

SOUND QUALITY IN THE CELLO*

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ABSTRACT

The perceived qualities of three cellos were rank ordered using subjective preference judgements. Median overall A-weighted sound levels were obtained at semi-tone intervals for a 3-octave range on each cello. Decreased deviations from the overall median sound level and decreased aggregate note-to-note changes in sound level were found to be ranked in the same order as perceived quality.

SOMMAIRE

Les qualités de trois violoncelles ont été classées d'après une évaluation subjective. Pour chaque violoncelle, les niveaux sonores médians globaux pondérés suivant la courbe A ont été obtenus à des intervalles d'un demi-ton pour une gamme de 3 octaves. Des déviations décroissantes du niveau sonore médian global et des variations décroissantes de note à note du niveau sonore ont été classées dans le même ordre que la qualité perçue.

INTRODUCTION

The study reported in this paper concerns the correlation between perceived cello sound quality over a range of frequencies and objectively measured note-to-note variations in the overall cello sound output. Specifically, it was proposed that increased cello quality would relate to: a) decreased deviations from the overall median sound level; and b) decreased note-to-note changes in the sound level of the cello sound.

PROCEDURE

This experiment involved a correlation between subjective and objective tests on three cellos. Some previous attempts to rate stringed instruments subjectively have used listeners' ratings on a scale of one to ten, or qualitative descriptions such as bright, soft, noble, and tight.¹ In this experiment, listeners were asked to decide

*This paper is an invited contribution based on the report of the author, a grade 10 student, to the Ottawa Science Fair.

which of two cellos they preferred. A panel of five judges made comparisons of all 60 possible instrument and player combinations. On each cello, a scale was played over one octave from C₁, (65.4 Hz) to C₂ (121 Hz) and in a second range from D₁ (147 Hz) to D₂ (294 Hz). The panel members all had musical training, and could not see the instruments throughout the test. The distance from the cello to the listeners was similar to that used for the objective measurements. The same bow was used in all the tests.

A sound level meter was used to measure the overall A-weighted sound level at semi-tone intervals at a point 125 cm away from the instrument and directly in front of it. An A-weighting was used on the sound level meter to approximate the sensitivity of the human ear.² Measurements were made on three cellos for a range of three octaves. Two trials were made on each cello in a small "live" room, and one in a larger, acoustically "dead" room. The musician tried to produce the loudest possible sound on each note while attempting to regulate the bow speed with the aid of a strobe light set to flash at one-second intervals. An even bow stroke, 45 cm long, was completed in three seconds. The bow-bridge distance was visually maintained at approximately 2.5 cm. The frequency of each note was kept as accurate as possible "by ear" without technical verification.

RESULTS

In each subjective comparison of each octave, a preference was stated by each judge. Of the 40 comparisons in which it was involved, cello #1 was preferred 64% of the time over its partner. Cello #2 was preferred 38% of the time and cello #3, 47% of the time in the comparisons in which each were involved. One player always played the scale the first time, and another then played on the second instrument in the comparison, after which the panelists stated their choices. The cellist who played second was chosen 62.7% of the time in all the trials, while the one who played first was chosen 37.3% of the time. However, there were two trials for each pairing of instruments which included both orders of presentation and musician. Therefore, the tendency to choose the second instrument heard would cancel out in the overall results. It can be stated, therefore, that the panel felt that the quality of the instruments ranked in the following order: #1, #3, #2.

A-weighted sound levels were first measured for each cello on each of the three trials. Then a "resultant" curve was plotted for each cello, using the median sound level reading for each note from the three trials. These resultant median sound levels are plotted for each cello in Fig. 1. The overall median level in decibels (over all notes) was calculated for each cello, and then the aggregate of the differences from that median was obtained. When this is expressed as an average deviation from the overall median, cello #1 had an average deviation of 1.4 dBA; cello #2, 2.4 dBA; and cello #3, 1.6 dBA. If the deviations are counted from a median range (2 dBA about the actual median) rather than from the median line itself, the cellos are ranked in the same way (from least to greatest deviation): cello #1, #3, #2.

The rate of change of instrument response was calculated by taking the aggregate of the differences in sound level in decibels between each note and the adjacent note. When divided by the number of notes for which data had been obtained, an average variation in decibels between adjacent notes was found. Cello #1 had an average rate of change of 1.67 dBA, cello #2, 2.54 dBA, cello #3, 2.37 dBA. Ranked from least to greatest rate of change, the order was: cello #1, #3, #2.

CONCLUSIONS

The experiment found a correlation between string instrument quality, as perceived by a panel of observers, and patterns in the variations of cello sound output as objectively measured over a range of frequencies. The ranking of the observers corresponded to the ranking (from lesser to greater) of deviations from the overall median sound levels, and of the rate of change in sound levels between adjacent notes.

It is likely that an instrument which produces a fairly consistent loudness from note to note when a scale is played on it is thereby more pleasing to a listener than one which displays unexplained variations in loudness from note to note. It may also be that an instrument which is more consistent in its response across its range has been more skillfully made and will also have a rich complexity of resonances enhancing each note in its range in a way that is pleasing to the ear of listeners. The resonances of wooden members and air chambers will have been made to complement each other and produce a consistency in "richness" as well as loudness, throughout its range. This experiment, of course, did

not make any direct measurements of the harmonic composition or timbre of the notes produced. It would be interesting to study the harmonic content of the sound produced by different stringed instruments and to explore the relationship between such an analysis and the subjective and objective measurements of this experiment.

REFERENCES

1. Yankovskii, B.A. "Methods for the Objective Appraisal of Violin Tone Quality." *Soviet Physics--Acoustics*, Vol. 11, No. 3, pp. 231-244 (see especially pp. 237f), January-March 1966.
2. Meyer, Jürgen. "Acoustics and the Performance of Music." Frankfurt am Main: Verlag das Musikinstrument, p. 67, 1978.

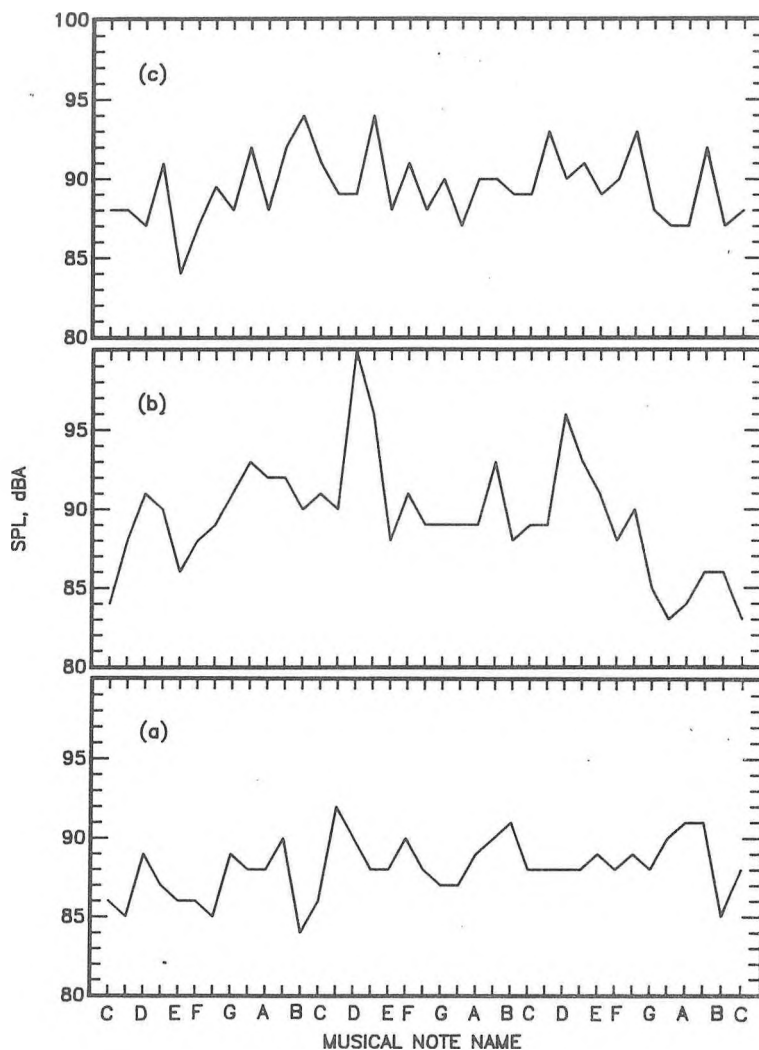


Fig. 1. Median Overall Sound Pressure Levels (SPL), (a) cello #1, (b) cello #2, (c) cello #3.



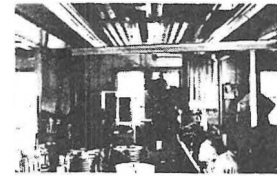
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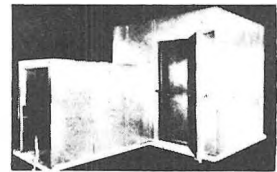
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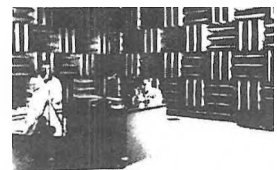
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