Table 1 shows the results in three octave bands of the simulation of the acoustical parameters at the selected position in the room for each directivity of the three instruments. In most of the cases the results of the comparisons proved that there existed a considerable difference in the acoustical parameters for the different directivity representations. As in the spatial distribution of the acoustical parameters, the difference are greater for the SPL and the C80, less noticeable for the LF80, and minor for the EDT.

Trumpet						
Frequency (Hz)	**500**		**1000**		**2000**	
Directivity Representation	C4	Average	C4	Average	C4	Average
SPL (dB)	13.7	6.7	8.6	6.8	7.2	6.6
C80 (dB)	0.1	0	1	2.1	2.8	2.0
LF80	0.28	0.20	0.14	0.2	0.16	0.18
EDT (s)	1.78	1.79	1.60	1.52	1.36	1.41
Bb Clarinet						
Frequency (Hz)	**500**		**1000**		**2000**	
Directivity Representation	C#4	Average	C#4	Average	C#4	Average
SPL (dB)	1.3	7.1	2.8	5	7.4	7.4
C80 (dB)	3.6	0.3	1.9	1.6	0.2	2.1
LF80	0.10	0.21	0.10	0.19	0.16	0.17
EDT (s)	1.29	1.82	1.49	1.58	1.54	1.4
French Horn						
Frequency (Hz)	**500**		**1000**		**2000**	
Directivity Representation	B3	Average	B3	Average	B3	Average
SPL (dB)	4.2	4.4	9.7	7.3	15	4.3
C80 (dB)	0.8	0.8	-0.3	-0.1	-0.5	1.2
LF80	0.16	0.17	0.22	0.21	0.32	0.17
EDT (s)	1.79	1.79	1.97	1.92	1.77	1.61

Table 1: *Room Acoustic parameters simulated for the three musical instruments in the position of the listener.*

4. LISTENING EXPERIMENTS

4.1. Method

Listening experiments were designed with the goal of testing the audibility of differences between the two directivity representations of each instrument. Using the software ODEON [6] pairs of room acoustic auralizations were created using these directivity representations in the previously described position in the Elmia concert hall. Short melodies of approximately 10 s played on the three musical instruments were recorded anechoically and used for the comparisons in the listening tests.

A forced choice paired comparison method was used for the listening tests, which consisted of eleven test subjects. The subjects were presented with pairs of auralizations, created for each of the instruments, through Sennheiser HD 250 headphones. After a training session the listeners were asked to make a qualitative comparison between the two auralizations and select one according to five perceived acoustical features: loudness, perceived reverberance in the hall, clarity, ease of source localisation and naturalness of instrument timbre. Each of the comparisons was tested twice as a part of a balanced random test sequence.

4.2. Results

The results of the experiments were first analysed using the McNemar test in order to determine the level of randomness of the data [7]. This method was used to separate the data provided by test subjects who were inconsistent from those who were consistent in their answers. A test was also used to determine which results were statistically significant compared to a threshold of 0.95 [8].

The results of the three instruments were analysed separately for each of the five parameters. Table 2 shows the significant results according to the McNemar test.

Instrument Parameter	**Trumpet**	**Bb clarinet**	**French Horn**
Loudness	C4	Average	B3
Reverberance	C4	Average	No preference
Clarity	No preference	No preference	B3
Localization	No preference	No preference	No preference
Timbre	No preference	No preference	No preference

Table 2: *Statistically significant results of the listening tests, according to the McNemar test. The directivity pattern that was found to be "favoured" for each parameter is shown as the average directivity or the directivity of a tone. In the cases where no conclusions could be made from the analysis, "No preference" is stated.*

As shown in Table 2, the results show that all test subjects could hear a difference in loudness between the two compared auralizations. The audibility of the changes of in reverberance proved to be significant for two of the three instruments and the audibility of the clarity was significant only for the French horn. The audibility of differences in timbre and the localisation of the source did not prove to be significant.

4.3. Discussion

The results of the listening tests have shown that there are changes in the directivity representation that were perceived by the listeners. Comparing the results of the simulation of the acoustical parameters of Table 1 with the results of the listening tests of Table 2, one can see that the only parameters that proved to have the same general tendencies in both cases were the sound pressure level and the loudness. The comparison between the results for the perceived reverberance and the simulated EDT showed some correspondence that could also be linked with the SPL. However these comparisons between the subjective reverberance parameter and the calculated EDT parameter are unclear due to the EDT fluctuating across frequency bands. The

level of the sound could have helped the subjects to hear better the sound decays in the room. The discrimination of the clarity of the listening tests for the French horn did not prove to be strongly correlated with the simulations of the C80 in the room. Not much information can be obtained from the other simulated acoustical parameters that could be related to the results of the listening tests.

5. CONCLUSIONS

Room acoustic simulations using averaged and specific directivities of tones of musical instruments have shown that the directivity has a direct influence on the distribution of acoustical parameters in a room. Listening tests with auralizations using different directivity representations showed that the directivity changes were mostly audible in the perceived loudness and that some of these results could be correlated to the simulated acoustical parameters in the room. Further investigations could consider alternative types of directivity representation where the changes of the directivity of the source could be considered as in a performance situation.

6. AKNOWLEDGMENTS

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