CHAPTER III

PRESENT STUDY
GENERAL STATEMENT AND SCOPE OF THE AREA OF INVESTIGATION:

In their search for the brain mechanisms underlying stuttering, investigators have employed a wide range of techniques, both behavioral and electrophysiological. In general, these studies have pointed towards hemispheric processing differences between stutterers and nonstutterers.

The dual task procedure is a behavioral technique that has been used to study lateralization of function. Greater right hand interference produced by the concurrent verbal task has been interpreted as indicating left hemisphere involvement for verbal activity. This laterality effect for language has been consistently reported for normal right-handed males.

A small number of dual task studies have utilized concurrent speech and motor tasks to study hemispheric functioning in stutterers. They have reported that stutterers do not show the expected pattern of greater right-hand interference with a concurrent verbal task. In order to explore this possibility of hemispheric processing differences existing in stutterers and nonstutterers, the present study utilized a motor-verbal dual task paradigm. Some limitations exist in these studies. First, most of the studies have focused on the effects of speech on motor tasks and neglected the effects of motor tasks on speech. Studies
using normal subjects have also been found wanting in this aspect. Second, the use of speech as a concurrent task is likely to produce increased anxiety and stuttering behaviour in stutterers which may adversely affect their performance. The present study attempted to overcome the above limitations (a) by studying the performance of both tasks and (b) by using a concurrent nonspeech verbal task.

The right hemisphere's superior ability to process visuospatial input has been well documented. EEG studies have found alpha suppression (Ornstein et al., 1980) and reduced beta II amplitude (Gruzelier et al., 1990) in the right hemisphere for visuospatial tasks. Tachistoscopic studies have also demonstrated right hemisphere superiority for visuospatial tasks like mental rotation (Hayashi and Hatta, 1978; Berlucchi et al., 1979) and face recognition (Geffen et al., 1971, Moscovitch et al., 1976; Moscovitch and Klein, 1980). The use of a concurrent visuospatial task then, can be expected to yield larger left-than-right hand tapping decrements indicative of right hemisphere mediation. This effect has not been clearly demonstrated so far. Hence a concurrent motor - visuospatial task was included in this study to explore the effects of visuospatial task on tapping.

The results of Greiner et al. (1986 a;b) as well as of Webster (1986a; 1988; 1989b) who used dual task techniques suggest that stutterers have inefficient interhemispheric
communication. A bimanual handwriting task was utilized to examine this hypothesis.

A number of studies have reported considerable heterogeneity in the performance of stutterers as compared to nonstutterers suggesting the possibility of subgroups (Tsunoda and Moriyama, 1972; Blood and Blood, 1984; Blood and Blood, 1986; Webster, 1988). The present study attempted to find out whether subgroups exist in the stuttering population.

In view of the issues arising from the examination of the findings of hemispheric processing studies in stutterers and normal subjects, the objectives of the present investigation were formulated.

GENERAL OBJECTIVES:

1) The aim of the present study was to examine hemispheric functioning in stutterers and nonstutterers by utilizing a nonspeech verbal task (word recognition) and a motor task (index finger tapping) in a dual task paradigm.

2) Another objective was to study hemispheric processing in the two groups when a visuospatial task (face recognition) was used as the concurrent task.

3) The present study also attempted to examine inter-hemispheric processes in stutterers by using a bimanual task.
4) The final objective of the study was to find out whether stutterers could be divided into subgroups according to characteristics like family history, age of onset and severity based upon their performance in the tasks.

HYPOTHESES:

The following hypotheses were formulated and tested:

I. Dual Task Study:

Baseline Conditions:

1) Stutterers and controls will not differ significantly in their performance under baseline conditions with regard to right tapping task, left tapping task, verbal (word recognition) task and visuospatial (face recognition) task.

2) Stutterers will not differ from controls in the degree of difference between right and left baseline tapping rates.

Dual task condition of tapping task and verbal (word recognition) task:

3) Controls will show decrements in right tapping only while performing the concurrent verbal task.

4) Stutterers will show decrements in left tapping or tapping decrements in both hands while performing the concurrent verbal task.
5) The verbal task will produce greater tapping decrements in stutterers than in controls irrespective of hand.

6) In both stutterers and controls, left tapping as well as right tapping will not interfere with the verbal task.

Dual task condition of tapping task and visuospatial (face recognition) task:

7) Stutters as well as controls will demonstrate decrements in only the left hand when performing the concurrent visuospatial task.

8) The visuospatial task will produce similar tapping interference in both stutterers and controls.

9) Both left tapping and right tapping will not interfere with the performance of the visuospatial task in stutterers and controls.

II. Bimanual Handwriting Task:

Quality of Letter Formation (QLF):

10) Stutterers will have poorer QLF than controls in positions 1, 2 and 3.

11) QLF will deteriorate progressively from positions 1 to 3 in stutterers as well as controls.

12) The degree to which QLF deteriorates from positions 1 to 3 will not differ between stutterers and controls.

13) Right-hand QLF will be superior to left-hand QLF in both stutterers and controls.
14) The degree to which right-hand QLF is superior to that of left-hand QLF will not differ between stutterers and controls.

**Mirror Reversals (MRs):**

15) Stutterers will have more MRs than controls in positions 1, 2 and 3.

16) The number of MRs will increase progressively from positions 1 to 3 in stutterers as well as controls.

17) The degree to which performance deteriorates from positions 1 to 3 will not differ between stutterers and controls.

18) The right hand will make fewer MRs than the left hand in stutterers as well as controls.

19) The degree of difference between right-hand and left-hand performance will not differ in stutterers and controls.

**Response Time:**

20) There will be no difference between stutterers and controls regarding response time in positions 1, 2, and 3.

III. With the information obtained from the stuttering group regarding the family history, age of onset and severity, the following hypotheses were formulated:

21) There will be no difference between stutterers who have a family history of stuttering (FH+) and stutterers
who do not have a family history of stuttering (FH-)
with respect to their performance on the dual tasks and
the bimanual handwriting task.

22) There will be no difference between mild, moderate and
severe stutterers in their performance on the two tasks.

23) The early onset stuttering group will not differ from
the late onset stuttering group with regard to their
performance on the two tasks.

SAMPLE:
The experimental group consisted of 30 right-handed male
stutterers while the control group consisted of 30 right-
handed male nonstutterers who were matched for age and
education.

The experimental group consisted of stutterers attending
therapy at the Institute of Speech and Hearing, Bangalore, as
well as those stutterers who had registered there but had
not yet begun therapy.

The control group was selected from volunteers. They
were students, friends of the stuttering subjects and
personal acquaintances of the researcher. They were
individually selected and matched for age and education with
the stutterers.
### TABLE 1
CHARACTERISTICS OF THE SAMPLE

<table>
<thead>
<tr>
<th></th>
<th>Stutterers (n=30)</th>
<th>Controls (n=30)</th>
<th>Significance</th>
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<tbody>
<tr>
<td><strong>Age Range</strong></td>
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<tr>
<td>15-19 years</td>
<td>12</td>
<td>13</td>
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<tr>
<td>20-24 years</td>
<td>6</td>
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<tr>
<td>25-29 years</td>
<td>8</td>
<td>7</td>
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<tr>
<td>30-34 years</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>22.43 ± 5.99</td>
<td>22.80 ± 6.35</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
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<tr>
<td>SSLC</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>PUC</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Graduates</td>
<td>10</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>13.20 ± 2.83</td>
<td>13.30 ± 2.89</td>
<td>NS</td>
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<tr>
<td><strong>Occupation</strong></td>
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<tr>
<td>Students</td>
<td>14</td>
<td>16</td>
<td></td>
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<tr>
<td>Employed</td>
<td>16</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Stutterers and controls were comparable with regard to age and education as the difference between mean scores was not significant and there is more or less equal representation of students and employed persons in both the groups.
Only right-handed subjects were included in the study. Handedness was assessed using the Edinburgh Handedness Inventory (Oldfield, 1971). Although a positive laterality quotient (LQ) is considered as evidence of right-handedness, only subjects whose LQs were 75 and above were included in the study. Stutterers had LQs ranging from 75 to 100 with a mean of 97.2. Among the controls, LQs ranged from 79 to 100 with a mean of 92.6.

The final sample of 30 stutterers was arrived at after screening 43 subjects. Five subjects were taken for the pilot study and were not included in the final sample. They had a mean of age of 25 years. With regard to education, one was in the 9th std, three were college students, while one was an employed graduate. Of the remaining 8 subjects excluded from the final sample, two subjects had to be excluded because they did not complete all the assessment procedures. One subject was excluded as he had misarticulation in addition to stuttering, while another was excluded as he had had epilepsy in childhood. Two subjects were excluded as their LQs fell below 75. Two others were excluded as they could not speak English fluently even though they had completed 10 years of schooling in the English medium.

In order to assess whether subgroups exist in the stuttering population, the stutterers group was divided into
smaller groups based on three characteristics, namely, family history, age of onset and severity and their performance on the two tasks were compared.

Family History: Stutterers were interviewed for family history of stuttering in first degree relatives (Appendix I). They were divided into two groups, namely, those with a positive family history (FH+) and those with an absence of family history (FH-). There were 15 in each group.

Age of Onset: All stutterers whose stuttering onset began at or below the age of 5 years were in the 'early' group, while those whose stuttering onset began at or above the age of 6 years were in the 'late' group. The median age was used as the cut off point. There were 15 in each group.

Severity: The stutterers were subdivided into mild, moderate and severe groups based on their scores on the Riley Stuttering Severity Instrument. According to this grouping, there were 4 mild, 5 moderate and 16 severe stutterers. The remaining 5 subjects were excluded from this part of the analysis as their scores fell in the intermediate ranges.

Inclusion Criteria:

1) Age: Subjects in the age range of 15 to 35 years were selected (both years inclusive).
2) **Sex**: All subjects were males since sex differences have been reported in performance (McClone, 1980; Piazza, 1980; Geschwind and Galaburda, 1985a; Galaburda et al, 1990).

3) **Handedness**: Only right-handed subjects were selected as it has been found that handedness can affect performance (Piazza, 1980; Galaburda et al, 1990). Handedness was confirmed by positive laterality quotients on the Edinburgh Handedness Inventory (Oldfield, 1971) (Appendix II).

4) **Education**: Subjects who could read, write and speak English fluently were selected. The criterion for selection was that they should have passed 7th standard in the English medium.

5) **Diagnostic criteria**: Stutterers were first examined by a speech pathologist and were diagnosed to have stuttering before being selected for the study.

    In the case of controls, only fluent subjects were selected.

**Exclusion Criteria**:

1) Stutterers who had any other speech and language disorder in addition to stuttering were not selected for the study. In the case of controls, fluent subjects having any other speech and language disorder or who have had such a problem in the past were excluded from the study.
2) Subjects with a history of neurological or psychiatric illness were excluded from the study.

3) Professional typists and musicians were excluded from the study.

Prior to the main study, a pilot study was undertaken in order to assess the suitability of the various tools and test procedures.

PILOT STUDY

The pilot study was initially undertaken for a period of ten months. The data collected in the pilot study was not used in the main study.

The objectives of the pilot study were:

1) To finalize the tools to be used.
2) To finalize the design of the study.
3) To decide the inclusion and exclusion criteria for the selection of the sample.
4) To modify and adapt the tools selected for the present study.
5) To get familiarized with the test procedures.

Procedures of the pilot study:

Each instrument was tested on a selected group of subjects. The details of the procedures are given below:

1) The Edinburgh Handedness Inventory was administered to
three nonstutterers in order to get familiarized with the administration as well as the scoring procedures.

2) The Stuttering Severity Instrument was tested on five stutterers.
A passage for the reading task was selected.
The three judges familiarized themselves with the scoring procedures and cleared any doubts they had in this connection.

It was decided that each judge would have a copy of the passage on hand when the reading task was being conducted. The words stuttered were circled. This made scoring more accurate and reliable. With regard to job task, only the words stuttered were noted down.

3) The dual task paradigm was tested on two stutterers and eight nonstutterers.
The instrument used for the motor task was originally constructed to include index finger tapping as well as sequential finger tapping. Sequential finger tapping was abandoned when it was found that the instrument was unable to record the entire range of errors. Taking the time factor into consideration, it was decided not to make any further modifications in the instrument and to use only the index finger tapping task.
The number of words and photographs to be used for the cognitive tasks, namely the word recognition and face recognition tasks were decided. It was observed that
fewer than 15 was too simple and more than 15 was confusing.

With regard to the word recognition task, a master list consisting of forty five words of low imagery value was constructed in the following manner. Sixty words which were felt by the researcher to be of relatively low imagery value were selected from the dictionary. Another twenty words which were considered to be of high imagery value were added to this list. All the words selected were monosyllabic words. The words were randomly presented in a list to ten subjects. The subjects were instructed to give a + rating to a word which evoked a strong mental image immediately and to give a - rating to words which evoked a mental image with difficulty or not at all. 45 words which were given a - rating were selected from the list to form a master list.

The cognitive tasks were counterbalanced with the motor task.

4) The bimanual handwriting task was tested on 8 nonstutterers and 2 stutterers.

In the apparatus used by Webster (1988) the writing surfaces were tilted backward by 5° to make writing easier. This was considered unnecessary and the writing surfaces were kept perpendicular to the base.

In the original study, subjects were separated from the apparatus by a cloth held by an upright frame in order
to prevent them from viewing their hands as well as the results of the procedure. In the present study it was found to be equally effective and less cumbersome if subjects closed their eyes when writing and kept their heads down until the paper was replaced.

While the subjects in Webster's (1988) study were required to write the lower case letters of the alphabet, the present study employed cursive letters. This change was made when it was found that subjects had difficulty writing lower case letters and frequently reverted to capital letters or cursive letters. With cursive writing too, the correct orientation and the mirror reversed orientation of the letters can be clearly distinguished from each other.

Once the tools and test procedures were finalized, the main study was begun.

DESCRIPTION AND ADMINISTRATION OF THE TESTS USED IN THE MAIN STUDY:

After obtaining informed consent and confirming suitability for participation in the study, testing was initiated. Sociodemographic data (Appendix I) were first collected from the subjects followed by an assessment of handedness. Severity of stuttering was next measured for the stutterers. The dual task study was then conducted, followed
by the bimanual handwriting task. Testing was usually done in two sessions, each session lasting 45 minutes.

I. Assessment of handedness:

Handedness was assessed using the Edinburgh Handedness Inventory devised by Oldfield R.C. (1971) (Appendix II). It has 12 items. The items include activities like writing, using a spoon and opening a box. The subject had to indicate his preference in the use of hands with regard to the various activities mentioned by writing + in the appropriate column (left or right). If the preference is very strong, he had to write ++ and if he uses both hands equally for an activity, he had to write + in both columns.

To calculate the laterality quotient (LQ), the +s for each hand were summed up and the sum for the left was subtracted from that for the right. This was divided by the sum of both and multiplied by 100. Scores ranged from +1.00 (strongly right-handed) to -1.00 (strongly left-handed).

The Edinburgh Handedness Inventory is used extensively in neuropsychological as well as clinical and experimental work. It can be administered easily and takes little time to complete. It provides a single quantitative measure of handedness. In his review of hand preference measures, Bryden (1982) considered it to be the most carefully developed measure of handedness.
II. Assessment of severity of stuttering:

Severity of stuttering was measured with the Stuttering Severity Instrument devised by Riley C.D. (1972) (Appendix IIIa).

The subject was administered two tasks. The first is a job task or school task where he had to talk about job, college, school or home for three minutes. This was recorded. The method of scoring the number of words stuttered differed from the original test in the following manner: Riley suggested using dots for the fluent words and slashes for the stuttered words. In the pilot study, it was found that it was simpler to note only the words stuttered.

The second was a reading task. A passage in English from a social studies text book used by Standard V (SSLC Syllabus) was selected for its neutral content and because it could be read by all the subjects. The selected passage contained 176 words (Appendix IIIb). This passage was also recorded. The examiner had a copy of the passage and marked those words that were stuttered.

Three parameters were considered for scoring. They were:

a) Frequency of repetition and prolongation of sounds and syllables.

b) Estimated duration of the longest blocks.

c) Observable physical concomitants.
a) **Frequency:**

This was scored in the following manner. The first 25 words in each of the two were omitted. Only the next 100 words were considered. The number of stuttered words were then counted. If fewer than 100 words were spoken by the subject during the job task, the percentage was computed.

Repetition of sounds and syllables, prolongation of sounds, as well as blocks, which are silent prolongations of an articulatory posture, were considered as stuttering behaviour. Rephrasing, pausing without blocking and repeating whole words of more than one syllable were not counted as stuttering. Two sets of scores were obtained for two tasks. The total frequency score was obtained by adding the two scores.

b) **Duration:**

Three scores were obtained for the three longest blocks and summed up to get the total duration score. Riley (1972) suggests that a watch is adequate for estimating duration. In the present study duration was estimated with the help of a stopwatch for more accuracy.

Frequency and duration were scored initially at the time of administering the instrument and later by repeated listening to the recorded passages in order to ensure reliability.
c) Physical concomitants:

Physical concomitants such as distracting sounds and facial grimaces were scored when they were associated with the blocks or with attempts to avoid blocking. They were scored at the time of administering the test. The scores were added to get the total physical concomitant score.

Frequency, duration and physical concomitant scores were then added to arrive at a total overall score. The level of stuttering severity was obtained by comparing the subject's total overall score to the normative data.

Three judges assessed stuttering severity. One was the researcher and the other two were speech pathologists who have MSc. degree in speech pathology and audiology and have five years of experience working with stutterers. At the time of administering the instrument all the three judges were present. During administration they rated the subject in the three areas independently. Later, each of them listened to the recorded passages independently and completed the scoring.

The Pearson's Product Moment Correlation Coefficient \( r \) was estimated to assess the degree of correlation between ratings of severity of stuttering by the three judges. These correlations were:
Judges A and B, $r = 0.97$ (df = 28, $P < 0.001$)
Judges B and C, $r = 0.99$ (df = 28, $P < 0.001$)
Judges A and C, $r = 0.94$ (df = 28, $P < 0.001$)

The stuttering severity instrument by Riley (1972) is among the most popular scales for assessing stuttering severity in research and clinical settings. It offers a simple and objective method of evaluating severity. It was standardized on 109 children and 28 adults. Interexaminer reliability was found to be 0.84. Concurrent validity was demonstrated by a 0.89 rank correlation coefficient with the IOWA Scale of Stuttering Severity.

A drawback of the scale is that whole word and phrase repetitions as well as rephrasing have been omitted in the estimate of frequency of stuttering thus limiting the content validity. Another problem is that judges are required to discriminate in real time between fleeting, one half and one full second disfluencies while estimating duration. This may affect inter- and intra-judge reliability. In the present study, the difficulty was partly overcome by the use of a stopwatch and by repeated listening to the recorded passages.

A more accurate estimate of stuttering severity could have been obtained if the subjects had been videotaped. Unfortunately, this was not possible in the present study.
The Dual Task Paradigm:

The dual task or interference paradigm has been used in experimental psychology to study a wide variety of issues. In recent years it has been increasingly used as a third technique for the investigation of hemispheric specialization for language in addition to tachistoscopic recognition and dichotic listening techniques (Ikeda, 1987).

In a dual task paradigm, the subject is required to perform two tasks simultaneously. The scores obtained on the two tasks are compared with the scores obtained on the same tasks when performed individually (baseline scores) and the degree and direction of interference is measured.

The dual task paradigm has been used to investigate hemispheric lateralization in stutterers (Brutten and Trotter, 1985; 1986; Sussman, 1982). It has also been used to study interhemispheric integration processes in stutterers (Fitzgerald et al., 1984; Greiner et al., 1986a; 1986b; Webster, 1986a; 1988; 1989b).

The present study meets the criteria laid down by Bryden (1982) as well as Webster (1988) that in a dual task paradigm, measures of both the tasks should be obtained when they are performed alone and when they are performed together. All the measures of performance are required "...in order to know for certain how adequately a subject is maintaining performance in the face of interference" (Bryden, 1982). In most of the studies using the dual task technique, only performance on the motor task has been measured. Single task measures of the concurrent activity have not been assessed nor has the interference of the motor task on the concurrent task been measured (Kinsbourne and Cook, 1971; Wolf and Cohen, 1980; Sussman, 1982). The present study attempts to overcome these limitations by obtaining measures of the two tasks when performed alone as well as when performed together.

In the present study, motor tasks and nonspeech cognitive tasks were utilized. The motor tasks consisted of index finger tapping. This task was selected as it has been used
extensively in the past as the motor task in dual task studies (Bowers et al, 1978; Hiscock and Kinsbourne, 1980; Sussman et al, 1982; Kee et al, 1983) and continues to be used in the present (Green et al, 1990). In index finger tapping, each hand is known to be controlled by the contralateral hemisphere (Brinkman and Kuypers, 1972; Gevins et al, 1987 and Shafran et al, 1989).

Previous dual task studies have used speech measures as the concurrent task (Sussman, 1982; Brutten and Trotter, 1985; 1986; Greiner et al, 1986a). In the present investigation a silent word recognition task was utilized.

It was decided to use a task which does not involve speech. With regard to stutterers, speaking may produce anxiety as well as stuttering behaviour which can affect task performance (Webster, 1985).

The words selected for the word recognition task were of low imagery and were abstract nouns as studies show that such words are accessed more efficiently in the left hemisphere (Geffen et al, 1971; Ellis and Shepherd, 1974; Hines, 1976; Moscovitch and Klein, 1980; Gruzelier et al, 1990).

A face recognition task was used as the second cognitive task, as it is known to be mediated by the right hemisphere. Unfamiliar faces are known to be processed primarily by the right hemisphere (Moscovitch et al, 1976; Moscovitch and
Klein, 1980). In a recent study which utilized a memory for face recognition task with concurrent monitoring of topographical EEG, the right temperoparietal area showed a reduction in beta II amplitude (Gruzelier et al., 1990).

A detailed description and administration of each task is given below:

1) Finger tapping task: In this task, the subject was required to tap a key with the index finger of either hand as quickly as possible for a period of 15 seconds. This was considered as a single trial.

The instructions given were as follows:

"Place your index finger on the key, keeping your wrist and elbow resting on the surface of the box. Tap the key repeatedly with your index finger as fast as you can. Start tapping as soon as you hear the beeping sound and stop tapping when the sound ceases".

The subject was initially given six trials, three for each hand, in order to familiarise himself with the task.

Five trials were then given for each hand beginning with the right hand. The hands were alternated for each trial in order to reduce fatigue. The first trial for each hand was omitted and the remaining four trials were taken into
account for scoring. The number of taps made for the four trials by each hand was averaged. This yielded two scores, one for the right hand and the other for the left. These were considered as the baseline tapping rates for the right hand and left hand respectively.

Index finger tapping was measured using a switch key fixed in a box. The box has an opening measuring 20 cms by 7 cms for the hand to enter. In this manner, the subject cannot see his hand or the key when he is tapping. Previous studies indicate that visual feedback should be eliminated if lateralized interference is to occur (Lomas, 1980; Webster, 1985).

At the beginning of each trial, a timer which emitted a beeping sound was activated. At the end of 15 seconds, the sound stopped, indicating the end of the trial.

2) Word Recognition task: The subject was given the following instructions:

"You will be shown a list of words. Scrutinize it carefully. After a short period of time, the list will be taken away and will be replaced by another list which will display the old words from the first list along with some new words. You will have to point out the words you saw in the first list from this list".
The subject was shown a word list consisting of 15 words. 15 seconds later, the list was removed and replaced with a longer list consisting of 30 words. The time was noted with a stopwatch. The subject then had to point to the words he had seen in the first list and these were noted down.

Prior to the actual task, the above mentioned procedure was followed using a list of 10 words followed by a corresponding list of 20 words. This was done for practice and familiarisation with the task. The main task, was given after the practice task and this was considered as the baseline word recognition task.

The word list consisted of 15 single syllable words which were selected at random from a master list of 45 words. The second word list had 30 words displayed in two columns of 15 words each. It contained all the old words from the first list as well as 15 other new words displayed in a random order.

Three sets of word lists were constructed in this manner, each set consisting of a 15-word list and a 30-word list. One set was used for the baseline task and the other two for the dual task procedures (Appendix IVa-h).

3) Face Recognition Task: Instructions similar to those given for the Word Recognition task were given:
"You will be shown a card on which a number of photographs of faces will be displayed. Look at each of them carefully. After a short while, the card will be removed and will be replaced by another card. This card will display the old faces you just saw along with other new faces. You will have to point out the faces you had seen in the previous card".

The subject was shown a card displaying 15 faces first. After 15 seconds, the card was removed and was replaced by a card displaying 30 faces. The subject had to point to the faces he had seen in the first card and these were noted down. This was considered as the baseline task.

Prior to the baseline task, the same procedure was followed with a card displaying 10 faces followed by a corresponding card displaying 20 faces. This was done for practice and familiarisation with the task. The baseline task was given after the practice task.

For this task, black and white photographs of male executives 3.5 cms by 4 cms were cut from copies of "Business India" magazines. Photographs of men who are well known or who had striking or easily identifiable features were not selected. 15 photographs were picked at random from a group of 90 photographs. They were displayed on an ivory card in three rows, five in each row. The distance between each
photograph within a row was 5.5 cms and there was a 2 cm space between the rows. The corresponding card displayed 30 faces which included duplicates of the 15 faces shown on the first card along with 15 other new faces displayed in a random order. The second card had 6 faces in each row 2 cms from each other. There were five rows with a 2.5 cm space between the rows.

Three sets of cards were constructed in this manner, each set consisting of a card with 15 faces and a corresponding card displaying 30 faces. One set was used for the baseline task and the other two sets were used for the dual task procedures (Appendix Va-h).

4) Dual task condition: Once the baseline performance was assessed for the tapping task (left as well as right hand), the word recognition task and the face recognition task, the subject was required to perform under dual task conditions. Here, the subject had to do the tapping task along with either the word recognition task or the face recognition task simultaneously. He was given the following instructions:

"This time you will have to do the tapping task along with the word recognition task. This means that while tapping, you will have to scan a list of words. Start tapping when the sound begins and at the same time look at the words. When the sound ceases, stop tapping. The word list will be replaced by another list which will contain all the words you
just saw along with other words. You will have to point out the words you saw in the previous list from the second list."

Similar instructions were given when the tapping task and the face recognition task were administered.

A rest period of one minute was given between conditions. Each of the two tasks, namely, word recognition and face recognition, had two versions, one for each hand. All the tasks were counterbalanced with respect to the tapping hand.

Thus, there were four baseline conditions and four dual task conditions.

The baseline conditions were:
1) Right hand tapping
2) Left hand tapping
3) Word recognition
4) Face recognition

The dual task conditions were:
1) Right hand tapping with word recognition
2) Left hand tapping with word recognition
3) Right hand tapping with face recognition
4) Left hand tapping with face recognition
The word recognition and the face recognition tasks were scored in a similar manner. The formula adapted from Woodworth and Schlosberg (1976), for calculating the recognition score is as follows:

\[
\text{Recognition score} = \frac{\text{Right} - \text{Wrong}}{\text{N}}
\]

N represents the total number of stimuli, that is, old + new.
Right represents the number of old stimuli recognized + the number of new stimuli excluded.
Wrong represents the number of old stimuli not recognized + the number of new stimuli included.

The Bimanual Handwriting Task:

The bimanual handwriting task was used to study the hypothesis that interhemispheric communication in stutterers is relatively poorly regulated. It is known that bimanual motor activity involves integrated interhemispheric functioning to a much greater extent than unimanual activity (Cohen, 1970; Kreuter et al, 1972; Preilowski, 1972; Zaidel and Sperry, 1977; Wolf and Cohen, 1980). The integration of functions between the hemispheres for the performance of bimanual co-ordination requires an intact corpus callosum (Dimond, 1976; Zaidel and Sperry, 1977). The corpus callosum is also involved in the inhibition of mirror movements (Cohen, 1970) and the mediation of independent hand movements.
(Corballis and Beale, 1982; Preilowski, 1975). Thus, poor performance in a bimanual co-ordination task such as the bimanual handwriting task marked by poor letter quality formation and more mirror reversals would indicate an inefficiency in the control of interhemispheric communication.

The bimanual handwriting task was devised by Webster (1988). He used it to replicate the findings of Fitzgerald et al (1984) and Greiner (1986) that stutterers show less independence of bimanual movements than do fluent speakers. His main objective was to study the hypothesis of ungated interhemispheric transfer in stutterers.

The bimanual handwriting apparatus was devised by Webster (1988) and was adapted from Van Riper's (1934) Critical Angle Board. It comprises of two vertical writing surfaces which are hinged together. The surfaces can be fitted into a board which has slots in three different angles. Thus, the writing surfaces can be placed in three different positions. In position 1, the surfaces are placed parallel to the frontal plane, that is, they are separated by 180°. In position 2, each surface is rotated backward by 30° (separated by 240°). In position 3, each surface is rotated backward by 60° from the frontal plane. In other words, they are separated by 300°.
On each surface a sheet of blank paper can be clipped for the subjects to write on. After writing on it the paper can be removed and a fresh sheet of paper can be clipped on each surface.

In the apparatus used by Webster, the front of the base was elevated so that the surfaces tilted backwards by about 5°. This was done to make writing easier. When the pilot study was done, this was considered unnecessary and the base was kept horizontal while the surfaces were perpendicular to the base. Also, in the original study by Webster (1988), subjects were separated from the apparatus by a soft black cloth held by an upright frame. This was done to prevent the subject from looking at his hands and the results of the procedure. This was not included in the present study. Instead, they were asked to keep their eyes closed when writing. After writing they had to keep their heads down until the paper was removed from the board.

The three word lists originally constructed and used by Webster (1988) was used in this study also (Appendix VI). Webster constructed the word lists in the following manner: A master set of 48 words were constructed. The words were all single syllable, high frequency and of relatively low imagery value. Each of these words began with one of the following 16 letters: a b c d e f g h k n p q r s y z. Each letter was used as the initial letter for three words. The
master set of 48 words was constructed in this manner. From the master set, three different lists of 16 words each were constructed randomly. Each of the 16 initial letters, however, occurred only once in each list.

The subject was given a sheet of paper and a pencil and was asked to write all the alphabets in cursive writing as neatly as possible with the right hand.

He was then shown the apparatus with blank paper clipped on the two surfaces. He was given two pencils, one for each hand. He was then given the following instructions:

"Position the pencils near the top of the two sheets of paper. Four words will be called out. You will have to repeat them in the same order. As soon as you finish saying the fourth word, close your eyes and write down the initial letter of each of the words in a column, that is, one below the other, with both the hands simultaneously. Write them as quickly as you can. When you complete the task, keep your head 'down. Do not look at the apparatus until you are told to do so".

The subject received one practice trial. However, the words used for the practice trial began with letters whose mirror reversals are identical to their correct orientation namely, w l u v i. These letters were used to prevent the subject from knowing the true nature of the task. The
subject was shown the results of his work and any doubts expressed by the subject regarding the test procedures was cleared. A second practice trial was conducted if the subject was still unsure of what was required of him.

Each trial consisted of 4 words and there were 24 trials in all. Two blocks of testing were assigned to each of the 3 writing surface positions. Thus there was a total of 6 blocks, each block consisting of 4 trials. The subject was tested in the 3 positions in the following order 1-2-3-3-2-1.

Each subject was presented with the three lists in a random order for blocks 1 to 4. The same three lists with the words in different random orders were used for blocks 4 to 6 keeping in mind that a list could not be used twice for the same writing surface position.

The words were called out at the rate of approximately one per second. The subject had to repeat the four words and then write the first letter of the words using both hands simultaneously while keeping his eyes shut. Performance time was noted with the help of a stopwatch. The stopwatch was started when the subject finished saying the fourth word and was stopped when he finished writing the fourth letter.

If the subject was unable to repeat the four words or if he could not remember the words while writing the letters, the trial was stopped and repeated at the end of that particular block.
All the subjects were tested in this manner.

The protocols were scored by the researcher after all the subjects were tested. While scoring the protocols, the researcher used a blind procedure, (and was neither aware of the subject's identity nor of the group to which he belonged).

Webster's (1988) scoring procedure was used which is as follows:

Each letter was scored for mirror reversals (MRs) and quality of letter formation (QLF).

Mirror reversals were judged on a 5-point scale:

0 : No evidence of a mirror reversal of any part of the letter.
1 : Some small part of the letter is in reversed orientation, but the letter is mainly in the correct orientation.
2 : Part of the letter is reversed, and the rest is in the correct orientation and complete.
3 : Part of the letter is reversed, and the rest is scribbled or incomplete.
4 : Letter is a complete mirror reversal.

Quality of letter formation independent of orientation was also rated using a 5-point scale:

0 : Scribble or random scrawl
1: Letter cannot be identified or recognised without at least knowing what the letter was supposed to be.

2: Letter can be identified but is poorly formed.

3: Letter has reasonable orientation and is legible but with some parts incomplete (e.g., shortened or missing verticals on letters like h, b, d, p, or missing portions of the letter like the tail on g).

4: Accurately formed letter that is legible, complete and with no excess writing.

The data for the main study was collected over a period of 15 months. The initial interview of the subject for suitability of testing, collection of sociodemographic data, assessment of handedness, assessment of stuttering severity and the dual task study were usually completed in the first session in that order. The bimanual handwriting task was conducted in the second session. The order of testing procedures was identical for the stutterers and the control subjects.

The subjects participated in the study with keen interest. They completed all the assessments within two sessions taking about 90 minutes in all.

STATISTICS

The data thus collected was subjected to statistical analysis. The following inferential statistics were applied to the data.
t tests (with modified degrees of freedom, wherever indicated, to correct for heterogeneity of variances) were used to compare the means of two independent groups (e.g., to compare the baseline conditions of stutterers and controls). One way analysis of variances (ANOVA with log transformations, wherever indicated, to homogenise variances) were applied when means were compared across three independent groups (e.g., when subgroups of stutterers were compared with controls).

If the ANOVA appeared significant, Tukey's Honestly Significant Difference Multiple Comparison Test was applied to identify the source of significance of the ANOVA. If Tukey's test emerged non-significant, the Fisher's Least Significant Difference Test, Multiple Comparisons Procedure was used. The former test is more conservative and inflates the Type II error risk while the latter is less conservative and inflates the Type I error risk (see Table 26).

Nonparametric data - frequency distributions in contingency tables - were analysed using the Chi-square test (continuity corrections for 2x2 distributions) or the Fisher's exact probability test, whenever the requirements for Chi-square analysis were not fulfilled (e.g., to examine the relation between age of onset and family history and the relation between age of onset and severity of stuttering respectively). Heterogeneity testing of contingency tables followed the method described by Zar (1984).
Correlation co-efficients were derived to explore the possible relationship between pairs of parametric variables (eg., to assess the degree of correlation between ratings of severity of stuttering by the three judges).

Comparison of means of two correlated groups (eg., due to a single repeating measure) was done using the paired t test (eg., to study the difference in verbal scores in the baseline and dual task conditions). Comparison of independent groups across a repeating variable in a factorial paradigm was done using two way repeat measures ANOVA (eg., to compare right or left tapping scores in baseline and dual task conditions between stutterers and controls). Where groups were categorized along two independent variables and across one repeating measure, three way repeat measures ANOVA was used (eg., to compare the quality of letter formation in positions 1, 2, and 3 for right and left hand between stutterers and controls).