Leonardo and Gaffurio on Harmony and the Pulse of Music

EONARDO, in his famous comparison of the arts, seeks to vindicate for painting the same elevated status enjoyed by music because of its position in the Quadrivium. While he cannot deny the mathematical foundation that justifies music's placement with arithmetic, geometry, and astronomy, he seeks to undermine music's prestige by comparing it unfavourably with painting on a number of points. The main argument takes place in his Paragone, but scattered remarks are found elsewhere: these show that Leonardo has thought much more deeply about the nature of music, especially polyphonic music, than most music theorists, if we can judge from their treatiseswhich, of course, we cannot really do, but that is the evidence we have. For all their treatment of consonance and dissonance and the intricacies of mensural notation, we find very little theoretical discussion about the most fundamental aspect of all: how music operates in time. It is the element of motion that Leonardo returns to again and again, and it is the concept of time that plays a crucial role in the redefinition of harmony at the end of the fifteenth century. Leonardo frequently appeals to two concepts that have a technical musical meaning: harmonic proportionality and harmonic tempo. In this article I investigate what those concepts meant to him, and whether his understanding of them agrees with contemporary music theory, especially as expounded by Franchino Gaffurio, his colleague in Milan.

Leonardo believed that painting was not numbered among the sciences for lack of writers on the subject; but since painting "is the sole imitator of all the manifest works of nature" and "nothing can be found in nature that is not part of science," and furthermore, since it draws upon the lines and points of geometry, and perspective depends on arithmetic (discontinuous quantity) and geometry (continuous quantity), painting can rightly be considered a science.¹ In the *Paragone* Leonardo compared the arts of poetry, painting, and music.

1. Leonardo on Painting, ed. Martin КЕМР, selected and Yale University Press, 1989), 13-14, hereafter referred to trans. Martin КЕМР and Margaret WALKER (New Haven: as Kemp and Walker.

Because the eye, "which is said to be the window of the soul," is superior to the ear, painting is superior to poetry and to music. The poet is limited because his descriptive words "are separated from one another by time, which leaves voids between them and dismembers the proportions."² Music, by contrast, "composes harmony from the conjunction of her proportional parts sounded simultaneously," but is "constrained to arise and die in one or more harmonic beats (*tempi armonici*)."³ Thus painting "excels and is superior in rank to music, because it does not perish immediately after its creation"; moreover, the eye can grasp the whole simultaneously. Therefore, if music is among the liberal arts, "either you should place painting there or remove music."⁴

Statements such as these show that Leonardo was thinking in terms of musical performance: the sound of music is continuous—unlike poetry, where there are gaps between words in recitation—but it cannot be grasped as a whole, and when the piece finishes, the music is gone. Some writers on music *were* concerned with this phenomenon, but from a somewhat different point of view: is music evanescent and lost after performance, or is there such a thing as a work of art that remains? Tinctoris makes a distinction between music that arises in the process of singing *super librum*, "on the book," that is, improvising a melodic line over a written melody taken from chant or polyphony, which he calls counterpoint, and music that is composed according to rules regulating the relations between all the voices, which he calls *res facta*, a "made thing," and which I have proposed to call "harmonic composition."⁵ A *res facta* is fixed in writing; later authors called it an *opus perfectum et absolutum*. After performance it did not vanish, although it existed in another dimension.⁶ A *res facta* was also a visual object, and often a very beautiful one, but in that form it is not music. (On Leonardo's admiration of a *res facta* as a work of art, see the Appendix.)

2. Ibid., 20, 24 (Urb II⁹: "il tempo le divide l'un da l'altro & infra mette la oblivione et divide le proportioni"). I cite the Italian from the earliest version of the treatise on painting, prepared by Leonardo's pupil Francesco Melzi, now in the Vatican Library (MS Urb. lat. 1270), known as the Codex Urbinas. A facsimile has been published in vol. 2 of *Treatise on Painting by Leonardo da Vinci*, ed. and trans. A. Philip McMAHON, intro. Ludwig HEYDENREICH, 2 vols. (Princeton: Princeton University Press, 1956).

 Ibid., 34, but Kemp and Walker translate operate nel medesimo tempo as "which make their effect instantaneously" and armonici tempi as "harmonic intervals" (Urb 16^t: "compone armonia con le congiontioni delle sue parti proportionali operate nel medesimo tempo costrette a nascere e morire in uno o piu tempi armonici").
Ibid., 35 (Urb 16^s: "ma la pittura eccelle & signoreggia la musica perch'essa non more immediate dopo la sua creatione") and 37. Luca Pacioli makes much the same claim for perspective's equal right to belong to the Quadrivium in *De divina proportione* (Milan, 1497), Part I, chap. 3. See Arnaldo BRUSCHI, Corrado MALTESE, Manfredo TAFURI, and Renato BONELLI, eds., *Scritti rinascimentali di architettura* (Milan: Il polifilo, 1978), 67-68. On the role of music in the *Paragone*, see also Emanuel WINTER-NITZ, *Leonardo da Vinci as a Musician* (New Haven: Yale University Press, 1982), chap. 12.

5. See Bonnie J. BLACKBURN, "On Compositional Process in the Fifteenth Century," *Journal of the American Musicological Society* 40 (1987): 210-84, esp. 246-68.

6. Leonardo anticipated this riposte from the musician, but answers not quite to the point: "If you should say that music lasts for ever by being written down, we are doing the same here with letters"; Kemp and Walker, 35 (Urb 17⁹: "et se tu dicessi la musica s'eterna con lo scriverla el medesimo facciamo noi qui con le lettere"). Let us consider the words Leonardo used to describe music: it composes harmony from the conjunction of proportional parts in one or more harmonic *tempi*. Just what did Leonardo mean by harmony, the conjunction of proportional parts, and *tempi armonici*? There is no easy answer to this question, because the definition of harmony was a matter of considerable controversy in his time. In the 1470s Tinctoris could define *armonia* as "a certain pleasantness caused by a combining of sound" and, given that general definition, he could also claim that melody is the same as harmony.⁷This same general meaning is the one we use today when we speak of something being harmonious because we think the parts fit together well, sometimes appealing to proportion, sometimes to symmetry. But at a certain point harmony began to develop a specifically musical use. Did Leonardo use "harmony" in a general or a technical sense?

Our modern understanding of harmony—the relationship of tones sounded simultaneously—brings us up short when we are confronted by some fifteenth-century definitions. In 1482 Bartolomé Ramos stated that many people believed that harmony and music were the same thing. He disagreed, defining harmony as "the mixture of concordant voices," but music as the intellectual investigation of these concords, recalling Boethius' definition of the *musicus.*⁸ It has been suggested that theorists of the late fifteenth century "reserved the term 'harmony' for a chord of three pitches; chords of two pitches were concords or discords."⁹ This is true of Niccolò Burzio, who, in 1487, gives a definition of harmony that specifies music of three or four parts: "It is a modulation of the voice and a concord of many sounds, as is very evident in mensural music, especially when we sing in three or four concordant parts."¹⁰

Franchino Gaffurio differs: for him only the harmonic division of a consonance produces what is called harmony. This view is set forth most clearly in his *Angelicum ac divinum opus musice* (Milan, 1508).¹¹ In his *Practica musice* (Milan, 1496) he notes that the

7. Terminorum musicae diffinitorium [Treviso, ca. 1495]: "Armonia est amenitas quedam ex convenienti sono causata" and "Melodia idem est quod armonia."

8. "Harmoniam atque musicam idem esse multi credunt, verum nos longe aliter sentimus. Ex quorundam enim musicorum sententiis longa investigatione collegimus harmoniam concordium vocum esse commixtionem, musicam vero ipsius concordiae rationem sive perpensam et subtilem cum ratione indaginem." *Musica practica* (Bologna, 1482); ed. Johannes WOLF (Publikationen der Internationalen Musikgesellschaft, Beihefte, 2; Leipzig: Breitkopf & Härtel, 1901), 3. The following section is based on the more extensive discussion in Blackburn, "On Compositional Process," 224-28. See also BLACKBURN, "The Dispute about Harmony 6.1500 and the Creation of a New Style," to be published in a volume of papers given at the conference "Théorie et analyse musicales 1450–1650" (Louvain-la-Neuve, 23-25 September 1999).

9. Richard L. CROCKER, in his seminal article "Discant, Counterpoint, and Harmony," *Journal of the American Musicological Society* 15 (1962): 1-21 at 18.

10. "est modulatio vocis et concordia plurium sonorum, quod in cantu figurato latissime patet maxime dum cantus triplici concordia vel quadruplici cantamus"; Florum libellus, ed. Giuseppe MASSERA ("Historiae musicae cultores" Biblioteca, 28; Florence: Olschki, 1975), 74-75-11. "Ma la harmonica e dicta proprie mediocrita: perche la chorda de mezo in questa consyderatione conduce et conclude con le extreme sue quello suave concento che e dicto harmonia" (sig. D2^v), referring to Pietro d'Abano's exposition of the 12th problem of Pseudo-Aristotle: "Medium est constitutivum harmonie." Furthermore, octave is the first of the intervals that can be divided according to a harmonic ratio, and this "harmony" imparts a more pleasing movement (modulatio) to all musical composirions.12 The mediated fifth (a triad) and mediated sixth (a sixth or first-inversion chord) achieve the same effect, but he hastens to say that they are produced by almost harmonic divisions. The fifth mediated to produce a major and minor triad "brings about a sweeter concord of the extremes as if it adhered to the harmonic mean by a kind of imitation"; the mediated sixth makes a concord "as if it were neighbor and partaker of the harmonic mean."13 But in the De harmonia musicorum instrumentorum opus (completed by 1500 but not published till 1518) Gaffurio appears to relax his strict understanding of the term "harmony": a marginal note in chapter 10 of Book III summarizes: "What harmony is. Harmony differs from consonance: consonance consists of two sounds, harmony of three." The text explains that a consonance forms only one proportion, but a harmony has at least two. Therefore every harmony is a consonance, but not every consonance a harmony.¹⁴ In the next chapter, however, we discover that Gaffurio is using both a loose and a strict definition of harmony: "Having disposed three tones according to a harmonic division . . . a melody is thus produced that we properly call harmony."15 Having conceded this much, he feels bound to invent a term for other pleasant three-voice sonorities that are not "proper" harmonies. His solution is to characterize them as consonances divided by a "sonorous mean," which accounts

"aben che La consonantia corresponda in li soi extremi soni bona concordia como e diapason: niente dimanco non se po dire harmonia per non esser mediata de uno sono conditionato ali soy extremi steundo la convenientia harmonica." (Ibid.; italics added, and in all of the following quotations.)

12. Practica musice, Bk. III, chap. 2: "Octava qua aequisonantem diapason ... perfecta est contrapuncti species: et prima quidem barmonica medietate consistens ..." (sig. cc7"). "Est Itaque octava barmonice mediata prima ac simplex illa barmonia qua musicus omnis concentus gratiore atque suaviore modulatione perfulget ..." (sig. cc8"). An English translation is available in Franchinus Gaffurius, Practica musicae, trans. Clement A. MILLER (Musicological Studies and Documents, 20; n.p.: American Institute of Musicology, 1968).

13. Practica musice, sig. cc7*: "Quinta autem quam diapente integra tribus s. tonis ac minore semitonio ducta sesqualtera dimensione producit: mediam obtinet concordem chordam cum extremis. Componitur enim ex duabus primis simplicibus s. tertia minore arque tertia maiore concordi medietate servata. Inde suaviorem ducit extremitatum concordiam quasi quae certa imitatione barmonicae adbaereat medietati." "Habet enim sexta solam chordam mediam et concinnam quae s. tertia est ad graviorem et diatessaron subsonat ad acutam. Diatessaron enim consonantia et si simplex ducta dissona sit: coniuncta tamen concordi commixtioni concordem efficit cum extremis medietatem: quasi harmonicae medietatis proxima sit et particeps..."

14. "Quid sit harmonia. A consonantia differt harmonia[;] duobus sonis fit consonantia. Tribus vero harmonia." "Ea enim est extremarum contrariumque vocum communi medio consonantias complectentium suavis et congrua sonoritas. quam iccirco a consonantia differre constat. Haec namque sola proportione: duabus saltem Illa producitur. Hinc falso sunt arbitrati qui consonantiam et harmoniam idem esse posuerunt. nam quamquam harmonia consonantia est: omnis tamen consonantia non facit harmoniam. Consonantia namque ex acuto et gravi generatur sono: Harmoniam vero ex acuto et gravi conficiunt atque medio" (f. 80°). An English translation is available in Franchinus GAFFURIUS, De Harmonia Musicorum Instrumentorum Opus, trans. Clement A. MILLER (Musicological Studies and Documents, 33; Neuhausen-Stuttgart: American Institute of Musicology – Hänssler-Verlag, 1977).

15. "Dispositis vero tribus chordis secundum harmonicam medietatem . . . ea tunc producetur melodia: quam proprie harmoniam vocamus" (1bid., ff. 80^v-81^r).

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for the not quite harmonic division of major and minor sixths and tenths.¹⁶ Similarly, Ptolemy's adjustment of the intervals to superparticular ratios is deemed to produce a pleasing but not a harmonic division.¹⁷

Gaffurio does not have a word for "chord"; the concept certainly exists for him, as we can see from his remarks, but it has to be ferreted out from circumlocutions. (It could trap the unwary reader that he uses the term *chorda* to describe the mediating note; here, however, it means "string" and goes back to the Greek nomenclature for the notes of the Greater Perfect System, deriving ultimately from the strings of the lyre. Leonardo, incidentally, uses the word *chorda* to mean nerve, tendon, or ligament.)

There has been much speculation on Leonardo's acquaintance with Gaffurio, which is likely but not supported by direct evidence.¹⁸ Given Leonardo's intense interest in music, as demonstrated by scattered remarks in his notebooks, his acoustic experi-

16. Bk. III, chap. 12, headed "De sonora medietate sextae et decimae maioris atque minoris": "Est quoque alia in sonis mediocritas quae neque eisdem et terminorum et differentiarum proportionibus commixta est ut Geometrica: neque aequalibus differentiis ut Arythmetica: neque aequalibus extremorum terminorum proportionibus ac differentiarum ut harmonica: sed his penitus tribus noscitur aliena quippe quae coniungitur ex communi chorda, s. concinna et consona" (f. 82^v).

17. "At Ditono huiusmodi coniuncta Diatessaron in acutum Sextam ipsam maiorem mediabit et *concinnam (non tamen harmonice)*" (f. 78^t). The major and minor third in Ptolemy's syntonic diatonic, the basis of just intonation, are in fact harmonic divisions, and Gaffurio's reluctance to recognize them as such drew him into an argument with Giovanni Spataro. For a summary, see the introduction to Clement Miller's translation of the *De harmonia*, p. 21.

18. Cf. WINTERNITZ, Leonardo da Vinci, 5-8, who offers a perhaps too optimistic assessment of the circumstantial evidence, which in fact is mainly that Leonardo and Gaffurio were in Milan at the same time (1484-99 and 1506-13; Leonardo had arrived in 1483). On p. 6 Winternitz claims that "They lent each other books," without documentation. As far as I can see, he may have had in mind the following: Leonardo refers to Plutarch's Lives in a marginal note; Gaffurio owned a copy of the 1491 edition, which he purchased in Milan in 1494. On this copy, see Kate TRAUMAN STEINITZ, "Two Books from the Environment of Leonardo da Vinci in the Elmer Belt Library of Vinciana: Gaffurio and Plutarch," Libri 2 (1951-52): 1-14; figs. 1 and 2 show Gaffurio's inscriptions on the colophon and title-page.

Some authors (including WINTERNITZ in New Grove,

10:671, but not in his book; see his Preface, p. xviii) believe that Leonardo refers to Gaffurio's De barmonia musicorum instrumentorum in a passage in his notes on anatomy discussing pitch in relation to the length and width of a pipe or tube, written ca. 1508-10. Leonardo remarks "And I do not go into this at greater length because it is fully treated in the book about harmonical instruments": see Edward MACCURDY. The Notebooks of Leonardo da Vinci, Arranged, Rendered into English and Introduced, 2 vols. (2d. ed., London: Jonathan Cape, 1956), 1: 171. Earlier it had been thought that Leonardo was referring to a book written by himself, "ne ho trattato," but the wording is actually "ne [= n'e] trattato," as MacCurdy has translated it, according to Carlo PEDRETTI, The Literary Works of Leonardo da Vinci, Commentary, 2 vols. (Oxford: Phaidon, 1977), 1:107, who commented: "This is probably a reference to Franchino Gafurio's De harmonia musicorum instrumentorum opus quadripartitum, published in 1508 [sic], rather than a reference to a book 'delli strumenti armonici' written by Leonardo himself." It is a common misunderstanding of Gaffurio's title to believe that the book deals with musical instruments; in fact it refers to the harmonies of the universe and the harmonious relations of the human mind and body. (There is, however, a brief passage on the pitch of organ pipes at the end of the last chapter of Bk. II [ff. 69"-70], but it does not appear in the Angelicum opus.)

I agree with Winternitz (p. 8) that the "Portrait of a Musician" in the Pinacoteca Ambrosiana, once ascribed to Ambrogio de Predis but now accepted as by Leonardo, cannot be of Gaffurio; it is much more likely to be of one of the Sforza court musicians. (In *The New Grove*, 10:671, written earlier, he had suggested that Gaffurio was "probably the subject of Leonardo's painting.") ments, and his sketches of the mechanics of musical instruments—in addition to his known ability as a performer on the lira da braccio—it would seem fruitful to investigate his acquaintance with music theory of the time. Emanuel Winternitz, in his wide-ranging book on Leonardo and music, barely mentioned Gaffurio's theoretical writings as of possible interest to Leonardo; instead he concentrated on acoustics, improvisation, and musical instruments, apart from the discussion of the *Paragone*. This omission was noted with regret by Martin Kemp in his review of Winternitz's book.¹⁹ In particular, Kemp wondered about the basis of Gaffurio's musical thought and the association between harmonic systems and the science of nature, and whether Leonardo's ideas had any impact on Gaffurio. This, of course, would require a very wide-ranging investigation; in the present article I shall limit myself to Leonardo's notions of harmony and "tempi armonici," especially as they relate to polyphonic music.

Leonardo frequently uses the term "proportionalità armonica" in his writings on painting.²⁰ "Proportionality" is a technical mathematical term; as Boethius and, following him, numerous music theorists explain, a proportion consists of two terms (e.g. the octave, 1:2), but a proportionality consists of three (e.g. a fifth-octave chord, 3:4:6). Simple proportions become proportionalities when divided by an arithmetic, geometric, or harmonic mean. The terms are in harmonic proportion if the greatest is to the least as the difference between the greatest and the mean is to the difference between the mean and the least, i.e. if the greatest term be *a*, and mean *b*, and the least *c*, *a*: *c*:: *a* - *b*: *b* - *c*. The harmonic mean may be found by the following formula:

$$b = \frac{2ac}{a+c}$$

Leonardo is aware of the technical meaning, as can be seen in the following statement:

The eye is the true intermediary between the objects and the *imprensiva*, which immediately transmits with the highest fidelity the true surfaces and shapes of whatever is in front of it. And from these is born the proportionality called harmony, which delights the sense with sweet concord, no differently from the proportionality made by different musical notes to the sense of hearing.²¹

Nevertheless, he seems to use "proportionalità armonica" in a looser sense, more equivalent to "a harmonious proportion." Indeed it would not be possible to compose a "dolce concento" using only harmonic proportionalities: in Gaffurio's strict definition, based on Pythagorean intonation, one could not have any triads.

21. KEMP and WALKER, 23 (Urb 11¹: "l'occhio vero mezzo infra l'obbietto & la impressiva il quale immediate conferisse con somma verita le vere superficie e figure di quel che dinanzi se gli appresenta delle quale ne nasce la proportionalita detta armonia che con dolce concento contenta il senso non altrimente che si faciano le proportionalita de diverse voci al senso dello audito").

^{19.} In the Journal of the American Musicological Society 36 (1983): 312-16.

^{20.} See e.g. KEMP and WALKER, 23, 24, 26, 37, mostly translated as "proportional harmonies."

Harmonic proportionality is applied to painting in the same loose sense: music and painting are sister disciplines because they both make use of it. The great failure of poetry is that it lacks proportionality, since words are spoken successively. Leonardo relates an anecdote of King Matthias' dispute with a poet to illustrate this point. The king says:

Do you not know that our soul is composed of harmony, and that harmony cannot be generated other than when the proportions of the form [*le proportionalita delli obbietti*] are seen and heard instantaneously? Can you not see that in your science, proportionality is not created in an instant, but each part is born successively after the other, and the succeeding one is not born if the previous one has not died? From this I judge that your invention is markedly inferior to that of the painter, solely because it cannot compose a proportional harmony [*non componesi proportionalita armonica*].²²

The same criticism applies to monophonic music, or voice parts sung singly:

The poet may be regarded as equivalent to a musician who sings by himself a song composed for four choristers, singing first the soprano, then the tenor, and following with the contralto and then the bass. Such singing cannot result in that grace of harmonic proportionality which is contained within harmonic beats [*tempi armonici*]....Yet music, in its harmonic beat [*tempo armonico*], makes its suave melodies, which are composed from varied notes. The poet is deprived of this harmonic option, and although poetry enters the seat of judgement through the sense of hearing, like music, the poet is unable to describe the harmony of music [*l'armonia della musica*], because he has not the power to say different things at the same time. However, the harmonic proportionality of painting is composed simultaneously from various components, the sweetness of which may be judged instantaneously.²³

In the comparison of painting with music, the argument from harmonic proportionality draws these two disciplines together, likening optical to harmonic space. Indeed, Leonardo seems in both cases to be using harmonic proportionality to indicate depth or volume, whereas poetry can produce no more than surface. It should be emphasized that Leonardo is not talking about music *per se* but specifically about polyphonic

22. KEMP and WALKER, 26 (Urb 14^v-15^t: "non sai tu che la nostra anima e composta d'armonia ed armonia non singenera se non in istanti ne quali le proportionalita delli obbietti si fan vedere o udire[;] non vedi che nella tua scientia non e proportionalita creata in istante anzi l'una parte nasce dallaltra successivamente e non nasce la succedente se l'antecedente non more. Per questo giudico la tua inventione essere assai inferiore a quella del pictore solo perche da quella non componesi proportionalita armonica").

23. KEMP and WALKER, 37 (translation slightly changed, as noted above) (Urb 18^r-19^r: "et al poeta accade il medesimo come al musico che canta sol'un canto composto di quatro cantori et canta prima il canto poi il tenore, e cosi seguita il contro alto e poi il basso e di costui non risulta la gracia della proportionalita armonica la quale si rinchiude in tempi armonici ... et la musica ancora fa nel suo tempo armonico le soavi melodie composte delle sue varie voci delle quali il poeta e privato della loro discretione armonica et ben che la poesia entri per il senso dell'audito alla sedia del giuditio si come la musica, esso poeta non puo descrivere l'armonia della musica perche non ha potesta in un medesimo tempo di dire diverse cose, come la porportionalita harmonica della pittura composta di diverse membra in un medesimo tempo"). music. Music "composes harmony from the conjunction of her proportional parts sounded simultaneously."²⁴ "Conjunction of proportional parts sounded simultaneously" must be Leonardo's circumlocution for "chord." Gaffurio had described only specific chords, in terminology that does not lend itself to a general description, except perhaps as "consonantia mediata"; later writers will use the word "a harmony" to describe two or more superimposed consonances.²⁵ I shall return to this below.

We now come to the more difficult passage in the *Paragone* where Leonardo uses the expression "tempi armonici." It comes directly after the above passage in the following context:

Music is not to be regarded as other than the sister of painting, in as much as she is dependent on hearing, second sense behind that of sight. She composes harmony from the conjunction of her proportional parts sounded simultaneously, constrained to arise and die in one or more *tempi armonici*. These *tempi* surround the proportionality of the component parts of which such harmony is composed no differently from the linear contours of the limbs from which human beauty is generated.²⁶

Here Leonardo turns from the aspect shared by painting and music—harmonic proportionality—to the aspect that separates them, the dimension of time. A painting can be grasped as a whole; music unfolds in time and is evanescent. This is a point he returns to several times because it is the linchpin of his argument for the superiority of painting: music perishes immediately after its creation, painting endures.²⁷

25. See BLACKBURN, "The Dispute about Harmony." 26. KEMP and WALKER, 34, with the change in translation noted above (n. 3); (Urb 16r-16": "La musica non e da essere chiamata altro che sorella della pictura conciosia ch'essa e subjecto dell'audito 2.do senso al occhio e compone armonia con le congiontioni delle sue parti proportionali operate nel medesimo tempo costrette a nascere e morire in uno o piu tempi armonici liquali tempi circondano la proporcionalita de membri di che tale armonia si compone non altrimente che si faccia la linea circonferentiale le membra di che si genera la bellezza humana"). Kemp and Walker give the last sentence as "These intervals may be said to circumscribe the proportionality of the component parts of which such harmony is composed-no differently from the linear contours of the limbs from which human beauty is generated." In Latin circumdare means to surround and does not have the geometrical implications of circumscribe. 27. Urb 16": "ma la pittura eccelle & sinoreggia la musica perch'essa non more immediate dopo la sua creatione come fa la sventurata musica anzi resta in essere" (KEMP and WALKER, 35).

Emanuel Winternitz translated tempi armonici as "harmonic sections" and interpreted the passage not as chords moving in time but as the proportional relationships between sections of a musical composition, though he saw the text as "obscure or at least inconsistent" (Leonardo, 211). Thus he credits Leonardo with having "applied the concept of proportion to the relation between successive portions of Music and thus established the notion of a quasi-spatial structure of portions balanced against one another" (ibid.). In another section Winternitz translates in tanti tempi armonici as "in as many sections of musical time" (p. 212), and elsewhere as "moments of harmony," interpreted as chords, and tempo armonico as "harmonious flow [time]" (p. 217). Leonardo certainly was acquainted with the proportionability of sections of a composition (the subject is covered thoroughly in Gaffurio's Practica musice, Bk. IV, and Tinctoris' Proportionale), since he discusses the proportionability of time in the Codex Arundel (the passage is cited by Winternitz on p. 221), but I do not believe that this is what he means by tempi armonici. Winternitz did not take into account Leonardo's use of the term in other contexts that do not refer to musical compositions.

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^{24.} See above, n. 3.

Tempi armonici is a term Leonardo uses many times, also in other contexts.²⁸ Often tempo armonico is used to indicate a regular beat, which can be employed to measure the velocity of moving objects since, Leonardo says, it is more reliable than the pulse. He uses it to ascertain how far water travels in an hour:

This is done by means of harmonic time [tempo armonico], and it could be done by a pulse if the time of its beat were uniform; but musical time is more reliable in such a case, for by means of it it is possible to calculate the distance that an object carried by this water travels in ten or twelve of these beats of time; and by this means it is possible to make a general rule for every level canal.²⁹

As a musician himself, Leonardo was familiar with the concept of a regular musical beat. Since harmony or harmonic proportionality is not relevant in this context, tempo armonico means no more than musical beat; in the early Codex B he in fact says "tempo di musica." How fast is this beat? In Codex Arundel one hour is said to contain 1080 tempi, based on human respiration, making one tempo equal to 3.33 seconds, or 18 per minute.³⁰ This is quite slow; thus it is likely that Leonardo is using the word tempo in its technical musical sense: $tempus = breve.^{31}$ In tempus perfectum 1080 tempi per hour would come to 54. semibreves per minute.

Placing the musical beat on the breve reflects early fifteenth-century thought: in his treatise of 1434, Giorgio Anselmi, one of the earliest authors to discuss the musical beat, states:

And this notated mensura is called one tempus. Still, this mensura is not fixed, not exceeding limits, but according to the judgement of the singer [is] here more broad and now more strict ... the mensura is near enough to a moderate tempo in which the singer, not much accelerating the song or extending the note-lengths, stamps the front part of the foot, keeping the heel still, or claps one hand to the other or the back of the student as regularly as possible.³²

By Leonardo's time, however, the musical beat, called mensura, battuta, or (in Germany) tactus, was considered to fall on the semibreve. Like Leonardo, both Bartolomé

28. Leonardo's tempo armonico is the subject of an article by Augusto MARINONI, "'Tempo armonico' o 'musicale' in Leonardo da Vinci," Lingua nostra 16 (1955): 45-48, from which the following quotations are taken.

29. MACCURDY, The Notebooks of Leonardo, 2:165 (Codex Leicester 13^v: "Modo di sapere quanto un'acqua corre per ora. -Questo si fa col tempo armonico, e potrebbesi fare col polso, se 'l tempo del suo battere fussi uniforme; ma è più securo, in tal caso, il tempo musicale, col quale si noterà quanto spazio cammina una cosa portata da essa acqua per dieci o dodici d'essi tempi e con questo tal modo si farà regola generale in qualunche canale equale"; quoted by Marinoni, 46).

30. "1080 son quelli li quali universalmente l'omo tras-

passa nel suo spirare e respirare, e l'ora è composta di 1080 de' medesimi tempi" (f. 223'; quoted in Marinoni, 46). This is the standard division in the Jewish calendar; the connection remains to be explained.

31. In Greek rhythmic doctrine, chrónos indicates the minimum measure of time, corresponding to our "beat in the bar."

32. Quoted in Anna Maria Busse Berger, Mensuration and Proportion Signs: Origins and Evolution (Oxford: Clarendon Press, 1993), 78, from Giorgio Anselmi, De musica, ed. Giuseppe MASSERA ("Historiae musicae cultores" Biblioteca, 14; Florence: Olschki, 1961), 171. In n. 80 she lists later theorists who mention the former placement of the beat on the breve.

Pamos and Gaffurio liken the musical beat to the beat of the pulse.³³ Ramos considers the mensura to be the interval between the diastole and the systole;³⁴ Gaffurio, however, says that the mensura comprises both the diastole and systole.35 (The discrepancy will be explained below.) When discussing the permissible length of dissonances in composition, Gaffurio states that a dissonance cannot last the length of a semibreve, calculated as the full mensura of time "in modum scilicet pulsus aeque respirantis."³⁶There has been some disagreement as to how this phrase is to be understood: is Gaffurio equating the length of the semibreve with the time between beats of a normal pulse, allowing thereby an approximate indication of the tempo at his time, or is he simply likening a regular musical beat to a regular pulse? Clement Miller translated this passage as "For a semibreve, equal to a complete measurement of time [a tactus], like the pulse of a man breathing evenly, cannot be given to a dissonance," noting that "aeque respirantis" had frequently been mistranslated as "quietly breathing."37 Irwin Young translated it as "a normal semibreve occupying a full measure of time, in the manner of a pulse throbbing evenly, cannot support a discord."³⁸ Dale Bonge, pointing out that the pulse and respiration were considered to be linked in contemporary medical thought, believes that Gaffurio intended no more than the analogy of the regularity of musical beat and pulse. He would therefore translate it: "For a regular semibreve equalling a full measure of time, namely, in the manner of a pulse dilating and contracting evenly, cannot lie under a dissonance in counterpoint."39

It would indeed seem that Gaffurio's statement emphasizes regularity of beat, not the particular length of the semibreve. However, the restatement of this passage in his Italian treatise, the Angelicum ac divinum opus musice of 1508, clearly makes the equation of tempo between semibreve and pulse:

33. They are writing about the pulse of music, not the music of pulse. Since antiquity physicians had sought to discern musical proportions in the uneven rhythms of the pulse as a diagnostic tool. The discussions were still very much alive in the Middle Ages. See Nancy G. SIRAISI, "The Music of Pulse in the Writings of Italian Academic Physicians (Fourteenth and Fifteenth Centuries)," Speculum 50 (1975): 689-710. For Greek sources, some transmitted through Latin and Arabic writings, see Leofranc Holford-Strevens, "The Harmonious Pulse," Classical Quarterly NS 43 (1993): 475-79.

34. "Mensura enim, ut diximus, est illud tempus sive intervallum inter diastolen et systolen corporis eucraton comprehensum." Musica practica, ed. WOLF, 83. A translation is available by Clement A. MILLER: Bartolomeo Ramis de Pareia, Musica practica (Musicological Studies and Documents, 44; Neuhausen-Stuttgart: American Institute of Musicology - Hänssler-Verlag, 1993).

35. "Neoterici postremo rectae semibrevi temporis

unius mensuram ascripserunt: diastolen et sistolen uniuscuiusque semibrevis sono concludentes. Cumque Diastole et Sistole seu Arsis et Thesis quae contrariae sunt ac minimae quidem in pulsu: solius temporis mensura consyderentur: semibrevem ipsam integra temporis mensura dispositam: duas in partes aequas distinxere: quasi altera Diastoles in mensura pulsus tanquam in sono: altera Sistoles quantitatem contineat." Practica musice, Bk. II, chap. 3, sig. aaiii.

36. "Semibrevis enim recta plenam temporis mensuram consequens; in modum scilicet pulsus aeque respirantis: in contrapuncto discordantiae subiacere non potest" (ibid., Bk. III, chap. 4, sig. ddiij^r).

37. Practica musicae, 129 and n. 10.

38. The Practica musicae of Franchinus Gafurius, trans. Irwin Young (Madison: University of Wisconsin Press, 1969), 137.

39. "Gaffurius on Pulse and Tempo: A Reinterpretation," Musica disciplina 36 (1982): 167-74 at 171-72.

For just as the *mensura* of the human pulse is considered to be one *tempo* divided into two motions, that is in one ascending and the other descending, which physicians call systole and diastole, and musicians arsis and thesis, so have the scholars of later ages ascribed the *mensura* of a sonorous *tempo* to the semibreve equal to the *tempo* of the pulse: and it is divided into two equal motions of *tempo* that are dedicated and applied to two minims.⁴⁰

The Angelicum ac divinum opus musice, a compendium derived from all of Gaffurio's treatises, including the as yet unpublished *De harmonia musicorum instrumentorum opus*, was written in Italian for the benefit of practical musicians (and nuns) who were not able to read Latin, or who found the sometimes ornate and obscure style (such as Gaffurio's own humanistic Latin) difficult to understand.⁴¹ The decision to write in the vernacular must reflect Gaffurio's experience in speaking with many musicians in Milan, and quite possibly Leonardo himself, whose Latin was rudimentary at best.

Leonardo clearly does give a length to the *tempo armonico*. This was necessary for his purpose: he needed to calculate how fast an object was moving, and therefore the measurement had to be based on exact units of time. He calculated the length not from the pulse, rejected for its irregularity, but from human respiration: "1080 are those [*tempi armonici*] that man universally passes in breathing in and out." As mentioned above, this tempo is quite slow and must correspond to the breve, not the semibreve. At some later point Leonardo changed the calculation of the *tempo armonico* so that an hour was equal to 3000 *tempi*.⁴² Augusto Marinoni believed that the reason for the substitution was that 3.33 seconds per beat was too large for measurement, leaving too many fractions; at 3000 *tempi* per hour the unit is 1.2 seconds. He also believed that just as the previous measurement had had its origin in a natural rhythm (respiration), so must the new one, which he took to be the rhythm of the pulse, but a rather slow one, 50 beats per minute (Leonardo does not clarify his change from 1080 to 3000). Marinoni wondered how Leonardo became accustomed to the new tempo, and posited the need for an instrument to mea-

40. "Nam secundo che la mensura del pulso humano se consydera in uno tempo diviso in duy moti: cioe in uno ascendente et l'altro descendente: quali son dicti da Physici sistole et diastole: da Musici Arsis et thesis: così li Curiosi posteri hano ascripto la mensura de uno tempo sonoro a la semibreve aequale al tempo del pulso: et e distincto in duy moti aequali de tempo quali son dicati et applicati a doe minime" (Tr. III, chap. 1; sig. Fi^Y). Here Gaffurio uses the word *tempo* to mean unit of time, not breve.

41. The book begins: "Perche molti illiterati fano professione de musica: et con grande difficultade pervengano a la vera coginitione de li praecepti harmonici per non intendere le opere nostre et de altri degni auctori latini quale son scripte con qualche ornato et alquanto obscuro stillo: havemo consyderato subvenire non solamente a lor voti et desiderii: ma anchora a la devotione de molte donne religiose intente ad laudare lo eterno Dio con tuta la corte celeste" (sig. Bi^{*}). There is a facsimile edition (Antiquae musicae italicae scriptores, 1; Bologna: A.M.I.S., 1971), but no translation. Gaffurio had already published, under the name of his pupil Francesco Caza, a short Italian version of his treatise on notation, which eventually became Book II of the *Practica musite*. See Francesco CAZA, *Tractato vulgare de canto figurato* [Milan, 1492], facs. and trans. by Johannes WOLF (Veröffentlichungen der Musik-Bibliothek Paul Hirsch, 1; Berlin: Martin Breslauer, 1922).

42. In the Codex Arundel, on f. 191[°], he first wrote "essendo un'ora 1080 tempi," then crossed out 1080, writing 3000 above it. See MARINONI, p. 47. sure time.⁴³ But a musician would have had no difficulty with the alteration in tempo: instead of placing the beat on the breve, Leonardo has in effect changed it, in line with contemporary music theory, to the semibreve. Still, this semibreve is even slower than before, 50 rather than 54 per minute. Scholars assume that the normal tempo of music ranged between 60 and 80 beats per minute.⁴⁴ Rather than attempting to reproduce any exact rate of musical time, then, Leonardo chose a mathematically convenient figure close to that of the length of the semibreve, which, after all, was not fixed. Moreover, musicians were used to changing the speed of the beat even within a composition, when a proportion was encountered.

In calculating the length of the semibreve according to Leonardo's figure of 1080 tempi armonici per hour, I have assumed tempus perfectum, three imperfect semibreves per breve. If we were to assume tempus imperfectum, the beat of the semibreve would be even slower, at 36 per minute. But this difference holds true only if we consider the breve to have the same temporal value in all mensurations. Such was the theoretical position held by Bartolomé Ramos (and his disciple Giovanni Spataro) and the great majority of theorists in the fifteenth century: the breve is the central unit of mensuration; it is multiplied to achieve modus (longs and maximas) and divided to achieve prolatio (semibreves and minims).45 Thus a semibreve in tempus perfectum will be 1/3 of a breve, but in tempus imperfectum 1/2, producing a proportion between semibreves of 3:2.46 Not all theorists agreed: Franchino Gaffurio-and Johannes Tinctoris, by whom Gaffurio was heavily influenced in his younger years-held instead that the minim, the smallest of the five figures of mensuration, was the invariable unit, and that all larger notes were multiples of minims. Thus the breve that contains nine minims (tempus perfectum, prolatio maior) will be one-half longer than the breve that contains six minims (tempus perfectum, prolatio minor, or tempus imperfectum, prolatio maior).47

Herein lies the explanation for the discrepancy between Ramos and Gaffurio with regard to the analogy between the *mensura* (semibreve) and the pulse. Ramos, unlike Gaffurio, took into account the unequal parts of the pulse: he equates the *mensura* with the time between diastole and systole; the interval between diastole and diastole (or systole and systole) is equated with the breve. Therefore he can extend his analogy by liken-

45. "Consideratione temporis accepta, quae in pulsus

noscitur palpitatione, scire nos oportet, utrum duplari aut triplari aut quadruplari eam contingat aut etiam dimidiare aut trifariam sive quadrifariam dividere" (*Musica practica*, ed. WOLF, 77). *Tempus* here means breve, not time.

46. This phenomenon allows mensuration signs to be used as signs of proportion.

47. On the controversy and its historical background, see BUSSE BERGER, Mensuration and Proportion Signs, chap. 3.

^{43.} Ibid. Indeed, on the same page Leonardo had noted that one could divide the hour into 3000 parts "coll'oriolo alleggerendo e aggravando il contrappeso," which to Marinoni suggested that he had anticipated Maelzel's metronome.

^{44.} There is even greater variation in the rate of pulse, which differs with age, physical condition, and even country.

ing the unequal movements of the pulse to unequal musical proportions.⁴⁸ Gaffurio, however, considers the diastole and systole to be equal in length (except in a fevered state), and therefore he equates the length of the semibreve with the whole pulse, which conveniently makes the arsis and thesis on the minims equivalent to the systole and diastole.⁴⁹ Thus, even though both theorists place the *mensura* on the semibreve, the regular invariable unit for Ramos is the breve and for Gaffurio the minim.

Leonardo's use of tempo armonico as a unit of measurement stresses the aspect of tempo; when he uses it in a musical context more weight is given to armonico. "Harmonic time" is a unit of time encompassing a harmonic simultaneity: music "composes harmony from the conjunction of her proportional parts sounded simultaneously, constrained to arise and die in one or more tempi armonici." So much is clear. The continuation, however, is somewhat obscure: "These tempi surround the proportionality of the component parts of which such harmony is composed no differently from the linear contours of the limbs from which human beauty is generated."50 Here Leonardo seems to be attempting a visual image of an auditory phenomenon. Time envelops sound just as a line may be drawn around the members of a human body. Does he have in mind here the famous image of the Vitruvian man, whose outstretched limbs fit exactly within a circle? Or does he mean the outline of a human figure? The proportions of the human body greatly occupied Leonardo,⁵¹ as did outlines, contours, and boundaries, not only of the human figure but also objects of nature, including landscape. Outlines define the wholeness of a figure, the conjunction of proportional parts, which might be likened to a chord in music.

By attaching *tempo* so firmly to *armonia* and stressing the successive nature of musical sounds, Leonardo underlines another aspect of music that has a counterpart in painting: motion. The painter, of course, has much the more difficult task: he must convey the appearance of motion, not motion itself. Time is frozen in painting, and yet everything that happens in that frozen moment can be conveyed at once. Music, by contrast, is continually in motion and can never be grasped as a whole.

Motion plays a very important role in the dispute concerning harmony in the late fifteenth century. While all theorists agreed that two-note chords formed either conso-

48. "De cuius inaequali alteratione insurgunt inaequales musicae proportiones" (*Musica practica*, ed. WOLF, 83). 49. See above, n. 35, for one passage. Earlier he had stated: "Rectam autem brevis temporis mensuram Physici aequis pulsuum motibus accomodandam esse consentiunt: Arsim et thesim quas Diastolen et Sistolen vocant in uniuscuiusque pulsus mensura aequaliter comprobantes: Constat tamen febricitantium pulsus inaequali diastoles et sistoles proportione accessionem seu alterationem suscipere quod ipsis physicis curae est. Diastole

graece dilatatio seu ellevatio interpretatur latine: Sistole vero contractio" (*Practica musice*, Bk. II, chap. 1, sig. aai^v). 50. See above, n. 26. Cf. a similar remark in Gaffurio, *De harmonia*, Bk. IV, end of chap. 18: "Quod quum corporis partes consyderaveris: eas quae pulchritudinem participant consonis diastematibus senties proportione convenire (pulchritudinem inquam)..."

51. See the section on proportions in KEMP and WALKER, 119-43. nances or dissonances, they did not agree on the classification of three-voice chords.⁵² Gaffurio, as we saw above, limits the strict use of the term "harmony" to consonances mediated by a harmonic division, although he also uses it in a looser sense to describe other divisions that produce a pleasant concord. Burzio was willing to describe any three- or four-voice chord made of up consonant parts as a harmony, and he probably reflects the attitude of contemporary musicians as well as other theorists who did not have as great a stake in ancient Greek theory as did Gaffurio. But there was one theorist who accepted neither of these definitions of harmony, Giovanni Spataro. In his polemical answer of 1491 to Burzio's equally polemical treatise against Spataro's teacher, Bartolomé Ramos, he was scathing about Burzio's knowledge in general and his discussion of harmony in particular. For Spataro, harmony was something quite different. He agreed with Burzio that "consonance is only the consideration of the interval between a low and a high note and vice versa," but insisted that the addition of one or more voices does not turn consonance into harmony. To have harmony, movement is necessary: "it is called harmony when considering the process they make by concording together (il procedere che fanno inseme concordando), because if they do not move (se non se moveno), even if there are four voices, it is not called harmony, but consonances.... Let harmony be defined as the mixture of consonances and dissonances in a composition, because it is quite true that good composers exert themselves to make dissonances marvellously consonant in harmony."53

Here, then, is that elusive view of music as a process that unfolds in time, a process sometimes called by another term that has a different meaning today: modulation. *Now*, modulation indicates a change of key area; originally it simply meant measurement of any kind: measured or rhythmical in respect of music, or singing or playing, whether melody alone or a whole composition. Burzio had used "modulation" in his definition of harmony, calling it a *modulatio vocis*, a modulation or movement of the voice. Leonardo understood this very well: for him, harmony is a conjoining of proportional parts, and this conjoining is described as arising and dying in harmonic *tempi*: we have here a description of the process chords make in musical time.

Musical notions and musical terminology have a central position in Leonardo's discussion of painting. In fact, if the subject is not stated, one would sometimes be hard put to know whether Leonardo is talking about painting or music: "thus x simultaneously conveys the proportional harmony of which the parts of the whole are com-

52. The special position of a fourth, which is not allowed in two-part counterpoint but is permitted in composition if the interval is between upper voices, will not be considered here. Apart from this, the theorists assume all chords of more than two voices to be consonant. 53. Honesta defensio in Nicolai Burtii parmensis opusculum (Bologna, 1491), sig. EIII+*. Quoted and translated in BLACKBURN, "On Compositional Process," 224-25, where I discussed the passage as adumbrating functional harmony.

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posed, and delights the senses." The subject here is painting.⁵⁴ Indeed, the parts of a painting can have the same "proportione armonica" as music, and when viewed together, they can make a "armonico concento."⁵⁵ "Concento" could be interpreted in the general sense of sounding together, but it is also a technical term at this time for a polyphon-ic composition; Gaffurio calls his musical examples *concentus*.

It has been suggested with some plausibility that Leonardo based the *Last Supper* on musical proportions,⁵⁶ even that the four groups of disciples resemble the four vocal ranges.⁵⁷ To be a truly *armonico concento*, however, the parts of this painting would have to move in harmonic time, that is, harmony in Spataro's definition: dissonance resolving into consonance, which in modern parlance could be termed "functional harmony." I would submit that this happens in the *Last Supper*. Leonardo has captured the moment where the disciples react with harsh gestures to Jesus' words, "One of you will betray me," as if he had portrayed a dissonant suspension. The painting is alive with harmonic movement, resolving in the calm, central figure of Jesus.

Quite possibly Gaffurio saw Leonardo at work on the *Last Supper* in the refectory of Santa Maria delle Grazie. Did he remark on its musicality? So far I have considered only whether Leonardo discussed music with Gaffurio. Did Gaffurio discuss art with Leonardo? There is a passage in the *De barmonia* that would gladden the heart of Leonardo, for it pays tribute to the mathematical basis of painting. It comes in a chapter entitled "Consonant numbers offer much to other arts":

Again, if attention is paid to other arts, how much utility has accrued precisely from numbers may easily be perceived; for when you look at painting, you will discover that nothing has been done in it without numerical proportions, but you will see that both the measurements of bodies and the mixtures of colours, and thus the beauties of painting, have

54. KEMP and WALKER, 23 (Urb 11⁴: "La pittura ti rapresenta in un subito la sua essentia... et anchora nel medesimo tempo nel quale si compone l'armonicha proportionalita delle parti che compongono il tutto che contenta il senso").

55. Urb 10': "molto piu farà le proportionali bellezze d'un angelico viso posto in pittura della quale proportionalità ne risulta un'armonico concento."

56. Thomas BRACHERT, "A Musical Canon of Proportion in Leonardo da Vinci's Last Supper," Art Bulletin 53 (1971): 461-66. A reconsideration is offered in Martin KEMP, Leonardo da Vinci: The Marvellous Works of Nature and Man (London: Dent, 1981), 189-99, who recognizes a "substratum of mathematical intervals" in the treatment of the ceiling coffers and in the diminution in size of the tapestries approximating the ratios 12:6:4:3, noting that Leonardo's jottings show that he was interested in musical ratios in this period (p. 198). Indeed Kemp goes so far as to suggest that "Gaffurio may well have introduced Leonardo to the definitive theory of musical harmonics" (p. 170). In a later book Kemp discusses the incongruencies in the painting and concludes that Leonardo was using a pictorial effect of perspective rather than orthodox perspective: "Leonardo's space looks logical but actively resists unequivocal translation into an actual space"; *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat* (New Haven: Yale University Press, 1990), 49. The same might be said, mutatis mutandis, of Gaffurio's recognition of the "concinnity" and "concord" of triads and sixth chords that are not "proper" harmonies.

57. John ONIANS, Bearers of Meaning: The Classical Orders in Antiquity, the Middle Ages, and the Renaissance (Cambridge: Cambridge University Press, 1988), 233. For Onians, Judas is the figure "expressively jarring the harmony of the whole." been determined according to numbers and symmetries, and that it is thus that the beauties of the paintings have been arranged, and that in turn it is through numbers that the art itself imitates primary nature. For whatever proportion has created beauty in natural bodies, such proportion has also ensued in the measurements of shapes and the comparisons of colours; for which reason, by colours, form, and shape painters themselves meant character and life to be understood.⁵⁸

What a generous compliment to contemporary artists, one thinks! But in fact, these are not Gaffurio's words at all. He has taken the whole passage, verbatim and unacknowledged, from a Latin translation made for him in 1494 of the *Peri mousikis* of Aristides Quintilianus, a writer of the late third or early fourth century AD.⁵⁹ It was Gaffurio's habit—and not only his—to incorporate passages from many ancient sources without specifically crediting them. We need to be aware of this in evaluating theoretical statements, even those that have a contemporary ring. The habit was surely common among teachers, who taught by explicating texts.

That Gaffurio viewed himself above all as a teacher is made clear in the woodcut that graces his two last treatises, where he is shown expounding music *ex cathedra*, as holder of the chair in music at the University of Milan, to twelve disciples (see Plate 1). From his mouth issues the famous saying, "Harmonia est discordia concors," "harmony is concordant discord," or harmony is concord brought forth from disparate parts. This is not merely a play on words, or even only a statement about the nature of music: it places music at the heart of the universe. The phrase *discordia concors* comes from the *Astronomica* of Manilius, an author of Augustus' and Tiberius' time who after centuries of neglect had been discovered during the Council of Constance and copied many times over in the

58. "Rursus exhibita in alias artes consyderatione quanta ex ipsis numeris prodierit utilitas facile percipi potest: Namque dum picturam animadvertis: nihil absque numerorum proportionibus in ea factum comperies: sed et corporum mensuras: colorumque mixtiones per numeros et symetrias: atque ita picturae ornamenta conspicies esse disposita: rursus per numeros ipsam artem primam imitari naturam. Qualis namque proportio in naturalibus corporibus fecerit pulchritudinem talis et in figurarum mensuris et colorum comparationibus est subsecuta: ob quam causam coloribus forma atque figura Pictores ipsi mores atque vitam intelligi voluerunt." *De harmonia musicorum instrumentorum*, Bk. IV, chap. 16 (fol. 96^v). The English translation is by Leofranc HOLFORD-STREVENS.

59. The passage quoted by Gaffurio appears in Bk. III, chap. 8, which is entirely based on Aristides. The borrowing was noticed by Clement Miller; see his translation of the *De barmonia*, 204, n. 88. Aristides has been edited most recently by R. P. WINNINGTON-INGRAM (Leipzig: B. G. Teubner, 1963). Leofranc Holford-Strevens has kindly provided the following translation from the Greek: "It will be plain to one who has examined the other arts how much benefit they gather from numbers. Should anyone care to consider painting, he will discover that it does nothing without numbers and proportions, but even seeks out the symmetries of bodies and blendings of colours through numbers and from these creates beauty in the paintings. One can also see that it is through numbers that this same art is also imitative of primary nature; at any rate, whatever proportion applied in natural bodies has created beauty it is this proportion that [painters] pursue both in the measurements of shapes and in the mixtures of colours. They too have shapes, colours, and figures that express ways of life and character..."

For an English translation of the treatise, see Aristides QUINTILIANUS, On Music, in Three Books, trans. Thomas J. MATHIESEN (Music Theory Translation Series, New Haven: Yale University Press, 1983). Concerning Aristides' dates see pp. 10-14.



Plate 1 Gaffurio lecturing ex cathedra, in his Angelicum ac divinum opus musice Bodleian Library, University of Oxford, E.1.13(2) Art.Seld., sig. Aii recto

course of the Quattrocento; there are six or seven incunable editions (including one published by Dulcinius at Milan in 1489 with an enthusiastic preface on the rebirth of letters). Reviewing the various competing theories of the universe, Manilius comes to Empedocles' view that it is the product of four elements in the two relations of love and strife:

> aut neque terra patrem novit nec flamma nec aer aut umor, faciuntque deum per quattuor artus et mundi struxere globum prohibentque requiri ultra se quicquam, cum per se cuncta crearint, frigida nec calidis desint aut umida siccis, spiritus aut solidis, sitque haec discordia concors quae nexus habilis et opus generabile fingit atque omnis partus elementa capacia reddit:⁶⁰

60. Bk. I, ll. 137-44; "else it may be that neither earth nor fire nor air nor water acknowledges a begetter, but

themselves constitute a godhead of four elements, which have formed the sphere of the universe and ban all

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Seneca similarly declares (*Naturales quaestiones* 7. 27. 4): "tota haec mundi concordia ex discordibus constat," this entire universal concord is formed out of discordant elements. The same notion is expressed by Horace (*Epistles* 1. 12. 19), with explicit mention of Empedocles, as "rerum concordia discors," the discordant concord of things, and by Ovid, *Metamorphoses* 1. 430–33:

> quippe ubi temperiem sumpsere umorque calorque, concipiunt, et ab his oriuntur cuncta duobus; cumque sit ignis aquae pugnax, vapor umidus omnes res creat, et discors concordia fetibus apta est.⁶¹

Gaffurio acknowledges Ovid as his source and quotes these four lines in Bk. I, chap. 1 of the *De harmonia*, though he has them indirectly, from Lactantius, *Divinae institutiones* ("2. $_{10}$ " = 2. 9. 20).

In the woodcut this concord is illustrated in the harmonic division of the octave, 3:4:6, shown in string lengths on the right, and in organ pipes on the left. A pair of compasses underlines the geometrical aspects of music as continuous quantity. An hourglass is set at Gaffurio's left elbow: this might have been used to time his lectures, but it is also a reminder of the temporal aspect of music. His listeners are, on the left, monks and clergy; in the center, young laymen who wish to learn about music; and on the right, adolescents who are probably choirboys. Not included here are men and women in the wider social world of Milan, especially those associated with the court, with whom Gaffurio must have come in contact. "Harmonia discordia concors" is a concept that would have had particular resonance for one of them, Leonardo.

search for a source beyond them, having created all things from themselves, so that cold combines with hot, wet with dry, and airy with solid, and the discord is one of harmony, allowing apt unions and generative activity and enabling the elements to produce all things"; trans. G. P. GOOLD in the Loeb ed. (Cambridge, Mass.: Harvard University Press, 1977), 15. The parallel passages cited here are taken from Housman's note on Manilius 1. 142 in his edition: Marcus MANILIUS, *Astronomicon*, ed. A. E. HOUSMAN, 2 vols. (London: Grant Richards, 1903-30; repr. Hildesheim: Olms, 1972). I am grateful to Leofranc Holford-Strevens for bringing Manilius to my attention and supplying the translated passages. 61. See the translation by Arthur GOLDING (1567), *Ovid's Metamorphoses*, ed. John Frederick NIMS (New York: Macmillan, 1965), 17:

For when that moysture with the heate is tempred equally, They doe conceyve: and of them twaine engender by and by All kinde of things. For though that fire with water aye debateth

Yet moysture mixt with equall heate all living things createrh. And so those discordes in their kinde, one striving with the other,

In generation doe agree and make one perfect mother.

Appendix

A Musical Silhouette at the Sforza Court

"The first picture was merely a line, drawn round the shadow of a man cast by the sun upon a wall."⁶² As commonplace as this notion was, for Leonardo it had particular meaning because of his continuing involvement with pictorial boundaries, outlines, and contours. Thus one can understand his astonishment and delight at a demonstration of the art of paper-cutting at the court of Milan in 1499. In his youth, the Spanish chronicler Gonzalo Fernández de Oviedo visited Milan and met Leonardo. In his memoirs, written some fifty years later, he relates the following story:

In 1499 in Milan I cut a polyphonic motet for four voices with the arms of the Duke, who was at that time Ludovico Sforza, also called El Moro, who, astonished at the subtlety of that work, wanted to see me cut, and in his presence I cut everything he wished to give me. Marveling at what he saw, he asked his great painter and sculptor named Leonardo de Avince, whose art, as some said, was unique in Italy, what he thought about what I was doing. And Leonardo said: "Your Excellency may believe that of all the things I have seen in the world, this is the one that has impressed me the most, and if I myself had not seen him cut, I would not believe that a man could do something so subtle with scissors alone, without any drawing, but moving the hands solely by memory." Then the Duke said: "If this Spaniard had lived at the time of the ancient Romans, he would have been crowned God of the Scissors."⁶³

I know of no motet on the arms of Ludovico, and it is a puzzle how they might have been shown in polyphony. Ghiselin Danckerts's *Tua est potentia* was written using a representation of the arms of Paul III in the tenor part; the arrangement of the six lilies

62. KEMP and WALKER, 193.

63. "Corté en Milán, el año de 1499, un motete de canto de órgano puntado a cuatro voces, con las armas del Duque, que era a la sazón el señor Ludovico Esforza, que por otro nombre le llamaban el Moro, el cual, maravillado de la sotileza de aquella obra, quiso verme cortar, y en su presencia corté todo lo que él quiso mandarme; e maravillándose de lo que veía, preguntó a un su grandísimo pintor y escultar llamado Leonardo de Avince, que era su arte, según algunos decían, el único en Italia, que qué le parecía de lo que yo hacía; y el Leonardo dijo: 'Crea Su Excelencia que ésta es la cosa del mundo que hasta hoy he visto que más me haya maravillado, y si no lo viera cortar yo, no creyera que hombre podía hacer cosa tan sutil con solas las tijeras y sin dibujo alguno, más de solamente a memoria mental mover las manos. Entonces dijo el Duque: 'Si questo spañol fuora al tempo de aquei antiqui romani, fuora laureato per Dió de le forfectie." Gonzalo FERNÁNDEZ DE OVIEDO, Historia general y natural de las Indias, ed. Juan Pérez DE TUDELA BUESO, 5 vols. (Biblioteca de Autores Españoles, 117-21; Madrid: Ediciones Atlas, 1959), 1:xix-xx. The passage was quoted in Pedretti, Literary Works, 1:372, wrongly translating "canto de órgano" as "organ motet." The memoirs have been partially published in Las memorias de Gonzalo Fernández de Oviedo, ed. Juan Bautista AVALLE-ARCE, 2 vols. (Chapel Hill: University of North Carolina Press, 1974), who unfortunately omitted "todas (o casi todas) las muestras de gárrula ancianidad," including the present anecdote. The memoirs, entitled Batallas y Quincuagenas, exist in several manuscript sources; Pérez de Tudela used one in the Real Academia de la Historia (without signature); see p. xi, n. 13. They were written in Fernández de Oviedo's last years.

superimposed on a staff can be read as the six initial notes of the *Da pacem*.⁶⁴ Perhaps there was some such device in the tenor of the motet.⁶⁵

Like many men who became famous in later life, Fernández de Oviedo regretted the time wasted in his youth on frivolities. He is known today as the great chronicler of the Indies (he was officially appointed in 1532), author of *Historia general y natural de las Indias*, the first part of which was published in Seville in 1535, the second part in 1557. It was based on five trips to the New World, between 1514 and 1546.⁶⁶ He was born in Madrid in 1478, and at about the age of 12 became a page in the household of the Duke of Villahermosa, nephew of Ferdinand the Catholic. Three years later he became a *mozo de cámara* in the household of Prince John, only son of Ferdinand and Isabella, who at the time of his early death in 1497 was married to Margaret of Austria. In 1499 he went to Italy, serving various patrons until his return to Spain in 1501. Details of his career are vague until the point where he became deputy to Lope Conchillos, Secretary for Indian Affairs, and left for the New World in 1514. From the time he published a novel on chivalry in 1519 he continued to write and to translate from Italian.⁶⁷

Obviously Fernández de Oviedo had some musical knowledge. What little we know of the musical establishment of Prince John is based on his *Libro de la Camara Real del Principe Don Juan e offiçios de su casa e servicio ordinario.* In it he recalls Prince John's inclination to music, his instruments, his musicians, and the master of his chapel, Johannes de Anchieta.⁶⁸

Fernández de Oviedo's memoirs reveal that his skill with scissors was not unique: there were others who had learned the art, both in Spain and outside it, but he held that none surpassed him. He disapproved of those who drew their patterns first, with rulers

64. The cryptic version was in the lost Treviso Ms. 30; for a sketch of the tenor and an explanation see Bonnie J. BLACKBURN, Music for Treviso Cathedral in the Late Sixteenth Century: A Reconstruction of the Lost Manuscripts 29 and 30 (Royal Musical Association, 1987), 112 and 40-43. The motet was printed by Kriesstein in 1540 with the tenor resolved. Other compositions on coats of arms by Isaac (Palle palle) and Costanzo Porta (Missa ducalis) are discussed ibid. See also Mitchell P. Brauner's interpretation of the two cantus firmi in Carlet's seven-voice motet Vidit Dominus in "The Manuscript Verona, Accademia Filarmonica, B 218 and its Political Motets," Studi musicali 16 (1987): 3-12.

65. The Sforza arms are a crowned eagle quartered with the Visconti *biscia*. Jeffrey Dean has suggested to me that the arms might have been separate from the music, say within the soprano initial. If so, there is a good candidate for the composition (though the piece is rather long): Gaffurio wrote a motet addressing Ludovico, *Salve decus genitoris*, found in Milan, Archivio della Veneranda Fabbrica del Duomo, Sezione Musicale, Librone 1 (*olim* 2269), ff. 82^v-84^t, facsimile edited by Howard Mayer BROWN (Renaissance Music in Facsimile, 12a; New York: Garland Publishing, 1987). There is a modern edition of the piece in Franchino Gaffurio, *Motetti*; ed. Luciano MIGLIAVACCA (Archivium musices metropolitanum mediolanense. 5; Milan: Veneranda Fabbrica del Duomo di Milano, 1959), 69-74.

66. See Daymond TURNER, Gonzalo Fernández de Oviedo y Valdás: An Annotated Bibliography (University of North Carolina Studies in the Romance Languages and Literatures, 66; Chapel Hill: University of North Carolina Press, 1966), introduction.

67. Ibid., pp. x-xv.

68. See Higinio ANGLÉS, La música en la Corte de los Reyes Católicos, I (Monumentos de la Música Española, 1; Madrid: Consejo Superior de Investigaciones Científicas, 1941), 74-75, and Mary Kay DUGGAN, "Queen Joanna and her Musicians," Musica disciplina 30 (1976): 73-95 at 74-76. The Libro de la camara real was edited by J. M. ESCUDERO DE LA PEÑA (Sociedad de Bibliófilos Españoles, 7; Madrid: Viuda é hijos de Galiano, 1870). and compasses, and used gouges and tools in addition to scissors (making the technique more similar to wood-cutting). He recalls cutting the arms of Prince John and Margaret, some in size no larger than a small coin.⁶⁹ With such a skill he must have found an easy entry into the Italian courts.

The history of the art of paper-cutting is badly in need of study. Although related to the silhouette, paper-cuts are much more ornate since they involve cutting not only around the edges to create an outline but cutting inside; the result can be reminiscent of filigree technique. The art has not died out; I have seen extremely elaborate modern Chinese paper-cuts. The English term "silhouette" derives from the name of Étienne de Silhouette (1709–67), and the technique became extremely popular in the later eighteenth century, but it is not at all the same as a paper-cut.

Because the name and the technique of the silhouette are so well known, scholars have been misled into believing that the paper-cut that is pasted to one of the opening folios of Bologna, Museo Civico Bibliografico Musicale, Ms. Q 19, a stag chained to a tree, is of eighteenth-century origin.⁷⁰ Rainer Heyink, in his 1994 study of the manuscript, was more inclined to see it as close to the date of the manuscript (one piece is dated 1518), but without producing new evidence on the history of the technique. Instead, he proposed that the emblem itself was that of Lucrezia Gonzaga, a member of the Bozzolo branch of the Gonzaga family, born in 1522.⁷¹ Leeman Perkins first drew attention to the bird perched in the tree as a possible Gonzaga emblem.⁷²

Fernández de Oviedo's biographical remarks permit us to discard the theory of the eighteenth-century origin of the paper-cut, as it should now be called, in Bologna Q 19. Indeed, one is even tempted to suggest that it is one of his own works, and therefore made before, not after, the preparation of the manuscript. After his visit to Milan, Fernández de Oviedo went to Mantua, where his art impressed not only Isabella d'Este but also Andrea Mantegna ("another Leonardo da Vinci").⁷³ Joining the entourage of Car-

69. Historia general, ed. PÉREZ DE TUDELA, XX-XXI. 70. The first to suggest this was Ludwig Finscher, in his review of Edward Lowinsky's edition of the Medici Codex in *Die Musikforschung* 30 (1977): 477-78. There is a facs. ed. of the Ms., ed. Jessie Ann OWENS (Renaissance Music in Facsimile, 1; New York and London: Garland Publishing, 1988).

71. Rainer HEYINK, Der Gonzaga-Kodex Bologna Q19: Geschichte und Repertoire einer Musikhandschrift des 16. Jahrhunderts (Paderborn: Ferdinand Schöningh, 1994), 31-36, esp. 33-34. As has often been remarked, the silhouette and the initials "D P" are separate objects and not necessarily related. Heyink sees Lucrezia's father, Pirro Gonzaga, as the original owner. I do not find his evidence entirely convincing, nor Robert Nosow's argument for Padua; see "The Dating and Provenance of Bologna, Civico Museo Bibliografico Musicale, Ms. Q 19," in *Journal of Musicology* 9 (1991): 92-108. This is still a manuscript in search of a provenance.

72. In his review of the Medici Codex, in The Musical Quarterly 55 (1969): 265-67 at 267.

73. "En Mantua, viviendo la excelente marquesa Isabel, madre del señor duque de Mantua e del señor Hernando de Gonzaga, mujer que fué del excelente marqués Francisco de Gonzaga, yo corté algunas cosas que aquellos señores dudaban que fuese posible hacerse, hasta que en su presencia me vieron cortar otras gentilezas. Y mucho más se maravillaba de eso aquel excelente pintor que entonces allí vivía, llamado Andrea Manteña, que era otro Leonardo de Avince, y aun en la pintura algunos dinal Juan Borgia, nephew of Alexander VI and archbishop of Valencia, and newly appointed legate *a latere* to the French king, Fernández traveled to Milan, where he saw the entrance of Louis XII, then to Turin, Ferrara, Bologna, Urbino, Rome, and finally Naples, returning to Spain in 1501.⁷⁴ In all these courts he demonstrated his art. Quite possibly there are still examples of his artistic creations, tucked away in books or manuscripts of the early sixteenth century or later, preserved because of their beauty.

le hacían el principal sobre los de aquel tiempo en toda Italia. Muchas historias o imágenes corté contrahaciendo tablas de Martinus e de otros grandes varones del buril, y tan proprio que daban admiración." See *Historia*, ed. PÉREZ DE TUDELA, XXIV.

74. Ibid., xxiv-xxxi. He admired the cardinal greatly for his intelligence and magnanimity: his household included five or six bishops, and he sought out famous men of letters and musicians, giving them substantial salaries ("vivían con él cinco o seis obispos; e cuantos hombres particulares había por Italia famosos en letras, música e en otras facultades e de gentiles habilidades, todos los buscaba e daba salarios competentes" (p. xxvi). In Naples he became acquainted with Pontano, Serafino Aquilano, and Sannazaro (p. xxxi; unfortunately, no excerpts are given).