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WHAT IS OLD ITALIAN TIMBRE?

by A Buen

Abstract

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WHAT IS OLD ITALIAN TIMBRE?

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ABSTRACT

Violin timbre is discussed and demonstrated in light of Heinrich Dünnwald's work on parameters for relative levels of certain frequency ranges of narrowband violin body spectra. He analyzed more than 700 violins and found some characteristic objective features in the spectra of Old Italian violins that differed from modern master and factory made violins.

Using data from my impact hammer data set of violins and hardangers I compare the spectra of instruments with low versus high values of these Dünnwald parameters and make "difference filters" between them. These filters are then used in modifications of a short played violin phrase demonstrating the effects as the Dünnwald parameters are varied. I will also present some preliminary results from a data mining project where I extract some simple significant correlations between construction details and these objective timbre parameters.

1. INTRODUCTION

Heinrich Dünnwald studied sine swept violin spectra from some 700 instruments in his PhD work from the late 80's [1,2]. He measured spectra from some 55 old Italians, 75 old master instruments made before 1800, 300 master instruments made after 1800, 170 factory made violins and 100 of another category (probably amateur made etc). Dünnwald measured all instruments using the same method exciting the instruments by a very light exciter pushing against the bridge G string side giving a close to flat force input. The measurements were conducted in an echo and noise free environment.

2. METHOD

His measurement technique would be equivalent to using an impact hammer system where the input force signal is accounted for, as shown in Figure 1.

Figure 1: Rig for measurement of SPL(ω)/F(ω) "impact hammer" spectra. The fiddle is insulated from the rig by rubber bands. The strings are damped with rubber foam pieces.

2.1 The relative A0 level, L, in old violin spectra

One of the main findings was that the level of the A0 resonance compared to the mid frequency range from 650Hz-1,12kHz tended to be stronger in the old Italians as compared to most of the rest of the instruments. Figure 2 shows how the L-parameter was measured out of the violin spectra in his study.

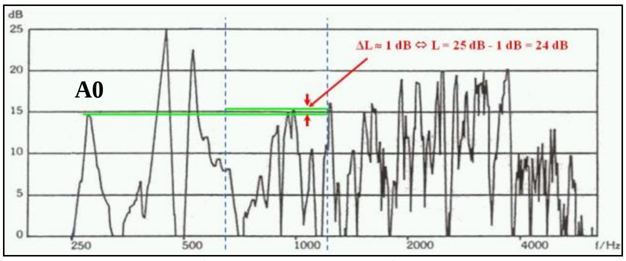

Figure 2: Sine swept frequency response of a violin by A. Stradivari from 1708. The two green lines show the level difference between the A0 and the strongest peak in the 650Hz-1,12kHz region. Dünnwald adjusted the excitation so that the strongest peak in the mid frequency range was at 25dB. The level of the A0 was then read directly off the graph and given the name "L" (L = 25dB – ΔL). Graph from [3].

Figure 3 shows the cumulative distribution of the L-parameter from all the 700 instrument spectra sorted on these four groups of instruments:

a) Factory violins
b) Master violins made after 1800
c) Master violins made before 1800
d) Old Italians

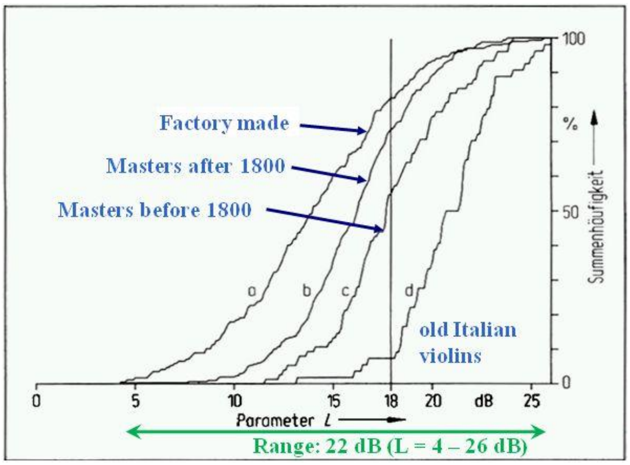

Figure 3: Cumulative curves for the measured L parameter values from the four groups of instruments. Graph from [3].

The Old Italian (OI) violins cumulative curve in Figure 3 show a small "plateau" ending at 18 dB. Only four of 55 OI violins have L lower than 18 dB (each step in the curve is an instrument).

Dünnwald chose L ≥ 18 dB as the main requirement for Old Italian violin sound. That is: at most a 7 dB difference between A0 and the strongest resonance in the region from 650Hz to 1120 Hz. For the Stradivari in Figure 2 the ΔL is 1 dB. L = 25dB – ΔL = 24 dB, close to the max values in Figure 3. 66% (462) of all the instruments do not meet the criteria.

2.2 Data on L and the A0 level from my study

I have spectra from 18 violins and 18 Hardanger fiddles measured in the impact hammer rig shown in Figure 1. There are data from a few very good to mediocre instruments. Some are master built from about 1860 up to the present, a few are recent mass produced Chinese violins. Some of these, and some Hardanger fiddles, are regraduated and set up by me. There are no Old Italian violins included. Figure 4 shows the cumulative curve for the L parameter from my set of spectra. They basically perform like the group of pre 1800 master instruments in Figure 3, but with a smaller range in the data towards the low end. (Dünnwald's L = 4 dB versus my L = 11 dB as minima)

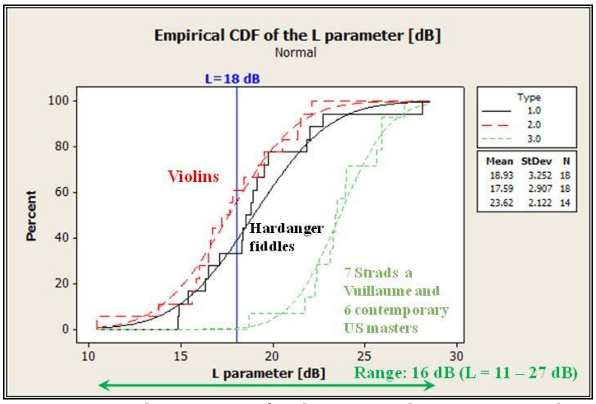

Figure 4: Cumulative curves for the measured L parameter values from my dataset of 36 violins and Hardanger fiddles. Data for 7 Strads, a Vuillaume and 6 contemporary US makers are included.

The Hardanger fiddles tend to have slightly higher values. 18 of the instruments meet the Old Italian violin criteria for the L parameter, 7 violins and 11 Hardanger fiddles.

2.3 Data mining set

A quite extensive set of data are collected from the instruments such as thicknesses, arching heights, dimensions, wood sound speed data, wood density, plate weights (if tops come off), different tap tones, f-hole lengths, distances between them, bridge properties, sound post position, etc. There are about 200 construction data inputs per instrument with a main weight on the recorded thickness graduations.

These construction data are tested for any correlations with e.g. Dünnwald parameters extracted from the recorded spectra in a sort of "data mining process".

2.4 Factors affecting L and A0

In the study several factors appear with significant correlations with the A0 and L levels. Two of these are the resonance frequency of the first twisting mode and the weight of the free top plate. Lighter and less stiff tops tend to occur more often in instruments with higher L-parameter values, as illustrated in the contour plot in Figure 5.

Top plate weights and tap tones have been the focus of recent studies of data from some Old Italian violins [4]. The tops weighed an average 64.8 ± 3.8g with the bass bar in place. Only frequency data for mode 2 and 5 were given.

Using Figure 5, violins with 58-70g tops are likely to have L parameters spectra values in the green zone.

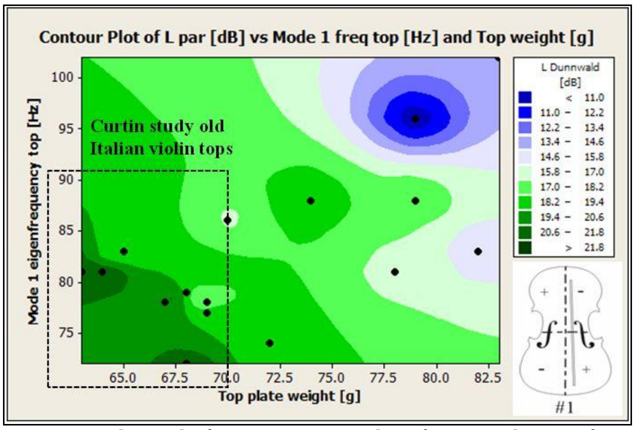

Figure 5: Color scale for L parameter values from my dataset of 36 violins and Hardanger fiddles. Top plate weights along the x-axis and first twisting plate mode (Mode 1) frequencies along the y-axis.

In normally graduated violin and Hardanger fiddle top plates, the free plate Mode 1 resonance is seldom above 90Hz.

2.5 Method for the filtering experiments

One of the aims of this study is to listen to how real instruments with high and low values of Dünnwald parameters, as well as A0 and overall SPL, sound. The procedure was:

- The SPL(ω)/F(ω) spectra were extracted in narrowband and 1/12th octave bands
- The Dünnwald (DW) parameters were extracted from these spectra
- The spectra were sorted by the DW parameters, the A0 level and the overall SPL
- Average spectra of the instruments with the 5 highest and lowest parameter values was made
- The difference between these were used to filter a short played violin phrase in *SpectraPlus v.5.0*

3. RESULTS

The spectra are imported into an Excel spreadsheet for sorting, calculating the average, making filters and plotting the spectra.

3.1 High versus low A0 spectra

Figure 6 show the average curve for the 5 instruments with the highest and lowest level of the main air, A0, resonance.

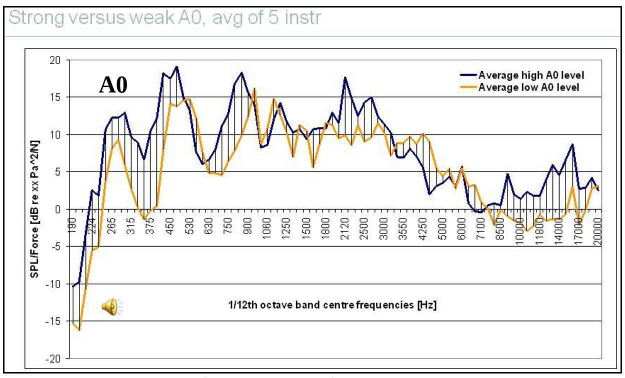

Figure 6: Averages of the spectra from the instruments with the 5 highest versus the 5 lowest absolute A0 levels.

The difference is not only seen for the A0 level, but over the entire spectrum. In general there are 5-7dB stronger levels in four frequency regions. The weakest A0 instruments are stronger only from 3,5Hz-5kHz. Most listeners should hear the difference between these spectra.

3.2 High versus low L parameter spectra

Figure 7 show the average curve for the 5 instruments with the highest and lowest level of the L parameter value.

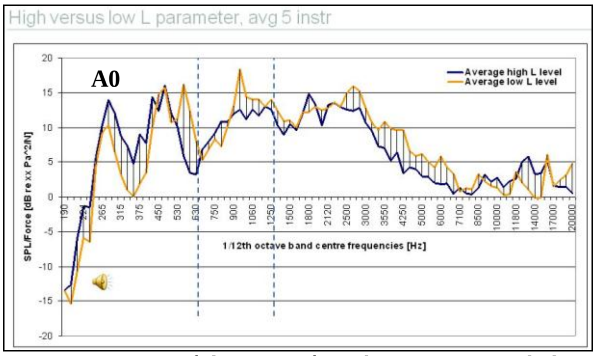

Figure 7: Averages of the spectra from the instruments with the 5 highest versus the 5 lowest L parameter values.

The spectra show differences also outside the region of the A0 and the 650Hz-1.12kHz range. The differences are a bit more moderate than in Figure 6 (the A0). Still there are some 5-7dB differences, but now there are more regions where the low L parameter value instruments have stronger response. I think the difference between the high versus low value sound sample is heard quite well, but less pronounced than for the A0.

3.3 Further sound quality parameters, ACD-B

The high L-parameter value ($L \geq 18$dB) was a necessary but not sufficient property for sorting the Old Italian violins from the rest in Dünnwald's study [1, 2]. There were some mediocre instruments among those meeting the $L \geq 18$dB criteria. Dünnwald extended the number of factors to better characterize the very good sounding instruments. He divided the spectrum into frequency regions from A to F as shown in Figure 8.

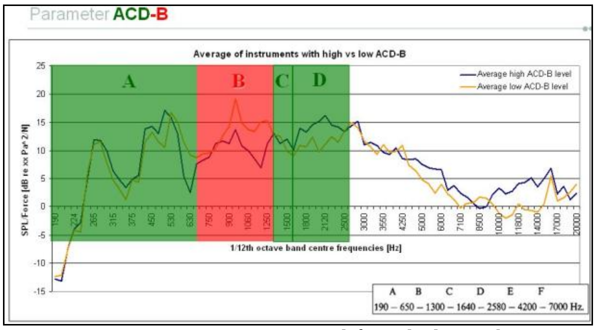

Figure 8: Frequency regions A-D used for calculating the ACD-B sound level.

He found that the sum of the sound pressure levels in the A, C and D was beneficial, and that the B region was having a negative influence on the timbre if it was strong. Often that region was strong in factory violins. So the parameter became ACD-B and he denotes that instruments with B stronger than the sum of ACD regions would sound more *Topfig* or nasal [2].

3.4 High versus low ACD-B spectra

Figure 9 shows the average curve for the 5 instruments with the highest and lowest level of the A+C+D-B (ACD-B) sum.

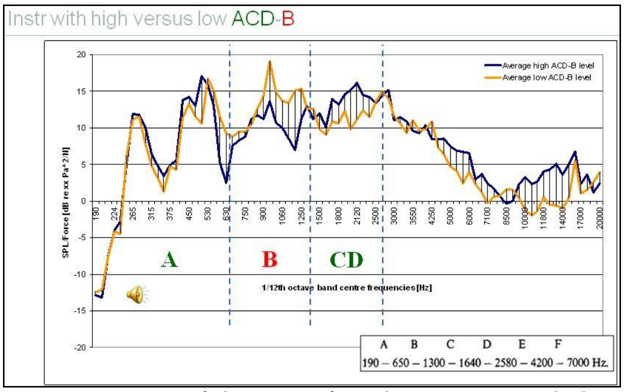

Figure 9: Averages of the spectra from the instruments with the 5 highest versus the 5 lowest ACD-B sum values.

The differences in Figure 9 are more pronounced in the mid and high frequency region with differences outside the range from A-D. In this set the A region differences are small, while the B and CD region differences are some 0-7dB and opposite in the B and CD regions.

There are less sound differences in this comparison than the former two examples.

3.5 High frequency sound quality parameter, DE-F

A strong response in the high frequency region D and E were often found in the spectra from the best instruments, while the very high frequency region F (harshness region) was weak. The DE-range is the 'body hill' - 'singers formant', brilliance and carrying power region [5]. Dünnwald made a parameter combining the levels of the D and E regions and subtracted the level in the 'harshness' frequency range F: DE-F. He connects higher values of this parameter to a clearer or warmer sound.

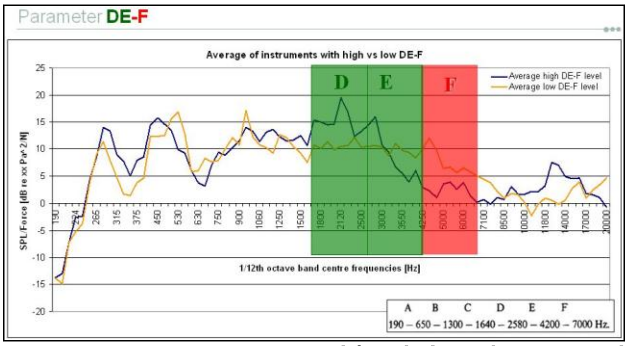

Figure 10: Frequency regions D-F used for calculating the DE-F sound level.

3.6 High versus low DE-F spectra

Figure 11 shows the average curve for the 5 instruments with the highest and lowest level of the D+E-F (DE-F) sum.

There are larger differences in certain $1/12^{th}$ octave bands in the DE and F regions than in the former spectra, up to 10dB. There are smaller differences outside the DE-F region too.

The difference in the sound samples here are more pronounced than for the ACD-B and maybe also the L examples.

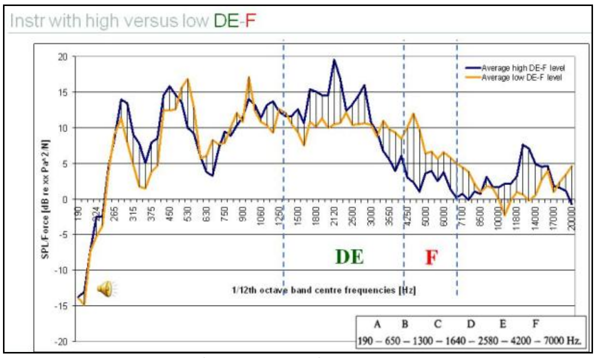

Figure 11: Averages of the spectra from the instruments with the 5 highest versus the 5 lowest DE-F sum values.

3.7 High versus low overall SPL

Figure 12 shows the average curve for the 5 instruments with the highest and lowest overall sound pressure level SPL. In timbre experiments variations in SPL is often compensated for, as it is known to be a dominating factor. However, instruments do tend to be more or less loud as a natural property.

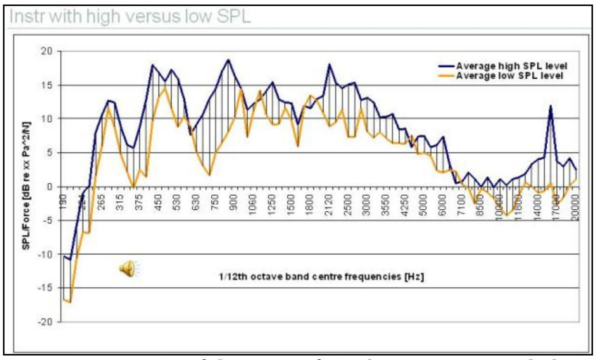

Figure 12: Averages of the spectra from the instruments with the 5 highest versus the 5 lowest overall SPL values.

There are differences of about 0-8dB or so between the spectra, and the louder instruments tend to be stronger almost all the way. A trained eye will see that the stronger instruments probably are the better ones. The mid frequency range is moderate. (The peak seen at 16 kHz is from my tube TV). The difference in the sound samples is heard as a louder sound plus possibly a more ‘punchy’ and piercing character.

3.8 A possible new combined timbre parameter

In earlier studies of recordings of fine old violins I have used a combined parameter combining Dünnwald’s parameters and the SPL: L + ACD-B + DE-F + SPL, [6].

Figure 13 shows the average curve for the 5 instruments with the highest and lowest overall summed Dünnwald parameter values and SPL. The differences are a bit more moderate than those shown in Figure 12 for the SPL, some 0-6 dB. In general the bands assumed to be beneficial are stronger for the blue curve. The assumed negative B and F regions are weaker.

The sound samples are less different than the DE-F and A0 examples, but are still quite pronounced. In general the higher values example is the better sounding.

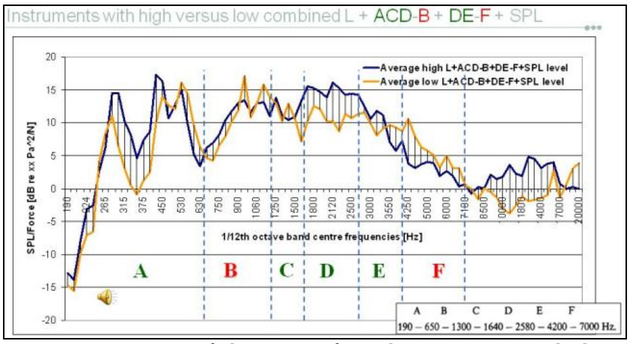

Figure 13: Averages of the spectra from the instruments with the 5 highest versus the 5 lowest combined Dünnwald parameter values + SPL.

4. CONCLUSIONS

Old Italian violin tone has been assessed through Dünnwald’s parameters extracted from spectra from 36 violins and Hardanger fiddles over time accessible to the author. Preliminary results indicate that:

- Stronger A0 levels seem to be a more robust than just stronger L parameter values in the data set
- Lighter tops and less stiff central part of the top plates may lead to instruments with higher L and A0 levels.
- The differences in the ACD-B parameter seems to be less dominating than the DE-F in the sound samples
- Differences in the overall SPL, and the combined parameter, seem to be clearly audible. Instruments with higher values seem to sound more ‘punchy’, and simply better.
- 7 golden age Strads, a Vuillaume and violins made by 5 contemporary US and German makers (6 instruments) all met the L $\geq$ 18 dB criterion.

5. REFERENCES

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