Now *that's* a quality instrument: how violinists evaluate violins

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Violins crafted 300 years ago by the master violin-maker Antonio Stradivari sell for millions of dollars on the rare occasion they reach auction. What is it about their quality that makes them prized above all others? Science has not provided any convincing evidence for the existence of any measurable property that would distinguish the Cremonese instruments from the finest violins made by the best violin makers today. This is, in part, due to the fact that science has mainly been focusing on the violin but little to none on the violinist himself. Although centuries of research have given us much information about the acoustics of the violin and the way in which said acoustics are shaped by violin makers, virtually nothing is known about how violinists' evaluations of violins correlate with their acoustical features. The aim of the project is therefore to better understand how violinists evaluate violins: the most important thing is indeed not whether a violinist likes this or that violin (or whether this violin is good or bad) but rather understanding why he has come to this opinion. From this information, we can finally correlate violinists' evaluations with violins' acoustical properties.

EXPLORING VIOLIN TIMBRE: NASALITY AND CLARITY

The first step of our research was to reduce the complexity of the problem to evaluations of the violin's sound only. Nothing was known about how human capacities for perceiving, discriminating and judging violin sounds matched up to their acoustical features. This is a very significant gap, as perceptual judgments obviously define what makes a violin different from, say, a cello, just as it makes one violin different from another, for listeners, performers and violin-makers alike. A three-year project funded by the Leverhulme Trust at the University of Cambridge from 2005 to 2008 was intent on filling this gap. The approach has involved collaboration between researchers from engineering, music, experimental psychology and computer science (Jim Woodhouse, Ian Cross, Brian C.J. Moore, Alan Blackwell and the author).

Virtual Violins

To carry out any comparative study of musical instruments, it is important to rule out variations caused by the player. Instead of achieving this by using a robotic violinist that repeats the same piece on a variety of real violins, in this project the violins themselves are virtual. The methodology of the "virtual violins", illustrated in figure 1, relies on the fact that the acoustical behaviors of the strings and the violin body can be treated separately, and that it is the latter that distinguishes different violins. In fact, on its own, a string makes hardly any sound at all and its acoustical behavior is rather similar from one instrument to another. The main acoustical feature that 'colors' the sound in ways that are unique for each violin is the manner in which the violin body responds to string vibration transmitted to the bridge. This characteristic transformation is known as the violin's 'frequency response'.

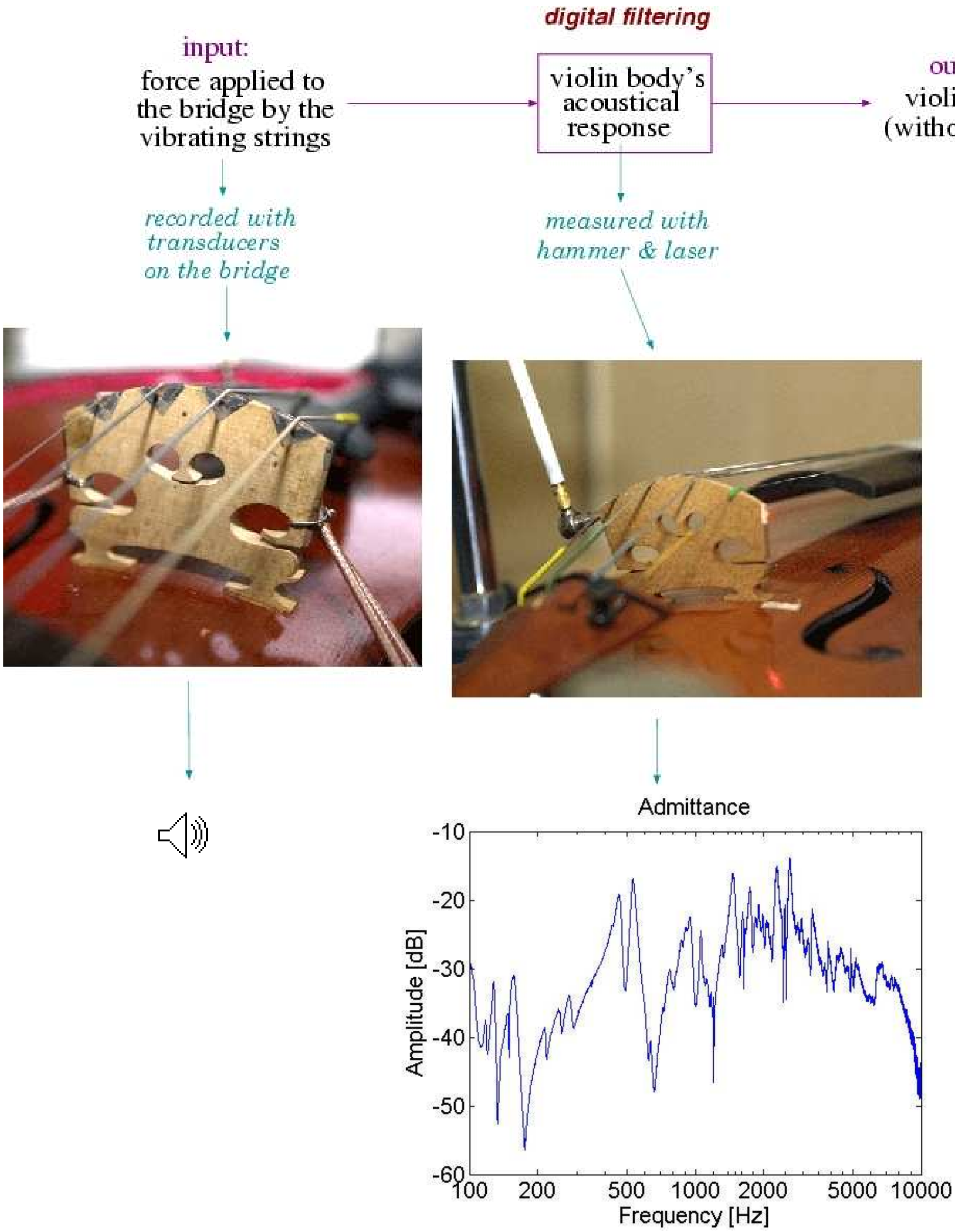

Figure 1: Principle of the 'virtual violins'

Sensors on a violin bridge record the string waveforms arising as a player performs normally on a real violin. This recording is 'played' through computer models of different violins' frequency responses using digital filters. The frequency responses can be derived from measurements made on a range of real violins. A prediction of the sound of the violin can thus be created without having to worry about any complications caused by variations in playing. Moreover, once the violin response is represented in digital filter form, it becomes very easy to make controlled variations of a kind that would be almost impossible to achieve by physical changes to a violin.

Listening test

Based on his measurement of the acoustical properties of a large range of violins that had previously been classified as of very good or moderate quality, Dünnwald (1991) suggested four important frequency bands in the frequency response for the judgment of sound quality. In particular, he associated a large amplitude (of the violin's reponse) in the band 650-1300 Hz with "nasality" and a low amplitude in the band 4200-6400 Hz with "clarity", but without any perceptual testing. The virtual violins that were used in a listening test put these assertions to the test. More specifically virtual violins were created by modifying the amplitude of the response of a baseline violin in 5 octave bands, from 200 Hz to 6400 Hz. An example of a violin where octave band 3 (800 – 1600 Hz) was modified is given in figure 2.

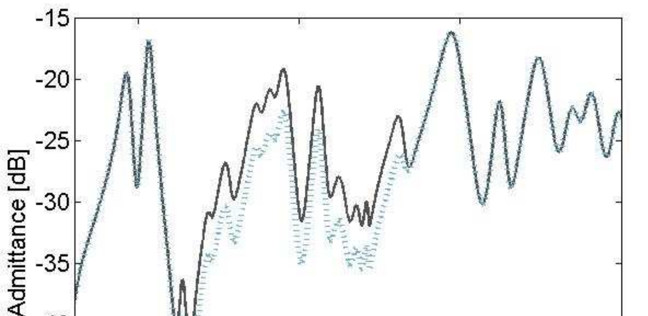

Figure 2: Frequency response of the original violin used as a baseline and frequency response of a virtual violin corresponding to a modification in amplitude of the original response in the third octave band (800-1600 Hz)

The sound files for the listening tests were then synthesized by playing a very short musical phrase through these virtual violins.

The listening test was conducted with 14 English native and 14 French native violinists. The participants had to choose, for 150 pairs of these modified violin sounds, which sound was the most “clear” / “clair” or “nasal” / “nasal”.

The results are very similar for both languages and conflict with Dünnwald’s suggestions. Like for “clear”, the results for “clair” yielded a high degree of consistency between subjects and the term was associated with an increase of energy in the frequency range 1.6 kHz to 3.2 kHz. For “nasal”, subjects could be divided into two groups, each showing high consistency. An increase in the band 1.6 kHz to 3.2 kHz increased nasality for the first group while decreasing it for the second one.

Analysis of the musicians’ discourse

To go beyond the simple labelling, the French participants were asked to give explicit descriptions of what “clair” and “nasal” means for them and the reasons of their choices, as suggested by Danièle Dubois, a cognitive psychologist with whom the author collaborates.

Linguistic analyses were thus conducted on the descriptions given by the participants. For “clair”, two meanings emerge: “clair” can characterize a sound which “is rich in high frequencies” or a sound which is “precise”, “definite”, “direct”. Regarding the consistency of the participants’ answers to the listening test, both definitions seem to correlate with a higher amplitude of the harmonics in the fourth octave band (1600-3200 Hz).

For “nasal”, the two groups obtained from the listening test were semantically identified as corresponding to two meanings of nasality. One refers to the quality of a twangy voice or instruments like the bagpipes. This correlates with a large content of high frequencies (group 1). The other meaning of nasal, less consensual, seems to correspond to the “phonetical nasality” (vowels like [õ],[ã]) and/or to the fact that the sounds appear “cut” or low-pass filtered, and therefore correlates with a low content of high frequencies (group 2).

VIOLIN QUALITY EVALUATIONS

Exploring sound quality and how it correlates to acoustical features can only tell part of the story, as a violin cannot be reduced to its sound. Otherwise, listeners would be on par with violinists in distinguishing between different instruments. One reason for this perceptive gap is that a listener will only hear the result of the interaction between the musician and the instrument. As a good musician will always try to get the sound he likes, this will smooth out the differences between instruments for the listener. A second reason is that the player can evaluate what he gets from his violin and the sound he produces in relation to what he gives to the violin. This feedback is most certainly essential for evaluating the quality of a violin.

A first series of interviews was thus conducted in order to better understand what makes a good violin. Three French professionals at a soloist level were asked to describe what a good violin was for them. The linguistic analysis of their answers gave straightforward and highly consistent results: what makes a good violin is first a quick and good response, a good projection and a large color range, and then, only then, its sound itself. Sound quality will only matter if the violin sounds for instance too nasal or too sharp. Otherwise, if there is no big defect, sound quality is not important as the player will shape it the way he likes it. However, after informal discussions with violin makers on this topic, it seems that this is not the case for amateur violinists, for whom the timbre of the violin will be more important. More interviews with violinists of different expertise need therefore to be conducted.

In addition, more interviews are needed to understand what are a good response, a good projection and a large color range. This will help us to infer mechanical properties that may have not been considered until now, in the acoustical studies which have been too much violin centered until recently. More research in collaboration between acousticians, psychologists, violin makers and high quality violinists will hopefully provide the keys to characterize the properties of fine quality violins that are relevant and important for violinists in meaningful physical terms that can eventually be measured.