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Difference in timbre of violin in a seat and on stage

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ABSTRACT

Generally, it is speculated that the tone of Stradivarius is superior to those of other violins, and it sounds farther. However, many points regarding the difference between the acoustic features of Stradivarius and that of the others are still unclear. In this study, we recorded the sounds from six violins from old violin to brand new violin on a stage and a seat. We then compared the frequency spectrum and the signal-to-noise ratio (S/N ratio) of those sound sources. Based on the results, the difference in the power spectrum was observed at approximately 3–5 kHz. And the difference of S/N ratio was also appeared in some frequency bands. In the higher harmonic overtone around 16 kHz, we found that there are violins which have the peaks of harmonic overtone and ones which do not have. We investigated whether the difference in the shapes of these frequency spectrums and S/N ratios were related to the tone color of violin and the so-called distant peal phenomenon.

Keywords: Violin, timbre, Frequency spectrum, S/N ratio

1. INTRODUCTION

Studies on the sound of antique violins such as Stradivarius have been conducted extensively.[1-5] We analyzed the tone color with focusing on a phenomenon called the “distant peal” in this study. “Distant peal” is a phenomenon that audience can hear the sound well and clearly even if the sound volume of performance is not so loud. In contrast, a phenomenon called “side rumble” which the sound is not sufficiently audible even when violinist performs violin loudly.[6] Generally, the sound by distant peal is considered good so that players keep in mind in playing and maintaining the distant peal. In addition, it is said that there are some violins which sound in distant peal and some which sound in side rumble. Therefore, in this study, we compared the power spectrum and S/N ratio on a stage and seat using six violins and examined the existence of the distant peal of the violins.

2. EXPERIMENT

The recording was conducted in a concert hall (Toppan hall, Tokyo) without an audience. The player was a professional violinist. The six violins used in this study were Stradivarius (1705, violin S), Del Gesu (1742, violin D), the beginner’s violin (violin P) made in Japan, Ferdinand (2011, violin F) made in Germany, and two other brand-new violins manufactured by two Japanese violin makers (violin H and N). The microphones used for measurements were two nondirectional microphones (Earthworks M23). As shown in figure 1, we placed the microphone on the stage (over a 20 cm from the bridge of violin) and the seat (15 m from the stage). We instructed the player to play G major scale (three octaves) with each musical instrument. We performed spectrum analysis after recording the sounds and compared the power spectrum and cross-spectrum for each violin. In addition, we calculated the S/N ratio in the 1/1 octave band around A4 (band 1), at approximately 3-5 kHz (band 2), and 10-12 kHz (band 3).

$$\mathrm{S/N\ ratio} = \frac{\text{Average of peaks}}{\text{Average of noises}} \quad (1)$$

Figure 1. Snapshot of Experiment

3. RESULTS

3.1 Comparison of the power spectrums

We present the results for the power spectrum (time average) in the A4 sound of each violin in Figures 2-7.

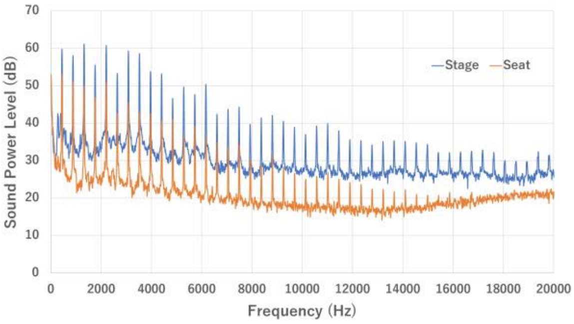

Figure 2. Spectrum in the A4 sound of violin S

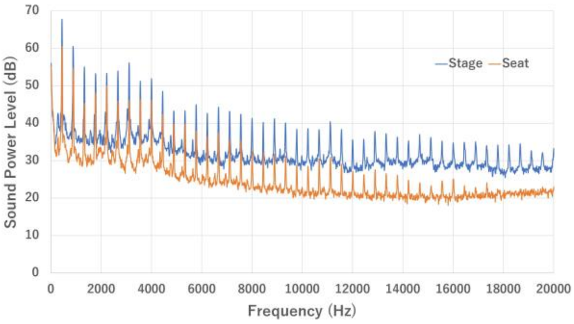

Figure 3. Spectrum in the A4 sound of violin D

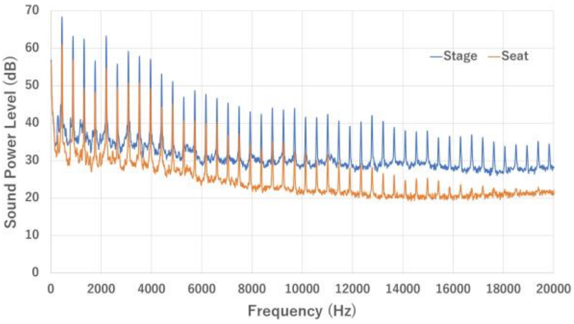

Figure 4. Spectrum in the A4 sound of violin P

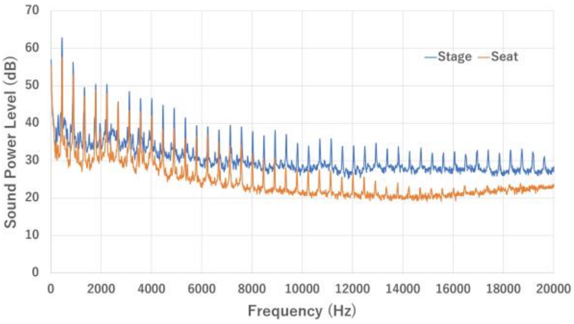

Figure 5. Spectrum in the A4 sound of violin F

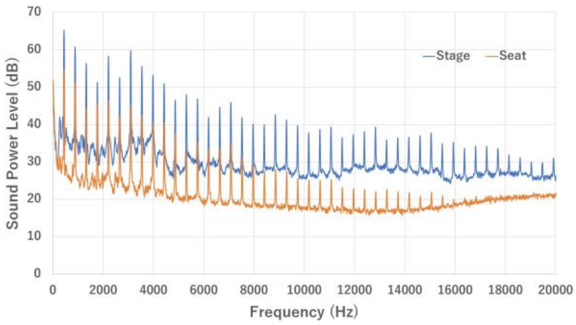

Figure 6. Spectrum in the A4 sound of violin N

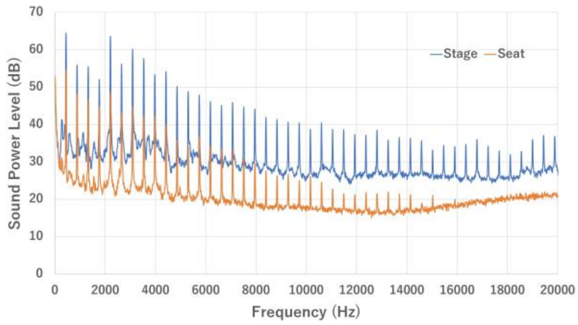

Figure 7. Spectrum in the A4 sound of violin H

We focus on the difference between the power spectrum of the stage and seat. First, for the spectrum on the stage, some strong peaks appeared from a fundamental frequency (f0) to 60 kHz. Second, while the peaks of violins P and F decreased gently over f0, the peaks of violins D, N, and H are significant at approximately 3 kHz. For the spectrum recorded on the seat, some peaks exceeding 40 dB were observed for violin S in the 3-5 kHz compared with the other violins. In addition, the peaks are not seen at approximately 16 kHz for violin N.
Next, we present the results of the cross-spectrum in the A4 sound of each violin in Figures 8-13.

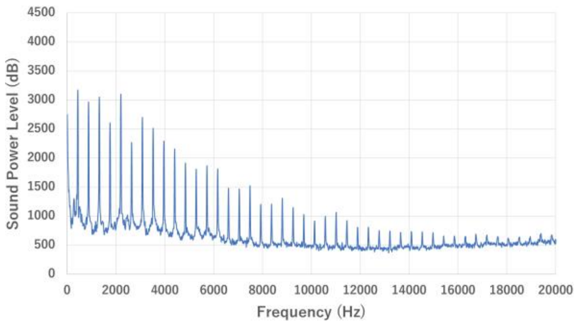

Figure 8. Cross spectrum in the A4 sound of violin S

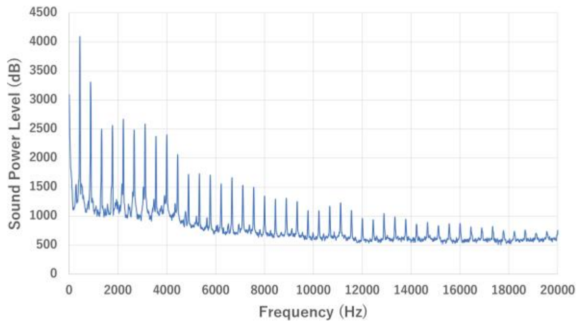

Figure 9. Cross spectrum in the A4 sound of violin D

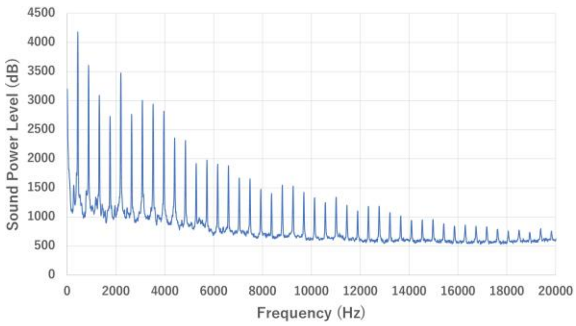

Figure 10. Cross spectrum in the A4 sound of violin P

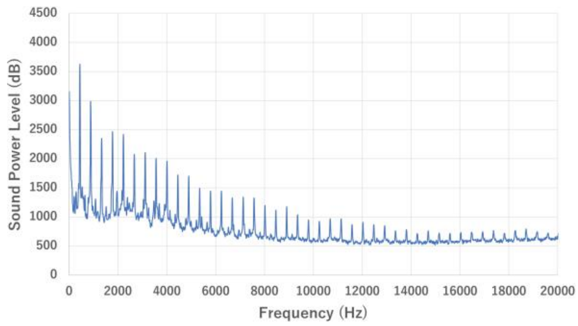

Figure 11. Cross spectrum in the A4 sound of violin F

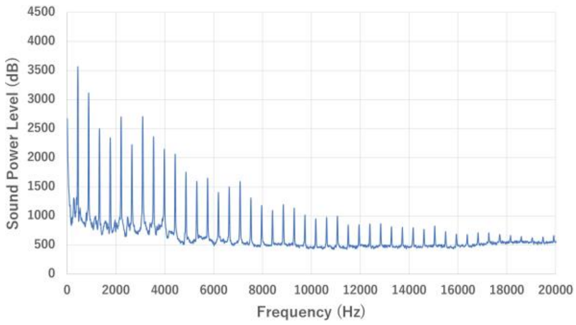

Figure 12. Cross spectrum in the A4 sound of violin N

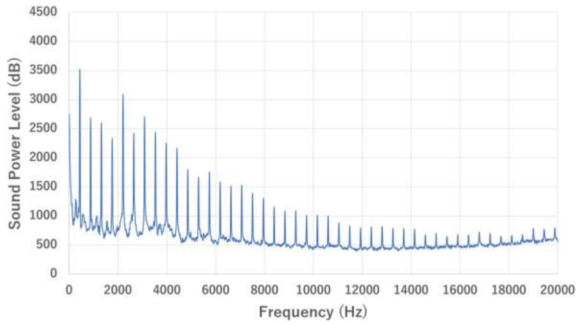

Figure 13. Cross spectrum in the A4 sound of H

First, the peak of the fundamental frequency of violin S was not significant compared to those of the other violins. Second, some peaks exceeding 2.5 kdB appeared in violin S from the fundamental frequency to 3 kHz. Third, gentle disruptions of the peaks appeared from 10 to 12 kHz for violins S and D. According to these results, the difference of power spectrum is observed in the A4 sound from a fundamental frequency to 6 kHz. It is seemed that this phenomenon is similar to the singers' formant which we often observe singers voice in opera. It is reported that the sound which the opera singer sings with emphasizing a specific frequency (2.5 kHz – 3.5 Hz) are not buried among the orchestra sounds. In addition, regarding the higher harmonic overtone over 16 kHz, the difference in the peak of harmonic overtone was observed among 6 violins, and it seems to be a characteristic of violin concerning the ease of distant peal.

3.2 Comparison of the S/N ratios

We show the difference in the S/N ratios of the 6 violins in the A4 sound in Tables 1 and 2.

Table 1. The S/N ratios on stage of each violin in A4

	Band 1	Band 2	Band 3
Instrument S	1.55	1.56	1.36
Instrument D	1.62	1.36	1.27
Instrument P	1.66	1.57	1.35
Instrument F	1.53	1.35	1.23
Instrument N	1.68	1.57	1.37
Instrument H	1.71	1.60	1.42

Table 2. The S/N ratios on seat of each violin in A4

	Band 1	Band 3	Band 3
Instrument S	1.76	1.75	1.42
Instrument D	1.65	1.47	1.37
Instrument P	1.70	1.58	1.35
Instrument F	1.62	1.40	1.26
Instrument N	1.85	1.40	1.26
Instrument H	1.91	1.73	1.33

In band 1, the values of the S/N ratio on seat increased for all instruments comparing with that of on stage. In particular, the values significantly increased in violins S, N, and H. In band 2, the values of the S/N ratio increased for all violins except instrument N; the increase for violins S, D, and H are significant. In band 3, the S/N ratio of violins S, D, and F increased, and the increase for violin D was significantly high. Based on these results, the S/N ratio of violins S, D, and F increased in all bands. Especially, that of violins S and D increased significantly. Therefore, it may be the reason that audience at a seat hear the sound well and clearly.

4. CONCLUSIONS

In this study, we observed the differences in the frequency spectrum and the S/N ratio on a stage and a seat and analyzed the tone color of violins. We analyzed the property of each violin by comparing the peaks and S/N ratios in some frequency bands. In particular, the phenomenon similar to the singers' formant was appeared in 3-5 kHz. This might be the acoustic explanation to the distant peal of violin. In a future study, we will compare the sound of violins in terms of various pitch and analyze other acoustic characteristics.

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