CHAPTER V

DISCUSSION
Thirty right-handed male stutterers were compared with nonstutterers in their performance on dual task procedures. The objectives of the investigation were:

1) To study the nature of hemispheric processing in the two groups using motor-verbal and motor-visuospatial dual tasks.

2) To examine interhemispheric processes in the two groups using a bimanual handwriting task.

3) To find out whether stutterers can be divided into subgroups according to characteristics like family history, age of onset and severity based upon their performance in the tasks.

The significant findings of each test will be presented and then discussed.

DUAL TASK STUDY

I Baseline Condition:

Stutterers were found to have a significantly poorer R tapping baseline rate than controls. These findings are contrary to those of Webster who found stutterers to be as proficient as nonstutterers in index finger tapping and repetitive sequential finger tapping, (Webster, 1985; 1986b). In one study however, Webster (1989b) did find poorer baseline performance in both right and left hands of
stutterers in a repetitive sequential finger tapping task.

In both groups right-hand performance was superior to that of left-hand. This finding is commonly reported in right-handers (Simon and Sussman, 1987). Stutterers did not differ from controls in the degree of difference between right and left baseline tapping rates. The degree of difference was compared between the two groups as it may have an effect on dual task performance (Simon and Sussman, 1987).

II Dual task condition of tapping - verbal task:

The significant findings here are as follows:

1) The verbal task significantly interfered with both R tapping and L tapping in stutterers.

2) The verbal task had no effect on either R tapping or L tapping in controls.

3) Tapping did not interfere with the verbal task in stutterers.

4) Both R tapping and L tapping interfered with the verbal task in controls.

5) Stutterers have poorer overall tapping scores than controls.

6) Stutterers and controls did not differ from each other with regard to verbal scores.

The verbal task was found to affect both R tapping as well as L tapping in stutterers. This has been found in
other dual task studies (Sussman, 1982; Greiner et al., 1986a; Brutten and Trotter, 1985; 1986).

It was found that tapping did not affect the verbal scores of stutterers. Greiner et al. (1986a) on the other hand found that tapping interfered with the verbal task. Since their study employed a speech task as the verbal task, their findings are not surprising as one can expect stutterers to have poorer verbal scores due to anxiety and speech blocks. The other studies (Sussman, 1982; Brutten and Trotter, 1985; 1986) omitted to study the effect of tapping on the verbal task.

In the case of controls, it was found that while the verbal task did not affect tapping, both R tapping and L tapping interfered with the verbal task. These findings underscore the importance of studying the performance of both tasks. Had only tapping performance been assessed, the results may have been interpreted differently.

The majority of studies with normals demonstrate significant R tapping decrements with a verbal task. In the present study however, bilateral decrements in verbal scores were obtained. The results cannot be explained on the functional distance model (Kinsbourne and Hicks, 1978) which proposes that two concurrently performed activities will interfere with each other if their cerebral representations are functionally close to each other. Thus interference
should be observed when right-hand tapping and a verbal task are performed concurrently as both these activities are processed by the left hemisphere. Lomas and Kimura (1976), Greiner et al (1986a) and Brutten and Trotter (1986) have reported bilateral interference effects. Summers and Sharp (1979) reported right index finger tapping interference with a verbal task. However, when the tapping task was sequential finger tapping, the verbal task decreased tapping in both hands.

There is evidence to suggest that as the demand characteristics of a task increase, bilateral disruption can occur. This has been demonstrated by McFarland and Ashton (1978). Rodney (1980) found both structural and capacity factors to account for interference. Unlike the Brutten and Trotter (1986) study, the present investigation did not use verbal tasks of increasing difficulty. The verbal task used in the present study may have been demanding enough to produce bilateral disruption.

Another factor that was not considered in the present study is the issue of bilinguals. Although left hemisphere dominance for language in right-handed monolinguals has been well documented, studies with bilinguals have produced conflicting results. Bilinguals have been reported to show weaker left lateralization for language (Albert and Obler, 1978) and difference in laterality patterns for early and
late bilinguals (Vaid and Lambert, 1978). In a dual task study of bilinguals and monolinguals, Sussman et al (1982) found that while monolinguals showed highly asymmetric lateralization effects, bilinguals revealed tendencies toward more symmetric hemispheric lateralization effects for language. Green et al (1990), also used the dual task paradigm and found that bilinguals were less left lateralized for language when compared to monolinguals.

Although the subjects of the present study spoke English fluently and had studied in English medium schools, their native language was not English. Hence the generalized interference effects that were observed in both stutterers and controls may be due to the fact that the subjects were not monolinguals.

In the present study, overall tapping scores of stutterers were found to be poorer then those of controls. These results have also been found by Sussman (1982), Brutten and Trotter (1986) and Greiner et al (1986a).

Stutterers and controls did not differ with regard to verbal scores in any of the conditions. These findings differ from those of Moore and Lorendo (1980) as well as Moore, Craven and Faber (1982) who found stutterers to have significantly poorer recall and recognition scores than controls. Cox (1982), using various neuropsychological tests
including finger tapping and memory, found no evidence of significant cerebral dysfunction in stutterers. He, however, had compared their performance with those of brain-damaged and nonbrain-damaged psychiatric patients. He had not included normal controls in his study.

In the dual task condition of tapping task and visuospatial task, the significant findings are as follows:

1) The visuospatial task significantly interfered with R tapping and L tapping scores in stutterers.
2) It did not significantly interfere with tapping in controls.
3) In both groups, the left hand was less affected than the right hand.
4) Tapping did not interfere with visuospatial scores in both stutterers and controls.
5) Stutterers had poorer overall tapping scores than controls.
6) Stutterers and controls had comparable visuospatial scores.

Only stutterers showed interference effects and here again interference was seen in both hands.

Only one other dual task study, that of Sussman (1982), with stutterers, used a visuospatial task. He found stutterers to have right-hand interference while the controls showed symmetric interference. Other studies with normal
right-handed subjects found mixed results. Bowers et al. (1978) found bilateral decrements with a visuospatial task. McFarland and Ashton (1975; 1978) found the expected left tapping decrements with a spatial task. However, he found that as the task difficulty increased, both hands were affected. Summers and Sharp (1979) observed a left tapping decrement with a visuospatial task. However, when the tapping task was sequencing, bilateral decrements were observed.

Although studies, which have used other techniques like tachistoscopic presentation have found strong evidence for right hemispheric processing of visuospatial tasks, the same cannot be said of studies which have utilized the dual task paradigm. Dual task studies, in general, have failed to document a left-hand visuospatial interference in right-handers. The present study too, did not find significantly greater L tapping interference with a concurrent visuospatial task.

The dual task study failed to elicit lateralized interference effects in both tapping-verbal condition and the tapping-visuospatial condition. Generalized interference effects were observed for both groups in the tapping-verbal condition. In the tapping-visuospatial condition only stutterers showed symmetric interference effects. No interference was observed in the control group. The
visuospatial task interfered with tapping in both hands of only the stutterers. Also, a main effect for hand was observed, that is the right-hand, irrespective of group was more affected than the left.

To summarize, the present study failed to elicit greater R tapping interference in the tapping-verbal condition and greater L tapping interference in the tapping-visuospatial condition. The present study's findings of (a) symmetric interference in the tapping-verbal condition in both groups and (b) interference effect in only the stuttering group with the left-hand being less affected in both groups, cannot be explained according to the Functional Distance model of Kinsbourne and Hicks (1978).

An alternative hypothesis has been offered by Simon and Sussman (1987) in order to explain the common dual task finding of greater R tapping decrements with a concurrent verbal task. They proposed that the dual task paradigm primarily reflects manual dominance rather than cognitive hemispheric processing. The dominant hand then, will display more interference than the non-dominant hand irrespective of whether the task is verbal or visuospatial. Although the above mentioned hypothesis can explain the present study's finding of L tapping being less affected than R tapping in the tapping-visuospatial condition, it fails to explain the symmetric interference results observed in the tapping-verbal condition.
Brutten and Trotter (1986) also found symmetric interference effects in both stutterers and controls in the motor-verbal condition and the motor non-verbal vocalic condition. The latter is known to be a right hemisphere dominant activity. They also found that the tapping rates in both hands decreased as the demand level of the tasks increased. This led them to conclude that the dual task methodology is not useful in studying cerebral lateralization. Hughes and Sussman (1983) also expressed similar doubts regarding its use as a measure of lateralization. In fact Sussman (1989), reanalysed earlier dual task data using ANCOVA procedures. This was done following Willis and Goodwin's (1987) suggestion that the difference between the baseline rates of the right and left hand can affect concurrent tapping rates. After reanalysis he failed to obtain lateralized interference effects. This led him to doubt whether the dual task paradigm should be used as a technique to study hemispheric lateralization. The results of the present study add to the growing evidence that the dual task paradigm is not useful in studying hemispheric lateralization.

In the case of stutterers, the results of the present study align with a capacity interference model. As Bryden (1982) points out "Drops in performance may be the result of exceeding the overall capacity of the information processing
system: the interference task may be creating capacity interference". Stutterers performed poorly in both conditions compared to controls suggesting that their neuromotor capacity is weaker than that of nonstutterers (Brutten and Trotter, 1986). The fact that the visuospatial task produced interference effects only in stutterers but not in controls suggests that the tapping-face recognition task was not demanding enough to exceed a normal subject's capacity and produce interference.

BIMANUAL HANDWRITING TASK

The significant findings of the bimanual handwriting task are as follows:

QLF
1) There was no difference between stutterers and controls with regard to QLF.
2) In both groups, the right-hand QLF was significantly better than the left-hand QLF.
3) In both groups, QLF deteriorated from positions 1 to 3.
4) The degree to which right-hand QLF is superior to left-hand QLF did not differ between the two groups.

The present study differs from that of Webster's (1988) in that no difference in QLF between the groups was observed in the present study. Webster found that stutterers had significantly poorer QLF than controls in both the dominant
as well as the nondominant hands. In the Greiner et al (1986b) study, stutterers did not differ from nonstutterers with regard to dominant hand. They however, were found to have significantly poorer nondominant hand scores than nonstutterers. In the Fitzgerald et al (1984) study too, significant differences were seen in the two groups only with regard to the nondominant hand.

The difference in results could be due to the difference in size of sample in the studies. The sample size of the present study was comparatively larger than that of the other studies.

MRS
1) Stutterers made more MRs and controls.
2) In both groups, the right hand made more MRs than the left hand.
3) In both groups, the number of MRs increased progressively from positions 1 to 3.
4) The degree to which right-hand performance was superior to that of left-hand performance did not differ between the two groups.

In the Greiner et al (1986b) study, stutterers made significantly more mirror reversals in both dominant and nondominant hand compared to nonstutterers. In the Fitzgerald et al (1984) study, stutterers made more mirror
reversals in the nondominant hand than did nonstutterers. Webster (1988) reported MRs in the nondominant hand of stutterers. The difference in these studies and the present study may be due to the following reasons. In the Fitzgerald et al (1984) study, the bimanual handwriting task consisted of writing the numbers from 1 to 12. Since this is a fairly automatic task, it is not surprising that no controls produced a mirror reversal and stutterers did not make MRs with the dominant hand.

Webster (1988) did not analyse the data of MRs with the dominant hand due to the very low frequency of MRs with the dominant hand. Evidence of MRs was present in the stuttering group with 3 right-handers and 2 left-handers showing some MRs.

Considering the results of the present study which replicated Webster's (1988) study, it is possible that had Webster's sample size been larger he would have found more MRs in the dominant hand of stutterers.

Response Time

Overall response time was the same in both groups.

In Webster's (1988) study, stutterers were significantly slower in response time. In the present study, no difference in response time was observed between the two groups. An interesting finding in the present study was the significant
group x position interaction. Controls' response time increased from position 1 to 3 while it was the inverse in the case of stutterers. This suggests that stutterers may have made more MRs in each position due to the fact that they wrote faster in each position.

Overall however, stutterers' performance was poorer than that of controls as they made more MRs in both hands and the overall response time did not differ significantly between the two groups.

Greiner et al (1986b) hypothesized from their results "that bimanual tasks involving symbols (digits, letters) that depend on motor lead control of the left hemisphere, interfere with the left hemisphere's inhibitory influence on motor activation of the right hemisphere". In both the Greiner et al (1986b) and the Fitzgerald et al (1984) study, the nondominant hand of stutterers was affected more than that of nonstutterers suggesting difficulties in interhemispheric integrative functions. The results from the present study cannot be explained by this hypothesis as stutterers made more mirror reversals than controls in both the dominant and the nondominant hands.

Webster's (1988) callosal gating deficit hypothesis predicts that interhemispheric communication in stutterers proceeds in a relatively unregulated manner. The callosal gating hypothesis predicts a greater tendency among
stutterers than among fluent speakers to have mirror image movements by the two hands. Consistent with this hypothesis, the stutterers in the present study showed significantly more mirror reversals in both the dominant and the nondominant hands.

Webster (1989b) suggests that one way to test the hypothesis directly is to use tasks where only the left hemisphere is activated. If the theory of interhemispheric interference in processing holds good then stutterers and controls should not differ in their performance on the intrahemispheric task. In the present study, such a condition was present, namely the dual task condition of right tapping and verbal task. In this condition also, stutterers performed significantly poorer than controls.

COMPARISON OF SUBGROUPS:

The significant findings that emerged from the comparison of subgroups is as follows:

1) FH+ and FH- stutterers had lower R tapping baseline scores than controls.

2) FH+ stutterers had significantly lower LTIIv scores than FH- stutterers.

3) Severe stutterers had poorer R tapping baseline scores than controls.
4) Moderate and severe stutterers performed poorer than controls in the VIIT condition. This agrees with the findings of Moore (1986) who found a positive correlation between severity and right hemispheric alpha suppression.

5) QLF in the early onset group was significantly poorer in the late onset as well as the control groups.

While a few significant findings were observed in the subgroups, the absence of statistical significance in the analysis of other related conditions should be noted. Considering the large number of comparisons undertaken (Table 21 to Table 32), there is a real possibility, that some or all of these significant findings may have emerged significant due to chance alone (Type I error).

The possibility of the existence of subgroups however cannot be excluded. Perhaps the inclusion of a large sample may have produced significant results.

When the evidence from the two tasks namely, the dual task study and bimanual handwriting task is examined against the present neuropsychological explanation of stuttering, the following points emerge:

1) The present findings do not add support to the hypothesis that stutterers have incomplete or bilateral dominance for language. Both stutterers and controls were found to have symmetric interference in the motor-
verbal dual task condition, thus questioning the utility of the dual task paradigm in studying hemispheric lateralization.

2) It partially supports Webster's (1988) hypothesis that the corpus callosum of stutterers functions in a relatively ungated manner.

3) The results can be explained in terms of capacity interference. That is to say, that stutterers have limited processing resources.

According to Kahneman (1973), the human organism has limited capacity which must be shared when two tasks are performed simultaneously. When the demand levels of the tasks exceed available capacity, interference occurs. Capacity interference then, is different from structural interference. The latter occurs when the same perceptual and response mechanism mediates the tasks.

In the dual task study of tapping and verbal tasks, bilateral decrements were seen in both stutterers and controls with stutterers' performance being poorer than that of controls. In the tapping-visuospatial condition, bilateral decrements in tapping were seen only in stutterers. In the bimanual handwriting task, stutterers made more mirror reversals than controls in both the right hand and the left hand. This suggests that the neuromotor capacity of stutterers is weaker than that of nonstutterers. The
hypothesis of relatively limited neuromotor capacity can also explain the success of rate control therapy (wherein stutterers are taught to speak at a slower or more comfortable rate) in improving fluency.

Finally, although the results from the present study are consistent with the hypothesis of limited capacity, it provides no insight about the nature of the resource limitation. Future research may be designed to address this issue.

IMPLICATIONS OF THE PRESENT STUDY:

Attempts to understand the neurophysiological basis of "functional" disorders have received great impetus with advances in knowledge of localization of function in the brain and the availability of technology to visualize brain function. Stuttering has long been considered to occur as a result of causes ranging from "a horrible tongue habit" to a dysfunction of the supplementary motor area. It is only recently that precise investigations have been undertaken to look for brain substrates underlying stuttering. The present study is an attempt in this direction and has several implications for future work.

In terms of methodology, the present study reiterates the question as to whether the dual task paradigm is indeed an adequate test to delineate lateralization effects for
different brain functions. In the present study the tapping-verbal condition of the dual task paradigm showed bilateral interference irrespective of the lateralized brain function being studied. Further, the present study underscores the importance of studying mutual interference effects during the performance of two concurrent tasks. It is suggested that future studies take this into account as an essential part of the methodological rigour.

The present study found bilateral decrements in the tapping-verbal dual task condition in normal bi/multi-lingual controls. This implies that language representations in people who acquire several languages may be a complex phenomenon. Lateralization of language functions may be governed by several factors such as age of acquisition of second language; gender; handedness; level of second language proficiency; manner, sequence and environment of second language acquisition and even the age at the time of assessment. All these factors must therefore be taken into account when trying to understand brain mechanisms underlying language processing in bi/multi-lingual subjects.

Theories of information processing have centred around either a particular brain structure being involved in the processing of a particular task or a model implicating an overall functional capacity of a processing system. The present study showed there were no differences in the pattern
of performance between stutterers and controls through the entire range of tasks. However, stutterers consistently performed poorly overall as compared to controls. This is in favour of the capacity model. The corpus callosum has been considered an important structure in the gating of information during interhemispheric tasks. However, whenever a task overloads the processing system it may fail to differentiate between failure of capacity and failure of structure (e.g., corpus callosum). Future studies need to define tasks more precisely such that they will test specific functions of brain structures without overloading the system as a whole.

One of the effective therapeutic strategies in stuttering is rate control. This is essentially geared towards reducing the processing load on the system. Since this study supports the capacity model, this may indeed be a rational approach to the treatment of stuttering.