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AN AUDIENCE SURVEY OF CONCERT HALL ACOUSTICS

B M Shield (1) and T J Cox (2)

(1) School of Engineering Systems and Design, South Bank University, London
(2) Department of Acoustics and Audio Engineering, University of Salford

1. INTRODUCTION

This paper describes a questionnaire and acoustic survey of three concert halls in the UK. At each hall the concert audience was surveyed by questionnaire to obtain the subjective response of general listeners to the acoustics of the hall. All three surveys took place during the same week and in each case the audience was listening to the same programme of music played by the same orchestra. The results of the surveys will thus provide direct comparisons of the subjective opinions of the three halls, as well as allowing variations within an individual hall to be examined. Objective measurements of acoustic parameters were also made in the three halls which will enable the correspondence between objective parameters and subjective response to be investigated. This paper discusses the design of the questionnaire and gives some preliminary results arising from an analysis of the data in one hall.

2. BACKGROUND TO SURVEY

There have been many studies investigating the subjective response of listeners to concert hall acoustics. Among the most well known are the surveys of Beranek [1,2] and the survey of British concert halls carried out in the 1980s by Barron [3]. There have also been several studies of musicians' preferences and laboratory studies to determine the most important acoustic parameters in the design of concert halls. All but the most recent results are summarized in standard texts such as those of Barron [4], Cremer [5], and Kuttruff [6]. In most of these studies the subjects used in the tests have been selected as having some specialist knowledge or previous experience, such as musicians, music critics or professional acousticians, on the assumption that the results obtained would give the most reliable possible judgements of the acoustics of an auditorium.

The study described here has used a different approach by selecting the whole of an audience as the subject group, in order to obtain the impressions of a wide section of the general concert going public to the acoustics of concert halls. An advantage of this approach is that it provides a large sample size for analysis, although there may be wide variations in responses. The use of typical audience members is unusual, with only one other similar study known to the authors [7], although the subject numbers in that case were not as large as in the current survey.

Another significant feature of the survey described here is that it was carried out in three major concert venues, with the same orchestra and conductor playing almost the same programme at the three halls. This therefore provides an opportunity to compare the responses to the three halls under almost identical conditions, in addition to correlating subjective response with objective measurements in each of the three halls.

3. THE SURVEY

The surveys were carried out at three concerts at the Royal Festival Hall London, Symphony Hall Birmingham, and St David's Hall Cardiff. All three surveys took place during National Science week, as part of a series of events to increase awareness of science among the general public. At each hall the concert was given by the City of Birmingham Symphony Orchestra conducted by Sir Simon Rattle. The programme consisted of works by Schoenberg, Britten and Shostakovich.

The intention at each concert was to ensure that every member of the audience received a questionnaire. This was achieved at Birmingham, and at Cardiff every member of the audience was given an opportunity to obtain a questionnaire if they wished. For practical reasons at the Royal Festival Hall it was not possible to distribute a questionnaire to every member of the audience and only those buying programmes received a copy, which may have biased the responses of the survey sample in this case. The numbers of completed questionnaires received at the three halls were approximately as follows:

Symphony Hall Birmingham	1000 out of an audience of 2000
St David's Hall Cardiff	300 out of an audience of 800
Royal Festival Hall	260 out of an audience of 1500

4. DESIGN OF THE QUESTIONNAIRE

As the questionnaire was to be distributed throughout the audience at a concert, rather than to a selected group with specialist knowledge, it was decided to design a new questionnaire specifically for this study. In order to ensure a high response rate, the questionnaire was kept as simple and as short as possible while acquiring the maximum amount of information. The questionnaire was restricted to two sides of a single sheet of A4 paper and in order to encourage answers to questions discrete 'tick boxes' were used rather than a continuous line scale. Before the main study was conducted, the validity of the questionnaire was tested by carrying out a pilot survey of the audience at a Sunday morning chamber concert at Blackheath Concert Halls in south east London; a response rate of over 50% (125 out of an audience of 240) was achieved.

The questions relating to personal details and to subjective response to the halls were identical for all three halls, but for each hall there were specific questions relating to details such as seat position. An example of the questionnaire is shown in Figure 1.

It was felt important to know how musically sophisticated and experienced a respondent might be, to see whether this influenced the judgement of the acoustics. Therefore the early questions related to number of concerts attended and musical activities to give an indication of the subject's musical knowledge.

General questions relating to loudness, enjoyment, and overall acoustics were assessed using a linear four or five point scale. In order to assess opinions of acoustic qualities such as reverberance, warmth and so on a set of descriptors was provided for the respondent to tick those which s/he felt were appropriate. The answers to these questions are treated effectively as being on a two point scale. This approach, while not ideal, enabled the questionnaire to be kept relatively simple and short, in order to maximise the response rate.

The respondents were also asked to indicate at what stage during the concert they completed the questionnaire. This was so that the influence, if any, of the most recently heard piece of music on the general impressions of the acoustics of the hall could be studied.

5. OBJECTIVE MEASUREMENTS

In each hall objective measurements of acoustic parameters were made when the halls were empty. Ideally, in order to correlate subjective response with objective measurements the measurements should be made when the hall is occupied. However, because of the practical aspects of the tests and the time required to carry out the measurements, this is not feasible at the present time.

Between twenty and thirty measurement positions were selected in each hall, to be representative of the different areas of audience seating. In each hall an omni directional source was positioned on the stage and the MLSSA maximum length sequence measurement system was used to measure the following parameters: reverberation time, sound pressure level, early decay time, clarity index, deutlichkeit, centre time, and early lateral energy fraction.

6. ROYAL FESTIVAL HALL RESULTS

6.1 Subject profiles

The age profile of the audience at the Royal Festival Hall is shown in Figure 2. It can be seen that the majority of respondents were in the 46 to 66 years age range. This may be due to the fact that

only those members of the audience buying programmes received a questionnaire. However, this age profile does seem to be repeated at the other two halls and in the pilot study, where all members of the audience were able to receive a questionnaire.

There were slightly more male respondents (58%) at the RFH than female (38%). It should be noted however that some people answered the questionnaire as couples rather than as individuals, possibly as a result of the distribution system in this hall. As might be expected for a concert of twentieth century classical music, respondents tended to be regular concert goers. The respondents were also found to have a relatively high level of musical experience with 47% being able to play a musical instrument and 67% owning a recording of at least one of the pieces performed.

6.2 Homogeneity of audience

An assumption is made when analysing the data for acoustic effects that the audience sample is homogeneous across the hall, so that any variations in response around the hall can be attributed to physical or acoustic factors rather than to changes in the sample. The questions relating to personal details and musical experience were used to test for homogeneity, and few differences were found between the respondents in different areas of the hall.

6.3 Time of completion of questionnaire

The responses were mostly independent of the time the questionnaires were completed. The only differences found seemed to indicate that there were more problems with audience noise during the second half of the concert.

7. ANALYSIS OF OBJECTIVE AND SUBJECTIVE DATA IN RFH

7.1 Variation in response across the width of the hall

The variation in objective and subjective data with distance from the centre line of the hall was tested for the different areas of the hall. Statistically significant correlations were found between distance from the centre and responses on audience noise, balance, enjoyment, brightness, dryness and warmth in most areas. In the stalls there was a change in balance of the orchestra, the balance improving towards the centre of the hall, whereas in the terrace and grand tier no such change was found. There was also a variation in balance between the soloist and orchestra across the stalls and terrace, the soloist sounding quieter towards the sides of the hall. There was an increase in disturbance due to audience noise towards the sides of the hall. This was probably due to the fact that the entrances to the hall are on the side walls. The audience found the sound more dry and the concert less enjoyable towards the sides of the hall in all seating areas.

Although in general the number of respondents describing the sound as bright decreased with distance from the centre of the hall, there was a noticeable dip in the numbers approximately half way

between the centre line and the sides of the hall. No objective measurement has been found to explain this phenomenon.

There was a significant correlation (ρ=0.71) between the distance from the centre of the hall and the early lateral energy fraction, as would be expected. However, no correlation was found between the variation in the early lateral energy fraction and subjective responses across the width of the hall.

7.2 Variation in response from front to rear of the hall

The variation in objective and subjective data with distance from the stage was analysed for the different areas of the hall. As expected, significant correlations were found between the view of the orchestra and seat position in all areas, the view being worse at the front of the stalls and towards the rear of the terrace and grand tier. The balance of the orchestra improved towards the rear of the stalls. In all areas the enjoyment of the concert decreased towards the rear of the hall. In the grand tier the feeling of involvement decreased towards the rear of the seating, and in this area there was a significant correlation (ρ=−0.63) between the degree of involvement and enjoyment of the concert.

There were significant correlations between distance from the stage and early decay time (ρ=−0.80) and sound level (ρ=−0.68) in the stalls and terrace, the values of both parameters decreasing towards the rear of the hall.

The most notable change in the subjective assessment of the acoustics occured in the rear of the terrace seating, under the grand tier balcony overhang. Fifty percent of the respondents in an overhung seat classified the sound as reverberant, compared with seventeen percent in a non-overhung terrace seat. However, the changes in objective parameters would appear to be inconsistent with these subjective impressions. For example, the early decay time was 1.3 s in the overhung area and 1.4 s in the non-overhung seating, and the clarity index C80 increased from 0.2 in the non-overhung area to 3.2 in the overhung seats.

8. CONCLUSIONS

This survey has shown that it is possible to obtain a substantial quantity of sample data which yields interesting results by conducting large scale surveys of concert audiences. Preliminary analysis of the subjective and objective data for the Royal Festival Hall has shown that there are noticeable variations in subjective response in different areas of the hall, and that there are significant correlations between subjective responses and objective parameters in some cases.

Further analysis of the data is being conducted and the data for the other two halls will also be analysed to see whether the results are consistent between the three halls. The inter hall variations in subjective and objective data will also be investigated, with a view to determining those acoustic

parameters that are the most important in determining the response of a general audience to a hall's acoustics.

9. ACKNOWLEDGEMENTS

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10. REFERENCES

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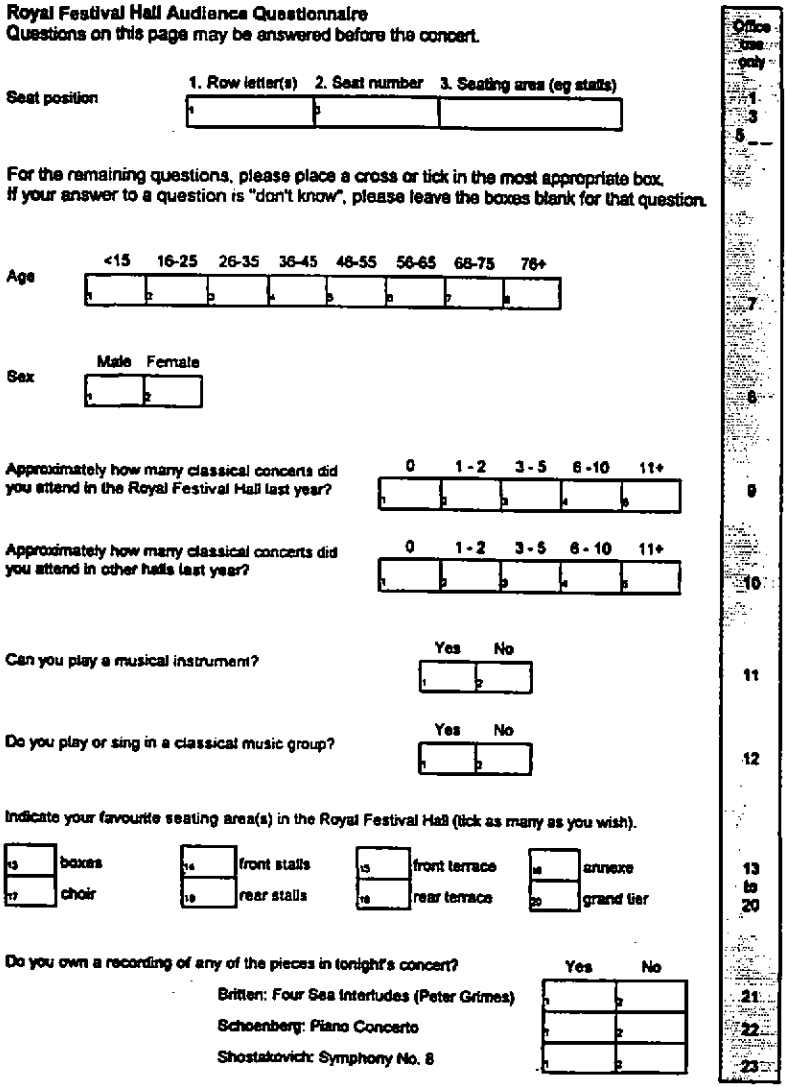
Figure 1a. Audience questionnaire, side 1



Royal Festival Hall Audience Questionnaire
Questions on this page may be answered before the concert.

Office use only

Seat position — 1. Row letter(s) | 2. Seat number | 3. Seating area (eg stalls)

For the remaining questions, please place a cross or tick in the most appropriate box.
If your answer to a question is "don't know", please leave the boxes blank for that question.

Age — <15 | 16-25 | 26-35 | 36-45 | 46-55 | 56-65 | 66-75 | 76+

Sex — Male | Female

Approximately how many classical concerts did you attend in the Royal Festival Hall last year? — 0 | 1-2 | 3-5 | 6-10 | 11+

Approximately how many classical concerts did you attend in other halls last year? — 0 | 1-2 | 3-5 | 6-10 | 11+

Can you play a musical instrument? — Yes | No

Do you play or sing in a classical music group? — Yes | No

Indicate your favourite seating area(s) in the Royal Festival Hall (tick as many as you wish).

boxes | front stalls | front terrace | annexe
choir | rear stalls | rear terrace | grand tier

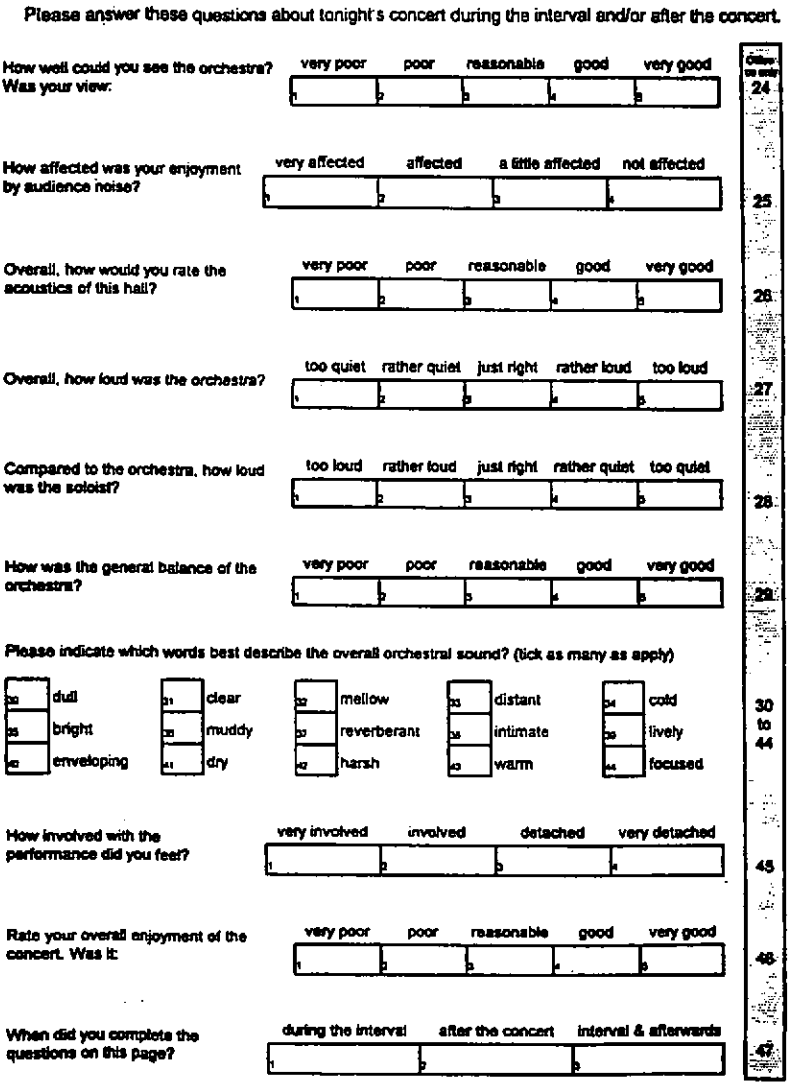
Do you own a recording of any of the pieces in tonight's concert? — Yes | No

Britten: Four Sea Interludes (Peter Grimes)
Schoenberg: Piano Concerto
Shostakovich: Symphony No. 8

1 3 5 7 8 9 10 11 12 13 to 20 21 22 23

[continued overleaf]

Figure 1b. Audience questionnaire, side 2



Thank you for completing the questionnaire. Please ensure you have given your seat position in questions 1 to 3 as your answers cannot easily be used without this information.
Please place your questionnaires in the survey boxes on levels 2 and 4, or return them to an usher.

Figure 2. Ages of respondents in Royal Festival Hall
(DNA: did not answer)