CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
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Project Number
J1625

Project Title
Quantifying Quality: Violin Sound Analysis

Abstract

Objectives/Goals
I currently play a 3/4-size violin and will soon need a full-size violin. I wanted to find out if it is possible to quantitatively determine the quality of a violin by analyzing the sound waves it produces, so that I will be able to choose the best instrument for purchase.

Methods/Materials
I found a free software program called Raven Lite 1.0, which is used to analyze bird sounds. It plots the wave amplitude as a function of time, and it gives the frequency spectrograph of a digitally-recorded sound wave. I attached an iSight camera with a built-in microphone to a Macintosh computer, and recorded violin sounds using Raven Lite 1.0. I played all the open strings on 13 violins using both up bow and down bow strokes. I analyzed the recorded sound waves using Raven Lite 1.0. I also used Mathematica 5.1 software to compute the Fourier transform of the sound wave, and to obtain additional quantitative information. I performed a total of 120 tests on 13 different violins.

Results
When you play a note on a violin, you do not produce a single frequency. On the spectrographs, the computer-generated tuning A note is just one line, because it is one pure frequency. In contrast, the note A on a violin contains many additional frequencies, which are harmonics (i.e. multiples) of the lowest fundamental frequency. The strength in the harmonics varies depending on the violin. I noticed that higher-quality violins produced similar sound wave patterns and had more strength in the fundamental note. The three best instruments tested, Stradivarius, Marcello Villa, and Schleske violins, had approximately 92, 82, and 70 percent of the sound in the fundamental, respectively.

Conclusions/Discussion
I noticed more symmetry in the sound waves generated by higher-quality violins than in the waves generated by lower-quality instruments. I also learned that violins produce harmonics, and that the strength of the harmonics varied on different violins. I found that higher-quality violins had significantly more strength in the fundamental frequency.

Summary Statement
Violin sounds are digitally recorded and their waveforms are Fourier analyzed to quantitatively measure what is so special about a Stradivarius violin, and to find a way to determine violin quality.

Help Received
Martin Schleske (violin maker in Munich) gave me information about violins; Jeff Thayer (Concertmaster, San Diego Symphony) allowed me to record his Stradivarius.