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TALKING COMFORT IN AUDITORIA. INTERPRETATION OF SUBJECTIVE JUDGEMENTS USING MULTIDIMENSIONAL SCALING.

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SUMMARY

When judging the talking comfort of simulated sound fields with multiple early reflections the level and the timbre were the most important subjective dimensions. The timbre differences were caused by differences in the periodicity of the pulse responses. Further, there seem to be an optimal distance to the wall behind the talker as a function of the individual speech level.

INTRODUCTION

The investigation presented here uses data from two previous experiments. The first concerning early frontal plane reflections preferred for talkers [1] and the second concerning the preferred distance to a wall behind talkers [2].

In all previous investigations with musicians and singers (no investigations with talkers have been published), where simulated sound fields have been used ([3] to [9]), only a very limited number of early reflections were simulated. This limitation will probably cause the test to be "oversensitive", that is, the subjects will perhaps detect differences between simulations that will never occur in reality. In real sound fields the great number of reflections will in some cases mask differences that would be detected if, for instance, only the first order reflections and reverberation were present. Furthermore the perceived tonal coloration of the reflected sound, caused by a periodic early reflection pattern, can only be simulated with multiple early reflections. In our tests we therefore simulated all early reflections with a delay time of up to approx. 125 ms corresponding to approx. 50 image sources (reflections) in experiment 1 and 100 image sources in experiment 2.

EXPERIMENT 1

In this experiment we wanted to investigate the effects of the relative ratio of lateral and vertical early reflections on the talking comfort. A number of investigations of the preferred conditions when listening to music have shown that there probably is a preference for early lateral reflections. Strong early vertical reflections have been suspected of causing tonal coloration and lack of spaciousness. It was therefore interesting to investigate the importance of the width/height ratio of the cross-section from the standpoint of the talkers.

Three different cross-sections with one symmetrical and one asymmetrical talking position in each were simulated in an electro-acoustic simulator. The talker mouth position in the asymmetrical cases were 12.5% of the width off center and situated approx. 1.75 m above the floor, cf. fig.1. The rear and the front wall were eliminated from this study since we were primarily interested in the relative merits of various cross- sectional shapes. The reflection factors of the remaining four surfaces were set to R=1 in the calculations. The reflection patterns were calculated according to the image source method and stored in a computer.

Due to the rather small perceptible differences the method of "forced choice" paired comparisons was used. The 10 subjects were asked to judge which sound field simulation they felt gave the highest "talking comfort". For more details about the test procedure and the equipment used see [1] and [2].

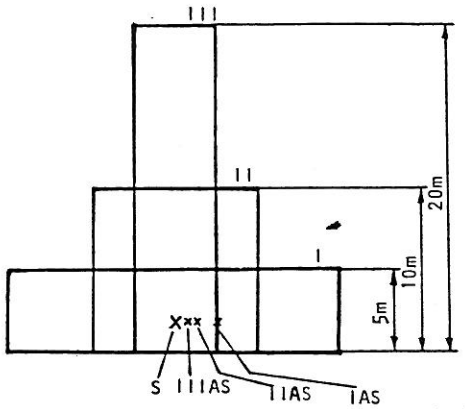


Fig.1 The three cross sections and the symmetrical (S) and asymmetrical (AS) talking positions.

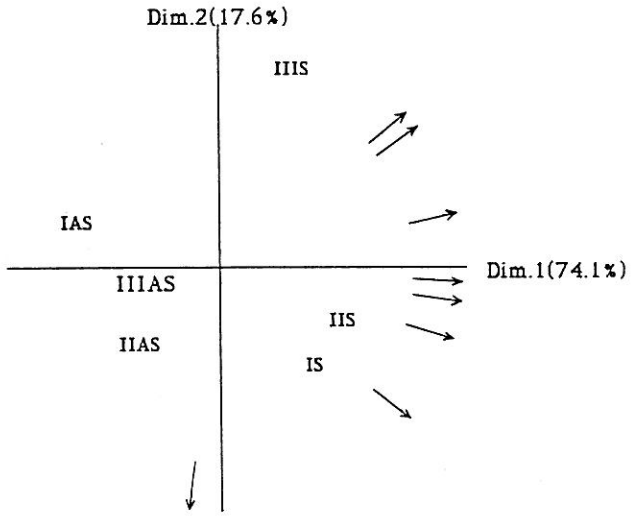


Fig.2. Two-dimensional MDPREF space.

MULTIDIMENSIONAL SCALING

A two-dimensional scaling of the preference judgements using the MDPREF program [11] is shown in fig.2. MDPREF is a FORTRAN program which provides internal analysis of a set of paired comparisons matrices, or a "first score" matrix, by means of a vector model. This program, developed by Carroll [11], performs an analysis similar to the Schiffman-Falkenberg approach which is described in [12]. The subjects are represented by vectors which indicate the direction of preference. Projection of the stimuli points on the vectors gives the individual preference scales. The basic assumption about the nature of an individual's preferences in this model is: "the more, the better". Therefore the vector model is generally most useful when the stimuli set does not contain stimuli which have either too much or to little of each characteristic. If there are stimuli which have either too much or too little of at least one characteristic the ideal point model is generally more suitable. The ideal point model is used in the classical multidimensional unfolding method developed by Coombs 1964 [12]. In the MDS(X) package [11] the MINIRSA program performs an unfolding procedure. However the results often yield degenerate spaces. As this also was the case for our data, only the MDPREF solutions are presented here.

RESULTS

In [1] significant preferences in the paired comparisons were found and a one-dimensional preference scale according to the Thurstone's case V model [13] was calculated. The symmetrical talking positions were preferred and the narrow cross-section was better than the wide one when standing in the asymmetrical position.

After inspection of the four replications 2 of the 10 subjects were eliminated because they were unreliable or did not hear any differences. As shown in fig.2 a two-dimensional MDPREF-solution was sufficient and explained 91.7% (74.1%+17.6%) of the total variance in the data. Along dimension 1, which is the most important, there is a clear difference between the symmetrical cases and the asymmetrical cases. The symmetrical talking positions have higher interaural correlations and also more periodic reflection patterns, cf. fig.3. When standing midway between the walls the two ears will get exactly the same pulse response. To average the two spectra, according to the central spectrum theory, will therefore not help to cancel the coloration caused by the periodic pulse response. This colored sound is preferred by the majority of the talkers probably because the sound in these cases are not as masked by the direct sound as in the asymmetrical cases. Therefore there seem to be a strong correlation between dimension 1 and the timbre perception. The second dimension has not yet been meaningfully interpreted.

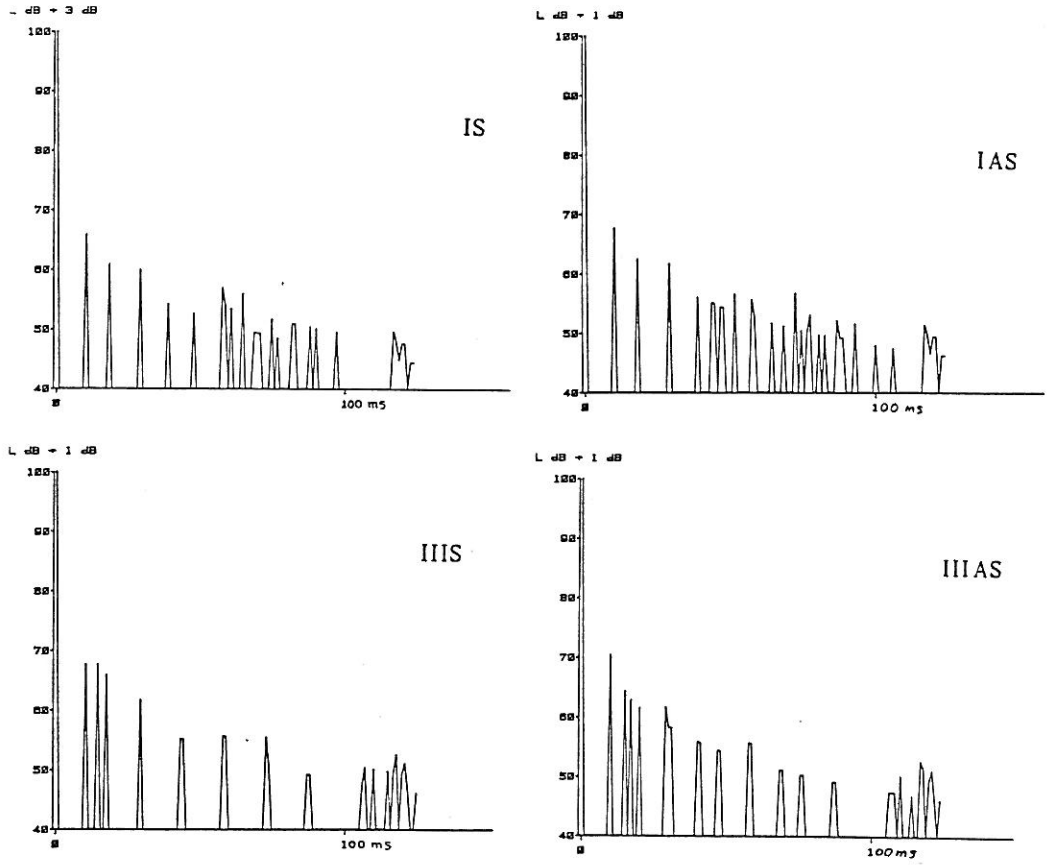
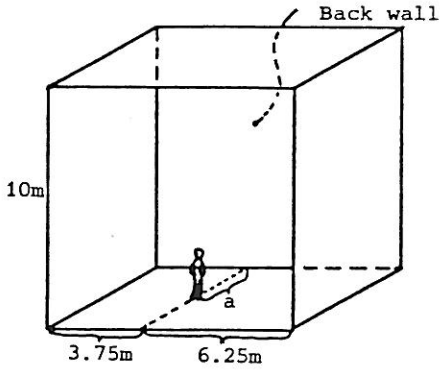


Fig.3. Calculated pulse responses for four of the six simulations. The symmetrical cases have more periodic pulse responses. The pulse length and the intergration time were set to 1 ms.

EXPERIMENT 2

In the second experiment we investigated the preferred distance to a wall behind the talkers. One of the cross-sections from the previous study (w x h = 10 x 10 m) was chosen and the distance to the wall behind the talkers was varied according to fig.4. All early reflections from the five surfaces with a delay time less than 125 ms (approx. 100 image sources) were simulated in the electro-acoustical simulator. Since we were only interested in the early reflections the front wall facing the talkers was eliminated from this study. The test procedure was the same as in the previous study.



Stimuli		
	1	1.5 m
	2	3 m
	3	6 m
	4	12 m
	5	∞ (no wall)

Fig.4. The simulated room.

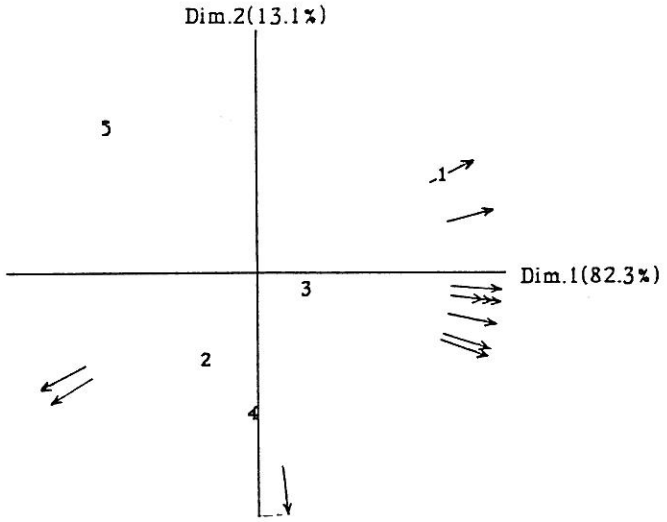


Fig.5. Two-dimensional MDPREF space.

RESULTS

A two-dimensional MDPREF-solution which explains 95.4% of the total variance is shown in fig.5. Three of totally 15 subjects were eliminated because their judgements in the four replications were unstable. There are obviously three subjects with very different preferences compared with the main group. Two of them dislike stimulus 1 and the third one dislikes stimuli 1 and 5. Stimuli 1 and 5 have the most periodic pulse responses which is disliked by this subject. He thinks that the timbre characteristic is very important when judging the talking comfort. One possible explanation of the individual differences concerning stimulus 1 can be different speech levels. If you produce a high speech level stimulus 1 gives you too much support.

The differences between stimuli 2,3 and 4 are probably too small to be of any significant importance. Therefore a preliminary interpretation of the dimensions could read: Dimension 1 - level, Dimension 2 - timbre.

As there seem to be an optimal distance as a function of the speech level the ideal point model would perhaps be more appropiate. However, the solution from a MINIRSA run yield a degenerate space. But, in spite of the vector model used in the MDPREF program, this model seems to fit the data rather well since the space was both meaningful and interpretable.

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