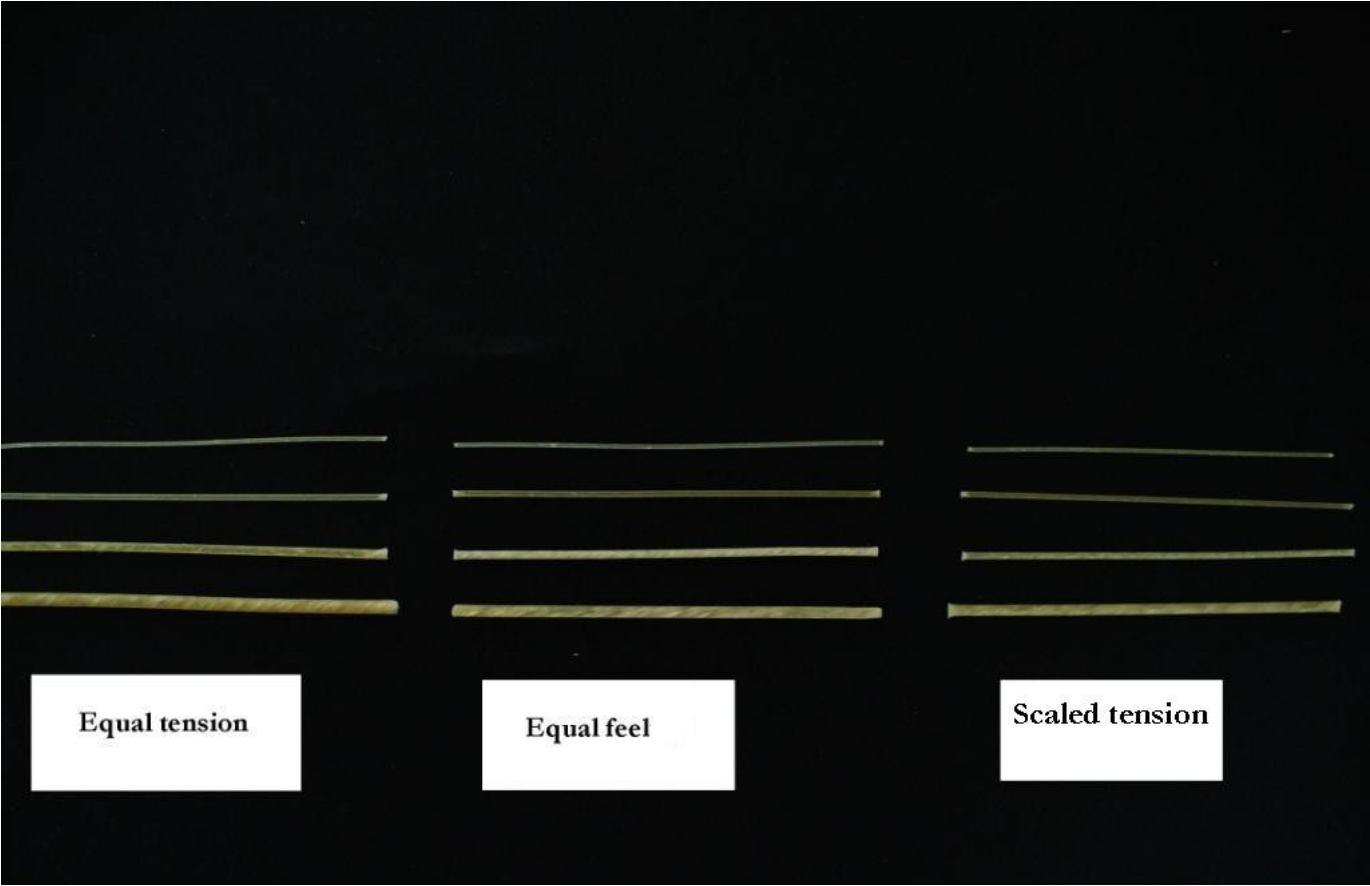


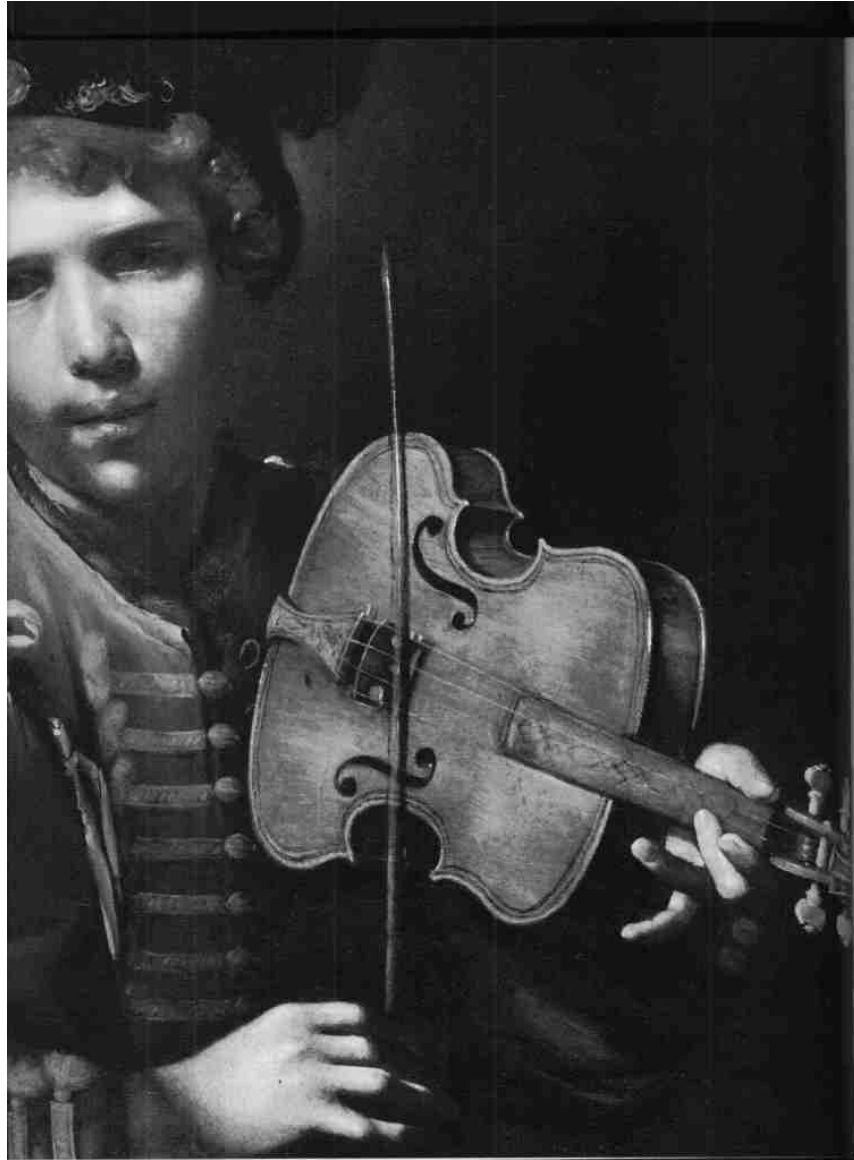
# Equal tension, equal feel and scaled tension



Violin string tension profiles



Anonymous 17th C. dutch painter; detail of a Violin. Equal tension, equal feel or scaled tension?



17th C. paint: detail of a Viola. Equal tension, equal feel or scaled tension?

The 17th, and especially 18th and 19th century violin-stringings do not at all lead to stringings with a system of *equal tension* but instead to one of the *equal feel* for the 17th C. and *scaled type* for the following two centuries (for comparison, an arrangement in equal tension, starting for example from a chanterelle **E of 0.70 mm**, would give the following diameters: **E = 0.70 mm, A = 1.05 mm, D = 1.60 mm,** ).

Today it is commonly held that a correct stringing for the violin (or for another bowed/plucked-instrument) must have all the strings **at the same tension** (in other words, with **the same kg**), but in fact this is not at all how things stand.

Before pursuing the analysis of the documentation we must therefore tackle this fundamental point, for it affects the way we reconstruct the stringings of all the plucked

and bowed instruments of the Renaissance and Baroque ages especially – not only the violin.

Let us begin our discussion of this subject with the concept of *'tactile sensation of stiffness'*. For it needs to be stressed that when a musician applying the pressure of his fingers evaluates the tension of the strings of his instrument, he is actually not evaluating the kg of tension at all, but instead **the sensation of tension**, which is quite another matter.

It comes natural to ask what criteria were used to evaluate a stringing in the past. This, for example, is what certain **seventeenth-century treatises** write about the lute (anyway, the same considerations must be applied with the bowed instruments):

*"Of setting the right sizes of strings upon the lute. [...] But to our purpose: these double bases likewise must neither be stretched too hard, nor too weake, but that they may according to your feeling in striking with your thombe and finger equally counterpoysse the trebles"* (John Dowland in 'Varietie of Lute Lessons', 1610).

*"When you stroke all the stringes with your thumbe you must feel an even stiffnes which proceeds from the size of the stringes"* (The Mary Burwell Lute Tutor, 1670 ca).

*"The very principal observation in the stringing of a lute. Another general observation must be this, which indeed is the chiefest; viz. that what siz'd lute soever, you are to string, you must so suit your strings, as (in the tuning you intend to set it at) the strings may all stand, at a proportionable, and even stiffness, otherwise there will arise two great inconveniences; the one to the performer, the other to the auditor. And here note, that when we say, a lute is not equally strung, it is, when some strings are stiff, and some slack"* (Thomas Mace in Musik's Monument 1676).

From the treatises of the XVII century one deduces therefore that the criterion for choosing the right string 'tension' in a given stringing responded above all to principles of empiricism: the strings were expected to be neither too tense nor too slack but to have a *just* degree of tension; and what is important, this tension was expected to be **evenly** distributed among all the strings. It goes without saying that any judgement of the degree of tension is merely subjective. A different matter, on the other hand, is the search for **evenness of tension** between the strings, which is the true, shared criterion of reference.

**In conclusion, when the early documents use the words *equal tension* (and we find them until at least the end of the eighteenth century) they consistently mean *equal feel* and not equal kg, as instead is commonly done today.**

A pertinent example is the following passage from Galeazzi (1791 year): *"la tensione dev'esser per tutte quattro le corde la stessa, perchè se l'una fosse più dell'altra tesa, ciò produrrebbe sotto le dita, e sotto l'arco una notevole disegualianza, che molto pregiudicherebbe all'eguaglianza della voce"* (the tension must be the same for all four strings, because if one were more tense than another, that would create under the fingers, and under the bow, a considerable

inequality very prejudicial to the equality of tone).

Here tension clearly means feel; as is equally plain in Bartoli's treatise: "*Quanto una corda è piu vicina al principio della sua tensione, tanto ivi è piu tesa. [...] Consideriamo hora una qualunque corda d' un liuto: ella ha due principj di tensione ugualissimi nella potenza, e sono i bischieri dall'un capo, e '1 ponticello dall'altro; adunque per lo sopradetto, ella è tanto piu tesa, quanto piu lor s'avvicina: e per conseguente, e men tesa nel mezzo*" (The closer a string is to the beginning of its tension, the tenser it is. [...] Just consider any lute string. It has two beginnings of tension that are absolutely equal in power: the pegs at one end, the bridge at the other. As a result, it will be tenser the nearer it is to those points and less tense in the middle) (17th c).

To try and give some kind of **scientific expression** to the concepts of 'even stiffness', 'equally strung', etc. described in the treatises is in itself a somewhat complex matter, both because there is no conclusive proof that by 'feel' they all meant the same thing and also because that 'feel' can be also understood in a, so to speak, *broader* sense.

A preliminary distinction (when evaluating the degree of 'tension') can be made, for example, by deciding whether in pressing down on the strings it is directly the fingers or the bow hairs, for in the latter case the thicker strings can oppose more resistance to the rubbing movement, thereby giving the musician the sensation of a certain unevenness. To resolve this specific problem the use of scaled tension was justified on the violin by Plessiard (mid XIX C.).

In the likely hypothesis that it is the fingers (and not the bow) that are required to assess the tension of the strings, we can again understand 'feel' in at least two ways. The first (that commonly accepted, by the present writer as well) considers the effort required to impart a certain measure of lateral displacement to a string, which obviously opposes the pressure exerted. If we replace the finger with a weight acting at the same point, we can exactly measure the quantity of lateral displacement for every string examined. The second hypothesis considers that a thinner string, which digs more deeply into the finger tip pressing down on it, would produce a greater *sensation* of tension than a thicker string, which, having a wider surface, does not 'dig into' the finger to the same extent. According to this second interpretation, therefore, 'equal feel' involves more tension in kg in the thicker strings than in the thinner. However, we have never yet had practical evidence that the bass strings have more tension than the higher ones.

Let us therefore examine the first hypothesis better: in other words, that which considers 'feel' to be the sensation of resistance given by a string pressed by the fingers and 'equal feel' to mean that this sensation is the same also for tuned strings of different diameters; in other words, that when the same weight acts at the same point, the lateral displacement encountered is the same. The vibrating length obviously has to remain constant.

According to the laws of physics such a conception of *equal feel* corresponds exactly to a stringing of *equal tension*. That is true, however, on condition that the initial diameters of the strings (as measured with the strings not yet mounted) remain unvaried even after they have been tuned, i.e. under tension. In practice, however, and especially with gut, **this never happens**: once the strings have been tuned to the required note, their respective calibres have diminished in different ways. This happens because the material possesses a certain longitudinal strain which is related also to the diameter (which in gut is divided into recoverable strain and non recoverable strain: in practice once a new string has been placed under tension, it no longer reattains its initial diameter at rest). This reduction of calibre will therefore also imply a corresponding *reduction* in working tension. It is observed that the thinner strings lengthen more and hence diminish in calibre by a greater percentage than the thicker ones (it is generally known that the thinner strings require many more twists of the peg than the thick ones). And so it also follows that, after tuning, the respective working tensions (established as identical to start with) will no longer be equal but scaled: in other words, the thinner the string, the lesser the tension.

As a result, therefore, the 'feel' between the strings is no longer *equal* (because the tensions are now different) but instead unbalanced in favour of the thicker strings. In other words, on the thicker strings more pressure from the fingers is needed to obtain the same quantity of lateral displacement as on the thinner ones.

Hence according to the laws of physics, if the tensions are not equal, nor is the lateral displacement; nor, therefore, is the feel even.

## EXPERIMENTAL

## TESTS

As an example, we tested two gut strings of medium twist calculated to have the same tension (8,3 kg at a pitch of 440 Hz) when brought to the required pitch (the violin 'E' and 'D' in this case). The vibrating length is obviously the same for both (33 cm). We obtained calibres of .65 mm for the 'E' and 1.45 mm for the 'D' when measured at rest, i.e. not under tension. Once they had been tuned and stabilized, we proceeded to measure their diameters: the calibre of the 'E' had reduced to .62 mm, whereas there was no noticeable drop in the 'D', even when measured by a micrometer. Hence while the thinner string had diminished in diameter by 5%, the thicker string be considered as unvaried for practical purposes. These values are of an experimental type: which means that strings made in different ways may provide different percentages of reduction. The constant factor, however, is that – manufacturing techniques being equal – it is always the thinner string (i.e. the chantarelle) that contracts more. In our case the tensions of the strings stretched on the instrument reduced to 7.6 kg on the 'E' and 8.3 kg on the 'D' compared to a calculation value of 8.3 kg in both cases.

In order to have 'E' and 'D' strings that retain the kg decided on initially when tuned to pitch, one must therefore **increase** the initial gauge of just the 'E' by 5%, i.e. .68 mm. When making the traditional calculation to obtain the tensions of this second

pair of strings 'at rest' one detects a trend of the scaled type: namely 9.2 kg for the 'E' string and 8.3 kg for the 'D'. To sum up: the experiment shows that calibres of .65 and 1.45 mm lead only to a *theoretical* state of equal tension; conversely, if one uses diameters of .68 and 1.45 mm, once the strings have been tuned (i.e. in traction) they will assume a new, and more reduced, diameter situation, such as would exactly produce equal tension, i.e. *equal feel* of the XVI and XVII centuries.

This situation was in fact verified – always with the assistance of a micrometer – in a second experiment carried out on this second pair of tuned strings.

If one wants a stringing of equal feel, it is therefore necessary to use criteria of scaling when selecting the diameters of strings 'at rest' (i.e. not in tension). As mentioned earlier, one advantage of scaled tension is that the increasing attrition encountered when moving the bow from thin to thick strings (because of the larger contact surface) is much less noticeable.

**If we respect the condition that there should be equal tension between the various strings at pitch, one concludes that scaled tension and equal tension (measured at pitch) express the same thing: equal feel.**

Although the test reported in the first version of this article (in *Recercare* IX of 1997) produced substantially correct results, the interpretation of the data turned out to be wrong. The same consideration applies to another example cited there: that of an elastic band and steel string whose diameters were calculated to have the same tension values to start with. When tuned to the same pitch, only the elastic band will reduce considerably in section to assume a new, lower state of tension, in contrast with the *unextendable* steel string. At this point, therefore, the feel will be different.

Let us now turn to the cases of Serafino Di Colco and Leopold Mozart.

Di Colco writes: "*Siano da proporzionarsi ad un violino le corde [...] distese, e distirate da pesi uguali [...]. Se toccandole, ò suonandole con l'arco formeranno un violino benissimo accordato, saranno bene proporzionate, altrimenti converrà mutarle tante volte, sin tanto che l'accordatura riesca di quinta due, per due, che appunto tale è l'accordatura del violino*" (The strings are to be proportioned to the violin [...] extended, and stretched by equal weights [...]. If by touching them or playing them with a bow they form an excellently tuned violin, they can be considered well proportioned, otherwise you will need to change them as many times as necessary to obtain fifths between pairs of strings, which is precisely the tuning of the violin).

The scholar Patrizio Barbieri believes that in all likelihood these considerations are purely speculative. Mozart, on the other hand, drawing on the same concepts, suggests attaching equal weights to each pair of strings: if the diameters are well chosen, the open strings will give fifths; otherwise the diameters will need changing until that result is obtained.

-The cases of Mozart and Di Colco can lead to a certain interpretative confusion. Indeed it has been attempted to conclude hastily that they are stringings in **equal tension**: as if they had been worked out by 'sitting at a desk', so to speak, i.e. based on formulas.

Appearances, however, are misleading. The test recommended by Mozart takes place in conditions of equal weights (i.e. equal tension) that **already** work on the strings. This situation therefore does not at all replicate that of apparent 'equal tension' obtained by means of calculation by establishing the same kg in the formula for the strings with the purpose of obtaining all the diameters of the stringing (a tension that, as we saw, will be diversified because of the differences in the thinning of each string after tuning). In his case the pairs of strings are chosen in a state of *actual* traction, not of calculations done on paper. Seeing that this is a situation of true *dynamic* equal tension (because the weight always remains the same), we therefore find that the strings also display equal feeling.

In other words, the method suggested by Leopold Mozart achieves what we indicated above, though by a different route. It is evident that the strings chosen by Mozart as suitable for the purposes of tuning in fifths would present initial diameters 'in the packet' that theoretically display a profile of scaled tension, exactly as in the other cases described.

-We conclude by observing that the degree of tension mentioned hitherto does not correspond to that found in most of the historical documentation of the XVIII and XIX centuries: the tension slope is steeper. In other word, one cannot detect a situation of equal feel.

Unfortunately, at present there are no documents that can offer illuminating evidence for why this practical choice was made by the violinists of the time.

Huggins (1880 ca) advances two hypotheses: the first takes into consideration the pressure exerted by each string on the table of the instrument. He stresses that in a state of equal tension (but also of equal feeling, we add) the pressures in kg exerted by the first three strings on the underlying table are not at all equal; and this is because the angle of incidence of the string on the bridge is increasingly acute towards the thicker strings. Hence a greater thrust on the table. To obtain equal pressures on the table from every single string what is needed therefore is an 'additional' scaling to the condition hitherto considered. The second hypothesis considers the fact that as a rule the thicker strings are progressively more distant from the fingerboard: the result, therefore, is that in a condition of equal tension/equal feeling the fingers of the left hand must make a further effort when pressing down on the fingerboard. Hence the reduction of tension, with the aim of recovering evenness of feeling in the fingers of the left hand.

A third and final hypothesis that tends to suggest a (markedly) scaled tension concerns the search for the maximum possible evenness of attrition vis-a-vis the bow hairs. This is

propounded by Riccati already in the eighteenth century and later repeated by Pleissiard in the second half of the nineteenth century:

*‘Egli è d’uopo premettere, che quantunque l’arco tocchi una maggior superficie nelle corde più grosse, nulladimeno la sua azione è costante, purchè si usi pari forza a premer l’arco sopra le corde. Questa forza si distribuisce ugualmente a tutte le parti toccate, e quindi due particelle uguali in corde differenti soffrono pressioni in ragione inversa delle totali superficie combacciate dall’arco.’ (Giordano Riccati ‘Delle Corde...’ 1760 ca)*

*(First it is necessary to say that in spite of the fact that the bow touches a greater surface in the bigger strings, its action is nonetheless constant, provided that equal force is used in pressing the bow on the strings. This force is distributed equally to all the parts touched, and hence two equal particles on different strings undergo pressures inversely proportional to the total surfaces encountered by the bow.’).*

Mimmo Peruffo, 2004



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