The Mystery of the Violin's Sound

The early violin sounded awful and remained that way for hundreds of years. But due to makers' persistence, brilliance, and sometimes luck, breakthroughs were made, and by about 300 years age, reached a sound that no-one has been able to improve.
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It has the richest sound of all instruments. The richness is due to the number of harmonics that ride on top of the tone being played (the fundamental). I'll discuss this later. The violin is remarkably sophisticated – people who specialize in the science of acoustics are amazed at how much modern technology is imbedded in the violin, made by people who had no knowledge of the theory of sound.

If you wave an object back and forth it pushes and pulls at the air, making waves (varying pressure). To make sound waves that you can hear, you'd have to wave it between 100 and 5000 times a second (cycles per second - cps). Open G-string vibrates at about 200 cps. The highest note the violin makes is about 3000 cps. The shape of the vibrating string with no harmonics is like that of a swinging rope – called a sine wave. If you pluck the center of the G-string sideways you will see this shape. There are no harmonics – just the fundamental.

When a string is plucked it vibrates in all directions – up and down and sideways. Now when the string is bowed the bow blocks the vertical motion. The rosin makes the bow stick, pulling the string a bit, the string tension builds up and breaks loose, letting the string swing through one cycle, when it reaches the bow's speed again. The bow sticks again and the cycle repeats – hundreds of times each bow stroke. Each time the bow lets go it jiggles the string, which adds many harmonics to the note being played. The closer the bow is to the bridge more harmonics are made, giving the violin a brighter sound.

The string, being so thin, is not able to push much air, so it makes almost no sound. The violin body acts as a resonator and amplifier so that the string sound can be heard. Most of the sound is made by the vibrating top, which has a much larger area than each string. The top vibrates vertically, like a drum-head or the front of a loudspeaker. The strings are coupled to the body by the bridge. Here is a puzzle: how do the strings make the top vibrate vertically when they vibrate horizontally? The strings make the bridge top move sideways back and forth which makes the bridge rock, moving the bridge feet up and down.

This creates another problem – when one side of the top moves up, the other moves down, creating two soundwaves side by side in opposite directions. This is no problem for high notes, whose soundwaves tend to move is one direction, like a flashlight beam. But low notes spread out in all directions – so notes in the D and G string regions get exposed to cancellation and become weak.

People had to put up with this for hundreds of years until someone wedged a stick under the bridge inside the violin body, probably to support a sagging top, and discovered , when placed under the E string bridge foot, the lower strings came to life! No one understood why until about 100 years ago. The stick, now called the soundpost , prevents E string bridge foot motion. Now there is only a single sound wave coming from about two thirds of the top, and therefore no cancellation of low frequencies. The French call the soundpost the violin's soul.

The soundpost gives us a second benefit. The inside of the violin body acts as a resonator. The vibrating top moves the inside air. Without the soundpost , with the top's sides moving in opposite directions, the total amount of air inside doesn't change. But with the soundpost in place, most of the top moves up and down together, pumping air out the f-holes. This makes a sound wave opposite in phase with the front wave. But if the f-holes are cut to a certain size, this airflow is restricted, slowing down the air and shifting the phase so that, instead of canceling, it reinforces the sound.. We didn't understand this behavior until electronic test equipment became available. But all this was accomplished without scientific help, but with incredible patience and skill, and many, many years. Some loudspeaker systems are using this very same technique!

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