THE PRESENT STUDY
OBJECTIVES

Handedness is related with brain and hand measures (White et al., 1994; Manning et al., 2000). Common genes express in brain and hand formation (Subin et al., 1997). Thus hand measures may serve as biological markers of lateralization (McManus, 1999).

The objective of present research is to study the link among handedness, other lateral preferences and disorders through their relationship with hand measures and thus to identify the determinants of handedness.

The study also seeks to validate relationship between hand measures and handedness through separately analyzing this relationship in two different but congruent samples i.e. equal left and right-handed, male and female.

Another objective of present study is to find out link between lateral preferences and personality.

HYPOTHESIS

Based on prior research, some hypothesis were formulated, which are given below:

- Male are weak handed as compared to female.
- Footedness, eyedness and earedness are closely related with handedness.
- The association between hand-foot, hand-eye, and hand-ear preference is stronger among right-handers as compared to left-handers.
- There is sex difference in hand-foot, hand-eye, and hand-ear concordance.
- Laterality in foot, eye and ear preferences are weaker as compared to laterality in hand preferences.
- Left-handers are more likely to have left-handed relatives as compared to right-handers.

- More left-handers have graying of hair, stuttering, learning disorders, allergies, nervous weakness, skin disorders, nail biting, drug abuse, asthma, migraine as compared to right-handers.

- Right-handers have larger right side asymmetry in hands as compared to left-handers.

- Left-handers have smaller 2\textsuperscript{nd} digit: 4\textsuperscript{th} digit ratio as compared to right-handers.

- Male have smaller 2\textsuperscript{nd} digit: 4\textsuperscript{th} digit ratio as compared to female.

- Right-handers have larger right-asymmetry in foot as compared to right-handers.

- Left-handers are more neurotic as compared to right-handers.

**VARIABLES**

In the present study, handedness and sex were *independent variables*. The footedness, eyedness, degree-of-handedness, disorders, forced handedness, familial-sinisterality and dimensions of personality were *dependent variables*.

For analysis in terms of hand measures, the handedness, footedness, eyedness, earedness, degree-of-handedness, levels-of-disorders and sex served as *independent variables*, while hand measures were the *dependent variables*.

**SUBJECTS**

The present study includes *two samples of students* from two institutes in different cities.
The first sample was taken from C.C.S. University, Meerut, with strength of 1000 students of postgraduate and research classes. The sample included 60 students with equal left, right, male and female categories. The subjects were aged: $M=25.18$ years, $SD = 2.46$ years.

The second sample was taken from D.A.V. (PG) College, Muzaffarnagar, with effective strength of 4000 regular students of undergraduate and above classes. 107 subjects including 27 left-handed female, 27 left hand male, 27 right-handed female and 26 right-handed male were selected. The subjects were aged: $M=21.53$ years, $SD = 4.01$ years.

Thus in combined sample, in a total of 167 subjects there were 42 left-handed female, 42 left-handed male, 42 right-handed female and 41 right-handed male. There were 20 left-handed female, 27 left-handed male, 24 right-handed female and 34 right-handed male above aged >21 years. All the subjects were neurologically normal.

The two places from where the samples were selected have some distinctive features. 

*Meerut is a metropolitan city with a cosmopolitan culture.* The C.C.S. University is partially residential and several students come from other states. The university has mix of rural and urban background students. With limited seats and merit list general IQ level is expected to be higher.

*The Muzaffarnagar on the other hand is a small city with stronger local cultural impact.* The D.A.V. College is an urban-based postgraduate college with minimal residential facilities and almost no student from other state. The population is a mix of urban and rural background students.
The description of subjects is given in tables below:

TABLE 1: Frequency of left- and right-handers between male and female in the first, second and combined data set.

<table>
<thead>
<tr>
<th></th>
<th>MALE</th>
<th>FEMALE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST SAMPLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(C.C.S.U, Meerut)</td>
<td>RIGHT-HANDED 15</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>LEFT-HANDED 15</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Population=1000</td>
<td>TOTAL 30</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>SECOND SAMPLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(D.A.V. College, Mzn)</td>
<td>RIGHT-HANDED 26</td>
<td>27</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>LEFT-HANDED 27</td>
<td>27</td>
<td>54</td>
</tr>
<tr>
<td>Population=4000</td>
<td>TOTAL 53</td>
<td>54</td>
<td>107</td>
</tr>
<tr>
<td>COMBINED SAMPLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population=5000</td>
<td>RIGHT-HANDED 41</td>
<td>42</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>LEFT-HANDED 42</td>
<td>42</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>TOTAL 83</td>
<td>84</td>
<td>167</td>
</tr>
</tbody>
</table>

TABLE 2: mean, standard deviation, minimum, maximum and range of age of the subjects in first, second and combined sample.

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
<th>STD. DEV.</th>
<th>MIN.</th>
<th>MAX.</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST SAMPLE</td>
<td>25.18</td>
<td>2.46</td>
<td>20.87</td>
<td>31.3</td>
<td>10.96</td>
</tr>
<tr>
<td>SECOND SAMPLE</td>
<td>21.53</td>
<td>4.01</td>
<td>16.22</td>
<td>36.44</td>
<td>20.22</td>
</tr>
<tr>
<td>COMBINED SAMPLE</td>
<td>22.84</td>
<td>3.94</td>
<td>16.22</td>
<td>36.44</td>
<td>20.22</td>
</tr>
</tbody>
</table>

TABLE 3: Frequency of left- and right-handed male and female among aged<21 years and aged>21 years in combined sample.
<table>
<thead>
<tr>
<th></th>
<th>MALE</th>
<th>FEMALE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGED&lt;21 YEARS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-HANDED</td>
<td>7</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>LEFT-HANDED</td>
<td>15</td>
<td>22</td>
<td>37</td>
</tr>
<tr>
<td>TOTAL</td>
<td>22</td>
<td>40</td>
<td>62</td>
</tr>
<tr>
<td>AGED &gt;21 YEARS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-HANDED</td>
<td>34</td>
<td>24</td>
<td>58</td>
</tr>
<tr>
<td>LEFT-HANDED</td>
<td>27</td>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>TOTAL</td>
<td>61</td>
<td>44</td>
<td>105</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>83</td>
<td>84</td>
<td>167</td>
</tr>
</tbody>
</table>

**TOOLS USED**

Three separate questionnaires, presented in the form of a composite questionnaire, were used to assess lateral preferences, personality and disorders.

Lateral preferences were assessed through a 31 items questionnaire. First 14 items measured handedness. The items were similar to one used in Oldfield questionnaire (Oldfield, 1971). Next 15 items, 5 items for each, assessed footedness, eyedness, and caredness. The items were similar to Coren’s lateral preference questionnaire as well as used in other studies (Coren, 1992; Singh et al, 2001; Mandal et al; 1993). The 5-point scale attached with the questionnaire was the same as used by Oldfield (Oldfield, 1971). The last two items referred to left-handed relatives (both maternal and paternal side and siblings) and experience of pressure to use right hand respectively.

The personality was assessed using a 60 items ‘Big Five’ personality questionnaire developed by Costa and McCrae (1992). A high reliability (test-retest = .91) and validity has been reported for this test (Costa & McCrae, 1992). The test
measured five broad personality traits: Agreeableness, Conscientiousness, Open-to-
experience, Neuroticism and Extroversion. Each item of personality test was
presented side by side in Hindi and English. A 7-point scale ranging from ‘highly
agree’ to ‘highly disagree’ was attached with each item.

A disorder questionnaire developed on the basis of prior research, assessed the
presence or absence (‘yes’, ‘no’ categories) of asthma, allergies, blood pressure,
learning disorders, migraine, sighting defects, skin disorders, stuttering, graying of
hair, nail biting, nervous weakness, and drug abuse.

Vernier calipers, measuring to the accuracy of .01 cm, were used to take the
measures of fingers, hand, and width of foot.

For foot length measure, in second sample, a foot-stand with heel rest at the back
and a millimeter scale placed under the foot was used.

**PROCEDURE**

Each subject was tested individually. Two questions i.e. *which hand do you use for
writing?* and, *which hand do you use for throwing ball?* (McManus, 1999), were
asked to initially screen the subjects. If subject reported left hand use for both or
either of activities, he/she was placed in left or non right-handed category. The
subject was then given the questionnaires of lateral preferences, personality and
disorders. The subject was asked to read carefully the instructions given with each
part of the composite questionnaire. The *following instructions* were given to the
subject:
General instructions:

“This questionnaire is only for the purpose of research, your cooperation is expected in the search of truth. The information given by you will be kept secret. This questionnaire has three parts separate instructions are given along with each part.”

Instructions for lateral preference questionnaire:

“If you always use one hand/foot/eye/ear then tick (✓) either always-right (e) or always-left (a). If you mostly use one hand/foot/eye/ear and sometimes other then tick (✓) generally right (d) or generally left (b). If you often use both hands/feet/eyes/ears equally then tick (✓) equally (c). Kindly don’t tick same answer to every question, instead, try to imagine doing each work and then accordingly give appropriate answer”

Instructions for personality questionnaire:

“Given below are some statements about you. It is likely that you may not fully agree or fully disagree with these statements. Therefore, a 7-point scale is attached with these statements, to let you express degrees to which you are in agreement or disagreement.

1 2 3 4 5 6 7
(Strongly-disagree) (Neutral) (Strongly-agree)

There is nothing right or wrong about these statements. You please give the answers that you feel are true about yourselves.”
Instructions for disorder questionnaire:

"Given below are varied questions regarding your physical-health?

Kindly read them carefully and answer. If the asked disorder has even occurred earlier then also give its details”

After completion of questionnaires, the subject was asked to put his hands on a smooth desk. The measures of hands and fingers of the subject were taken with the help of vernier calipers.

**HAND MEASUREMENT PROCEDURE:** 11 measurements in each hand were taken with the help of vernier calipers measuring to 0.01 cm accuracy. The measurement procedure has been found to show high degree of repeatability (Manning et al, 1998; Scutt & Manning, 1996). Efforts were made to measure hands along all the three axis of development — dorso-ventral, anterior-posterior, and proximo-distal (Shubin et al, 1997).

The measurement includes (a) **Dorsal-fingers-lengths**  (b) **Ventral-fingers-lengths** (c) **Widths-of-palm** and (d) **Length-of-palm**.

a) **Dorsal-fingers-lengths:** as shown in Figure (1a) the *dorsal finger length* (*a* to *b*) include the distance between the tip of the finger to the protruding base of proximal phalangial bone when the finger was bent at 90° angle to the palm.

b) **Ventral-fingers-lengths:** as shown in Figure (1b) the *ventral finger length* (*c* to *d*) includes the distance between the tip of finger to basal crease of proximal ventral phalange.

c) **Widths-of-palm:** it includes two measures, the *dorsal width* (*e* to *f*) and *ventral width* (*g* to *h*), as shown in Figure (1b). The *dorsal width* includes the
distance between the anterior limits of lifeline to posterior limit of heart line, which corresponds with the width at the base of dorsal fingers. The ventral width includes the distance between anterior limits of basal crease of ventral finger 5, which corresponds with the width at the base of ventral fingers.

d) Length of palm: as shown in Figure (1b), i to j points show the length of palm. It is the distance between the lower basal creases of ventral finger 3 to the protruding bone of wrist (in line with finger 3) at the base of palm.

Labels of the hand measures are shown in Table (4).

**FOOT MEASUREMENT PROCEDURE:** The foot measures were taken only in second sample. For taking measurement of foot the subject was seated on a chair and foot was placed on a foot stand with heel rest at the back.

Three measures (a) length of foot, (b) width of paw, and (c) relative length of toes, were taken in each foot.

a) **Length of foot:** included distance between back of the heel to tip of 1st toe (great toe), measured through the millimeter scale placed under the foot in foot stand instrument.

b) **Width of foot:** included distance between anterior limits of base of toe 1 to posterior limit of base of toe 5. The measurement was done through vernier calipers.

c) **Relative length of toes:** was assessed using toe formulas: toe 1 > toe 2 > toe 3 > toe 4 > toe 5 and toe 1 < toe 2 > toe 3 > toe 4 > toe 5.

Labels of foot measures in (a) and (b) are given in table (4).
Table 4: Hand- and foot-measure variables and the labels of the variables.

<table>
<thead>
<tr>
<th>VARIABLE LABELS</th>
<th>VARIABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-hand measures</td>
<td>Dorsal-finger-length</td>
</tr>
<tr>
<td></td>
<td>Ventral-finger-length</td>
</tr>
<tr>
<td></td>
<td>Width-of-palm</td>
</tr>
<tr>
<td></td>
<td>Length-of-palm</td>
</tr>
<tr>
<td>Within-hand ratios</td>
<td>dorsal-finger-lengths</td>
</tr>
<tr>
<td></td>
<td>Ventral-finger-lengths</td>
</tr>
<tr>
<td>Within-finger ratios</td>
<td>dorsal-ventral-lengths</td>
</tr>
<tr>
<td>Between-hand</td>
<td>dorsal-finger-length</td>
</tr>
<tr>
<td></td>
<td>ventral-finger-length</td>
</tr>
<tr>
<td></td>
<td>wid. &amp; length of palm</td>
</tr>
<tr>
<td>Within-foot</td>
<td>length measure</td>
</tr>
<tr>
<td></td>
<td>width measure</td>
</tr>
<tr>
<td>Between-foot</td>
<td>length measure</td>
</tr>
<tr>
<td></td>
<td>width measure</td>
</tr>
</tbody>
</table>

\( l = \text{Left} \quad d = \text{Dorsal} \quad wid = \text{Width of palm} \quad wd = \text{Width of foot} \)

\( r = \text{Right} \quad v = \text{Ventral} \quad len = \text{Length of palm} \quad ln = \text{Length of foot} \)

**TRANSFORMATIONS**

Some transformations were done in different measures:

**TRANSFORMATION IN LATERAL PREFERENCE SCORES:** Laterality quotients for each of the handed, footed, eyed, and eared were calculated using the formula:

\[
LQ_{......} = \frac{(\text{total value of items} - 3 \times \text{number of items}) \times 100}{(2 \times \text{number of items})}
\]
The frequency of right- and left-handed, footed, eyed and eared were calculated by converting the laterality quotient of respective lateral preferences into:

Left ...... = -100 to 0, and,
Right...... = 0 to 100.

Since the study involved a selected sample, a stringent criterion of strong preference was adopted. The strength of lateral preferences was categorized into weak and strong preferences by converting the laterality quotient of respective lateral preferences by a criterion given below:

Weak ... = -70 to 70

Strong... = -100 to −70, 70 to 100

**TRANSFORMATIONS IN PERSONALITY SCORES:** according to the procedure given in manual, reverse scoring was done in some of the items. Adding the scores of items five broad personality factors: Agreeableness, Conscientiousness, Neuroticism, Extroversion, and Open-to-experience, were calculated.

**TRANSFORMATIONS IN HAND MEASURES:** included calculating (a) within-hand-ratios (b) within-finger-ratios (c) between-hand-measures

a) Within-hand-ratios: included calculating (i) within-hand-dorsal-length-ratios, and (ii) within-hand-ventral-length-ratios. The two groups of ratios involve taking respective (dorsal and ventral) finger 2 lengths as numerator and then progressing to finger3 and finger 4 as numerator.

b) Within-finger-ratios: included ratios between dorsal and ventral length of same fingers in each hand.
(i) Between-hand-measures: included calculating (i) between-hand-dorsal-finger-length measures, (ii) between-hand-ventral-finger-length measures, and (iii) between-hand-widths-of-palm. The difference between corresponding length and width measures of right and left hand were calculated using the formula of bilateral asymmetry (Livshits et al, 1998):

\[ \text{Bet. Hand measure} = 2 \times \frac{(RH \text{ meas.} - LH \text{ meas.})}{(RH \text{ meas.} + LH \text{ meas.})} \]

The transformed hand measures are shown in Table (4).

Transformations of foot measures: included calculating (i) between-foot-length measure, and (ii) between-foot-width measure. The asymmetry in corresponding length and width of right- and left- hand were calculated using the formula of bilateral asymmetry as given above. The Table (4) shows the transformed foot measures.

**DESIGN AND STATISTICAL ANALYSIS**

The present study is a *quasi-experimental* study. The chi-square, odds ratios, correlations, t-test, uni-variate analysis of variance, multivariate analysis of variance and factor analysis were used to analyze the data. Prior to conducting the ANOVA, and MANOVA the variables were examined through SPSS- explore procedure for violation of assumptions of homosedasticity, and normality.