EFFICACY OF TUTORIAL ON ACOUSTIC IMMITTANCE MEASUREMENTS

Reg. No. M0121

An Independent project submitted in part fulfillment for the first year M.Sc (Speech and Hearing) to University of Mysore

All India Institute of Speech and Hearing
Mysore-570006

May- 2002

Dedicated to

My Amma, Achan, Viveku

Vijay and Biji

CERTIFICATE

This is to certify that this independent project entitled "EFFICACY OF TUTORIAL ON ACOUSTIC IMMITTANCE MEASUREMENTS" is a bonafide work in part of fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No.M0121)

Dr. M. Jayaram
Director
All India Institute of
Speech and Hearing.
Mysore-570006.

Mysore,
May, 2002

CERTIFICATE

This is to certify that this independent project entitled "EFFICACY OF TUTORIAL ON ACOUSTIC IMMITTANCE MEASUREMENTS" has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any degree or diploma.

Guide

Mr.Animesh Barman
Lecturer
Department of audiology,
All India Institute of Speech and Hearing.
Mysore-570006

Mysore,
May,2002

DECLARATION

This Independent project entitled "EFFICACY OF TUTORIAL ON ACOUSTIC IMMITTANCE MEASUREMENT" is the result of my own study under the guidance of **Mr.Animesh Barman,** Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore and not been submitted in any other University for the award of any degree or diploma.

Mysore,

May, 2002 **Reg. No. M0121**

Komal, Ponnu, Ramya - Thanks a lot for helping me cope up with some of the tough episodes in life.

Pawan - you 've been a great help through out. Thanks a bunch.

Sai and Amit - Thanks a lot for the timely help rendered and the transport facility. You guys are great!

Thanks to all my classmates for all the help.

Graphics - Thanks for the quick and efficient work.

ACKNOWLEDGEMENTS

/ take immense pleasure in thanking Mr. Animesh Barman, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore for his constant guidance, help and support.

I would like to thank Dr. M. Jayaram, Director, All India Institute of Speech and Hearing, Mysore for permitting me to undertake this project.

I extend my thanks to Dr.Asha Yathiraj, Reader and HOD, Department of Audiology, for permitting me to use software programme for statistical analysis.

I wish to extend my thanks to Dr. S. Venkateshan for helping me out in statistical analysis.

A big thanks to the first year batch of AIISH (2001-2002) without who, this project would have remained a 'Mission Impossible'.

Achan, Amma, Viveku and my entire family - thank you for everything.

Thank you dearest Vijjufor being a great teacher, for moulding my character, for helping me realize my potentials, for instilling self confidence, for being my inspiration ....and the list goes on.

My Biji, Nazu and Ammoos - you guys will always be my most precious possessions ! Thank you for helping me restore faith and confidence in myself and being with me through the ups and downs of life.

Nimmy and Nishi - special friends like you add more meaning to life. You mean a lot to me !

My M'lore batch - time flies, memories don 't. Three years with you all have been a blessing in disguise. I 'm so lucky to have been a part of such a wonderful family. Thomas and Neelchechi — Bestest of seniors I've ever had ! Your small gestures of concern and love have always made us (BANS) feel special.

TABLE OF CONTENTS

INTRODUCTION

The sense of hearing is perhaps the most important and the least cared for sense organ of all the five senses of the human body. The hearing abilities of man has made it possible for him to communicate through verbal language. The acquisition and monitoring of speech, the detection of potential danger, the elementary feeling of existing in a living universe, all depend upon the auditory modality.

Through out the waking life, the ear receives an uninterrupted stream of messages which are screened, stored and acted upon. How precious hearing is becomes clear only when it is lacking.

Hearing impairment affects the communication of an individual. In children it produces a delay or deviant speech and language development. Man's needs for communication with his fellow men is possibly his greatest need and the fulfillment of his other needs depend upon, or at least is greatly facilitated by his ability to hear.

Apart from this, hearing loss also affects language acquisition, especially, when the hearing loss occurs within the critical period. This is a period from five months to two years which is the best period for learning and most important for the acquisition of speech. Since we know that speech and language is the key stone of modern society, lack of adequate speech and language, causes devastating effects.

Hearing loss and the constraints imposed by hearing impairment not only affect the life of a hearing impaired child but also affects the lives of his or her family members. After much expectation about the child, when the parents realise that their child has a hearing impairment, a series of emotional reactions occur. These emotional reactions can manifest as shock, anxiety, anger, depression, guilt, resentment etc. They will be in a state of panic and confusion. Parents are faced with a multitude of problems. In addition to the concerns like providing appropriate hearing aids, initial auditory training, educational placement, speech therapy and corrective treatment required for the child, they are faced with strong feelings related to guilt, denial, anger, feelings of incompetence, self doubt and chronic sorrow.

Loss of hearing has also been seen to cause more social and adjustment problems than the loss of other human capacities such as that of vision, smell or even motor abilities like in the case of paralysis. This is because, a person with hearing loss, loses his ability to communicate and becomes a recluse in society.

All of us at some time or the other are affected by some disease or another in our lives. The faster these diseases are identified and earlier the proper treatment is initiated, the better are the results, but if they are neglected or ignored, they could turn out to be fatal to the person or can cause serious handicap that he would have to live with for the rest of his life.

Loss of hearing is one of the most common physical impairment because the 'ear' like any other organ is liable to damage from various sources, and this damage can occur in any part of the ear. As the saying goes "prevention is better than cure", one must try to prevent hearing loss.

Prevention includes primary, secondary and tertiary prevention. Primary prevention is composed of preventive initiatives inorder to prevent the occurrence of hearing loss. Secondary prevention relates to premature discovery of hearing loss and prevention of deterioration whereas tertiary prevention aims at limiting its consequences once they have already taken place.

Primary prevention can be propogated through public awareness measures. Increased public awareness can have positive effects on the implementation and planning of Hearing Conservation Programmes. This can be achieved with the help of audiologists also. It is their duty to develop interesting modes to convey valuable information to the public like what has been developed by Roshni(1991) titled 'Audiologist satisfies the Layman's doubts on hearing, hearing loss and rehabilitation[1]. Public awareness can be created using various modes, the main ones being the mass media and through public education. Through the mass media, it can be done via television, radio, magazines, posters, slogans, contests (on various aspects of speech and hearing), puppet shows, comics, cartoons, dance, drama, songs etc.

Public education can be carried out through exhibitions, homevisits, itenerant services, workshops, professional lectures, seminars, symposium, demonstrations pamphlets. One such pamphlet was developed by Monica (1995) titled 'Prevention of hearing loss-material for public education pamphlet.' Booklets, brochures, visual mode can also be used for public education. Two such have been developed by Luna (1995) titled 'Quest on audiology; learning through visuals' and also the project work named 'Hearing loss; Causes, prevention and management; A pictorial presentation' developed by Neelu. (1991). Audiovisual modes like the independent project work of Gopalkrishna (1994) titled 'Audiovisuals on Audiometers and Audiograms' and the one developed by Venugopal (1994) named 'Slides and audiotapes on normal and abnormal structures of the ear' can also be used. The efficacy of this mode (Audio visual) was later checked by Rajesh (1997) as part of his independent project entitled, 'Efficacy of audio visuals on normal and abnormal conditions of ear' and also by Ayasakanta (1995) as part of his independent project called 'Efficacy of Audiovisuals on hearing loss, a field study.'

Public education can also be carried out through street plays like the one developed by Sindhu (1997) titled 'Inactable play and its role in increasing public awareness', the efficacy of which was later determined by "Anusha (1998) as part of her independent project named 'Efficacy of street play'.

Secondary prevention strategies include hearing screening through means like High risk register (HRR). One such has been developed by Sunil (1993) entitled 'Infant screening with high risk checklist'. Prevention strategies also include detailed assessment by means of different subjective procedures like Behavioural observation audiometry and Pure tone audiometry and different objective procedures like Acoustic immittance measurements, Brain stem evoked response audiometry, Otoacoustic emission etc. So it becomes a must for a professional to gain sound knowledge about these assessment procedures.

Tutorials are the best means of gaining intensive instruction in any area. This has motivated many people to develop tutorial in different areas like, the tutorials on Pure tone audiometry by Kavita (2001) and Acoustic immittance measurements by Uma (1999), Clinical masking by Perumal (1998) developed at AIISH as part of their independent project. The information in a tutorial is carefully selected and delivered in an organised and structured manner. It also evaluates the user's knowledge through different kinds of questions which gives him or her an immediate feedback of the performance. It thus acts as an effective guide for students and experts linked with the particular field.

It is not only important that several tutorials are developed but also their efficacy in imparting information should be determined.

The tutorial of which the efficacy was studied aimed at providing intensive information regarding Acoustic immittance measurements.

Among the great number of tools, employed in the field of audiology, Acoustic immittance measurements is one which helps mainly in understanding middle ear, its functions and pathologies which is the most common cause of hearing loss during childhood.

In the present century when great importance is being given to early identification and intervention, it is obvious, how great an importance this technique has in school screening programmes conducted to identify middle ear and other otological abnormalities at an early stage. This would prevent many of the harmful consequences which may hamper the child's development. Thus Acoustic immittance measurements have a wide range of applications.

From the above discussion it is clear how important it is for students and professionals in this field to know about these measurement procedures in depth. The tutorial under study has been developed keeping this in mind.

Inorder to gather information about the efficacy of this tutorial or how much it is helpful for the beginners in the speech and hearing field, a set of questions were put up with respect to each chapter. Responses of students were then obtained so as to get an immediate feedback regarding the efficacy of the tutorial.

NEED:

The tutorials developed at AIISH should fulfil the criteria of being comprehensive and easy to understand. It must include sufficient information for the students. So it was essential to know whether any modifications were required and it would also bring into light the various precautions that have to be taken prior to the development of such manuals in the future.

AIM:

Thus this independent project has been developed to serve the following purposes:

1. To evaluate the efficacy of the tutorial on Acoustic Immittance Measurements developed at A11SH.
2. To find out which mode of exposure (visual or audio visual) to the manual is the most beneficial.
3. To find out whether any modification is required to the existing material to improve the efficacy.

METHODOLOGY

The project has been taken up to study the efficacy of the tutorial on Acoustic Immittance Measurements and also to check the effective mode of presentation. To carry out this study, the methodology used is given below.

SELECTION OF SUBJECTS:

The following criteria was considered for selection:

1. All the students belonged to 1st B.Sc Speech and Hearing who had no theoretical or practical exposure to Acoustic Immittance measurements as this tutorial has been developed with the intention of imparting knowledge to the beginners in this field. Only Speech and Hearing students were selected and not others because this tutorial was relevant for this field and students belonging to this field would pay more attention and would have more motivation to acquire more information regarding the same. Thus it would help to enhance the reliability of the efficacy of the tutorial.
2. All those students who had English as their medium of instruction during their pre-university course were selected because the medium of instruction of the course and the text was also in English.

3. The students had no sensory impairment like visual (if present, corrected) or hearing problems.

Keeping this criteria in mind 30 students were selected and was divided into two groups randomly with 15 in each group of which one group underwent the visual mode of presentation (V) and the other underwent the audiovisual mode of presentation (AV).

SELECTION OF CHAPTERS:

The tutorial on Acoustic Immittance prepared by Uma (1999) includes the following chapters.

1. Historical aspects
2. Concept oflmmillnncc
3. Instrumentation
4. Tympanometry
5. Interpretation and classification of Tympanometry
6. Tympanometry in children
7. Physical Volume Test, Static Compliance, Gradient.
8. Multi Frequency and Multi-component, tympanometry
9. Tests of Eustachian Tube Function
10. Acoustic Reflex

11. Diagnostic applications of Acoustic Reflex

12. Acoustic Reflex in children

13. Special applications of Acoustic Reflex

14. Non- acoustic Reflex

15. Calibration of Acoustic Immittance instruments

The chapters selected for the study were the following:

I. Historical aspects

II. Concept of Immittance

III. Instrumentation

IV. Tympanometry

V. Interpretation and classification of Tympanometry

VI. Physical Volume Test, Static Compliance, Gradient.

VII. Acoustic Reflex

VIII. Diagnostic applications of Acoustic Reflex

IX. Special applications of Acoustic Reflex

SELECTION CRITERIA:

Only those chapters that were felt most essential by the professionals for the beginners in this field were selected.

DEVELOPMENT OF QUESTIONNAIRE:

The questionnaire was developed based on the material provided in the tutorial. Ten questions were set for each chapter. The questions were in the form of binary choice (True/false) along with another option i.e., 'DON'T KNOW. This option was included so as to avoid the false positive responses. A total of 90 question were set. The questions also included those that were already given in the tutorial after each chapter, either in their original form or in a modified form.

PILOT TRIAL OF QUESTIONNAIRE:

The questionnaires developed for chapters were shown to the IIIrd B.Sc, 1 st M.Sc and II nd M.Sc students before administering it to the subjects and their opinions were considered in order to make sure that the questions were easy to understand and also to avoid ambiguity. After necessary modifications, the questionnaires were shown to some of the teaching professionals for approval.

COLLECTION OF DATA:

The data collection was done in three phases:

(1) Pre-exposure scores:

Both the groups (group V and AV) were given equal time (15 mins) to answer the questions before the exposure to the manual on a particular topic. The students were given instructions about the mode of answering. They were advised not to guess, instead to indicate, 'Don't know'. They were assured that the experimenter had no intention to assess their intelligence or aptitude.

The pre-exposure questionnaire required the subjects to give their identity on the right hand side so that it helped the experimenter to compare pre and post exposure scores obtained by each subject.

(2) Exposure to the manual:

Both the groups were exposed to the manual. The subjects were seated in a classroom in such a way that they could have a clear view and optimum audibility when the material was presented. The text was presented to group V only in visual mode i.e., projecting the manual on screen and for group AV it was presented in audiovisual mode i.e., projecting as well as the experimenter reading it aloud simultaneously at a normal rate of speech (160-180 words per minute) without giving any clarifications.

The subjects were also asked to note down the suggestions and modifications regarding each chapter in order to improve the efficacy of the tutorial.

(3) **Post-exposure scores:**

The respective questionnaires for the selected chapters were distributed to the students immediately after their exposure to the manual. The post exposure questionnaire had the same set of questions like the pre-exposures questionnaire but the sequence of questions was changed so as to avoid the chance factor.

The post-exposure questionnaire also required the subjects to give their identity on the right hand side. The students were given lesser time (approximately 12 mins) to answer this test, as they were familiar with the questions.

The students were exposed to one chapter per day because exposure to too many chapters in a day would have been very tedious.

Scoring pattern:

For each correct answer 1 mark was given and wrong answers including 'Don't know' was given no mark. The same was applicable to both pre and post exposure scores. The maximum score one could obtain is 10 and minimum score is 0.

Statistical analysis:

The two sets of scores (pre and post) and the differences between them was tabulated chapter wise for further statistical analysis in terms of mean, standard deviation and t-value. Paired t-test was used to determine the significant difference between pre and post exposure scores for visual and audiovisual modes of presentation.

RESULTS AND DISCUSSION

The project has been taken up with the aim to assess the efficacy of the tutorial on Acoustic Immittance Measurements using two different modes of exposure (Visual and Audiovisual). The data obtained was analyzed using statistical procedures.

1. Pre and post exposure scores obtained in the visual mode.

Table 1 shows the mean, S.D, range and t-values for each chapter. The graphical representation of pre and post exposure scores of each chapter is shown in fig. 1.

Mean of the pre-exposure scores range from 0 to 0.27 which clearly indicates that the subjects had hardly any knowledge regarding Acoustic Immittance Measurements.

Mean of the post-exposure scores range from 5.4 to 7.2. The post-exposure scores obtained in the first four chapters, the VI and the IX chapter are almost the same (around 6). This can be attributed to the usage of simple language as well as the different diagrams and illustrations that helped in easier grasping of concepts.

The V chapter that dealt with the 'Interpretation and classification of tympanograms' has obtained the maximum post-exposure score of 7.2. This may be due to the number of diagrams used to explain the text. After every explanation, the respective tympanogram is given just below that aided in better understanding. Moreover in the end of the chapter, details of the different tympanograms have been given in a tabulated form which serves as a revision material.

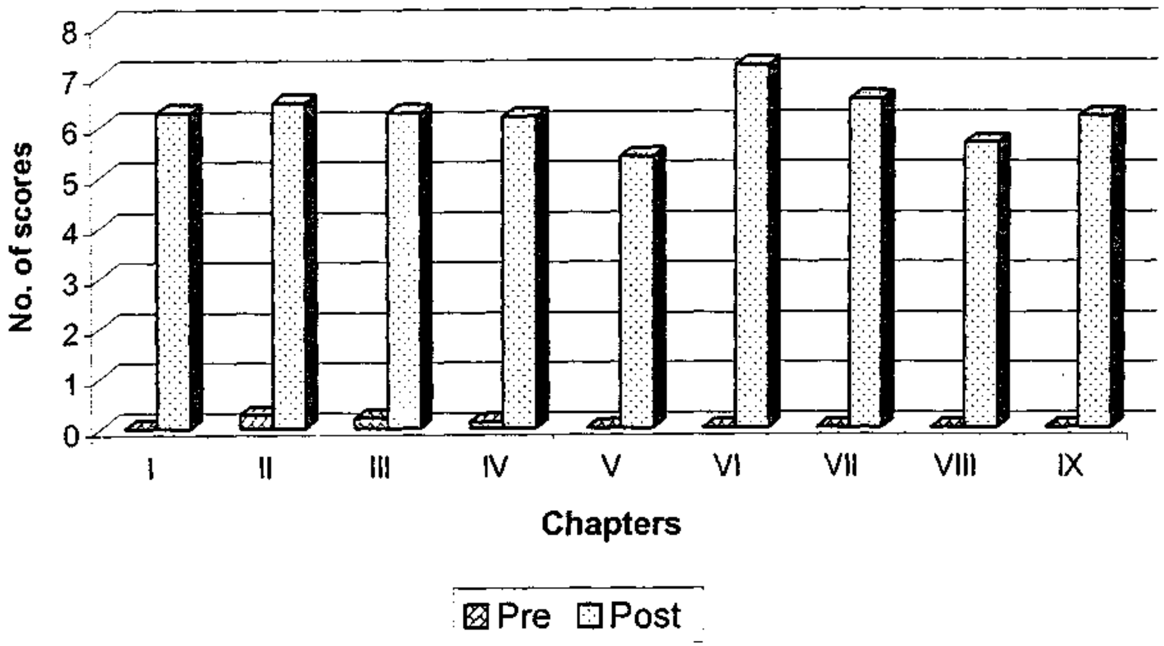
The VII and VIII chapters have obtained the least post-exposure scores i.e., 5.7 and 5.4 respectively. They dealt with 'Acoustic Reflex' and the 'Diagnostic Applications of Acoustic reflex'. These were different from the chapters dealing with tympanometry and was a separate procedure itself. Also, the text was lengthy and so a little difficult to grasp in one reading. And it did not include many diagrams for explanation.

However it is evident from the table 1 that there has been significant improvement in knowledge as can be seen from the post exposure scores in comparision to pre-exposures scores.

Table 1 Showing the Mean, S.D and range of pre and post test scores for visual mode of presentation (Group V) along with the t-value

Chapter	I		II		III		IV		V		VI		VII		VIII		IX	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	0	6.27	0.27	6.47	0.2	6.27	0.13	6.20	0	7.2	0	6.53	0	5.67	.0	5.4	0	6.2
S.D	0	1.53	0.45	1.12	0.41	0.96	0.35	0.94	0	1.26	0	1.45	**0**	0.82	0	0.82	0	1.20
Kange	**0**	5-10	0-1	5-9	0-1	5-8	0-1	5-8	0	5-9	0	4-9	0	4-7	0	4-7	0	4-8
t-value	15.82		19. 89		26.58		24.446		22.0 45		17.363		26.<379		25.:256		19.892	

Fig.1. Showing mean of pre and post scores in visual mode



2. Pre and post exposure scores obtained in the audio visual mode.

Table 2 shows the mean, S.D, range and t-values obtained for each chapter. The graphical representation of pre and post exposure scores of each chapter is shown in fig.2.

Mean of the pre-exposure scores range from 0 to 0.27. This group also showed hardly any knowledge in Acoustic Immittance Measurements like the visual group V.

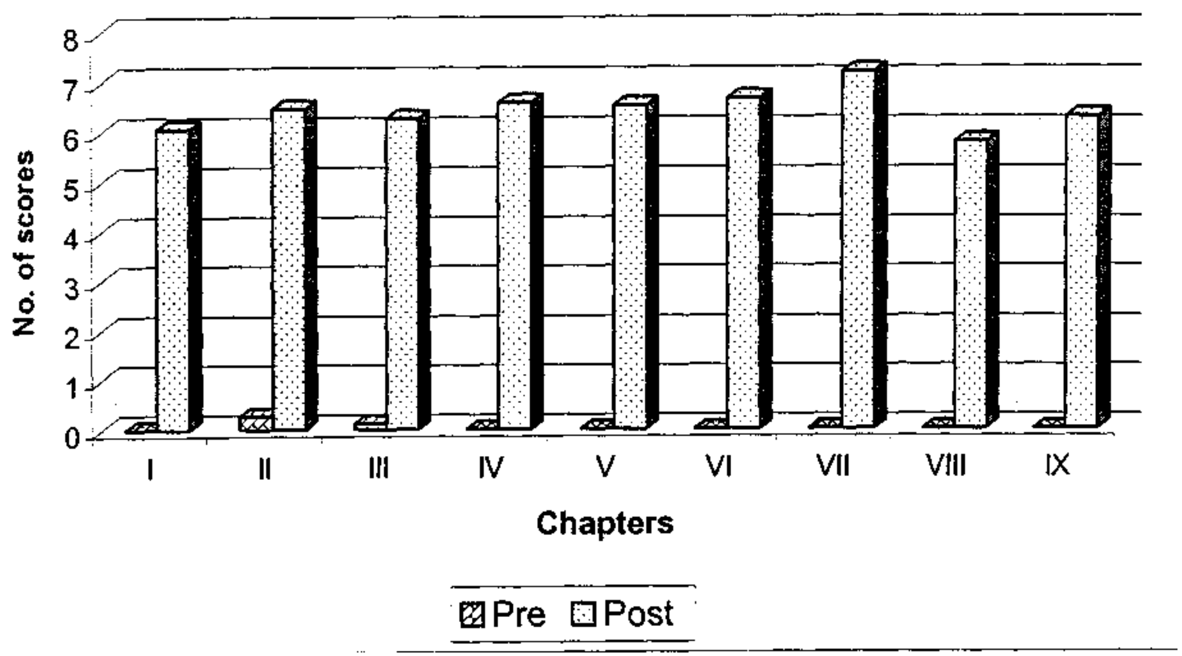
Mean of the post exposure scores range from 5.8 to 7.2. The post-exposure scores obtained in majority of the chapters are almost the same (around 6). Chapter Vll has obtained the highest score *of 7.2* and chapter VIII, the least score of 5.8. This may be due to the same reasons as stated before.

However pre and post exposure scores did show a drastic improvement in knowledge which is statistically significant at 0.01 level as evident in table 2.

Table 2 Showing the Mean, S.D and range of pre and post test scores for audiovisual mode of presentation (group AV) along with the t-value

Chapter	I		**II**		III		IV		V		VI		VII		VIII		IX	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	0	6.07	0.27	6.47	0.13	6.27	0	6.60	0	6.53	0	6.67	0	7.2	0	5.8	0	6.3
S.D	0	0.88	0.46	0.98	0.35	1.10	0	1.12	0	0.83	0	1.29	0	1.52	0	0.94	0	0.89
Range	0	5-7	0-1	5-9	0-1	4-8	0	5-9	0	5-8	0	5-9	0	5-10	0	4-7	0	5-8
t-value	26.588		23.482		22.408		22.798		30.347		20.00		18.330		23.869		27.262	

Fig.2. Showing mean of pre and post scores in audio visual mode



3. Comparison of improvement (difference of pre and post exposure score) obtained in visual and audiovisual mode.

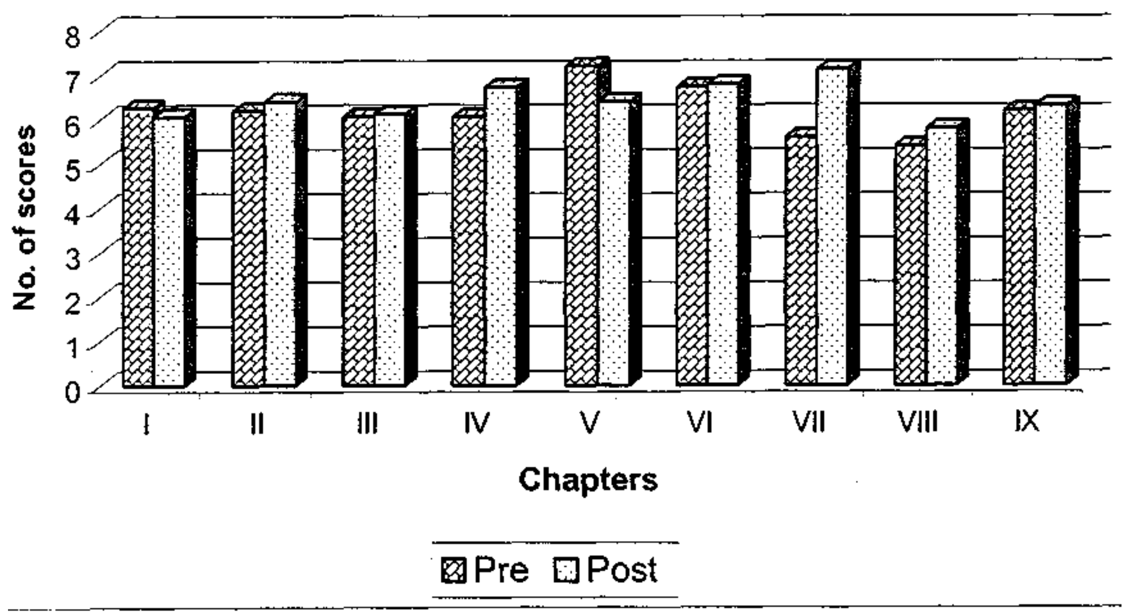
Table 3 shows the chapter wise differences in scores obtained in the visual and audio-visual mode. The graphical representation of improvement obtained in visual mode and audiovisual mode is shown in fig. 3.

As evident from this table, majority of the chapters have obtained slightly better scores in the audiovisual mode though it is not statistically significant (as revealed by the t-value). This can be attributed to the advantage of multisensory approach over the unisensory approach that facilitated better learning.

Table 3 Showing the Mean, S.D and range of the difference in scores (pre and post for both group V and AV) along with the t-value

Chapter	I		II		III		IV		V		VI		VII		VIII		IX	
	V	AV	V	AV	V	AV	V	AV	V	AV	V	AV	V	AV	V	AV	V	AV
Mean	6.27	6.07	6.2	6.4	6.07	6.13	6.07	6.60	7.2	6.5	6.53	6.7	5.6	7.2	5.4	5.8	6.2	6.3
S.D	1.53	0.88	1.21	1.06	0.88	1.06	0.96	1.28	1.26	0.73	1.58	1.42	0.83	1.46	0.83	0.94	1.21	0.90
Range	5-10	5-7	5-9	5-9	5-8	4-8	5-8	5-9	5-9	5-8	4-9	5-9	4-7	5-10	4-7	4-7	4-8	4-8
t-value	0.408		0.564		0.180		1.919		-2.347		0.135		3.617		1.309		0.397	

Fig.3. Showing mean of improvement in scores (post and pre) for visual and audio visual mode



4. Modifications required to improve the efficacy of the existing material.

In general, the students found the text as comprehensive and informative and they appreciated the usage of simple language and good diagrams and illustrations in certain chapters.

However, they put forth certain suggestions and also based on own experience the experimenter would like to suggest a few modifications that could be made to the existing material to add to its efficacy. They are given below.

1. HISTORICAL ASPECTS:

- Information with regard to names and years could have been better expressed in tabular form for better grasping.
- Easy learning strategies like mnemonics could have been included.

2. CONCEPT OF IMMITTANCE

- For better understanding, formulae for impedence, admittance, other related formulae like for stiffness/mass reactance and stiffness/mass susceptance could have been tabulated in the end so that the differences and similarities were presented clearly.

3. **TYMPANOMETRY**

- It would have been better if meanings of words and expressions like compliance and shift in amplitude were given in brackets.

4. INTERPRETATION AND CLASSIFICATION OF TYMPANOGRAMS

- It would have been useful if the respective reasons for obtaining the various tympanograms were included.
- Using two units like dapa and mmH20 was confusing. A sudden shift from dapa to mmH20 in consecutive sentences could have been backed with appropriate explanation in brackets.

5. PHYSICAL VOLUME TEST, STATIC COMPLIANCE AND GRADIENT.

- Better explanation should have been provided regarding the 2nd method for finding out the gradient.

6. **ACOUSTIC REFLEX**

- Explanation regarding the neural connections with regard to the ipsilateral and contralateral reflex pathways should have been provided in a much simpler manner.

7. DIAGNOSTIC APPLICATIONS OF ACOUSTIC REFLEX

- Explanations as to how the different Jerger Box patterns are obtained would have been helpful.
- It would have been helpful if the different Jerger Box patterns were listed together in the end.

Therefore these points should be considered while developing tutorials in future.

SUMMARY AND CONCLUSION

Acoustic Immittance Measurements, being one of the basic and essential tools in the field of audiology, one must be well versed with the subjects. The tutorial studied is the easiest way to attain intensive instruction regarding the same. To make sure that it serves its purpose effectively the efficacy of the manual had to be determined.

The main purpose of this study was to:

- Study the efficacy of the tutorial.
- Influence of mode of exposure (visual or audiovisual).
- And also to put forth some suggestions for the betterment of the tutorial.

To achieve these aims, questionnaires were developed for 9 chapters that were selected and were administered to 30, first year B.Sc. students so that the pre and post exposure scores could be obtained. Out of 30 students, 15 were exposed to visual mode of presentation and the other 15 were exposed to audiovisual mode of presentation.

The results indicated that there is significant improvement in post exposures scores in all the chapters when compared to pre exposures scores for both visual and audio visual modes.

The overall data obtained as shown in table 4 demonstrates a t-values of 36.490 and 47.448 for visual and audio-visual mode respectively which is also statistically significant at 0.01 level. Thus it clearly indicates that the tutorial has been highly effective in both the modes.

The two modes of exposure i.e., visual and audiovisual modes of exposure for each chapter did not show any significant difference in terms of post exposures scores.

The overall data also did not show any significant difference even at 0.05 significance level which is evident in table 5.

Thus from the combined analysis of each chapter in both the groups, we can infer that the tutorial was found to be highly effective, informative and useful to improve the knowledge in the subject, no matter which modality of exposure is given.

The overall impression of the subjects was that the tutorial was good and that the language was easy to understand and was highly informative. However they opined a few suggestions for improving the efficacy of the tutorial and development of tutorials in the future.

- More tables and graphs can be provided for the information to be grasped easily.
- More examples could be included so that the concepts become clearer.

Table 4 Showing the overall Mean, S.D and range of pre and post test scores of group V and AV along with the t-value

	Visual Mode		**Audio VisualMode**	
	Pre	Post	Pre	Post
Mean	0.06	6.25	0.04	6.46
S.D	0.11	0.51	0.21	0.41
Range	0-0.27	5.4-7.2	0-0.27	5.8-7.2
t-value	36.490		47.448	

Fig.4 Showing the overall mean score of pre and post exposure obtained in visual and audiovisual mode

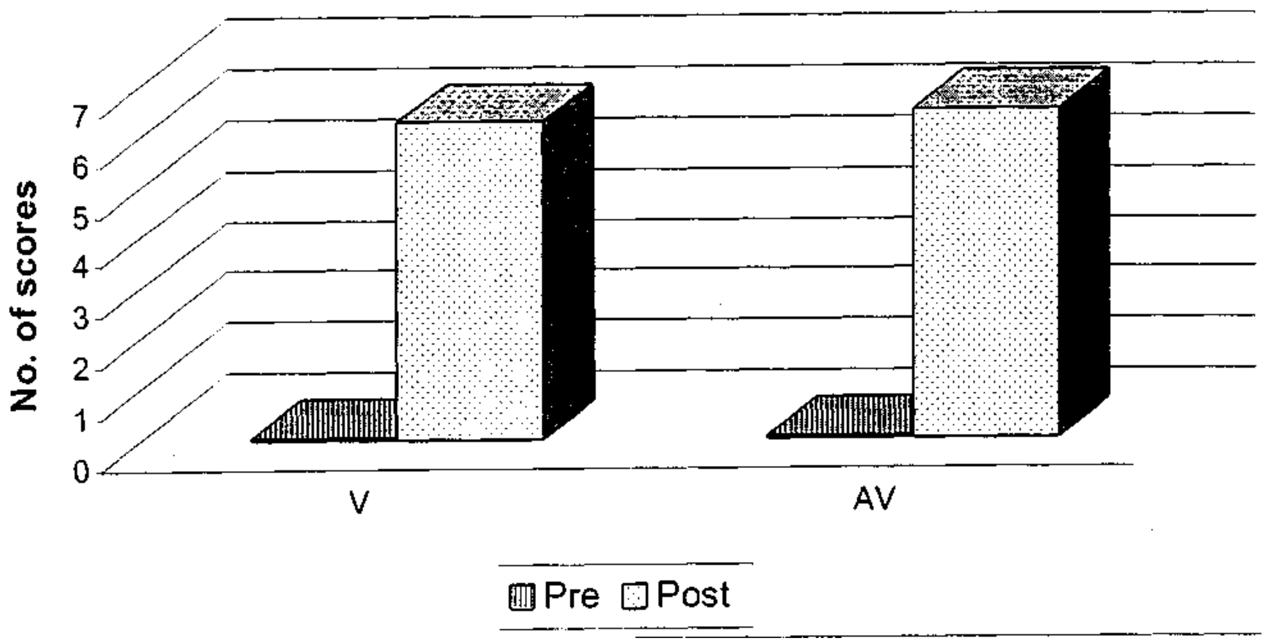
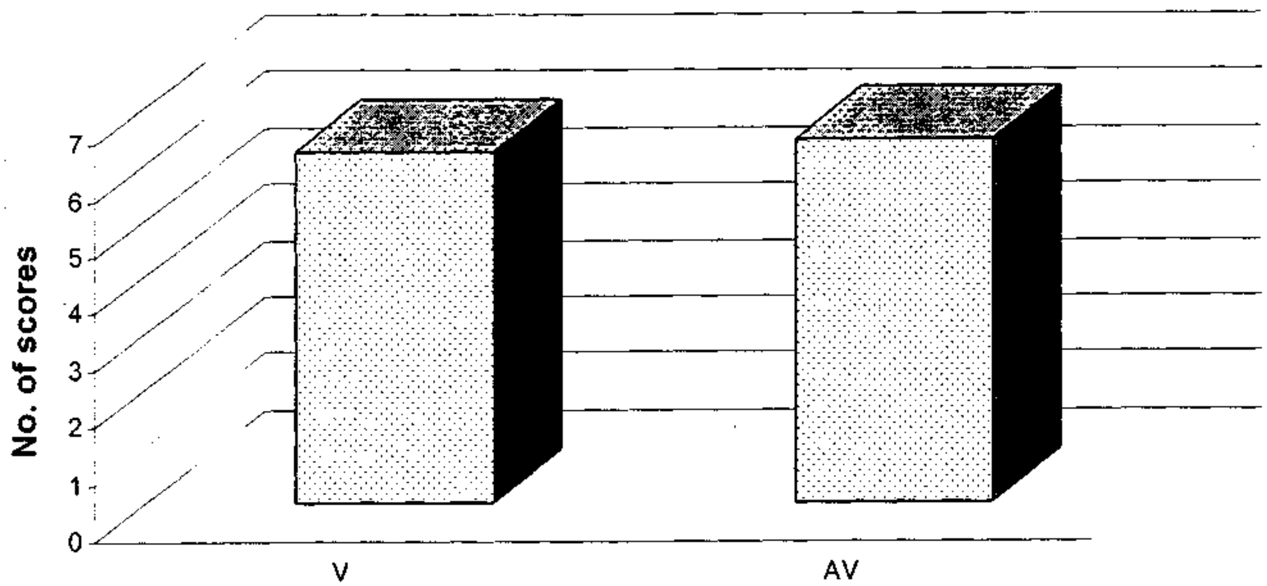


Table 5 Showing the overall Mean, S.D and range for improvement in scores (post and pre for groups V and AV) along with the t-value

	Group V	Group AV
Mean	6.193	6.417
S.D	0.5384	0.4109
Range	5.4-7.2	5.8-7.2
t-value	l.C61	

Fig.5 Shows overall improvement in scores (Post - Pre) for visual and audiovisual mode



BIBLIOGRAPHY

Anusha, A. (1998). *Efficacy of street play.* Independent project submitted to University of Mysore, Mysore.

Ayasakanta, R. (1995). *Efficacy of audiovisuals on hearing loss - Afield study.* Independent project submitted to University of Mysore, Mysore.

Elizabeth, J. A. (1997). *Efficacy of reading material for the parents of hearing impaired.* Independent projected submitted to University of Mysore, Myosre.

Gopalkrishna, S. (1994). *Audiovisuals on Audiometers and Audiogram.* Independent project submitted to University of Mysore, Mysore.

Kavitha, E. **M.** (2001). *A tutorial on pure tone audiometry.* Independent project submitted to University of Mysore, Mysore.

Luna, G. (1995). *Quest on audiology: learning through visuals.* Independent project submitted to University of Mysore, Mysore.

Monica, P. (1995). *Prevention of learning loss-Material for public education pamphlet.* Independent project submitted to University of Mysore, Mysore.

Neelu, K. (1991). *Hearing losses: Causes, prevention and management. A* pictorial presentation. Independent project submitted to University of Mysore, Mysore.

Perumal, D. (1999). *Tutorial on clinical masking.* Independent project submitted to University of Mysore, Mysore.

Rajesha, H. (1997). *Efficacy of audiovisual on normal and abnormal condition of ear.* Independent project submitted to University of Mysore, Mysore.

Roshni, R. (1991). *Audiologist satisfies the layman's doubts on hearing, hearing loss and rehabilitation.* Independent project submitted to University of Mysore, Mysore.

Sindhu, G.V. (1997). *Enactable play and its role in increasing public awareness.* Independent project submitted to University of Mysore, Mysore.

Sunil, P. N. (1993). *Infant screening with high risk checklist.* Independent project submitted to University of Mysore, Mysore.

Uma, R. (1999). *A tutorial on Acoustic immittance measurement.* Independent project submitted to University of Mysore, Mysore.

Venugopal, S. J. (1994). *Slides and audiotapes on normal and abnormal structures of the ear.* Independent project submitted to University of Mysore, Mysore.

APPENDIX -1

HISTORICAL ASPECTS

The history of clinical acoustic immittance is well over 100 years old. According to Feldmann (1970), first attempts at objective assessment of middle ear function using acoustic immittance measures were performed by Lucae (1867). The substantial literature on the measurement of acoustic immittance characteristics of human ears dates back to early 1900's.

The concept of acoustic impedance was introduced in 1914 (Webster, 1919). West (1928) was the first to do impedance measuring on the ear using electroacoustic devices. This was done in order to get necessary data for the construction of an artificial ear, required to measure the capacity of telephone (i.e. the energy radiation) under normal conditions.

Fowler (1923) studied hearing threshold changes resulting from positive and negative pressures in the external ear canal. The static pressure was seen to decrease the hearing sensitivity. Middle ear pressure was also estimated by observing the tympanic membrane through the otoscope during pressure application.

Troger (1930), he first determined the impedance in a tube introduced into the meatus and thus determined the impedance at the drum.

Keibs (1936) using a tubes, he measured the impedance on a subject with normal hearing.

Waetzman (1936) and Kurtz (1938) measured impedance using Keibs tube in connection with determination of the sensitivity of the ear.

Geffcken (1934) reported that voluntary contraction of middle ear muscle changes the acoustic impedance of the ear drum in humans.

Schuster (1934) developed a mechanical acoustic impedance bridge to determine the acoustic impedance of various materials. Prior to this only electroacoustic methods were used for impedance measurement.

Waetzman (1938) and Menzel (1940) were the first authors to adapt Schuster's bridge to human ear impedance measurement. They report only the absorption values obtainedsince phase measurement was difficult.

Application of acoustic impedance in clinical audiology is evident from the work of Metz. He published his classic monograph on impedance in (1946).

The origins of tympanometry as used in today's clinical practice were reported in 1959 by Terkildsen and Thomson. Thomsen demonstrated the principle that middle ear pressure could be determined by changing the air pressure into the auditory meatus until minimal impedance was obtained. Terkildsen was the first to use the word 'tympanometry' to describe the pressure compliance function of tympanic membrane. By late 50's and early 60's, elecrroacoustic instruments started becoming commercially available and following this acoustic immittance measures started gaining popularity.

In 1968, Denzil Brooks advocated the use of impedance meter in identifying children with fluid in the middle ear. Liden, Peterson and Bjorkman (1970) described four distinctive tympanometric patterns associated with normal and pathological ears.

The first 'tympanograms' as presently known were reported by Terkildsen and Thomson (1980) using Madsen ZO61. This marked the beginning of a new development of admittance and impedance measurements. Following this Terkildsen (1983) developed a sensitive monometric device for measuring tympanic membrane movements.

Over a span of 30-35 years acoustic immittance measurements have progressed from an experimental procedure in isolated clinics and laboratories to a routine clinical tool in most of the audiological set-ups.

CONCEPT OF IMMITTANCE

A. Impedance

1. Mechanical Impedance Let us first discuss the concept of mechanical impedance before going to acoustic impedance.

a. Constant Force -

When a constant force (F) is applied to **an** object, the object moves over a smooth surface, with **a** velocity (V). By constant force we mean a force having an amplitude which does not.change overtime. Since **a** certain degree of force is required to move the object of **a** certain weight by a certain distance, the object has an opposition to the force or in other words it has **a** MECHANICAL IMPEDANCE Z.

$$Z = \frac{\text{Force applied to the object}}{\text{Velocity of the object}}$$

$$Z = \frac{F}{V}$$

b. **Alternating** Force- An alternating force is one whose amplitude changes over time. Consider an alternating force being applied on a spring. This force is alternately pushing and pulling the spring.

In Fig. 1(A), the mechanical force has just been applied to push a spring. As we know, spring is a highly stiff object i.e. it is stiffness dominated. Initially, the force is'at a minimum and the velocity is at a maximum since the spring has not yet been compressed. In Fig. 1 (B), though the force is acting maximally on the spring, the velocity is minimum since the spring is completely compressed. In Fig. 1C mechanical force decreases until it reaches a minimum and the velocity of the spring increases until it reaches a maximum a point at which the spring is completely uncompressed. If we have to pull the spring further, force has to be applied maximally and velocity will be minimum at this point.

If we plot this graphically, with time on X-axis and force or velocity on Y axis, we can see that at t=0 ms. the force is minimum and velocity is maximum (in the +ve direction). At t=l ms. The force is maximum and the velocity of the spring is minimum, it is clear that velocity of the spring reaches a maximum (90 degree) before the force applied to the spring reaches a maximum. Thus velocity leads force by 90 degree. This is in the case of a stiffness dominated system.

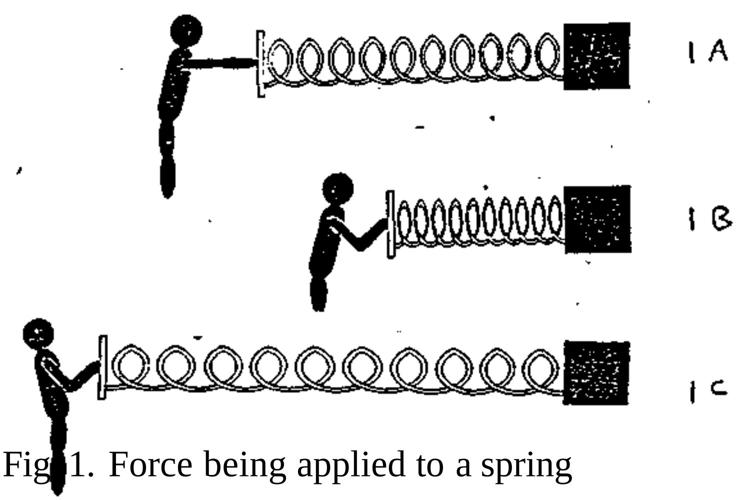


Fig. 1. Force being applied to a spring

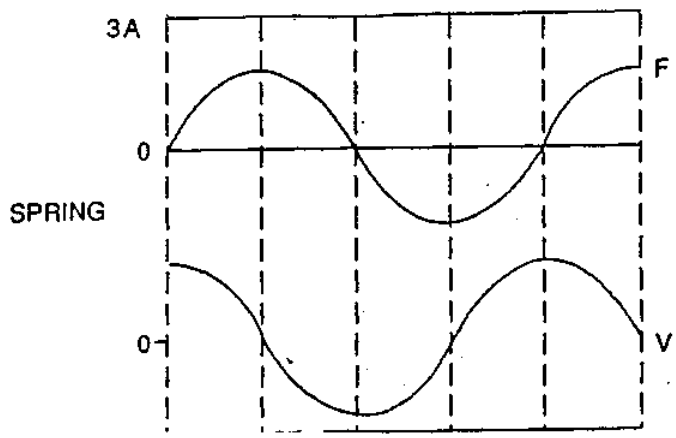


Fig.2 : Showing the relationship between force, velocity and time in a stiffness dominated system.

If we consider an object having mass, when a maximum force is applied to push the block, the velocity is minimum as the block initially rejects the push as a result of its inertia (a tendency for a mass to oppose a change in position). Once, the block starts moving, the force applied is less and velocity is more. If one has to pull the mass in the opposite direction, the force is more, but velocity is minimal. This is graphically represented below in fig. 3

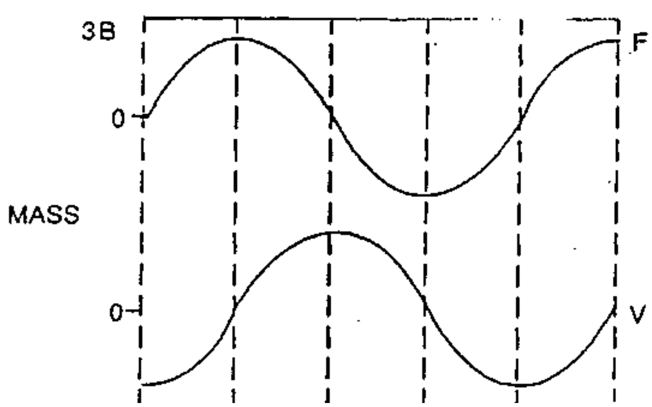


Fig.3 : Showing the relationship between force, velocity and time in a mass dominated system.

It is clear from this illustration that, velocity of the mass reaches a maximum 90 degree after the force applied to the mass reaches a maximum. Thus force leads velocity by 90 degree in a mass dominated system.

If we consider an object in a frictional system with negligible mass or stiffness, we can see that on applying an alternating force, the velocity and force attain maximum and minimum values at the same time. Thus velocity and force are in phase.

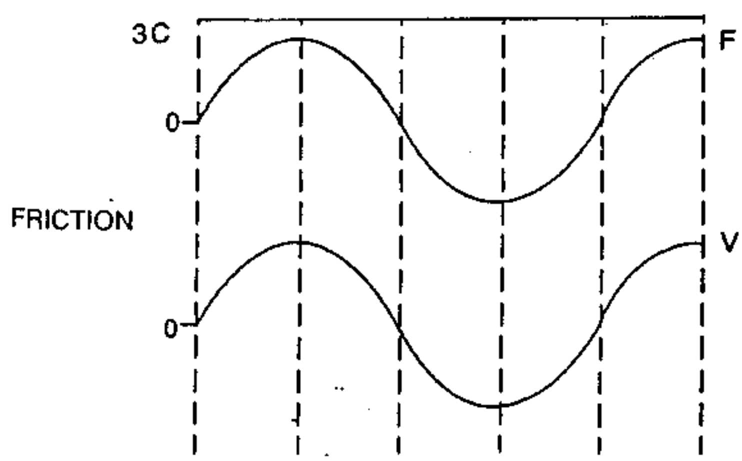


Fig.4 : Showing the relationship between force, velocity and time in a frictional system.

Thus impedance (Z) = force/velocity. Impedance consists of 3 components.

Mas reactance (+Xm) = Impedance offered by mass. The + sign indicates that force leads velocity by 90 degree.

Stiffness reactance (-Xs) = Impedances offered by spring. The- sign indicates that force lags velocity by 90 degree.

Resistance (R) = Impedance resulting from friction. For each impedance component, +Xm, -Xs or R, the impedance is equal to the force divided by the velocity.

When an alternating force is applied to several masses in a series, then the total impedance of the system is simply the sum of the mass reactances offered by each mass component. It is similar for a system having several springs in series on several frictional surfaces in series.

But if there is a system having the three types of impedance components, then the total impedance is not just the sum of the impedance components, since the relation between force and velocity is different for each of the impedance components.

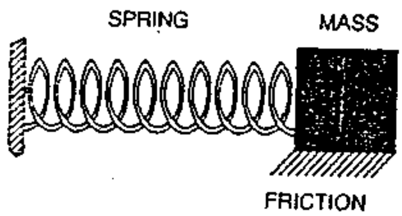


Fig. 5 : System having three types of impedance components

Therefore, a vector system is required to obtain the sum of impedance components. The resistance component of impedance is placed along the abscissa since velocity is in phase with the force.

Stiffness reactance component -Xs is placed along the negative ordinate as velocity leads force by 90 degree and mass reactance component +Xm is placed along the positive ordinate as velocity lags force by 90 degree. Xm and -Xs are out of phase by 180 degree. To obtain the net reactance, the stiffness reactance is added to the mass reactance i.e. Xt = Xm + (-Xs) = Xm-Xs. If the system has more stiffness than mass reactance. Xt will be negative and vice versa.

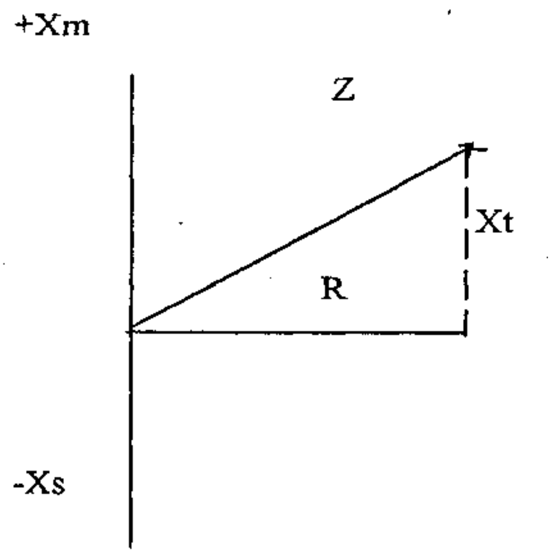


Fig.6 Vector System illustrating the total impedance.

Applying Pythagorus Theorem, Z2 = R2 + (Xt)2

i.e. Z2 = R2+(XM-Xs)2

The mechanical impedance of a system also varies with the frequency of the applied force. The relation between mechanical stiffness reactance (-Xs), stiffness (s) and frequency (f) is illustrated by the formula (-Xs = S/2πf. According to this, stiffer the spring, larger the stiffness reactance and higher the frequency, the smaller the stiffness reactance.

Similarly, $Xm = 2\pi fM$

Thus, mass reactance increases or decreases with respective increase or decrease in frequency or mass. Since, mechanical mass reactance decreases whereas mechanical stiffness reactance increases as frequency decreases and vice versa, there is a frequency at which, the stiffness and mass reactances are equal. At this frequency there is no mass or stiffness reactance. This frequency is called as the resonance frequency, which is given by the formula.

$fo = (1/2\pi) (S/M)$

Fo = resonant frequency M= mass

S = stiffness.

M = mass

Resistance, unlike mass or stiffness reactance, does not change with frequency.

Since $-Xs = S/2\pi f$, the total impedance of a system which has a net reactance, that is stiffness reactance can be written as

$Z2=R2 + (S/2\pi f)2$

Since $+Xm = 2\pi fm$, the total impedance of a system which has a net reactance, that is mass reactance can be written as

$Z2 = R2 + (2\pi fM)2$

Acoustic Impedance

In acoustics, the analog of a mechanical mass is the air volume in a tube open at both ends. Similarly, the analog of a spring is the air volume in a tube closed at both ends. When the air volume in a tube is compressed, it will behave like a spring. The analog of friction is the collision of the air molecules.

According to Van Camp, Margolis, Wilson, Gaten and Shanks (1986), the ear is an acoustico mechanical system that contains acoustical as well as mechanical impedance components. The tympanic membrane can be considered as a mechanical spring. The air volume enclosed in the middle ear can be considered an acoustic spring. The ossicular chain can be considered a mechanical mass and air molecules in the mastoid air cells can be considered an acoustic mass. The friction in the tympanic membrane, middle ear tendons and ligaments can be considered the mechanical friction and the air viscosity, the acoustic friction. As the ear also has certain impedance components, similar to mechanical impedance there is acoustic impedance which is represented by Za and +Xa represents the acoustic mass reactance and -Xa represents the acoustic stiffness reactance and Ra represents acoustic resistance.

Acoustic impedance is given by the formula Za = P/U where P represents the pressure and in dynes/cm2 and U represents the volume velocity in cm3. Volume velocity is the volume (cm3)of the sound - conducting medium which flows in a given area in a given amount of time (in sec). Za is the acoustic impedance in acoustic ohms= 105Pax S/m3.

Acoustic impedance of **a** system having a net acoustic stiffness reactance is

Za2 = (-Xa)2 + Ra2

Za2 = (S/2πf)2 + Ra2

Acoustic impedance of a system having a not acoustic mass reactance is

Za2 = (+Xa)2 + Ra2

= (27TfM)2 + Ra2

Admittance

Mechanical Admittance

It is defined as the ease with which energy flows through **a** system. It is the reciprocal of mechanical impedance. It is given by the formula Y=V/F

Y = mechanical admittance, V = velocity, F = force

The unit of admittance is mha The ease with which energy flows into a spring or an object having stiffness is called stiffness susceptance (+Bs) and the ease with which energy flows into a mass is called mass susceptance (-Bm) The signs of stiffness susceptance and mass susceptance are opposite to that of stiffness reactance and mass reactance respectively showing that they are reciprocal to each other. The ease with which energy flows into friction is called conductance (G).

-Bm is on the negative ordinate and Bs is on the positive ordinate and G is on the abscissa.

The admittance is given by the formula :

Y2 = bt2 + G2

Y2 = (B2 - Bm)2 + G2

Net susceptance

Bt =Bs + (-Bm)

=Bs-Bm

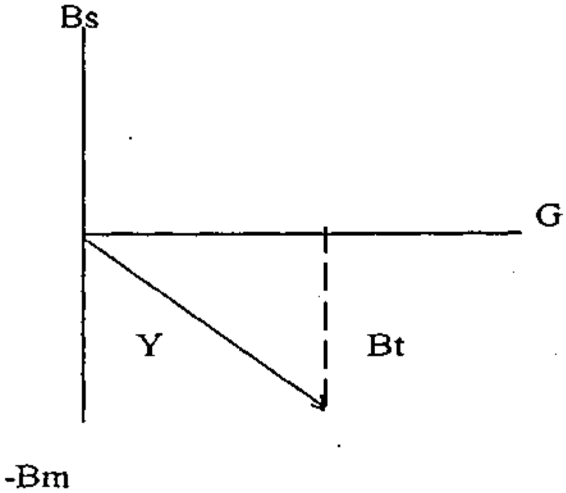


Fig. 7 Vector system illustrating the total admittance

If the system has more stiffness susceptance than mass susceptance Bt will be positive and vice versa.

Mass susceptance, stiffness susceptance etc. also varies with frequency.

+Bs = 2πf/s

-BM=1/2πfM

+Bs increases with frequency and decreases as stiffness increases. -BM increases with increase is frequency and mass and vice versa.

Acoustic Admittance

It is the ease with which acoustic energy passes through a system. It is represented by the formula :

Ya = U/P where Ya represents acoustic admittance in mho. One mho = m3 (10 Paxs). Acoustic stiffness susceptance is (+Ba) and acoustic mass susceptance = (-Ba) and acoustic conductance is (Ga).

Ya2 = Bta2 + Ga2

As we discussed earlier, the human ear contains various acoustical and mechanical impedance components. Our ear can be represented by the following diagram in which each block forms a particular component.

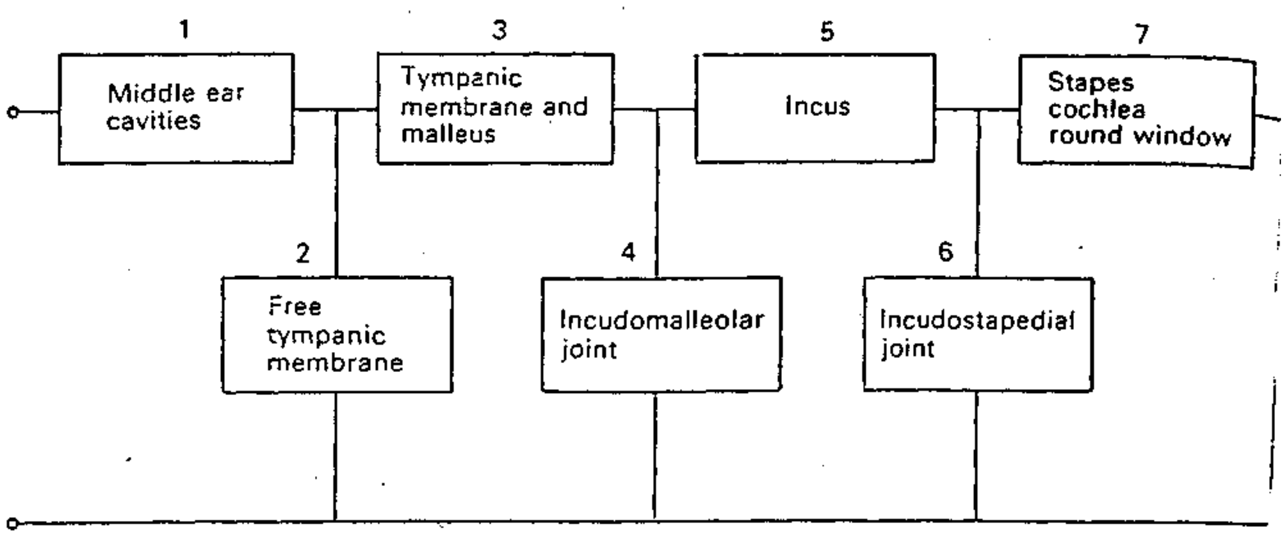


Fig.8 Functional block diagram of the middle ear.

All the blocks connected in series are associated with acoustic energy flow from the tympanic membrane to the cochlea. The shunt blocks (2, 4, 6) indicate where the energy is diverted from the cochlea and provide varying amount of decoupling between the tympanic membrane and the middle ear parts located medially to the shunt.

These shunts suggest that pathological changes in the vicinity of the tympanic membrane have a stronger effect on the acoustic impedance measured at the membrane than do medial changes.

Eg. Perforation of the tympanic membrane makes it impossible to detect the additional pathology of the middle ear.

These blocks may be substituted by electrical capacitances. We know that capacitances sum when they are in parallel. Thus C6 and C 7 can be added.

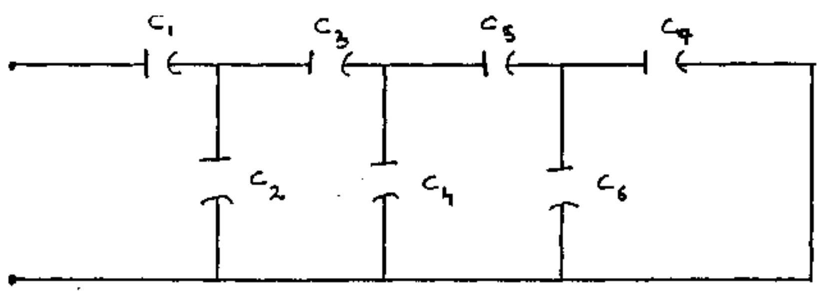


Fig. 9 Schematic representation of middle ear components in terms of capacitances.

Thus by knowing the abnormality in one component we can predict the impedance or admittance of the entire system.

Eg. C7 is the total capacitance of stapes and round window. By ankylosis of the stapes, there will be reduction in total capacitance. Thus one can expect a decrease in compliance in this case.

The current diagnostic interpretation of acoustic measurements in the ear canal are based on the above principle. It is to be noted that the term immittance refers to impedance or admittance.

It is tobe noted that the term immittance refers toimpedance or admittance.

The acoustic admittance or impedance is expressed using reactangular or polar notation. In reactangular notation, one value is given to the acoustic conductance or resistance component and one value to the net acoustic susceptance. Eg.Za = 1500 - j3000, where j is the square root of-1. It is an imaginary number. In polar notation, one number is given to the magnitude of the acoustic impedance or admittance and one number represents the phase angle of the acoustic impedance or admittance Eg. Ya=0.6<+30.

(cited in Silman and Silverman, 1991).

INSTRUMENTATION

Currently, there are several manufacturers who manufacture acoustic immittance devices. All these, measure immittance according to the same theories and concepts. Any instrument used for the immittance evaluation, will posses the following systems.

Sound Source - This consists of a pure tone generator and a speaker that is used to deliver a probe tone into the external auditory canal. The frequency of this tone is relatively low usually about 220 Hz, or may be of a higher frequency i.e., 660 Hz or 1000 Hz.

The use 220 Hz probe tone has become widely accepted for the following reasons :

a) The wave length of the probe tone should be greater than the probe physical length plus the ear canal length and low frequency tones have longer wave length.

b) 220 Hz is not a multiple of the common main frequencies (50 and 60 Hz).

c) A low frequency probe tone allows a wider choice of ipsilateral stimulus frequencies as these must be at least one octave away from that of the probe tone.

d) Low frequency probe tones are more sensitive to pathologies which alter the stiffness of the ear and such pathologies are the ones most commonly seen.

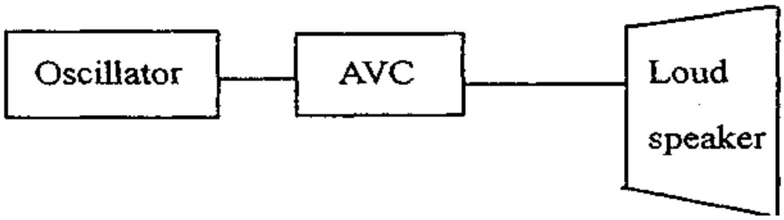


Fig.9 Sound Source

Measuring Apparatus - This consists of a microphone and an amplifier that is used to measure the intensity and/or phase of the sound pressure in the external ear canal.

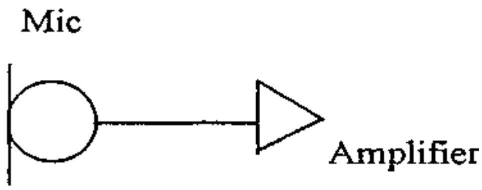


Fig. 10 Measuring apparatus

Air Pressure System - The air pressure system consists of a device capable of creating positive or negative pressures within a small sealed cavity. The range of pressures is generally from a positive 200 mm H2o to a negative 400 mm H2o. This range may vary from one instrument to another. The purpose of this system is to apply pressure of sufficient force to displace the tympanic membrane from its normal position in both the inward and outward directions, while at the same time of insufficient force which can cause damage to the hearing mechanism.

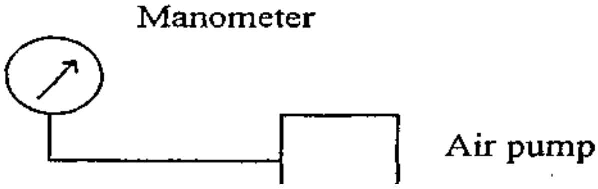


Fig. 11 Air pressure system

Probe Tip Assembly - This is a unit small enough to fit into the external ear canal with the capacity to accommodate some type of cuff that will allow an air-tight seal to be accomplished. This accommodates three lumina through which pass the access for the probe tone microphone pickup and the air pressure source.

Fig. 12 : Probe tip assembly

Comparator or Analysis System - This consists of an electronic network that compares what is being delivered into the sealed ear canal with what remains in the ear canal. It has a series of adjustment controls. These controls can be automatic or manual. Manual ones should be manipulated by the operator so that the energy matches the output energy. In an automatic one, this is done automatically by the deviceitself. There are read out devices also which can be digital, metered or adjustable scales. These controls help in maintaining a constant sound pressure level. These controls enables the examines with the proper manipulation of electroacoustic impedance device to gain useful information regarding the status of some aspect of the hearing mechanism.

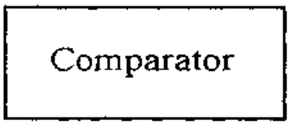


Fig. 13 : Comparator

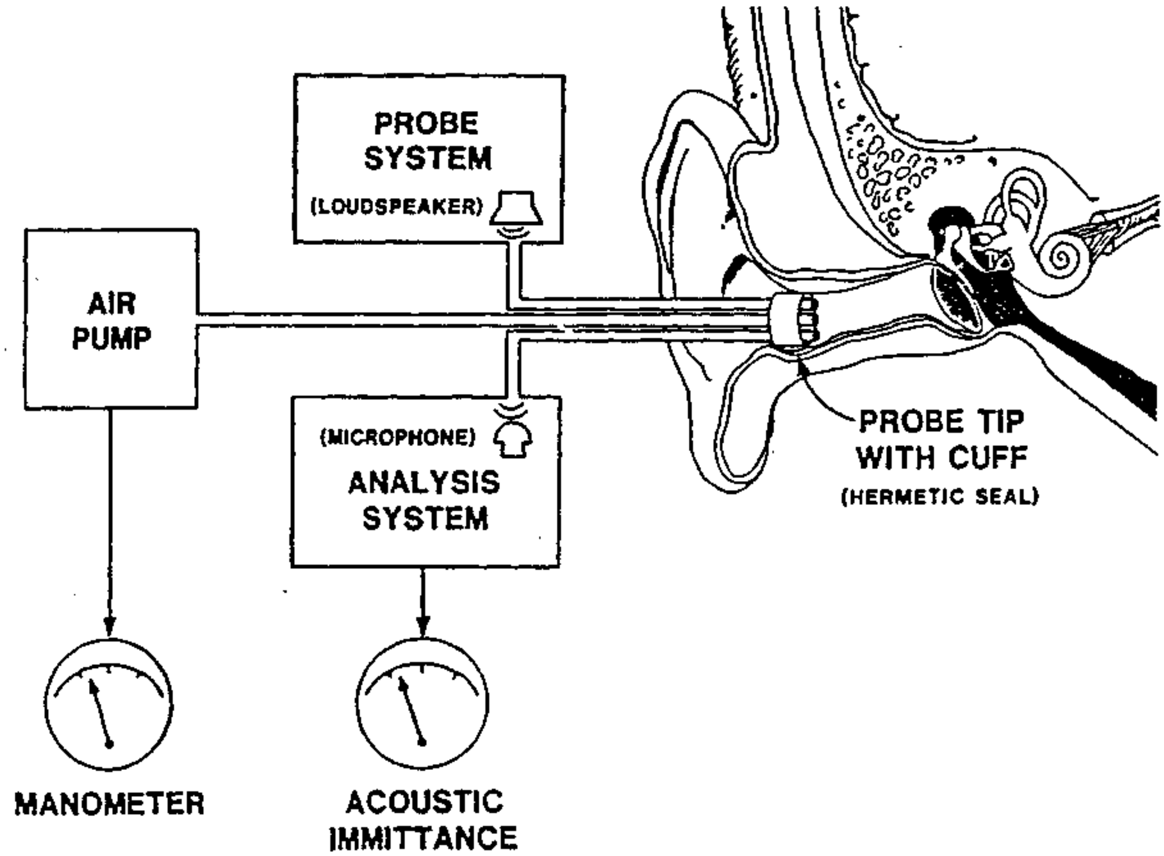


Fig. 14: Block diagram of acoustic immittance instrument.

The oscillator generates a puretone which is otherwise called as a probetone. This is altered by the automatic volume control (AVC) and it is then sent to the loudspeaker from where it goes to probe inserted into the ear canal of the subject. The reflected energy is picked up by the microphone and amplified. The comparator then compares the original signal and the reflected signal and if the energy is not at a constant level i.e. 85 dB SPL at 226 Hz, it is send to the automatic volume control. Otherwise it is send to thecompliance meter which displays the sound energy in terms of volume. If an instrument uses a variable control which can be manipulated in order to maintain the constant SPL, it is called an impedance bridge. If an AVC circuit is used for this purpose, it is called an immittance meter.

- (Cited in Block and Wiley, (1994); Crilson (1979); Keating and Olsen (1978) and Silman and Silverman (1991).

TYMPANOMETRY

The term tyrnpanometry means 'to designate impedance measurements which require systematic pressure variations in the external acoustic meatus'. Tyrnpanometry, is the measurement of eardrum compliance change, as air pressure is altered in the external auditory canal. These measurements are recorded on a graph which represents the compliance - air pressure function, known as a tympanogram.

Procedures in **Tympanometry**

Tympanometric measurement involves certain procedures. One of the important things to be remembered, is that, though it is an objective procedure, it does require at least passive cooperation of the patient.

The patient should be seated in a moderately quiet room (ambient noise level should preferably be less than 50 dB [A]) (British Society of Audiology, 1992). The patient should be instructed to sit still without speaking and the moving head and mouth. Swallowing should also be avoided. Since this procedure involves some discomfort, with young children, the testing should be done rapidly.

Inspection of the Ear Canal

Inspection of the ear canal with an otoscope is necessary prior to the actual measurement. This is done, in order to make sure that there is no obstruction in the ear canal, which can cause damage to the instrument. If there is presence of cerumen, it should be removed before starting the test. Visual inspection of the ear also helps in determining the size and shape of the ear canal, which will in turn help in choosing an appropriate probe tip.

Insertion of the Probe

Achieving an air tight seal is perhaps the greatest problem encountered while doing middle ear measurements. The clinician should lift the pinna back and up with one hand while the probe is inserted with the other hand, at the same time rotating it about 90 degree as it is pushed into the lumen of the ear canal in order to obtain an air tight seal.

Validating a seal

This is best accomplished by adjusting the pressure in the ear canal and observing the pressure meter. If the air pressure cannot be maintained, then this suggests a leak, either in the seal or in the test system. A leak which occurs only when a positive pressure is introduced implies an open tympanic membrane with the increased pressure being evacuated through the eustachian tube. Very small leaks can sometimes be tolerated.

After obtaining an airtight seal, a positive pressure (+200 mm/H2o) is introduced into the ear canal. At this point, the eardrum has least mobility. The air pressure in the external auditory canal is systematically reduced while changes in the complaince are recorded. As the air pressure is reduced, the eardrum becomes more complaint and when the air pressure in the external auditory canal is exactly the same as the air pressure in the middle ear cavity, the compliance of the tympanic membrane is maximum. As the air pressure is further reduced, the eardrum begins to show reduced compliance. This procedure can be done manually or automatically. (Cited in Feldman (1976) and Harford (1975).

The pressure sweep rate i.e., the rate at which the pressure is changed can be varied. Feldman et al. (1984) found that at a rapid pressure sweep rate the compliance is higher in both normals as well as in middle ear pathology cases. In normals, it was found that when the pressure change was faster, there was a shift in amplitude to the negative side and reverse was applicalbe for middle ear pathology cases. Hergils, Magnuson and Falk (1990) found that by using a decreasing pressure sweep followed by an increasing pressure sweep (forward-backward tracing tympanometry), the accuracy of tympanometric measures can be increased and this gives a better estimate of the true middle ear pressure than conventional decreasing pressure sweep tympanometry. The accuracy is maintained even at high sweep rates and therefore a forward-backward tracing tympanometry at a high sweep rate is recommended, but this may require limited modifications of the measuring instrument.

Interpretation and Classification of Tympanograms

Liden, Peterson and Bjorkman (1970) proposed a method for the quantification of tympanograms. Their suggestion did not receive much popularity, as the shape of the tympanograms changed dramatically from one type of conductive abnormality to another and therefore, it has not been adapted by clinicians. Following this, Jerger (1970), Bluestone et al. (1973), Feldman (1976), Cooper et al. (1982) etc. reported on low probe-tone frequency tympanograms. Jerger's (1970) system is simple and clinically popular.

In this system, tympanograms have been classified **as** type A, B or C. Since then, same additions have been made to this classification. There are mainly three parameters which are considered for the classification of tympanograms. These are :

a) the maximum compliance of the eardrum (amplitude).

b) the peak pressure (the air pressure point of greatest compliance of the eardrum)

c) shape of the tympanogram.

The different types of tympanograms are :

Type A - This is the normal tympanogram which is characterized by a smooth notch and the point of greatest compliance which occurs between 0 and -100 daPa (the peak may slightly be shifted to the positive side e.g. +25 daPa) or even +50 dapa. Different authors have proposed different values for this, but -100 mm H2o is generally accepted as the point between normal and abnormal middle ear pressure). The static compliance ranges between 0.5 cc -1.75

This is usually seen in normal middle ears and sometimes in otosclerotic ears also. It can also be seen in cholesteatoma cases where the cholesteatoma produces only a slight pressure against the ossicular chain.

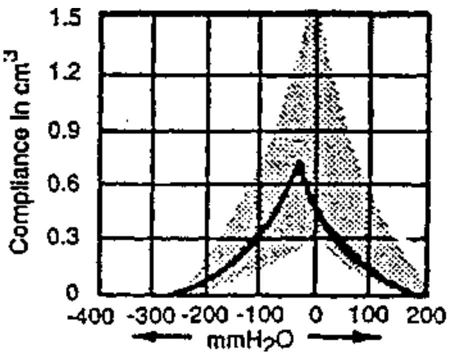


Fig. 15 Type 'A' Tympanogram

Type As - 'S' in As represents the word 'shallow'. These tympanograms usually have static compliance below 0.5 cc. The peak pressure is normal and they are smooth.

This is seen in cases of otosclerosis, tympanosclerosis etc.

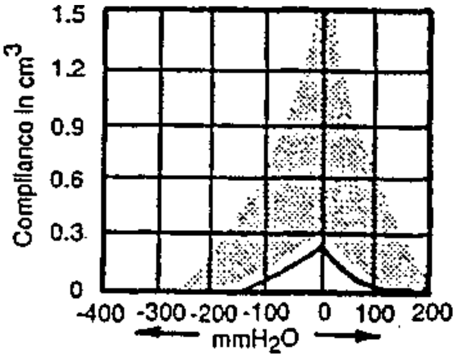


Fig. 16 : Type As tympanogram.

Type Ad - 'd' here stands for deep. The amplitude is above the normal value i.e. above 1.75 cc. The peak pressure is normal.

This is seen in ossicular chain disruption, scarred or flaccid TM (Jerger, 1970).

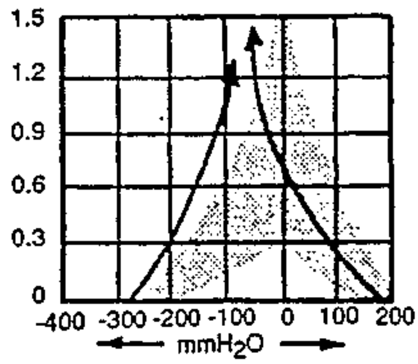


Fig. 17 Type Ad tympanogram.

Type B - There is no distinct point of maximum compliance in this type. There are relatively little changes in admittance, as the pressure in the ear canal is varied, it may be virtually flat. Sometimes, there might be a gradual increase in admittance with pressure change throughout the range of+200 - -400 daPa without a peak.

This is found in cases with fluid in the middle ear space (e.g. serous otitis media) and also in cases with perforated tympanic membrane.

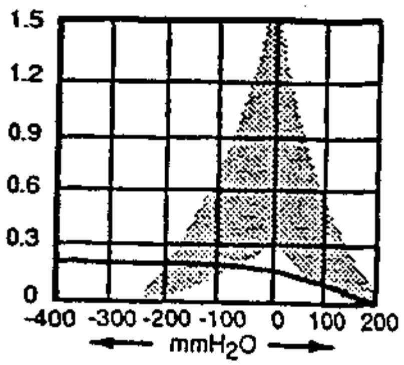


Fig. 18 Type B tympanogram

Type C - This tympanogram is characterized by a negative peak pressure i.e. it exceeds - 100 mm/H2o. There is a smooth peak.

This is seen in eustachian tube dysfunction and may be a precursor of serous otitis media.

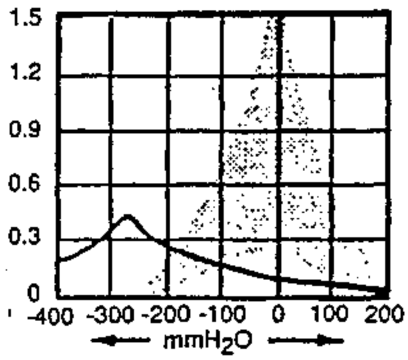


Fig. 19 Type C Tympanogram

Type D - This is a double peaked ' W shaped tympanogram (Liden et al. 1974). This is seen even in normals when a high frequency probe tone such as (600 or 800 Hz) is used. In pathological cases, this is found in simple scarred ear drums and in cases with atrophic or flaccid drum.

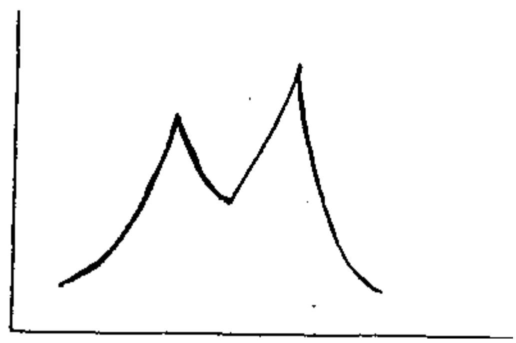


Fig.20 Type D tympanogram.

Type E - This has an undulating pattern (Liden et al. 1974). This also is seen in normal hearing subjects when a high frequency probe tone is used. It is found in ossicular chain discontinuity also.

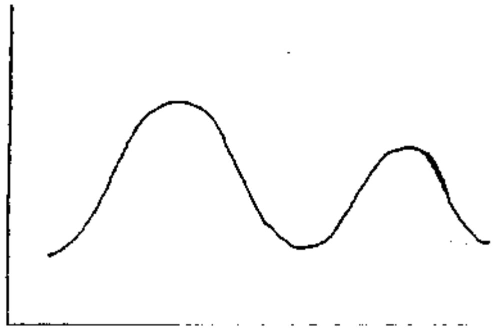


Fig.21 Type E tympanogram

Type	Amplitude	Peak Pressure	Shape	Conditions where it is seen
A	Normal	Normal	Smooth	Normal ears, otosclerosis, cholesteatoma.
As	Reduced	Normal	Smooth	Otosclerosis, tympanosclerosis
Ad	Increased	Normal	Smooth	Ossicular chain disruption, scarred/flaccid tympanic membrane.
B	Reduced	No peak	Flat	Fluid, perforation.
C	Normal	Negative	Smooth	Eustachian tube dysfunction, serous otitis media.
D	Normal	Normal	W	Scarred ear drum flaccid ear drum.
E	Normal	Normal	Undulating	Ossicular chain discontinuity.

Physical Volume Test, Static compliance, Gradient

Physical Volume Test

In this, a pressure of +200 mm H20 is maintained in the outer canal to make the tympanic membrane maximally stiff. At such extreme pressures, as the tympanic membrane is maximally stiff its compliance is negligible. The compliance reading at this point gives the actual volume in cc, between the probe and the TM i.e. the volume of the ear canal. This refers to the physical volume. In normal ears, it ranges between 0.6 cc to 1.8 cc with an average value of 1.1 cc. In rare cases it may range up to 2.8cc. In children, it may range between 0.7 to 1.0 cc.

In cases of perforation, it is more and may range from 1.3 cc to 5.0 cc. PVT may be helpful *in* delineating activity of a disease process behind a perforated TM, be it the middle ear or mastoid. For eg. in a space occupying condition like cholesteatoma, the physical volume will be reduced or in case of keratosis obturans, there is an increase in physical volume due to the destruction and enlargement of the total volume space. PVT also helps us in detecting any error in the measurement. For eg. if the physical volume is as low as 0.2 or 0.3 cc, it indicates an obstruction of the probe or the probe may be placed against the ear canal wall. Even a very high value such as 3.6 cc indicates erroneous measurement. It also helps in testing the reliability of the tympanogram. If an 'A' type tympanogram shows a physical volume of 3 cc, then the measurement is unreliable.

Thus, PVT is an important measurement which is helpful in differential diagnosis of various abnormalities of the ear.

Static Compliance/Static Immittance

Static compliance/static immittance is the acoustic immittance of the middle ear at rest, i.e. under normal atmospheric pressure. Though it is often calculated during tympanometry, static immittance is in contrast to the immittance - pressure function (tympanogram), which is a dynamic measure of middle ear physical properties.

Static compliance is measured in terms of equivalent volume in cubic centimeters. The recommended test method is to make two volume measurements with the impedance audiometer.

The first measurement Cl is made with the tympanic membrane in a position of poor compliance, clamped at +200 mm/ H20 air pressure. The second volume measurement (C2) is made with the tympanic membrane at maximum compliance. Since the sound is more easily transmitted by the tympanic membrane during the second volume measurement, (C2), the probe-sound pressure in the enclosed cavity of the external canal will be lower than noted for the first volume measure - but the equivalent volume in CC for the second measure will be larger than noted in the first volume measurement (Cl). The static compliance of the ear is calculated by subtracting C1 from C2. This gives the compliance of the middle ear mechanism in cubic centimeters.

The compliance of the normal middle ear system is influenced by variables like patient age, sex, etc. (Jerger, et al. 1972). Brooks (1971) reported that increase in age caused increase in compliance. Jerger (1972) found lower average compliance in women when compared to men. The maximum compliance value in men was between 30-39 years of age and beyond this age, the compliance decreased with advancement in age. There are no interarual differences in static compliance. A stiff middle ear system demonstrates a compliance value less than 0.50 msec. while a flaccid middle ear system should have compliance greater than 1.75 mho. However, the range of static compliance values for normal ears versus pathological ears overlap to some extent.

Though static immittance in isolation is of little value in the identification and differentiation of middle ear disorders, when interpreted in conjunction with other audiometric tests, it can be an important clinical measurement of middle ear status. The normal static compliance value ranges between 0.5 and 1.75 acoustic mhos for a 226 Hz probe frequency at a low pump speed. For a higher pump speed, it ranges from 0.57 - 2.00 acoustic mhos - Van Camp, et al. (1986).

Gradient

Gradient refers to the slope or width of the tympanogram at the peak. The gradient is given by the ratio of hp to ht, where hp is the distance from the tympanometric peak to the horizontal line intersecting the tympanogram such that the distance between the points of intersection (a and b) is 100 daPa and ht is the peak height of the tympanogram (Brooks (1969). The smaller the gradient the flatter the tympanogram. According to Brooks (1969) and Paradise, Smith and Bluestone (1976) a gradient is small if it is less than or equal to 0.15.

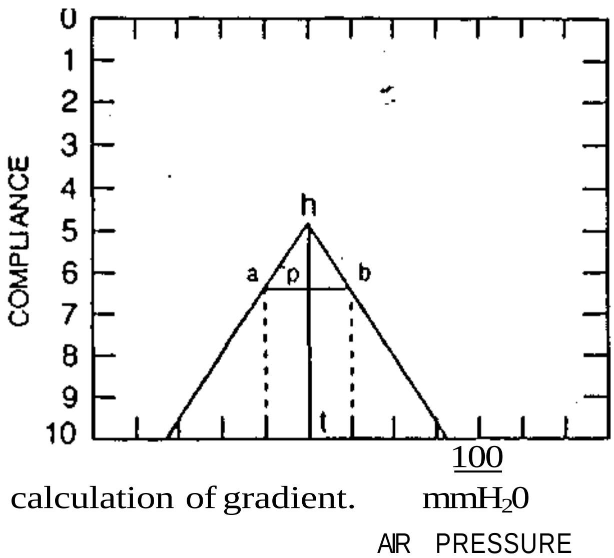
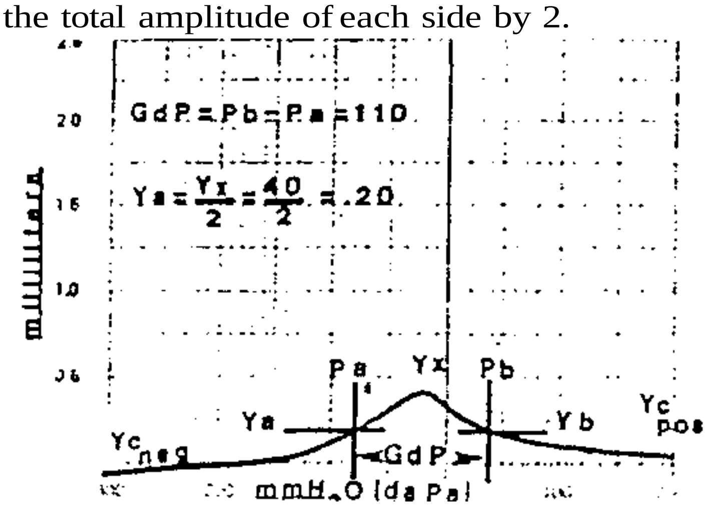


Fig.22 Showing calculation of gradient.

Another method of calculating the gradient, is the computa tion of tympanogram admittance relative to a pressure range. In this, a half-amplitude admittance (Y) point is determined and each side (positive pressure (Ya) and negative pressure (Yb) directions, by dividing the total amplitude of each side by 2.

Fig.23



Tympanogram gradient calculation based on the difference in pressure (GdP)

The difference in air pressure between each of these points on the slope of the tympanogram (Pressure for Ya, Pa; pressure for Yb, Pb) is referred to as delta (difference) pressure (dp) and is stated in daPa.

This method has been recommended by ASHA (1989) and is also incorporated into the Grason-Stadler 33 Middle Ear Analyzer. According to ASHA (1989), the 90% ranges for tympanometric width (gradient) of normal persons are 60-150 dapa in children and 50-110 daPa in adults (regardless of pumpspeed). A pressure interval wider than these values, suggest middle ear effusion.

Thus, it is a clinically useful tympanometric parameter. It can be used to supplement measurement of ear canal volume, pressure, peak admittance and static admittance.

ACOUSTIC REFLEX

Reflex is defined as the simplest form of involuntary response to a stimulus. Like in other organs, reflexes are observed in the middle ear also for loud sounds. It has been found that, on presenting loud sounds, the stapedius muscle contracts thereby stiffening the ossicular chain. This reflexive contaction of the stapedius muscle to loud sounds is termed as acoustic reflex. This results in an increase in middle ear impedance which can be measured by various impedance measuring instrument.

Thus, in order to determine whether or not an acoustic reflex has been obtained, the procedure requires that one measure the acoustic impedance at the eardrum and then, while continuing to monitor the impedance, one introduces an acoustic stimulus into either the contralateral or ipsilateral ear. If the stapedius muscle contracts following the acoustic stimulus, it should result in an increase in the monitored acoustic impedance.

Other direct approaches like opening the tympanic cavity and observing the muscle contractions or observing the changes in muscle activity with electromyography etc. have also been used. Clearly, these methods are not preferred for routine assessment of middle ear function.

The Neural Acoustic Reflex Pathways

The stapedius muscle is attached to the posterior side of the neck of the stapes and is the smallest muscle in the body. Our current understanding of the acoustic stapedius reflex pathway is based primarily on experimental study of the rabbit (Borg, 1973, 1976).

The neural network of the stapedius (acoustic) reflex is located in the lower brainstem and consists of both ipsilateral and contralateral routes. During loud acoustic stimulation, the ipsilateral pathway begins with impulses from the cochlear sensory cells from where it is transmitted to the ventral cochlear nucleus through the acoustic nerve. From here some fibres go to the facial motor neuron and from there to the stapedius muscle through the facial nerve. Some fibres from the ventral cochlear nucleus also go to the medial superior olivary complex and reach the facial motor neuron and then the stapedius muscle.

The contralateral acoustic reflex arc always contains four neurons. From the acoustic nerve and the neutral cochlear nucleus, impulses are transmitted to the medial superior olive and across to the contralateral facial motor nucleus. The fourth neuron transmits the impulse from the contralateral facial motor nucleus to the contralateral stapedius muscle. The other contralateral acoustic reflex are has (a) the first order neuron from hair cells of cochlea to ipsilateral ventral cochlear nuclei (b) second order nerurons from ipsilateral VCN to contralateral SOC and (c) third order neuron from contralateral SOC to contralateral FMN and (d) fourth from contralateral FMN conrralateral stapedius muscle. The stapedius muscle is innervatd by the facial nerve (cranial nerve VII).

The acoustic reflex response depends on adequate physiologic function of the entire reflex are including cochlea, eighth nerve, brainstem seventh nerve and stapedial muscle. The specific site of lesion within the acoustic reflex are is determined by comparing stapedial reflexes between crossed and uncrossed stimulation (Jerger, 1980; Jerger and Jerger, 1983).

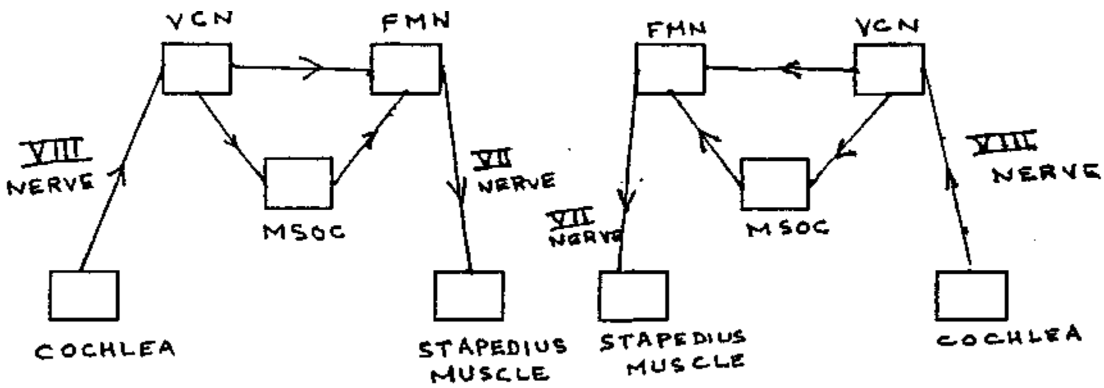


Fig. 32. Block diagram of ipsilateral pathways

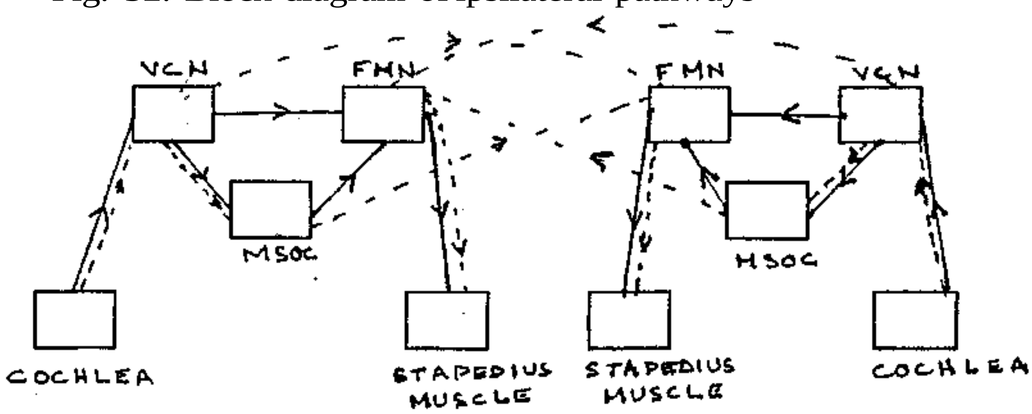


Fig.33 Block diagram of contralateral pathway (DOTTED LINES)

Acoustic Reflex Threshold

As mentioned earlier acoustic reflex is indicated by an increase in acoustic impedance or decrease in compliance of the middle ear system. Acoustic reflex threshold (ART) is the lowest intensity of an acoustic stimulus at which a minimal change in the middle ear compliance can be measured. The ART for normal hearing subjects is 70-100 dB hearing level (HL) (Metz, 1946; Fria et al. 1975). For contralateral stapedial reflex, the threshold value is approximately 85 dB HL for puretones and 65 dB HL for broad band noise. Ipsilateral reflex thresholds are slightly lower (Moller, 1962).

Acoustic reflexes are usually elicited using puretones pulse tones or broad band noise clicks can also be used and at higher click rates, the amplitude of acoustic reflex is found to be more (Rawool 1996 and 1997).

Variables that affect the ART

1. *Intensity*- Reflex amplitude increases as stimulus intensity is increased above the reflex threshold for 10-15 dB. Beyond this increase little additional amplitude change can be noted at higher stimulus intensities. Wilson (1979) reported that reflex magnitude for puretone stimuli is similar across frequencies.

2. *Duration* - Silman and Gelfand (1982) suggested that activators lasting 1 to 2 sec. are ideal, because with brief activators (i.e. 300 msec or less) stimulus level must be increased in order to compensate for the reduction in stimulus on-time. Signals longer than 2 sec. seem to have little effect on the ART.

3. *Bandwidth* - ART is found to be lower for broad-band noise than puretones. ART is reduced as bandwidth increases at each test frequency.

4. *Ipsilateral vs. contralateral reflexes* - Early studies report that ipsilateral acoustic reflex can be elicited at lower intensities than contralateral acoustic reflex (Moller, 1961; Fria et al. 1975). But Laukli and Meir (1980) did not find this difference. Jerger et al. (1978) used a special immittance measuring technique and reported that the differences between ipsilateral and contralateral reflex measurements were due to neuromuscular events. With the use of advanced instrumentation which uses signal averaging and the same stimulus origin for both sets of reflexes, such differences are not observed (Stach and Jerger, 1984, 1987).

Two other important points are to be noted here. One is that, artifacts are more in ipsilateral reflex measurements, as the probe tone and eliciting signals are presented through the same tube. Also intensity levels of ipsilateral reflex are reported in dB SPL rather than dB HL and therefore a correction factor has to be added before comparing it with contralateral reflexes.

5. *Drugs (including alcohol)* - Barbiturates and ethanol can elevate the ART, though the effect appears to be greater for alcohol (Bauch and Robinette (1978). Sedation is also seen to affect acoustic reflex thresholds. Borg and Moller (1968); Robinette etal. (1974) reported that acoustic reflex threshold may be elevated in sedated patients. Any drug that can alter central nervous system responses may have a dilatory or inhibitive effect on the acoustic reflex (Northern, 1980).

6. *Age* : Studies by Hall (1978), Jerger et al. (1978) and Hall and Weaver (1979) show that ART to puretone stimuli tend to improve

slightly with increasing age from 0-59 years but there is no change observed for broad band noise stimuli. Contrary to this, Silman and Gelfand (1982) found no significant clinical change in ART measurements as a function of age. Wilson (1981) noted what the amplitude, or size of the acoustic reflex diminishes with age.

7. *Handedness* - Johnson (1979) reported that left handed children were significantly slower than the right handed in terms of development or maturation of acoustic reflex sensitivity. Right ears in general gave reflexes at about 3.8 dB lower than the left ear did,

Acoustic Reflex Adaptation - During sustained activation of the acoustic reflex, the stapedius muscle begins to relax and the acoustic immittance of the middle ear mechanism begins to return to the preactivator state. Relaxation of the stapedius muscle during presentation of a reflex - activator signal is called acoustic reflex adaptation or decay. In normal auditory system, the amount and rate of reflex adaptation is directly related to the frequency of the activator signal (Djupesland, et al. 1967; Johansson, et al. 1967) and is inversely related to the level of the activator signal, especially for levels near the acoustic - reflex threshold (Dallos, 1964).

Acoustic Reflex elicited by Bone-Conducted Puretones

Djupesland et al. (1973) measured acoustic reflex threshold for bone conductive pure tones. It was tested using a mini shaker (Bruel and Kjaer, Type 4810) at frequencies 250, 500, 1000, 2000, 3000, 4000 and 6000. A considerable difference between reflex thresholds for air and bone conducted pure tones was found, especially in the lower frequency range, where the difference amounted to 5-25 dB. At higher frequencies, in some cases, it was not possible to elicit the reflex, even when the maximum intensity was used. This difference in air and bone conducted thresholds could be due to a difference in the inner ear distortion for air and bone conducted pure tones.

Suprathreshold Measures of the Acoustic Reflex

1. *Acoustic Reflex Latency* - The latency of the acoustic reflex is the time difference between the onset of the reflex - activator signal and the onset of acoustic reflex. This is not a very reliable measure due to the following reasons. First the definition of the onset of the acoustic reflex is imprecise. Second, the commercially available electroacoustic immittance instruments have various time consonants (Jerger, Olives and Stach, 1986; Lilly, 1984; Margolis and Gilman, 1977; Shanks, et al. 1985). Third, investigators use different onset landmarks to define onset of the acoustic reflex. Some investigators use the initial detectable change in acoustic immittance whereas some others use a percentage of the maximum immittance change, which can be 10%, 50% or 90% (Borg, 1982; Bosatra, et al. 1984; Lilly, 1984). Fourth, the latency of the acoustic reflex is inversely related to the level of the reflex -activator signal (Dallos, 1964; Hung and Dallos, 1972; Lilly, 1964;Moller, 1958; Ruth and Niswander, 1976; Terkildsen, 1960). Fifth, the latency of the acoustic reflex varies with the frequency and level of the activator signal. Ruth and Niswander reported that the latency was shorter for a 3000 Hz activator

than for a 500 Hz activator at levels less than or equal to 104 dB SPL, whereas at activator levels greater than 104 dB SPL, the latencies for the two frequencies were the same.

Acoustic reflex latency measures have been used as a part of the differential diagnosis which will be discussed in detail in later chapters.

2. *Acoustic reflex amplitude* - The magnitude or amplitude of the acoustic reflex is the difference between the immittance of the middle ear during the resting or baseline state and the immittance of the middle ear during the reflexive stage.

Level of the activator signal is directly related to the amplitude of the acoustic reflex and so is the duration. As duration increases to about 500 ras, reflex amplitude increases. Other observations include steeper reflex growth functions for mid-frequency activator signals than for low-frequency activator (Moller, 1961). Also binaural activator signals produce largest reflex amplitude, followed by ipsilateral activator signals which produce the second largest amplitudes and finally the contralateral signals which produce the smallest amplitudes (Moller, 1962).

Diagnostic Applications of the Acoustic Reflex Measurement

The diagnostic applications of the acoustic reflex considerably outweigh the contribution of tympanometry and static compliance in the acoustic immittance test battery (Jerger and Hayes, 1980; Northern, 1984). Since the publication of the classic monograph by Metz (1946), audiologists have realized the immense diagnostic value of this simple physiologic reflex. Acoustic reflex measurements, however should not be examined in isolation but must be considered as an integral part of the total immittance test battery.

Conductive Hearing Loss - It has been observed that when there is a middle ear disorder of even the slightest degree, reflexes are obscured in that condition. Since middle ear disorders prevent the tympanic membrane from showing a change in compliance when the stapedial muscles contract, both ipsilateral and contralateral reflexes are absent bilaterally in the presence of even a mild bilateral conductive hearing loss.

The presence or absence of the acoustic reflex also depends on the magnitude of the air bone gap. If the air bone gap is less than 30 dB contralateral reflexes are usually present but if it exceeds 30 dB contralateral reflexes are unlikely to be present. In the affected ear, the reflexes are absent (ipsilateral reflexes) even when the air-bone gap is very small, due to the mechanical problem of that ear. Thus, skillfull interpretation of acoustic reflexes in unilateral hearing loss cases can sugsest the degree and nature of hearing loss.

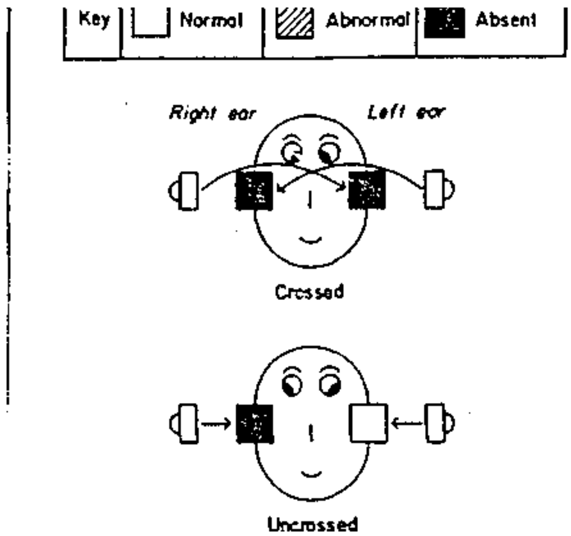


Fig.34 : Ipsilateral and contralateral reflexes in a unilateral right ear conductive hearing loss greater than 30 dB HL (inverted L pattern).

It has been observed that, patients with otosclerosis have a unique pattern of acoustic reflex. According to Terkildsen et al. (1973) and Jerger et al. (1973) the acoustic reflex is generally not observed in either ear. In early otosclerosis, there is a biphasic reflex pattern observed. This was first reported by Flottorp and Djupesland (1970). This is characterized by a momentary negative deflection at the start of the reflex and again at the end of the reflex as the stimulating signal is shut off (Bel et al. 1976). This is not seen in later stages of otosclerosis.

Biphasic reflexes are occasionally found in certain normal ears with loose coupling between the stapes and oval window. This is due to the decrease in the resistive component during acoustic reflex contraction. Another biphasic pattern in normal ears has been reported for high frequency probe tones. Another typical finding in conductive loss cases, is a combination of the following (a) presence of air bone gap with normal bone conduction threshold (b) 'A' type tympanogram (c) absence of reflexes. This combination is termed as impedance signature which is a defnite indication of a conductive pathology.

Unfortunately, certain middle ear pathologies are exceptions to the normal rule and they do exhibit acoustic reflex. Northern (1977) reported that an exception occurs in cases of ossicular disruption when the connection is maintained between the insertion point of the stapedius muscle on the stapes and the eardrum. A middle ear cholesteatoma that does not impinge on the eardrum of ossicular chain, as well as some ears with serous otitis media and negative middle ear pressure, may also produce normal patterns.

Sensory-neural Hearing Loss - The differentiation of cochlear versus eight nerve disorders has been a primary challenge in audiometric evaluation.Acoustic reflex measurements have been very helpful in this purpose.

Cochlear Pathology - An early application of the acoustic reflex was in the evaluation of the cochlear phenomena of abnormal loudness growth. Mezt (1952) found that acoustic reflex is elicited at sensation levels of less than 60 dB SL in ears with cochlear lesions. The comparison between the acoustic reflex threshold hearing level (HL) to the degree of hearing loss is referred to as the *Metz test for fondness recruitment.* If the acoustic reflex is obtained below 60 dB SL, it is considered to be a positive Metz test result.

There are a few other tests which can be employed for testing the presence of cochlear pathology.

Differential Ratio Quotient (DRQ) - Fitzland and Balkany (1974) [cited in Malini, 1980] gave a formula for determining the amount of recruitment which was termed as DRQ.

$$DRQ = \frac{(A-X)-(B-Y)}{X-Y}$$

Where A = ART of better ear

B = ART of poorer ear

X = Puretone threshold of better ear

Y = Puretone threshold of poorer ear

DRQ= 0-1 - Partial recruitment

= 1 - Complete recruitment

= >.] - Hyper recruitment

Reflex Relaxation Index - Norn's et al. (1974) compared the temporal characteristics of reflex in ears with sensori-neural hearing loss with that of normal ears, at 1000 Hz. He observed some difference between the normal and pathological ears in terms of latency.

To measure these alterations in reflex relaxation time, Norris, Stelmachowicz and Taylor (1974) described the procedure for obtaining reflex relaxation index. A pulse tone of 500, 1000 and 2000 Hz is presented at 10 dB above ART. The width of the pulsed component (b) is divided by the total reflex amplitude (a) to obtain RRI. An RRI of less than 30% was considered to be indicative of sensory hearing loss (Norris, et al. 1974). Letien and Bess (1975) suggested a cut off point of 40% instead of 30%.

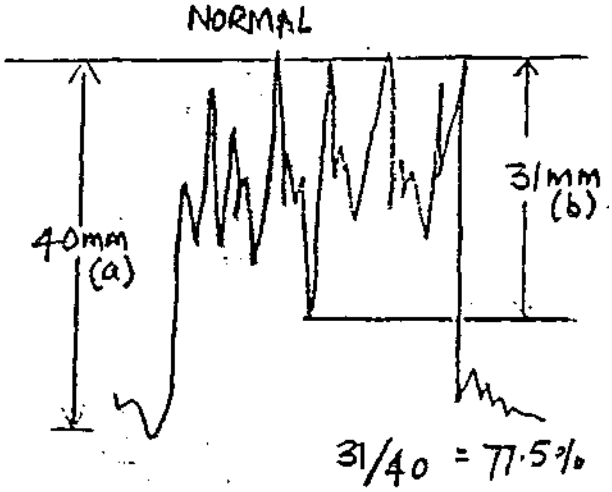


Fig.35

Thus cochlear pathology can be detected using any of these tests given above.

The acoustic reflex functions at 500, 1000 and 2000 Hz are quite similar' and show a decrease in sensation level of ART as a function of increase in hearing loss. The acoustic reflex function at 4000 Hz does not follow the exact pattern of the other stimulus frequencies and it is often absent at this frequency for no clear reasons.

As long as the cochlear hearing loss is less than 60 dB, acoustic reflex is usually observed. If the loss increases above 60 dB, chances of observing the reflex decrease.

Silman and Gelfand (1982) point out that acoustic reflexes should be observed at 125 dB HL or lower for cochlear hearing loss of 75 dB or less.

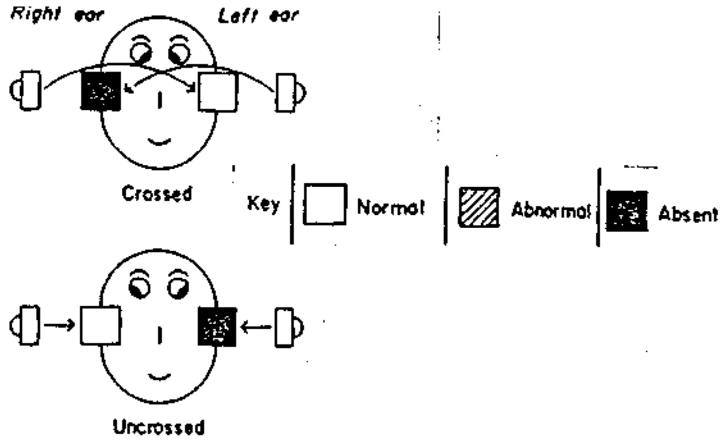


Fig.36 Ipsilateral and contralateral reflexes in a unilateral right ear profound sensorineural hearing loss and normal hearing in the left ear (diagonal pattern).

Retrocochlear Pathology

Pathologic ears with eighth nerve involvement and normal hearing do not exhibit acoustic reflexes 30% of the time. The likelihood of absent reflexes quickly rises to 70% with a mild 30 dB loss. In most patients with acoustic tumors the acoustic reflexes are absent when the involved ear is stimulated even if the loss is very mild. If acoustic reflex is present in a patient who is suspected to have an eighth nerve lesion, the acoustic reflex decay test may be applied. Reflex decay is determined by presenting the stimulus test tone at 10 dB above the acoustic reflex HTL for 10 sec at 500 and 1000 Hz. Reflex decay may be measured for both contralateral and ipsilateral test conditions. Reflex decay occurs when the amplitude of the acoustic reflex declines by more than half its initial magnitude in less than 10 sec under continuous puretone stimulation (Anderson et al. 1969). Frequencies 2000, 3000 and 4000 Hz are not used as even normal ears sometimes show decay at these frequencies (Givens and Seidemann 1979).

Acoustic reflex latency has also been found to be altered in cases with retrocochlear pathology.

Hughes and Strasser (1973) [cited in Jerger, 1975] noted that subjects with retrocochlear lesions may show a longer reflex latency than do normal hearing subjects or than subjects with cochlear loss.

Acoustic reflex measures have been found to be very sensitive to eight nerve disorders. However acoustic reflex measures may sho false positive results also for eighth nerve pathologies (Chiveralls, 1977; Jerger, 1983). Therefore, it is important that the clinician keeps this in mind while using acoustic reflex measures as part of a test battery approach to identify retrocochlear pathologies.

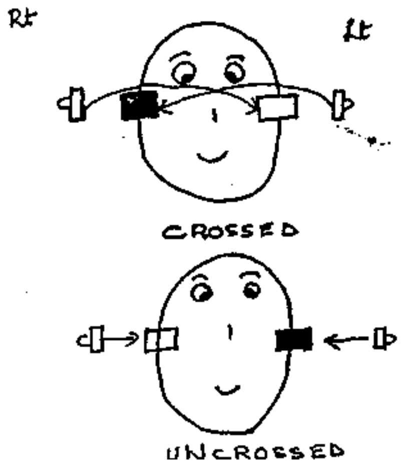
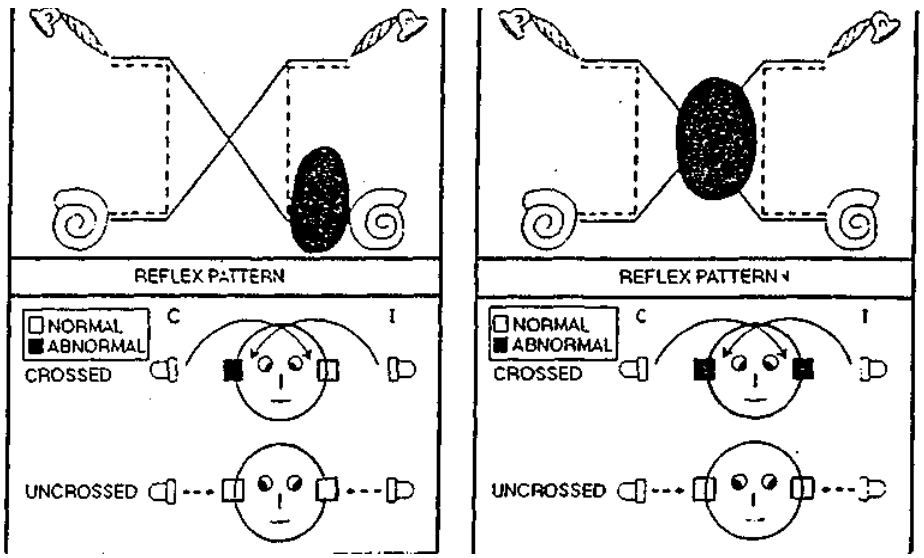


Fig.37 : Reflex pattern in right VIIIth nerve disorder.

Brainstem Pathology - The identification of brainstem pathology using acoustic reflex is done mainly by comparing the contralateral and ipsilateral reflex thresholds (Greisen and Rasmussen, 1970; Jerger and Jerger, 1975, 1983; Jerger, 1983). In the case of a lesion in the area of the crossed brainstem pathways with intact uncrossed brainstem pathways, the contralateral reflexes will be absent with ipsilateral reflexes intact.

If the lesion is higher in the auditory pathway, the acoustic reflex finding is likely to be within normal limits.



Reflex patterns in left extra axial brainstem disorder Unibox pattern

Reflex pattern in intra cranial brainstem disorder Horizontal pattern

Fig.38

Facial Nerve Disorder : Acoustic reflex measurement is helpful in determining the site of lesion of the facial nerve disorder as either distal (away from) or proximal (toward the point of origin) to the stapedial branch of the seventh nerve.
As the interpretation of facial motor disorder is a function of the efferent nerve pathway acoustic reflex results are interpreted

for the immittance probe ear only. If the acoustic reflex is present at normal HL, the localization of pathology is likely to be distal to origin of the stapedius branch of the nerve, if the reflex is absent, the disorder is likely to be proximal to the nerve. If reflexes are present but elevated, the disorder is likely proximal to the nerve.

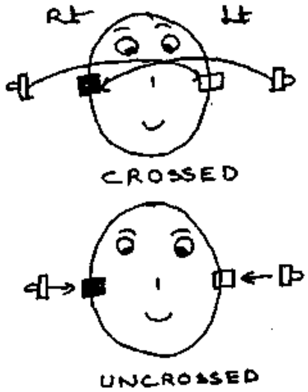


Fig.39 - Reflex pattern in right Vllth nerve disorder (vertical pattern)

Notwrganic Hearing Loss - Acoustic reflex measurement also helps in detecting patients having a nonorganic hearing loss. As we have already seen, the greater the hearing loss, the less the likelihood there is of obtaining an acoustic reflex.

It is highly unlikely to observe an acoustic reflex at a level less than 15 dB above the patient's threshold and impossible to obtain a reflex measure at a lower hearing level than the true hearing threshold (Olsen, 1991). Thus from the ART we can determine whether the patient has an organic hearing loss or not.

Special Applications of the Acoustic Reflex

1. ***Use of Acoustic reflex in hearing screening programs***

Immittance screening for the detection of middle ear pathology when implemented in conjunction with puretone audiometric screening is a useful technique as it increases the accuracy of correct identification of the disordered group. The use of acoustic reflex in screening is based on the presumption that presence of reflex is a negative indication of conductive pathology. However, absence of an acoustic reflex does not necessarily indicate the existence of a medical problem as acoustic reflexes are absent in 5% of the normal hearing population (Jerger, 1970; Brooks, 1978).

Harford et al. (1978), Asha (1979) suggest acoustic reflex screening at 100 dB HL with a contralateral stimulus or 105 dB SPL with ipsilateral stimulation at 1000 Hz. Brooks (1976) states that acoustic reflex screening is a more sensitive test that tympanometry. Hoover et al. (1982) also reported of high sensitivity of the screening procedure using 1979 ASHA guidelines. But specificity rate was found to be very low. In recent ASHA (1990) guidelines, use of acoustic reflex was left out of the screening protocol on the basis of research reports that show a high false-positive, or low specificity rate.

There is also great deal of controversy regarding pass-fail and referral criteria for the screening procedure.

2. Acoustic Reflex in Prediction of Sensitivity

Different investigators have suggested different procedures for the purpose of predicting the sensitivity of hearing. All of them are based on the difference in reflex thresholds for noise and tone.

a) *Niemeyer and Sesterhenn 's Method* - Niemeyer and Sesterhenn (1974) measured the reflex thresholds for puretones, white noise and mixture of puretones which consisted of puretones representing one critical bandwidth each. Reflex threshold was found to be highest for puretones. They arrived at a particular formula for calculating the PTA.

$$PTA = ART_{PT(avg)} - 2.5\,(ART_{PT(avg)} - ART_{WN})$$

(500 Hz - 4 KHz) (500 Hz - 4 KHz)

ART PT (avg) - This is the average acoustic reflex threshold for puretones within the frequency range of 500 Hz - 4 KHz.

ART WN - This is the acoustic reflex for white noise.

2.5 is a constant which was derived from certain calculations.

It was found that in majority of the subjects, accurate results could be obtained using this formula. In cases with flat loss the results obtained were less accurate.

b) *Baker and Lilly Method* - Baker and Lilly (1976) modified the previous formula. They have the following formula :

dB HTL =1.11 ART BBN (SPL) -0.81 ART 500 HZ (HL)
+ 0.85 ART 1000 Hz (HL) - 0.43 ART 2000 Hz (HL) + 0.25
ART 4000 Hz (HL) - 64.7122122

The demerit of this method is that, in subjects with severe hearing loss, the predicted hearing level was grossly under estimated.

c) *Sesterhenn and Brenninger 's method*- Sesterhenn and Breuninger (1976) suggested a method of sensitivity prediction which involved a pre-activation of the acoustic reflex. A tone of 6 kHz or 8 kHz was presented at a level high enough to initiate a reflex response. The test tone was then presented along with the pre-activating stimulus. Keeping the intensity of the preactivating stimulus constant, the intensity of the reflex eliciting stimulus was reduced till reflex response just disappeared. This gives the reduced reflex threshold.

The ratio of distance between the hearing threshold and normal reflex threshold to the difference between the two reflex thresholds was called as K. The value of K differed for each frequency. The distance between normal and the reduced reflex thresholds was found to be 30 dB at 125 Hz and 20 dB at 4000 Hz in normally hearing subjects.

4. *Jerger's method* - Jerger gave two formulae - unweighted and Weighted for the purpose of predicting hearing sensitivity. Out of these, weighted is more popular. This procedure given by Jerger (1974) is called as SPAR (sensitivity prediction with the acoustic reflex).

Unweighted formula

D = ARPT (500, 1K, 2K) - AR(WN) +*C*

C = 26 dB (Keith, 1977)

ARPT - Acoustic reflex for puretones

ARWN - Acoustic reflex for white noise

Weighted formula - Jerger et al. (1974).

$$D = \frac{1 + m + n}{3}$$

1 = ARTsoo Hz - ARTBBN (SPL)

m = ART(avg. of 5oo, IK, 2K) - ARTBBN (SPL)

n = ART(SPL) -ARTBBN (SPL)
(Lowest ART among that for 500 Hz, IK, 2K)

To predict the slope, Jerger et al. (1974) suggested that difference between reflex thresholds for low pass and high pass filtered noise be considered. When LPFN - HPFN was zero, a flat loss was predicted. A difference of-1 to -5 suggested a gradual slope whereas a slope of more than -5 suggested a steeply sloping hearing loss.

Jerger et al. also gave a table from which the degree of loss could be predicted by knowing the value of D. 'D' here represents the difference score i.e., the difference in reflex thresholds for 500, IK and 2K puretones and BBN.

5. The *Bivariate - Plot method*- This method was proposed by Popelka (1976). This divides the subjects into two groups based on presence or absence of hearing loss.

The acoustic reflex thresholds were determined for 500 Hz, 1 KHz and 2 KHz puretones and also for wide band noise. The ratio ART WBN is determined and it is plotted on a graph ART tones (avg. of 500, IK, 2K) which is separated into two regions by two lines.

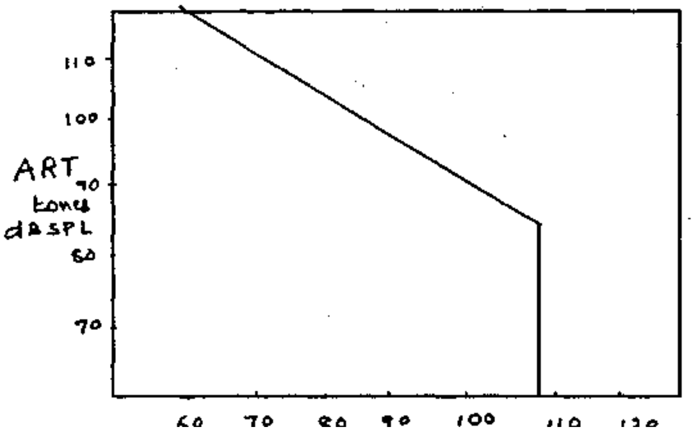


Fig.40 ART WBNX 100
ART tones

The region to the left of the two lines represents normal hearing and the region to the right represents hearing loss (Himmelfart et al. 1978). Depending on here the subject's score falls, the presence or absence of hearing loss can be detected.

3. *Hearing Aid Selection, Fittings and Management*

Acoustic reflex measurement has been suggested in the selection and fitting of hearing aids, especially with young children and mentally retarded patients.

Acoustic reflex measurement is an objective technique through which the maximum power output and gain can be determined which is in turn used in hearing aid selection. The unaided gain is determined first and then the gain with the hearing aid is obtained (aided gain). This is compared to the target gain (actual gain required for the subject) and thus an appropiate hearing aid is chosen.

Various authors have suggested various criteria for selecting hearing aid on the basis of AR measurements. According to McCandless and Keith (1980), the output of the aid should be at or slightly above the ART for puretones of 500 Hz, 1 K, 2 K and 4 K. Dudich et al. (1975) suggest that output of the aid ideally should be set 5-8 dB lower than the ART, for ART for puretones is higher than that for verbal stimuli.

Keith (1979) also reported that ART procedure is highly successful in setting hearing aid gain for children.

Additional research is needed in this area which would be of greater help in selection and fitting of hearing aids.

4. *Utility of Acoustic reflex for monitoring ototoxity in paediatric population*

Kay Rabbitt Park (1996) took 21 children of age range 3.08 - 19.25 years. These children were subjected to cumulative dosages of (250-400 Mg/m2) of cisplatin. He noticed a shift in acoustic reflex thresholds withthe increase in dosage. Thus it can be concluded that ART measurements maybe of great help in the early detection of ototoxicity in paediatric population. However future research reports are required for confirming this finding.

5. *Acoustic reflex in difficult to test patients*

In the difficult to test population, where conventional methods of sensitivity testing are difficult to be administered, acoustic reflex measurements may prove to be a boon. In multiple handicapped children, autistics and retarded and other such groups, ART measurements have been widely used to identify the presence of hearing-impairment (Keith et al. 1976; Suria and Serra-Raventas, 1975; Lamb and Norris, 1970).

6. ***Acoustic Reflex Measurements in Speech Pathology***

It is now well established that middle ear muscles contract in association with certain voluntary movements of head, neck and jaw and also during vocalisation. This is due to the reflexive interconnection between middle ear muscles and sensory nervous supply to larynx. On the basis of this it may be assumed that certain neuromuscular disorders affecting speech may show its effect on the middle ear muscles also.

Shearer (1966) reported of variations in the degree of contraction of middle ear muscles associated with stuttering. Thus impedance changes may afford a rather precise method of studying the initiation and course of stuttering.

McCall (1973) used acoustic measurements to study patients with spastic dysphonia. Tremor of one or both the middle ear muscles and problems in muscle relaxation were observed in these cases.

It has been observed that certain disorders of the central nervous system exhibit certain typical neuromuscular manifestations.

If these are exhibited in the middle ear functioning, acoustic reflex measurements may be helpful in the diagnosis, and differentiation of these disorders from one another.

Thus it may be assumed that the six different types of dysarthria - spastic, flaccid, hyperkinetic, hypokinetic, cerebellar and mixed and various other neuromuscular disorders can be diagnosed using ART measurements.

Blom and Zakrisson (1974) detected stapedial reflex decay of muscular origin in patients with myesthenia gravis.

Thus acoustic reflex measurements have its application not only in Audiology but also in Speech pathology.

APPENDIX - II

PRE-EXPOSURE TEST

CHAPTER-1

HISTORICAL ASPECTS

TICK THE APPROPRIATE:

Sr. No.		**True**	**False**	**Don't know**
1	Terkildsen was the first to use the word tympanometry			
2	The concept of acoustic impedence was introduced in 1914 by Fowler			
3	Troger was the first to determine the impedence at the ear drum using a tube			
4	Schuster was the first to develop a mechanical acoustic impedence bridge.			
5	Kurtz was the first to use impedence meter to detect fluid in the middle ear			
6	Liden, Peterson and Bjorkman described 4 distinctive tympanograms associated with normal and pathological ears.			
7	Schuster reported that voluntary contraction of middle ear muscle changes the acoustic impedence of the eardrum in humans.			
8	The classic monagraph of Metz marked the beginning of application of acoustic impedence in clinical audiology.			
9	West studied hearing threshold changes resulting from positive and negative pressures in the external ear canal.			
10	The first Tympanograms as presently known as were reported by Bjorkman and Liden.			

POST-EXPOSURE TEST

CHAPTER - 1

HISTORICAL ASPECTS

TICK THE APPROPRIATE:

Sr. No.		True	False	Don't know
1	Troger was the first to determine the impedence at the ear drum using a tube			
2	Terkildsen was the first to use the word tympanometry			
3	Schuster was the first to develop a mechanical acoustic impedence bridge.			
4	The concept of acoustic impedence was introduced in 1914 by Fowler			
5	Schuster reported that voluntary contraction of middle ear muscle changes the acoustic impedence of the eardrum in humans.			
6	Kurtz was the first to use impedence meter to detect fluid in the middle ear			
7	Liden, Peterson and Bjorkman described 4 distinctive tympanograms associated with normal and pathological ears.			
8	The classic monagraph of Metz marked the beginning of application of acoustic impedence in clinical audiology.			
9	The first Tympanograms as presently known as were reported by Bjorkman and Liden.			
10	West studied hearing threshold changes resulting from positive and negative pressures in the external ear canal.			

PRE-EXPOSURE TEST

CHAPTER-2

CONCEPT OF IMMITANCE

TICK THE APPROPRIATE

Sr. No		True	False	Don't Know
1	Constant force is one which does not change its amplitude over time.			
2	In a friction dominated system, velocity and force are in phase.			
3	The symbol for acoustic impedence is Bt			
4	The term immittance refers to impedence only.			
5	The symbol for acoustic admittance is Za			
6	Mass reactance and stiffness reactance are the only two components of immitance.			
	Resonance frequency is the frequency at which stiffness and mass reactances are equal.			
8	In a stiffness dominated system velocity leads force by 90°			
9.	In the case of absence of incus, the stiffness is reduced.			
10.	Conductance and susceptance are synonymous.			

POST-EXPOSURE TEST

CHAPTER - 2

CONCEPT OF IMMITANCE

TICK THE APPROPRIATE

Sr. No		**True**	**False**	**Don't Know**
1	In a friction dominated system, velocity and force are in phase.			
2	The term immittance refers to impedence only.			
3	Constant force is one which does not change its amplitude over time.			
4	Mass reactance and stiffness reactance are the only two components of immitance.			
5	The symbol for acoustic impedence is Bt			
6	In a stiffness dominated system velocity leads force by 90°			
7	Conductance and susceptance are synonymous.			
8	Resonance frequency is the frequency at which stiffness and mass reactances are equal.			
9	The symbol for acoustic admittance is Za			
10	In the case of absence of incus, the stiffness is reduced.			

PRE-EXPOSURE TEST

CHAPTER - 3

INSTRUMENTATION

TICK THE APPROPRIATE

Sr. No		**True**	**False**	**Don't Know**
1	The probe mic picks up reflected energy from the ear canal.			
2	The manometer compares the input and the output energy.			
3	The sound pressure level in the EAC during immitance measurement is 85 dB SPL at 226Hz			
4	The air pressure system creates only positive pressure within a small sealed cavity.			
5	226 Hz tone is generally used because of its longer wavelength.			
6	Probe tip assembly consists of probe tip, pickup mic and comparator.			
7	Low frequency tones are sensitive to pathologies that alter the mass of the ear.			
8	An AVC circuit is used in the case of impedence bridge.			
9	The compliance meter displays the sound energy in terms of volume.			
10	The sound source consists of a pure tone generator and speaker.			

POST-EXPOSURE TEST

CHAPTER- 3

INSTRUMENTATION

TICK THE APPROPRIATE

Sr. No.		True	False	Don't Know
1	The sound pressure level in the EAC during immitance measurement is 85 dB SPL at 226Hz			
2	The probe mic picks up reflected energy from the ear canal.			
3	226 Hz tone is generally used because of its longer wavelength.			
4	The manometer compares the input and the output energy.			
5	The air pressure system creates only positive pressure within a small sealed cavity.			
6	An AVC circuit is used in the case of impedence bridge.			
7	Probe tip assembly consists of probe tip, pickup mic and comparator.			
8	The compliance meter displays the sound energy in terms of volume.			
9	The sound source consists of a pure tone generator and speaker.			
10	Low frequency tones are sensitive to pathologies that alter the mass of the ear.			

PRE-EXPOSURE TEST

CHAPTER-4

TYMPANOMETRY

TICK THE APPROPRIATE

Sr. No.		**True**	**False**	**Don't Know**
1	The compliance - air pressure function of the tympanic membrane is called as a tympanogram.			
2	Tympanometry can be carried out in a highly noisy environment.			
3	Tympanometry is a purely objective procedure and requires no co-operation at all from the subject.			
4	One of the preliminary procedures in tympanometry is to obtain an air tight seal.			
5	Tympanometry, being an objective procedure can be carried out even if there is wax or discharge in the external auditory canal.			
6	The compliance of the tympanic membrane is maximum as the air pressure in the middle ear cavity equals the atmospheric pressure.			
7	At rapid pressure sweep rates, the compliance is higher both in normal and in middle ear pathology cases.			
8	For the accuracy to be maintained at high sweep rates, a forward - backward tracing tympanometry is a must.			
9	A leak which occurs only when a positive pressure is introduced implies an open tympanic membrane.			
10	The ear drum has maximum mobility as a positive pressure of + 200mm H_2O is introduced in to the canal.			

POST-EXPOSURE TEST

CHAPTER - 4

TYMPANOMETRY

TICK THE APPROPRIATE

Sr. No.		**True**	**False**	**Don't Know**
1	One of the preliminary procedures in tympanometry is to obtain an air tight seal.			
2	The compliance - air pressure function of the tympanic membrane is called as a tympanogram.			
3	Tympanometry, being an objective procedure can be carried out even if there is wax or discharge in the external auditory canal.			
4	Tympanometry can be carried out in a highly noisy environment.			
5	The compliance of the tympanic membrane is maximum as the air pressure in the middle ear cavity equals the atmospheric pressure.			
6	Tympanometry, being an objective procedure can be carried out even if there is wax or discharge in the external auditory canal.			
7	Tympanometry is a purely objective procedure and requires no co-operation at all from the subject.			
8	For the accuracy to be maintained at high sweep rates, a forward - backward tracing tympanometry is a must.			
9	The ear drum has maximum mobility as a positive pressure of + 200mm H_2O is introduced in to the canal.			
10	At rapid pressure sweep rates, the compliance is higher both in normal and in middle ear pathology cases.			

PRE-EXPOSURE TEST

CHAPTER-5

INTERPRETATION AND CLASSIFICATION OF TYMPANOGRAMS

TICK THE APPROPRIATE

Sr. No		True	False	Don't Know
1	Hiden, Peterson and Bjorkman's classification is the most popular and widely used system of classification of tympanograms.			
2	The maximum compliance and the shape of the tympanogram are the two parameters that are considered for the classification of tympanograms.			
3	The static compliance ranges between 0.5cc - 1.75cc for type A tympanogram.			
4	Ad type of tympanogram indicates otosclerosis, tympanosclerosis.			
5	The peak pressure is normal for As type of tympanogram.			
6	Type B tympanogram is virtually flat.			
7	Eustachian tube dysfunction is indicated by type D tympanogram.			
8	Type D tympanogram is a definite indicator of middle ear pathology.			
9	Type E tympanogram has an undulating pattern and is seen in normal hg subjects also.			
10	In a case with perforated eardrum, type B tympanogram is seen.			

POST-EXPOSURE TEST

CHAPTER-5

INTERPRETATION AND CLASSIFICATION OF TYMPANOGRAMS

TICK THE APPROPRIATE

Sr. No		True	False	Don't Know
1	The maximum compliance and the shape of the tympanogram are the two parameters that are considered for the classification of tympanograms.			
2	Ad type of tympanogram indicates otosclerosis, tympanosclerosis.			
3	Hiden, Peterson and Bjorkman's classification is the most popular and widely used system of classification of tympano grams.			
4	The static compliance ranges between 0.5cc - 1.75cc for type A tympanogram.			
5	Type B tympanogram is virtually flat.			
6	The peak pressure is normal for As type of tympanogram.			
7	Type E tympanogram has an undulating pattern and is seen in normal hg subjects also.			
8	Eustachian tube dysfunction is indicated by type D tympanogram.			
9	In a case with perforated eardrum, type B tympanogram is seen.			
10	Type D tympanogram is a definite indicator of middle ear pathology.			

PRE-EXPOSURE TEST

CHAPTER-6

PHYSICAL VOLUME TEST, STATIC COMPLIANCE, GRADIENT

TICK THE APPROPRIATE

SA No		True	False	Don't Know
1	Physical volume is the volume of the ear canal when the T.M is least compliant.			
2	In case of perforation of the ear drum, the physical volume decreases.			
3	The physical volume in normal ears is in the range of 0.6cc to 1.8cc			
4	Static compliance is synonymous to static immittance.			
5	The compliance of a normal middle ear system is not influenced by variables like, patient age, sex etc.			
6	No intcraural difference is found in static compliance			
7	Static immittance is equal to C2 - C1			
8	Static compliance is less in the case of a stiff middle ear system.			
9	Gradient refers to the shape of the tympanogram.			
	Gradient is obtained through hp/ht			

POST-EXPOSURE TEST

CHAPTER-6

PHYSICAL VOLUME TEST, STATIC COMPLIANCE, GRADIENT

TICK THE APPROPRIATE

Sr. No		**True**	**False**	**Don't Know**
1	The physical volume in normal ears is in the range of 0.6cc to 1.8cc			
2	The compliance of a normal middle ear system is not influenced by variables like, patient age, sex etc.			
	Physical volume is the volume of the ear canal when the T.M is least compliant.			
4	Static compliance is synonymous to static immiltance.			
5	In case of perforation of the ear drum, the physical volume decreases.			
6	Static immittance is equal to C2 - C1			
7	Gradient refers to the shape of the tympanogram.			
8	No interaural difference is found in static compliance			
9	Static compliance is less in the case of a stiff middle ear system.			
10	Gradient is obtained through hp/ht			

PRE-EXPOSURE TEST

CHAPTER-7

ACOUSTIC REFLEX

TICK THE APPROPRIATE:

Sr. No.		True	False	Don't Know
1	Acoustic reflex is an indirect approach used in human to study the contraction of middle ear muscles.			
2	The lowest intensity of an acoustic stimulus at which a minimal change in the middle ear compliance can be measured is termed as acoustic reflex threshold.			
3	When a loud sound is presented in one ear, the middle ear muscles of that ear only will contract.			
4	The cranial nerve innervating the stapedous muscle is cranial nerve V..			
5	ART for normal hearing subjects ranges between 70-100 dBHL:			
6	Reflex amplitude increases as stimulus intensity is increased above the reflex threshold for 10-15 dB.			
7	The most suitable stimulus duration for eliciting Acoustic reflex is 5 scs.			
8	As stimulus band width increases ART decreases.			
9	Acoustic reflex can be elicited through AC and BC.			
10	Acoustic reflex response depends on the physiological functioning of the entire reflex area.			

POST-EXPOSURE TEST

CHAPTER - 7

ACOUSTIC REFLEX

TICK THE APPROPRIATE:

Sr. No.		**True**	**False**	**Don't Know**
1	Acoustic reflex is an indirect approach used in human to study the contraction of middle ear muscles.			
2	Acoustic reflex can be elicited through AC and BC.			
3	The cranial nerve innervating the stapedous muscle is cranial nerve V.			
4	The most suitable stimulus duration for eliciting Acoustic reflex is 5 Sees.			
5	The lowest intensity of an acoustic stimulus at which a minimal change in the middle ear compliance can be measured is termed as acoustic reflex threshold.			
6	Acoustic reflex response depends on the physiological functioning of the entire reflex area.			
7	ART for normal hearing subjects ranges between 70-100 dB HL.			
8	As stimulus band width increases ART decreases.			
9	When a loud sound is presented in one ear, the Middle ear muscles of that ear only will contract.			
10	Reflex amplitude increases as stimulus intensity is increased above the reflex threshold for 10-15 dB.			

PRE-EXPOSURE TEST

CHAPTER 8

DIAGNOSTIC APPLICATIONS OF ACOUSTIC REFLEX

TICK THE APPROPRIATE:

Sr. No.		**True**	**False**	**Don't Know**
1	Impedence signature is a definite indicator of conductive pathology.			
2	If the acoustic reflex is obtained below 60dBSL it is considered to be negative Metz test result.			
3	A DRQ of 1 shows complete recruitment.			
4	A reflex relaxation time less than 30% was indicative of conductive hearing loss.			
5	Reflex decay occurs when the amplitude of acoustic reflex decays by more than half its initial magnitude in more than 10 sec.			
6	In case of a lesion in the crossed brainstcm pathway only, the contralateral reflexes will be absent.			
7	In case of a facial nerve disorder, if reflexes are present at elevated levels, the disorder, is likely to be proximal to the nerve.			
8	It is possible to measure a reflex at lower than the true hearing threshold.			
9	A unilateral conductive hearing loss shows an inverted L Jerger Box Pattern.			
10	Diagonal Pattern of Jerger box is obtained in case of facial nerve disorder.			

POST-EXPOSURE TEST

CHAPTER 8

DIAGNOSTIC APPLICATIONS OF ACOUSTIC REFLEX

TICK THE APPROPRIATE:

Sr. No.		**True**	**False**	**Don't Know**
1	A DRQ of 1 shows complete recruitment.			
2	Diagonal Pattern of .lerger box is obtained in case of facial nerve disorder.			
3	If the acoustic reflex is obtained below 60dBSL it is considered to be negative Metz test result.			
4	Impedence signature is a definite indicator of conductive pathology.			
5	A reflex relaxation time less than 30% was indicative of conductive hearing loss.			
6	In case of a facial nerve disorder, if reflexes are present at elevated levels, the disorder, is likely to be proximal to the nerve.			
7	A unilateral conductive hearing loss shows an inverted L Jerger Box Pattern.			
8	In case of a lesion in the crossed brainstem pathway only, the contralateral reflexes will be absent.			
9	Reflex decay occurs when the amplitude of acoustic reflex decays by more than half its initial magnitude in more than 10 sec.			
10	It is possible to get a reflex measure at a lower hearing level than the true hearing threshold.			

PRE-EXPOSURE TEST

CHAPTER-9

SPECIAL APPLICATIONS OF ACOUSTIC REFLEX

TICK THE APPROPRIATE:

Sr. No.		True	False	Don't Know
1	Acoustic Reflex screening has been reported of high sensitivity of the screening procedure as well as high specificity.			
2	Niemeyer and Sesterhenn's Method for calculating PTA requires the values of ART(PTA) and ART(NBN)			
3	Modification of Nuemeyer and Sesterhenn's method was dine by Baker hilly.			
4	Sesterhenn and Breuningeis method involves a pre activation of acoustic reflex.			
5	Jcrgcr's weighted formula for the purpose of predicting hearing sensitivity is D = 1 + m + n 3			
6	In the Bivariate plot method, the region to the right represents normal hearing.			
7	When LPFN - HPFN was zero, a gradual slope could be predicted.			
8	Through acoustic Reflex measurements, maximum power o/p gain can be obtained.			
9	A shift in acoustic reflex threshold with increase in dosage of drugs indicates ototoxicity.			
10	Acoustic Reflex Measurements help in identifying functional speech and language delay.			

POST-EXPOSURE TEST

CHAPTER-9

SPECIAL APPLICATIONS OF ACOUSTIC REFLEX

TICK THE APPROPRIATE:

Sr. No.		True	False	Don't Know
1	Sesterhenn and Breuningeis method involves a pre activation of acoustic reflex.			
2	Modification of Nuemeyer and Sesterhenn's method was done by Baker hilly. '			
3	Niemeyer and Sesterhenn's Method for calculating PTA requires the values of ART(PTA) and ART(NBN)-			
4	Acoustic Reflex screening has been reported of high sensitivity of the screening procedure as well as high specificity.			
5	Jerger's weighted formula for the purpose of predicting hearing sensitivity is $D = \frac{1 + m + n}{3}$			
6	In the Bivariate plot method, the region to the right represents normal hearing.			
7	When LPFN - HPFN was zero, a gradual slope could be predicted.			
8	Through acoustic Reflex measurements, maximum power o/p gain can be obtained.			
9	Acoustic Reflex Measurements help in identifying functional speech and language delay.			
10	A shift in acoustic reflex threshold with increase in dosage of drugs indicates ototoxicity.			

APPENDIX-III

TIME : 15min NAME : ANJALI

PRE-EXPOSURE TEST

CHAPTER -1

HISTORICAL ASPECTS

TICK THE APPROPRIATE:

Sr. No.		True	False	Don't know	
1	Terkildsen was the first to use the word tympanometry				o
2	The concept of acoustic impedence was introduced in 1914 by Fowler				0
3	Troger was the first to determine the impedence at the ear drum using a tube				
4	Schuster was the first to develop a mechanical acoustic impedence bridge.				0
5	Kurtz was the first to use impedence meter to detect fluid in the middle ear .				0
6	Liden, Peterson and Bjorkman described 4 distinctive tympanograms associated with normal and pathological ears.				0
7	Schuster reported that voluntary contraction of middle ear muscle changes the acoustic impedence of the eardrum in humans.				0
8	The classic monagraph of Metz marked the beginning of application of acoustic impedence in clinical audiology.				0
9	West studied hearing threshold changes resulting from positive and negative pressures in the external ear canal..				*0*
10	The first Tympanograms as presently known as were reported by Bjorkman and Liden.				*0*

TOTAL *SCORE* : o

TIME: : 12 mins. NAME : ANJALI

POST-EXPOSURE TEST

CHAPTER -1

HISTORICAL ASPECTS

TICK THE APPROPRIATE:

Sr. No.		**True**	**False**	**Don't know**	
1	Troger was the first to determine the impedence at the ear drum using a tube				**0**
2	Terkildsen was the first to use the word tyrnpanometry				***1***
3	Schuster was the first to develop a mechanical acoustic impedence bridge.				**1**
4	The concept of acoustic impedence was introduced in 1914 by Fowler				**1**
5	Schuster reported that voluntary contraction of middle ear muscle changes the acoustic impedence of the eardrum in humans.				**0**
6	Kurtz was the first to use impedence meter to detect fluid in the middle ear				**1**
7	Liden, Peterson and Bjorkman described 4 distinctive tympanograms associated with normal and pathological ears.				**1**
8	The classic monagraph of Metz marked the beginning of application of acoustic impedence in clinical audiology.				***c***
9	The first Tympanograms as presently known as were reported by Bjorkman and Liden.				***0***
10	West studied hearing threshold changes resulting from positive and negative pressures in the external ear canal.				**1**

TOTAL SC*ORE* : 6