TO MY PARENTS

ATTENUATION CHARACTERSTICS OF

CRASH HELMENS

An Independent Project in Audiology

Presented to the University of Mysore

In Partial Fulfillment for the M.Sc. III Semester

Examination in Speech and Hearing – December 1980

CERTIFICATE

This is to certify that the independent project, in Audiology entitled "Attenuation Characteristics of Crash Helmets" is the bona fide work in part fulfillment for the M.Sc. III Semester Examination, carrying 50 marks, of the student with Register No. 8

Director,

All India Institute of Speech Hearing,

Mysore – 6.

CERTIFICATE

This is to certify that this independent project in Audiology has been prepared under my supervision and guidance.

GUIDE

DECLARATION

This Independent project in Audiology is the result of my study undertaken under the guidance of Mr. Jesudas Dayalan Samuel, Lecturer in Audiology. All India Institute of Speech and Hearing, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore

December, 1980 Register No. 8

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Chapter I

INTRODUCTION

NOISE POLLUTION

Pollution has caused so much concern here and aboard, that it is becoming a public issue. Among various pollutions, noise pollution has attracted a great deal of attention. The existence of noise as an annoyance problems is an undisputed fact of our modern way of living. In the dim past, noise was largely confined to factories, mills, and foundries where it harassed the imprisoned worker. Noise, like other forms of pollution is a byproduct of man's gregariousness. More and more people are becoming concerned that as a nation develops as new industries are born, as consumer facilities increase , and people, noise inevitably is also being spread to more and more people.

Noise is unique among pollutants. Its effects can be highly subjective, and can produce an immediate reaction.

NOISE AND HEARING LOSS

The crescendo of noise in our environment is not just an isolated disturbance or nuisance. An exposure to noise either of a short duration to intense noise or of or prolonged exposure to loud sounds, has been found to damage man's hearing, disturb his physiology and affect his productively.

At one time coal the main source of power for all kinds of transportation and industrial functioning. With advancement in technology, other sources of power like diesel, petrol, and electric power came into the picture. Even in the olden days people who were exposed to revitting noises of boilers incurred a type of hearing loss which was called "Boiler maker's deafness".

With the availability of electric power, petrol, and diesel as sources of power there was an increase in automobiles and industrial plants which were more efficient and also more noisy. Thus there was an increase in noise. This caused more hearing loss. However, noise induced hearing loss has been known from a long time.

Admirallord Rodney (1782), stated his own experience as, "being almost entirely deaf for 14 days following the firing of eighty broadsides from his ship in 1782".

Parry (1825) described cases in which "hearing was stated to have been impaired, temporarily or permanently, due to noise".

Crowden (1933) used speech audiometry to investigate the hearing loss those exposed to the noise of riveting.

Dickson, Ewing and Littler (1939) studied the hearing pattern of workers exposed to aeroplane engine noise using pure tones.

Since the end of the Second World War, the relation of hearing pattern with the noise picture has been studied widely, but the complexities of the situation are such that there are yet many uncertainties.

Effects of noise on Hearing

Hearing losses from noise exposure can be either conductive or neural or mixed in nature. Perceptive type of noise induced loss results from prolonged exposure to excessive amounts of noise. The site of the disorder is usually in the cochlea. Initially exposure to excessive noise produces a temporary loss in hearing which is recovered after a short time away from the noise. With repeated or prolonged exposure for months or years, the likelihood of the ear recovering all of its temporary loss is diminished. The residual or non-recovered part of the loss constitutes a permanent hearing impairment due to noise. The mechanism responsible for deafness from noise exposure remains to be more fully determined. Studies done in this regard suggest biochemical, metabolic, vascular, mechanical changes which are probably caused by exposure to noise.

Apart from hearing loss another widespread reaction to noise is that of annoyance. Worker's exposed to excessive noise for many years appear to suffer from greater incidence of neurologic, digestive, metabolic disorders. In heavy industries the noise seems to affect the cardiovascular, system by causing angiospastic effects, fluctuations in blood pressure, impairment of certain properties of cardiac muscles and reproductive functions. Thus, workers in heavy noisy industries suffer in an usually higher percentages from circulatory digestive metabolic neurological and psychiatric difficulties (Jansen, 1961; Andrinkin, 1961).

The available information thus indicates that there is a need great deal of research about the effects of noise and prevention from noise.

Noise is the price we pay for being civilized. Therefore it is becoming increasingly, important for us to know what noise is present in our society and what type of preventive measures could be taken.

There is little information available in India in this regard.

Traffic Noise:

Surface transportation noise is not a new problem. The movement of people from country to city has increased the number of people exposed to noise. During World War II the motor truck emerged as a transportation giant in the military service. There are no great technical barriers to better control of vehicular noise; there is though a cost penalty ultimately borne by the citizen for such improvements. Once the vehicle is in use the mufflers wearout and deteriorate to increase the noise output (Apps, 1969).

Hearing Protection from Noise

Hearing protection from noise could be achieved by noise control. Noise control is the technology of obtaining an acceptable noise environment with economic and operational considerations. Noise control could be achieved by reducing the level of noise at the source, or during transmission, or by providing personal ear protection.

In many industrial, military and other situations it is not practical or economical to reduce the noise to levels that present neither hazards to hearing nor annoyance. As long as hazardous noise cannot be reduced at its source by quieting or isolating the machine in the working areas personnel ear protectors are of great values and provide adequate remedy to guard the workman's hearing (Lindeman & Leiden, 1965).

Ear protectors are capable of reducing the noise level at the year by 10 to 45dB, depending on their make and sound frequency. A personnel ear protector or a combination of personnel ear protectors often permits the reduction of noise at year, if not to a pleasant level, atleast to a harmless one (Zwislocki, 1957). The object of ear protection is to reduce the amount of sound energy transmitted is to inner ear thus protecting the cochlea.

The widespread belief that ear protectors impair hearing acuity holds true only in a quiet environment where ear protectors are not necessary. At noise levels justifying their use, they not only do not impair hearing acuity but may even improve it (Zwislocki, 1957). A possible exception is an intermittant noise with periods of silence between the bursts of noise.

Kinds of Ear Protectors

Ear protectors can be divided into four categories according their to position relative to the ear;

I ear plugs, II semi-inserts, III ear muffs, and IV helmets.

Ear plugs are inserted into the ear canal and usually remain there without any additional means of support.

Semi-inserts close entrance to the ear canal without being inserted into it and are supported by a head band. They can provide high sound attenuation. Ear muffs are rigid cups specially designed to cover completely the external ears. They may be held in place by a head band or helmet, or they may be a part of some other head covering.

Helmets cover most of the head surface. They are not commonly used for ear protection alone; usually they combine this function with protection of the head against cold or injury. They may act also as a support for other ear protectors, such as ear plugs or ear phones or muffs. All helmets are made of nonmetallic materials with soft cushion lining on the inner surface. The size and shape vary to great extent. But the ISI standard helmets are usually of different. On the other hand the local helmets i.e. with no ISI mark vary to a great extent in their shaoe, size, and the material. However most of the helmets cover the head completely including the ears.

Ear plugs, when correctly inserted, provide high sound attnuation, are unobtrusive, and do not interfere with head covers, masks goggles, or other devices morn on the head. On the debit side, they are often uncomfortable and may cause pain, and in the extreme case, inflammation.

Zwislocki(1957) opines that ear muffs are more effective than ear plugs. Almost anyone can be fitted satisfactorily with little difficulty. The average sound attenuation for frequencies under 1000hz is usually lower than that of ear plugs. Together with their means of support they are rather large and cumbersome.

Average sound attenuation of various ear protectors are shown in figure I.

Helmets are the largest and usually the most expensive of all ear protectors. But a helmet can be very practical as an ear protector when it performs some other functions at the same time. The acoustic importance of the helmets may increase when sound attenuation at the ear reaches such a high level that transmission through the skull becomes a controlling factor (Zwislocki, 1957). In this situation a helmet covering the greater part of the head can introduce additional transmission loss.

Helmet can be used as an ear protector, because it is made of hard non-metal, which is smoothly finished with soft cushion lining the inner cavity. It covers the whole head and it has no adversed effect on the skin. In addition, other ear protectors could be worn inside with its primary purpose of protection of the skull being undistrurbed.

Helmets of various types have been manufactured. Thus helmets of different shapes and sizes are available in the market. But the Indian standards institution (1977) have given specifications for protective helmets of scooter and motor cycle riders. The ISI (1957) is also provided specifications for industrial safety helmets. But there

Figure 1. Average Sound attenuation values of various Ear protectors.

Is no mention about the attenuation characteristics. Some aspects of the of the specifications are given below:

Material:

1.1 shell—The shell of the helmet shall be of non-metallic material.

1.2 Protective padding—It shall be of rubber pads or expended polystyrene or materials of similar properties.

1.3 Retention system:

1.3.1Head band—The criteria for the selection of material for the head band is that there

shall be sweat-resistant, non-irritant and should not cause skin disease.

1.4 Metal parts—The metal parts in the helmet shall be either inherently corrosion- resistant or shall have been treated for correction resistance.

2. Size—Helmets shall be of the sizes having circumference of inside head band from 520 to 600mm.

3. Constructional requirement.

3.0 General—The construction of the helmet shall be essentially in the form of a hard outer shell, containing the necessary additional means of absorbing impact energy like protective padding and retention system.

3.1 Shell—The shell have outer surface smoothly finished and shall not be specially reinforced at any point. The shape shall be of convex curve, with no visible discontinuities. There shall be no sharp edges on the inside of the helmets; rigid internal projections shall be covered with padding.

3.2 Protective padding--It shall be lined to inner surface of the skull.

3.3 Retention System

3.3.1 Head band—The head band shall be not less than 30mm in width and shall be fixed with any part of the retention system.

3.4 The extent of Protection provided by the shell and the protective padding shall include all areas above circumference of a horizontal plane drawn at a height of 127mm from bottom of the head form. It is desirable that the shell extents downwards as much as possible and atleast up to the level of external opening and lower edge of eye socket, subject to requirement of peripheral vision.

Apart from these, the specifications also include performance requirements such as shock absorption, resistance, strength etc

4. Instructions.

4.1 Each helmet shall be supplied with a printed card fixed with a to having the following information:

a) For adequate protection this helmet must fit closely and drawlace is knotted tightly enough to hold the helmet;

b) The chinstrap must be under tension;

c) This helmet is made to absorb some energy of a blow by partial destructions of its component parts and even though the damage may not be readily apparent, any helmet subjected to severe impact should be replaced; and

d) To maintain the full efficiency of this helmet there shall be no alteration to the structure of the or its component parts.

The helmets are marked with the ISI certification mark.

Purpose:

The purpose of this was study was to find out the attenuation characteristic of the commercially available helmets, which are used by recreational drivers of the two wheeler vehicles. There is a great demand for crash helmets in the open market by the vehicles users.

The presently available ISI standards on helmets do not specify anything regarding sound attenuation characteristics. Even the helmet manufacturers do not consider the sound attenuation characteristics of the helmets (this is true even for the industrial safety helmets also.) This is because the helmet manufacturers admittedly designed their product for the express purpose of crash and wind protection, and give little or no consideration to their noise attenuation properties. Zwislocki (1957) supports this notion by saying that "Most helmets do not contribute to sound attenuation".

In India no standard are available regarding the noise level and hearing damage risk. The ISI has not considered the area of noise and ear protection, and ear yet to determine the standards.

A recent study by Bharath raj et.al (1976) on localization under helmet wearing conditions, revealed that the localization of sounds is affected by about 20% for the sounds coming from the back direction under helmet wearing conditions. There are no other studies done using helmets in India..

Problem:

The present study was planned to answer the following questions.

1. Do recreational helmets provide any sound attenuation?

2. Is helmet wearing alone sufficient to provide ear protection?

3. Is there difference in terms of attenuation for front and back sounds under helmet wearing conditions?

4. Do helmets provide better sound attenuation in combination with ear plugs?

5. Does the attenuation provided by the helmets affect the user in listening to horns or other warning signals?

6. Is there difference in terms of sound attenuation between helmets with ISI marking and local helmets?

Importance of this Study:

1. It is hoped that this study will draw attenuation of helmet manufacturers and ISI, to consider sound attenuation characteristics of the helmets.
2. It will emphasize the need for prevention of hearing loss and also to make constructive suggestions to helmet manufacturers as well as users.

Limitations of his study:

1. Only 10 subjects were studied (tested).
2. Only 3 recreational helmets were included for the study.
3. Industrial safety helmets were not included for the study.

Chapter 2

REVIEW OF LITERATURE

The excessive output produced by both on-the-road and off-the-road vehicles has a subject of growing concern (Bess, 1974). The noise level of these machines have been accused of disrupting the quiet and peacefulness residential areas, affecting the behavior of wild life, and even possibly causing loss to the drivers themselves (Bess, 1974).

Salmivalli and puhakka (1973) in their study reported that the intensity of traffic noise at a street intersection varies from 75-95dB; the pitch being of low frequencies.

This can be visualized from the figure 2.

In United Stated "quantitative" limits for vehicle noise were first introduced by individual state , beginning in 1965 with Newyork, which set a limit of 88dB(A) measured at 50ft with speed at 35mph; and kept 90dB(A) as maximum (Crocker, 1978).

The main sources of surface transportation noise are

a) Traffic, i.e, trucks, cars and motor cycles;
b) Rail roads;
c) Off-the-road recreational vehicles; and
d) Aircraft. Off-the-road recreational vehicles, may at times include motorcycles.

Crocker, (1978) reported that the reason for the emergence of traffic noise as the main source of annoyance in most countries is because of the manufacturing

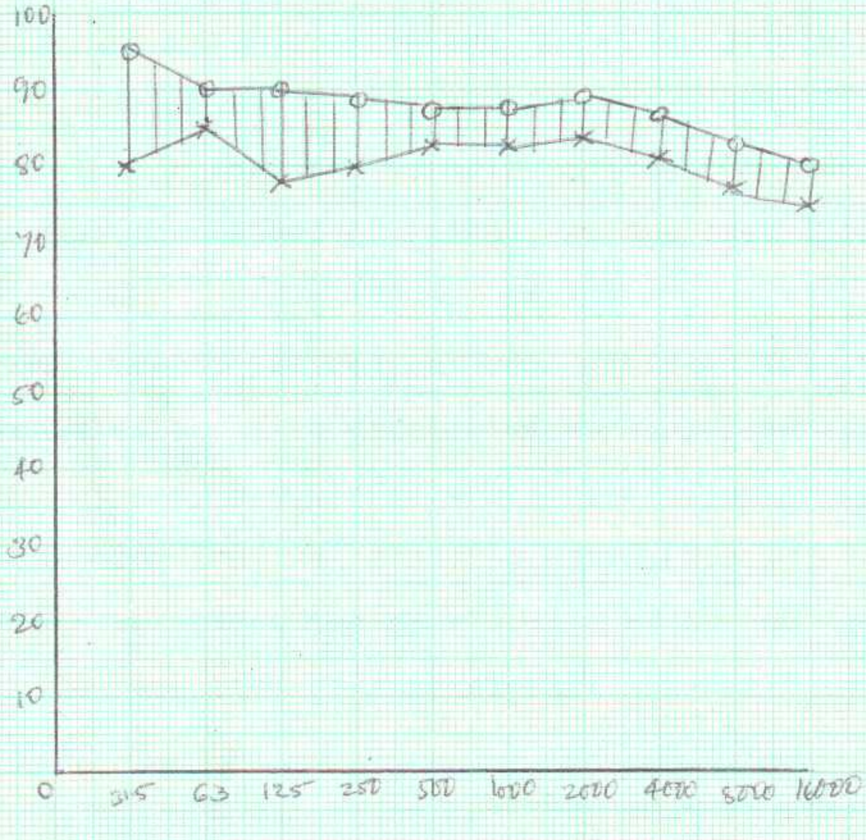

Figure 2. Traffic Noise in a Street Corner by Salmivalli and Puhakka (1973).

Of the higher engines which are usually more noisy than the lower powered ones. In addition to this the number of vehicles has also increased considerably.

Olson (1972) reported that the motor vehicles share of acoustical energy is infact so large that they alone can account for the overall steady, or slowly varying ambient sound levels. In his survey of motor vehicle noise, he found the noise levels of vehicles which are given in table I.

The results indicated that the speed and vehicle weight are important parameters governing the noise level. In the case of motorcycles, throttles setting rather than speed or weight was the most important factor.

Amongst the recreational vehicles the following vehicles could be considered as the chief sources of noise; they are a) snow mobiles, b) pleasure motor boats, c) motorcycles, and d) mobile homes (Rose, 19780). Out of these vehicles, the snow mobile noise and the motorcycle noise have been studied widely.

Motor Cycles:

Motor Cycle noise has long been considered in the nuisance class. In many cases the motorcycle is used as an utilitarian means of transportation. Nevertheless, its recreational usage is high, off-the-road motorcycle usage is virtually completely recreational.

Motorcycle sound level is a function of speed. The exhaust is the main source, and its spectrum is preponderantly a high frequency one in the case of a 2 stroke engine, and low frequency one in the case of four stroke

Table 1.

Average sound levels of motor vehicles

Reported by, Olson, N(1972)

Vehicles	Speed (mph)		
	30-39	40-49	60-69
Passenger cars	64.4	67.4	73.0
Tractor Trailors	80.9	84.0	87.9
Heavy Trucks			
loaded	78.4	81.0	-
empty	75.2	77.6	84.2
Light Trucks	69.0	70.3	83.9
Motor cycles	72.6	79.0	85.7

engine. The second source of noise is the air intake and the third is the engine itself. Rose (1978) reported that the sound level at the driver's position can vary between 80dB(A) and 115dB(A).

Harris (1957) gives a graph showing the motorcycle noise.

Snow mobile noise has been subject to increasingly strict legislation in a great number of American States and in Canada. Rose (1978) reports that the spectral share of snow mobile noise is annoying and irritating. The sound level at the driver's position varies between 90 to 115dB(A). Bess and Poynor (1974) reported permanent in a group of racing snow mobile driver's and mechanics.

Chaney et.al (1973) found TTS of varying degrees in 87% of snow mobile operators tested after operation periods as short as one-half hour. They also observed positive signs of recruitment in their subjects after exposure.

Thus the known acoustic output of many of these machines are also potentially capable of causing ear damage.

Most recreational vehicle driver's feel that their helmets provide them adequate attenuation and reject the idea of any additional protection (Bess, 1974).

A pilot study by Gale and Bess (1972)revealed that the helmets investigated provided little attenuation

Below 2000Hz, the frequencies which appear to predominate in two cycle-engines. In addition to this they came across a sudden irreversible hearing loss case, which was acquired after a 5 hour on a snow mobile; the subject was wearing a full size crash helmet. This could have been due to the sound leakage occurred particularly in the low frequencies.

Later they did an elaborate study to find out the attenuation characteristics of the helmets and found that the helmets had no attenuation at 2000Hz or below. The helmets provided, adequate attenuation when were worn in combination with ear plugs. The results are given in table II, figure 3.

Guild (1958) reported greatest sound attenuation when ear muffs were worn with ear plugs.

Tobias (1958) recommends the use of ear muffs or ear plugs along with helmets to pilots to protect against the physiologically damaging intensities of aircraft noise.

Zwislocki (1957) reported that maximum sound attenuation is achieved when ear muffs are worn in addition to ear plugs. But the total attenuation is not the simple sum of the two ear protectors, as it is appreciably less.

However, not much information is available regarding the attenuation characteristics of helmets when worn with ear plugs. Ear plugs introduce an insertion loss between the sound source and the ear drum of the listener. Helmets can exclude the direct transmission from the surrounding

Table 2.

MEAN ATTENUATION DATA AND STANDARD DEVIATIONS (S.D.) OBTAINED AT FREQUENCIES 125-8000 HZ UNDER DIFFERENT HELMET WEARING CONDITIONS BESS ET. AL (1974).

Test Condition		Frequency in Hertz 125	250	500	1000	2000	4000	6000	8000
II	Mean	0.12	0.70	2.59	3.84	8.79	17.4	21.7	24.5
Helmet I	s.d.	(2.9)	(3.2)	(2.1)	(3.8)	(3.3)	(3.9)	(5.3)	(5.9)
III	Mean	0.18	1.23	0.15	0.55	5.46	16.9	19.2	21.5
Helmet	S.D.	(3.9)	(2.4)	(2.1)	(3.4)	(3.4)	(3.2)	(3.8)	(5.0)
iv									
Custom	Mean	9.80	10.4	11.3	13.7	20.8	32.8	25.2	20.3
Ear Protection	S.D.	(5.0)	(3.7)	(3.4)	(4.2)	(2.6)	(6.3)	(5.7)	(6.6)
V									
Helmet I Plus	Mean	13.8	18.2	18.8	22.3	32.8	47.0	45.9	46.0
Custom Ear Protection	S.D.	(5.3)	(5.7)	(4.6)	(5.6)	(6.8)	(7.0)	(7.3)	(7.2)

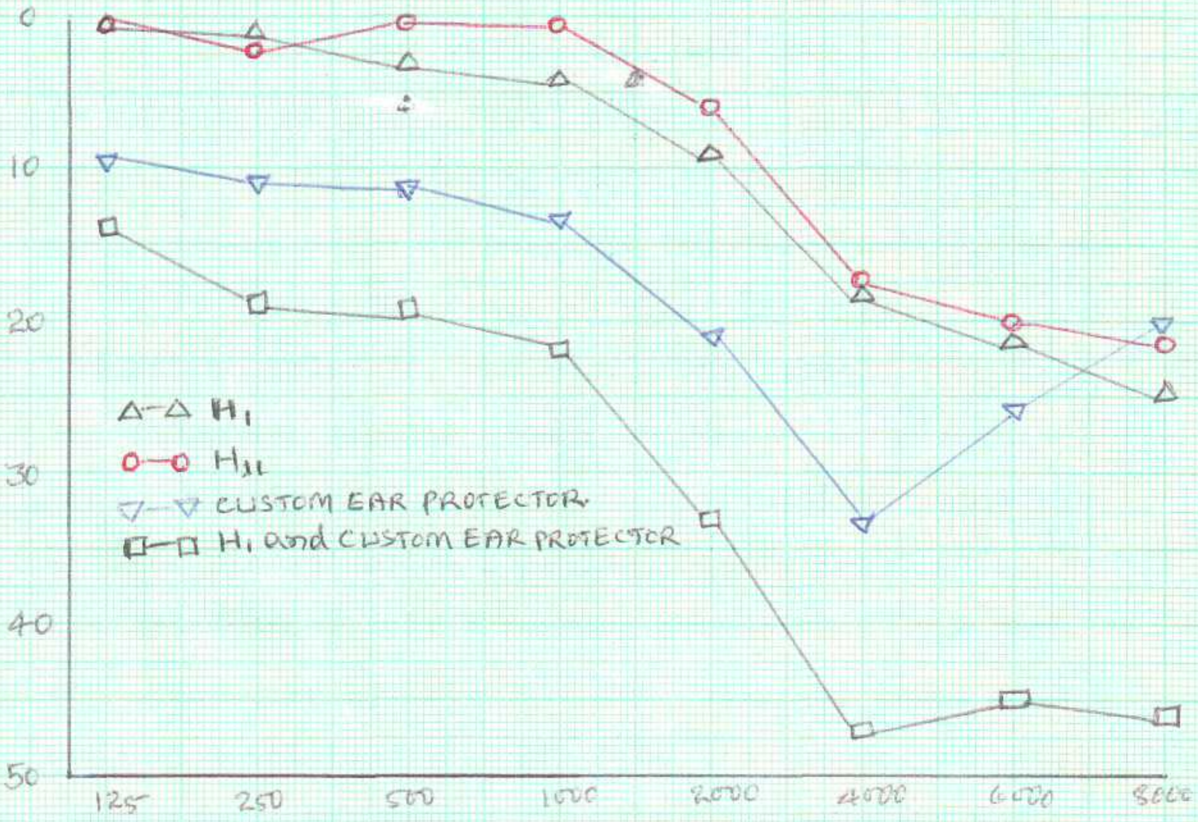

Figure 3. Mean attenuation values at each test frequency for different listening conditions (Bess et al 1974).

air to the skull. Zwislocki (1957) reports an attenuation of about 10dB by an ideal helmet.

The literature is still less to know whether the helmets are dangerous to the vehicle driver in listening to the warning signals, such as horns, and other sounds.

Burgess (1974) reports that the intensity of sound source in emergency vehicles varies from 100 to 115dB in Hawaii. He found that in the presence of vehicular noise, only 10% of the driver's heard the warning signals early enough to avoid possible collision and all of 60% heard it too late or not at all. In addition to this 40% of the driver's, who heard, the signals localized the emergency vehicle wrong.

A study by Bharath raj et.al (1976) revealed that auditory localization functions become impaired or distorted under helmet wearing conditions. But the disturbance in localization was only 10% under helmet wearing conditions when compared with nonhelmet wearing conditions. The sounds from the back were the more affected by about 21% in accuracy of localization.

Even though the ear protectors are older than the present century, it is only after the second world war they have been investigated systematically in the laboratory.

Chapter 3

METHODOLOGY

As noise control at the source or during transmission does not come under the purview of this study, personal ear protection was of major concern.

The study was intended to find out the real-ear attenuation values at threshold for different frequencies under different conditions.

Real-ear attenuation of a helmet at threshold is the difference (in decibels) between the threshold of audibility for an observer with helmet or custom ear plug or both in place (test threshold) and that measured when his ears are open and uncovered (reference threshold); ISI, 1977.

The methodology of the present study followed the steps mentioned below:

1. Obtaining thresholds for narrow band noise and wide band noise, in sound field, on

normal hearing subjects.

2. Obtainng thresholds for the same ears for narrow band noise and white noise in sound
field, under helmet wearing conditions;

a) Subject facing the speaker (signals from front), and,
b) Subject's back facing the speaker (signals from back direction).

3. Obtaining thresholds for the same ears using the same stimuli in sound field, with ear plugs worn inside the ears.

4. Obtaining the thresholds for the same ears using the same stimuli in sound field, with ear plugs worn in combinations with a helmet.

All subjects were seated facing the loud speaker except in condition 2.b during which the position was exactly the reverse.

Three medium sized commercially available crash helmets were selected for evaluation. Two helmets were moderate to highly priced, around Rs200 to 300 (they had ISI mark). One local helmet of a lower price was also selected.

The custom ear protector used in the study was an ear tip made of plastic, with the holes the filled by a mixture of zelgan paste.

<u>Subjects:</u>

The subjects were 7 males and 3 females. Their age range was 17 to 23 years with a mean age of 20 years. The subjects were not aware of the purpose of the study. Eight of them were undergraduates and two were graduates. All of them had normal hearing bilaterally as ascertained by a puretone screening procedure, i.e better thresholds than 256B (ReANSI, 1969).

Equipment and Test Environment:

A commercially available diagnostic audiometer (Madsen OB70) was used for both preliminary screening and sound field testing.

The signals from the channel Two of the audiometer (OB70) were presented through a Madsen FF72 loud speaker placed inside the sound treated room. The loud speaker was kept at a distance of 5ft from the subjects head.

Testing was performed in the custom made sound treated room of the All India Institute of Speech & Hearing, Mysore. The noise level in the test room was measured by a sound level meter (B&K2203) and the noise levels at the position of the listener were far below the interference levels.

The test equipment (Madsen OB70) was placed in the examiners room. Subjects were seated in the testing room and the observation window facilitated visual communication between the two rooms. The loud speaker was placed in the test room. The figure 4 shows the digram of the apparatus used in the study.

Calibration of the Test Equipment:

The channel Two output of the audiometer was calibrated so that the output was in accordance with the expected levels (Wilber, 1978). FF72 speaker of channel two was calibrated as instructed by the manufacturer (Madsen manual; madsen electronics).

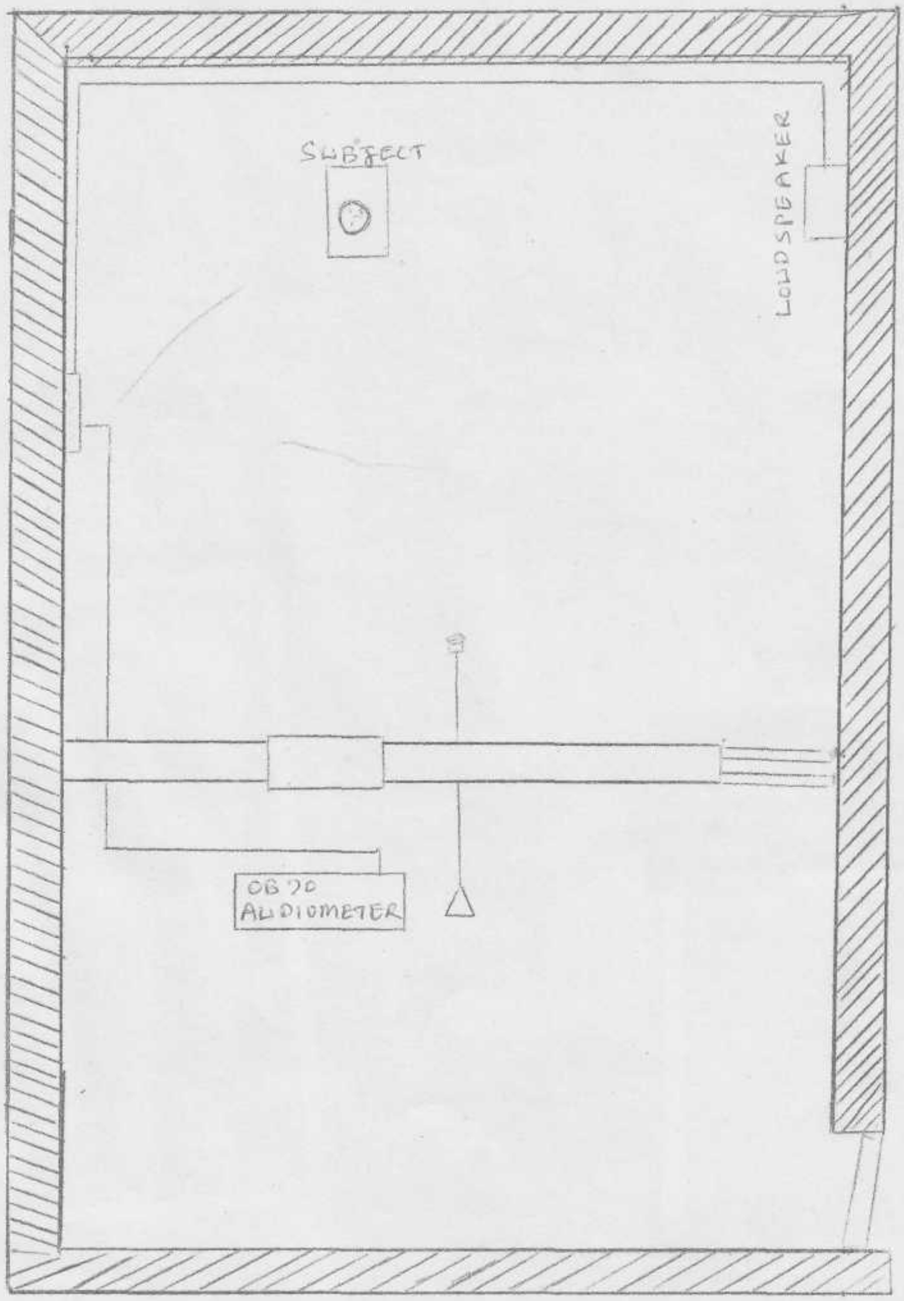

Figure 4. A SCHEMATIC DIAGRAM OF THE APPARATUS USED IN THIS STUDY.

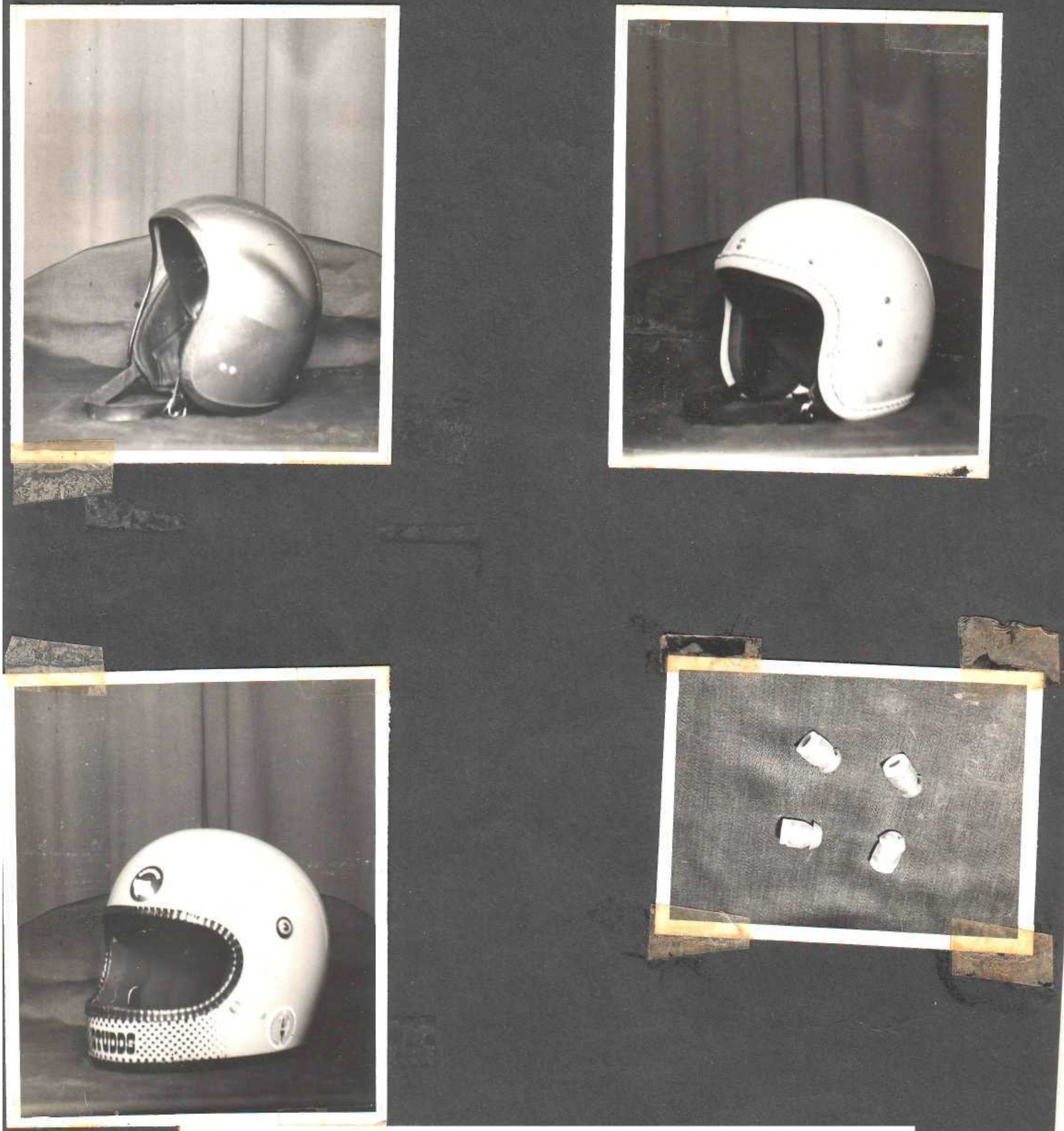

Figure 5

Photopies of the helmets and custom ear protector used in this country

Stimulus Material:

The stimulus material consisted of Wide Band Noise and Narrow Band Noise of the following frequencies presented through the FF72 loud speaker.

NBN: 250, 500, 1000, 2000, 4000, and 6000Hz.

Noise as stimulus material was preferred, because

1. To avoid standing wave formation if pure tones are used,
2. To simulate the natural situation.

Test Procedure:

All the subjects were instructed as follows:

"You are going to hear sounds similar to noises which gets decreased from a moderate level to a softer one. As soon as you hear the sound you raise your finger and drop the finger when you cease to hear. Respond in the same way whenever you hear. I am interested in the softest levels whenever you hear. I am interested in the softest levels at which you can hear these sounds. So listen carefully. Do you have any questions?".

All subjects were tested individually under four conditions on different days. Conditions were randomized to each subject, except condition 4, which was the last one to be tested.

Condition 1:

In the first condition threshold for the test signals in sound field were determined using Hughson-Westlake procedure (Carhart & Jerger, 1954) for all the subjects.

Condition 2:

a) In this condition subjects wore one of the test helmets and were seated facing the speaker. Thresholds were determined in this position. This procedure was carried out with three helmets.
b) Again the thresholds were determined when subjects wore a helmet and sat with their back facing the loud speaker. This procedure was carried out with two helmets (one ISI and one local helmet used in condition 2a).

The 2b condition was just to compare the attenuation values of helmets for the front and back sounds.

Condition 3:

In this condition, thresholds were determined when subjects wore an ear plug in each ear.

Condition 4:

In this condition thresholds were determined when subjects wore ear plugs in combination with a helmet. (Helmet which provided the maximum attenuation was used with all the subjects).

Subjects attended all the four conditions. The subjects responses were recorded in each condition.

Attenuation values were computed for each condition separately and the mean attenuation values were plotted on a graph.

Chapter 4

RESULTS AND DISCUSSION

For a given subject the attenuation data were obtained by subtracting the thresholds in condition 1 from the thresholds in one of the other conditions (2 to 4) at each test frequency band.

The results of the study are shown in table-3 and figure-5.

The mean attenuation values of the conditions 2 to 4 are represented in figure-3. The findings are almost similar to the findings of Bess et.al (1974) which are given in table-2 and figure-3.

It is apparent from the figure-5 that the helmets provide very less attenuation below 2000Hz (range is from 2.0 to 8.5dB). Helmet II provided better attenuation than the other two helmets, even though the difference is not much below 2000Hs. Thus, the local helmet provided better attenuation than the two ISI standard helmets.

The custom ear protector alone provided more sound attenuation than the three helmets at all frequencies, which is obviously due to a better acoustic seal.

When the custom ear protector and helmet II were worn in combination there was an increase of about only

2dB to 3dB below 1000Hs.

On the other hand there was an increase of 7dB to 20dB in attenuation values after 2000Hz.

For wide band noise none of the helmets provided significant attenuation. On the other hand the custom ear protector provided 21.5dB attenuation for white noise. There was an increase in attenuation by 9dB when helmet II was worn with custom ear protectors.

Table-3 gives the attenuation date along with standard deviation values obtained at each test frequency. Greater threshold variations are seen above 1000Hz in almostall conditions.

All these findings are consistant with the findings of Bess et.al (1974). Bess et.al have attributed the threshold variations at higher frequencies, to variations in the acoustic seal obtained with the custom ear protector as well as to the differences in helmet fit.

The finding of the present study, that is when the helmet II and ear protection were used in combination the total attenuation was slightly more than the added attenuation of each condition, agrees with the findings of Bess et.al(1974). But this finding is somewhat contrary to the previous studies. Zwislocki (1957), Guild (1958) reported that ear muffs and insert type ear plugs combined attenuate much less than the simple addition of each protector.

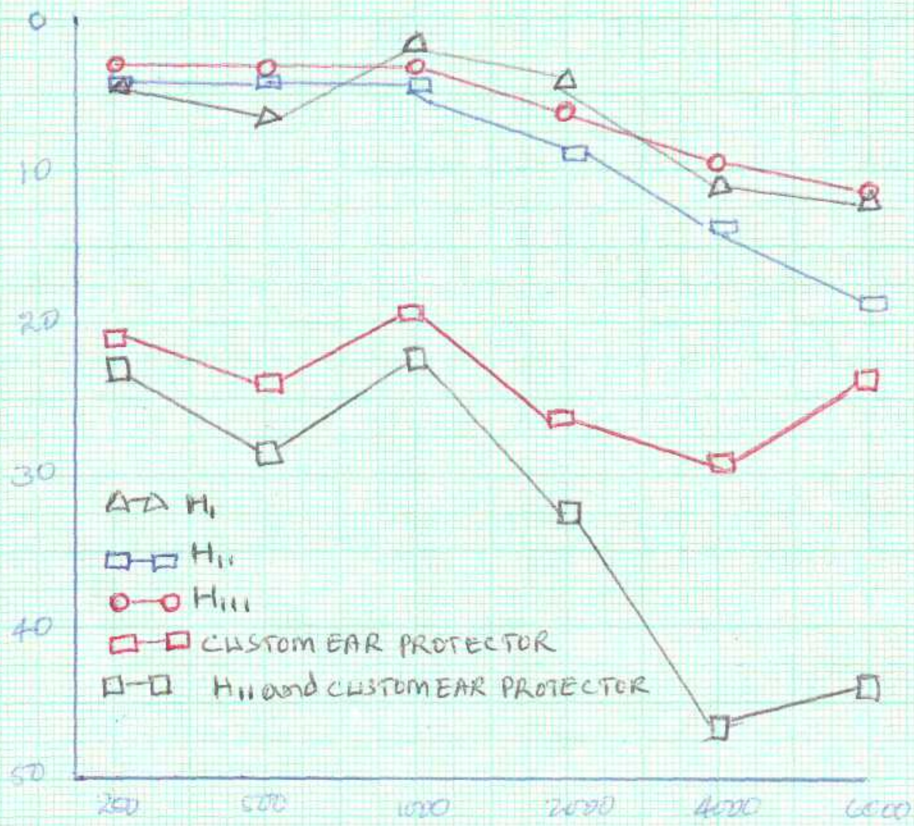

Figure 6. Mean attenuation values at each test frequency for different listening conditions of this study.

Table 3

Mean thresholds in sound field of the subjects and Mean attenuation data and standard deviations

(S.D.) of the present study under different test conditions.

		Frequency in Hertz						
Test Condition		250	500	1000	2000	4000	6000	WBN
1								
No Protection	Mean	19.5	16.5	13.5	12.0	7.50	9.50	7.50
2	Mean	4.5	6.0	2.0	4.5	10.5	12.0	3.00
Helmet I	S.D.	3.7	2.5	4.3	4.5	4.5	5.4	4.6
Helmet II	Mean	4.5	4.5	4.5	8.5	16.5	19.0	4.5
	S.D.	2.0	3.0	2.6	5.5	5.0	7.1	4.6
Helmet III	Mean	4.0	4.5	3.5	6.0	9.5	12.0	5.0
	S.D.	4.8	4.3	4.0	6.0	4.0	4.8	1.5
3	Mean	20.5	23.5	19.5	26.0	28.5	23.5	21.5
Custom Ear	S.D.	3.1	3.1	5.0	4.0	4.0	4.0	4.8
Protection								
4								
Helmet II	Mean	22.5	28.5	22.5	33.0	46.5	44.5	30.5
Plus Custom	S.D.	2.4	3.1	4.8	3.1	4.8	3.7	5.0
Ear Protection								

Bess et.al (1974) have attributed their contradictory results to the pressure obtained by placing the helmet on the custom ear protector which there by gave a better acoustic seal. This would account for the greater sound attenuation obtained with the custom ear protector when used in combination with a helmet.

Table 4 gives the attenuation data for the sounds coming from front and back directions under helmet wearing conditions. The findings suggest no significant difference in attenuation values for the front and back sounds under helmet wearing conditions.

Discussions:

The results of the present study indicate that the recreational head gears provide little attenuation for sounds of all frequencies. Thus the helmets provide little ear protection for loud noise levels, especially at the lower frequencies. In addition to these findings results also indicate no significant difference in attenuation values for front and back sounds under helmet wearing conditions.

Thus wearing recreational helmets for noise protection does not seem to help the driver or the worker much from the loud noise levels. He needs to wear some form of ear protection along with the head gear to protect his ears from loud noises.

Thus the ISI and the helmet manufacturers should considers the attenuation characteristic of the helmets

Table 4

Mean attenuation values of the helmets for front and back sounds.

	Frequency in Hertz						
	250	500	1000	2000	4000	6000	WBN
Helmet I							
Front---	4.5	6.0	2.0	4.5	10.5	12.0	3.0
Back----	5.0	6.5	1.5	5.5	13.0	12.0	5.0
Helmet II							
Front---	4.5	4.5	4.5	8.5	16.5	19.0	4.5
Back-----	3.0	5.0	5.0	9.5	18.5	22.5	6.0

with more importance, especially for the industrial workers. On the other hand the presently available helmets do not appear to affect the driver of the two wheeler vehicles in listening to the sounds of other vehicles.

But the helmets may affect the localization of sound as found by Bharath raj et.al (1974).

Chapter 5

SUMMARY AND CONCLUSIONS

The noise levels of many on-the-road and off-the-road vehicles are potentially hazardous to the human auditory system. Most driver's wear crash helmets and some of them feel that the helmets are capable of providing ear protection. The ISI and also the helmet manufacturers have not yet considered the aspect of attenuation, even for the industrial safety helmets.

Hence this study was attempted to find out the attenuation characteristics of the crash helmets. 10 normal subjects were tested under different helmet wearing conditions in sound field.

Even though the head gear is primarily meant for the protection of the skull, the results of the study indicate that the head gears when worn with some form of ear protectors improve the attenuation to a considerable degree. If the helmets are modified atleast to a little extent with regard to sound attenuation, such helmets when worn with some form of ear protection would serve both the purposes, such as; protection of the skull, and the protection of ears from noise.

If we achieve this objective, we would be able to protect both the driver's exposed to high engine noise levels and also the industrial workers.

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