Perceptual Evaluation of Acoustic Source Width

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***Abstract*:- In this work, we examine the effect of inter loudspeaker distance on acoustic source width perception for different frequencies. The inter loudspeaker distance is varied as 0,60,120,180and 240cm.The cut-off frequencies are varied as 1000Hz,2000Hz,4000Hz,8000Hz.The stimuli are presented on a linear loudspeaker array. Three normal hearing listeners rate the perceptual ASW of these stimuli on a scale of (0-100) using a MUSHRA-type presentation. It show that lesser inter loudspeaker distance produces higher ASW. Thus, through this work ,we develop an experimental methodology to study the large acoustic source width using a linear loudspeaker array in an anechoic setup.**

Keywords:- Acoustic source width,ASW,Interaural time difference,Inteaural level difference.

I. INTRODUCTION

Acoustic source width perception is multidimensional in nature. Localisation of the source ,its speed ,acceleration, the source width, listener envelopment ,size of the enclosure, nature of the ambience-are some of the spatial attributes a listener can extract through auditory perception. these spatial attributes can be broadly grouped as source attributes and ambience attributes. The auditory perception of the source attributes is influenced by the ambience factors .Focusing on the source attributes ,while localization has been addressed as perception of a point source ,acoustic source width is studied as a continuous integrated perception of many point sources like symphony in orchestra. In contrast to localized sources ,a sense of envelopment is produced by the continuous distributed sources around the listener.

In this work , we examine the effect of interloudspeaker distance on acoustic source width perception for different freuencies.The interloudspeaker distance is varied as 0,60,120,180and 240cm.the cutoff frequencies are varied as 1000hz,2000hz,4000hz,8000hz.the stimuli is presented on a linear loudspeaker array.three normal hearing listeners rate the perceptual width of the stimuli on a scale of (0-100).

The human ear can be structurally divided into three parts-the external ear, the middle ear and the inner ear. The external ear simply transmits the signals further into the ear it consists of three parts: the pinna, the ear canal and the tympanic membrane. the pinna is the visible part of the ear and helps in directional hearing by filtering sounds depending on their directions the ear canal amplifies the signals around 3-4 khz because at those frequencies it can be seen as a linear resonator the tympanic membrane ,also called the eardrum ,changes the wave signals in the air into mechanical vibrations in the ossicles.

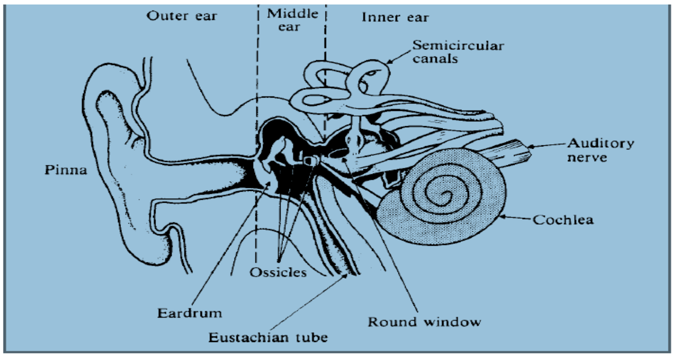

Fig. 1. Diagram of EAR

The middle ear consists mainly of the ossicles, there are three bones called malleus, incus and stapes .they conduct the mechanical vibrations further into vibrations in the liquid of the inner ear. Humans perceive sounds coming from different directions and localize the event accordingly the most important cues in accomplishing this are interaural time difference(ITD)and interaural level difference. When the sound travels towards the listener, it arrives first at the ear closer to the sound source and the travels around the head to the opposite ear, this delay is called ITD. From pinna and shoulders affect certain frequencies of the signal in one ear, these affects together cause Inter aural level difference(ILD).

II. EXPERIMENTAL PROCEDURE

ASW perception with noise stimuli

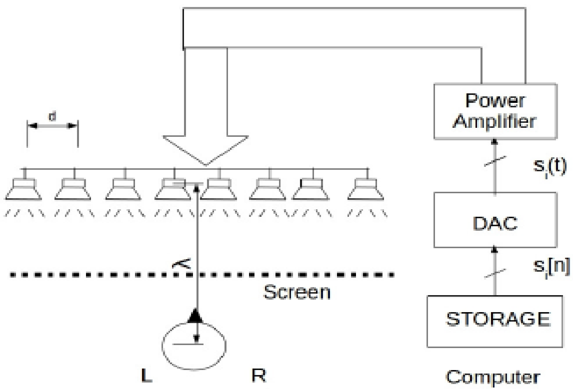

Fig. 2. Experimental setup for ASW listening test. 'd'= inter loudspeaker distance.

A. *Stimuli synthesis*

The stimuli presented is a narrow band white gaussian Noise of sampling frequency 48khz.the signal is generated using a band pass filter .in signal processing, white noise is a random signal having equal intensity at different frequencies ,giving it a constant power spectral density in discrete time ,white noise is a discrete signal whose samples are regarded as a sequence of serially uncorrelated random variables with zero mean and finite variance ;a single realization of white noise is a random shock.

B. *Filter design*

The white gaussian noise signal generated is passed through a band pass filter whose centre frequency is varied as 1000hz,2000hz,4000hz,8000hz.the filter order is 250.after the signal is filtered ,the narrow band white gaussian signal is shaped using the ASD(Attack-Sustain Decay)technique in order to not loud the speakers immediately.the above ASD technique can also be done using a Tukey Window function which is given by

$$w(n) = \begin{cases} \frac{1}{2}\left[1+\cos\left(\pi\left(\frac{2n}{\alpha(N-1)}-1\right)\right)\right] & 0 \leqslant n < \frac{\alpha(N-1)}{2} \\ 1 & \frac{\alpha(N-1)}{2} \leqslant n \leqslant (N-1)(1-\frac{\alpha}{2}) \\ \frac{1}{2}\left[1+\cos\left(\pi\left(\frac{2n}{\alpha(N-1)}-\frac{2}{\alpha}+1\right)\right)\right] & (N-1)(1-\frac{\alpha}{2}) < n \leqslant (N-1) \end{cases}$$

Figure 2: Tukey Window equations

Loudness normalisation GUI

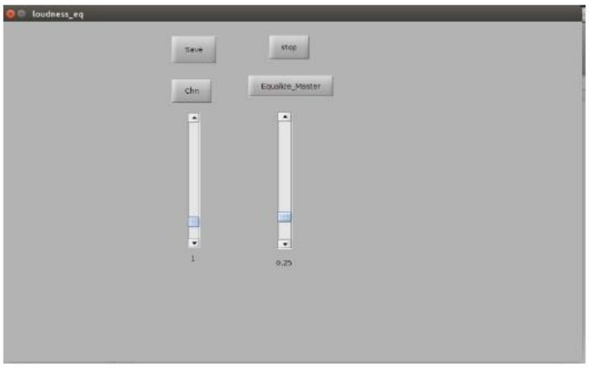

Fig. 3. Loudness, Normalisation GUI

The scaling factor to achieve this is given across the corresponding slider .The desired stimuli is obtained as the product of the corresponding and the master scale value .the scaling factor is calculated as follows :

Say the measured loudness is 60db.we want to scale it up to 63db.an additonal 3db has to be added to the signal.

10=20log10(s*x)

Where ‘ s’ is the scaling factor and ‘ x’ is the signal energy.

The GUI is prepared as follows:-

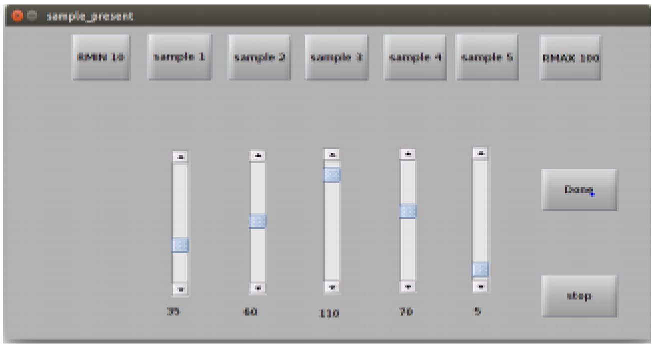

Fig. 4. Experimental procedure

- **Objective:** To study the effect of interloudspeaker distance ‘ d’ on acoustic source width perception for different cutoff frequencies.
- **Apparatus:** Loudspeaker,power amplifier,scarlett 18i20.
- **Procedure**: To study the effect of inter loudspeaker distance “ d” on asw for different cutoff frequencies.
- A white Gaussian noise stimuli is synthesized with sampling frequency=48,000hz. This noise is stored in a “ .wav” file.It is passed through a Tukey window function for Sigmodal attack and decay(y). A bandpass filtered signal of order=250 with different “ fc” are created .(b1,b2,b3,b4)

  C=convolution of y and b1

  C1=convolution of y and b2

  C2=convolution of y and b3

  C3=convolution of y and b4 are created.

TABLE I. THE STIMULI WITH DIFFERENT FC ARE CREATED.

	Fc hz	**Fl hz**	**Fh hz**	**D1 (cm)**	**D2 (cm)**	**D3 (cm)**	**D4 (cm)**	**D5 (cm)**
C	1000	800	1200	0	60	120	180	240
C1	2000	1600	2400	0	60	120	180	240
C2	4000	3200	4800	0	60	120	180	240
C3	8000	6400	9600	0	60	120	180	240

III. RESULTS

TABLE II. THE STIMULI WITH DIFFERENT FC ARE CREATED.

Listener1			**Listener2**		
Fc=1000hz	D1=distance	58	Fc=1000hz	D1	60
1000hz	D2	100	1000hz	D2	30
1000hz	D3	35	1000hz	D3	10
1000hz	D4	77	1000hz	D4	30
1000hz	D5	12	1000hz	D5	40

Listener3		
1000hz	D1	8
1000hz	D2	3
1000hz	D3	0
1000hz	D4	0
1000hz	D5	25

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Listener1

2000hz	D1	0
2000hz	D2	60
2000hz	D3	81
2000hz	D4	42
2000hz	D5	30

Listener2

2000hz	D1	10
2000hz	D2	20
2000hz	D3	20
2000hz	D4	50
2000hz	D5	40

Listener3

2000hz	D1	9
2000hz	D2	2
2000hz	D3	0
2000hz	D4	16
2000hz	D5	33

Listener1

4000hz	D1	10
4000hz	D2	30
4000hz	D3	40
4000hz	D4	30
4000hz	D5	50

Listener2

4000hz	D1	10
4000hz	D2	77
4000hz	D3	91
4000hz	D4	37
4000hz	D5	57

Listener3

4000hz	D1	1
4000hz	D2	22
4000hz	D3	5
4000hz	D4	2
4000hz	D5	11

Listener3

8000hz	D1	9
8000hz	D2	8
8000hz	D3	2
8000hz	D4	13
8000hz	D5	20

Listener1

8000hz	D1	11
8000hz	D2	47
8000hz	D3	29
8000hz	D4	13
8000hz	D5	59

Listener2

8000hz	D1	10
8000hz	D2	40
8000hz	D3	20
8000hz	D4	50
8000hz	D5	30

IV. CONCLUSIONS

Through this work we develop an experimental setup and methodology for linear source width study. We have studied the ASW perception for different inter-loud speaker distance with different cut-off frequencies. More experiments need to be performed to study the effect of inter loudspeaker distance on ASW.

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