6. SUMMARY AND CONCLUSION

6.1 Summary: A number of investigations have been undertaken in the past to study auditory function in stutterers to determine the cerebral dominance for language and or look for possible anomalies along the auditory pathway. Objective tests such as evoked potentials are more valid and useful in evaluating auditory processing as they are direct reflectors of changes in the nervous system as the stimuli is processed. Studying the auditory pathway at both the brainstem and cortical level would help in evaluating the possible site of dysfunction.

These AEPs can also be used to find out the occurrence of neuroplasticity in the central nervous system as a result of speech therapy. When pre and post therapy AEP measures are compared the changes in wave latencies as well as wave amplitude may indicate that functional neuroplasticity has taken place.

The results through AEPs by various authors are contradictory. The present study was undertaken to contribute in the direction of substantiating the findings obtained through AEPs in the past.

The present study aimed to find out the following:

1. Whether there is presence of central auditory processing disorder in person with stuttering which may be indicated by deviant findings in wave latency and amplitude of ABR, AMLR or LLR measures. And
2. Whether there are any changes in AEP measures after speech therapy which may indicate whether the functional neuroplasticity has been taken place or not.

Objectives of the study were as follows:

1. To characterize the auditory evoked potentials of ABR, MLR, and LLR in persons with stuttering.
2. To compare the ABR, MLR and LLR measures in persons with stuttering with that of fluent speakers.
3. To compare pre and post speech therapy measures of ABR, MLR and LLR in PWS as well as in fluent speakers.
4. To compare pre and post speech therapy measures of ABR, MLR and LLR measures in adults and children with stuttering.
5. To compare pre and post speech therapy measures of ABR, MLR and LLR in right and left ears of persons with stuttering.
6. To compare pre and post speech therapy measures of ABR, MLR and LLR in male and female in persons with stuttering.

Hundred persons with stuttering (PWS) (60 males and 40 females) between the ages of six to fifty years (mean age 21.5 years) formed the study group (SG). SG consisted of two groups of 1) adults with stuttering (G1) and 2) children with stuttering (G2). G1 consisted of 60 adults (35 males and 25 females) in the age range of eighteen to fifty years (mean age 30.3 years) while G2 consisted of 40 children (25 males and 15 females) in the age range of 6 to 12 years (mean age of 8.4 years). Hundred persons with no stuttering (PWNS) with a mean age of 21.3 years who were age and gender matched with the SG formed control group (CG). CG also had two subgroups G3 (adults with no stuttering) with a mean age of 29.9 years as well G4 (Children with no stuttering) with a mean age of 8.3 years. The range of stuttering was from moderate to very severe as determined by the stuttering severity index (SSI). A calibrated electrophysiological unit, IHS Auditory evoked potentials system with disposable electrodes (to record the potentials) and insert earphones (to present the stimulus) was used to record ABR, AMLR and LLR measures.

After the AEP recordings all the SG participants were enrolled in speech therapy program comprised of biweekly three months therapy module which was adapted from comprehensive therapy program by MN Hegde (2001). AEP recording was readministered after speech therapy program was over and both pre and post therapy measures were compared. In order to verify possible changes in AEP measurements due to the application of the speech therapy program, participants of CG underwent the same testing procedure pre and post treatment.

In pre assessment out of 100 PWS 28 had moderate stuttering, 56 had severe stuttering while 16 had very severe stuttering. Out of 28 PWS with moderate stuttering on pre assessment, 13 had normal fluency while 15 had mild stuttering on post assessment.
Similarly, out of 56 PWS with severe stuttering in pre assessment, 9 had normal fluency 43 had mild stuttering and 4 had moderate stuttering on post assessment. Also, out of 16 PWS who had very severe stuttering in pre assessment, 6 had mild stuttering, 8 had moderate stuttering and 2 had severe stuttering on post assessment. Thus analysis of pre and post assessments reveals improvement in terms of stuttering severity in the majority of PWS.

In AEP measures the pre therapy results obtained did not indicate abnormal mean values for latency and amplitude measures on any of the AEPs recorded for persons with stuttering as well as persons with no stuttering. However, inspection of individual data revealed that out of hundred PWS who participated in the study, fifty three (53%) showed deviancy in at least one measure of AEPs, being that five same adult subjects presented alterations on ABR and AMLR and one same child subject presented alteration on ABR and LLR.

ABR pre and post measures included latency measures of wave I, wave III, wave V and interpeaks I-III, III-V and I-V as well as amplitude ratio V/I. In pre assessment ABR measures among SG, wave I latency was prolonged (> ±3SD of mean value in PWNS) for 9 subjects (9%) in both ears. Out of these 9 subjects 6 subjects were adults with stuttering (4 males and 2 females) and 3 were children with stuttering (2 males and 1 female). Alteration was seen for both the ears. Regarding the comparative study of ABR between assessments (before and after speech therapy), there was no significant difference between pre and post assessments ABR measures in PWS (SG, G1 and G2) and PWNS (CG, G3, G4).

AMLR pre and post measures included latency measures of Pa, Na, Pb, and Nb as well as amplitude measure NaPa. In pre assessment measures, among SG wave Pa and Nb latencies was prolonged for 40(40%) subjects (> ±3SD of mean value in PWNS) in persons with stuttering. Out of these 40 subjects 24 were adults with stuttering (14 males and 10 females) and 16 were children with stuttering (10 males and 6 females).
In comparative study of AMLR between assessments (before and after speech therapy), post therapy there was significant decrease (p value .008) in wave Pa latencies in right ears in SG. In adults with stuttering (G1) the decrease in wave Pa was significant in right ears (p value .047). Gender based analysis revealed significant difference between pre and post assessments of Pa wave latencies in right ears of male participants in PWS (SG) (p= .008) and right ears of male participants in adults with stuttering (G1) (p=.035).

LLR measures included measures of latencies of waves P1, N1, P2, and N2 and wave amplitude N1P2. Pre assessment measures revealed an increase (> ±3SD of mean value in PWNS) in N2 wave latencies for 10(10%) subjects in PWS. Out of these 10 subjects 7 subjects (4 males and 3 females) were adult with stuttering while 3 subjects (2 males and 1 female) were children with stuttering. An increase in N2 peak may be indicative of slow neural conduction at the level of N2 generating site.

In comparative study of LLR between assessments (before and after speech therapy) there was significant decrease in wave P2 (p value .005) and N2 (p value .004) in right ears in SG. The decrease in wave P2 and N2 latencies was significant in right ears of adults with stuttering (G1) (p value for P2 wave .048 and N2 wave .047) and for children with stuttering(G2) the decrease was significant in P2 wave latency (p value .045) and in N2 wave latency (p value .04) in right ears. Comparisons based on side of ears showed significant difference (p=.023) between the pre and post assessments for N2 wave latency measure between right ears in persons with stuttering (SG) and persons with no stuttering (CG). When findings were analyzed based on gender there was significant decrease in P2 wave significant only for right ears in males in SG (p value .027) while significant difference was seen in N2 wave latency in male as well as female participants in SG (p value .042 for male and p value .041 for female respectively).

From pre-therapy AEP recordings, though it cannot be ascertained that the deviancy shown by 53 PWS is related to stuttering, yet results do indicate a central auditory processing problem in stutterers. Hence anomalies on the auditory AEPs may be used as a means to distinguish the organic from the psychogenic etiology of stuttering. This
suggests that the cortical auditory pathway functions differently in persons with stuttering and that they can benefit from speech therapy to improve their auditory abilities.

Pre and post speech therapy changes in AEPs in SG show a significant change in AMLR (Pa) and LLR (N2 and P2) components in right ears. The findings of this study suggest that central auditory pathways suffered a structural reorganization with speech therapy which directly influenced the processing of acoustic information. The reductions in wave latencies indicate improvement in acoustic processing which occurred for the SG who was given speech therapy and not for CG. This suggests that the plasticity type evidenced in the present study was learning-related plasticity.

The results of this study have also suggested that as significant improvement was seen from right ear which shows a greater change in left hemisphere functioning. It indicates that speech therapy program resulted into greater functional neuroplasticity in the left hemisphere.

6.2 Conclusions:
Following conclusions were drawn based on the basis of the study:

1. There is improvement in stuttering severity in persons with stuttering when pre therapy and post assessments are compared.

2. There is no significant difference in any parameters of ABR in persons with stuttering when compared with the mean values of ABR measures in persons with no stuttering. Individual data analysis revealed prolonged wave I latency for 9 subjects (9%) in SG. but the mean values for all the ABR measures in persons with stuttering are comparable to mean values of ABR measures in persons with no stuttering.

3. There is no significant difference in pre and post measures of ABR in persons with stuttering.
4. There is no significant difference in pre and post measures of ABR in persons with no stuttering.

5. There is no significant difference in pre and post measures of ABR in persons with stuttering based on side of ears.

6. There is no significant difference in pre and post measures of ABR in persons with no stuttering based on side of ears.

7. There is no significant difference in pre and post measures of ABR in persons with stuttering and persons with no stuttering based on side of ears.

8. There is no significant difference in pre and post measures of ABR in persons with stuttering based on age variable.

9. There is no significant difference in pre and post measures of ABR in persons with no stuttering based on age variable.

10. There is no significant difference in pre and post measures of ABR in persons with stuttering based on gender variable.

11. There is no significant difference in pre and post measures of ABR in persons with no stuttering based on gender variable.

12. There is no significant difference in pre and post measures of ABR in persons with stuttering and persons with no stuttering based on gender variable.

13. There is no significant difference in pre and post measures of ABR between persons with stuttering and persons with no stuttering based on gender variable.

14. There is no significant difference in any parameters of AMLR in persons with stuttering when compared with the mean values of AMLR measures in persons with no stuttering. 

Analysis of individual data revealed alteration in form of prolonged Pa and Nb
latencies for 40 subjects (40%) in SG. However the mean values for all the AMLR measures in persons with stuttering are comparable to mean values of AMLR measures in persons with no stuttering.

15. In pre and post measures, post therapy there is a significant decrease of Pa wave latency measure in the right ear in persons with stuttering (subject group) as well as in right ear in adult persons (G1) with stuttering.

16. There is no significant difference in pre and post measures of AMLR in persons with no stuttering.

17. There is no significant difference in pre and post measures of AMLR in persons with stuttering between sides of ears.

18. There is no significant difference in pre and post measures of AMLR in persons with no stuttering between sides of ears.

19. There is no significant difference in pre and post measures of AMLR in persons with stuttering and persons with no stuttering between sides of ears.

20. There is no significant difference in pre and post measures of AMLR in persons with stuttering based on age variable.

21. There is no significant difference in pre and post measures of AMLR in persons with no stuttering based on age variable.

22. In pre and post measures of AMLR in persons with stuttering there is significant decrease in Pa wave latencies in male participants in person with stuttering (SG) and male participants in adults with stuttering (G1).

23. There is no significant difference in pre and post measures of AMLR in persons with no stuttering based on gender variable.
24. There is no significant difference in pre and post measures of AMLR in persons with stuttering and persons with no stuttering based on gender variable.

25. There is no significant difference in pre and post measures of AMLR between persons with stuttering and persons with no stuttering based on gender variable.

26. There is no significant difference in any parameters of LLR in persons with stuttering when compared with the mean values of LLR measures in persons with no stuttering. Analysis of individual data revealed alteration in form of prolonged N2 wave latencies for 10 subjects (10%) in SG. However the mean values for all the LLR measures in persons with stuttering are comparable to mean values of LLR measures in persons with no stuttering.

27. In pre and post measures there is significant decrease of P2 wave and N2 wave latency measures in right ears in persons with stuttering (SG), and in right ears of adults with stuttering (G1) as well as in right ears of children with stuttering (G2).

28. There is no significant difference in pre and post measures of LLR in persons with no stuttering.

29. There is no significant difference in pre and post measures of LLR in persons with stuttering based on side of ears.

30. There is no significant difference in pre and post measures of LLR in persons with no stuttering based on side of ears.

31. There is significant decrease in N2 wave latency in pre and post measures between right ears in persons with stuttering (SG) and persons with no stuttering (CG).

32. There is no significant difference in pre and post measures of LLR in persons with stuttering based on age variable.
33. There is no significant difference in pre and post measures of LLR in persons with no stuttering based on age variable.

34. **There is significant decrease in N2 wave latency in male as well as female participants in persons with stuttering (SG) while for P2 wave such difference was significant only for right ears in male participants in persons with stuttering (SG).**

35. There is no significant difference in pre and post measures of LLR in persons with no stuttering based on gender variable.

36. There is no significant difference in pre and post measures of LLR in persons with stuttering and persons with no stuttering based on gender variable.

37. There is no significant difference in pre and post measures of LLR between persons with stuttering and persons with no stuttering based on gender variable.

6.3 **Limitations of the study:**

Some limitations of the present study are as under:

1. Among AEPs only ABR, AMLR and LLR could be included due to instrumental constraints. P300 could be included for the study.
2. The study was limited in duration i.e. pre and post assessment in a gap of three months. Long term effects of therapy in stuttering could not be assessed using AEPs.
3. Dependent variables were limited like side of ears, age and gender. Other variables like family history and handedness could be included.
4. There was no comparison in findings between persons with stuttering in whom therapy was effective and persons with stuttering in whom therapy was ineffective.
6.4 Suggestions for future study:

1. Future studies should focus on investigating whether this type of testing can really differentiate individuals for whom therapy was successful from those for whom therapy was not effective.

2. It would also be interesting to investigate if for those individuals who present improvement in both latency and wave amplitude; results of speech measurements are more stable in a long term follow-up (indication of a better maintenance).

3. We also, emphasize the need for more studies on such correlation, as the parameters in electrophysiological evaluation are many, besides the complexity of factors involved in disfluency.

4. The study can be extended so that long term effects of speech therapy can be studied in persons with stuttering.

5. P300 may be included in the study.