SUBJECTIVE COMPARISONS OF MASSEY HALL AND BOSTON SYMPHONY HALL

Gilbert A. Soulodre
Graduate Program in Sound Recording
McGill University
555 Sherbrooke West, Montreal, H3A 1E3

John S. Bradley
Institute for Research in Construction
National Research Council, Ottawa, K1A 0R6

1. Introduction

Massey Hall and Boston Symphony Hall date from the same period but are quite different architecturally. Whereas Boston Symphony Hall is a classic narrow shoebox, Massey Hall is shaped more like a square. One might expect that, given these architectural differences, the two halls should sound significantly different. In this paper we describe a detailed subjective comparison of the two halls and correlate the results with objective measurements within the halls.

2. Experimental Procedure

Sound fields were produced by convolving anechoic music (Mozart, "Le Nozze di Figaro") with measured binaural impulse responses taken in the two halls [1]. The resultant binaural sound fields were played back to listeners over a pair of loudspeakers with appropriate steps taken to eliminate cross-talk. The validity of the system for such subjective testing was demonstrated in an earlier study [2] and a detailed description of the system can be found in [3].

The subjective testing was in the form of double-blind paired comparison tests. A computer provided random playback of pairs of sound fields and subjects could switch back and forth between the two sound fields until they had made their decision. Subjects conducted eight sets of tests and were asked to rank the two halls in terms of *reverberance*, *clarity*, *loudness*, *spaciousness*, *treble*, *bass*, *apparent source width*, and *overall preference*. This list of parameters is based on the one used by Barron in his subjective study of British concert halls [4]. Prior to each set of tests, a description of the parameter under test was read to the subject. Also, to ensure that they fully understood their task, subjects were given a brief training sequence before each test. All of the subjects used in the study had previous experience in critical listening tests and most had extensive musical training.

Eight sound fields were used in the study. These were produced from binaural impulse responses taken at four seats in each hall. The seats were chosen to represent a reasonable cross-section of the acoustical characteristics of each hall.

3. Results

Loudness

Figure 1 shows the perceived loudness of the various sound fields versus measured G values. A higher value of loudness implies a subjectively louder sound field. The values of G consist of an average value of the 500Hz and 1kHz octave bands. It is not well understood how to add G values across frequency and therefore an average mid-frequency value seems like a reasonable first guess. There is very good correlation between the subjective and objective results. Also, the two halls are similar in both their measured and perceived loudness. It is interesting to note that the subjects were able to accurately resolve very small differences in G.

Clarity

The perceived level of clarity is plotted against measured values of C80 in Figure 2. Again these values are derived by taking the average of the mid-frequency octaves. There is a fairly strong correlation between the subjective and objective measures of clarity. There is however one seat where the objective measure does not correctly predict the subjectively perceived level of clarity. The point on the graph corresponding to this seat has been circled. This seat was located on the main floor (Massey) under the balcony. Inspection of the impulse response for this seat revealed two very strong and distinct reflections arriving at about 27msec and 47msec after the direct sound. It may be that these reflections are in some way reducing the perceived clarity at this seat, although further investigation is certainly necessary before any conclusions can be drawn. We see also that the two halls share a similar range of C80 values and that neither hall dominates in perceived clarity.

Reverberance

Figure 3 shows the subjectively perceived level of reverberance versus the average of the mid-frequency EDT's. Again, there is reasonable agreement between the subjective and objective results. It can be seen that Massey Hall has a much wider range of EDT values than Boston Symphony Hall. Mid-frequency EDT's in Massey Hall vary by as much as a second.

Treble
The perceived level of the treble frequencies is plotted against the average high frequency (2kHz and 4kHz) values of G in Figure 4. The results show that the high-frequency values of G act as a good predictor of the amount of treble perceived by a listener. It is interesting to note that all of the sound fields measured in Boston Symphony Hall have greater high-frequency G values than any of the sound fields measured in Massey Hall. This is the only measured acoustical parameter for which this is true.

4. Conclusions

We have compared subjective and objective measures of several acoustical parameters in two concert halls. The results indicate that the objective measures are able to predict subjective opinion reasonably well. Also, except for the high-frequency G values, the two halls are quite similar in their measured acoustical performance. Results for the remainder of the acoustical parameters, including overall preference, will be presented at the annual meeting.

References

[1] John S. Bradley and Gilbert A. Soulodre (1993) Objective Comparisons of Massey Hall and Boston Symphony Hall. *Presented at the annual meeting of the Canadian Acoustical Association*, Toronto.

[2] Gilbert A. Soulodre, John S. Bradley, and Dale Stammen (1993) Spaciousness Judgments of Binaurally Reproduced Sound Fields. *Presented at the 125th meeting of the Acoustical Society of America*, Ottawa.

[3] Gilbert A. Soulodre and Dale Stammen (1993) A Binaural Recording and Playback System for the Reproduction of Virtual Concert Halls. *Proceedings of the 1993 International Computer Music Conference.* Tokyo: International Computer Music Association.

[4] M. Barron (1988) Subjective Study of British Symphony Concert Halls. *Acustica* (66).

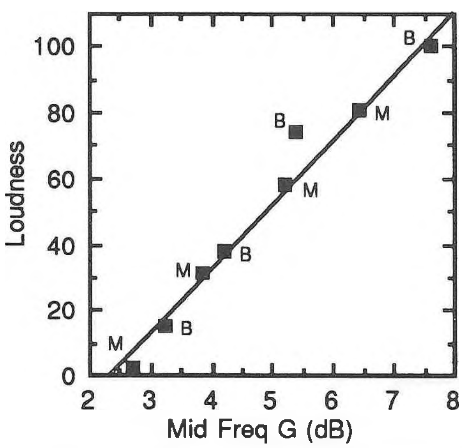

Fig. 1 Perceived loudness vs. mid-frequency G. M-Massey Hall, B-Boston Symphony Hall

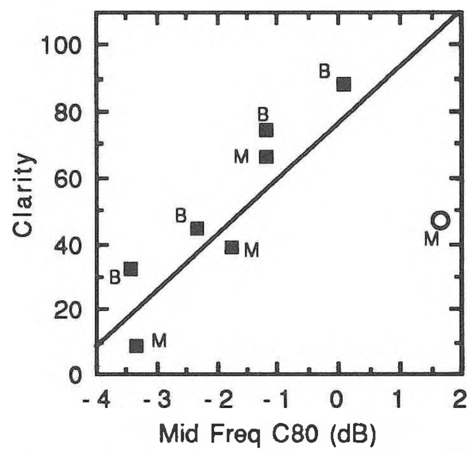

Fig. 2 Perceived clarity vs. mid-frequency C80. M-Massey Hall, B-Boston Symphony Hall

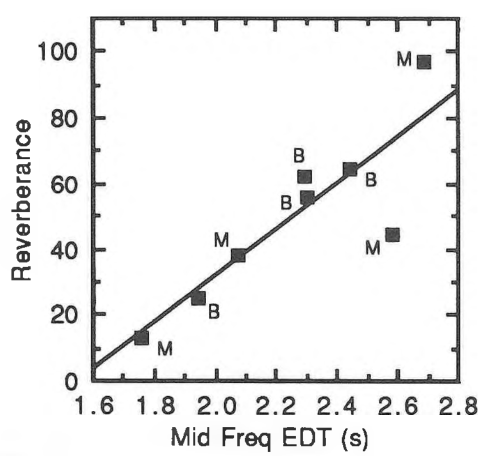

Fig. 3 Perceived reverberance vs. mid-frequency EDT.

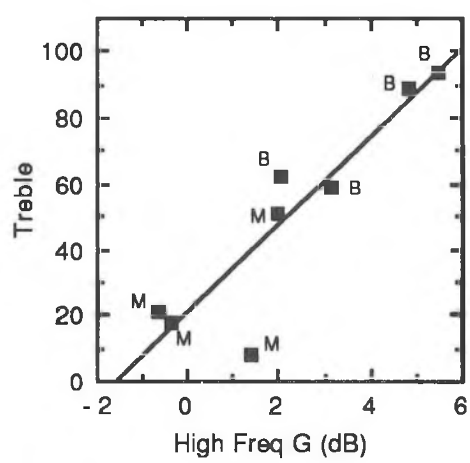

Fig. 4 Perceived treble vs. high-frequency G.