

Violin Sound Radiation - Directivity of Violin Timbre

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Summary: Directional dependence of timbre and loudness is demonstrated on violin tones. A violin was played in an anechoic room and recorded simultaneously using microphones arranged in a circle, sixteen microphones in five consecutively moved planes and nine microphones in two planes. The goal was to develop a technique for subjectively describing directional dependence of timbre and loudness. The listening test searching for sectors of sound directions with similar timbre and loudness was arranged for tones G_3 , D_4 , A_4 , and E_5 . Results indicate a strong influence of the top and bottom violin plates together with the player's body.

1. INTRODUCTION

1.1 Directivity of musical instrument sound radiation

The directivity of sound radiation of various musical instruments influences the perception of musical sounds. This appears through direct sound and sound reflections in a room; therefore, the position of a listener during listening or a microphone during recording has a non-negligible effect on the resulting timbre of the instrument. The directivity of sound radiation of different instruments for individual frequencies and its influence on orchestra sound is described and discussed in [1].

The directivity of violin sound radiation, both artificially driven and when played by a violinist was again measured and compared in [2]. Theories explaining the directivity of violin corpus radiation and the so-called 'directional tone color' are found in [3].

1.2 Verbal description of violin timbre

Various methods for investigating musical timbre are possible. Analyses of verbal descriptions of violin sound from a survey (without a musical context) for the Czech and German languages led to three main orthogonal dimensions [4]. A more detailed study of violin timbre using listening tests (spontaneous verbal descriptions and dissimilarity in tone pairs) of five different pitches indicated four dimensions [5]. It showed that listeners are able to distinguish and describe in words the timbre in a group of tones, played on the same type of instrument having the same pitch, loudness and duration.

The goal of this study is to show the directional dependence of timbre on violin tones and to demonstrate listeners' abilities to distinguish and describe it.

2. METHOD

2.1 Violin tone recording

A violin was played by a violinist in *detache*, *non-vibrato*, *naturale*, and *mezzo forte*. Recordings were made in an anechoic room simultaneously using sixteen microphones arranged in a circle with a diameter of 3.2 m or 1.6 m respectively and in a plane perpendicular to the floor. The plane of microphones was raised from the floor by 0.5 m so that five consecutive recordings were made using sixteen microphones, in addition to two recordings using nine microphones (see FIGURE 1).

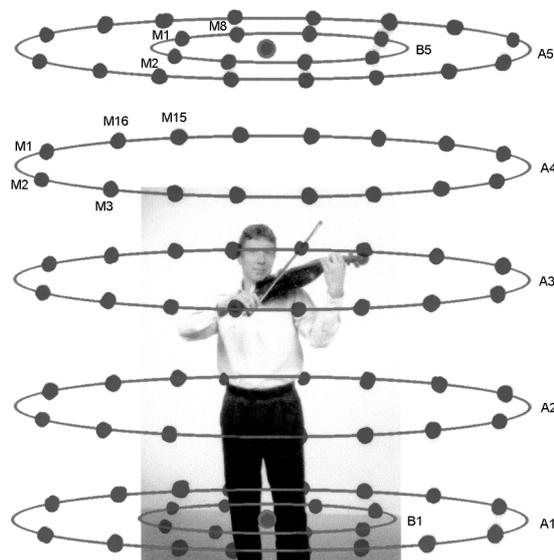


FIGURE 1. A configuration of microphones and violin position during recordings. Microphone sets are denoted from A1 to A5 and B1, B5.

Signals from the microphones were simultaneously recorded by two ARC88 sound cards (16 bit A/D and D/A, sampling frequency 44.1 kHz) directly to a Pentium hard drive in mono WAV format. An SPL of recordings was corrected for different distances of microphones from the instrument and for the player's variability in loudness.

2.2 Listening test - sound sorting

The recordings in sets of sixteen (nine) signals exhibit some differences not only in timbre but also in loudness. The goal of the listening tests was therefore to determine the context of recorded sounds from the point of view of timbre and loudness, and to find the sectors of directions with similar sounds.

Due to time constraints it was not possible to carry out the classical similarity scaling test (pair comparisons) for the 98 signals of each tone. Nor was a pair comparison of sets of sixteen (nine) signals acceptable with regard to future intended testing of a larger number of tones. For this reason the sound sorting test (categorisation without models) was selected and used individually for each set of sixteen (nine) signals.

The subjects' task was to consecutively listen to signals from a set of signals and sort them into categories of similar signals according to timbre and loudness. The number of categories was not prescribed but was limited to eight. It was possible to repeatedly play signals or move them into categories. The subject simultaneously also wrote word characterisations for each category.

The test was prepared in a MATLAB environment, using a PC Creative SB Live! Value sound card. The subjects heard the signals in closed Sennheiser HD 250 linear II headphones.

3. RESULTS AND DISCUSSION

To avoid or minimize differences arising from the player's variability in pitch, only tones G_3 , D_4 , A_4 , and E_5 played on open strings were used for the tests at the beginning of the project. Three subjects (a musician, sound engineer and acoustician) made a full set of 28 sorting tests, each test session lasting between 15 and 20 minutes. The ordering of tests of tones and signal sets, and signals in every set were randomised for each subject according to the test plan.

To compare sound sorting and similarity rating tests, the similarity rating in timbre and loudness of the tone D_4 and microphone set A2 was carried out. Distances were rated on a scale from 0 to 5. The sorting was three times faster and subjects identified sorting to be simpler, while they did express some difficulties at the beginning with word category descriptions. This type of description is not commonly used in rating.

Resulting dissimilarity matrixes were treated by Multidimensional Scaling (MDS). An example of the result together with marked categories from the sorting is indicated in FIGURE 2. Both test results are in good agreement, (at least until the position of the signal from the microphone no. 4).

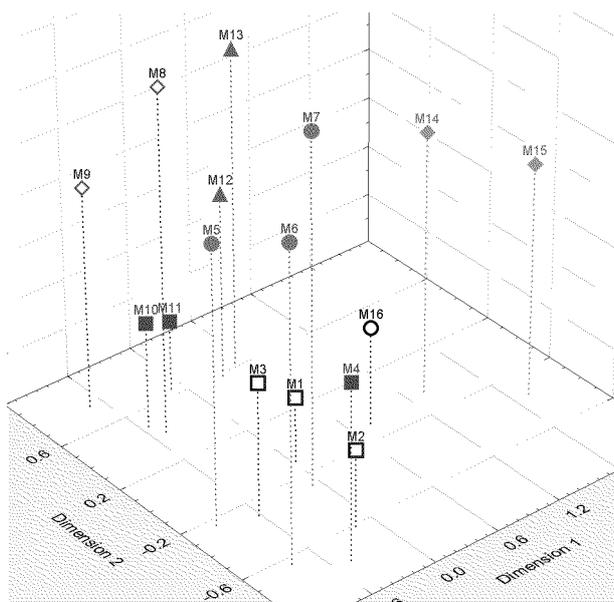


FIGURE 2. Three dimensional solution of MDS (stress 8.2%) from the similarity rating together with marked categories from the sorting of one of the subjects for the tone D_4 and microphone set A2.

The results of sound sorting were drawn individually for each tone, subject and signal set. Individual words assigned to each signal were displayed as a circular curve of a specific line style and radius. An example of sound sorting from two subjects is indicated in FIGURE 3.

Comparison of results of three subjects reveals an acceptable discrepancy in establishing of categories and the diversity of single word descriptions. All subjects noted well-marked distinctions of timbre in the directions of the top and bottom violin plates as well as a prominent influence of the player's body.

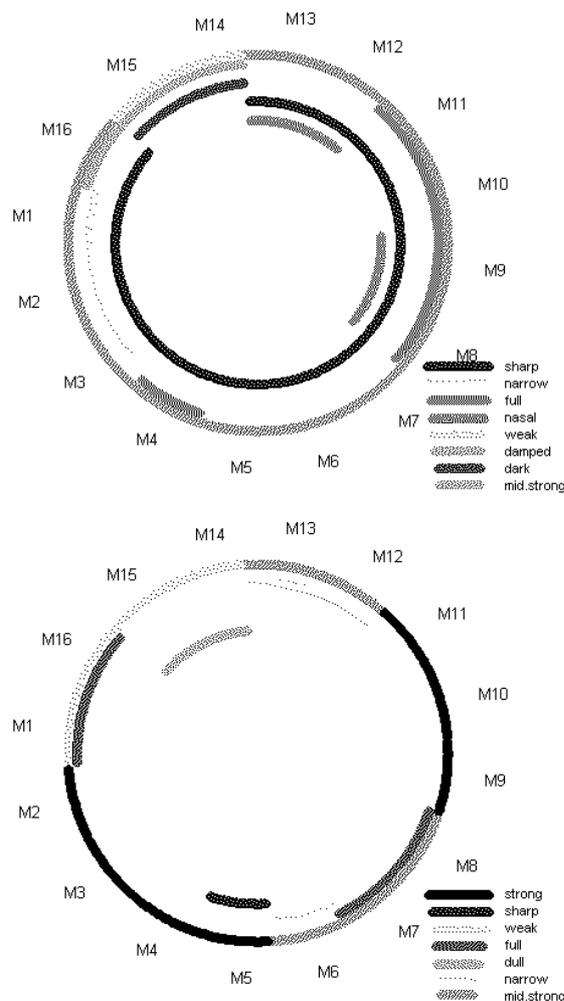


FIGURE 3. Graph of word descriptions of categories of sounds, tone D_4 and microphone set A2 of two subjects.

4. CONCLUSION

Sound sorting was revealed as suitable method for evaluating directivity of violin timbre and loudness. It will be necessary to unify results of individual subjects over sets of signals of a given tone and of the verbal descriptions used by all subjects, whereupon tests with more subjects and more tones will be possible.

ACKNOWLEDGMENTS

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REFERENCES

- [1] MEYER, J. (1972): *Akustik und musikalische Aufführungspraxis*, Verlag Das Musikinstrument, Frankfurt am Main.
- [2] OTCENASEK, Z., SYROVY, V. (1999): Directivity of violin radiation, CD-ROM of Joint Meeting 137th ASA, 2nd EAA Forum Acusticum 1999, 25th DAGA Berlin, 5aMUb7.
- [3] WEINREICH, G. (1997): Directional tone color, *J. Acoust. Soc. Am.*, 101 (4), 2338 - 2346.
- [4] MELKA, A., STEPANEK, J., OTCENASEK, Z., (1996): Czech and German verbal description of violin sound properties: multidimensional analyses of survey data, *ACUSTICA - acta acustica*, 82, Suppl. 1, Antwerpen, 214.
- [5] STEPANEK, J., OTCENASEK, Z., MELKA, A. (1999): Comparison of Five Perceptual Timbre Spaces of Violin Tones of Different Pitches, *137th Meeting ASA and 2nd FORUM ACUSTICUM and 25th DAGA*, CD-ROM (5AMUb), Berlin.