EFFECT OF MPO SETTINGS ON GAIN AND DISTORTION CHARACTERISTICS IN VARIOUS BODY LEVEL HEARING AIDS

RegisterNo:M9018

An Independent project submitted as part fulfilment for

First year M.Sc, [Speecn and Hearing]

to the University of Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570 006

MAY-1991

DEDICATION

Dear Parents,

You hove tought me through love and experience.

Those things that make me who I am.

And give me strenght to believe in myself.

Novine,

We have seen a lot of changes in the world and our selves,

But one thing never changes_____

I am so thankful you are my sister.

CERTIFICATE

This is to certify that the independent project entitled **"EFFECT OF MPO SETTIHGS Of GAIN AND DISTORTION CHARACTERISTICS IN VARIOUS BODY LIVIL HEARING AIDS"** *is the bonafide work in part fulfilment for the degree of Master of Science (Speech & Meeting), of the student with Register NO.M9018.*

Director

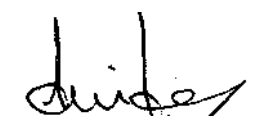
All India Institute of Speech & Hearing
Mysore - 570 006

CERTIFICATE

This is to certify that the independent project entitled

"EFFECT OF MPO SETTINGS ON GAIN AND DISTORTION CHARACTERISTICS IN VARIOUS BODY LEVEL HEARING AIDS"

has been prepared under my supervision and guidance.



May 1991

DR.(Ms).S.NIKAM
Guide

DECLARATION

I hereby declare that this independent project entitled **"EFFECT Of MPO SETTINGS ON GAIN AND DISTORTION CHARACTERISTICS IN VARIOUS BODY LEVEL HEARING AIDS"** *is the result of my own study under taken under the guidance of Dr. S. Nikam Director and Head Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier any University for any other Diploma or Degree*

Mysore
May:1991

Reg.No.M.9018

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CONTENTS

INTRODUCTION

The function of a hearing aid is to amplify sound to a required degree and in a manner that will enable a hearing impaired person to utilise his residual Hearing in an effective manner.

Perhaps the first amplification system to be used was the hand cosmetically but providing a significant amount of amplification. Next in the order of invention case the acoustic amplifiers such as horns, speaking tubes etc. These were followed by carbon hearing aids which were based on the . principles of telephone. Vaccum tube hearing aids appeared in about 1938 and offered much greater amplification . possibilities, wider frequency response and lower harmonic distortion. Today's hearing aids are all based on the invention of the transistor by Bell . Telephone Laboratories. This development made possible much smaller size, far lower battery cost and a flexibility of design for the hearing aid engineer never before possible. The parallel development of the hearing aid components such as microphones, receivers* capacitors integrated circuits contributed equally to, today's hearing aid technology.

Certain technical factors must be considered to successfully match the amplification characteristics of a hearing aid to an individual's residual hearing. The goals are to make speech and other important sounds comfortably

loud in the frequency region between 250HZ to 6000Hz, to limit the maximum acoustic output. So that the sound does not become uncomfortably loud and to see that the distortion of the instrument does not reach beyond a certain limit.

The only way to determine whether the preselected hearing aid is comfortable, provide acceptable sound quality gives the prescribed characteristics, is to measure its electroacoustic characteristics.

For the last decade, hearing health professionals have been questioning the validity, repeatibility and subjectivity of the standard methods of, hearing aid evaluation and fitting procedures. The advent of practical electroacoustic measurements has helped the professionals to become more objective to find the acceptable sound quality prescribed characteristics and distortion level.

The hearing aid that is evaluated maybe the individual's own or that which has been preselected. In either case it is important to determine whether the prescribed real ear gain has been provided and whether saturated sound pressure level prevents amplified loud sound from being too loud.

Before testing a person with a hearing aid it is important to determine whether it is functioning properly, This is done by using a charged battery and measuring the aid response in either a . H/A 1 or H/A 2 couplers. The

mearurements of these parameters should agree with the manufacture's specificity.

Electroacoustic measurements will indicate wheather it provides the prescribed real ear and Saturating Sound Pressure Level(SSPL 90) if and if not how much it differs from these characteristics.

The present study was designed to study Acoustic Gain, saturation Sound Level (SSPL 90) and Total Harmonic Distortion characteristics of the body level hearing aids. These body level hearing aids were of 3 categories as per IS : 10775.

1) Mild
2) Moderate
3) Strong

The hearing aids randomly selected were the ones distributed under the ADLIB scheme.

DEFINITION *OF* TKEMB (UNDER STUDY)

1) SATURATION SOUND PRESSURE LEVEL (SSPL. 90)

It is important to know at what level a hearing aid limits its output when it receives a high level input signal. The *maximum* possible level should not exceed the threshold of discomfort for a user. Conversely too little output capability will not allow a clean signal to be delivered when

the hearing impairment is large. A practical measure of output handling capability of a hearing aid is the SSPL 90 defined as "sound pressure level developed in a 2CC earphone, coupler when the input is 90dB and the gain control of hearing aid is full on. The SSPL 90 is a function of frequency- The maximum value is required to be specified by manufactures in ISI regulations.

2) REFERENCE *TEST* GAIN (RTG)

The RTG setting is achieved using an input SPL of 6OdB and adjusting the gain control of the hearing aid 80 that the average of 1000, 16000 and 2500Hz values of coupler output are 17 ± 1dB less than HF average SSPL 90 value. If hearing aid does not have enough gain to permit this particular adjustment, then the gain control should be set to full on.

The rationale for the RTG setting is that the long terms average SPL for speech at a distance of 1 meter is approximately 6OdB with speech peaks typically occuring hearing aid gain control is adjusted to give aa output SPL 12dB below saturation with a 65dB input level it is assumed that the speech peaks typically will not exceed the SSPL of the aid. Thus situation can be duplicated by using a 60dB input SPL with a 17dB gain reduction .

3) TOTAL HARMONIC DISTIRATION (THD)

tHE ability Of a hearing aid to deliver a clean signal at the required output level is indicated by measuring its

non -linear distortion characteristics. Total harmonic distortion is a measure of non-linearity. Numerous studies in the past have not clearly indicated an expected in verse correlation between speech discrimination and total harmonic distortion. Moderate harmonic distortion does not degrade discrimination as one might expect.

Total harmonic distortion is measured using the

reference test gain control position previously described. Higher input SPLs of 70dB at 500Hz, 800Hz and 65dB at 16OOHz are used to simulate a loader than average input signal in order to measure total harmonic distortion.

THE MAIN AIM OF THIS *STUDY* WAS TO KNOW

1) If there is a significant change in the acoustic gain and saturation sound pressure level with a change in the MPO (Maximum Power Output) level of different categories of hearing aid (mild, moderate, strong).

2) If the total harmonic distortion of the hearing aids was within the required limits for different categories of hearing aids (mild, moderate and strong).

NEED FOR THE STUDY

1) It has been found that several hearing aid users are not aware of the presence of MPO controls in the hearing aids. It is needed to measure the gain and output characteristics of different hearing aids at each MPO levels i.e., 0, 10, 20 and make people aware of the same.

2) To know the real use of MPO for different types of degrees of hearing losses and thereby satisfactory reliable hearing aid prescription.

3) To provide baseline data for further research.

4) To see if the hearing aids satisfy the manufacturer's claims of gain and output.

This study would increase the awareness among the audiologists regarding the functioning of MPO control and effect of harmonic distortion.

Lastly the outcome of the study would help in improving the service delivery system.

METHODOLOGY

SELECTION OF HEARING AIDS

A total of 35 hearing aids wEre taken up for the study. Of these 35 hearing aids 15 belonged to strong category, 15 belonged to moderate category and the remaining 5 belonged to mild category. Bearing aids were classified into strong moderate and mild categories (IS:10775 1984) as per the manufacturer's claims.

The hearing aids were manufacturer 3 Indian hearing aid manufacturer available under the aids and appliance scheme (ADLIB, Ministry of Welfare, Government Of India).

SElECTION *OF* BATTERY

A battery of 1.5 voltage was used with the hearing aid and its voltage was periodically checked in order to maintain the constant voltage of the battery.

TEST ENVIRONMENT

The test was carried out in an air conditioned sound treated room, the ambient noise levels inside the room were within the permissible limits (IS 10776 -1984).

INSTRUMENTATION

The instruments used for the study are as follows.

1) Hearing aid analyser
2) BAT 1000

3) 1/2 inch test microphone (B & K)

4) Dummy microphone

5) 2CC H/Az coupler (Type DBO 138)

CALIBRATION

After power up "testing hearing aids" mode was selected. Test site calibration was assessed from the hearing aid monu- procedura for test site calibration

1) HAT speaker push button in the front of the HAT 500 was pushed.
2) The dUmmy microphone was inserted into a 2CC coupler.
3) Test microphone was placed at a distance of 5mm from the hearing aid microphone facing each other hearing aid was in off position.
4) The lid of HAT box was closed.
5) Dummy microphone, test microphone and hearing aid were connected as shown in the diagram (See Appendix-I).
6) "Enter" on the operating panel was pressed to calibrate the instrument.

After test site calibration, electroacoustic measurements were made for 35 hearing aids.

RECORDING OF GAIN AND TOTAL HARMONIC DISTORTION AT DIFFERENT SETTING

(A) Recording OF GAIN AT MPO SETTING.
(i) MPO - 0
(ii) MPO- *10*
(iii) MPO - 20

See Appendix-I for illustration of MPO setting.

(B) RECORDING OF TOTAL HARMONIC DISTORTION

Tone Control = N MPO = 0
Tone Control = N MPO = 10
Tone Control = N MPO = 20

PROCEDURE FOR RECORDING

Dummy microphone and test microphone were inter changed from their earlier position as was in Test site calibration.

The hearing aid was switched on and the volume control was set at Full-on position.

On the operating , panel 'Menu' was pressed on and 'Automatic Test (Tone)" mode was selected ANSI - 1987 standards were selected (Appendix-II).

ANSI S.31 waa selected as IS was not programmed in the system.

SSPL 90 curve and full on gain curve were obtained by pressing ENTER on the operating-.

By adjusting the volume control RTG (Reference Test Gain) position was obtained so that the measured value met the goal value.

After the recording was done with the tone control at TC = N, MPO=O, position testing was done at all the other setting to measure the following parameters:

1) Maximum SSPL90
2) Reference Test Gain (RTG)
3) Total Harmonic Distortion (THD)

For position during test situation see Appendix-I.

RESULT AND DISCUSSION

The aim of the study conducted was to find oUt if there was any significant differs in the gain and output of the different categories of body level hearing aids (strong, moderate and mild) when different MPO settings (0, 10, 20) were used.

The objective was also to find out it there is any change in the total harmonic distortion values of different categories of hearing aids when different HFO settings (0, 10, 20) were used.

For these objectives to be verified the data was collected based oa the methodology given in the previous chapter. The data thus obtained was tabulated and statistically treated.

The mean and standard deviation of the max. SSPL 90, RTG and THD values were calculated. These values are shown in the Table-I.

MPO SET-TING	MAX SSPL90	RTG	THD	MAX SSPL90	RTG	THD	MAX SSPL90	RTG	THD
0	118.6 (6.760)	36 .46 (0..64)	1.47 (.28)	112.9 (1.88)	33.70 (1.86)	1.39 (.29)	114.4 (1.14)	32.0 (.70)	0.4 (.289)
10	123.8 (0.837)	42..4 (1..17)	1.17 (.28)	117.0 (2.40)	39.90 (l.O8)	0.89 (.28)	117.4 (1.14)	34.8 (.83)	0.5 (.28)
20	135.6 (0.923)	54.7 (. 923)	1.29 (.28)	128.8 (2.114)	47.7 (0.89)	1.08 (0.28	120.6 (0.54)	37.6 (0.54)	0.4 (.281)

TABLE-I : Mean and standard deviation (within brackets) values of SSPL90, RTG, THD at MPO settings 0,10,20 of different catagories strong, moderate mild.

The above table shows the wean and standard deviation values of max.SSPL90 and RTG of each category of hearing aids (strong, moderate and mild), at different MPO setting.

As can be observed from the table the mean value of more SSPL90 increase with increase in the MPO settings. for example at MPO '0' the mean of the max SSPL 90 value in strong category hearing aid is 118.8d8 SPL, at MPO 10 the SSPL 90 value increase to 123.8dB SPL and at MPO 20 the SSPL 90 value is 135.6dB SPL. The data also shows that the mean value of max SSPL 90 decrease from strong category to mild category. For example the mean value of max SSPL 90 of strong category hearing at MPO 20 is 135.6dB SPL, where as, that is. mild category is 120.6dB SPL. However this increase is not seen in the mean of max SSPL 90 readings at MPO 0 and

10 between mild and moderate category. As seen in the Table-I, the mean of max SSPL 90 value of mild category is 114.4dB SPL whereas that in the moderate category hearing aid is 112.9dB SPL at MPO '0' setting. At MPO '10' setting the max SSPL 90 value of mild category is 117.4dB SPL and that in moderate category is 117dB SPL. This discrepancy of the max SSPL 90 values between different category of hearing aids might be doe to the number of hearing aids tested in that category {There were only 5 hearing aids of mild categories used for the electroacoustic measurements' data collection). Upon seeing the raw data collected it was observed that the range of max SSPL 90 value is 113dB SPL to 121dB SPL from 0-20 MPO settings in mild category hearing aid. In moderate category range was from 106dB SPL - 131dB SPL. Less number of hearing aids of mild category might be one reason to get higher value in the mild category than in the moderate category.

Observing the mean RTG values of the Table-1 it can be understood that the gain of a hearing aid increase with increase in the MPO settings. For example for MPO setting '0' the RTG value of strong category hearing aid is 36,46dB and for MPO setting 20 the RTG value in the same category is 54.7dB.

Increase in the mean values of RTG is seen when a strong class hearing aid is compared with a moderate class hearing aid for example; the RTG value of a strong class hearing aid

at MPO setting '0' in 3*6.46dB* whereas the RTG values of moderate class and a mild class hearing aid are 33.7dB and 32dB SPL.

Table-I also shows the Total Harmonic Distortion values of different categories (strong moderate and mild) hearing aids at MPO settings 0, 10. 20. As can be observed from the table the THD values of the strong category hearing aid is highest (1.47). the value of moderate category hearing aid being lower (1.33) and that of mild category hearing aid being the lowest (0.4). However Lotterman and Kaslon (1967) have reported that some Instruments will produce relatively high levels of distortion when gain control is advanced beyond 1/2 *or 3*/4 position.

Standard deviation values of Max SSPL 90 show that the strong cata*gory* is the most consistent of the 3 categories of hearing aid when 0.760 of *S.D.* is compared with 1.14 of the mild catagory. This consistency is also seen in the different MPO controls of strong category. The lowest S.D. value is seen in mild category hearing aid at MPO setting '20' (0.54). The maximum standard deviation values are in the moderate categories at MPO controls '10' and '20' (2.40 and 2.114 respectively).

With respect of RTG values of different categories of hearing aids it can be seen from the Table-I that the mild category hearing aid has the minimum standard deviation of

HPO settings 0,10,20,(0.70, 0.83, 0.56). The maximum standard deviation in seen the moderate category hearing at MPO '0' (1.66).

The THD readings show consistency within and between the difference categories of hearing aids at each MPO settings '0', '10', '20'.

Diagram (A), and (B), are the graphic representation of Table-I

In order to determine whether this difference in the mean values of max SSPL 90, RTG and THD was statistically Significant between and within the categories of hearing aids at different MPO setting '0', '10', '20'. Analysis of variance was conducted.

Table- II Two-way ANOVA showing the interaction within and between each catergory of hearing aid (strong, moderate and mild) and SSPL 90 at different MPO setting 0, 10, 20.

Source	D.F	F. Ratio	Significance
A	2	327.42	P $\leq$ 0.001
B	4	99.68	P $\leq$ 0.001
AxB	12	9.37	P $\leq$ 0.001

Where A = Max SSPL90

B = Categories of hearings *aids*

The above table shows that there is a significant difference at P$\leq$ 0.001 level for within and between.

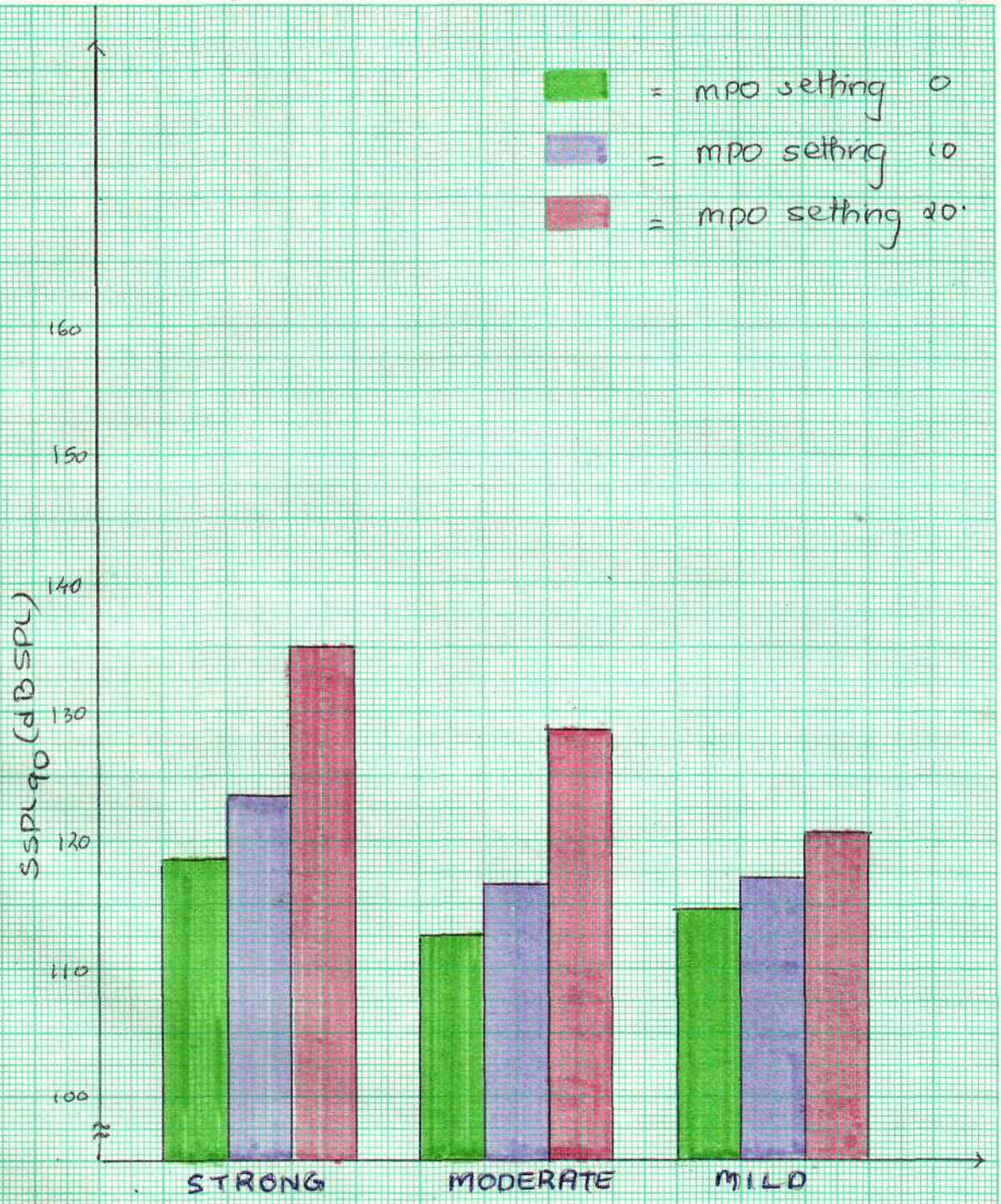

Fig A: Mean Values of $SSPL_{90}$ (dBSPL) in different categories of body level hearing aids (strong, moderate, mild) at different MPO settings (0, 10, 20)

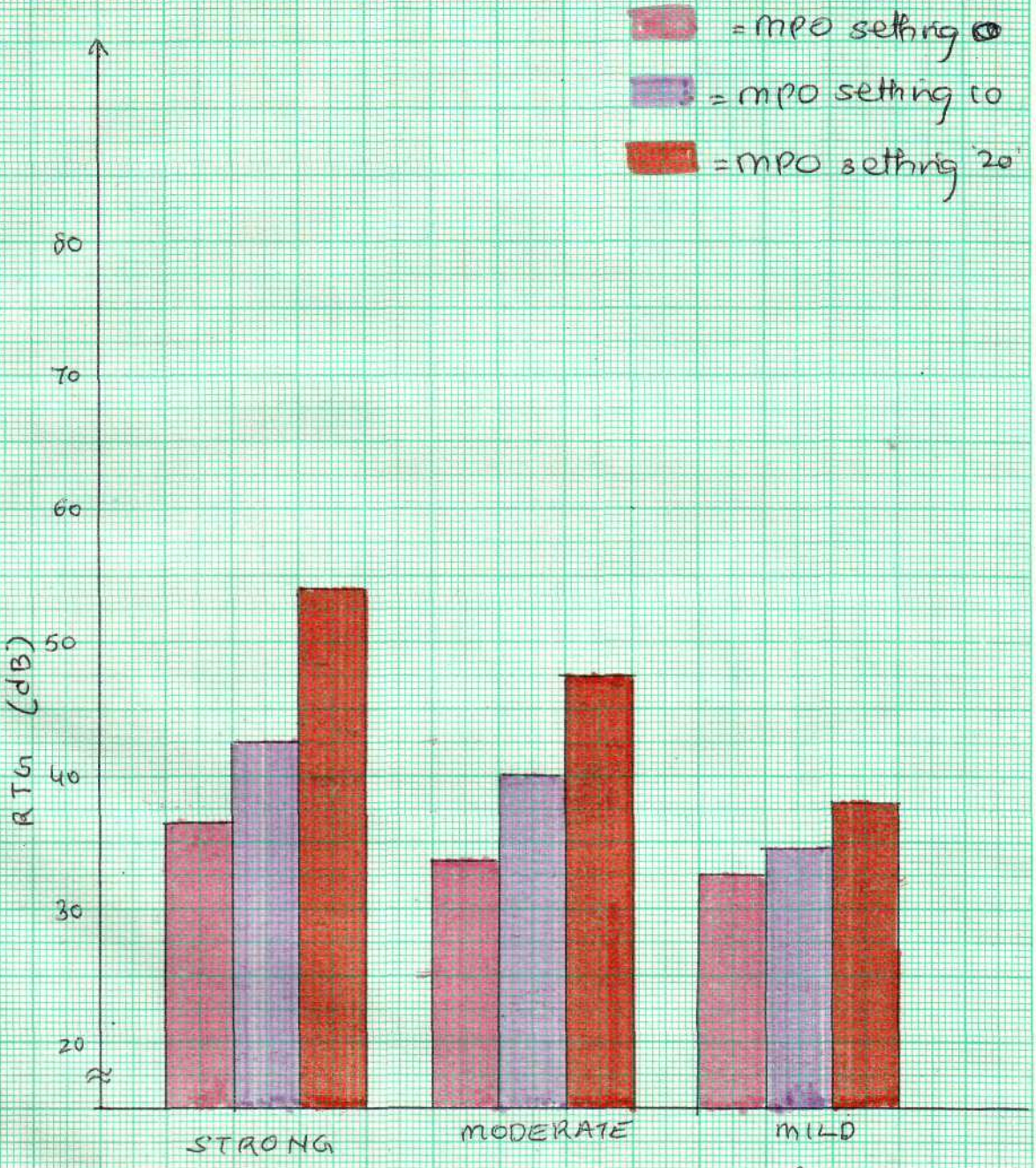

FIG-B :- Mean Values of RTG (dB) of different categories of body level hearing aids (strong, moderate and mild) at different MPO settings 0, 10, 20

interaction of- each category of hearing aid (strong, moderate and mild) and SSPL 9O at different MPO settings 0, 10, 20.

Table-II shows the statistically significant difference in the mean values of the SSPL 9O in the Table-I, statistically. Hence the objective of the study (to find out if there is a significant change in the SSPL90 values of different categories at different MPO setting) is verified.

TABUT-III: Two-way ANOVA showing the interaction between and with in each category {strong, moderate and mild) of hearing aid and RTG at different MPO settings 0, 10, 20.

Source	D.F.	F. Ratio	Significance
A	2	453.25	$P \leq 0.001$
B	0	142.13	$P \leq 0.001$
AxB	12	135.58	$p \leq 0.001$

Where, A = RTG values
B = Categories of hearing aids

The above table shows a significant difference at $P \leq 0.001$ level (d.f being 2, 6,12) for the interaction within and between each category of hearing aid (strong, moderate and mild) at different MPO setting 0, 10, 20.

Therefore the objective (there is significant difference in RTG values of different categories of hearing aids when MPO settings 0, 10, 20 are used).

TABLE-IV: Two-way ANOVA showing the interaction between and within each category (strong, moderate and mild) of hearing aid and THD at different MPO settings 0, 10, 20.

Source	D.F.	F. Ratio	Prob. > F	Significance
A	2	2.62	0.1136	Not significant
B	6	5.73	0.0051	Significant
AxB	12	1.99	0.0347	Significant

Where, A = Total Harmonic distortion
B = Categories, of hearing aids

There is no significant difference in the THD values of different categories of. body level hearing aids (strong, moderate and mild) when different MPO settings are use. This is seen in both within and between categories of body level hearing aid. However, there is a significant difference in THD values when different categories are used i.e., within and between each category of hearing aid (Strong, moderate and mild).

Hence, the objective of the study i.e., there is a significant difference is the THD values when different MPO settings are used in not verified. The objective of the study [there is within and between a significant difference in the THD values different categories (strong, moderate and mild) of body level hearing aids] is verified.

CLINICAL IMPLICATIONS

The experimental study implies that whenever MPO setting is used maximum output and gain is obtained *(135.6dB SPL* 54.6dB SPL) in the strong category hearing aid. Hence MPO 20 setting can be utilized to achieve maximum output at reference test gain position. However, the UCL of the hearing aid user is also needed to be considered before prescribing the MPO setting. The MPO setting can be adjusted to such a level (MPO 10) so that the individual gets adapted to the amplified sounds of every day life (Skinner 1988):

Usually an individual using a hearing aid complains of auditory feedback whenever he tries to increase the volume control wheel. There are Various reasons, one of then being that SSPL 90 may below and speech signal becomes grossly distorted when the gain is turned up. Raising the SSPL 90 should remedy this problem. This can be done by adjusting the MPO controls (Skinner 1988).

Hovever, hearing aids with output in an excess of 132dB SPL should be used only with great caution because their use may lead to further hearing loss (Binnie 1985). Increase in the gain beyond 132dBHL produces little increase in gain but aa increase in the harmonic distortion say negatively affect speech intelligibility (Eodgson and Skinner 1981).

Hence while prescribing a hearing aid it becomes very important to consider MPO setting in order to increase or

decrease the SSPL 90 as per the requirement of the individual hearing aid user. A well aware, sophisticated hearing aid user can regulate the maximum output of the hearing aid with the help of the MPO setting based on the environment sounds and situation.

While amplifying a sound through a hearing aid different forms of distortions take place total harmonic distortions being one of them. THD results is reduction of clarity and intelligibility of the amplified signals. Several studies (Harris et al 1961, Jerger et al, 1966, Olsen and Carhart 1967, Olsen and Wilber 1968) revealed that speech intelligibility is inversely proportional to the level of harmonic distortion produced by hearing aids. The results of the present study conducted implicate that total harmonic distortion values have significant difference within and between different categories of hearing aids (strong, moderate and mild). However, no significant difference in THD values is seen when MPO increases in different categories (MPO settings 0, 10, 20). Hence it can be interpreted that while prescribing a hearing aid a clinician can safely prescribe a high MPO setting of 20 as it would not lead to a significant increase in THD values. But it should be considered that a strong category hearing aid has higher level of THD than mild category body level hearing aid.

SUMMARY AND CONCLUSIONS

An experimental study was conducted in order to find out the effect of MPO control (0, 10, 20) on gain, output and total harmonic distortion characteristics in various body levels hearing aids. The hearing aids were randomly selected from the ones distributed under the ADLIB scheme. The hearing aids were of 3 categories mild (5 hearing aids) moderate (15 hearing aids) strong (15 hearing aids) (as per IS:10775 1984).

Hearing Aid Text Box along with 2CC coupler was used to the electroacoustic measurements of all the hearing aids. The parameters taken into account were, Maximum Saturation Sound Pressure Level (SSPL 90). Reference Test Gain (RTG) and Total Harmonic Distortion (THD). All these measurements were done at MPO 0, 10, 20 settings at 'N' control.

Having collected the data mean, standard deviation, Two-way ANOVA were done. The statistical analysis showed the following results.

1) There was a significant difference in the max SSPL90 and RTG values of different categories of hearing aids (strong, moderate and mild) when different MPO settings (0, 10, 20) were used. This difference was seen both within and between the different categories of hearing aids.

2) There was nO significant difference in the THD values of different categories (strong, moderate and mild) when different MPO settings are used.

3) There was a significant difference in the TED values within and between the different categories of hearing aids.

Hence it can be concluded from this experimental study that

1) MPO control setting (0, 10, 20) is very useful in order to control the output and gain of a hearing aid.
2) A prescriber while prescribing a hearing aid should consider the maximum output of a hearing aid with MPO setting in order to see that the maximum output, does not reach beyond the uncomfortable loudness level of the individual. It can lead to permanent threshold shift due to prolonged overexposure to acoustic stimuli.
3) Increase in MPO setting does not lead to increase in THD.
4) There is an decrease in the THD values from strong to mild category of body level hearing aid which is statistically significant.

APPENDIX-I

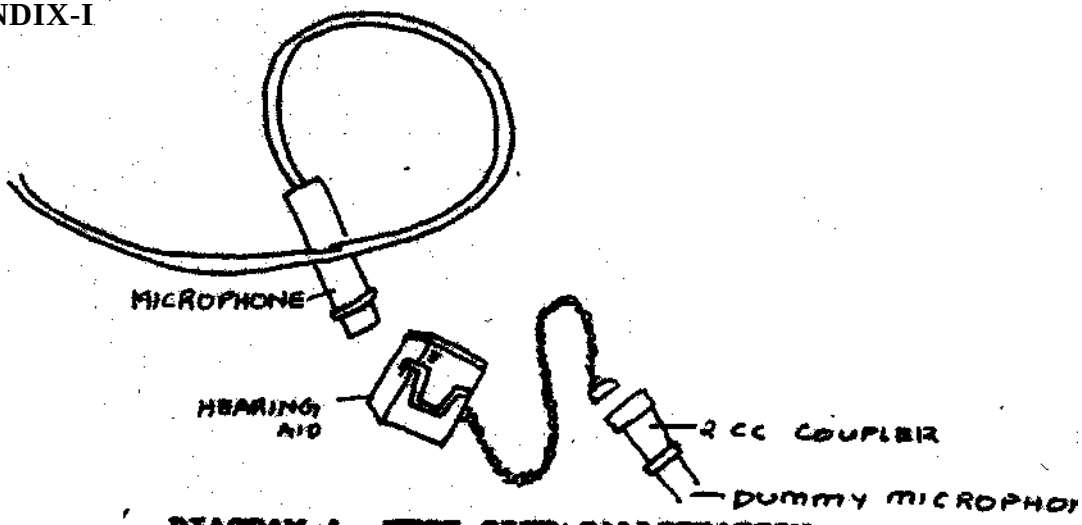

DIAGRAM-A: TEST SITE CALLIBRATION

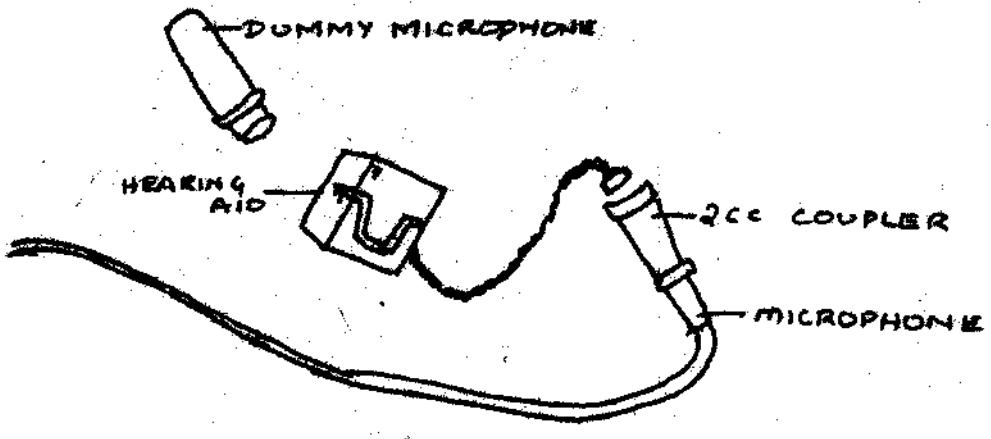

DIAGRAM-B: POSITION DURING TEST SITUATION

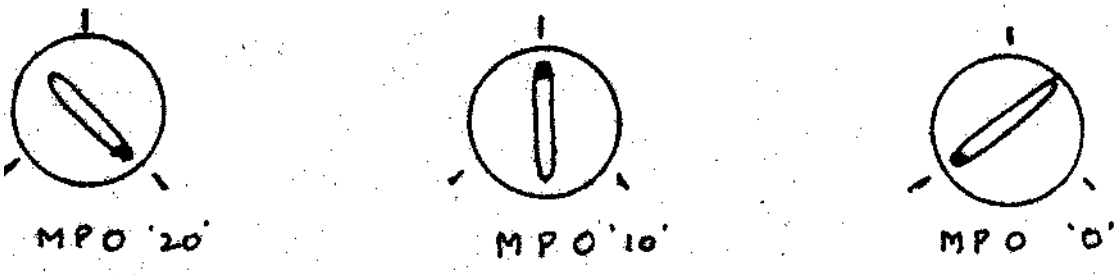

DIAGRAM-C: MPO CONTROL SETTINGS

APPENDIX-II

SPECIFICATION FOR BODY LEVEL HEARING AIDS

IS: 10775 - 1984

3.2 Hearing aid are classified into following 3 classes

CHARACTERISTICS	CLASS OF BEARING AID		
	MILD	MODERATE	STRONG
(a) Maximum saturation Sound pressure level	115dB	125dB	135dB
(b) Avg. OSPL90	105-114dB	115-124dB	125-134dB
(c) Full on Acoustic gain	45dB (min)	55dB (min)	65dB (min)
(d) BF Avg. Full on gain	40dB (min)	50dB (min)	60dB (min)

NOTE: Hearing aid with max SSPL90 greater than 135dB are likely to damage the ear.. Hence their use should be under strict medical advice.

TEST SCHEDULE MEASUREMENTS

Total harmonic Distortion

Method of measurement: 6.12.1 of IS:10776 (Part-1) 1984 (to be measured at frequencies 500Hz IKHz and 1.6KHz)

Values shall not exceed *7%.*

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