VIOLIN STRINGS, SET UP, BOWS AND PERFORMANCE TECHNIQUES

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Abstract

Violins developed through nearly 500 years of music. For renaissance music, they where at first constructed as a family: 1 treble, 3 middle size and 1 or several basses. In the baroque era, they split to privilege a treble violin for sonata and concerto, and the bass violin disappeared to be replaced by the violoncello. Violins and violoncello where played in ensemble music up to the classical period, when the modern viola appears to play quintets and quartets as well as symphonies. The "modern" violin emerges with larger orchestras. In the 20th century, it was adapted to recording for diffusion on radio, television and disc.

We are studying the history of string-making and set-up. We will show how the violin works as a system, and link these features to changes that occur in the history of violin playing : the way hair sticks to the bowed strings; the influence of string length on instrument design, the shapes of arching, the evolution of the bow. The performance techniques are linked to the bow-string-bridge system. Some archetypes of set-up correspond to different aesthetics of the violin sounds.

INTRODUCTION

If we look at the violin's history, we can see that some of it's actual features appeared at different times: The violin 's predecessors : *gittern, vihuelas, viole, Geigen, fiddle, oval viols, crwths, five strings fiddles, organistrum, and "rebecs"* are carved out or sawn out and assembled pieces of wood, with added sheets of wood or animal skin for the soundboards.

Spain was a fruitful ground for experiments in different ways of playing : the meeting of Moorish and Spanish musicians playing on their knees and on the chest, bowing or plucking, is shown in the Cantigas di Sant Maria from Alphonse XII. The civilisation of *Al Andalus* broke in parts with the end of the *Reconquista* in 1492, as Catherine the Catholic chases away Muslims and Jews. Many Spanish musicians arrive in Rome with the Aragonese new Pope that same year with their *vihuelas.* Scholars brought classical literature and science books translated from Arabic, Greek, and other languages. This wide corpus of Mediterranean knowledge became more available in Italy by the means of new technology coming from the far east, in particular China : the paper and printing industry : Renaissance was arising in Italy.

Venice became quickly a large centre for printing, and many wood carvers from the southern states of Germany migrated to the Po valley where a lot of work was available for them in the printing trade. These migrants included many German lute makers from Füssen. Hans Frei and Laux Maler à Bologne, Magno Tiefenbrücker in

Venice, Venere à Padoue, etc…New families of *viols* and *violins* were to emerge from their skills and from the influence of the spanish *vihuelas*.

Instrumental music had developed with families of different sizes of wind instruments in order to imitate the voices and to play the polyphony by Dufay, Willaert, Obrecht and Josquin Després. Bowed instruments began also to be designed as families, just as the wind instruments. Peter Holman published the letter by which Isabelle d'Este In Mantova was to order what was may be the first family of "*viols*" in those years. Treble, middle-sized instruments and basses where made to play equal parts. The viola and violin families are played in different contexts, viols being more aristocratic, and violin more popular. In Germany, the *Geige* was played by street musicians and had slightly different features. It had a great influence in northern Europe.

Studying technical details, we will show how changes in strings, set up and bows, have participated in the evolution of violin. Because before 1800 very few instruments are left in or near original condition, some iconographic evidence and a methodology of history of techniques is necessary to understand the changes that took place.

We could synthesise the history of violin playing in relation to the physical aspects of the instruments into 4 themes **:**

1. Sustained notes: bow, hair, rosin and strings
2. From chords to polyphony : arching and curved bridges
3. Left hand virtuosity: heavier and thinner strings
4. Right hand reactivity : lighter, tense, and flexible bows and bridges

SUSTAINED NOTES : ROSIN, BOW, HAIR AND STRINGS

Bows, Rosin or Colophany

The mediaeval bow for musical instrument appears in Europe around the 10th century. Bowed string instruments had been known in East Asia and China probably long before. The figure of a bowed instrument was identified on a frescoe from the 9th century in the caves of Mogao (Dunhouang caves) in North-Ouest China, a large settlement carved out in a cliff at the edge of the Gobi desert on the silk road. The bows appears in western Europe only around 1000 AC. The first known bow is a Viking bow of the 11th century, made from a dogwood stick (cornus). Its length is 57 cm and its diametre is 1,5cm. The second ancient bow known is from the 15th century and was found in Italy with a small "viola".

Nevertheless, the role of the colophany and the bow hair has been explained only recently. Sticks covered with rosin can also put strings into vibration. Norbert Pickering showed in 1992 that the horse hair on the bow is not by itself responsible of the sticking and slipping action, but rather that it is the properties of the rosin that permit the bowed instruments to function, just as it does for the wheels of hurdy-gurdies as well. The back and fourth movements of the string are thus directly linked to significant and quick heating up and cooling down of the rosin, which grips more or less depending on the heat obtained by the rubbing. One understands then the influence of the conductivity to heat of the material of the string, and the significant differences of the grip of the bow, whether thei are made of gut, silk or metal.

What strings where first used before 1700 ?

We have studied the history of string makers and noted the texts mentioning technical details about the making of strings before 1700 give us some clues on their

nature. Although different materials have been used like silk and more surprisingly horse hair, gut was the main basic.

A Persian treatise, *Kanz-al-Tuhaf*, 14th century describes the making of silk strings. The cocoons are put to boil, treated with wood ashes and rinse in clear water. The threads are twisted all together, 64 for the lowest string, 16 for the highest string. Then, a viscous resin coloured in yellow by the saffron, is rubbed on string to impregnate it, it makes it stronger an more elastic, and also enables it to bear a higher tension. To make gut strings, it is only mentionned that he recommends to use sheep rather than goat guts, as they are better. **A Latin 14th manuscript of receipes, *Secretum Philosophorum***, describes how to make musical strings out of the intestines of sheep : "soak at least for half a day in water or in lees until the external coating and the residues are separated from the fibrous membrane of the intestine. Once clean, let them soak in lees or wine some more days, and twist them together by two, three or four while they are still wet, to get a string of the desired strength. After that, wipe them with a cloth and let the gut string dry under tension."

The technology of gut strings was part of the weapon industriy, as the strings fo archery where of the same nature. As such, it was probably well financed and well spred. The development of artillery after a slow beginning increased in speed from 1450, and the archery must have decreased from then. After bow becomes obsolete in armies with the development of powder and canons in the 15th century, the skill of making good harmonic strings became a narrower speciality. The king of Naples encouraged the musical string making trade to develop in the Abbruzzes, in organising the corporation of *cordari*. **The strings for bows in archery and for lutes in Turkey are described by Pierre Belon around 1550** : made with intestines collected from the butchers the same day and delivered by them to those who make all kind of strings. They know especially well how to make them for bows (for archery) (…) as for the ones for lutes, the make them of all kind and very fine, and very fine ones that tune as high as ours ; but they are not as silvery, because they are made of three strips, nevertheless I strung my venetian lute with them having no other. Such top strings are found in different colours : red, blue, green, yellow, white : they are sold in most shops, as well as other strings for the local lutes played everywhere in Turkey. In ***Varietie of lute lessons* (London, 1610), Robert Dowland** writes that strings are better if they are fresh, transparent and not oiled. The trebles must be pale grey or of an ash colour. They must not show curls in front of the light which shows that their twist is badly made and they will never be true. Some strings are coloured, but the lighter colours are better: pale green, pale red or blue. He gives different places where they are made, showing that they are imported to England. Roma, Livorno, Germany, Monnekin (München ?) Nürnberg , especially for basses, Strasbourg. The best strings, he says , are made in Bologna, and then sent to Venice, where they are sold to the Frankfurt and Leipzig fairs under the name of "Catline of Venice" . The best are sold in September because they are made in the summer.

Later evolutions in strings

Before the invention of wound strings in the second part of the 17th century, at the end of Nicolo Amati's carrer and at the beginning of Stradivari's, all the members of violin and viol families, including the largest ones where strung with this type og gut strings, the thicker ones being made of many more guts, while the E of the trebble violin could be made of one gut. Later, with the development of industry, the *Boyaudier* mostly made belts for machinery. Whether good trebble harmonic string of the

Neapolitan trade were made from sheep or had to be made of lamb was discussed among engineers in the 19th century France, where most gut were made out of cow stomacs. The development of the centerless lathe around 1880 made the stucture of gut strings more homogeneous, which is a quality when the criterium is not judged anymore by ear, but by measuring devices. It must be noted that string tension is not mentionned in the texts before the end of the eighteenth century. Nor do the string makers announce it in commercial documents, but mentioned the number of guts, and different colours to distinguish them. It is only after the Palmer was designed in the nineteenth century that they used diametrers. Even now, makers, usually, test for the appropriate tension by ear, and if the tension is believed to be too great, the string is tuned down or a thinner string is chosen.

But the design of the instrument is made accordingly to the availibility of the thinnest and thickest strings, in the range of quality that is found acceptable. And this has changed over time.

FROM CHORDS TO POLYPHONY : ARCHING AND CURVED BRIDGES

A bowed instrument with a flat body and flat bridge

At the end of the 15th century, the "fiddle" doesn't have an arching yet. We can see an good example of a **flat bowed instrument in the inlaid panel of the *Studiolo* of the Duke of Urbino dated 1474**. It has a body made out of cut out planks in a guitar shape, without arching, glued onto a rib structure. The pegs are inserted from the front into a rounded peg box. The edges of back and belly have an overhang above the ribs. The sound holes are in a C shape and face each other, the branches inwards. The perspective is very precise and allows us to perceive that the bridge is placed at the top of the holes, is flat, and that when it is bowed, the strings are not played independently but in chords. The waist of the instrument is quite wide and doesn't give much clearance to the bow.

A good example of ***lira da braccio* is painted in 1505 by Giovanni Bellini**, who was protected by the d'Este family, on his representation of the Virgin, in the church San Zaccharia in Venice. Five strings and two drowns are to be played in chords with the bow. Here, instead of a guitar shaped body, four corners are now distinct in the outline. The table is also flat, as is the bridge, which is moved a little more towards the tailpiece. The instrument is big, of the size of a "contralto viola" or even a tenor. Since the strings are not played independently, the bow doesn't need to change direction, so the waist is large. This painting shows the skill of the painter in geometry and drawing techniques that derive from perspective and proportional thinking. It is interesting to look at the conjunction of event in which these forms have evolved.

Influences between art, geometry and architecture

During the Italian wars (1495-1569) due to French expansionism towards the Kingdom of Naples, alliances change from year to year between the Aragon Kingdom, Spain, the Habsbourg Roman Emperors, the Dukes of Milan, the Pope, The Republic of Venice and France. Large armies cross over the country. Milan is occupied several times by the French, and Brescia is taken from Venice. With the numerous passages of armies, it is also a time of the dissemination of techniques and ideas. In 1496, Leonardo da Vinci starts friendship with mathematician Luca Pacioli, and both men work towards the publication of *de divina proportione* published in 1509. Leonardo writes theoretical

notes on the nature of arches and on the resistance of beams. In 1500 Scipione Del Ferro solves the cubic equation, Leonardo paints a portrait of Isabella d'Este in Mantova. In 1513 Leonardo works on parabolique mirors. Dürer learns Italian drawing techniques in 1494 and his *Underweysung der Messung (...)*, is published in Nuremberg in 1525. The use of compasses for proportional drawings, as described in his treaty, is widely used by craftsmen in northern Italy: Tartaglia, was a mathematician born in Brescia and severely wounded in his youth by French soldiers. He translated Archimedes and is known to have hearn a living in teaching mathematics and geometry to craftsmen. Concerning the reflection of sound on curved walls, architects of the time were rediscovering the works of Vitruvius. One of the remarkable parts of *De architectura* is Book 5 where Vitruvius discusses acoustics. Sarton writes [9]:- *Vitruvius explains sound as a displacement of air in waves which he compares with the waves that can be observed on the water's surface when a stone is thrown into a pond. What is more remarkable was Vitruvius' application of the wave theory to architectural acoustics. The wave theory of sound was Greek, its application to the acoustics of a hall typically Roman. ... Vitruvius analyzes the acoustics of a theatre and the phenomena that may spoil it, which we call interference, reverberation, echo.* Mathematicians of that time taught drawing techniques to craftsmen, and this allows us to assess that this kind of information was accessible to instrument makers.

Arched instruments around 1500

It is in this context that arched bowed instruments appear. One of Bellini's students, **Carpaccio**, represents a ***lira da braccio,*** five years after his master's, in a detail of the **"Presentation of Jesus at the Temple"** kept in the Galleria del Accademia in Venice, dated 1510. Here, the arching of the table is clearly visible. The outline, even if there are only two bottom corner, is already more in proportions to what will be seen later in violins. It is a *lira da braccio* again, but from the point of view of techniques in lutherie, it bears already the features of the violin. Proportional construction of the outline has pushed the sound holes lower, the bridge is positioned in harmony with the length of the holes, even though they still have the C shape. The width of the bridge equals the spacing of the sound holes cut in the table. The analogy between light and sound may have been used to evolve from flat plates to carved out inside volumes, while works on the volts in architecture showed the better resistance to pressure of certain types of arches.

It is only around **1535** that the well known **fresco of Saronno's sanctuary** represents for the first time members of the violin as a family and we see for the first time the sound holes in the f shape. Andrea Amati, the father of the Cremonese School, is at that time 30 years old. From a solo instrument accompanying the voice, the *lira da braccio*, the violins become melodic instruments able to take their part within an ensemble of violins, or an group of different instruments playing contrapuntal music. The narrowing of the C bouts that allows the bow to take only the G or the E string on the treble violin is completed by the curvature of the bridge, and the bowing technique allows the performer to bow one string at a time if needed in the medium. A right hand technique is developed for the *frottole*. These very basic features are the mark of the invention of violin playing in the sixteenth century.

HEAVIER AND THINNER STRINGS : LEFT HAND VIRTUOSITY

Work of the Galilei on the tension of strings

In **1588** at the time of the brothers Amati, sons of Andrea, Vincenzo Galilei performed experiments on strings, with his son Galileo who was then living at home and giving private lessons in mathematics. Vincenzo was a renown composer an lutenist. He has published a number musical scores for the lute and several books on musical theory. Since antiquity, the theory of music had consisted of a mathematical discussion of harmony, in other words of the mathematical ratios of the lengths of strings producing consonance, and of the way to divide the octave to produce the scales. It had always been thought that 2:1 was not only the ratio of lengths of two strings sounding an octave apart, but also the ratio of the tensions of strings of equal lengths tuned an octave apart. The Galilei showed that this is not the case: the ratio of tensions is 4:1. They found that ratio by hanging weights from strings. **Mersenne** (1588-1648) publishes his ***Harmonie Universelle*** **in 1636**. Numerous correspondents have helped him to compose this work, including Descartes, Gassendi, Huygens, Roberval, Galileo, and Isaac Beeckman. (1588-1637), who sends him in 1629 a law about vibrating strings : "the ratio of the number of time all types of strings return to their original location is inverse of their length". Marin Mersenne describes the pulsation of two strings nearly in tune, and determines the first frequency of an audible tone ever given. The hypothesis of the source-air-motion- frequency equivalence is given in his treatise, acknowledging that the perception of the note is explained by this motion transmitted to the air and to the ear. The nature of the work of instrument makers of that time, contemporaries of Nicolo Amati in Cremona, is to make instruments that suit the new needs of music for the treble instrument of the violin family: sonatas for violins.

Wounded strings

Wounded strings were put on the market twenty years after the relationship between the linear length, tension and tuning was understood. **Playford reports in 1664** the invention of gut strings covered with metal wire to give them a greater linear weight. The result is the possibility to have a thinner bass string : for the same string length and tuning, the diameter of the string is smaller. Playford states that a recent invention consist of strings for bass violins and lutes which sound better and louder than the usual gut strings, whether they are touched with a bow or plucked with the fingers. It is a small metal wire twisted around a gut or a silk string. Here is how **Claude Perrault,** member of the Académie des Sciences in Paris describes in 1680 an invention to increase the sound of strings: "as well as the external impulse of a blow can do a lot to increase the sound in wind instruments, the one that causes the movement of the whole resonant body has not a less effect. So does the weight of a bell, that with its swing makes it move entirely with a greater force, gives the backward impulse of the particles livelier and its sound louder. It is by the same proportion that the material that has been used recently to charge the gut strings makes the sound much more powerful. Because the wire of metal, which they are twisted with, gives vehemence to all the vibrations and gives more impulse to the return of the particles that where displaced, and this happens without changing the tone produced, because the way it moves is not changed in its parts, and the stiffness or the flexibility of the resonant body is not changed."

New sizes for viola and cello designs

But the wound strings being heavier don't only make them sound louder, but also allows the makers to make shorter instruments for the same tuning. The string length, with the pitch of the note it produces, is the basic measure to design a string instrument from. A piece of string is kept in Cremona's Museum with a note by Stradivari explaining the instrument it was made for. Changing the weight of bass strings by making them heavier opens new possibilities for players an makers. Stephen Bonta has shown how the violoncello is mentioned for the fist time on music scores from Bologna. It corresponds with a shorter bass violin tuned at the same pitch, but with smaller string length. In consequence, there is a progressive disappearance of the bass violin, of the same tuning but much longer string length than the violoncello, and more awkward to play. The majority of the instruments of the violin family had been up to that time middle sized instruments: contralto and tenors. A tenor for the Medici court by Stradivari, the only instrument he made that is still in its original state, is kept in Florence at the Offici Museo. The reason why this instrument is so well kept is that it has'nt been played much. The obsolescence of the three middle sized instruments of the violin family happened at that time. The violin itself changes its possibilities to become a solo instrument. Some soloists are able to play the instrument in such a way as to replace all the others: Bach writes his *partitas* and *sonatas* were the *basso continuo* is not necessary any more, because the bass notes are produced by fast moves of the bow catching the lower register. So does Vivaldi in his violin concertos. Would it be possible to get that same effect on playing very fat gut strings, difficult to put into motion ? The change of strings really opened new sounds and new performance techniques for the violinists. Not all the member of the family were needed now: the large *contralti* and *tenori* vanished, and were very rarely kept, even in collections. The violoncello and the violin were to jeopardise the existance of other members of the family in scores for a century. Venetian makers such as Goffriller, Montagnana, Busan, Guarneri of Venice, designed beautiful violoncellos, and Stradivari establishes new types of arching that allows the musician to modulate the character of the sound with his bow.

RIGHT HAND REACTIVITY : LIGHTER, TENSE, FLEXIBLE BOWS AND BRIDGES

Bows

Anne Penesco, analyses the question of virtuosity in Italy and shows the influence of Francesco Maria Veracini from Florence who played the violin in a very daring way at concerts given in Venice in 1716 for the Prince of Sax. After meeting him on that occasion, Tartini is considered to have learned to play his technique. He wrote *L'Arte dell'arco,* a method for practising the new bow techniques. He is said to be the first to ask for the making of longer bows, increased in length by around 6 cm. It is also the time of Stradivari's so called "golden period" where he experiments on flatter arching that give more projection to the sound and a flexibility to the body of the instrument that is favourable to a mellower sound, and which can be modified by the violinist with the articulation of the bow. So during the 18th century innovation is concentrated on a change of the nature of the sound that is now expected from a violin. From a fluted sound at the time of the higher and stiffer arching, it must now sing with a mellow tone, and the ornamentation is progressively passing from the left hand "trilles" made by fingers on the fingerboard, to increase of the right hand techniques of *legato,*

marcato, spiccato, saltato, etc… The evolution of the bow between 1740 to 1790 tends to go from bouncing short and stiff bows, to long and light bows that tend to stick to the string. The convex turns to concave, with every try on curvature in between. They change from being short to being longer, from thick to flexible, from low heads to high heads. Heavy and light frogs are tried as well as high and low. Different position of the balancing point and hand grip are experimented. The change of curvature appears in four different stages :

1. convex - short- stiff,
2. double curved - longer - thin and flexible,
3. hollowed, bigger distance between stick and hair, also longer - thin and flexible
4. concave, higher on the head .

Tourte père and his two sons Leonard and François-Xavier experiment with the better instrumentalist of their time. They end up with the model of the modern bow, that is going to enhance the expressive possibility of romantic music.

Necks and fingerboards

Increased virtuosity demands thinner necks for the rapidity of fingering and easier shifts in higher positions. The modern neck appears in several stages. as early as 1687, in his "Traité de la viole" Rousseau mentions that the best English viols are transformed by the French makers, who replace the original necks with thinner and tilted necks. This doesn't necessarily mean that the tension or the angle of the strings are altered, but that the fingerboard is parallel to the string and the neck as well. This allows the left hand to shift in higher positions more easily. The violin necks are becoming thinner and thinner, and when full ebony is used from around 1760, reinforcing the now thin and tilted necks, and the modern setting appear around 1800.

Bridges

The curved bridge seem to have some changes at certain times. The round ears cut out of the sides of Stradivari's bridges are still quite small, and that what can be seen in Baschenis's paintings in the 17th century seems to be still in use well into the 18th century. We have little evidence of its different shapes while the bow changes quickly. Then, a bridge signed Pique around 1810 shows small round ears as well, and that the cutting out of the heart comes after that. Generally speaking, in the nineteenth century, the heart tends to be opened and the centre of gravity lowered. The bridge seems to change height as it adapts to different strings which don't all need the same clearance over the fingerboard, depending on their elasticity and rigidity. Different alloys are experimented in 19th and 20th century. After the first world war, the use of metal stringing seems to have been in fashion, thanks to the progress of wire and cable industries. The second world war started the spread of nylon strings.

The demand for loud instrument increases a lot until the middle of the nineteenth century, with the size of concert halls meant for orchestral music. As a solo violin above a symphonic orchestras, it needs to pass the ramp. The set up has therefore to improve the power, and the *vibrato* is also used to enhance the audibility in such a mass of sound.

Radio and recording modifies again the demand, because scratching sounds that couldn't be heard from far away become dreadful for broadcasting, when a microphone is placed near the bridge for the recording session.

SUMMARY

In conclusion, taking into account the history of the violin allows different perspectives to acoustical researches.

Specific arching has developed within the first decade of the 16th century with curved bridges to play strings separately, exactly at the same time as the new family of different sizes of violins was established to play different parts of musical instruments ensembles. Stiff body went with a stiff arched bow and bridges that were very woody. The playing was that of ensemble music.

The wounded string was the innovation around 1660-1680 that allowed the invention of the violoncello, and eased the transition of bowing thin and thick strings. Composer take advantage of these new qualities and write for solo violin and cello.

The influence of flatter arching in relation to flexibility of the body is a feature developed around 1700. It is associated with a different violin playing introduced by sonatas and concertos for solo violins. It introduced longer bows and more effects of long and short, slower and quicker bow strokes, bouncing and right hand techniques.

Increased virtuosity demands thinner violin and cello necks for the rapidity of fingering and shifts in higher positions, and the modern neck appears in several stages between 1760.

Bows evolve between 1740 and 1790 from convex to modern bow, that is going to enhance the expressive possibility of romantic music.

Nineteenth century's bridges get thinner and more open, probably more flexible.

If the different shape of each of these settings where to be tested individually, but linked to their specific development, we could have a different understanding of why the makers, after many experiments, adopted this or another shape for an arching, a bow, a fingerboard, a bridge. Working by trial and error for the musicians, they followed their needs and demands to satisfy the music of their time, to open possibilities to composers and instrumentalists. The acoustical properties of these items, such as bridges for instance, cannot be fully understood if they are not related to the bracket of variations they were allowed, in order to be set and coupled to a specific instrument for a specific music. Also, they were adapted for arching space between ff holes, bass bars and strings that are not anymore in use today.

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