E6-1

EARLY FRONTAL PLANE REFLECTIONS PREFERRED FOR TALKERS.

M. Kleiner and A.C.O. Berntson

Dept. of Building Acoustics, Chalmers University of Technology, S-412 96 Gothenburg, Sweden.

BACKGROUND

The background to this investigation was an interest in the effects of the relative ratio of lateral and vertical early reflections on the talking comfort. The question whether the lateral-vertical ratio has the same influence on talking comfort as on listening quality in the auditorium has not yet been answered. Some investigations on the standpoint of musicians and singers have been reported by Marshall et.al. (1,2) and Gade (3), but to our knowledge no investigation has yet been made on the conditions preferred for talkers.

ACOUSTICAL CONSIDERATIONS

A typical measure of the cross-sectional area of many auditoria and proscenia is about 100 m². Preliminary tests indicated that it was fairly hard to form firm judgements on the respective quality unless the cross sectional room shape was rather extreme. The following cross sections were therefore chosen for the tests (w x h in meters) I) 20 x 5, II) 10 x 10, III) 5 x 20. Two characteristic talker positions were used as follows: S) symmetrical and AS) asymmetrical. The talker mouth position in the asymmetrical case was 31.25% of the width off center in each of the cases I-III, and situated appr. 1.75 m above the floor, cf. fig. 1. The rear wall and the front walls were eliminated from this study since we were primarily interested in the relative merit of various cross sectional shapes. In practice the front wall (facing the talker) is often so far removed that its reflections are part of the general reverberation and the rear wall may be thought of merely adding another plane of mirror sources.

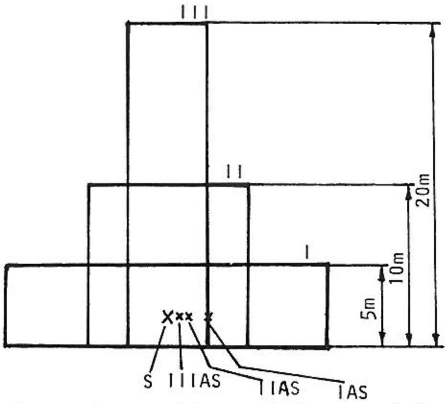

Fig.1 The three cross sections and the symmetrical (S) and asymmetrical (AS) talking positions.

REFLECTION PATTERNS

The reflection patterns were calculated and entered into the simulator. Only reflections with a delay time of up to 125 ms were taken into account, due to the limited number of delay lines (13) in order to preserve the natural delay times of the individual reflection patterns as much as possible. This limit corresponds to appr. 50 image sources. In order to avoid rebuilding the simulator the lower image sources were created by reflection in a reflecting floor plane.

SIMULATOR SYSTEM DESCRIPTION

The speech signal of the experimental subject was picked up using a directional microphone (AKG 451 & CK1) 50 cm away from the mouth at an angle of ca 90° laterally and 45° vertically. From the microphone the signal entered the delay unit. The 13 delayed signals were then mixed in the mixer.

The entire system was calibrated in free field using pink noise. The mixer is controlled by a minicomputer which may be used in manual or automated mode, so that mixer settings may be introduced at the terminal or by a special program using computer calculated image source data.

As explained earlier the simulation was limited to sources in the frontal plane where the simulator has 9 speakers. These speakers are separated by an angle of 22,5° which means that some directional information is lost. In the same way the delay unit only provides for 13 delayed signals which means that the delays have to be approximated in order to correspond to the 50 image sources. The overall frequency response of the system was within ∓ 3 dB from 100 Hz to 5 kHz.

EXPERIMENTS

Before running the experiments a suitable experimental procedure had to be chosen. Preliminary tests showed that the differences in perceptibility were rather small in most cases, therefore the method of paired comparisons was settled upon.

The test subjects were all trained listeners and talkers, 7 male and 3 female, varying from 20 - 50 years of age.

The subjects was allowed to talk for unlimited time for each alternative but could not go back to the earlier presentation. The switchover to the next alternative of the pair was done by the test subject by pressing a button. The talkers were asked to judge which sound field simulation they felt gave the highest "talking comfort". After each pair the talker gave his response by pressing corresponding button which then indtroduced the first of the next pair of signals. The test was a "forced-choice" test and the alternatives of the pair (A, B) were presented as AB, BA in random order between various configurations. Each pair was repeated four times, i.e. four replications were used. Since 6 cases were to be tested this resulted in 15 pairs which meant that 60 comparisons had to be made by each subject. In practice this resulted in an average test time of 1.5 hrs for each subject, the test was therefore subdivided into three blocks of equal length.

STATISTICAL TREATMENT

In order to obtain the judgements on a relative preference scale the results were treated statistically, and the following assumptions were made (Guilford (5), Torgerson (6)).

1) Data was assumed to correspond to Thurstone's case V, which entails
   a) The distribution of discriminal differences is normal.
   b) The response variable is one-dimensional.
   c) The response variable has constant standard deviation and coefficient of correlation.
   d) Internal consistency of judgements.

For each paired comparison using a large number of judgements (> 30) the frequency function for the number of preferences for one signal may be assumed to have an approximately normal distribution.

The response matrix is shown in table 1.

	IS	IIS	IIIS	IAS	IIAS	IIIAS
IS		20	18	5	16	8
IIS	20		21	11	12	10
IIIS	22	19		13	15	12
IAS	35	29	27		25	27
IIAS	24	28	25	15		21
IIIAS	32	30	28	13	19	

Tab.1. Response matrix. The number of preferences for the column with a total of 40 judgements.

Each element of the matrix shows the number of preferences for the column. With a total of 40 judgements per pair a significant difference (5%) is obtained if the number of preferences is outside the interval [14,26].

RESULTS

The figures shown in table 1 do not support the hypothesis that there were significant differences between cases Is, IIs and IIIs. However, in some cases there were significant differences as shown in table 2.

	IS	IIS	IIIS	IAS	IIAS	IIIAS
IS						
IIS						
IIIS						
IAS	X	X	X			X
IIAS		X				
IIIAS	X	X	X			

Tab.2. Significant (5%) preferences for the column.

When trying to scale the performance of the various reflection patterns the following scale was obtained as shown in fig.2.

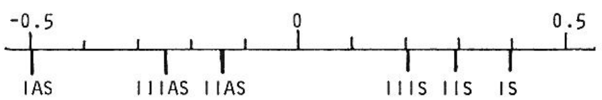

Fig.2. Preference scale obtained from the paired comparisons.

The χ^2-test showed that the assumptions b and d above was fulfilled.

DISCUSSION

As shown above the cases IS), IIS) and IIIS) are preferred. These correspond to symmetrical cases. It is possible that the higher interaural correlation for these entirely symmetrical cases is responsible for this preference due to the more periodic reflection pattern. The periodicity of these reflection patterns resulted in sound being slightly coloured by picket fence echo effects, and therefore not beeing as masked by the direct sound as the less coloured sound of the asymmetrical cases.

In fig.3 the pulse responses for case IS) and IAS) are shown. The pulse responses are calculated by the image source program with a simulated pulse length and integration time of 1 ms. Comparing the two pulse responses the symmetrical case shows a much sharper concentration of reflections at a longer delay time. This gives a sudden rise in energy which probably results in a higher audibility.

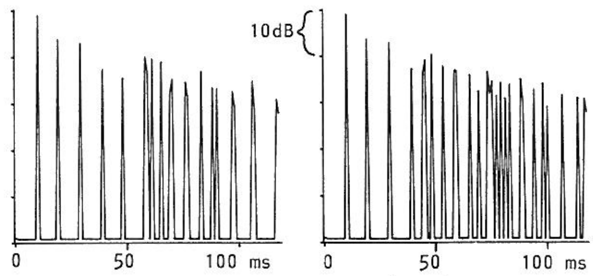

Fig.3. Pulse responses for case IS (left) and case IAS (right).

In the asymmetrical positions these results show that a narrower cross section is to be preferred for talkers. However, the perceived differences between the positions in the same cross section is as significant as the differences between cross sections. Therefore, since differences percieved by talkers are much less than differences percieved by listeners recommendations concerning the width-height ratio should be determined by listener criteria.

ACKNOWLEDGEMENT

The authors wish to thank Börje Wijk for technical assistance during the work.

REFERENCES

(1) Marshall, A.H.; Gottlob, D. and Alrutz. H.: Acoustical Conditions Preferred for Ensemble. J.A.S.A. vol. 64(5) p 1437 (1970).

(2) Marshall, A.H. and Mayer, J.: The Directivity and Auditory Impressions of Singers. Acustica vol. 58(3) p 130 (1985).

(3) Gade, A.C.: Subjective Room Acoustic Experiments with Musicians. Dissertation, Technical University of Denmark, Lyngby (1982).

(4) Kleiner, M.: Speech Intelligibility in Real and Simulated Sound Fields. Acustica vol. 47(2) p 55 (1981).

(5) Guilford, J.P.: Psychometric Methods. McGraw-Hill, New York (1954).

(6) Torgerson, W.S.: Methods of scaling. John Wiley, New York (1958).