

Harpsichord & *fortepiano*

Vol. 16, No. 2 Spring, 2012

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Musical Instrument Research Catalog
(MIRCat)

OPTIMISING HARPSICHORD STAGGERING

by Claudio Di Veroli

1. Introduction

Most “Grand” harpsichords (as opposed to virginals and spinets) can play two or three strings using the same key. To avoid a heavy action, these strings are plucked at different points along the key dip: this regulation, produced by a careful calibration of jack lengths, is called “staggering”. The question we will explore here is which plucking order is best to avoid a heavy action. As soon as a harpsichord is voiced relatively loudly (a frequent requirement by many soloists and chamber ensembles in modern times), this matter becomes crucial, both to avoid a heavy action and to provide a pleasant sensation when the finger lowers the key.

A first approach would be to follow ancient customs, but they are largely unknown, and in most extant antiques the original plucking order is uncertain. An often quoted case is the famous Blanchet 1733 in Thoiry, Boalch 2a¹, where the extant original action has the 4’ speaking last: unfortunately this was the result of a regulation dated towards the end of the eighteenth century. As for museum instruments for which jacks have survived, even well researched publications with the action extensively documented, such as those by Koster² or Waitzman³, do not to include the plucking order among the details. Hubert Bédard, who restored scores of antiques for the Paris Conservatoire, observed that ancient actions hinted at different plucking orders. Summing up, extant evidence is both scarce and inconsistent. Hubbard found it preferable always to have the 4’ speaking first but acknowledged⁴ that some instruments “insist” on a particular order, which has to be respected.

The goal of this study is not to delve more deeply into the uncertainties of the past, but simply to find a recommended plucking order for the convenience of the modern player, achieving a lighter feeling of the action, or facilitating a louder voicing without incurring a heavy action. Needless to say, staggering is to be regulated after the jacks have been given their final voicing. We will not deal here with the very rare 16’ and 2’, but only with the 8’ and 4’, in the two alternatives for two manual harpsichords: coupler or doglegs. [Note: of the 8’ variants, we

can ignore the lute stop—jacks near the nut—and also the *peau-de-buffle*, as they were both meant to be solo stops and are thus not relevant to staggering. We will also ignore here the rare—mostly German—16’ and 2’ stops, as well as 8’ rows of jacks outside the gap (other than the lute stop): they total about 1% of extant instruments and a much smaller proportion of modern ones.]

2. Sound and Playing Technique

Makers and musicians prefer different plucking orders for different reasons. These days most harpsichords with a 4’ stop have it speaking first, but some makers prefer to have it sound last. As for instruments with two 8’ stops, preferences about their plucking order are also varied.

Staggering certainly affects the sound when a key is depressed slowly: at least one harpsichordist has recommended this effect in an online forum, but the consequence is loss of control, as the player cannot predict with any accuracy when every string will pluck. More importantly, there is no evidence that lowering keys slowly was ever part of the historical harpsichord playing technique. In practice, a player often plays more than one note per second, which means that every key is being fully lowered in a fraction of a second: the difference between plucking points of the two or three strings is therefore in the order of a few hundredths of a second. Some players insist that they can hear the difference between different plucking orders; having carried out a few blind tests, with normal fast-lowering technique, this author can find no audible difference.

However, plucking order is indeed very important because—other things being equal—some orders produce a significantly lighter action than others: this is most useful to players, especially those with a loudly-voiced harpsichord. Let us see then how to achieve this “optimal” staggering.

3. Understanding Weight Curves

This study is based on the different resistance that the player encounters as he/she lowers the key. *Prima facie* plucking order needs to be farther apart in the bass, where the

strings require more jack travel to be plucked: however, the midrange and treble, where most fast passages and ornaments are found, require a lighter action. All things considered, the author finds it suitable, throughout the instrument's compass, to have the strings playing as far apart in time as possible, within constraints to be explained below.

The resistance the finger encounters is produced by the weight of the action plus every single plectrum plucking its string. Having checked in different parts of the keyboard range, we find that the weight curves are different, but their shapes and proportions are very similar. Thus for this study it is enough to scrutinise what happens for a central note, such as Middle C. The measurements reported below were obtained using calibrated weights, one gram apart and checked electronically to an accuracy of .10 gram. The experiment setup is illustrative. For a single keyboard harpsichord with 8' + 4', a typical sequence is as follows:

1. With both stops off, yielding only the "action weight" produced by the key and the jacks, the key is lowered by carefully adding successive weights, measuring key dip in tenths of a millimetre with a calliper, and finally writing down each measurement, i.e. the pair weight vs dip.
2. As before with the 8' foot on, yielding the action weight plus the plucking action of the 8' jack.
3. As before with the 4' foot on, yielding the action weight plus the plucking action of the 4' jack.
4. As before with both stops on, yielding the total full harpsichord weight. Needed as control only.
5. Now the researcher has 4 sets of data, each one consisting of pairs of values (weight vs key dip), equally spaced by weight. The data are entered into a spreadsheet.
6. Using mathematical techniques, the data are converted, with no loss of precision, to values equally spaced by .1 mm key dip.
7. For each measurement, the action weight is subtracted from the other measurements, yielding the net weights produced by the solo 8' and the solo 4'.

In the spreadsheet the action weight is unmovable, but the data for the two stops can be moved up or down, simulating different regulations of staggering, i.e.

different jack lengths. In the spreadsheet, charts are set up to visualize the different curves and their combined effect. It is important to keep in mind the following properties of the 8' and 4' weight curves:

8. The curves in this study were derived from a French double harpsichord, and although absolute values vary for different instruments, their shape and proportions are the same for the practical purpose of finding the best plucking order. In the curves below, the middle section is shown straightened: in practice it shows small undulations that can safely be ignored here.
9. The weight curve does not only start when it points upwards, but much earlier: at first the key starts raising the jack, the damper leaves the string, and then the plectrum encounters the string. Only at this point does the curve start to rise. If, misled by the initial flatness of the curve, we make the jack too long, rising too early in the key dip, the string will not be properly damped when we release the key.
10. Vice versa, if the jack is too short, to play the string the player needs to press at the end of the key dip, which is absolutely to be avoided. Normally one millimetre or so is allowed for the finger to reach comfortably to the bottom of the key dip with minimal pressure.
11. The above explains why, in a loud instrument with 8' + 4', it is not uncommon for the 8' to require two thirds of the key dip to function properly.

Further details will be seen below for each different disposition.

4. Disposition 8'+4'

This is the typical disposition for the very common Flemish singles and the lower manual of 18th-century doubles. Some modern makers prefer to have the 8' speaking first, but most makers prefer to have the 4' speak first. Let us find out which alternative achieves the lightest action.

Let us begin with two empirical considerations/tests. (1) Everybody agrees that the 4' is more efficient acoustically and that it has to be voiced more softly than the 8'. As a consequence, plucking a 4' string always requires significantly less effort and key dip than plucking the corresponding 8' string. (2) This is more involved. We check that central (Middle)

c1 and d1—with the same plucking order and staggering distance—feel absolutely identical in volume and action weight. Then we regulate jack lengths so that the c1 has the 4' plucking as soon as possible while the 8' plucks as late as possible, and the d1 the other way around. Now let us try playing both keys slowly, staccato, legato, trills; the d1 will feel distinctly heavier.

Is the above subjective? Let us try objective measurements and calculations, as explained above: first with no stops on, then with each stop on, and finally both together. When the data are gathered, and converted to equidistant key dips, clearly the 4' plucking action requires much less weight and key dip (2.6mm) than the 8' (4.2mm), as will be apparent from the charts below. Now we can reproduce the two staggering alternatives by moving the 4' and 8' data sets up and down. Optimisation is easy; one string has to speak as soon as possible, the other one as late as possible, with the constraints explained above (too early does not damp properly, too late is not comfortable). The charts below show the three components and the total weight curve.

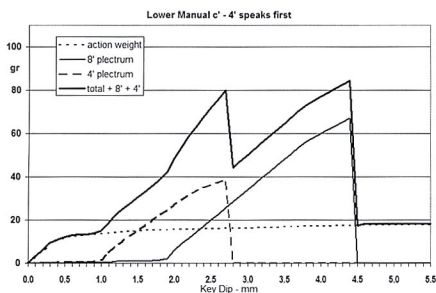


Fig. 1 - Two stops 8' + 4' - The 4' speaks first

When the 4' plucks first, its action weight conveniently “fills” a part of the key dip where the 8' plucking action is just beginning. The resistance soon reaches a plateau with a total of 80.2 g, then it decreases after the 4' plucks but is soon compensated by the rise in 8' resistance, reaching 84.6 g before the 8' plucks.

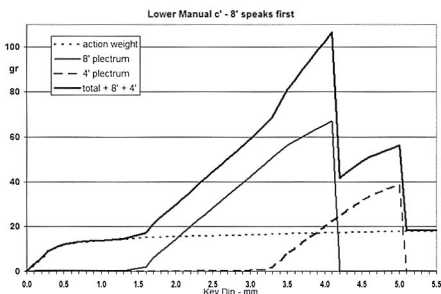


Fig. 2 - Two stops 8' + 4' - The 8' speaks first

Let us now optimise for the other plucking order. Now the 8' has to pluck as early as possible (It is never very early, because a relatively loud 8' needs about 70% of the key dip.). The curve shows how the key comes down at first with minimum resistance, then it rises very steeply reaching a maximum of 106.6g. This is a whopping 26% more than with the 4' plucking first: to make matters even worse, the 4' is now plucking uncomfortably near to the bottom.

Conclusion: empirical tests, measurements and calculations coincide with the old recommendation by Hubbard in 1963 and most modern makers ever since, to have the 4' speaking first. Recommendation: the 4' should speak first.

Disposition 2x8'

This is the typical disposition for Italianate harpsichords. Arguments have been voiced for having either the back 8' or the front 8' voiced more loudly or softly, and plucking first or last. Some musicians insist that the order of the two stops changes the resulting sound. The author has carried out some blind tests pressing keys at reasonable live speeds: while a few listeners could distinguish a staggered regulation from a non-staggered one (the two 8' strings speaking at the same time), nobody could tell the difference between two keys staggered by the same amount but in the opposite plucking order. Therefore, the best policy is again to determine which order produces a lighter action.

Due to different sound efficiency in plucking back vs front, and also to different musical tastes, in most instruments we find that one of the 8' stops is heavier, requiring more key dip for the action and more finger pressure. At this stage, we are in exactly the same situation as the 8'+4' disposition above, even if the difference between the two stops may not be so extreme.

Conclusion: For optimal distribution of resistance along the key dip, and a lightweight action, it is best to have the lightest 8' plucking first, its tension filling the curve while the other string comes under tension.

Recommendation: for a lighter action, the 8' stop that when played solo offers less resistance to the player's finger is the one that should be regulated to pluck first.

Disposition 2x8' + 4', Single or Double with Dogleg

This applies to Flemish single-manual three-stop harpsichords and also to classical English doubles with the lute stop off. In both models,

the lower manual plays three string choirs directly by means of three separate jacks. Both the combined effects explained above apply here. Since either 8' stop needs more weight and key dip than the 4', it is the 4' that should speak first. As for the two 8' stops, it depends on the instrument's voicing. In English instruments, the upper 8' is normally voiced more softly and therefore should speak after the 4', leaving the lower 8' to speak last.

Recommendation: the 4' should speak first, then the 8' stop that offers less resistance to the player's finger, and finally the other 8' stop.

Disposition 2x8' + 4', Double with Coupler

We have a new ingredient here: staggering in the lower manual now includes coupling action. The upper 8' plucking action needs less weight because it (a) is mostly voiced slightly more softly and (b) is acoustically more efficient. Conversely, playing it from the lower manual adds the weight of the coupling action and the upper key. For this reason, instead of the 4.2 mm key dip required by the lower 8', the upper 8' played from the lower manual in our typical French action needs 4.5 mm plus the coupler's lost motion (between 0.5 and 1.0 mm): the total is thus between 5.0 and 5.5 mm, using most of the instrument's lower manual key dip.

At this stage it is apparent that the upper 8' should be plucked last, not only for an optimal distribution of resistance along the key dip, but also to allow the coupled upper keyboard to start very slightly delayed with respect to the lower keyboard. This is desirable to prevent wear of the coupling surfaces and even broken action parts in case the coupler is engaged while a lower key is accidentally slightly touched.

Let us now see whether accurate measurements confirm the above policy. We first measure the upper 8' coupled action, deduct the already-measured lower key idle action and separated jacks, and as a result in the spreadsheet we can manipulate the three stops simulating any possible staggering. There is not much that can be done with the upper 8'. With coupling action and jack action taking a whopping 90% of the key dip, it has to pluck last: any maker that prefers doing otherwise has to produce either a very soft upper 8' or a very large key dip, and there are good musical and historical reasons to avoid either. Now we have to find out which of the two lower manual stops should speak first. Let us optimise both alternatives.

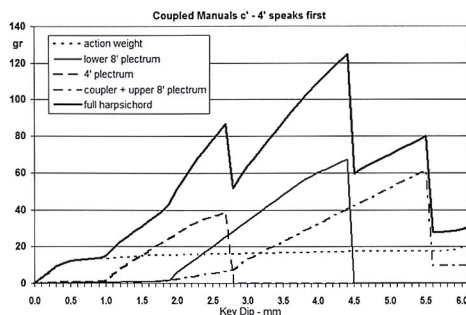


Fig. 3 - Three stops 2x8' + 4' with coupler - The 4' speaks first

In the above chart we can see how if the 4' speaks first, the lower 8' should pluck so as to minimise maximum peak and also distribute resistance evenly along the key dip. This is clearly achieved in the above curve, with peaks conveniently spread along the key dip for a smooth action, whether any two of the stops or the three together are engaged. Players that use 2x8' more often than 8' + 4' will find it preferable to raise the lower 8' to its uppermost limit: plucking at 4.2mm instead of 4.5mm and lowering the maximum resistance from 125g to 119g.

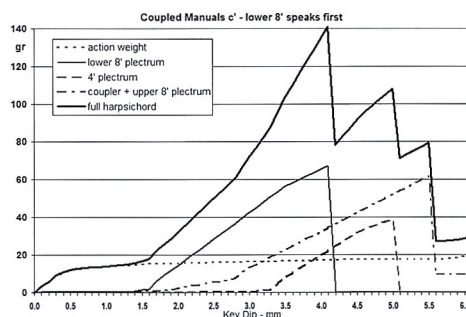


Fig. 4 - Three stops 2x8' + 4' with coupler - The lower 8' speaks first

The above chart shows that, if the lower 8' is plucked as soon as possible, and the 4' "inserted" afterwards, the key at first goes down easily, then the resistance increases sharply as both coupler and 4' are added to the mix. Not only is the maximum peak now significantly heavier, but the three peaks are concentrated in the lowest part of the key dip, making for a significantly heavier action, other things being equal.

Conclusion: for French doubles, the lightest action is achieved by having the 4' plucking first and the coupled 8' last: this was

recommended decades ago by Hubbard and is followed by most makers today, especially for instruments voiced relatively loudly. An optimal staggering following this policy is shown by the Australian harpsichord maker Carey Beebe in a video on Youtube.⁵ Recommendation: the 4' should speak first, then the lower 8', finally the coupled upper 8'.

Generalisation

The measurements above were made on one instrument. How proper is it to extend them for general use? A first observation is that the weight curve of any stop varies between instruments. However, harpsichord action and the laws of physics yield resistance curves that follow a uniform general shape: a first section that is almost flat, followed by a section with increasing resistance, falling down to zero when the string is released. Also and very importantly—except for abnormal harpsichords that have stops with plectra of extremely different lengths and/or made of different materials—given two stops, if one has a significantly higher maximum weight, the action will also take a significantly larger amount of key dip. Under these conditions, as shown above, sheer mathematics shows

that the best plucking order of the stops—achieving smallest maximum peak and best distribution of resistance along the key dip—is from lightest to heaviest.

In particular, we recommend above that the 4' be plucked before the 8'; all the instruments known to the author have a 4' with significantly less resistance than the 8'. As for the plucking order between lower 8' and coupled upper 8', again in most instruments the coupler makes the upper 8' heavier and causes it to require more key dip. The author has seen however at least one antique by Taskin where the upper 8' was voiced quite softly and the coupling action was particularly efficient: in these cases, obviously it is the lower 8' that is heavier and has to pluck last. However, there is good evidence that in historical harpsichords the two 8' stops were voiced for similar loudness.⁶

The reader will find a few further details about staggering in manuals on harpsichord maintenance. An excellent short essay is available online⁷. Let us stress again that the above recommendations are mainly meant for modern replicas. In authentic antiques, they can be used as ideal guidelines only; absolute priority should be given to any evidence about their original staggering order.

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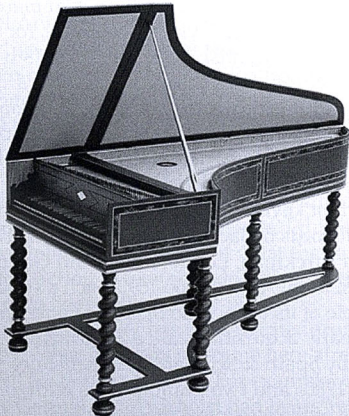
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