The Strings of Paganini

Essay on the use of gut strings in the early Romantic era
– an interview with Mimmo Peruffo –

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Introduction

In his letter from Breslau, 31 July 1829, Paganini writes to a friend in Naples:

> **I need a favour: to be done with care and solicitude. I am without chantarelles […]. Even if they are very thin, they must be made of four strands to endure. Make sure the string is smooth, even and well stretched […]. I beg you to keep an eye on the makers and to do this soon and well.'**[1]

What does this mean? What does he mean 'using four strands'? And ***how*** thin would have been these 'very thin' strings?

Nicolò Paganini (1782-1840)

To find out about these things, I went to Mimmo Peruffo in Vicenza, Italy. He is an expert on the historical production of gut strings. In the last six years many new things have been discovered about gut strings as they were used in the past, and this has recently led to many violinists changing their set-up. For my own choices, and perhaps the reader's, I would like to know more about these discoveries.

Also, I wanted to ask Mimmo Peruffo about a package of strings found in a palace in Genoa in 2002. What does he think about it: are they really Paganini's? What do these strings say about sound in the early Romantic time?

Sources

I made use of many articles on the Internet, as the latest discoveries and knowledge in this field are not yet published in books. To search for comments by Paganini himself about the choices of his strings and to learn about his way of playing, to learn about his sound, I read the 1929 biography ‘Paganini of Genua’ by Lillian Day. I also checked what Leopold Mozart writes about strings in his treatise on playing the violin, as this was already known when Paganini was born.

But most of the information for this essay was obtained in an interview with Mr. Mimmo Peruffo. He is one of the very few scholars on the history of gut strings and has spent many years doing research, investigating old strings. He explained to me a lot of things that only historical string makers know, information that is not possible to find in books. His articles, published on the Internet, were a big help in preparing the interview. Also, seeing all the stages in the gut string making process with my own eyes, even feeling the guts with my own hands, accompanied by the explanation of the string maker himself, was a great way to learn more about gut strings.

Mr. Mimmo Peruffo is a scholar in the history of gut string production and a professional string maker himself. He is one of the very few string makers in the world who can produce gut strings based on a historical approach.

He is the owner of AQUILA CORDE ARMONICHE S.a.s., Vicenza, Italy and provides thousands of musicians in Europe and overseas with gut strings for their authentic instruments.

Mr. Peruffo is internationally acknowledged as a leading expert on historical string instruments and their set-ups. He travels widely, doing research on old instruments and investigating historical documents on string production in libraries.

Background

At this moment in the period instrument world a lot of discussion is going on about choosing the right strings. For violinists, but for other string instrumentalists as well, choosing a good stringing is very important. As one of the main aspects of violin set-up, strings have a big impact on sound, articulation, feel, balance and the blending capacity of the violin.

When the first musicians started to experiment with gut strings again, around 1960, no true musical gut strings were available for the violin. The technology how to produce these strings was forgotten, the last string makers who remembered it had died. The old documents that provide us with some information about it had not yet been discovered and so the earliest players started with harp strings, the only gut they could get.

This caused a shock in the musical world: the audience heard sounds that were new for them and which were said to perhaps sound as violins had sounded centuries ago. It was fantastic. Musicians and audience liked the sound and more and more musicians wanted to play in this way and started searching for information about the origins of their instruments in order to imitate the sounds of the time from the music they performed.

With the little knowledge they had string makers started to produce gut strings for the violin again, experimenting with the process and looking for solutions. They developed modern ways to produce old strings. Musicians were satisfied with the results, and they got used to these strings. The public got used to their sound and regarded it as being the ‘Baroque’ sound.

It is now 40 years ago since the first musicians put harp strings on their instruments, and a kind of ‘standard’ is established for the features of the modern gut string. The gauges (the diameter of the string) from which musicians can now choose form a window around a more or less mean thickness per string, the ‘medium’ gauge. These medium gauges are similar in all countries where gut strings are available. Musicians can order to their taste ‘light’ or ‘heavy’ strings around this medium gauge, being a little thinner or thicker than the average thickness.

During the past six years though, scholars such as Mimmo Peruffo, Patrizio Barbieri and Ephraim Segerman, have discovered much new, historical, information regarding the use of gut strings in the past. Mimmo Peruffo in particular did research on original strings found on old instruments in museums, and investigated old documents that describe the process of musical gut string production in the past.

Peruffo studied chemistry and worked as a chemist before he became a scholar of historical strings, and discovered that a lot of the ingredients being used today in the production of strings are giving them features that are very different from the features the historical strings had. For example, the use of aluminium, added to the chemical baths preparing the gut before being twisted, makes the modern gut strings much stiffer than the original strings were.

There are several more examples, described in this essay, where modern gut strings now appear to be very different from the old descriptions of strings and their production. Modern strings tend to be stiffer, some are varnished, and they have a different thickness, all of which have a big influence on the sound. So, one can draw the conclusion that it is very well possible that the sound to which we are now used to as being ‘authentic’ differs greatly from the sound as it was originally!

That is why in the last years very few string makers (1 or 2) are trying to produce their gut strings as closely as possible to the historical way of producing them. They try to return to this historical way by studying sources that describe the process and by doing research on samples of original strings.

This development is a dynamic one. Together with the discoveries about manufacture it became clear that in fact the gauges of strings being used in the past were considerable higher than we use in the modern gut strings: the old strings were thicker. After taking note of this, musicians started to try to use the thicker gauges, but some did not like their sound and found the strings difficult to work with, and so many of them returned back to the ‘normal’ thinner gauges. But, after the very few string makers produced strings following as much as possible the historical process, musicians discovered that the thicker gauges now became possible to use and that they sounded well!

The thicker gauges appear to allow a much deeper and richer sound than the usually somewhat thin and nasal sound we are used to as the ‘Baroque sound’. Also, the tension of the strings appears to be not lower than in modern instruments, something that was always associated with period string instruments.

So at the moment, for period violinists, there are two worlds: some of them choose to stay with the modern ‘standard’ gut strings, because after many years they are used to those strings and because they like the sound, and others who choose to use ‘historically’ produced gut strings and are experimenting with this newly discovered sound.

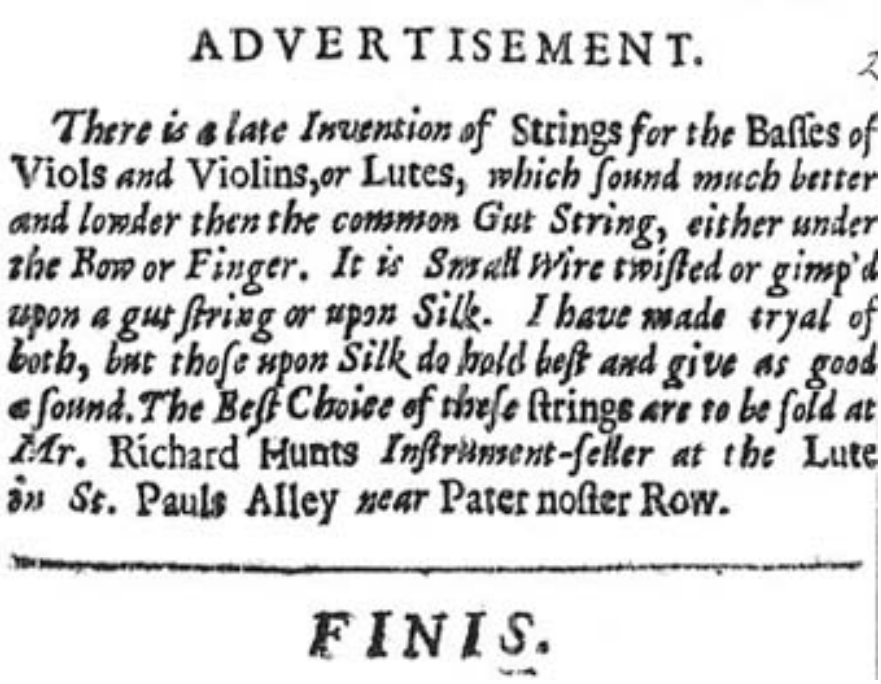
This all becomes clearer in the interview with Mimmo Peruffo. Before reading it, though, I would like to provide the reader with some historical and technical background information in order to make it easier to understand his words.

The fourth string

In this essay, if we speak about tension and gauges for example, usually only three numbers are given. These three numbers belong to the three higher strings of the violin, starting with the highest, so they mean the E-, A-, and D-string. The reason for this is that in the time of Paganini, the early Romantic period on which this essay focuses, it was common in all countries to use a G-string that was wound with silver or with silver-plated wire. The common tradition nowadays that some 'authentic' orchestras play music of this time with two wound strings (the G and the D) is based on practical reasons (it is easier to play), but is not historical.

A violinist in this time, normally bought his E-, A-, and D-string from a string maker, and when he needed a G-string he took one of his A-strings and took it to a luthier. The luthier wound the string for him with silver wire, or sometimes they used brass as well, and the violinist had his G-string.

Wound strings were invented in the 1650s, first for use on the lowest strings of bass instruments – 'the basses of viols, violins and lutes' according to Playford in 1664:[2]



ADVERTISEMENT.

There is a late Invention of Strings *for the* Basses of Viols *and* Violins, *or* Lutes, *which ſound much better and lowder then the common Gut String, either under the Bow or Finger. It is Small Wire twiſted or gimp'd upon a gut ſtring or upon Silk. I have made tryal of both, but thoſe upon Silk do hold beſt and give as good a ſound. The Beſt Choice of theſe* ſtrings *are to be ſold at Mr.* Richard Hunts *Inſtrument-ſeller at the* Lute *in St.* Pauls Alley *near* Pater noſter Row.

FINIS.

What is twist

If we speak about ‘twist’ in this essay, it means how many times the strands of the string are turned around each other before drying. The string maker can choose how many times he does this and it influences the features of the string strongly. A very high twisted string is turned around many times and will be very supple and elastic, but, if it is a thinner string, will break much easier. A low twisted string is stronger, stiffer, but the sound is poorer than from a high twisted string. Usually players can choose from high, medium or low twisted strings when ordering them. I have seen the twisting of fresh gut strings… it splashes!

In this picture the difference is very clear, a somewhat higher twist makes an angle from around 45º and a low twist around 25º:

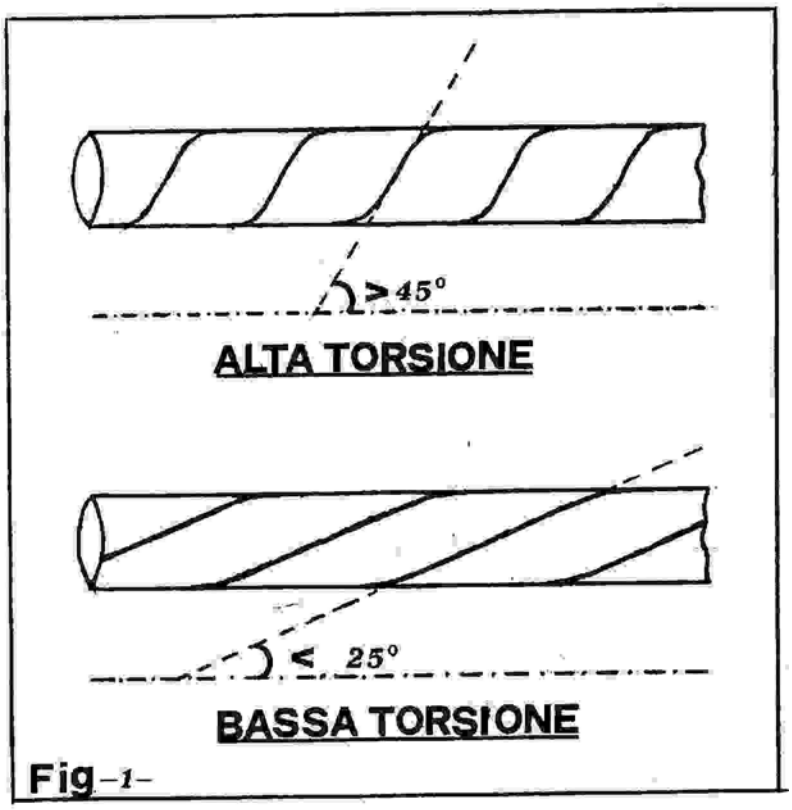


Fig –1–

Globally, a string with a twist that has an angle *under* 25º is named ‘low twist’; between 25º and 50º is ‘medium’ and over 60º is ‘high’.

In the package of strings considered to be Paganini’s, researchers found seven strings. Two of them can be assumed as D’s, three A’s and two E’s. Both E-strings have a medium twist of around 45º, while the A- and D-strings have decidedly high twist, close to 80º.

Tension / Pressure

Sometimes there is confusion amongst musicians when speaking about the tension of the string. Some have the idea that Baroque stringing was generally at a lower tension than modern, but this is a myth. I will explain why.

Tension (in Kg) is calculated by the string formula:

$$Kg = \frac{3{,}122}{Ø^2 . \rho^2 \times L^2 . F^2}$$

(diameter) (density) (length) (frequency)

The parameters are diameter, density, length of the string and the pitch (for example A= 440).

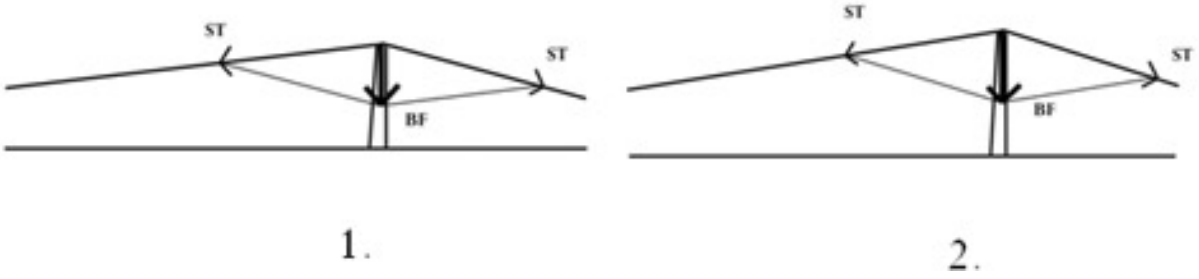
So, changing something in for example the angle of the neck of a violin, or changing to another bridge, makes no difference in string tension. It has no place in the formula. The difference when you change from a modern angled neck to a Baroque straight neck will appear in the *pressure* that the bridge makes on the violin. This is something different. The tension of the string stays exactly the same.

It is true that for some Baroque violin players the tension is lower than those of modern players, but this is because they chose to use thinner strings. If they use thicker strings on the same violin, the tension will be higher.

In fact, much evidence points in the opposite direction: the stringing in the past was sometimes even of a higher tension than that commonly used today on modern violins. From Tartini's experiments with strings we know for example that he was said to have a total of 30 Kg on his violin in 1734 (which translates to an E string of at last .65 mm at A=415). By way of comparison, a Dominant violin set today totals 22 Kg.[3]

This picture illustrates it: Number 1 is a violin with an early baroque set-up and number 2 a Classical violin after Stradivarius. BF is the Bridge Force, the *pressure*.

In the early Baroque set-up BF is about 35% of the ST (string tension) and on the Classical violin about 45%. The string tension is the same.



1. 2.

With this background information, I think we are enough prepared to understand all the interesting information that Mimmo Peruffo will give in the interview.

On choosing your strings

At the beginning of the interview, Mimmo explains me the fundamentals of gut string making.

> **When we have a fresh gut, at the beginning we put it in fresh water to throw out the salt. After this, we need 7 days, sometimes 10 - it depends from the string you need to produce - of different chemical baths. We change the water very fast. And so the gut understands that it is for musical purposes, not for surgical, not for tennis…so we bring the gut in such a direction by chemical treatment. Or, if we need a tennis string, another chemical bath, another direction… If we don't put gut in a chemical bath, the gut will not understand the right way, it will be ok for everything, but not for the best.**[1]
>
> **Chemical baths for musical strings are to obtain more or less two conditions: First, the gut becomes whiter. But that's not so important. Especially, they become more pliable, softer, able to become very elastic at the end. It is very important, because the elasticity is the true background to obtain the best sound. It is the first thing. I have seen a lot of historical documents, this is my job, and so my question is: What values do good gut strings have, what do we call 'a good string'?**
> **A string is very good, when we have these properties:**
>
> - **They last long**
> - **They are very stable to humidity change**
> - **It is possible to obtain a true pianissimo, true fortissimo and every kind of taste in colour with them, to follow the human voice**
>
> **For example, imagine a person who works in the theatre. His face is able to produce every kind of emotion. This is the better string. Vice versa if you don't work in the theatre, you are not able to do. This is the bad string. Or, if you are a painter, if you are Caravaggio, imagine you have a palette… a bad string has only four colours. A very good string has a lot of different colours. If you are Caravaggio, you are able to use a lot of colours to produce *your* work, but if you are Caravaggio and you have only four colours, it's nothing. So, if you are Paganini, but if the strings are very bad in quality: No**

[1] For this essay, I chose to literally quote the words of Mimmo Peruffo. I think his lively way of talking will make very clear to the reader exactly what he means and that a lot of that would be lost if it was reformed into a description, although some sentences may not always contain proper English use of the language.

pianissimo, no fortissimo, no expression…the string does not last long and is not stable under humidity change.

This is clear. I am happy to hear that Mimmo is so focused on the musical properties of the string, together with the practical advantages.

Than, I wonder if the words of Paganini are still up-to-date today:

'I need a favour: to be done with care and solicitude. I am without chantarelles […]. Even if they are very thin, *they must be made of four strands* to endure. Make sure the string is smooth, even and well stretched […]. I beg you to keep an eye on the makers and to do this soon and well.'

Can we choose, order them with you, too, an E with 4 strands?

Yes, I ask it to musicians. If I know that his instrument produces a very high stress for strings, I switch to this automatically. The sound quality is more or less the same, the difference is the string homogeneity: The surface is more homogeneous using 4 strands.

But, is it possible, 4 strands - instead of 3 - with the same gauge of .70?

Yes! Because we start from thinner gut!

So, Paganini, who probably knew well the problem, asked to the string maker to make special strings for him. The standard, for that time, was 3 strands, he asked for 4 strands instead. Due to the fact that he required thin strings in the same time, the normal gauge for the E-string, they needed to search for really thin guts for him. His words were in fact meaning: 'Please, check the thinner guts for me, because I need 4 strands'.

But why? Why did he ask for 4 strands and not 3? Because at that time were not in use the rectifying machines to obtain polished surfaces. So, a string made of 4 strands, is smoother and more homogeneous in surface. I mean, less prone to be false. This was the first problem in that time. Second, a string made of more ribbons is stronger. So the advantages are: stronger and more homogeneous. But the sound is not better than with 3 strands, because at the same twist quantity the 3 strand string is more elastic. But we speak of the violin first string that works at 95% of the breaking stress.

So, Paganini probably preferred to have a stronger and more homogeneous sound than the better sound. This is my explanation.

Can we be sure? I mean, his words were: ‘even if they are very thin, they must be made of four strands to endure’. How can we be sure ‘strands’ means really the whole gut here, if in his time sometimes they split the gut as well?

> **Why I am sure it is not split gut? Because it was the standard technology of Naples. There are several documents that explain that around Paganini’s time gut was not split. For example, De Lalande wrote ‘I was in a workshop in Neaples, I have seen the producing of strings. They brought lamb gut…etc.’ and explained the technology in short. The splitting gut is a very important operation, it is not a thing quickly done under the table, no, it is a very important operation and De Lalande described actually every phase, so we know it was not there. It is almost completely similar to what the old man I told you about, still in live, explained to me [**Mimmo interviewed half a year ago a very old string maker who still remembers some parts of the forgotten skill to produce musical gut strings**]. The technology did not change! The only difference was that at the end of the 19th century, they split the gut in most of the workshops. That’s the only thing, all the rest is the same.**

It’s amazing…for so many centuries! (De Lalande lived in 1760 and this man remembers it from around 1920)

Than I ask Mimmo about the package of strings, found in Genoa, that are believed to be Paganini’s, as I know he did research on them and was one of the first people to see them. Did this find influence his production?

> **My average gauges of the so-called ‘historical violin set’ are now exactly the Paganini ones. Not only because they are of Paganini. Paganini is not important. It’s important because due to Paganini we have strings of that time, with the documents that, as sure as, they are original. This is a fantastic thing, thanks to Paganini.**

So you think they are real?

> **Yes. The Paganini gauges were, more or less, .70 - .88 – 1.16. But remember we work in windows of gauges, it’s more or less. These numbers are for the market, for musicians that work with the background of exact things. But we know that things are very different, and they *were* different in that time. Anyway, these are more or less the Paganini gauges. The .70 was not .70 exactly. I**

remember .71…but we have a little piece of a Paganini string here now… Here it is. This is the E, it's very fragile.

To my surprise Mimmo has a little piece of those strings in his workshop. He keeps it preserved in a little plastic tube and he let me even touch it. How is it possible he could take a piece with him?

The piece was not obtained by cutting the string, but when that person brought me the strings...tack…like a biscuit…

So, check the surface: This is why I consider the half-rectified. Here, now you have a Paganini string in your hands. Look, it's not a smooth surface. You check the fibers…they are not broken.

So they are whole guts?

Yes.

The second thing to do is to check the diameter. Of course the original ones were much longer. We see .69.5 mm, but such a half is not important. Look, another point, .70, another point .71! I mean, there is a range from .69 to .71 in my hands, so my solution is .70 for the market. It is hard to explain to musicians, because when they measure, they say 'oh, but I asked for another and you send me this!'…they don't understand.

The third thing to consider is the colour. Yes, it is very old, but more or less it is a yellow dark colour. So we know that this colour also existed in the late 18th / begin 19th century. This is a medium twist. Not very high twisted, it's obvious, because more twist means less strength and vice versa less twist means the sound is more bad but the string is stronger.

Why do you think Paganini chose only for his top string a medium twist?

Yes, the other two were high twisted. Now, if we work with the violin top string, we work close to it's breaking index. Our work, from all string makers, is to obtain the highest twist possible with at the other hand not too much, because otherwise the sound is great but the string is broken after one hour. Vice versa, if we make a low twist: 'Yes, fantastic, it never breaks!', but the sound…no, and the string produces a whistle tone by the bow, sometimes. They have a kind of glass sound, very poor, not like the theatre man, you remember? So

our goal is to work to give the string the highest twist as possible but with a right safety. When I speak about right safety I don't consider the standard condition of spring. I must consider summer, when humidity is very high, or when it's very cold, these are the situations that the musicians will easily find themselves in. This string is perfect for that.

So, Paganini knew what he was doing…

But how can we, nowadays, make sure we obtain the same possibilities in quality as Paganini had? It is quite common for users of gut strings to open the violin case and to see again a string has broken, sighing 'oh, those gut strings…', or to be in stress tuning the instrument 100 times in a rehearsal, because of the bad weather. Was this normal in Paganini's time, too?

At this point comes the explanation about the start of the 'historical' stringing as an alternative for the 'standard' stringing. As you can read, Mimmo played a big part in that development:

Since I began my work as a scholar, I discovered a lot of things. I started to study the modern [Baroque] instrument problems. I discovered very important documents in Venice, in Florence, in Padua, in Naples, in Rome. A lot of things were never seen before. So I understood one thing:

- **First: Modern gut strings are wrong**
- **Second: Modern baroque gauges are wrong**
- **Third: The modern set-up is not historical**

My conclusion: as consequence, all Baroque performances are a farce, it was not at all like that in the past.

This was very critical for me. It is all a farce…maybe not the performance, not the study of practises how to play, but the set-up, the string, the gauges…everything was wrong. So, that nasal and weak sound that they have is not historical!

This conclusion was very hard. I started to write articles about this matter and immediately I had a lot of people against me. But… 'Hey, guys, here are documents.' When I speak, it's not for Mimmo, I speak for documents that have not the possibility to speak. For example for violin, only for violin, I have 40 documents. You must demonstrate

that these 40 documents are not original. We must re-write the history of Baroque music. I am sorry, this is life…

But Mimmo strongly reminds:

So, Segerman, before me, put *also* very important matter of historical stringing and started to say these things: The gauges in the past were thicker, etc.

Then, he explains to me what the specific features of string produced in the historical way are, based on his discoveries in the old documents:

Well, do you remember what we said in the beginning of the discussion…about a good string? We consider a good string as a string that last long, is stable and has a lot of colours in sound. But the second question is, how can we obtain such a quality from a string? Not too complicated, we follow the historical directions:

- **First: a very high twist, but we prevent this from the top string, because it's closer to a break.**
- **Second: avoid modern substances that make a string harder, for example the aluminium-salt.**
- **Third: the use of potash. It is not important if the potash comes out of plants or from pure chemical salt, the function is the same. You must switch from modern, alkaline solution to potash, that's important.**

John Dowland was the first lute player of Queen Elizabeth, one of the most important musicians in the Elizabethan time. He wrote: 'to obtain the best sound of the lute, your skin must be as soft as possible. We obtain this by putting our fingers in the oil of Tartar.' Oil of Tartar, I discovered it in one document, that is potash. So, the same…only not so concentrated. The skin becomes softer, the gut becomes softer and so, when the gut is softer, the sound becomes better.

The last thing was to check pieces of old strings, and we discovered this: most of the old strings are very soft and flexible. The vibration is very strong [Mimmo demonstrates with the double bass string, sweeping it between two hands, you can feel the vibrations in your thumbs]. If we have a similar modern string, low twisted and with aluminium inside, it produces only a 'tack' and it stops. No vibration.

This is not the sound of a Monteverdi or a Beethoven, this is the sound of stupid ideas!

So, this is why the sound was so nasal, so weak, in modern Baroque performances. But I understand…at the time it was not possible to know more. The information was so little that we were lucky enough that it is possible to play Early Music. When we understood that historical gauges were thicker, people started to employ thicker gauges, but with strings made following the modern technology, so: impossible to obtain the best sound, especially with the d-string on the violin. The bow produces whistles, the sound is hard to produce, and so they told me: 'Mimmo, we follow your ideas, but the strings don't sound, we must work on the technology.' You will be able to use historical gauges if you use historical technology. The strings become more elastic, so it is possible to switch to thicker ones. If you use a stiffer string, it is not possible to use the thicker ones. This is why I fast employed the soft string.

Mimmo brings me a long, dark brown, very thick gut string that curls around. I take it and it feels amazingly supple.

This is very probably a 19th century double bass string. Yes, it is very elastic…Ok, it's very old, so it is also even…stiffer than in that time.

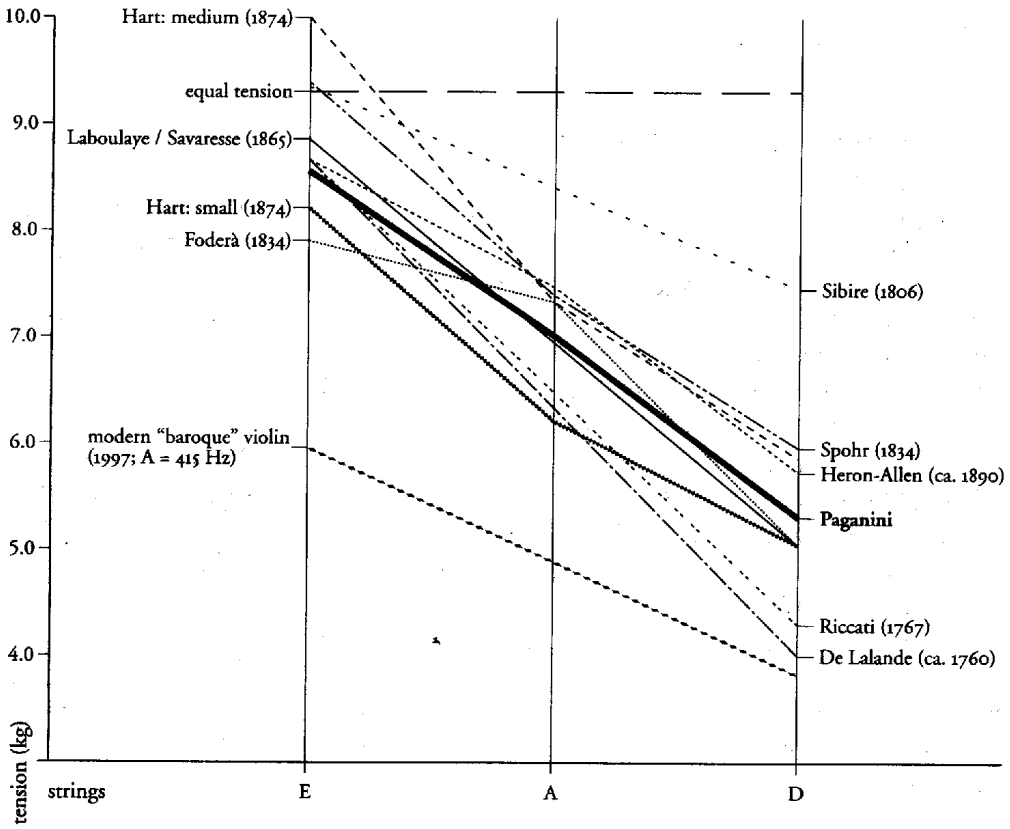
The string feels really soft and flexible. It looks very high twisted, like 70% or something, and I wonder which string from the double bass is. Perhaps the lowest?

No…this is the third, the E… Perhaps for an Italian 'Bassetto' with 3 strings…Dragonetti. This one is 5 mm, more or less.

It's really thick.

Thinking about the difference between modern gut strings and the historical produced ones just explained by Mimmo, I remember a graphic, published in one of Mimmo's articles on the Internet[4] in 2003, that very clearly illustrates the misunderstanding about gauges in the modern 'standard' Baroque stringing.

Mimmo explains:



My intention was to put in graphic the tension profile of the historical information we had, and also one example of a modern set-up. So my problem was: Is it possible to put an example taken out from other string makers? Probably they don't like this, because probably they think it will be a problem for their selling. So, ok, I took my own strings like an example. The question was: light, medium, heavy? Because it is just an example to show the difference between the modern idea and the true historical gauges. At the time, my medium tension was .62, .79 and 1.04 mm. Now, my medium is different, the historical gauges. But then, I knew it was more or less also what happened with the other, modern, string makers. So, ok, this is the Aquila, and the Kurschner and the rest I checked were in that range, so we can consider this as 'the modern idea'.

But how, if you see the Kg at the left, can one know the gauges?

How to calculate tension of the strings? If you take a string, an E for example and you know the Kg, you can calculate the pitch. I will show:

$$Kg = \frac{3{,}122}{Ø^2 \cdot \rho \times L^2 \cdot F^2}$$

(diameter) (density) (length) (frequency)

I consider, as a standard, this: the 3,122. The density is 1,3 for gut, and you have the length (.33 m). F is the frequency for the pitch. So this gives the tension, in kg.

I think I understand. So I try the following question:
And in equal tension, you give every string exactly the same tension in Kg?

I have seen you asked me strings for equal tension…this we have to speak about, too, because it's not historical…anyway, so for example 6 kg for the first string, 5 kg for the second and 4 kg for the third string.

At this point in the interview I did not quite understand this, but later I understand that this 6, 5, 4 kg (examples) will lead to scaling tension, that was the true historical way, not the modern concept of equal tension. This will become clear further in the interview.

First, Mimmo explains the conclusions of this graphic:

These are the conclusions.

First: the modern set-up is not historical. Historical set-ups all appear somewhere in this tube, in this window. This means in the same time that string making was strongly standardized. Not only in Italy, but also in France and Germany!

The second conclusion is about equal tension. As you can see in the graphic, all the set-ups of the old documents were for scaling tension, no one for equal tension.

So we know:

- **The diameters were higher**
- **The tension was scaled**

Sibire is a little exception from the tube, but his information could be not correct, because he was not a musician. So, with the modern set-up we were right for the scaling tension, but the tension itself was much higher than we used.

In this table[5], one can see the gauges, belonging to the graphic discussed before:

Source	E	A	D
De Lalande/Angelucci ca. 1760	.70 mm	/	/
Riccati 1767	.70 mm	.90 mm	1.10 mm
piece of gut string (ca.1770 ?)	.71 - .72 mm	/	/
Fouchetti ca. 1770	.70 mm	/	/
Baud ca. 1795	.70 mm	/	/
Sibire 1806	.70 mm / .73 mm	.98 / 1.03 mm	1.38 / 1.45 mm
Foderà 1834	.66 mm / .70 mm	.92 - 1.03 mm	1.15 - 1.19 mm
Sphor 1834	.72 mm	.92 mm	1.24 mm
Paganini ca. 1840	**.71 - .72 mm**	**.87 - .89 mm**	**1.15 - 1.16 mm**
Delezenne 1853	.61 - .70 mm	.82 - .96 mm	1.02 - 1.39 mm
Laboulaye/Savaresse 1865	.70 mm	.89 mm	1.14 mm
Maugin and Maigne 1869	.63 mm	.89 mm	1.09 mm
Hart 1874	.65 / .72 / .73 mm	.84 / .89 / .90 mm	1.14 / 1.23 / 1.19 mm
Huggins/Ruffini 1883	.67 mm	.90 mm	1.17 mm
Bishopp 1884	.61 / .68 / .69 mm	.80 / .85 / .85 mm	1.08 / 1.16 / 1.19 mm
Heron-Allen 1890	.69 mm	.93 mm	1.22 mm
samples of E strings	.66 - .68 mm	/	/
Aquila corde armoniche	.62 mm	.79 mm	1.04 mm

So it appears that Paganini's gauges, found in the envelope in Genoa, fit exactly in the middle of the tube of set-ups, found in the old documents about set-ups.

Yes, it's fantastic. Another thing: do you see the gauges, and the tension of George Hart? George Hart, in 1874, was the first to put the arranging of the gauges. In this year, strings were made of 3 lamb guts. This range is the range of natural substances and I am very happy, because it is the same as Aquilas. At that time, they had no machines to produce each gauge. You have seen: our gauges are made by machine, but they appear to be the same as Hart describes!

Mimmo continues:

I have to explain you one thing, which is very important. My problem is that I know that gauges of that time existed between .68 and .75, but if I change to such thick strings in one step, I stop to sell strings, because at this point musicians say: 'What? This is crazy!' They don't understand it. So it was a big problem. At one side there are the true historical gauges and at the other side, there are many people who work here, we must sell the strings. My solution: I made two tables on the website, one that explains those are the standard for the modern concept of the Baroque stringing and they are close to the historical ones. And another table, with the true historical gauges. So people are able to choose what they ask.

If they ask for a historical set, I give them the true historical gauges, but most violins are not able to support historical strings, because their set-ups were made by the luthiers to have the best performance for thin gauges. Sometimes it happens that when they put .70, the sound drops, because they need to work on the instrument…to change something, the bridge, the sound post position, all this things, because it is not possible to put the historical gauges on the instrument and play immediately. It needs a short work on the instrument, because the pressure on the table increases.

The best solution, for example, for the tailpiece is this: The angle normally is very high, the pressure is for example 5 kg on the table. If you increase the diameter it becomes 6 kg, but if you put a little piece of wood under the tailpiece, the pressure goes back to the old 5 kg. So the balance is perfect, you have the best balance again, better than before, because the strings are thicker. It is a historical way to solve it, it's one of the solutions that permit to use historical gauges without any problem.

What are your current medium gauges for historical strings?

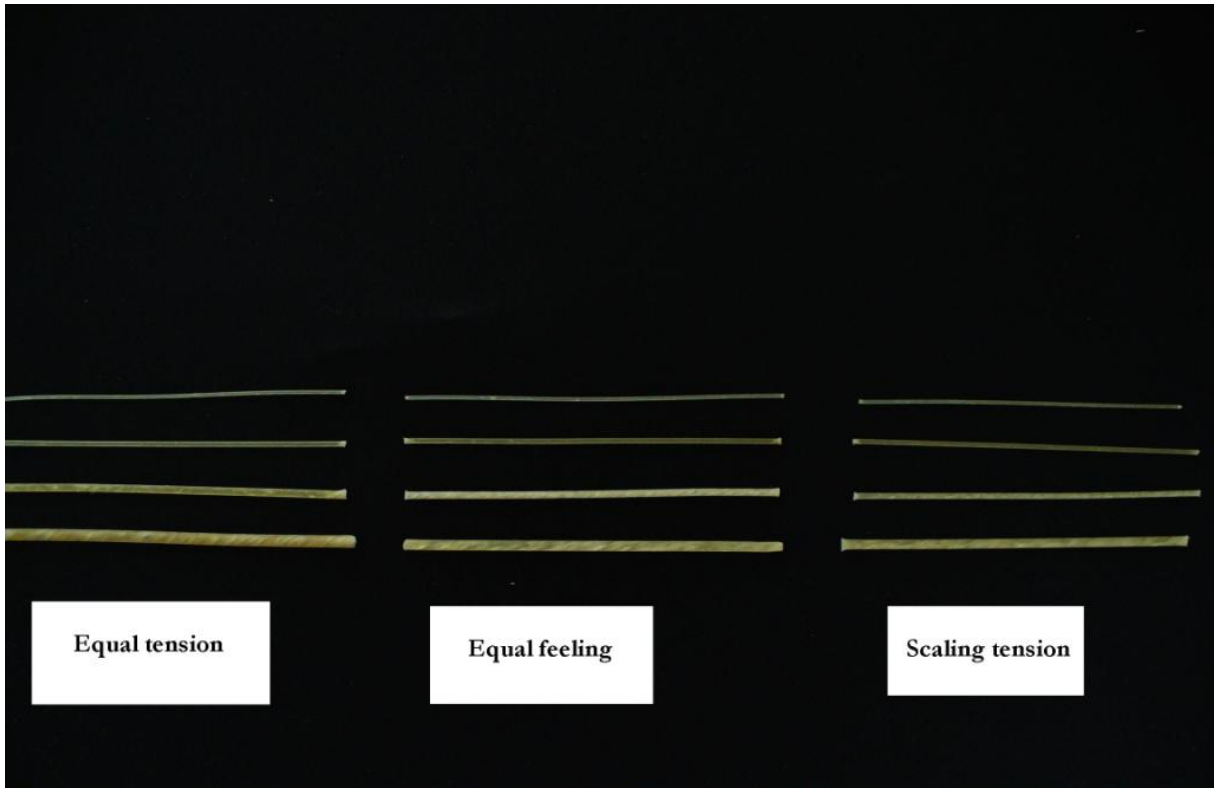
I use the Paganini gauges, because I have seen they stay exactly in the middle of the range [see graphic]. Also because these gauges cover all the range that George Hart describes. I have discovered that Paganini stays exactly in the middle between the 'light' and the 'heavy' of Hart's gauges, and so, this is my solution for the market for historical strings. And I have also, for my safety, the modern idea but with the solution to increase that slowly. So more or less the 'heavy' modern string is the 'light' of the historical strings. So if we have .64 mm, we are already close to the historical situation in any case. Because before, it was .58 only, it is a very big difference from .58 to .64. I am

sure there is no problem if we change slowly from .60 to .64, for example. It would be a problem if we switched to .70 immediately.

But then, if you manage to decide what gauge you like to try for the E-string, what to do with the gauges of the other two strings? What about the relationship between them?

Now Mimmo explained exactly his idea of the equal and scaling tension, as promised before in this interview.

Well, the question of the scaling, did you well understand the question of the scaling tension? It's very important. My information points out that, starting form the beginning of the 18th century, tension was scaling. Why? It is subject to much discussion, because there are different schools. The English school and my school. They are different. Equal tension shows this wide range of diameters, see the first set on the picture:



I don't see this range (the first set in the picture) in the paintings.

The third set is the scaling situation and it is very common in the paintings.

The English believe that in the past there was 'equal tension'. I think that is a mistake. I will show you why.

But in any case, in the iconography it is very hard to find an equal tension situation, because normally we see the transition [of the diameters in the strings on the painting] **going very slow. You see for example here:**

You see? This low string is not so thick.

So, first, I don't agree with George Stoppani, who suggests for the violin 4th string a 2.5 mm. Now I *ask* you to play violin with a double bass first string, on only 30 cm long…they do not work, it's very hard. Sigiswald was trying it, because in the beginning they followed this way, and he had more or less a 5 mm gut string on his C viola da braccio!

Then, one of the women who work from Mimmo brings a paper.

Look, here comes a new email. It's a new customer, it's interesting. This customer starts to order for violin a .60 E-string.

At the moment there is a very interesting situation in Europe. There are exactly two worlds with a wall in the middle, the historical one and the not-historical. There is a sort of a battle here. But, it's not possible that the not-historical option is in the first place, because the sound is not good. Many people still order in the old system, from .56 -.60, maybe .62 mm. The others order from .64-.74 mm for an E-string.

If you are the Spalla of a baroque orchestra, you use this, (the not-historical) very thin strings, you are covered by the rest of the violins!

I have seen the situation in Vicenza, they played J. S. Bach Passion. The sound of the violins is back, with the historical gauges. Much more powerful than the Spalla, because they use such thin strings. But this was a really deep, nice sound. So it is very critical. I know that slowly they will switch to use historical strings. But when they put immediately bigger gauges, after a week the violin will go down, because there is a problem. This is why I made the FAQ on the website, because sometimes they say: 'oh, it does not sound…' and they come back. No, it is not so easy! You must work, you are a professional, you must know everything about your instrument. So I have made such suggestions.

After this, Mimmo returns to the equal tension and explains why equal tension is not historical.

Tension means Kg. The first source that wrote about Kg, is of 1870, more or less. It is the method of Maigne from the opera in Paris. Before this age, nothing is written about Kg, but there is written about the feeling of Kg, better: feeling of tension. That is not properly the tension like we know.

Well, 'moderns' believe that the equal tension is the same as equal feeling, but this is wrong. Why?

When you have two strings, one of .70 and one of 1 mm, if they are on 10 Kg each, they give also the same feeling, it is correct. But this is true only, when they are already stretched into tension! Moderns, instead, make the calculation by calculator, in strings that are *not* already in tension, but still in the envelope.

I put an example:

10 Kg ----------.70 mm 8%
10 Kg ----------1.00 mm 3%
10 Kg----------1.45 mm X
10 Kg----------2,50 mm X

At these gauges, all strings produce by calculation 10 Kg. But, when you put them in tuning, the higher strings will drop in its gauge, because of the stretch. The E-string will drop around 8% and the A-string 3%. The D- and G- string will drop practically nothing. So, the tension is not equal anymore, like in the beginning. It became scaling in vice versa. Because of the scaling, the feeling is different. So you check, the E-string is not 10 Kg, but less. So it's not historical, because the feeling is different. This is why the equal tension, by calculation, is wrong.

To obtain the same tension after tuning, we must start from a scaling tension, to compensate for the stretching. You start for example from 12 Kg for the E, 11 Kg for the A and 10 for the D and G. When they are in tuning, the E drops 8%, becomes 10 Kg. The A drops 3%, becomes 10, and the others stay 10 Kg. The true equal tension is the same as equal feeling.

My documents suggest .70, .88, 1.16 mm if you play music after the beginning of the 18th century. If you need to play 17th century music, early 17th century especially, I suggest you the equal feeling, for

example .70, .95, 1.32 mm, because every source works in matter of feeling. The gauges .70, 1.04, 1.60 mm (the calculated equal tension) I consider wrong. It produces a lot of problems for musicians of the Northern Europe, because it is wrong. The 1.60 mm for a D-string simply not functions!

This is really nice, practical advice. But I still wonder, if we play music from Paganini's time, does it make no difference if we choose the same stringing as for music from the 18th or from the 19th century? Was the situation so stable?

I ask if Mimmo knows if there was any difference in stringing between the time that Paganini was a child (1790) and when he died (1840). He answers firmly:

Nothing. Documents show that string making did not change, it was uniform, no innovation. I know it is strange, but between 1750-1890 the strings changed nothing, the string technology stayed exactly the same. It went from father to son, and so on. Animals were the same.

The only thing that we know is that the French switched to use lamb, more or less around 1830. Before that year, it was forbidden by the government in France to kill lambs. The tradition in Naples and Rome was on the contrary to kill these young animals for cooking. In France they killed only older moutons, so they had only thicker guts and that's why they used only two strands and the quality was not so good. The French government established money and a golden medal for the string maker who discovered the secret of the good Neapolitan gut violin chantarelles. Savarez was the first (he was in origin from Neaples) and obtained the money, because the secret was to use lamb guts. After this year it became allowed to kill young animals, but not only for strings, nobody kills an animal for strings. First, they killed them for food and secondary you have material for your use.

At the end of the 19th century the Italian production started to drop and the French lifted. In Germany they improved the quality, enormous production, cheaper prices, but the strings were not so good as the Italian and French strings, because they were stiffer and made in a fatter way. They had almost 500 string makers, an enormous quantity. The area were they bought gut was very large, even from China, because Germany was not sufficient to give them enough. I imagine that those strings were at a cheaper price, for people who play just for fun, or for little orchestras, but not for professionals. Professional players most frequently asked for Italian production, but in that time, London for example, sometimes

Germany produced false Italian strings, because of the prices…like nowadays. Nothing has changed.

What do you think: when Paganini went away in 1820, for a 6 year tour, he did not take from Naples for six years strings with him, did he? Do you think he just bought strings in the country where he played?

I don't know…I think that Paganini was for the better production, in a way, because his performances needed a better quality. All documents that I have show that Neapolitan production was the most preferred, maybe also the stringmakers of Padua. Because in that time Padua became on the second place, interesting, and they stopped in 1911 to produce quality strings because several people who worked there died, and so, in the end there were 2 or 3 women, and after a while they stopped to produce strings and the Paduan tradition, that started in 1613, stopped. I have documents from when they closed.

I know that Paganini asked for Neapolitan gut. Maybe also Paduan, but I am sure Neapolitan. I have no information about different suppliers. I have read his letters about his strings and also about the 4th string, because that one was not made by the string maker but by luthiers. The musician gave to him a second string and the luthier covered it with silver wire. In Milan, Paganini wrote about that. So we know that Paganini used three gut and the 4th was wound, a common tradition.

And what do you think about the pitch in the different countries where he played? Was it not a problem for the strings? Or did he stick with his own Italian pitch in concerts?

The question of pitch is a big problem, because I have seen it ranged from 430 till 470 hz. But I think it was not a problem for him. I don't know what solution he had, but I know strings were sold not as one single string in one envelope, but in a bundle of 30 strings in a very big envelope. On the envelope you could see the number 3. What does that mean?

They are all made of 3 guts. If the number was 5, they were made of 5 guts. The problem is, imagine you live in 1838 now. You have no micrometer; you have nothing, just the violin. You open your envelope nr 3, so you have 30 strings of 1,5 meter, more or less, because that was the way. First problem: they were hand polished, so it is clear it was not possible to just take one string and put it on the instrument. No…you must check, like I showed you, the good, the middle and the bad strings. The bad strings you throw away. The middle quality you use for your study, and the better for concerts, for high quality performances. It's very clear described in some documents, it's like horses: you employ the better horses for the best performance. The second question is: Ok, now I must try out the right gauges. You select the small, the medium and the heavy, because they all were different. You know: this one is perfect for you, this one not. In this point, on 30 strings, you have if you are lucky 6, maybe 4 good gauges. 10, 20, sometimes 40% are not good. So at the end you have very few strings for the best performances. Some are too thick, other too thin for your violin. Ok, too thick, no problem, I use these for the best performance; maybe you can exchange some others with your friend who likes thinner strings for his instrument. So, at the end, at 30 strings probably you have just 5, maybe 7 of not false strings *and* the right gauge. The rest are for study or for exchange. This was the situation.

So I imagine, when Paganini went to play in London, in general they had 460 as a pitch. He could have been saying: 'O, I remember I have this gauge! I will put it on my violin if I need to play together with the English musicians.' Like nowadays: if you play in Paris, because they are crazy for 392 nowadays, you switch from gauge .66 to gauge .70.

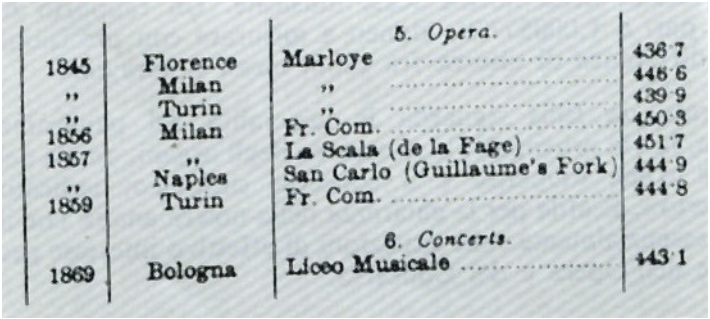
So, no problem, you put one step thicker strings and you have the same feeling. And for higher pitches vice versa. Maybe you must play on a modern pitch? Than you can use the same gauges, or better you switch to thinner ones for the occasion and you return back when you are finished. This is the solution. *Or* you change the bridge position, if you have no panic. In the past, before the middle of the 17th century, it was no problem to change the bridge position. 'I am in Venice, I go to Rome were there is a lower pitch? No problem, I take the bridge closer to the tailpiece, this compensates everything and I play easily the one tone lower pitch they you there.' They did it frequently.

As I ordered exactly the same strings as Mimmo is convinced that Paganini was using, to try how his caprices will sound in this way, but how to tune my violin? So my next question is: which pitch was used in Genoa around 1800?

I am not sure. Segerman confirmed that in the 19th century in Italy the pitch was higher than in the other countries, normally. It became lower in 1859, when France made a law in which they said: 'Ok, started from today, all pitch in France must be between 440 and 435 hz.', but after one year they went up one semi-tone already. This situation of confusion was the same in whole Europe.

Giuseppe Verdi, in Italy, wrote to the Italian government of the time: 'Please, I don't like such very high pitch, because my singers become crazy, so I suggest a law to drop the pitch like the French do.'
But nothing happened. In the end of the 19th century, 1880/1890, the first convention in all European states decided to stay at the French pitch of 435 hz. It was the standard, more or less. The last convention was at the beginning of the Second World War, in 1939, where is written: 'starting from now, the pitch must be modern, 440 hz.'

These tables show that it is not possible to draw sure conclusions. But note that frequently the pitch was higher than the modern pitch now is:



		5. *Opera.*	
1845	Florence	Marloye	436·7
,,	Milan	,,	448·6
,,	Turin	,,	439·9
1856	Milan	Fr. Com.	450·3
1857	,,	La Scala (de la Fage)	451·7
,,	Naples	San Carlo (Guillaume's Fork)	444·9
1859	Turin	Fr. Com.	444·8
		6. *Concerts.*	
1869	Bologna	Liceo Musicale	443·1

		5. Opera.	
1752	Berlin	Marpurg, Fr. Com.	421·9
1806 —14	,,	Wieprecht, Fr. Com.	430·5
1822	,,	Fischer's Pichler's fork	437·3
1830	,,	Wieprecht, Fr. Com.	440·0
1834	,,	Scheibler "trustworthy"	441·8
1857	,,	Taubert	448·4
1858	,,	Wieprecht, Fr. Com.	450·8
1859	,,	Fr. Com.	451·8
1861	,,	Näke	451·5
1869	,,	Sent to Society of Arts	435·5
1815 —21	Dresden	Näke's Fork of Weber's time	423·2
1826	,,	Reissiger	435·0
1859	,,	Fr. Com.	441·0
,,	,,	Näke, during performance	446·0
1862	,,	Fürstenau's official Fork	437·8
1869	,,	Sent to Society of Arts from Leipzig	438·9
,,	,,	Rietz's Fork (probably an error)	449·4
1878	,,	Jehmlich's Fork	439·4
1859	Brunswick	Fr. Com.	443·5
1859	Carlsruhe	,,	435·0
,,	Gotha	,,	443·3
,,	Weimar	,,	444·8
1859	Stuttgardt	Fr. Com.	443·0
,,	Munich	,,	448·1
1869	,,	Sent to Society of Arts	436·1
,,	Baden	,, ,,	434·5
,,	Würtemburg	,,	436·9
1879	Hamburg	Opera, under Krebs	448·0
		6. Concerts.	
——	Hamburg	Old Orchestral Pitch	445·0
1859	Leipzig	Conservatoire, Fr. Com.	448·8
,,	Würtemburg	Fr. Com.	444·8
1869	Leipzig	Gewandhaus, sent to Society of Arts	448·2

		5. Opera.	
1823	Vienna	Näke (Euryanthe)	437·5
1834*a*	,,	Scheibler I.	433·9
,,	,,	,, II.	436·5
,,	,,	,, III.	439·4
,,	,,	,, IV.	440·3
,,	,,	,, V. (Blahetka)	441·1
,,	,,	Scheibler's Streicher's Fork	443·2
,,	,,	Scheibler VI. (monstrous growth)	445·1
,,	,,	Vienna Old Sharp Pitch	456·0
1862	,,	Näke, sharpest	466·0
1878	,,	Ullmann	446·8
1859	Pesth	From Fr. Com.	446·0
,,	Prague	,, ,,	449·8
		6. Concerts.	
1845	Vienna	Marloye (Conservatoire)	445·4

		5. Opera.	
1752	Berlin	Marpurg, Fr. Com.	421·9
1806 —14	,,	Wieprecht, Fr. Com.	430·5
1822	,,	Fischer's Pichler's fork	437·3
1830	,,	Wieprecht, Fr. Com.	440·0
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1858	,,	Wieprecht, Fr. Com.	450·8
1859	,,	Fr. Com.	451·8
1861	,,	Näke	451·5
1869	,,	Sent to Society of Arts	435·5
1815 —21	Dresden	Näke's Fork of Weber's time	423·2
1826	,,	Reissiger	435·0
1859	,,	Fr. Com.	441·0
,,	,,	Näke, during performance	446·0
1862	,,	Fürstenau's official Fork	437·8
1869	,,	Sent to Society of Arts from Leipzig	438·9
,,	,,	Rietz's Fork (probably an error)	449·4
1678	,,	Jehmlich's Fork	439·4
1859	Brunswick	Fr. Com.	443·5
1859	Carlsruhe	,,	435·0
,,	Gotha	,,	443·3
,,	Weimar	,,	444·8
1859	Stuttgardt	Fr. Com.	443·0
,,	Munich	,,	448·1
1869	,,	Sent to Society of Arts	436·1
,,	Baden	,, ,,	434·5
,,	Würtemburg	,,	436·9
1879	Hamburg	Opera, under Krebs	448·0
		6. Concerts.	
——	Hamburg	Old Orchestral Pitch	445·0
1859	Leipzig	Conservatoire, Fr. Com.	448·8
,,	Würtemburg	Fr. Com.	444·8
1869	Leipzig	Gewandhaus, sent to Society of Arts	448·2

		5. *Opera.*	
1810	Paris	Grand Opera, Drouet	423·0
1811	,,	,, Scheibler	427·0
1819	,,	,, Cagnard de la Tour	434·0
1822	,,	,, Fischer	431·7
1824	,,	,, lowered for Branchu	425·8
1829	,,	,, recovered Pitch	434·0
,,	,,	,, Cagnard de la Tour	438·0
,,	,,	,, Orchestral Pitch	440·0
1830	,,	,, Drouet	430·8
,,	,,	,, ,,	435·8
1834c	,,	,, Scheibler's Petit-bout	434·0
1836	,,	,, Cagnard de la Tour	437·0
1836—9	,,	,, Delezenne's Leibner	441·0
1854a	,,	,, ,, Forks	437·4
,,	,,	,, ,, Pleyel	440·5
,,	,,	,, ,, Reeds	448·3
856	,,	,, Lissajous & Ferraud	449·0
1856	Paris	Grand Opera, Pianoforte-makers' Fork	446·2
,,	,,	,, Bodin's Fork	445·8
1858	,,	,, French Commission	448·0
1823	,,	Italian Opera, Fischer	424·2
1829	,,	,, Cagnard de la Tour	435·0
1836	,,	,, ,, ,,	437·0
1854	,,	,, Delezenne's Reeds	442·5
1856	,,	,, Bodin	447·4
1820	,,	Opéra Comique or Feydeau, Conservatoire	423·0
1823	,,	,, Fischer	427·6
1829	,,	,, Cagnard de la Tour	438·0
1836	,,	,, ,, ,,	441·0
1854	,,	,, Delezenne's Reeds	448·0
1859	Bordeaux	Provincial Opera, Fr. Com.	443·6
1848 & 1854	Lille	,, Delezenne	450·5
1859	,,	,, French Commission	452·0
,,	Lyons	,, ,, ,,	448·0
,,	Toulouse	,, ,, ,,	442·5
		6. *Concerts.*	
1636	Paris	Mersenne, Ton de Chambre	563·1
1812	,,	Conservatoire, Museum Fork	439·5
1834a	,,	,, Scheibler	435·3
,,	,,	,, ,,	440·9
,,	,,	,, Scheibler's Gand	435·2
1856	,,	,, de la Fage	446·2
1815	,,	De Prony (iron wire)	438·2
,,	,,	,, (brass wire)	444·5
1859	Toulouse	Conservatoire, Fr. Com.	437·0
,,	Lille	,, ,,	452·0
,,	Marseilles	,, ,,	447·0

As the strings of Paganini, probably together with hundreds of thousands of other strings in that time, were made of unsplit strands, I ask the last curious question:

Did you ever try to produce strings made of whole gut?

> **I made some cello strings, made of whole gut. Strange, but the sound is dull. I never understood why. I have done a lot of tests…but strange: the gut was from very high quality, very thin tube, fantastic material. The strings were so soft, so well twisted, but the sound is not open. Why? I was so astonished, and the musicians also. It's without overtones, the sound is not deep. Strong but not full. My explanation**

is that maybe inside the tube there is a little quantity of potash that does not go out. Maybe it works as a damper.

But in the past they could do it without any problem?

Yes, maybe there is some secret in the production.
Astor [the old string maker, Mimmo interviewed him] **was born when they already switched to split gut, so the older technology was lost. Maybe they washed the gut inside. My next experiment is to check that. One string without any change and one string washed inside, to hear the difference. If the difference is strong, ok, I have a good explanation, and that will be my next discovery. But if it doesn't work, I don't know… This work is very strange sometimes. Sometimes we must ask ourselves 'are you stupid or not?' Really…**

Conclusion

For me, Mimmo Peruffo's explanations about how stringing in the early Romantic era could have looked like are very convincing.

Since I did the interview, almost three weeks ago, I have been using these 'historical' strings on my violin. I chose exactly the same gauges as the strings of Paganini (.70, .88, .116 and a silver wound gut G-string of medium thickness). At the moment I am very happy with the result: my violin (an original 18th century Italian violin, made by Paolo Testore in 1750 in Milano, which is lent to me by a sponsor) seems to accept the thicker strings – and higher tension – without any problem. The instrument was restored to Baroque condition but with a slightly longer fingerboard for the Classical and early Romantic repertoire about half a year ago. The sound with these strings is deep, warm and the violin is resonating much more than with the 'modern' standard gut strings I used before.

It seems natural to me having copies of Paganini's strings to try some of his music, and I have been trying to play some of the Caprices for solo violin. One of the most revealing results was that the harmonics work much better than on metal strings: they are easier to find and sound much stronger than on a modern violin, which is very nice to hear. The articulation on the D-string is different than on modern 'standard' gut strings: just like Paganini I used a high twisted D- and A-string, which means that especially the thicker D-string responds a little slower to the bow, and perhaps a heavier bow would help to compensate for this. Apart from the fact that I was 'cheating' using a chin rest (this was invented in 1835, so Paganini did not use one), the shifting of the left hand is still more difficult than on a modern violin because gut has much more resistance to the skin of the fingers than the smooth metal, especially using thicker strings. But it was nice to feel how this probably felt for Paganini, although there is still an element of the super-natural about what he seems to have been able to achieve!

Sigiswald Kuijken, who started his experiments 40 years ago using harp strings on his violin, has heard me play using these strings, and he was very happy with the results.

However, I am interested to hear which reasons the followers of the English school have that leads them to believe that we should really use a calculated equal tension on our instruments, and I would like to try this in practise.

I would recommend every string instrumentalist to try at least once these historical produced strings, in equal tension or not, to compare them with the

strings they are used to. I have found it a very interesting experience and I think there is a big chance that other players would like the sound better.

As period instrumentalists in 2007, I think we should keep searching for information about the origin of the sound of our instruments. There is still much to discover, as is apparent from the last paragraph in the interview. The process does not finish with the work our teachers have done before us.

I am very impressed by the work Mimmo Peruffo does to rediscover the old way of producing gut strings, providing us, musicians, with many new possibilities. He took a whole day to show me the complete process and tell me all I wanted to know about the history of gut strings. In fact, in this essay I have reproduced only a small part of the original interview. I would like to take this opportunity to tell him I am very grateful that he was willing to share his time and knowledge with me in such a welcoming way.

Esther Visser

March 2007, for the Abbaye aux Dames, Saintes
Centre Européen de Reserche et Pratique Musicales

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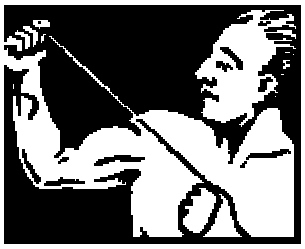
List of gut string makers[6]



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Notes to pages 1-37

[1] Edward Neill: *Nicolo' Paganini; Registro di lettere, 1829,* Graphos, Genova 1991, p.80
[2] Oliver Webber: *Strings* www.themonteverdiviolins.org
[3] Oliver Webber: *Strings* www.themonteverdiviolins.org
[4] Mimmo Peruffo: *Italian violin strings in the 18th and 19th cenuries,* Vicenza 2003 (updated version)
[5] Mimmo Peruffo: *Italian violin strings in the 18th and 19th cenuries,* Vicenza 2003 (updated version)
[6] This list comes from: www.vanzandtviolins.com