SOUNDS LIKE A MATCH?

If someone makes an exact copy of a Stradivari, will it sound like a Stradivari? **Sam Zygmuntowicz** attempts to answer the question by making duplicates of the 'Titian' and 'Willemotte' Strads, as well as the 'Plowden' Guarneri 'del Gesù'

Violin makers have flirted with science for a long time, and that relationship has only intensified with the passing years. In 2009 my project 'Strad3D' brought together the 1715 'Titian' Stradivari, the 1735 'Plowden' Guarneri 'del Gesù' and the 1734 'Willemotte' Stradivari in Dr George Bissinger's lab, where they underwent 3D laser vibration scanning, CT scanning and sound analysis, to which we added traditional photos and measurements, plus musical reference recordings.

With research like this, there are certain questions that sceptics always ask. Does acoustic analysis deepen our understanding in a useful way? Can new violins really capture the characteristics of old instruments? Does all this inquiry actually help us make better instruments? To find out, I decided to use the Strad3D resources to make faithful copies of those three original violins. Perceptions of any violin can be intensely individual, and vary with the player, repertoire or venue. But as models for my new instruments, I endeavoured to consider the three originals not just as individual specimens but as a grouping, to compare and contrast construction details and the resulting sound.

In this article, I'll first examine the old violins, and describe my own process while constructing the new instruments. I'll briefly explore sound and timbre subjectively and analytically. Finally I'll compare the finished copies to each other, and to their original models. Will they show the same relative colours of sound as the original models?

Qualified scientific researchers associated with the Oberlin Violin Acoustics Workshop have added greatly to our basic understandings of sound and violin function. But for makers to answer their own questions at the bench, we must venture on to thin ice, to draw our own ideas from the violins that we study. Pure science is not my process and perspective here, but rather analytical speculation based on personal observations, to be taken as such.

I've previously discussed these superlative violins at length in these pages (see *The Strad*, April 2009, July 2011 and December 2020) so here I will highlight just a few notable aspects:

- The 'Plowden', owned by Mark Ptashne, is from Guarneri's elegant middle period. It has a quite compact back length of 351mm and shows dramatic wood and thick red varnish.

Sam Zygmuntowicz's copies of (*left–right*) the 'Plowden' Guarneri 'del Gesù' and the 'Titian' and 'Willemotte' Stradivaris

Notable on this instrument are its streamlined outline and small corners, delicate overhang and low, smooth arching, about 14mm on the top.

• The 'Titian' Stradivari is an example of his 'golden period', with a back length of 353.3mm. The arching is moderate, about 15.5mm on the top, well sculpted around the f-holes and with a full horizon arch. It gives an impression of strength and elegance.

• The 'Willemotte' was built in the final years of Stradivari's life when Antonio would have been 91. This violin still shows his distinctive working style, with an impressive consistency across time. With a longer body length of 357mm, the 'Willemotte' also has the highest top arching, at about 17mm, with an extended top horizon very full to the ends.

Copying is an old sport, but it is apparent that exact copying is not fully possible, as we always have to confront natural arching distortion and stress, ongoing modifications such as differing bass-bars and set-up, and the effects of hard usage moderated by deliberate restorations.

SHOULD WE COPY WHAT WE SEE NOW, INCORPORATE PERSONAL PREFERENCES, OR ADAPT TO THE WOOD DIFFERENCES?

Plus our wood will never be a perfect match. So, should we copy what we see now, try to reconstruct the original intent, incorporate personal preferences, or adapt to the wood differences? Each of the proposed new violins seemed to call for its own approach.

From our CT scans, radiologist Steve Sirr estimated that the 'Plowden' and 'Titian' had comparatively low-density spruce and maple, and the 'Willemotte' top had a more moderate density. I tried to find wood with similar density, while still matching its appearance. ▹

ALL PHOTOS AND FIGURES S. ZYGMUNTOWICZ/M.J. KWAN

I first measured and traced the 'Plowden' in 1982 and I've looped back to revisit this model many times, making both close copies and reinterpretations – even a personal variation I had nicknamed the 'Zowden'. In 2015 I returned to the source material again, this time with the full Strad3D data set.

At the time of the first tests in 2006, the CT scans revealed the 'Plowden' to have a comparatively small bass-bar, compared to the 'Willemotte' and particularly to the 'Titian', which had the largest bass-bar of the three. For my copy of the 'Plowden' I chose to fit a higher bass-bar, consistent with my own sound preference for less 'butter' and more 'sizzle'.

I first encountered the 'Titian' in 2005 and was struck by its healthy response to adjustment, and its massive sound. I used the CT scans to design my 2017 copy. Fitting the purfling into the short corners required much finesse, with the outer purfling strip strongly deviating from the scribed purfling mark to form the characteristic Strad mitre 'bee-sting'.

I followed the general thickness specifications of the originals closely. For example, both the 'Plowden' and 'Titian' backs have a 'bull's-eye' thickness pattern, about 4.5mm in the centre, then thinner in the flanks. I emulated this thickness pattern on the backs of my copies, which to me felt relatively stiff when flexed through the C-bouts, while comparatively flexible in the outer bouts. The wood for my 'Titian' copy may have been a bit denser than the original, so I reduced my thickness slightly. The 'Willemotte' back has a more even thickness pattern, about 4mm in the centre, and I thought this made the new back relatively flexible through the middle bouts, and stiffer in the outer bouts. The 'Willemotte' top was somewhat thicker than the other two. For my first interpretation of this distinctive violin, I chose to follow that original thickness, and wait for the results.

The arching on each original showed expected asymmetry, pushed higher on the soundpost side of the top and back. I emulated the archings and included some of the asymmetry, but not all, anticipating that the new archings will continue to change under string tension, and come closer to the original over time.

The 'Willemotte', with its full arching and wide edge margins, gives a generous and massive impression. Simply following the specifications of the original offered insight into the structural choices. For example, the purfling here has a generous inset from the edge of almost 4.5mm, compared with the 'Titian' inset of 3.8mm. When I inlaid the purfling corners on the copy, it was easy to see why the elderly Antonio may have made this choice. Unlike the 'Titian', the wide margin allowed the purfling to meet in the corner easily, without much deviation, giving an almost effortless version of Stradivari's distinctive bee-sting.

Working on the edgework of the 'Willemotte' copy in 2021

With the new violins completed, it was time to evaluate their sound, individually and in comparison to each other, and in reference to the original models. For a player, subjective evaluation is always the arbiter, but perceptions of violin sound are difficult to describe. Leaving aside preference and rankings, what's missing from the discussion is a link between our language and an objective measure of sound.

Anyone who has equalised a recording has experienced how small changes to the harmonic balance can change our perception of tone colour. In a related approach, we used calibrated sound tests of the original violins, which were analysed to document and display the harmonic balance in a 'spectrum' of sound. I'll be focusing on three key frequency ranges within this spectrum: low medium and high (see right). ▹

THE ARCHING ON EACH ORIGINAL SHOWED ASYMMETRY, PUSHED HIGHER ON THE SOUNDPOST SIDE OF THE TOP AND BACK

UNDERSTANDING SPECTRA

To generate the 'sound spectra' shown below and on page 46, each violin was supported, the bridge was tapped with a calibrated impulse, and the resulting sound radiation of the top and back recorded with a microphone. Computer software then analysed the sample to display the violin's resonance profile. I last tested the 'Plowden' and 'Willemotte' in 2011, and the 'Titian' in 2016. My testing microphone amplitude settings have subsequently changed, so the older results have been adjusted in amplitude display, for comparison purposes only.

Figure 1, below, shows the relative amplitude of the varied resonances, with frequencies displayed horizontally, higher from left to right. The amplitude is displayed vertically, rising from bottom to top. Both are displayed logarithmically, which gives a better visual approximation of our perception of sound. Some displays are smoothed, to highlight the overall profiles or 'formants'.

All three original violins have had adjustment or modifications over the years, including new bass-bars on the 'Plowden' and 'Willemotte'. These modifications did change the perceptions of their sound, and altered details of the spectral response, particularly increasing the frequencies of the 'B1-' and 'B1+' modes. However, the general formant and harmonic balance of each violin remained recognisable.

While playability and other aspects of sound remain elusive, these spectra seem useful to document timbre. Every played note contains many higher harmonics, so the entire spectrum is relevant. Here I present a simplification of the influential frequency regions, and an attempt to describe the associated tone colours:

- Our **lower range** here extends from about 200Hz to 600Hz, which includes the violin's strongest resonances, and is generally associated with fullness and warmth
- The **mid range** extends from about 800Hz to 1,200Hz. I associate this frequency region with presence and edge. Instruments with low output here might have a dulcet and smooth sound, while excessive output here may be perceived as edgy or rough. I think of the mid range as the 'spice' of violin sound: good in moderation, seasoned to taste.
- The **high range** extends from about 1,800Hz to 4,000Hz. The human ear is most sensitive in this region, which seems associated with brilliance, 'sizzle' and carrying power.

There have been many interpretations of spectra. I have tried to isolate the most influential frequency areas or bands that could describe timbre. My chosen bands are where the 'hills' of activity are commonly found, and the space between is where one finds the dips of less activity. The placement and depth of the dips is significant, but not as well studied.

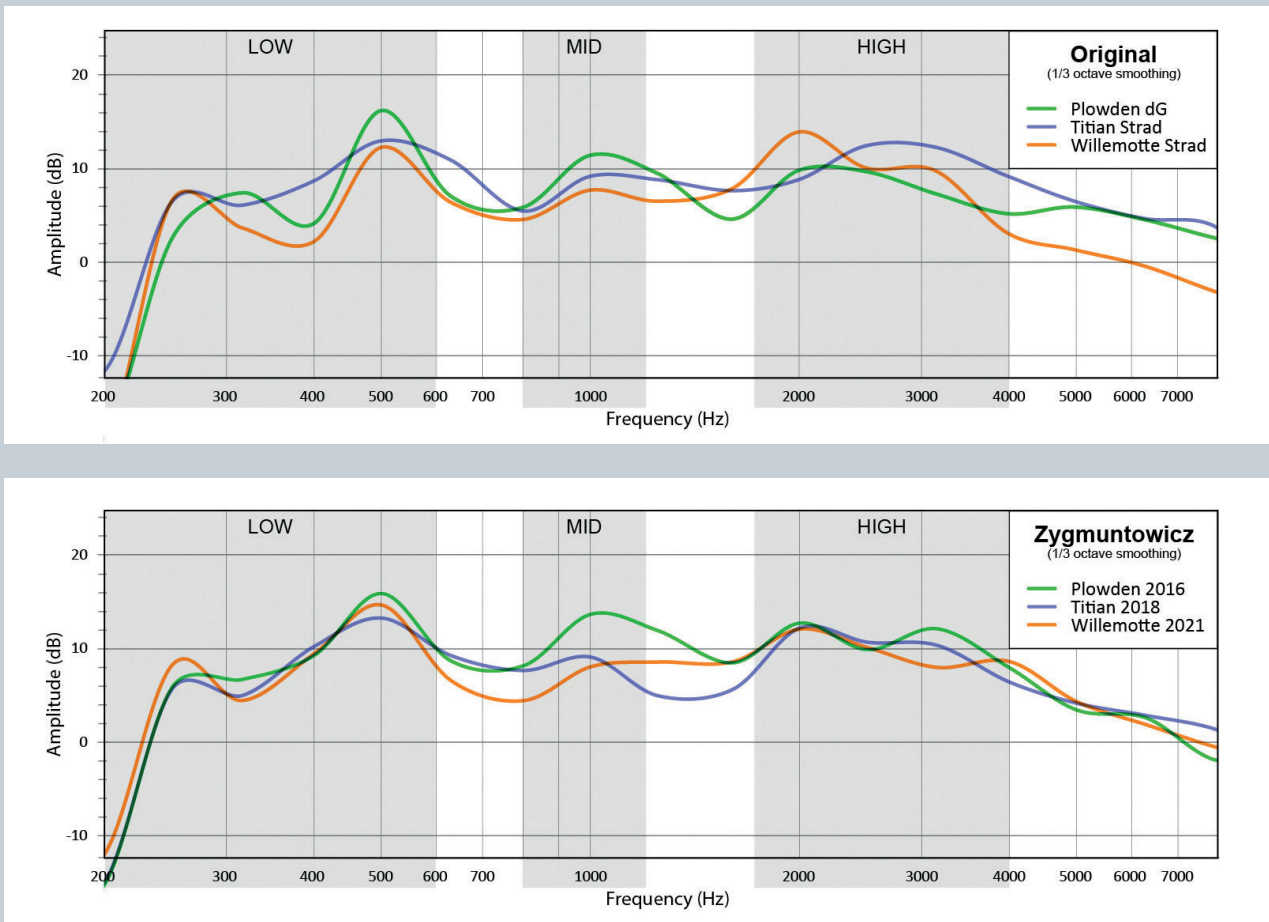
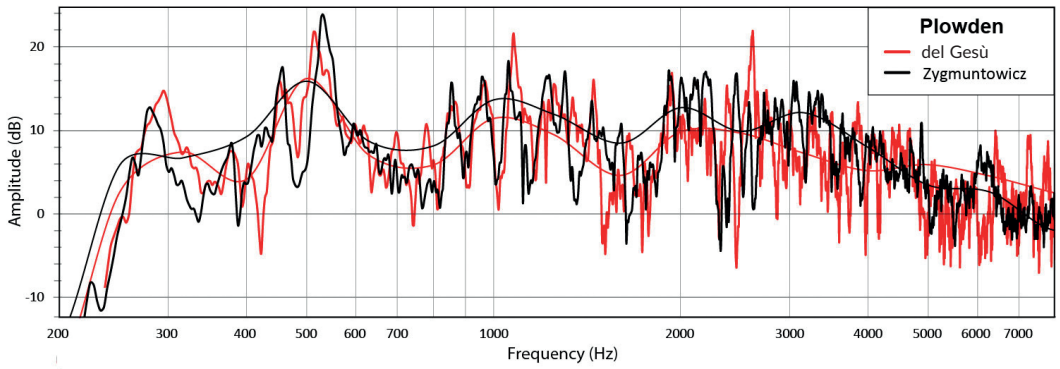
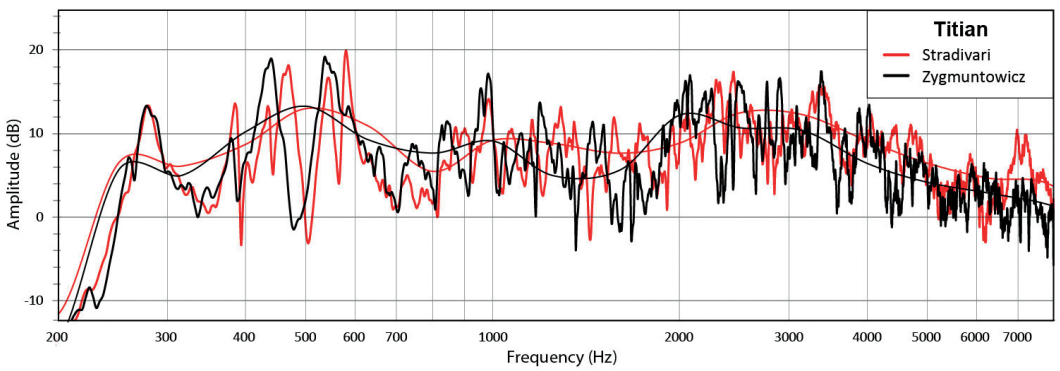
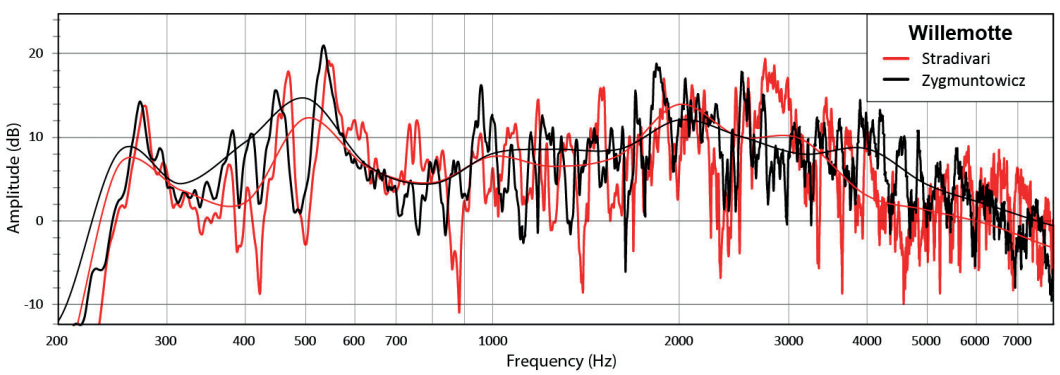


FIGURE 1 Sound spectra of (*top*) the three original violins, and (*bottom*) the three Zygmuntowicz copies







In each case, the red line shows the spectrum of the original instrument, while the black line shows that of the copy. Superimposed is a smoothed line to indicate trends.

The 'Plowden' spectrum shows a strong extended mid range, separated from the high hill by a marked dip around 1,700Hz.

The 'Titian' has a smoothed spectrum with a distinct high range plateau.

The 'Willemotte' has a lowered mid range, allowing the high hill to rise at a lower frequency.

These spectra should be interpreted with caution, but they do show the arrays of resonance peaks which contribute to timbre.

Each peak is produced by a specific pattern of vibration of the violin body, and these patterns of vibration are determined by each violin's body's shapes and stiffness.

Describing the 'Plowden' in 2011, I stated: 'Tonally this is one of the most appealing violins I have played. The tone is smooth and velvety, with a touch of reediness that gives presence to the sound'. Compared to the sound spectra of the'Willemotte' and 'Titian', the 'Plowden' showed strong resonance in the low frequency band, and less prominent output in the high frequency ranges, which would fit with a 'smooth and velvety character', but it presented a strong mid-range output, which I find consistent with a 'reediness that gives presence'.

Cho-Liang Lin writes about his instrument: 'I would describe the "Titian" sound as aristocratic, with a really ringing upper register and a rich, full G string. Throughout the entire range of the violin, there is an incredible core of sound that is both powerful and nuanced.' The 'Titian' shows relatively balanced spectra, with filled-in dips and moderated peaks throughout its spectrum. I think this is consistent with Cho-Liang Lin's description, and to my ears the 'Titian' does have a strong focus to the sound, and a consistent intensity on the E string.

Leonidas Kavakos comments about his violin: 'The "Willemotte" is a very robust, powerful instrument... It has a refined, perfumed kind of tone quality under the ear, yet when I hear someone else play it in a concert hall, it has an incredibly complex, multidimensional character.' This combination, supple under the ear yet complex and carrying in the hall, may seem paradoxical but it can be understood in context. The sound spectrum of the 'Willemotte' is distinctive, with a moderate low range and a lowered output in the mid-range region. I find that stronger mid-range output enhances the sensation of presence or edge under the ear, so this reduced mid range might well give a more refined impression to the player, and would highlight the extended high range, which we would expect to carry well in a hall and aid modulations and vibrato.

I started this discussion with three questions. First: does acoustic analysis help us understand violin function in a useful way? For me, considering instruments in this full context is the most direct way to perceive trends in cause and effect. For example, in this study set, arching emerged as the clearest variable. The 'Willemotte' and 'Plowden' had the highest and lowest arching respectively, and tonal comparison suggested that the high full arch of the 'Willemotte' could be linked with its lowered mid range and strong high-range output, compared to the low arch of the 'Plowden', its attendant strong mid range and relatively reduced high range. The moderately arched 'Titian' was placed in between, with a more even response across the low, mid and high ranges. If this type of observation holds, we may begin to get our fingers on the tone sliders that create the sounds our clients want.

Secondly: can the new violins capture the characteristics of the old instruments? In fact, the new instruments did show comparable trends related to the originals, along with some differences. The low-arched 'Plowden' copy had a similar strong and extended mid range, for a good 'del Gesù' growl, but a somewhat enhanced high range for some extra brilliance. The 'Willemotte' copy followed the trends of the original closely, with a lowered mid range and stronger extended high range. To my ears this gave a stentorian gravity, which to me seems reminiscent of the original. The spectrum of the 'Titian' copy was slightly less full in the low range, but to my ears still projected the focus and mass that I associate with the original.

Not surprisingly, the three new instruments also showed a strong resemblance to each other, especially in response and playability. A maker faces a hundred small decisions, and will tend to use the same type of bass-bar, the same ground and varnish, and a similar set-up each time. One can never leave one's own sensibility behind, and individual style and preferences will always show through even in the process of close copying.

The ideas proposed in this article are subject to debate and revision, but the Strad3D data and documentation have proved a deep and enduring resource for this project. To make this presentation and archive available again, we have completely reprogrammed Strad3D for a new edition, with the interface and interactive features fully restored. More information is available at www.Strad3D.org.

At the completion of this project, we are left with the original question: does this inquiry help us make better instruments? The first answer would have to be: better for what? Blind tests of old and new violins consistently show that tastes differ widely, but individual players know what they like. So for a player, 'better' means getting more of what they want. And for a maker, 'better' means reliably giving that player more of what they need. To me, understanding the link between structure and sound is the key to these aims. I find that this expanded approach leads to a strangely satisfying way of working, with structure and vibration, instrument and future player, original intent and potential changes all intertwined, and projecting forward to help visualise the violin yet to be, in action. ●

The three copies set up for adjustment

The 'Plowden' copy suspended in tap-testing apparatus

Posters of the 'Titian', 'Willemotte' and 'Plowden' are all available at The Strad Shop: **www.thestradshop.com**