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Binaural Summation in Normals and Sensorineural Hearing Loss

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Abstract

Binaural summation was tested in fifteen normal hearing adults and fifteen subjects with bilateral symmetrical SN loss for 500 Hz & 200 Hz puretones and wideband noise of 500 m sec. duration at O dBSL, 20 dBSL & 40 dBSL. Results indicated thai SN loss group showed significantly less summation than normals and there was a non-linear increase in summation with increasing frequency and intensity in both groups. A few theoretical explanations and recommendations are suggested.

Introduction

Flctcher&Munson(1933)had first reported the loudness gain under binaural hearing, which has been termed as binaural summation. This summation in loudness was reported to be ranging from 3 to 6 dB by the earlierstudics done by Pollack (1948) and Hirsh(1950).

Later Stevens (1955, 1956) from his classical work reported that the binaural and monaural loudness difference equals to approximately 10 dB and with every 10 dB rise in SPL above 40 dB the binaural gain doubles in the sone scale.

Many of the recent work by Hellman & Zwislocki (1963), Scharf & Fishken (1970) and Marks (1987) also found that to reach the same loudness binaurally, a monaural tone must be approximately 10 dB more intense than the binaural tone.

On explaining this phenomenon Treism an & Irwin (1967) slates that the binaural summations arc necessarily a result of neural signal mingling process and binaural loudness becomes increasingly larger than monaural as overall level increases, which resembles classic neural recruitment and not clinical auditory recruitment.

It is not known from the literature, that whether binaural summation is constant or variable across frequency and

intensity and whether there is any similarity or difference in summation in normals and clinical groups.

Here, it has been the objective of the present study to:

1. Find the binaural summation of speech frequency puretones of 500 Hz, 1000 Hz & 2000 Hz and wideband noise at threshold and suprathreshold level.
2. Compare and discuss the results of normal hearing individuals with a group of symmetrical scnsorincural hearing loss cases.

Method

Subjects

Fifteen normal hearing speech & hearing adult trainees with PTA of 20 dB and less (ISO, 1964) and airbone gap of maximum 5 dB in both cars were taken. None had any past history of ear/ hearing complaint. A selected sample of fifteen adult literate cases with acquired bilateral symmetrical sensorineural hearing loss ranging from 50 - 60 dB PTA with absent recruitment and reflex decay on impedance audiometry were included as the clinical group.

Equipment and Stimulus

This experiment was carried out in a sound treated room using Hearing Science Laboratory system of Starky Laboratories. Ffg. I shows the block diagram of the instrumentation used. Reference purctone signals of 500 Hz, 1000 Hz & 2000 Hz of 500 msec duration were presented at selected sensation levels first monaurally to a TDH 39 earphone from a sinewave generator through a master attenuator, gating network and an independent attenuators. The comparison purctone signals of 500 Hz, 1000 Hz and 2000 Hz of 500 msec duration were also produced from the same sine generator

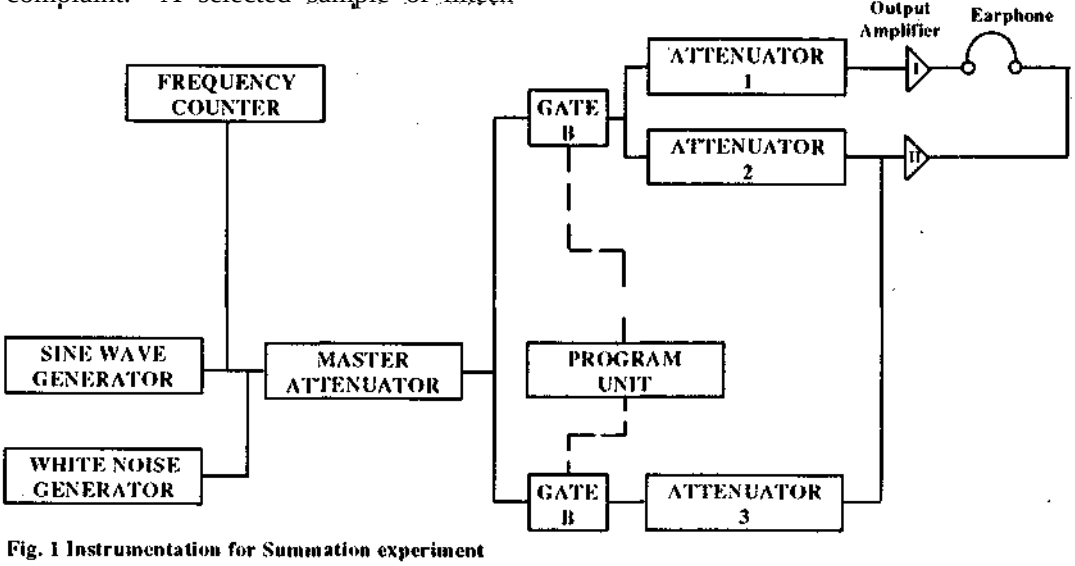

Fig. 1 Instrumentation for Summation experiment

and presented binaurally in phase to the TDH 39 earphone always at the same intensity through two separate attenuators and a gating network.

Between the reference monaural puretone signal and the comparison binaural puretone a gap of 10 msec was maintained and between each presentation an interval of 500 msec was maintained. The white noise generator produced the wide band noise. The time relationship and durational parameters of the signal were set by suitable programming of the programmer unit of the instrument. Both frequency and intensity output were calibrated using the built-in frequency counter and B & K SPL meter 2330 & artificial car 4152 set.

Procedure

After the following instruction all the subjects were given a few trial runs for listening practice through free field speaker and later through earphone.

" You will hear a fixed tone on your left ear. First you have to make a loudness judgement and hold out left hand at some height. As soon as test starts you will hear an additional comparison tone in your both ears after the. left ear tone. Using your right hand you can keep judging the second tone's loudness as compared to the left ear tone. When you find both tones appearing to be equally loud you can say orally 'both are equal'.

Testing was done in the following sequence.

1. The re Terence monaural thresholds oT dilTcrcnt purctones were first found and then the level oT binaural tone was adjusted in 1 dB steps (by changing attenuators 1 & 2 simultaneously) using adaptive psychoacoustic method till the binaural tone appeared to be equal to monaural tone in loudness. This was done lor all three frequencies. The difference between the monaural tone and binaural tone appearing to be equally loud was taken as the loudness gain at threshold level (summation at threshold).
2. The reference tones were then presented at 20 dB above the initial threshold and binaural tones appearing equally loud were again noted. The difference between these two values were taken as the loudness gain at 20 dBSL (summation at 20 dBSL).
3. Finally summation Tor 40 dBSL re Terence tones were (bund out as in previous step (summation at 40 dBSL).

Summ ation Tor wideband noise were also found out for all subjects following the above sequence.

Results and Discussion

The obtained mean & standard deviation values of binaural summation in normals for the three puretonc frequencies arc shown in the Table. I, and the mean and standard deviation values of binaural summalion in SN loss group arc shown in Table. II.

Masking

Table I showing the Mean and SI) values or threshold shirt for loncbursls under three masking conditions using WBN & NBN in normals.

Masking Condition	Noise	500Hz		1000Hz		2000 Hz	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Forward	WBN	10.00	3.58	12.20	4.68	10.47	3.02
	NBN	13.40	4.15	12.33	4.80	9.80	3.02
Backward	WBN	9.00	4.00	8.33	3.94	8.07	2.79
	NBN	10.60	4.45	11.93	5.82	8.27	4.49
Simultaneous	WBN	32.27	6.97	41.53	8.38	42.40	7.29
	NBN	32.33	6.53	40.66	6.73	41.33	6.17

Masking

Table 11 showing the Mean and SI) values of threshold shift for toncbursts under three masking conditions using WBN & NUN in conductive loss group.

Masking Condition	Noise	500 Hz		1000 Hz		2000 IIz	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Forward	WBN	9.13	2.61	11.33	3.02	8.13	2.85
	NBN	12.93	4.38	12.80	5.49	7.86	4.53
Backward	WBN	10.20	3.26	7.67	3.44	5.73	3.94
	NBN	11.86	5.74	13.26	6.72	6.46	4.52
Simultaneous	WUN	31.40	8.24	36.46	10.20	33.46	6.97
	NBN	26.67	8.12	32.67	7.81	32.53	5.84

Normals

From the Table I it is seen that the mean binaural summation at threshold level for normals is around 7 dB to 7.9 dB for all the signals. There is also gradual increase in summation value from 500 Hz to 2000 Hz which appears to be significant. It can be observed that binaural summation value increases as the monaural level increased from OdBSL to40dBSL for all the purctone

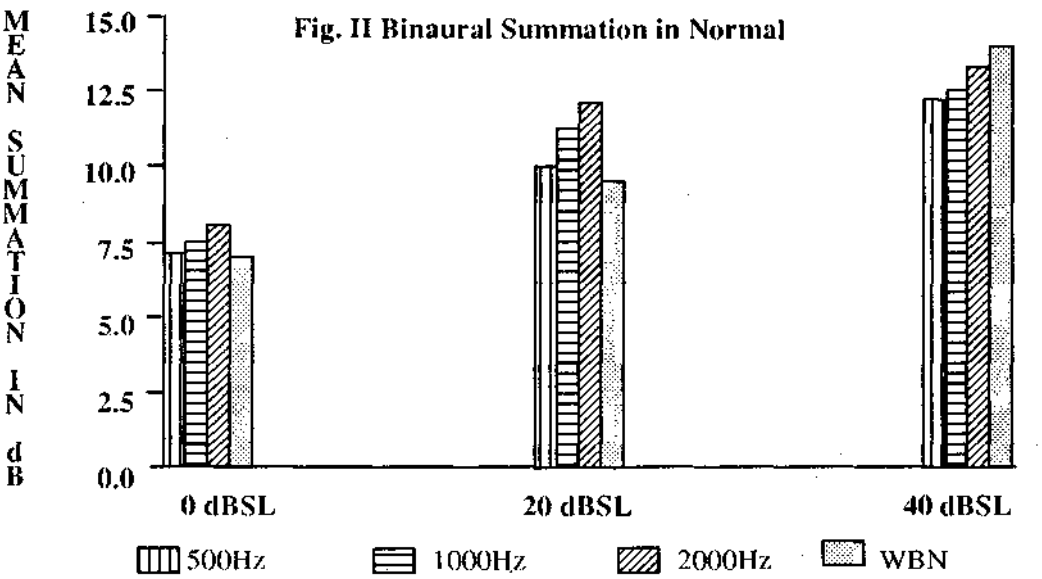

Fig. II Binaural Summation in Normal

signals and also WBN. This can be seen in the bar diagram depicted in Figure II. On a two-tailed test there were significant differences across sensation levels for all the signals presented binaurally. In general there was no linear increase in binaural summation as the monaural level was increased. This is contrary to Stevens (1957) finding. It may be because that the linear increase can be observed in the tone scale only above 40 dBSPL, as he found. The maximum mean binaural summation of 14 dB was noted for WBN which may be due to the fact that loudness judgement of WBN i s difficult and because of incomplete summation as stated by Marks (1987).

Symmetrical SN loss group

Like normals, there was a tendency for the mean binaural summation value to increase with frequency and with sensation level as seen in the Table II and diagrammatically shown in Figure **III.** Summation at high frequency (2000 Hz) was more than at low frequency (500 Hz). On a two - lailcd-t test the mean summation value across 20 dBSL & 40 dBSL were significantly different for all the four signals.

It was noted that the maximum mean binaural summation was 11.2 dB for 2000 Hz purclonc at 40 dBSL. But the SN loss group shows comparatively reduced summation at all frequencies and across sensation levels which may be attributed to the inherent sensitivity loss, distortion, abnormal loudncss growth and intolerance characteristics. It is also possible that as the degree of SN loss increases the binaural summation reduces which needs further exploration. Summation requires finer temporal integration and loudncss discrimination.

Inter - group comparison

As concluded above the binaural summation in SN hearing loss is compara-

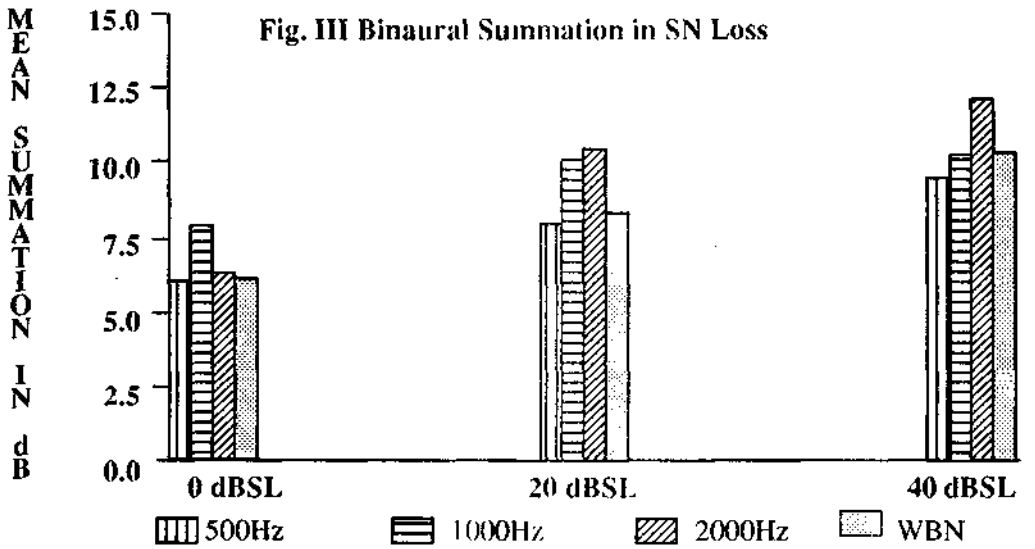

Fig. III Binaural Summation in SN Loss

tively reduced than normals for 500 Hz, 1000 Hz and 2000 Hz puretone and WBN both at threshold level and at suprathreshold levels. There may be a close correlation between the differential sensitivity and the summation value in various SN loss group. On comparative test of both groups, it is noted that the summation value of SN group at suprathreshold levels for all the signals were significantly lowerlhanlhatof normals. This study proposes a range of binaural summation of 7 to 14 dB for normals and a range of 3 to 11 dB for SN hearing loss cases. On the contrary to Dermody & Byrne (1975b) finding, the decrease in binaural summation appears to be a disadvantage for binaural amplification.

Conclusion

In conclusion, it can be stated that binaural summation differs with frequencies and with sensation levels both in normals and in SN hearing loss. Normals have higher binaural summation than subjects with SN loss. There is no linear increase in summation with every intensity increase when summation is expressed in dB. Studies on the relationship between the differential sensitivity for time, intensity & frequency and loudness summation in normals and SN hearing loss should highlight further in this direction.

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