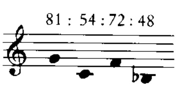
Introduction

Tuning a lute or viol really well is not a simple matter of adjusting the open strings: one must also see to the exact spacing of the frets down the neck of the instrument. Some thirty players and theorists wrote about this problem between the 1520s and the 1740s. The key passages are here transcribed and translated and, when it is informative to do so, are analysed in relation to music of the day. I have made it a point to include some misleading theories of well-known authors, because it can often be as useful to know why one theorist should be dismissed as to know why another should be taken into account. My conclusions about performance practices are summarized in Chapter 7. Chapters 3 and 4 include fretting instructions for equal temperament and for two shades of meantone temperament. The index may be of use to readers with particular historical interests.

Chapter 1 explains that most of the various fretting methods which have been proposed for lutes and viols can be discussed under four broad headings:

pythagorean intonation, in which the 5ths and 4ths are untempered (tuned quite pure) and as a result most of the major 3rds and 6ths, including those among the open strings, are nearly 1/9 tone larger than pure,[1] and the diatonic semitones (those forming part of a diatonic scale, such as C♯-D or A-B♭) are smaller than the chromatic ones (such as D♭-D or A-A♯);

equal temperament, in which the octave is made up of twelve equal semitones, and the 5ths and 4ths are slightly tempered, but much less so than the 3rds and 6ths;



1 Among the notes shown here, if the frequency of vibration for the G is 81 during every scant 1/4 or 1/5 second (which is the right range), then the C a pure 5th below will have a frequency of 54 (2/3 of 81); the F, 72 (4/3 of 54); and the B♭, 48 (2/3 of 72). But a pure major 6th above the B♭ would have a frequency of 80 (5/3 of 48); so the 81:48 major 6th is larger than pure by 81:80, which is slightly less than 1/9 of 81/72 (the whole-tone between G and F). The 81:80 discrepancy is called the syntonic comma.

meantone temperaments, in which the 5ths and 4ths are tempered rather more than in equal temperament so that the 3rds and 6ths will be only moderately tempered (indeed, the major 3rd may even be pure in one well-known form of meantone temperament), and the diatonic semitones are larger than the chromatic;

just intonation, in which not only most of the 5ths and 4ths are untempered, but also the major 3rd at fret 4 and between the two middle courses. Two sizes of whole-tone (9:8 and 10:9) and several sizes of semitone are involved. Also, if one of the open-string 4ths is not tuned some 1/9 tone larger than pure, the double octave between the first and sixth courses must be left smaller than pure by that amount.

Chapters 2-5 discuss each of these types in turn. Chapter 2 describes the pythagorean fretting schemes of some sixteenth-century writers, notably Oronce Fine (p. 10) and Juan Bermudo (pp. 13-18), who were no doubt impressed by its theoretical venerability and unaware that competent players of the day favoured a tempered intonation. Some lute music issued by Fine's publisher, Pierre Attaingnant, is examined in this light (pp. 12-13).

Late-renaissance theorists established that lutes and viols were normally set for equal temperament (unlike keyboard instruments), and composers ever since have assumed that they could be played in all keys without the extra frets which would theoretically be necessary for any system other than equal temperament. Chapter 3 complements this basic point with: evidence for the use of equal semitones on some fretted instruments before 1550 (pp. 19-22); a critical comparison of the $\sqrt[12]{2}$ and 18/17 methods (p. 21); an explanation of why early-sixteenth-century theorists described equal temperament obliquely (pp. 23-27); an analysis of relevant passages from Aristoxenus and Macrobius (pp. 30-31); a description of Bermudo's frettings for an approximation to equal temperament (pp. 27-30); a scheme for lutes invented by the first president of the Royal Society and based on the golden section (pp. 33-36); and finally, evidence from Michael Praetorius (pp. 36-37) and Marin Marais (pp. 38-41) that players could, without particularly altering the frets, make the instrument produce some kind of intonation other than equal temperament.

Chapter 4 explains the technical and musical characteristics of meantone temperament (pp. 43-45 and 51-54) and complements the last section of the preceding chapter with a survey of testimony from various late-sixteenth- and early-seventeenth-century writers (with particular attention to Giovanni Battista Doni) as to how well lutes and viols could match the intonation of keyboard instruments, which at that time were tuned to one or another of the various regular forms of meantone temperament (pp. 46-50). Chapter 4 also shows that two early-sixteenth-century composers, Arnolt Schlick and Luis Milán, probably intended their music for some shade of meantone temperament (pp. 51-58), and examines the fretting instructions of Hans Gerle (pp. 58-60) and Silvestro Ganassi (pp. 60-65): these are irregular schemes, but they may have served as pragmatic approaches to a meantone temperament. The chapter concludes with some practical fretting instructions.

Chapter 5 examines some representative schemes for just-intonation fretting (Mersenne is treated at some length) and explains why none of them have been taken beyond the experimental stage. Chapter 6 analyses the rather chaotic fretting instructions published by John Dowland, and shows that he himself never used them (pp. 81-83). Also, the 'modified meantone' for fretted instruments which J. Murray Barbour attributed to Giovanni Maria Artusi is shown to have been, in reality, a theory of equal temperament for vocal music, attributed implicitly to Claudio Monteverdi (pp. 84-92).[2] Chapter 7 summarizes the practical implications of the preceding six chapters.

Some ancillary topics are dealt with in the first three appendices. In Appendix 4 Gerhard Söhne shows how certain historical lute designs embody a fairly close matching of proportions and more complex geometric elements (mathematically not unlike the matching, for equal temperament, of 18:17 and $\sqrt[12]{2}$). The lute-makers and designers cited in Appendix 4 include Henri Arnaut, Matteo Sellas, Vvendelio Venere, Hans Frei, and as a counter-example – a distinguished maker whose designs resist mathematical analysis – Michielle Harton.

I should like to describe briefly here the criteria by which it can be shown that Dowland's music requires a more or less equal temperament, that the music of Schlick and Milán fits meantone temperament, and that the preludes published by Attaingnant are *not* suited to pythagorean intonation.

The only real test is the sound. On several occasions when I have tuned a suitable instrument in an historically likely manner and then tried out some part of the appropriate repertory for the first time, I have met with surprises; and always I have heard *something*, some effect in the harmony, some rapport between a nuance of the tuning and the instrument's timbre, which could not be anticipated from looking at the score. (Of course some composers have cultivated such subtleties less than others.) The tablature notation (explained in Appendix 1 for readers unfamiliar with it) does give us

2 Part of Chapter 6 appeared, in somewhat different form, in *Early Music History 2* (Cambridge 1982), 393-404, and an early version of part of Chapter 3 in *JLSA* XI (1978), 45-62.

some valuable clues. It allows us to determine whether the composer has called upon the same pair of frets for a diatonic semitone on one string and a chromatic semitone on another. If he has done so quite freely among the first few frets (where it is harder for the player to fudge the intonation) or between the nut and fret 1, a meantone temperament can be ruled out, because in that kind of tuning the substitution of a chromatic semitone for a diatonic one will usually produce a sour chord. On the other hand, if he has gone out of his way to avoid using the same fret for a diatonic and a chromatic semitone, particularly in the same composition, we may infer a sensibility to the limitations of meantone tuning. In the case of pythagorean intonation the issue is more elaborate: here the exchange of one size of semitone for the other may sometimes have a good effect, because the difference in size between the two kinds of semitone in pythagorean intonation is virtually the same as the difference between a pythagorean and a pure 3rd or 6th. As we look for a convincing pattern of distribution among the relatively pure and impure chords (and among the relatively dull and incisive semitones), we are led again to tune an appropriate instrument and discover the musical effect.

A certain kind of scholar will complain – indeed has complained[3] – that this method is too subjective, even when accompanied by the other kinds of evidence described here. I think it worthwhile, however, to use our ears as best we can, and hope for a well-informed consensus to confirm our perceptions, or improve upon them. To that end the publishers (to whom I am grateful for the care which they have lavished upon this little book) have distributed also a tape cassette with recordings of some of the examples from Attaingnant, Milán, Valderrabano, Louis Couperin and Marais. Each example on the lute is played twice, with different fretting schemes. The example from Louis Couperin complements Appendix 2 and supplies the necessary background for an appreciation of John Hsu's ability to match the harpsichord's tuning on the viol. Presumably Marais could do this as well.

3 So far I have received this complaint only from a scholar who had not heard the tunings.

1 *Classifying temperaments*

Any account of the history of tempered tuning on lutes and viols might well begin with an admission that even the best tuner cannot impose a theoretical scheme upon these instruments very exactly. For one thing players cannot help but alter, in greater or lesser degree, the tension and therefore the pitch of a stopped string when they press it down to the fret. Pietro Aron referred to this leeway when he said in 1545 that the lutenist's finger can aid the intonation of the instrument by the *intensione* and *remissione* of a minute space;[1] and Michael Praetorius in 1619 spoke of a 'give and take' in the string by which the player's grip at the fret of a lute or viol could mitigate the defective semitones of equal temperament (see below, p. 36). On a viol the pressure of the bow stroke can also modify the pitch.

Gut strings are in any case less uniform than metal. Their mass per unit length may vary so much that, as Hubert Le Blanc declared in 1740, 'Two strings of the same thickness, as clear as rock crystal, make the 5th at a considerably different degree forward and back.'[2] Fastidious players will discard strings which are altogether false (renaissance and baroque tutors show that this was a recurrent problem), but even the best gut strings will have some slight irregularity. It is part of their charm.

How far the player's leeway and the string's irregularity may go is hard to say, but certainly far enough to render it immaterial that a perfect 5th in equal temperament is theoretically smaller than pure.[3] The amount – two cents – is just enough for most keyboard-tuners to have to take it into account, but is too slight to be worth mentioning in practical instructions for the lute or viol. A knowledgeable pianist such as Johann Nepomuk Hummel will carefully specify the quality of the 5ths in equal temperament (1828):

1 Aron 1545: 35^{v}.
2 Le Blanc 1740: 138.
3 In equal temperament all twelve 5ths are smaller and all 4ths larger than pure by 2 cents, or 1/12 of the pythagorean comma, the amount (theoretically 23.4 cents) by which a chain of twelve pure 5ths and 4ths will yield an impure unison or octave.

To afford the ear some guide respecting these flattened fifths, we may divide them into three species, into good, bad and absolutely perfect. A fifth is bad when it sounds too flat with regard to the lower note. It is good, when not indeed absolutely perfect, but yet so nearly so as not to sound offensive to the ear.[4]

But it would be idle to expect such finesse in tuning instructions for fretted instruments. Instead, the Burwell instruction book for the lute (*c* 1670) says: 'Now one cannot well tune his lute unless it be well strung and have good fretts . . . the best way to place them [is] by the Eare Singing the Gamott . . . You must use several meanes for the accomplishment of so important a thing as the tuneing . . .'[5] Jean Rousseau (1687) says:

On peut accorder la Viole par Quartes,	One can tune the viol by 4ths,
& c'est la maniere ordinaire des	and this is the usual method of
Maistres qui distinguent facilement	master players, who distinguish readily
la justesse de cét Intervalle	the proper tuning of this interval
en touchant deux chordes à l'ouvert.	while playing two open strings.
On peut encore accorder la Viole par	One can also tune the viol by
Quintes & par Octaves, mais il est	5ths and by octaves; but it is
certain que la veritable maniere de	certain that the true method of
bien accorder est de se servir de	tuning well is to use
toutes ces manieres l'une après	all these methods one after
l'autre, comme d'un moyen infaillible	the other, as an infallible means
pour connoistre le deffaut des	for detecting faults among the
chordes, pour y remedier quand	strings, in order to remedy them (when
la chose est possible, en avançant	that is possible) by moving
ou ritirant un peu les Touches.	the frets slightly up or down.[6]

Danoville (also 1687) is just as vague:

les Musiciens . . . par la justesse de	Musicians by the trueness of
leur oreille accordent toutes leurs	their ears tune all their
Cordes à l'ouvert,	strings open
& arrangent par ce moyen les Touches	and thereby arrange the frets
dans les lieux & places qu'elles	where they
doivent estre . . . Le plus facile &	ought to be . . . The easiest and
le plus aisé à pratiquer c'est celuy	most convenient [method] is that
des unissons, les autres il les faut	of unisons; the others must be
laisser pour les Musiciens.	left to musicians.[7]

In the sixteenth century, Ganassi (1543) and certain unnamed vihuelists referred to disapprovingly by Bermudo (1555) would also habitually refine the fretting by ear rather than adhere literally to any mathematical scheme (see below, pp. 60-65 for Ganassi and p. 18 for Bermudo).

All of which means that when we consider the various ways of tempering a lute or viol, we should avoid too minute a system of classification, and

4 Hummel 1827: 443 (1828: 70). Similar passages can be found in earlier writers, for example Rameau (1737: 101); Fritz (1756: 22); Marpurg (1776: 169).
5 The Burwell Lute Tutor: 7^{v}-8^{r}; or see Dart 1958: 16-17.
6 Jean Rousseau 1687: 36-38.
7 Danoville 1687: 34 & 37.

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favour a broader one allowing for vagaries of string tension during the playing and of mass per unit length in the string. It may be informative to reduce a fretting formula to a set of intervals calculated in cents, but it would be very naive to imagine that the frets will impose such an intonation of the scale upon the performance as definitively as the harpsichord- or organ-tuner's handiwork does.

Certain choices, however, do have to be made merely to get the open strings of a normal six-course instrument in tune. The syntonic comma – the amount by which four pure 4ths and a pure major 3rd fall short of two full octaves[8] – has to be distributed somehow among them. Presumably the double octave between the outer courses should not be compromised, at least not perceptibly. Should then the 4ths be made pure and the major 3rd left a comma larger than pure? This would imply pythagorean intonation. Or should all five intervals be 'stretched' the same amount, that is, by 1/5 comma each? This would be one form of meantone temperament. There are other possibilities: to stretch the 3rd by more than 1/5 comma and the 4ths less (as in equal temperament, for example); to tune the 3rd pure and stretch each of the 4ths by 1/4 comma (a well-known form of meantone temperament); to temper some 4ths more than others.

In due course the fretting scheme and tuning of the open strings must be coordinated. Everyone's instructions agree, for instance, that the open strings must make good unisons and octaves with stopped notes on the other courses. Ganassi is among those who specify that good octaves and unisons should govern the final adjustments of all the frets, as indicated in Example 1. Here one can see that frets 2, 4, 5, 7 and 8 are to be tested against open strings. On the middle strings fret 1 is adjusted for a good unison with fret 5. Then 3 and 6 have to provide a good unison or octave with 1. While the

Example 1. Some of Ganassi's tuning checks for the viol (1543: ch. 6). In the tablature notation (explained below in Appendix 1) each line represents one of the instrument's six strings. Ganassi presented the 1-3-1 and 1-6-1 checks melodically because to play them harmonically would make the left hand stretch too far, and because the 1-3-1 check involves non-adjacent strings that cannot be bowed in one stroke without touching the others between.

8 As explained in the note to p. 1, this amounts to 1/9 whole-tone (more exactly, $21\frac{1}{2}$ cents) and its ratio is $\frac{4}{3}\times\frac{4}{3}\times\frac{5}{4}\times\frac{4}{3}\times\frac{4}{3}\times\frac{1}{4}=\frac{80}{81}$.

open-string intervals and fret locations are thus mutually tested, no unison between 5 and 0 is overlooked, and we have seen that this particular habit is implicit in the instructions of other writers, such as Danoville and Jean Rousseau. So if the open 4ths are tuned differently in any systematic way, fret 5 should slant or zigzag accordingly. But since renaissance and baroque tutors never suggest this, we may assume for purposes of classification that the open 4ths are tuned alike. In which case, if the octaves are pure, the 5ths will also be alike.

Now, among the various 'regular' tunings – that is, theoretical schemes with uniform 4ths and 5ths – we may observe various salient characteristics which distinguish each type. Meantone temperament has major 3rds that are either pure or only slightly tempered, whereas equal temperament and pythagorean intonation have major 3rds that are distinctly larger than pure. Equal temperament has uniform semitones, but pythagorean intonation and the various shades of meantone temperament have unequal semitones. These characteristics will suffice to reduce most of the fretting schemes given in the various renaissance and baroque tutors to three reasonably broad types. Writers are usually explicit as to whether they intend equal or unequal semitones; the quality of the open-string 3rd can normally be inferred from the placing of fret 4. Table 1 shows how these criteria may be used to distinguish the three categories of regular tuning – pythagorean intonation, equal temperament and meantone temperament – which will be discussed in Chapters 2, 3 and 4.

Table 1. Classification of regular models of tuning and temperament for fretted instruments. The model represented by the empty space at the lower right (which would divide a pure or nearly pure major 3rd into four equal semitones) is discussed on p. 84 below.

	open courses	
fretting:	distinctly large major 3rd	approximately pure major 3rd
distinctly unequal semitones	*pythagorean intonation*	*meantone temperament*
functionally equal semitones	*equal temperament*	

2 Pythagorean intonation

Pythagoras is a somewhat legendary figure from whom no writings are extant and whose name has therefore been attached to various ideas he may perhaps never have dreamt of. The term 'pythagorean intonation' has traditionally been taken to refer not so much to a scale as to a way of reckoning or constructing intervals: the string-length ratios 2:1, 3:2 and 4:3 are used (for the octave, 5th and 4th), but no ratios involving 5 or any larger prime number are allowed. The normal ratio for a whole-tone is thus 9:8 (3:2 divided by 4:3, since the whole-tone is the difference between a 5th and a 4th). The ratio for a 'ditone' or major 3rd is $(9:8)^2$, that is, 81:64. This interval is a syntonic comma[1] larger than a pure major 3rd, for which the proper ratio is 5:4. By further calculations one may reach 256:241 as the ratio for a pythagorean minor 2nd or diatonic semitone (4:3 ÷ 81:64), and 2187:2048 for a chromatic semitone (9:8 ÷ 256:241).

The traditional term, from ancient Greek theory, for the diatonic pythagorean semitone is 'limma'; and for the larger, chromatic semitone, 'apotome'.

The oldest extant fretting formula, that of the ninth-century theorist Al-Kindī for the '*ud* (the Arabic lute), is pythagorean. It calls for five frets, to make the following succession of semitones down from the nut: limma, apotome; limma, apotome; limma.[2] In pythagorean schemes for the European lute or viol, one would expect frets 2, 4 and 5 to have the same positions, so that if the open-string note is *ut* in the traditional Guidonian hexachord, then those frets will give *re*, *mi* and *fa* respectively. Of course fret 7 (*sol*) will be 1/3 of the distance from the nut to the bridge. But where should we expect to find the 'chromatic' frets 1, 3 and 6? We shall find that different theorists gave different answers, particularly for fret 6.

When Pierre Attaingnant began to publish lute music in 1530, he

1 See p. 1 for a discussion of the syntonic comma.
2 Wright 1980: Table 1. According to Wright, fret 1 was a hypothetical addition not actually used. This is suggested by the Arabic names of the other four frets, which mean 'first finger', 'middle finger', 'ring finger', and 'little finger'.

published also a brief 'epitome' of music theory by Oronce Fine. Fine was a fairly accomplished engraver as well as a humanist and mathematician (in 1530 or 1531 he became Professor of Mathematics at the new Royal College in Paris), and for the *Epithoma musice instrumentalis*[3] he made a woodcut of his fretting scheme for the lute (Figure 1). In this scheme each 'chromatic' fret is placed in the lower half, musically, of the whole-tone which it divides. Fine also included a monochord scheme of the same description (Figure 2).

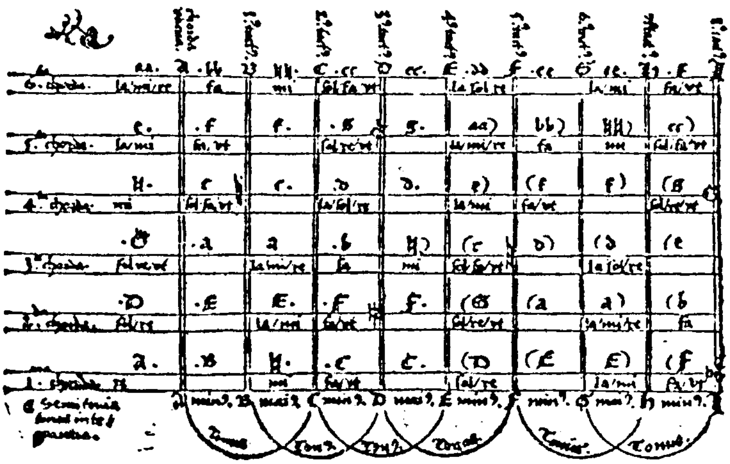

Figure 1. Fine's fretting scheme (1530). The open courses, reading from the bottom up, are named A, D, G, ♮, e and aa.

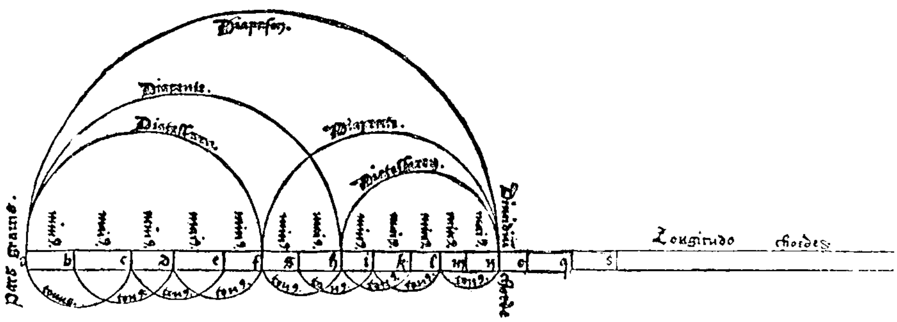

Figure 2. Fine's monochord diagram (1530). Going up from the *pars gravis* at the left, the semitones are labelled: minus, maius, minus, maius, minus; minus, maius; minus, maius, minus, minus, maius.

3 A copy of this short work, with unnumbered pages, is in the Österreichische Nationalibiliothek at Vienna.