Influence of Diffuse Reflections on the Playing of Musicians

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To date, there has been little evidence available on how musicians perceive diffuse reflections in the early sound field in comparison to specular reflections. Two series of subjective tests were conducted among musicians, one in a small room and one in an auditorium, to investigate how diffuse reflections affect the playing of musicians. Subjects were asked to play the same tune in several room configurations. For the first series, two types of diffusers were tested as well as flat walls. For the auditorium, musicians had to play with a reflective shell and with a diffusive shell. For all configurations, subjects were asked to assess on rating scales mutual hearing, self hearing, articulation and sound quality. This study shows how diffusers affect the perception of various attributes that are specific to musicians.

EXPERIMENTAL PROCEDURE

The room used for the first series of tests was of about $60m^3$ in volume with carpet on the floor, absorbing tiles on the ceiling, and reflecting side walls. A total surface area of about 10 m^2 of diffusers was applied on two adjacent walls, in a corner the room. Two types of diffusers were tested. They are referred to as QRDs (Quadratic Residue Diffusor) and BAD (Binary Amplitude Diffsorbor) panels. The BAD panels have fairly high absorption coefficients in comparison with the QRDs. Three room configurations were presented to the participants: with BAD panels applied on the walls, with QRDs, and with flat surfaces.

The second series of tests was conducted in Peel Hall, a Victorian concert hall based in Salford University campus, with tiered seating for 385. A shell that provided either diffuse early reflections or specular early reflections was set on the stage, at about 2 m from the musicians. The shell was composed of six panels. Each panel was made of two rows of two QRDs set on benches and represented a diffusing surface of 1.44 m^2. A flat board was nailed on the back of the diffusers. The shell was made reflective by simply turning around the diffusers, so that their flat side was facing the musicians.

Six groups consisting of two or three musicians took part in the test conducted in the small room. A brass ensemble composed of six musicians participated in the test conducted in Peel Hall. A questionnaire was given to the participants, where they had to rate on a 9-point scale self hearing, mutual hearing, articulation and sound quality. Each session ended with a short discussion.

RESULTS

The major effect when specular surfaces were exchanged for diffusers was to reduce harshness and echo problems that were caused especially by loud instruments. Diffusers definitely improved the sound quality of powerful instruments by providing a more mellow sound. Quiet instruments did not produce as many echoes, and therefore were less sensitive to the difference between diffuse and specular reflections. Diffusers also tended to improve the articulation. This is shown in Fig. 1 and 2. In Fig. 1, AMH@, ASH@, AArt@ and ASQ@ stand for mutual hearing, self hearing, articulation and sound quality. The probability is that of the null hypothesis (the treatments do not differ significantly). Low p-values imply high levels of significance, showing that the treatment had an effect.

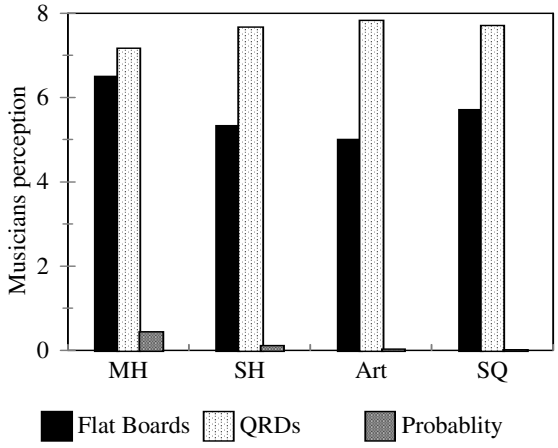

FIGURE 1. Musicians preference response in Peel Hall.

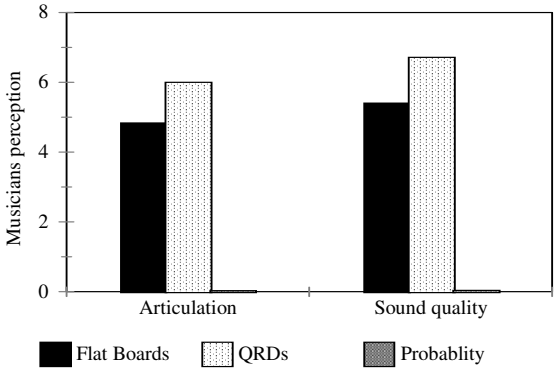

FIGURE 2. Musicians preference response in the small room

Self and mutual hearing were affected only when comparing surfaces that had different absorption coefficients. For the first series, the preferred configuration depended on the instrument power and the size of the group. Loud instruments or large groups who play in a small room needed a certain amount of absorption, and therefore favoured the configuration with the BAD panels, while quiet instruments or small groups preferred a more reverberant space, as shown in Fig. 3 and 4. When comparing QRDs and flat surfaces, which had similar absorption coefficients, self and mutual hearing were in average rated higher with diffusers, but levels of significance were low.

Mutual and self hearing are primarily dependent on the level difference between a musician=s own sound and the sound coming from his co-players [2]. Nevertheless, diffusers, by providing reflections outside the specular sector may partially improve mutual hearing [1].

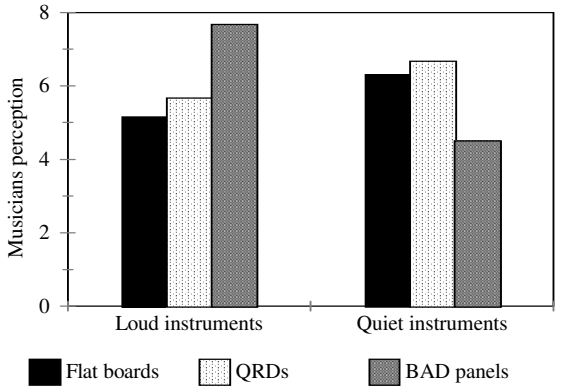

FIGURE 3. Musicians preference for self hearing. Test conducted in the small room.

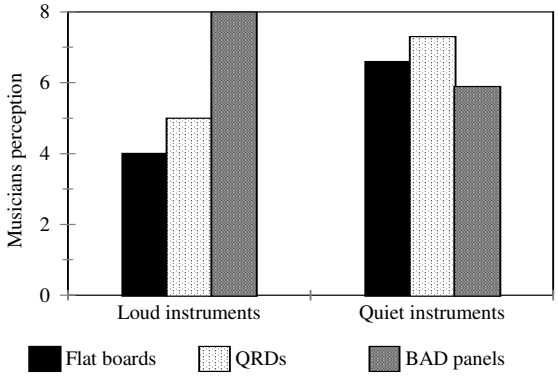

FIGURE 4. Musicians preference for mutual hearing. Test conducted in the small room.

A few problems associated with QRDs were spotted, such as some difficulty with the tuning and occasionally a lack a clarity. In fact, opinions of musicians differed regarding the impact of diffusers on clarity. Additionally, it was found that sound quality was a very subjective attribute. Subjects had a different understanding of what was a Agood sound quality@ according to their musical background, their everyday experience, or the sound effects they wanted to produce. These comments point out that more data is required to draw valid conclusions.

CONCLUSION

Most of the subjects noticed a difference between diffuse and specular reflections in the early sound field. Effects were mainly perceived in terms of reduction of harshness. The impact produced by diffusers varied with the size of the group that was playing, the power of the musical instruments, and the musical background of the subjects. Some further work needs to be conducted to get a more complete view of the problem.

REFERENCES

1. P. D=Antonio and T.J. Cox, Appl. Acoust. **60**, 113-142 (2000).
2. G. Naylor, Acustica **65**, 95-100 (1988).