Harpsichord & fortepiano

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TAILORING THE SOUND OF YOUR KEYBOARD INSTRUMENT, PART I

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While much attention has been paid in the last several decades to copying the dimensions, case materials, and appearances of historical keyboard designs, there have been many major discoveries by historical keyboard researchers, and others, that have in general not filtered down into application by modern makers. Even less have the important musical consequences of these discoveries reached the attention of many players, teachers, and performers. This article will begin an exploration of some of these discoveries, their influence on tone and tone production, their advantages for performance, the reduction in time and frequency of tuning, and how the benefits might be applied to your instrument.

This instalment will discuss the desired qualities of historical sound, some factors that can adjust these qualities after the instrument is made, some of the performance benefits of historical tone production, some reasons for the difference between historical and modern perceptions of early keyboard sound, and finally the feature that provides the start for the final sound the instrument produces —wire.

The Importance of Tone

The importance of having an attractive tone is obvious for a singer. Tone is the first opportunity to capture (or not) a listener's attention, whereas a singer's technique takes more time to be appreciated.

The importance of tone production for instrumentalists can be seen in the design of many musical instruments where both arms are involved in playing (the bowed string family, lute, guitar, even French horn), with the dominant arm taking the task of tone production while the other arm has the task of determining pitch. Obviously playing the correct notes is important, but assigning to the more finely coordinated arm the task of tone production appears important in instrument design. For instance, the French horn has its valves operated by the left hand while the right hand is used in the bell to control tone. All the other valved brass instruments use the right hand to operate them, since only the lips are needed to control tone.

Tone is also a very important factor for successful keyboard performance. As with singers, if the tone produced by the instrument is not very musically engaging it will be more difficult for the audience to appreciate the performer's skill.

Vocal Qualities

Merely a "pretty sound" is not enough. How the tone begins, develops, and changes is of prime importance in providing vocal qualities to the sound. Electronic tones are often only sounds of an unchanging character that are either on or off. The static quality of this kind of tone is quickly boring to the ear, especially with lyrical music and long-held notes. A tone that changes slightly during its duration holds the ear's interest. However, a sound that changes its character too much during its duration creates problems for performing music.

The initial speech qualities, and the loudness, timbre, and sustain patterns of sounds that are sung, bowed, and blown can be varied intentionally by the performer during the duration of a note, but sounds produced by plucking or striking cannot be controlled to anywhere near the same degree by a keyboardist.[1] Consequently, the maker and/or technician of these types of instruments must create conditions such that, by an instant's contact with the strings, a sound is produced that possesses the most musically useful qualities from its very beginning until it fades to inaudibility several seconds or more later.

As with a beautifully sung tone, the plucked or struck sound must begin clearly with a well focused sense of pitch and continue a stable, well defined character throughout a smoothly fading sustain lasting long enough to allow a useful variety of phrasing possibilities for the performer. Well played, good quality lutes, guitars, and harps provide sonic models for the

kind of sound that should also be expected from harpsichords. Good quality hammered dulcimers, cymbalons, and even percussion instruments like kettle drums, marimbas and bells provide models for clavichords and fortepianos.

In fact, the 20th-century view — putting plucking instruments in one category and striking instruments in another — is quite likely a hindrance for understanding the type of sound that is desirable, and can be achieved, from keyboard instruments. Historically, clavichords, lutes, harps, and vihuelas were often grouped together because their sounds were considered to be so much alike[2].

The vocal qualities of changing timbre and volume are extremely important for determining the range of musical expression possible for a harpsichord, clavichord, or fortepiano. A more limited sound limits the ways the player can blend, contrast, phrase, express, and project musical ideas, and vice versa.

Different sound qualities encourage different playing approaches. The more different an instrument's qualities are from those heard historically by the composer, the more difficult it will be for players to grasp the composer's ideas themselves, or to convey successfully the composer's intentions to the audience.

Since good tone and tone production are so central to performing music, these should not be left to chance. Learning what factors are responsible for each of the various properties of sound, and learning how to tailor the amounts of each quality in the sound, is vital for the full realization of any instrument's musical potential

What Keyboard Designs Can Tell Us About the Sound

It might seem impossible to deduce what kind of tone and tone production was pursued historically since it seems as though that sound would have died away a long time ago without leaving a trace. However, there are quite sufficient written documents concerning the type of sound and tone production desired historically from voices and instruments, the way music was composed, and the way keyboards were designed.

Fortepianos and clavichords made with only one string per note would be much quicker to tune, quicker and cheaper to produce, and possibly somewhat lighter than the usual double strung versions. However, single stringing in these instruments is rarely found and only in models designed to be as compact as possible (and these are only slightly smaller than other models which use double stringing). The rarity of single strung historical fortepianos and clavichords would appear to indicate that historical makers and players perceived a significant advantage to the effects of double stringing – a preference for a type of sound that also likely influenced other decisions in tailoring sound. The simpler single strung approach is so rare owing to very important musical concerns that were also central to tone production, and were important enough to establish the characteristic design of these keyboard instruments.

While two strings do usually provide twice the vibrating energy of one string, the actual increase in loudness is very slight, close to the minimum limits of what many people can actually reliably discriminate; this is far less increase than can be achieved by a slightly heavier finger strike.

The real benefit of multiple stringing is an effect much more obvious, and much more musically advantageous. Multiple stringing produces a much smoother (i.e. less spiky) beginning to the sound and a longer sustain than can ever be produced by single strings that are struck or plucked.[3]

This effect can be heard in these instruments by listening to the sound of one string being played while the second string of the pair is kept damped, and then comparing it to the sound when the second string is allowed to ring freely. The single string condition has a more abrupt sound and a faster, straight line, decay rate. Having two strings vibrating together smoothes the spiky beginning of the single string condition by dramatically slowing the decay rate. (See illustrations at the end of this article.).

The smoothing effect that double stringing produces also benefits harpsichords.

1. When two 8′ strings are played together (even 8′ + 4′ to a lesser extent)

2. When notes are being held in the left hand. These undamped strings help smooth and provide more sustain to right hand notes that are harmonics of or harmonically related to them.

3. The fact that historical harpsichord dampers were intentionally shaped to leave the strings of unengaged registers free to vibrate sympathetically promotes this effect.

While single-strung harpsichords might seem unable to smooth and sustain their tones as compared with double strung fortepianos,

clavichords, and harpsichords, the plucking motion itself gives a means, not available to the vertically striking fortepiano and clavichord, to manipulate this smoothing feature further.[4] The timbre and decay rate produced by the vertical vibrations of a soundboard are very different from those of its horizontal vibrations. The vertical motion is looser and freer to move; it therefore produces a higher proportion of lower frequencies that use up the energy of the string very quickly, with a fairly quick decay rate (i.e. short sustain). The stiffer horizontal motions of the excited soundboard resist moving and so produce a greater proportion of higher frequencies which take longer to fade away. These two distinct contributions to an instrument's sound can be controlled to shape a smooth, integrated sound using different sets of factors for the harpsichord, fortepiano and clavichord.[5]

Tone Controls

It is necessary to understand that, as important as the case and soundboard may be for the sound of a keyboard instrument, these features do not by themselves produce historical sound, or even necessarily "good" sound. Just as details of set-up are crucial to achieve the most musically useful sound from a violin or guitar, such factors also affect strongly the tone production of keyboard instruments.

These set-up factors are very likely the major reason that people often notice that many early keyboard makers seem to have "their own sound" that can be heard no matter which keyboard model they are making or copying. These factors might also go far to explain why the same design made by different experienced makers sounds different, since if the historical design itself were truly the dominant factor in determining the sound, one would expect less variety of final result than is often heard. The influence of set-up factors on the sound of an instrument can be verified by the marked degree to which an individual instrument's sound can be changed by altering various factors having nothing to do with case and soundboard design.

All people have "voice boxes" which produce sound useful for speech. The particular physical construction of each box gives a particular set of resonances that provides a unique voice for each person. The basic voice might be more, or less, attractive, but it is not generally considered a musically useful sound until the person learns to control and modify the basic qualities of the sound that the box provides through manipulation of the vocal tract (throat, mouth, nose, chest, etc.). Similarly, each keyboard, due to the particular design and materials used in its construction, will have a unique basic sound, but in order for it to produce its most musically useful voice it is necessary to know how to control and modify its basic qualities.

From my over 40 years experience making harpsichords and clavichords and servicing fortepianos, I have found that some of the significant factors that need to be understood and controlled in order to achieve the most useful musical sound qualities from any keyboard "box", or to hope to achieve something approaching historical sound, are features that can be adjusted after the instrument is made.

Some of the important factors in producing musical results from historically based keyboard instruments are:

1. The **wire** used must closely match the physical properties of historical wire.
2. The **pitch** must match appropriately the original instrument's scaling.
3. The entire **stringing schedule** must be appropriate for the model.
4. **String termination properties** must sufficiently replicate that of the model.
5. **Details of string activation** must be accurately reproduced. Among other details, in harpsichords this means the amplitude and release angles of the pluck must be appropriate for the type of harpsichord; for clavichords careful attention to tangent voicing; for fortepianos, attention to hammer mass and specifics of leather properties and application.
6. **Damper qualities**, cloth, shape and fit must match that of the historical harpsichord model (similarly for the tangent cloth qualities and installation approach in clavichords, and for damper properties in fortepianos).

Understanding how these various factors influence sound and performance possibilities will allow you to alter considerably the sound from any particular instrument design in order to better reproduce historical practice, to produce a sound more musically useful for your intended purpose, and/or to suit your taste and performance ideas.[6]

Each of the first five tone control factors listed above affect several different qualities of the sound. In turn, each individual sound quality (discussed below) is influenced by more

than one of these factors. For instance, the type of wire chosen affects a note's focus, clarity, amount of fullness/brightness, degree of smoothness or "pop" at the start of the sound, and also its amount of sustain. In turn, the degree of brightness that was influenced by the choice of wire is also affected by the pitch chosen, the gauge size used, the string's termination conditions, and the voicing method used.[7] Thus, many sound qualities can be altered through using one or more of these factors, with the maximum degree of control being achieved by employing all the applicable factors.

Musical Sound Qualities and Their Performance Consequences

Timbre

All musical instruments produce sounds that can be characterized by the proportional strengths of their overtones, often referred to as **timbre**. Examples are the mellow sound of a muselar virginal with most of its energy in the lower overtones, or the bright incisive sound of a lute register on an English harpsichord with proportionally more energy in the higher overtones.

A significant proportion of low overtone content is needed in order to give a good sense of fundamental pitch and fullness of sound; if there is not enough of this, the tone will sound thin. Having sufficient mid level overtones is important to provide **clarity** and **projection.** Having too many and/or too high a proportion of high overtones will actually blur the basic pitch of the note by giving too much prominence to frequencies associated with notes that are not harmonic with its fundamental pitch, as well as frequencies that are simply out of tune with any note in the chromatic scale. The clashing of these higher overtone frequencies along with their intensity will create a shrill sound that blurs the musical line.

When notes share too many high frequencies it is much more difficult to hear counterpoint and inner voice melodies. This also makes tuning more difficult, and calls more attention to any slight mistunings, Additionally, the intensity and shrillness will make it difficult to blend with other instruments that do not have these characteristics. Consequently, it is important to be able to control the proper balance of overtones needed for an instrument's intended purpose.

Dynamic qualities

While timbre is certainly an important element of musical sound, it is important to realize that in plucked and struck instruments the timbre changes during the duration of the note, just as its loudness does.

When a sound is activated in any musical instrument (whether by plucking, striking, bowing, or blowing) the beginning **transient** sound is made up of many, many frequencies. Soon unrelated noise frequencies drop away[8], leaving essentially only the harmonically related frequencies that determine the pitch and timbre of the note. The more quickly tone can **focus** to just these harmonic overtones, the more quickly the ear can identify its pitch and timbre and consequently, the more quickly notes can be played together and in sequence without losing their identity or blurring or the musical line. Quickly focused tones will allow very rapidly played notes to produce proportionately more musical sound and less transient noise.

The focusing of transient sound into a musical tone is usually a rapid change of timbre, but there is also a slower change to consider. In order to create a **stable** musical tone, the timbre must be controlled for as long as it is audible. It is all too common to hear a two part sound in plucked and struck keyboard instruments: a "prompt" sound with one timbre and a quick initial decay, followed by an "after" sound with a noticeably different timbre and slower decay rate, but this feature is not obvious in other high quality plucked and struck instruments such as lutes, harps and guitars.[9] (See Fig. A.)

A marked shift of timbre during a note is obviously not like the natural human voice when saying or singing "open" vowels such as "ah" and "oh". The two part sound, however, can be heard when listening to spoken or sung diphthongs like "eye" and "ow" that are created from just such a timbre change. "Twangs" in spoken speech also come from such a gliding shift. However, when such a shift is present in *every* note it creates unstable tone that blurs musical focus. (See Fig. B.)

When an instrument's tone has a smooth, rounded beginning with a continuing character (i.e., a one part rather than a two part sound) notes can easily be not only blended smoothly in a phrase, but also separated as desired by timing the release of fingers between notes, which provides virtually an infinite number of phrasing possibilities. When notes have a two part tone, especially in legato passages, each note's obvious beginning makes the attempted phrase sound like separated notes, while

supporting left hand notes can easily sound like punctuation competing with the punctuated beginning sounds produced by the right hand. Also, the timing change between prompt sound and after sound will always be the same and this can conflict with the timing of the music. Additionally, when very short notes are played and/or when many notes are being played quickly together, the tone may never resolve to its after sound, giving only an impression of staccato sounds. In contrast, a stable, integrated tone can be concluded after any length and will always present its whole nature. (See Fig. C-H.)

Sustain/decay is often measured by the length of time a note can be heard, but decay frequently does not happen evenly. The **decay rate** is actually a more revealing measure of this quality. In fact, the "two part" sound discussed above is virtually always accompanied in keyboard instruments by a fast decay rate for the prompt sound which releases much of the string's energy; then the after sound begins at a quieter level and continues at a slower rate of decay. (There are several causes for this two part sound, and so several ways of controlling it, which will be discussed as the various Tone Controls are explored.). (See Fig. J.)

The decay rate characteristics of an instrument's sound strongly influence the range of phrasing available to a performer. Many harpsichord compositions, for instance, contain notes written to be held for six to eight beats in either hand. If an instrument cannot produce adequate volume for this long, it will be difficult for the player to convey successfully the composer's intentions to listeners. With a sound that decays quickly, or with a sudden loud release of energy and a quieter follow up, notes played rapidly will produce staccato-like accents rather than the suspended tones heard from other musical instruments.

(While Italian harpsichords are often characterized as having a loud initial sound and a quick decay, much of Italian music does not appear to be written with this expectation. As we shall see in a future article, this type of sound is primarily a 20th-century impression due to unhistorical instrument set-up. The same also appears to be true for 17th-century French harpsichords where the sound is also far more rounded, full, and sustained when set up according to the historical evidence, instead of using the more familiar 18th-century approaches. This will be explored further in an article about Stringing Schedules.).

FIGURES: General Notes on these figures

Vertical axis: Volume, from audibility at 0 to louder as it is higher on the axis. These go vertically from the loudest down to inaudibility at 0.
Horizontal Axis: Time, with 0 as the start of the sound, and increasing towards the right.

The markings on either scale are just relative and not intended to be exact units of loudness or seconds since both of those measures would vary depending on many circumstances.

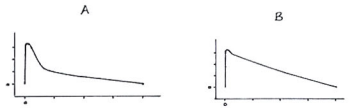

Fig A. Here the beginning "prompt sound" quickly drops to a quieter, longer-lasting "aftersound". Each of these "sounds" has its own timbre, and this, along with the change in decay rates creates an audible two-part tone.

Fig. B. By adjusting various Tone Controls in an instrument, the two-part sound can be changed into a more integrated, unified sound that gives a fuller, more supported tone.

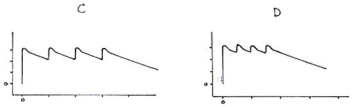

Fig. C, D. It is relatively easy to link one-part sounds together and give a smooth impression when playing at different speeds.

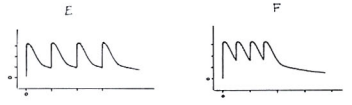

Fig. E, F. When two-part sounds are linked at different playing speeds their linking is less obvious since the prompt sound reduces in loudness so quickly that it can give a sense of separated notes, or even staccato. In the first example, the prompt sound timbre resolves into the aftersound timbre before the next note is heard, providing a change in timbre for each note (which happens with the same timing whenever the note is played, no matter the timing needs of the music). In the second example, the timbre of the aftersound is never heard before the next note is played.

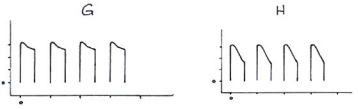

Fig. G, H. When one-part sounds are played with separations, they give a fuller sound when contrasted to the silences. When a two-part sound is played with separations it has already dropped half-way to

inaudibility (in this example anyway) which makes the following silence less of a contrast, and sometimes not even noticeably different than when such notes are playing linked, especially when several musical lines are being played together.

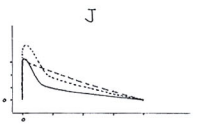

Fig. J. Here are the familiar two-part and one-part sounds with the same initial loudness which we have seen previously, along with another two-part sound that is markedly louder initially and then drops off more quickly in its aftersound portion, but has approximately the same amount of energy as the one-part sound. All three of these sounds drop to inaudibility in the same amount of time, so they all have the same decay times in seconds. Obviously though, it is their decay rates that tell us much more about what they would actually sound like.

The second half of this article will explore this topic further, including the musical importance of wire. I wish to thank very much Stephen Birkett, Gregory Crowell, Carol Linne, and Richard Troeger for their suggestions and help in writing this article.

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1 Except to a significant, but not complete, degree by clavichord players.

2 Gregory Crowell, "The Clavichord as a Plucked String Instrument", *De Clavicordio VII, The Clavichord and the Lute*, ed. Bernard Brauchli, Alberto Galazzo, Judith Wardman, (Musica Antica a Magnano, 2006), 181-194.

3 This occurs from the coupling back and forth of the energy between the two strings through the bridge, changes in the impedance relationships of the strings with the soundboard, as well as other factors. The relative smoothness of the sound can be adjusted by intentional mistuning of the strings that is slight enough to affect this smoothing quality yet not produce beats. See Gabriel Weinreich, "The Coupled Motion of Piano Strings", *Five Lectures on the Acoustics of the Piano*, ed. Anders Askenfelt (Royal Swedish Academy of Music No. 64, Stockholm, 1990), 75-80.

4 To be discussed in future Voicing article.

5 How these factors work will be explained in a future article.

6 In all fairness to the original maker, and for the sake of future owners as well as listeners, it would be best to note the date and nature of any such changes somewhere on the instrument (on rear surfaces of lowest key lever, back of nameboard or namebatten, inside bottom of the instrument under the keyboard, etc.).

7 It is worth pointing out here that because these factors so markedly affect the sound that an instrument produces, unless all of these factors are accounted and controlled for, it is meaningless to try to draw conclusions about "the sound" of a particular case design, or to try to compare two different designs when these factors are different on the two instruments.

8 Except for bells, gongs, and other such non-stringed percussion instruments.

9 While many people may assume that a harpsichord naturally should have a noticeable "pluck" component to its sound, this is not true of other plucked string instruments such as well played, good quality harps, lutes and guitars which produce a stable unified tone without an obvious two part nature. Similarly, for the striking action of the fortepiano, other percussion instruments like the marimba, bells, gongs, etc., can be used as models, where the crispness of the attack can be regulated by the hardness and speed of the strikers used, but the sound is still a unified tone that does not abruptly divide into obvious separate parts with accompanying volume changes. Most of the specific explanations about how a two part sound can be made into a more unified character will occur in future discussions about stringing schedules, string termination conditions, and plectrum and tangent voicing.