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Keyboard Tuning

Tuning Renaissance and Baroque Keyboard Instruments: Some Guidelines

Mark Lindley

Rudiments

Normally a single string or pipe is tuned to another single string or pipe, and the tuner either eliminates beating (for a pure unison or interval) or obtains a certain desired rate of beating (for a tempered interval). Beats emanate primarily from the lowest unison between overtones of the two notes forming the interval. Figure 1 shows where that unison will be for various consonant intervals on a harpsichord or piano, or on an organ diapason-type stop (or salicional, dulciana, or reed stop):

In a perfect 5th, the second partial of the upper note is in unison with the third partial of the lower note.

In a perfect 4th, the third partial of the upper note is in unison with the fourth partial of the lower note.

In a major 10th, the second partial of the upper note is in unison with the fifth partial of the lower note.

In a major 6th, the third partial of the upper note is in unison with the fifth partial of the lower note.

In a major 3rd, the fourth partial of the upper note is in unison with the fifth partial of the lower note.

In a minor 3rd, the fifth partial of the upper note is in unison with the sixth partial of the lower note.

Figure 1. *Unisons between overtones in consonant intervals.*

In each case, if the timbre is harmonic (which it is on the organ, and nearly so on the harpsichord and in the middle octaves of a piano), then if the unison between overtones as shown in Figure 1 is pure, the interval as a whole will be pure, and if that unison is not pure, its rate of beating will show how much the interval has been tempered—except that one other factor must be taken into account: the approximate pitch-frequency of the unison itself. For example, to temper identically two intervals of the same kind but a step apart in the scale (say, *F-C* and *G-D*, or *F-A* and *G-B*), the interval a step below should be made to beat just barely slower (about 10 % slower) than the one a step above. This principle is basic to setting any regular temperament: if two equivalent intervals are a 5th apart—for instance *C-E* and *G-B* a 5th higher—the higher one should beat half again as fast as the lower one (because the ratio for the 5th between the unisons among the overtones is approximately 3:2); but if they are a 4th apart—for instance *C-E* and *F-A* a 4th higher—the higher one should beat 1/3 again as

fast as the lower one; and so on. In any temperament (regular or irregular), each tempered interval should beat twice as fast as its duplicate an octave lower—and each note should beat the same with the notes a major 6th above and minor 3rd below (see Figure 2a), with those a 5th above and 4th below (see Figure 2b), and with those a major 3rd and major 10th above (see Figure 2c): this rule can be helpful in refining the purity of the octaves.

Figure 2. *Some comparisons for testing the purity of an octave. (The two intervals within each comparison should beat equally fast.)*

Quasi-Pythagorean Temperament

Tune pure all the intervals shown in Figure 3. Start with a pure octave between middle *B* and tenor's low *B*; then tune pure a chain of eight 5ths and 4ths as shown (*B-E-A-D-G-C-F-B^b-E^b*), while taking care to make none of the 5ths larger than pure, nor any of the 4ths smaller. Upon reaching ***E^b*** check to see if it makes a pure major 10th with the initial low *B* (see the end of Figure 3), and if not, review the chain *B-E-A-D-G-C-F-B^b-E^b* and take more care to assure that none of the 5ths are larger, nor 4ths smaller than pure. Then tune *A^b/G#* pure with *E^b*, *E*, and *B*; then *D^b/C#* pure with *A^b*, *A*, and *E*; and finally *G^b/F#* pure with *D^b*, *D*, and *A*.

Figure 3. *A procedure for setting a quasi-Pythagorean temperament.*

Three Shades of Regular Meantone Temperament.

Start with the major 3rd *F-A* in the tenor octave (see Figure 4). Tune it larger than pure and beating three times per second for 1/6-comma meantone, or slightly more than twice per second for 1/5-comma meantone; or else altogether pure for 1/4-comma meantone.

Figure 4. *First steps in setting a meantone temperament.*

A,F C,G,D

Now tune *C*, *G*, and *D* to make the chain of 5ths and 4ths *F-C-G-D-A* as shown in Figure 4. Make *A-D* beat twice per second for 1/6-comma meantone, or slightly less than three times per second for 1/4-comma meantone. In any case, make *G-C* beat half again as fast as *C-F*, and *A-D* half again as fast as *G-D*. (Meet these requirements by adjusting *C*, *D*, and *G* while leaving *F* and *A* alone.)

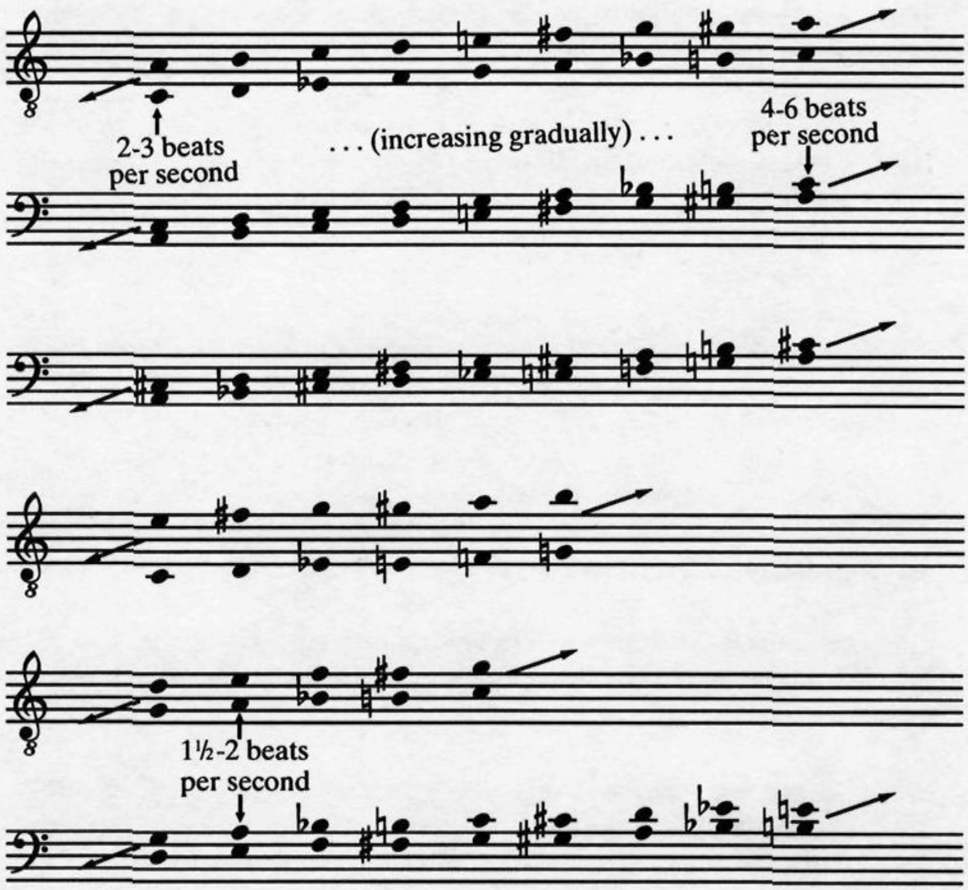
Figure 5. *Next steps in setting a meantone temperament.*

etc.

E B B♭

Figure 5 suggests how, in expanding the temperament to include additional pitch classes, each new one should be tuned to form intervals which beat just slightly slower or faster than any equivalent intervals a step above or below that have already been tuned. Figure 6 shows the final result (and includes some beat rates for 1/4- and 1/6-comma meantone, the corresponding rates for 1/5-comma meantone being intermediate to these).

Figure 6. *Final results in a meantone temperament with two flats (B^b, E^b) and three sharps (F#, C#, G#)*



A *Tempérament Ordinaire.*

Tune the diatonic notes and *F#* in a regular meantone temperament with the initial *F-A* beating about twice per second (or perhaps 1½ or 2½: explore these alternatives and judge the musical results). Then:

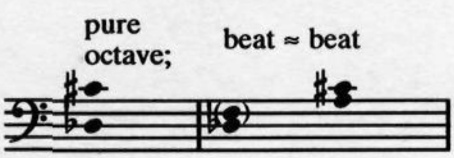
> Make the *D#/*E^b below middle *C* beat equally fast with the *B* and *G* which are a major 3rd below and above it respectively; or else let it beat slightly faster with the *G* than with the *B*.
>
> Tune B^b as nearly pure as possible with both E^b and *F*.
>
> Make *C#* pure to *F#*, and *G#* pure to *C#*; then raise *F#* enough to make it impure with *C#*, but not enough to make it pure with *B*.
>
> Test and refine by playing historically appropriate music and judging critically the intonation of the various chromatic notes.

An Approach to a Bach-Style Irregular Temperament.

Tune the diatonic notes in a regular meantone temperament with the initial *F-A* beating three or four times per second (or at an intermediate rate). Then:

> If you like, raise *B* and lower *F* slightly (by equal amounts)—not enough to make *E-B* or *F-C* pure, nor enough to make the major 3rd *G-B* beat as fast as the major 3rd *C-E* a 4th higher. See that *F-A* and *G-B* are tempered the same (i.e. with *F-A* beating imperceptibly slower than *G-B* a step above).
>
> Tune tenor's low D^b and middle *C#* a pure octave apart and with the major 3rd D^b*-F* beating at about the same rate as the major 3rd *A-middle C#* (see Figure 7).

Figure 7. *D^b/C# in an irregular temperament for Bach*



> Tune *F#* to be tempered as little as possible with *B* and with *C#*.

Tune A^b, E^b, and B^b in such a way that the 5ths and 4ths in the chain D^b-A^b-E^b-B^b-*F* are virtually pure; if there must be some perceptible impurity, give it to D^b- A^b- E^b rather than to E^b-B^b- *F*.

Test and refine by playing Bach's music and judging critically the intonation, especially of the various chromatic notes.

Equal Temperament

Start with a chain of major 3rds extending through more than an octave, for instance from low *A* up to middle *F* as shown in Figure 8; make each octave pure and meanwhile make the beating of the 3rds increase smoothly throughout the chain. (Low *A* should beat about 4¼ times per second with either *C#*; low D^b about 5½ per second with either *F*; tenor's low *F* 7 per second with *A*; and *A* 220 about 9 per second with middle *C#*:  .)

Figure 8. *First stage in setting equal temperament.*

Then tune the following notes:

A^b, E^b, and B^b to make the chain of 5ths and 4ths D^b-A^b-E^b-B^b-*F*;

C, *G*, and *D* to make the chain *F-C-G-D-A*;

E, *B*, and *F#* to make the chain *A-E-B-F#-C#*.

See that each new note forms (with notes that have already been tuned) intervals which beat imperceptibly slower or faster than any equivalent intervals a step (or half-step) above or below that have already been tuned. It hardly matters in which order the new notes are tuned, so long as this principle is applied consistently.

Here I have drawn upon Sorge's instructions (*Ausführliche und deutliche Anweisung zu Rational-Rechnung*, Lobenstein, 1749, p. 199) for *die gleich-schwebende Temperatur*, which start with a chain of three equal major 3rds making an octave and conclude with

a check of twelve major triads in chromatically rising sequence—*F-A-C, F#-A#-C#*, etc.—to ensure that they are all "equal in sharpness' (ob sie einander an Schärffe gleich sind).