

The Just Intonation System of Nicola Vicentino

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Nicola Vicentino (1511-c.1576) was a remarkable theorist and composer whose fame today rests chiefly with his advocacy of chromatic and even microtonal music. Unlike the traditional theorist of the Middle Ages, he was not content to just confine himself to abstract mathematical theory; he showed how his theories could be applied to practical composition and tuning. In fact, he designed and built at least two keyboard instruments designed to play in all of the Greek genera: a harpsichord with thirty-six keys per octave which he called the *archicembalo* and a comparable portative organ, the *arciorgano*. His tuning system included thirty-one pitches within an octave, which, as Barbour reasonably interprets it, was most probably applied to the archicembalo through a cycle of fifths tempered by $1/4$ -syntonic comma, the same interval commonly used in meantone temperament at the time [1]. However, it is less well known that he also defined the intervals of his system either implicitly or explicitly at least two other ways: as just ratios derived from ancient theorists, and as divisions of other intervals.

Humanism began having a profound effect on music theory and aesthetics in the sixteenth century, when musicians began rediscovering or reevaluating the writings of ancient theorists such as Boethius and Ptolemy. The ancient theories of modes and tetrachordal divisions, though often misunderstood, were widely considered prerequisite knowledge to the art of composition. Vicentino presented his own theories and interpretations of ancient theory in his treatise *L'antica musica ridotta alla moderna prattica* (*Ancient Music Restored to Modern Practice*), first published in Rome in 1555.

The reevaluation of the sources to which Vicentino refers, especially Ptolemy, Aristoxenus, and Boethius, had become very controversial in the first half of the sixteenth century. Boethius, who advocated Pythagorean tuning, was the primary theoretical source throughout the Middle Ages. However, important discrepancies surfaced between theory and practice with the evolution of polyphony. Specifically, thirds and sixths were considered dissonances by Boethius because of their complex ratios (major third, or ditone, = $81/64$ and minor third, or semiditone = $32/27$ or $19/16$), and yet they were used as "imperfect" consonances in polyphony. Likewise the fourth, considered by Boethius a consonance, was treated as a dissonance. The first Renaissance theorists who suggested that thirds and sixths were consonant because of their proximity to the more simple ratios found corroboration in Ptolemy, who had presented several just systems in his *Harmonics*, including those of Archytas, Didymus, and Eratosthenes. Ptolemy wrote that the best systems are those in which sense and mathematics agree, and such agreements to him were primarily superparticular just ratios.

Aristoxenus, though, presented an even more radical viewpoint, that the musician's ear should be the ultimate arbiter. Because pitch was a continuum, it could be divided into equal intervals, even if the whole number mathematics of the Pythagoreans could not express them as string lengths. Thus he was considered by sixteenth-century theorists to be the first writer to describe equal temperament, in theory though not in practice. Such use of irrational divisions of a continuum ultimately challenged the whole mystical relationship of music and number which was so much a part of medieval music theory. Vicentino put himself on the middle road of Ptolemy and just intonation, between the strict rationality of the Pythagoras/Boethius school, and the subjectivism of the Aristoxenians. Still, as Kaufmann points out, Vicentino's language, if not his tuning, comes much closer to the Aristoxenian viewpoint in his constant invocation of the musician's aural judgement and instinct in final musical decision [2]. While Vicentino's first-hand knowledge of

3147
ALVES, B.
1989

common confusion of the modern modes, with an implication of a tonic, with the Greek *tonoi*, which had no such center [7]. Vicentino also consciously strays from Boethius, his principal model for the definitions of the genera, in stating that the major diesis of the enharmonic genus may be split into two minor dieses, thus forming an extra interval within the tetrachord. This means that an octave species, or mode, constructed in the enharmonic genus may have from nine to thirteen tones per octave. Similarly, the extra whole tone in the diatonic species of the fifth becomes two semitones when transformed into the chromatic genus, forming a mode of eight notes per octave. Such concepts as the variable number of tones in an octave species as well as a gamut containing all intervals were also foreign to the ancient theorists.

Vicentino's just ratios are not always defined explicitly but often in terms of other intervals. His gamut of intervals, with some holes filled in, is given in [table 1](#). The whole tone (or "natural" tone) is exceptional. In order for two whole tones to add up to a pure major third ($5/4$), two different whole number ratios are needed: $9/8$ between *ut* and *re* in the hexachord and $10/9$ between *re* and *mi*. This is normal in just tuning, but the discrepancy apparently disturbed Vicentino, who finally justified it by saying that the difference was insignificant, especially in singing [8]. As can be seen in the [table](#), this difference of 21.5 cents is in fact the syntonic comma and is no more insignificant than Vicentino's comma or many of the steps between the other adjacent intervals. Nevertheless, it does lead to some confusion for those other intervals which are defined in terms of the whole tone. The tritone, for example, is by definition made up of three whole tones, which gives four possibilities. The ratios chosen in this [table](#), when there is a choice, were made in favor of Ptolemy's tuning systems.

Interval Name	Ratio	Cents	Remarks
Minor diesis	$40/39$	43.8	Difference between major and minor semitones
Major diesis	$21/20$	84.5	Same as minor semitone
Minor semitone	$21/20$	84.5	Same as major diesis
Major semitone	$14/13$	128.3	
Minor tone	$13/12$	138.6	
Whole tone	$10/9$ or $9/8$	182.4 or 203.9	Two different sizes are needed for correct derivation of scales (see text)
Major tone	$8/7$	231.2	
Minimal third	$7/6$	266.9	Whole tone ($10/9$) plus minor semitone ($189/160$ if $9/8$ whole tone is used)
Minor third	$6/5$	315.6	
Less than major third	$39/32$	342.5	Major third minus minor diesis
Major third	$5/4$	386.3	
Greater than major third	$50/39$	430.1	Major third plus minor diesis
Less than perfect fourth	$13/10$	454.2	Perfect fourth minus minor diesis
Perfect fourth	$4/3$	498.0	
Greater than fourth	$160/117$	541.9	Perfect fourth plus minor diesis
Tritone	$45/32$	590.2	Major third plus $9/8$ whole tone ($25/18$ if $10/9$ whole tone is used)
Diminished fifth	$75/52$	634.1	Tritone plus minor diesis

5/4 386.3							5/4 386.3
							39/32 342.5
		6/5 315.6					6/5 315.6
	7/6 266.9						7/6 266.9
			8/7 231.2	8/7 231.2			8/7 231.2
				9/8 203.9		9/8 203.9	9/8 203.9
			10/9 182.4		10/9 182.4	10/9 182.4	10/9 182.4
					11/10 165.0		
					12/11 150.6		
	12/11 150.6						13/10 138.6
							14/13 128.3
		15/14 119.4					
						16/15 111.7	
			21/20 84.5				21/20 84.5
	22/21 80.5						
24/23 73.7							
		28/27 63.0		28/27 63.0			
						40/39 43.8	
46/45 38.1							

Table 2: Ptolemy's Tetrachord Tunings Compared with Vicentino's Intervals

Vicentino either implicitly or explicitly defines the intervals within his system up to three different ways: as a just ratio, as a division of another interval, or through the tempered fifth tuning system of the archicembalo. Unfortunately these three rarely coincide. For example, he initially defines his "comma" as the difference between the tempered and pure fifth. If one accepts that he is using common meantone temperament for his practical tuning, this would be one-fourth of the syntonic comma, or 5.4 cents. However, he also defines it as one-half of his minor diesis, for which he gives a ratio of 40/39. Using the geometric mean, or square root, of this ratio, it would come out to 21.9 cents. In his archicembalo tuning the minor diesis varies in size from 13 to 65 cents, so that the comma would not be a constant interval. Perhaps it is best to just to accept the informal definition of it as the smallest audible interval [9]. The comma is not included in the gamut because it is smaller than the smallest step necessary to realize the enharmonic genus; however, it does play a role in the tuning of the archicembalo.

Vicentino's additive definitions of his intervals are given in [table 3](#), and, if these definitions are to reconciled with the ratios in [table 1](#), the same problem would result as with two whole tones adding up to a major third. However, these discrepancies are not mentioned by Vicentino, and one is left to assume that, like the discrepancy of temperament, these differences were, to Vicentino, insignificant enough to be ignored (at least in so far as it suited his purposes). Exactly what is

than the tempered D, E, G, A, and B. If the definition of a comma as the difference between the tempered and pure fifth is used, one could maintain just triads by playing the fifth in this order and the root and third in the appropriate tempered order. Furthermore, Vicentino gives an optional tuning in which all of the notes in orders four, five, and six are tuned likewise a comma sharp. Presumably, this would limit the number of available intervals from the gamut, but would provide more opportunity for consonant fifths, if one could reach the keys, of course. Both Kaufmann [16] and Barbour [17] have pertinent questions about the interpretation of this tuning system, but Vicentino does say that the main purpose of the comma is "to aid a consonance" [18].

As reflected in the carefully worded title of his treatise, *Ancient Music Restored to Modern Practice*, Vicentino did not attempt to resurrect ancient composition, but rather to use the theories of the ancients as the proper starting point for a modern theory of composition. Vicentino's view of music history is essentially as an evolution towards a more perfect art. Hence, while he often used ancient sources (somewhat selectively) to justify his own positions, he was not at all afraid to modify them for the sake of modern progress. The tempering of the fifth is an example of one of his "improvements" as well as his desire for practical system that is "downwardly compatible" with contemporary practice.

Vicentino's system was a unique solution to the problems of tuning faced by musicians of this period, and he made a noble effort to reconcile the wisdom of the ancients the needs of polyphony and modulation within one consistent system. His radical advocacy of microtonality seems very modern to us but was still very much born of the spirit of his time, the same way Partch's system was in our own century. Vicentino's studies and applications of ancient music theory, though flawed, were very influential and controversial throughout the second half of the sixteenth century, and he was an important part of the late renaissance "avant garde" that ultimately led to the baroque era.

Notes

1 Barbour 117-118.

2 Kaufmann 1966, 105.

3 Palisca, 253.

4 Translated in Palisca, 109.

5 Danckerts, Part II, Ch. 9, fol 401v., translated in Berger, 41.

6 For a detailed reconstruction of these derivations, see Berger, 8-18.

7 Gombosi, 21.

8 Vicentino, fol. 143. Kaufmann 1966, 119.

9 Vicentino, fol. 143.

10 Bower-Boethius 171-178.

11 Palisca, 241-243.