod et.al. (1984), Mc Manus et.al. (1993) & Resch et.al. (1997). There was a strong
relation between hand preference scores and laterality indices as is evident from Table 4.4.

On the basis of averaged L.I. the three genotype groups viz., rs --, rs + -- and rs ++ were formed. The 1st group rs -- consisted of the subjects whose L.I. was < Q₁ (86 and below). The rs ++ genotype group comprised of the subjects who obtained a L.I. > Q₃ (119.67 and above). With regard to second genotype group (rs + --, heterozygotes), it was decided to include those subjects who obtained a L.I. around Q₂. The subjects who obtained L.I. below the average of Q₁ & Q₂ : (Q₁ + Q₂)/2 = (87 + 109)/2 = 98 and below were dropped and the subjects whose L.I. was above the average of Q₂ & Q₃ : (Q₂ + Q₃) / 2 = (110 + 119.33) / 2 = 114.67 & above were also dropped. Thus, in this group only those subjects were included whose laterality indices (L.I.) were between 98 and 114.67. It was done to ensure that each group is composed of pure genotypes and there is no contamination as criticised by Mc Manus et.al. (1993) in case of Annett’s group II. Mc Manus et.al. (1993) criticised Annett’s group I (rs --, homozygotes) and group II (heterozygotes) by saying that these are non-comparable because group II contains some individuals having rs ---- genotype.

On the basis of above criterion, the number of subjects in each genotype group was 61, 51 and 55 for rs --, rs + -- and rs ++ respectively. From these 32 subjects in rs -- group were eliminated because there was no family history (FS -) of left-handers in their family and 11 subjects in rs ++ group were dropped as there was a positive family history (FS +) of left-
handers in their family. The number of subjects in each genotype group are presented in the table 4.7.

Table 4.7: Showing subjects in each genotype group

<table>
<thead>
<tr>
<th>Handedness groups</th>
<th>B</th>
<th>→</th>
<th>rs −</th>
<th>rs +</th>
<th>rs ++</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex A ↓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>10</td>
<td>18</td>
<td>24</td>
<td>52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>19</td>
<td>33</td>
<td>20</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>51</td>
<td>44</td>
<td>124</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Third stage sampling for comparison among right-handers only

The subjects were also divided into three groups of right-handed subjects only on the basis of Mc Manus et al’s (1993) criterion. The subjects whose laterality index (L.I.) was < 100 (subjects scoring negative L.I. after subtracting the constant of 100) were dropped because they were left handers by performance. In this way out of 240 subjects who were tested on HPTB and cognitive measures 90 were dropped. 50 subjects were having laterality index of 120 and above. From these 10 subjects having positive family sinistrality were dropped, thus R₃ (strong dextrals) group comprised of 40 subjects. 20 subjects having laterality index from 0 to 106.33 were excluded and the remaining 80 subjects were divided equally into R₁ (weak dextrals) and R₂ (less strong dextrals) groups. R₁ group included subjects having laterality indices between 107 to 114 and R₂ group having laterality indices from 114.33 to 120.00.
Table 4.8: Showing Subjects in each $R_1$, $R_2$ and $R_3$ group

<table>
<thead>
<tr>
<th>Sex</th>
<th>$R_1$</th>
<th>$R_2$</th>
<th>$R_3$</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>14</td>
<td>16</td>
<td>24</td>
<td>54</td>
</tr>
<tr>
<td>Males</td>
<td>26</td>
<td>24</td>
<td>16</td>
<td>66</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>120</td>
</tr>
</tbody>
</table>

The sample selection at various stages is given in Table - 4.9
Table 4.9 - Showing Multi-Stage Sampling

1st Stage Sampling on the basis of Hand Preference

Total Subjects = 2645

- Females (1180)
- Males (1465)

- Left Handers (-34 to -30)* (80)
- Mixed Handers (-10 to +10) * (80)
- Right Handers (+34)* (80)

- Females (25)
- Males (55)
- Females (28)
- Males (52)
- Females (44)
- Males (36)

- FS + (10)
- FS - (15)
- FS+ (28)
- FS- (6)
- FS + (32)
- FS - (8)
- FS + (36)
- FS - (6)

2nd Stage Sampling on the basis of Laterality Index

- rs -- (86 & below)** (61)
- rs + - (87 - 109)** (58)
- rs + - (110 - 119.33)** (66)
- rs + + (119.67 & above)** (55)

- FS + (29)
- FS - (32)

- Females (10)
- Males (19)

- Females (18)
- Males (33)

- Females (24)
- Males (20)

3rd Stage Sampling on the basis of Laterality Index

- 50 (Below 100)** (40)
- 20 (100.33 to 106.33)** (40)

- R1 (107 to 114)** (50)
- R2 (114.33-120)** (50)
- R3 (120 & above)** (50)

- FS + (10)
- FS - (40)

- Females (14)
- Males (26)

- Females (16)
- Males (24)

- Females (24)
- Males (16)

FS + = Positive Family Sinistrality
FS - = Negative Family Sinistrality

* Hand Preference Scores
** Laterality Index (L.I.) = 100 x (R - L) / (R + L)
INSTRUMENTS:

The following tools were used in the present study:

I. **Handedness Inventory (Hindi)**

For measuring hand preference Handedness Inventory developed by Sharma (1986) consisting of 17 items was translated in Hindi by the investigator (Appendix-A). This inventory (Sharma, 1986) was given to five teachers who were teaching Psychology and English in P.G. Colleges. They were asked to translate it into Hindi. On the basis of majority opinion the most agreed translation of the items was retained. The Hindi version of the inventory was again given to these teachers after a few days to re-translate it into English. The English translation was almost similar to the original one. This inventory was administered during the 1st stage of sampling to 2645 subjects. It yielded hand preference scores (HS-I). It was also given to 240 subjects selected during second stage of sampling within a gap of one month to six months. These hand preference scores were titled as HS-II.

The coefficient of correlation between 1st testing (HS-I) and 2nd testing (HS-II) was found to be 0.99. It indicates that the handedness inventory (Hindi) is a highly reliable instrument. To estimate the validity of the inventory, the HS-I scores were correlated with 11 tasks of HPTB. The obtained coefficients of correlation (Table 4.4) are significant (beyond .01 level of significance). The HS-I scores significantly correlated with all the 11 tasks of HPTB (External criterion) indicating high criterion validity of
the handedness inventory in Hindi. The range of coefficients of correlation is 0.57 to 0.74.

The correlation matrix was factor analysed. The Unrotated Principal Component Analysis (Table 4.5) yielded only one factor. All the 11 tasks of HPTB significantly loaded on the 1st factor. HS-1 also loaded significantly on this factor. It is another indication of high validity of the handedness inventory (Hindi).

The original Handedness Inventory (Sharma, 1986) contains 17 items with coefficients of reliability ranging from 0.85 to 0.979 and validity from 0.63 to 0.69. It is a 5 point scale. For each item there are five categories describing scoring the degree of hand preference:

<table>
<thead>
<tr>
<th>Response Categories</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always Right</td>
<td>+2</td>
</tr>
<tr>
<td>Mostly Right</td>
<td>+1</td>
</tr>
<tr>
<td>Left &amp; Right Hand Equal</td>
<td>0</td>
</tr>
<tr>
<td>Mostly Left</td>
<td>-1</td>
</tr>
<tr>
<td>Always Left</td>
<td>-2</td>
</tr>
</tbody>
</table>

The sum score of the 17 items, indicating degree of hand preference can vary from +34 for strong right handers to −34 for strong left handers. The scoring system for Handedness Inventory (Hindi) is exactly similar to the original one. Thus, the scores on this inventory ranged from −34 to +34. A constant of 50 was added just to convert the scores in unidirection.
Hand Proficiency Task Battery (HPTB)

To find out as to which hand a subject is more proficient, a Hand Proficiency Task Battery (HPTB) was prepared by the investigator. It included 11 tasks (Appendix - B):

(i) Dotting Circles (DC)
(ii) Tracing Stars (TS)
(iii) Copying Alphabets (CA)
(iv) Cutting Marked Paper (CMP)
(v) Thread Pegging (TP)
(vi) Pegging Holes (PH)
(vii) Screwing Holes (SH)
(viii) Grip Power Holding (GPH)
(ix) Grip Power Counting (GPC)
(x) Tapping Both Hands (TBH)
(xi) Tapping Alternatively from left to right and right to left (TA)

Each task except grip power holding (GPH) was to be performed with maximal speed and precision for 30 seconds. Each task has enough length or items to make sure that no ceiling effect appeared. For all the tasks practice trials were given and tasks for the right hand started from left to right and those for the left hand from right to left. A brief description of each task is given below:
(i) **Dotting Circles (DC)**

It is a paper and pencil dexterity task where discrete pencil marks (dots) had to be put in a curved rows of small circles. The subject was asked to put dots in the circles for 30 seconds with each hand. The number of dots put in the circles with right and left hand were taken as the scores on this test (Appendix - B).

(ii) **Tracing Stars (TS)**

It is also a paper and pencil dexterity task where a line within a twisting and narrow track of a star had to be drawn in the shape of stars for 30 secs. with each of the left and right hand. The number of corners of the star traced per unit of time was taken as the scores on this test (Appendix - B).

(iii) **Copying Alphabets (CA)**

It is a paper and pencil dexterity task. The subject was asked to copy the written alphabets with right and left hand for 30 secs. The number of words copied with each hand was taken as the score on this test (Appendix B).

(iv) **Cutting Marked Paper (CMP)**

It is a paper and scissors dexterity task where an English ruled white paper sheet was to be cut with the help of scissors. The length of
paper cut (in inches) per unit of time (30 secs.) with each hand was taken as the score on this test (Appendix - B).

(v) **Thread Pegging (TP)**

It is a peg-board dexterity test in which the thread is to be wrapped to pegs with each hand. There are 20 pegs on a wooden board of 17½” x 5½” x 3/4” with pegs fitted away from each other. The number of pegs wrapped with thread was taken as the score on this test as per unit of time (Appendix - B, Plate - I).

(vi) **Pegging Holes (PH) and (vii) Screwing Holes (SH)**

These two tasks were completed with the help of Crawford Small Parts Dexterity Test (CSPDT, Crawford & Crawford, 1981). It is metal plate fitted in a wooden board about 10”x10”x1” with separate wells for pins & screws. The plate contains 7 rows of small holes for the pins and 7 rows of threaded holes for the screws. The first row of each series of holes is for practice. The number of pins put in the holes and number of screws tightened in the threaded holes were taken as the scores for these tests (Appendix - B, Plate - II).

(viii) **Grip Power Holding (GPH)**

In this task the subject has to tightly hold a gripper purchased from a sports shop and attached to a electronic chronoscope to measure time. The length of time in seconds was taken as the score on this task. It is
the only task where time was not restricted. The subject can hold the instrument tightly unless he feels tired (Appendix-B, Plate - III)

(ix) **Grip Power Counting (GPC)**

In this task the subject has to hold and release the gripper for 30 seconds. Grip power counting was done with the help of an electronic counter with reset facility. The number of times the gripper was held and released gave the total number of counts and it was taken as the score on this test (Appendix-B, Plate - IV).

(x) **Tapping Both Hands (TBH) and (xi) Tapping Alternatively (TA)**

_ from left to right and right to left_

These two tasks were measured by a simple instrument fitted with two independent telegraphic keys for both hands and two electronic counters contained within an automatic sequence and time controlled device with preset time arrangement and reset facility. It was an A.C. operated apparatus. Number of finger taps with each hand was taken as score for tapping both hands (TBH). Number of finger taps from left to right with right hand and number of finger taps from right to left with left hand was taken the total score for right and left hand respectively for tapping alternatively (Appendix-B, Plate - V).

The coefficients of correlations were calculated among all the laterality indices (L.I.) and H.S-I (after adding a constant of 100 to L.I. and 50 to HS-I). The correlation matrix is given in Table 4.4. All the L.I. correlated significantly and positively with each other. Factor analysis

92
Principal Component Analysis and Varimax Rotation) yielded only one factor with Eigen value > 1 accounting for 51.9% of the variance (Table 4.5). The L.I. of three tasks viz., dotting circles (DC), copying alphabets (CA) and tapping alternatively (TA) were taken since these were having highest factor loadings (Table - 4.5). The three laterality indices were summed up and the average was taken as the final laterality index (L.I.) score for dividing the subjects into different, putative genotype groups as described under sample.

3. **Cognitive Abilities:**

To evaluate cognitive ability a battery of the following tests was carefully selected.

(i) **Raven's Standard Progressive Matrices (SPM), Sets A-B-C-D and E.** Developed by J.C. Raven (1958) to measure the non-verbal intelligence of the subjects (reasoning and thinking).

(ii) **Group Test of General Mental Ability (Hindi) standardised by Dr. S. Jalota (1976)** to measure the verbal, numerical and reasoning abilities of the subject.

(iii) **Non-verbal Test of Creative Thinking, developed by Baqer Mehd (1985)** to assess the two dimensions of creative ability, namely elaboration and originality.

(i) **Standard Progressive Matrices (SPM)**

The Standard Progressive Matrices, is used to judge a person's capacity, at the time of the test, to apprehend meaningless figures presented for his observations, to see the relations between them and to
conceive the nature of the figure. Completing each system of relations presented, and by so doing develop a systematic method of reasoning. Each problem in the scale is really the "mother" or "source" of a system thought—hence it is called "Progressive Matrices".

The scale is intended to cover the whole range of intellectual development from the time a person is able to grasp the idea of finding a missing piece to complete a pattern.

The author claims that the scale has reliability, varying with age from .83 to .93. It correlates .86 with Terman Merill Scale and has been found to have a "g" saturation of .82. Some studies with adults have yielded very high correlations ranging from + 0.75 to + 0.88 between SPM and WAIS scores.

Scoring: A person's score on the scale is the total number of problems he solves correctly when he is allowed to work quietly through the series from the beginning to the end.

The consistency of his work can be assessed by subtracting from a subject's score on each of the five sets, the score normally expected on each set for the same total score on the scale. The difference between the score a subject obtains, on each set and that normally expected for his total, can be shown numerically as:

"Discrepancies : 0, -1, +2, +1."
If a subject’s score on one of the sets deviates by more than 2, his total score on the scale cannot be expected at its face value as a consistent estimate of his general capacity for intellectual activity."

However, Raven (1958) believes that, for general purpose, the total score appears to be relatively valid even if discrepancies of more than 2 points occur in the break-up. This is the reason that discrepancies were not taken into account in the present study. Similarly, the time taken by the subject in completing the task was not recorded as it was not to be used in the interpretation of the scores. In fact, all the scores obtained from the subjects were ultimately used in the analysis of the data.

**ii) Group Test of General Mental Ability -Hindi (Jalota, 1976)**

Jalota’s general mental ability test in Hindi (Jalota, 1976) was first developed in 1951. It was a group test consisting of 100 items divided into 5 sub-tests of 20 items viz., vocabulary, classification, number series, reasoning and analogy test. The author revised the test in 1972 with certain modifications. This revised test has 100 items. It consists of seven sub-tests. These seven sub-tests are similarity, opposites, classification, number series, best answers, reasoning and analogies having 10,10,20,20,10,10,20 items respectively. These 100 items were mixed according to an estimated order of difficulty, from minimum to the maximum difficulty of about 20 percent success. It is a group administered speed test with a strict time limit of 20 minutes. This test has been found to be useful for the age range of 12-18 years.
The standardization study of this test was conducted on one thousand students of the three classes - 8th, 9th and 10th in various groups from rural and urban areas. The split-half reliability coefficients for different classes, were found to be 0.879, 0.932 and 0.979 for 8th, 9th and 10th class respectively, the validity of the revised test has been reported on the basis of factor analysis of inter-element scores, which gave a pattern of three centroid factors. Further, the contribution of V, N, R (Verbal, numerical and reasoning ability), sub-tests of the total scores of the final version have also been reported. Multiple correlation between V, N, R and total scores for a group of 363 students of 10th class were reported to be 0.683, 0.599 and 0.874 for the total score and V,N, R sub tests. And for the 9th class these were reported to be 0.9033, 0.8004 and 0.8565 for total score and V, N, R sub-test scores respectively.

A score of one is to be given for each correct response. Thus, the total score can range from 0 to 100. For verbal ability (V) there are 40 items. The scores may range from 0 to 40. There are 20 and 40 items respectively for numerical ability (N) and reasoning ability (R). The scores on these factors can range from 0 to 20 for (N) and 0 to 40 for (R).

(iii) Non-verbal Test of Creative Thinking (Bagher Mehdi, 1985)

This test was meant to identify creative talent at all stages of education except pre-primary and primary. The types of tasks included in the test have been chosen so that they could be most easily and economically administered over a wide range of sample, starting from middle school and going up to the higher level of education. This test is being extensively used in researches on creativity in all parts of the country.

The non-verbal test is a part of the total battery which consists of both verbal and non-verbal tests. The non-verbal test of creative thinking is intended to measure the individual’s ability to deal with figural content in a creative manner. Three types of activity are used for this purpose, viz., picture construction, picture completion, and triangles and eclipses. The total time required for administering the test is 35 minutes. A brief rationale and description of these activities are given below.

1. **Picture Construction Activity**

Picture construction has long been used as a measure of child’s creative thinking. This activity allows for unrestricted fluency of ideas which may enable the subject to use his unconscious mind to help him to construct a picture which is relevant to his thought and personality structure.

This activity presents the subject with two simple geometrical figures, a semi-circle and a rhomb, and requires him to construct an elaborate picture using each figure as an integral part. The subject is allowed to turn the page to use the figure in any way he likes for making the picture. Emphasis is put on originality and elaboration. Originality is emphasized by the instruction that the subject should try to make as novel a picture as possible, such that no one else will able to produce. Elaboration is emphasized by the instruction that the subject may add as many details as he thinks necessary in order to make the picture tell as complete and as interesting a story as possible. Ten minutes are allowed for the two tasks.
The pictures are scored for elaboration and originality. The subject is also asked to give an interesting and unusual title to each picture. The titles may also be scored for verbal elaboration and originality.

2. **Incomplete Figures Activity**

This activity has also been used by a number of psychologists to study the personality and thought patterns of children. "An incomplete figure sets up an individual's tension to complete it in the simplest and easiest way possible. Thus, to produce an original response, the subject has usually to control his tensions and delay gratification of this impulse to closure" (Torrance, 1966). The activity consists of 10 line drawings which could be made into meaningful pictures by different objects. The subject is asked to make the picture which no one else in the group will be able to think of. He is also asked to give an interesting and suitable title to each picture he makes. The subject is given 15 minutes for the 10 items. Each item is scored for elaboration and originality. Titles may also be scored for verbal elaboration and originality.

3. **Triangles and Eclipses Activity**

This activity is based on the idea of Torrance's parallel lines and circles where repeated figures are given and the subject's novelty can well be assessed by the construction of different types of figures from the same given structure. Generally, non-creative subjects fail to construct new patterns out of the same figure, but creative subjects originate new patterns and also do a good deal of elaboration.
In this activity the subject is provided with 7 triangles and 7 eclipses and he is required to construct different meaningful pictures based on the two given stimuli. As the subject is here encouraged “ to make multiple associations to single stimuli”, the responses could be scored for flexibility also, besides elaboration and originality, but as this is the only activity in which flexibility scoring is possible, it is recommended that here too the test user should confine himself to elaboration and originality scoring alone. So in the present study flexibility was not scored. A total time of 10 minutes is allowed for this activity.

The subject is also asked to give an interesting and suitable title to each picture which should also be scored for verbal elaboration and originality.

The three activities taken together provide ample opportunity to the subject to use his imagination with different types of figural tasks and come out with some novel ideas.

**Reliability and Validity of Non-verbal Test of Creativity:**

The retest reliability of the test is considerably high, ranging from 0.932 to 0.947. The validity coefficients against the teacher ratings and the total creativity scores are reported to be 0.346, 0.329 and 0.385 respectively for elaboration, originality and the creativity scores. A scoring guide is also provided in the manual. The investigator used this scoring guide and also made his own norms.
PROCEDURE:

The study was conducted in two stages. In the 1st stage a total of 2645 subjects (Males = 1465; Females = 1180) were administered handedness inventory in Hindi. On the basis of hand preference scores 240 Ss (80 in each handedness group) were selected (criteria described in the section of sample).

In the IInd stage these 240 subjects were tested on Hand Proficiency Task Battery (HPTB) and measures of intelligence and creativity. In this stage the subjects were tested either in schools/colleges or at the investigator’s residence. A date was fixed according to the convenience of the subjects and the school/college authorities. HPTB and measures of intelligence & creativity administered in two sessions.

In the 1st session Hand Proficiency Task Battery (HPTB) was administered individually. A separate and quiet room with proper electricity fittings and ventilation for air and light was chosen for the purpose. The table on which apparatuses were set, was chosen to be suitable for the average height of the subjects (children and adults), so as to make their tapping and other tasks easily. The subject was seated in front of the experimenter. The experimental arrangement was suitable and convenient to both the subject as well as experimenter. The conversations were carried out in Hindi.

In these experiments, the subjects after being made comfortable and acquainted with the apparatuses were instructed to perform the different tasks as fast as possible with their left or right hand as
instructed. Uniform sets of instructions were given and testing conditions were same for all the subjects. The subjects were tested by the investigator with the help of a trained assistant. After ensuring that, the subjects had fully understood the way he had to perform and the apparatuses were functioning properly, the experimentation began. With the verbal command of ‘start’, the subject began to work as instructed. After 30 seconds he was asked to stop. The total number of scores according to the method described earlier were recorded on the record blank. Here ends up the experimentation of one subject on Hand Proficiency Task Battery (HPTB). Proceeding in the same manner, the remaining subjects of the 1st session were tested. In this session the subjects were also administered Handedness Inventory (Hindi). All the relevant informations such as family sinistrality, domicile and permanent addresses of the Ss were gathered. After completion of the 1st session, a rest of 15 minutes was provided so as to control the fatigue effect.

IIInd Session

During the IIInd session a battery of tests was given in a group setting. The subjects were served with different cognitive ability measures described at an early stage in this section. All the tests were administered strictly according to the prescribed procedures given in the tests' manual. Strict vigilance was maintained during the course of administration of the tests.

In this session, first of all Standard Progressive Matrices (SPM; Raven, 1958) was administered to a group of ten subjects. A break of 5 minutes was given when all the Ss completed this test. After the break, these ten subjects were given General Mental Ability Test (GMAT; Jalota, 1976).
After completing this test a Non-verbal Test of Creative Thinking (Baqer Mehdi, 1985) was administered to the subjects in group setting.

As per the requirement of the design, first of all handedness groups on the basis of HPTB should have been formulated. But keeping in view the practical limitations such as availability of the Ss, time schedule from school/college authorities etc., it was decided to administer the measures of cognitive ability alongwith HPTB in the second stage of testing. The Ss were then divided into different genotype groups according to the laterality index (Table 4.9).

After completing the data collection scoring and tabulations were done. Scoring for Hand Proficiency Task Battery (HPTB) and Handedness Inventory was done as mentioned in the earlier section (Instruments) of this chapter. Scoring for all other tests was done strictly according to the procedures laid down in the tests’ manuals.

**STATISTICAL TREATMENT:**

The data were analysed on the basis of (i) Descriptive statistics, and (ii) Inferential statistics.

(i) Descriptive statistics like mean and standard deviation were employed to know the nature of the distribution of the variables taken up for the study.

(ii) Inferential statistics like two way analysis of variance with unequal cell frequencies weighted with harmonic mean, trend analysis through orthogonal polynomials and post-hoc analysis by Newman Keuls Test were done in order to suggest some definite relationship between handedness
groups and cognitive abilities. To examine the nature of this relationship
graphical representations were also portrayed.

All the sources in the analytical design were not of interest
and, therefore, not described in the results. To operationalize the effect of
handedness on cognitive abilities, two sources in the design were relevant to
hypotheses i.e. handedness and its interaction with sex. Therefore, even if
the sex difference is significant, it was not described in results.