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# Study of Western String Music Instruments

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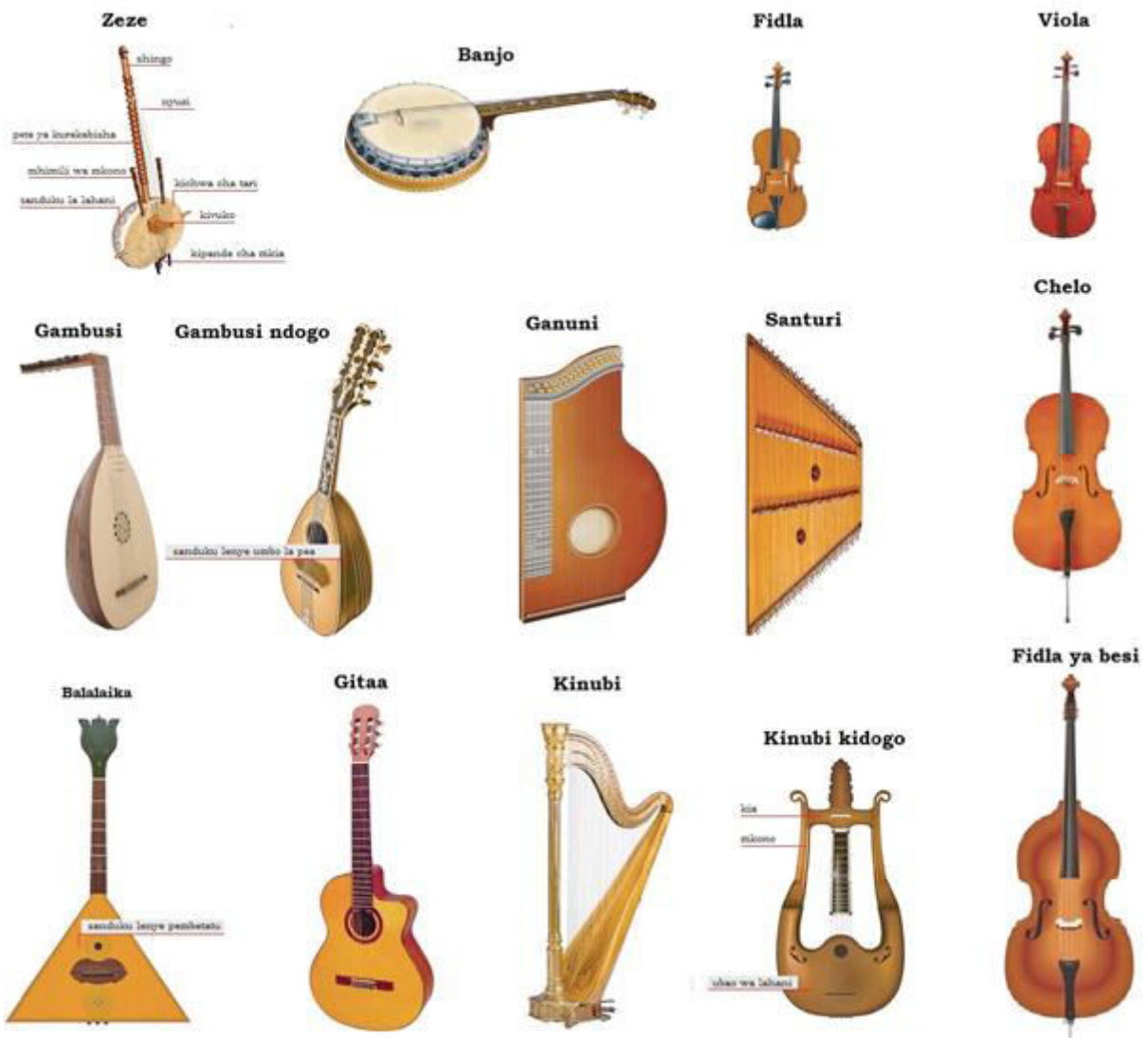
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**ABSTRACT:** String instruments (chordophones) are sounded by bowing and plucking. Bowed strings include violin, viola, cello, and double bass; plucked strings include harp and guitar. Woodwind instruments (aerophones) include flute, oboe, clarinet, bassoon, and saxophone.

**KEYWORDS:** western, music, string, instruments, chordophones, aerophones, saxophone

## I. INTRODUCTION

Stringed instruments or Chordophones are instruments that make a vibration generated sound when their strings are plucked. When a string is stretched it starts to vibrate, making the resonator amplify the picked vibrations. Consequently, an appealing sound is produced. The String Family includes Violin, Viola, Double Bass, Cello, Harp and Guitar (electric and acoustic).



The Don Wright Faculty of Music offers strings students diverse course options and performance opportunities including solo and studio recitals, weekly faculty-led masterclasses, and ensembles (including symphony and chamber orchestras), plus competitions and awards including the Maritsa Brookes Concerto Competition, Young-Ja Park Chamber Music Competition and the London Music Scholarship Foundation Endowment Award.

Western Music also offers learning opportunities and masterclasses with international guests of renown. Annual Artists in Residence have included New Orford String Quartet, Tafelmusik Baroque Orchestra and Ensemble Made In Canada. The Music Building and Talbot College house over 100 practice rooms, studios, and large and small rehearsal spaces, plus three modern performance venues with concert pianos and state-of-the-art recording capabilities.

Western's String Instrument Bank is a collection of more than 40 fine Italian, French and English instruments and bows, which are available for loan to select string students in Music Performance and are carefully maintained by our resident luthiers.

In musical instrument classification, string instruments or chordophones, are musical instruments that produce sound from vibrating strings when a performer plays or sounds the strings in some manner.[1,2,3]

Musicians play some string instruments, like guitars, by plucking the strings with their fingers or a plectrum (pick), and others by hitting the strings with a light wooden hammer or by rubbing the strings with a bow, like violins. In some keyboard instruments, such as the harpsichord, the musician presses a key that plucks the string. Other musical instruments generate sound by striking the string.

With bowed instruments, the player pulls a rosined horsehair bow across the strings, causing them to vibrate. With a hurdy-gurdy, the musician cranks a wheel whose rosined edge touches the strings.

Bowed instruments include the string section instruments of the orchestra in Western classical music (violin, viola, cello and double bass) and a number of other instruments (e.g., viols and gambas used in early music from the Baroque music era and fiddles used in many types of folk music). All of the bowed string instruments can also be plucked with the fingers, a technique called "pizzicato". A wide variety of techniques are used to sound notes on the electric guitar, including plucking with the fingernails or a plectrum, strumming and even "tapping" on the fingerboard and using feedback from a loud, distorted guitar amplifier to produce a sustained sound.

Some string instruments are mainly plucked, such as the harp and the electric bass. Other examples include the sitar, rebab, banjo, mandolin, ukulele, and bouzouki.

In the Hornbostel–Sachs scheme of musical instrument classification, used in organology, string instruments are called chordophones. According to Sachs,<sup>[1]</sup>

Chordophones are instruments with strings. The strings may be struck with sticks, plucked with the bare fingers or a plectrum, bowed or (in the Aeolian harp, for instance) sounded by wind. The confusing plenitude of stringed instruments can be reduced to four fundamental type: zithers, lutes, lyres, and harps.

In most string instruments, the vibrations are transmitted to the body of the instrument, which often incorporates some sort of hollow or enclosed area. The body of the instrument also vibrates, along with the air inside it. The vibration of the body of the instrument and the enclosed hollow or chamber make the vibration of the string more audible to the performer and audience. The body of most string instruments is hollow, in order to have better sound projection. Some, however—such as electric guitar and other instruments that rely on electronic amplification—may have a solid wood body.

## II. DISCUSSION

In musicology, string instruments are known as chordophones. It is one of the five main divisions of instruments in the Hornbostel–Sachs scheme of musical instrument classification.

Hornbostel–Sachs divides chordophones into two main groups: instruments without a resonator as an integral part of the instrument (which have the classification number 31, also known as 'simple'); and instruments with such a resonator (which have the classification number 32, also known as 'composite'). Most western instruments fall into the second group, but the piano and harpsichord fall into the first. Hornbostel and Sachs' criterion for determining which sub-group an instrument falls into is that if the resonator can be removed without destroying the instrument, then it is classified as

31. The idea that the piano's casing, which acts as a resonator, could be removed without destroying the instrument, may seem odd, but if the action and strings of the piano were taken out of its box, it could still be played. This is not true of the violin, because the string passes over a bridge located on the resonator box, so removing the resonator would mean the strings had no tension.[4,5,6]

From the musical bow, families of stringed instruments developed; since each string played a single note, adding strings added new notes, creating bow harps, harps and lyres.<sup>[6]</sup> In turn, this led to being able to play dyads and chords. Another innovation occurred when the bow harp was straightened out and a bridge used to lift the strings off the stick-neck, creating the lute.<sup>[7]</sup>

Bowing the body of the instrument

Bowing the body of a string instrument (which can include bowing the sound box, neck, tuning pegs, or scroll) produces a quiet sound whose amplitude differs according to the place bowed, bow pressure and bow speed. At most the sound is a whisper of the bow hair moving over the wood. A good example of this technique in a musical work is Helmut Lachenmann's *Toccatina*, a piece written in 1986 for solo violin which uses many extended techniques.

Bowing on the bridge



Bowing the bridge, second method

Bowing on the bridge produces two different effects depending on how it is done. If it is done while the performer is in normal playing position, the sound produced is quiet, whispery and a bit squeaky. This method could more properly be called 'bowing over the bridge', since the bow hair is usually still in contact with the strings. *Sul ponticello* (bowing near the bridge) is a similar, more common technique.

The other method involves the performer holding the instrument in their lap, placing the bow parallel to the instrument and firmly dragging it across the side of the bridge. In this case the sound is loud, high pitched and squeaky. An example of this playing technique can be found in Gérard Grisey's *Vortex Temporum* (1995). Helmut Lachenmann often uses a soft version of this technique, creating a quiet, white-noise-like sound.

Bowing on the fingerboard

Bowing on the fingerboard (*sul tasto* or *sulla tastiera*) creates a soft thin tone. The effect is a muffled and flute-like sound (the technique is often also called *flautando*).

Bowing the tailpiece

Drawing the bow across the tailpiece creates a very quiet resonant sound. Because the tailpiece is large and heavy this sound is general of a quite low pitch.

Scratch tone

A scratch tone is produced by bowing the instrument in normal playing position, but applying very hard pressure to the bow. This produces an extremely loud and grating sound.





Behind the bridge

#### Bowing behind the bridge

This fairly common extended technique involves bowing the instrument on the afterlength, the short length of string behind the bridge. The tone is very high and squeaky. 3rd bridge is a term more used on electric guitars or prepared guitars, but is the same technique. Playing the instrument at a string part behind the bridge causes the opposed part of the string to resonate. The tone is louder at harmonic relations of the bridge string length. On violins the tone can be very high, even above human hearing range. Depending on the instrument the pitch of the tones may or may not be perceived (cellos and double basses are more likely to produce recognizable pitches because of the longer length of their strings). This technique is used extensively in Krzysztof Penderecki's *Threnody to the Victims of Hiroshima*. Another interesting example is found in Ferde Grofé's *Grand Canyon Suite* where bowing behind the bridge on a violin cadenza is used in the representation of a donkey's braying.[7,8,9]

#### Col legno

This technique uses the stick of the bow, where the player flips the bow around so the bow hair is facing up. This technique produces a faint sound.

### III. RESULTS

Musicologists have put forth examples of that 4th-century BC technology, looking at engraved images that have survived. The earliest image showing a lute-like instrument came from Mesopotamia prior to 3000 BC.<sup>[11]</sup> A cylinder seal from c. 3100 BC or earlier (now in the possession of the British Museum) shows what is thought to be a woman playing a stick lute.<sup>[11][12]</sup> From the surviving images, theorists have categorized the Mesopotamian lutes, showing that they developed into a long variety and a short.

String instrument design was refined during the Renaissance and into the Baroque period (1600–1750) of musical history. Violins and guitars became more consistent in design and were roughly similar to acoustic guitars of the 2000s. The violins of the Renaissance featured intricate woodwork and stringing, while more elaborate bass instruments such as the bandora were produced alongside quill-plucked citterns, and Spanish body guitars.

In the 19th century, string instruments were made more widely available through mass production, with wood string instruments a key part of orchestras – cellos, violas, and upright basses, for example, were now standard instruments for chamber ensembles and smaller orchestras. At the same time, the 19th-century guitar became more typically associated with six-string models, rather than traditional five-string versions.

Major changes to string instruments in the 20th century primarily involved innovations in electronic instrument amplification and electronic music – electric violins were available by the 1920s and were an important part of emerging jazz music trends in the United States. The acoustic guitar was widely used in blues and jazz, but as an acoustic instrument, it was not loud enough to be a solo instrument, so these genres mostly used it as an accompaniment rhythm section instrument. In big bands of the 1920s, the acoustic guitar played backing chords, but it was not loud enough to play solos like the saxophone and trumpet. The development of guitar amplifiers, which contained a power amplifier and a loudspeaker in a wooden cabinet, let jazz guitarists play solos and be heard over a big band. The development of the electric guitar provided guitarists with an instrument that was built to connect to guitar amplifiers. Electric guitars have magnetic pickups, volume control knobs and an output jack.



In the 1960s, larger, more powerful guitar amplifiers were developed, called "stacks". These powerful amplifiers enabled guitarists to perform in rock bands that played in large venues such as stadiums and outdoor music festivals (e.g., Woodstock Music Festival). Along with the development of guitar amplifiers, a large range of electronic effects units, many in small stompbox pedals were introduced in the 1960s and 1970s, such as fuzz pedals, flangers, and phasers enabling performers to create unique new sounds during the psychedelic rock era. Breakthroughs in electric guitar and basses technologies and playing styles enabled major breakthroughs in pop and rock music in the 1960s and 1970s. The distinctive sound of the amplified electric guitar was the centerpiece of new genres of music such as blues rock and jazz-rock fusion. The sonic power of the loudly amplified, highly distorted electric guitar was the key element of the early heavy metal music, with the distorted guitar being used in lead guitar roles, and with power chords as a rhythm guitar.[10,11,12]

The ongoing use of electronic amplification and effects units in string instruments, ranging from traditional instruments like the violin to the new electric guitar, added variety to contemporary classical music performances, and enabled experimentation in the dynamic and timbre (tone colour) range of orchestras, bands, and solo performances.<sup>[18]</sup> String instruments can be divided into three groups:

#### Lutes

Instruments that support the strings via a neck and a bout (gourd), for instance a guitar, violin, or saz

#### Harp

Instruments that contain the strings within a frame

#### Zithers

Instruments that have the strings mounted on a body, frame or tube, such as a guqin, cimbalom, autoharp, harpsichord, piano, or valiha

It is also possible to divide the instruments into categories focused on how the instrument is played.

All string instruments produce sound from one or more vibrating strings, transferred to the air by the body of the instrument (or by a pickup in the case of electronically amplified instruments). They are usually categorised by the technique used to make the strings vibrate (or by the primary technique, in the case of instruments where more than one may apply.) The three most common techniques are plucking, bowing, and striking. An important difference between bowing and plucking is that in the former the phenomenon is periodic so that the overtones are kept in a strictly harmonic relationship to the fundamental

#### Plucking

Plucking is a method of playing on instruments such as the veena, banjo, ukulele, guitar, harp, lute, mandolin, oud, and sitar, using either a finger, thumb, or quills (now plastic plectra) to pluck the strings.

Instruments normally played by bowing (see below) may also be plucked, a technique referred to by the Italian term pizzicato.

#### Bowing

Bowing (Italian: arco) is a method used in some string instruments, including the violin, viola, cello, and the double bass (of the violin family), and the old viol family. The bow consists of a stick with a "ribbon" of parallel horse tail hairs stretched between its ends. The hair is coated with rosin so it can grip the string; moving the hair across a string causes a stick-slip phenomenon, making the string vibrate, and prompting the instrument to emit sound. Darker grades of rosin grip well in cool, dry climates, but may be too sticky in warmer, more humid weather. Violin and viola players generally use harder, lighter-colored rosin than players of lower-pitched instruments, who tend to favor darker, softer rosin.<sup>[20]</sup>

#### Striking

The third common method of sound production in stringed instruments is to strike the string. The piano and hammered dulcimer use this method of sound production. Even though the piano strikes the strings, the use of felt hammers means that the sound that is produced can nevertheless be mellow and rounded, in contrast to the sharp attack produced when a very hard hammer strikes the strings.



Violin family string instrument players are occasionally instructed to strike the string with the stick of the bow, a technique called *col legno*. This yields a percussive sound along with the pitch of the note. A well-known use of *col legno* for orchestral strings is Gustav Holst's "Mars" movement from *The Planets* suite.

#### Other methods

The aeolian harp employs a very unusual method of sound production: the strings are excited by the movement of the air.[13,14,15]

Some instruments that have strings have an attached keyboard that the player presses keys on to trigger a mechanism that sounds the strings, instead of directly manipulating the strings. These include the piano, the clavichord, and the harpsichord. With these keyboard instruments, strings are occasionally plucked or bowed by hand. Modern composers such as Henry Cowell wrote music that requires that the player reach inside the piano and pluck the strings directly, "bow" them with bow hair wrapped around the strings, or play them by rolling the bell of a brass instrument such as a trombone on the array of strings. However, these are relatively rarely used special techniques.

Other keyed string instruments, small enough for a strolling musician to play, include the plucked autoharp, the bowed *nyckelharpa*, and the *hurdy-gurdy*, which is played by cranking a rosined wheel.

Steel-stringed instruments (such as the guitar, bass, violin, etc.) can be played using a magnetic field. An E-Bow is a small hand-held battery-powered device that magnetically excites the strings of an electric string instrument to provide a sustained, singing tone reminiscent of a held bowed violin note.

Third bridge is a plucking method where the player frets a string and strikes the side opposite the bridge. The technique is mainly used on electric instruments because these have a pickup that amplifies only the local string vibration. It is possible on acoustic instruments as well, but less effective. For instance, a player might press on the seventh fret on a guitar and pluck it at the head side to make a tone resonate at the opposing side. On electric instruments, this technique generates multitone sounds reminiscent of a clock or bell.

Electric string instruments, such as the electric guitar, can also be played without touching the strings by using audio feedback. When an electric guitar is plugged into a loud, powerful guitar amplifier with a loudspeaker and a high level of distortion is intentionally used, the guitar produces sustained high-pitched sounds. By changing the proximity of the guitar to the speaker, the guitarist can produce sounds that cannot be produced with standard plucking and picking techniques. This technique was popularized by Jimi Hendrix and others in the 1960s. It was widely used in psychedelic rock and heavy metal music.

In bowed instruments, the bow is normally placed perpendicularly to the string, at a point halfway between the end of the fingerboard and the bridge. However, different bow placements can be selected to change timbre. Application of the bow close to the bridge (known as *sul ponticello*) produces an intense, sometimes harsh sound, which acoustically emphasizes the upper harmonics. Bowing above the fingerboard (*sul tasto*) produces a purer tone with less overtone strength, emphasizing the fundamental, also known as *flautando*, since it sounds less reedy and more flute-like.

Bowed instruments pose a challenge to instrument builders, as compared with instruments that are only plucked (e.g., guitar), because on bowed instruments, the musician must be able to play one string at a time if they wish. As such, a bowed instrument must have a curved bridge that makes the "outer" strings lower in height than the "inner" strings. With such a curved bridge, the player can select one string at a time to play. On guitars and lutes, the bridge can be flat, because the strings are played by plucking them with the fingers, fingernails or a pick; by moving the fingers or pick to different positions, the player can play different strings. On bowed instruments, the need to play strings individually with the bow also limits the number of strings to about six or seven strings; with more strings, it would be impossible to select individual strings to bow. (Note: bowed strings can also play two bowed notes on two different strings at the same time, a technique called a double stop.) Indeed, on the orchestral string section instruments, four strings are the norm, with the exception of five strings used on some double basses. In contrast, with stringed keyboard instruments, 88 courses are used on a piano, and even though these strings are arranged on a flat bridge, the mechanism can play any of the notes individually.

Similar timbral distinctions are also possible with plucked string instruments by selecting an appropriate plucking point, although the difference is perhaps more subtle.



In keyboard instruments, the contact point along the string (whether this be hammer, tangent, or plectrum) is a choice made by the instrument designer. Builders use a combination of experience and acoustic theory to establish the right set of contact points.

In harpsichords, often there are two sets of strings of equal length. These "choirs" usually differ in their plucking points. One choir has a "normal" plucking point, producing a canonical harpsichord sound; the other has a plucking point close to the bridge, producing a reedier "nasal" sound rich in upper harmonics.[16,17,18]

A single string at a certain tension and length only produces one note. To produce multiple notes, string instruments use one of two methods. One is to add enough strings to cover the required range of different notes (e.g., as with the piano, which has sets of 88 strings to enable the performer to play 88 different notes). The other is to provide a way to stop the strings along their length to shorten the part that vibrates, which is the method used in guitar and violin family instruments to produce different notes from the same string. The piano and harp represent the first method, where each note on the instrument has its own string or course of multiple strings tuned to the same note. (Many notes on a piano are strung with a "choir" of three strings tuned alike, to increase the volume.) A guitar represents the second method—the player's fingers push the string against the fingerboard so that the string is pressed firmly against a metal fret. Pressing the string against a fret while plucking or strumming it shortens the vibrating part and thus produces a different note.

Some zithers combine stoppable (melody) strings with a greater number of "open" harmony or chord strings. On instruments with stoppable strings, such as the violin or guitar, the player can shorten the vibrating length of the string, using their fingers directly (or more rarely through some mechanical device, as in the nyckelharpa and the hurdy-gurdy). Such instruments usually have a fingerboard attached to the neck of the instrument, that provides a hard flat surface the player can stop the strings against. On some string instruments, the fingerboard has frets, raised ridges perpendicular to the strings, that stop the string at precise intervals, in which case the fingerboard is also called a fretboard.

Moving frets during performance is usually impractical. The bridges of a koto, on the other hand, may be moved by the player occasionally in the course of a single piece of music. Many modern Western harps include levers, either directly moved by fingers (on Celtic harps) or controlled by foot pedals (on orchestral harps), to raise the pitch of individual strings by a fixed amount. The Middle Eastern zither, the qanun, is equipped with small levers called mandal that let each course of multiple strings be incrementally retuned "on the fly" while the instrument is being played. These levers raise or lower the pitch of the string course by a microtone, less than a half step.

The string instruments usually used in the orchestra,<sup>[25]</sup> and often called the "symphonic strings" or string section are:<sup>[26]</sup>

- Violins (divided into two sections—first violins and second violins; these sections play exactly the same instruments; the difference is that the first violins play higher-register lines and the second violins play lower-register parts, accompaniment parts or counter-melodies)
- Violas
- Cellos
- Double basses

When orchestral instrumentation specifies "strings", it often means this combination of string parts. Orchestral works rarely omit any of these string parts, but often include additional string instruments, especially the concert harp and piano. In the Baroque orchestra from the 1600s–1750 (or with modern groups playing early music) harpsichord is almost always used to play the basso continuo part (the written-out bass line and improvised chords), and often a theorbo or lute or a pipe organ. In some classical music, such as the string quartet, the double bass is not typically used; the cello plays the bass role in this literature.

Plucking techniques

On string instruments plucking the strings is called pizzicato.





Cellist performing a buzz pizzicato. Note the fingernail placed parallel to the string.

#### Buzz pizzicato

Buzz pizzicato is created by placing a left hand finger parallel to the string and plucking the string forcefully so that the plucked string buzzes against the fingerboard. An example of this can be found at the beginning of Zhou Long's Song of the Ch'in (1982).

#### Snap pizzicato

Also known as Bartók pizz, snap pizzicato is used extensively in the music of Béla Bartók. (It is commonly thought that Bartók invented the technique, but Gustav Mahler already in his Seventh Symphony was the first to direct its use.)<sup>[1]</sup> The technique consists of plucking the string away from the fingerboard with the right hand with sufficient force to cause it to snap back and strike the fingerboard creating a snapping sound in addition to the pitch itself.

#### Nail pizzicato

Nail pizzicato is another technique invented and used extensively by Bartók. To perform a nail pizzicato, the performer plucks the string with only the fingernail (in standard string performance technique the player uses the pad of the finger). The resulting sound is a bit more harsh and metallic.

#### Tapping techniques

##### "Silent" fingering

A performer can stop the strings with their left hand in an unusually forceful maneuver and thereby produce a percussive effect. Although quiet, the name "silent" is a misnomer and refers to the fact that the bow is often not applied when performing this effect.

##### Slapping the strings

The strings can be struck with the hand or with another object to produce a loud ringing or percussive sound. The performer's right hand is often used for this which leaves the left hand free to finger pitches or dampen the strings.

##### Knocking the instrument

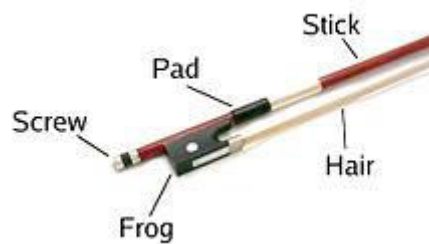
String instruments can be tapped just about anywhere. The body of a string instrument, since it is a resonant cavity, can resound quite loudly when struck with the fingers or another object.

## IV. CONCLUSION

#### "Chewing"

An effect sometimes used for humorous effect by string players, "chewing" is performed by loosening the bow hair and placing the bow, bow hair side up, against the back of the instrument. The bow is then rotated causing the bow stick to pop and crunch as it goes over the coarse bow hairs. This effect, which sounds remarkably like a person chewing something crunchy, is fairly quiet and could benefit from amplification.[19]

#### Bow screw glissando



Parts of a violin bow

The bow can be held vertically and the screw of the bow placed firmly against a string either at the location of a fingered note or at some other point. The string can then be plucked with the right hand and the screw of the bow can be simultaneously dragged up or down the string. The effect of this is to produce a quiet rising or falling ping. This effect is used in Helmut Lachenmann's Toccata.[20]

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