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INTRODUCTION

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Demonstrating music

1 *Musical models*

Today musical theory is mainly "the study of the structure of music."¹ Originally it was a mathematical discipline: its characters were not sounds but numbers, and the ratios between the numbers defined the relationships between the sounds. The problem of choosing the sounds to make music with, therefore, was the problem of selecting the right numbers to generate pleasant musical sequences, the consonances. This particular approach to the problem dates back to Pythagoras and the Pythagoreans (7-5th centuries B.C.). Within the framework of the cosmology of the Ionian philosophers, Pythagoras and the Pythagoreans set a universe of precision, quantitative and dualistic, against the approximative universe, qualitative and materi-

¹ Claude V. Palisca, entry "Theory, theorists," *The New Grove Dictionary of Music and Musicians*, 20 vols. (London: Macmillan, 1980), 18:741-762, p. 741.

alistic, of the early naturalists. They were looking for a formal principle of the cosmos (number), not material (water, air, fire), and mathematical models rather than qualities became the basic constituents of reality. In Aristotle's words:

The so-called Pythagoreans applied themselves to mathematics, and were the first to develop this science; and through studying it they came to believe that its principles are the principles of everything. And since *numbers* are by nature first among these principles, and they fancied that they could detect in numbers, to a greater extent than in fire and earth and water, many analogues of what is and comes into being... and since they saw further that the properties and ratios of the musical scales are based on numbers, and since it seemed clear that all other things have their whole nature modelled upon numbers, and that numbers are the ultimate things in the whole physical universe, they assumed the elements of numbers to be the elements of everything, and the whole universe to be a proportion or number.²

According to Aristotle, numbers are, in Pythagorean cosmology, the constituent principles and elements of the whole, and the whole is held together (cosmos) by mathematical proportion, the equivalent of musical harmony. Nothing is further from the constructionism of the first musical thinkers than the idea, common today, of the conventional nature of mathematical and musical objects.³ To the Pythagoreans musical and mathematical objects are the ultimate components of reality that the Greeks called *physis* (nature). The discovery of musical universals in nature is what Pythagoras is traditionally famous for.

Pythagoras, says Boethius, spent a day "for a divine chance" ("divino quodam casu") outside a work-shop. Inside, he noticed that four of the five hammers struck by the blacksmiths produced on the anvil a pleasant harmony. He weighed them: one hammer was respectively double ($2/1$), one and a half ($3/2$) and one and a third times ($4/3$) heavier than the other three hammers it so pleasantly played along with. The fifth hammer, on the other hand, was dissonant. Pythagoras later perfected the experiment, first with strings, vases, water-filled glasses and pipes, (Figure 1) and finally with a certain and secure method he called canon or rule: a single string stretched over a sounding board to which a movable bridge is attached, so dividing the string into two parts in different ratios, known by the name monochord and still in use today for the investigation of musical ratios.⁴

² Aristotle, *The Metaphysics* 985b 24 - 986a 4, trans. Hugh Tredennick, 2 vols. (London: Heinemann, and Cambridge, Mass.: Harvard University Press, 1961), 1:33.

³ Simeon K. Heninger, Jr., *Touche of Sweet Harmony. Pythagorean Cosmology and Renaissance Poetics* (San Marino, California: The Huntington Library, 1974), pp. 75-76. See, also, Section 6 of this Introduction.

⁴ Anicius Manlius Severinus Boethius, *De institutione musica*, I, 10.



1. The invention of the consonances, from Franchino Gaffurio, *Theorica musica* (1492)

With the canon Pythagoras deduced three fundamental consonances: by dividing the string in two parts, one of which double ($2/1$), then one and a half ($3/2$) and finally one and a third ($4/3$) times longer than the other, and

The limits of the Pythagorean model are the rigid distinction between consonance and dissonance defined by the first four numbers, and the search for the perfect system of intonation based on whole rational numbers. Let us go back to Gaffurio's plate depicting the discovery of consonances, (Figure 1) which in the minds of the men of letters remained up to the 18th century the archetype of musical science. In Gaffurio's table the numbers are not the first four simple integers but rather 6, 8, 9 and 12: they are the smallest numbers for producing the ratios of the consonances of octave, fifth and fourth, plus the distance between the fifth and the fourth, a tone, corresponding to the ratio $\frac{9}{8}$ ($\frac{3}{2} : \frac{4}{3} = \frac{9}{8}$). By means of the fundamental consonances it is possible to fix four notes (C-F-G-c) in the ambit of an octave (C-c), at intervals of a fourth, a tone and a fourth ($\frac{4}{3} \times \frac{9}{8} \times \frac{4}{3} = \frac{2}{1}$); therefore four notes are still needed to complete the octave, two inside each interval of fourth. The most immediate criterion consists in selecting the interval of tone $\frac{9}{8}$ between the two tetrachords (i.e. a four-note scale segment spanning a fourth). Since the difference between a fourth and two of such tones is $\frac{4}{3} : (\frac{9}{8})^2 = \frac{256}{243}$, the diatonic division of the tetrachord and consequently of the octave becomes:

$$C \frac{9}{8} D \frac{9}{8} E \frac{256}{243} F \frac{9}{8} G \frac{9}{8} A \frac{9}{8} B \frac{256}{243} c$$

This scale is known as the Pythagorean or diatonic intonation.⁶ It was the most important among ancient Greek tunings, and in almost all the Medieval treatises it was the only one for which instructions to divide the monochord were given. As long as music was homophonic, based on octave, fifth and fourth, and sung, as in plainchant, Pythagorean intonation represented the theoretical framework for musical composition. From the 12th century these conditions were no longer general: music became polyphonic and the production of simultaneous intervals in song involved the use of intervals, major and minor thirds, not recognized in the Pythagorean scale where they are dissonant (major third C-E = $\frac{81}{64}$, and minor third A-c = $\frac{32}{27}$). The increase in consonances was accompanied in musical practice by the use of more complex musical rhythms. The introduction into 14th century polyphonic compositions of major and minor thirds, and the replacement of the ternary with the binary metre led to the break between modern musical praxis (*ars nova*) and academic musical theory which, apart from a few significant exceptions, generally reflected the *ars vetus*. Polyphonic music complicated the rigid Pythagorean borderline between consonance and dissonance, which was moved forward beyond the first

four whole numbers and beyond the consonance of fourth, to include the 'imperfect consonances' of third, major and minor.

The greater complexity of the consonance/dissonance relationship led to a questioning of the other premise of Pythagorean musical arithmetic: the search for the perfect system of intonation based on rational numbers. If consonance is thought to require simple number ratios, the arithmetic division of the octave cannot produce perfect intervals: ascending the scale seven octaves from a given C yields a C that is very close, but not identical, to the high C (really a B $\sharp$) reached by piling up twelve fifths: $(\frac{3}{2})^{12}$: $(\frac{2}{1})^{12}$ is roughly $\frac{74}{73}$, a difference known as the 'Pythagorean comma', which makes itself heard as 'wolf-fifth', a pseudo-fifth exceeding the perfect $\frac{3}{2}$ by the comma. In other words, perfectly normal progressions, if made in perfectly pure intervals, result in clearly audible gains or losses in pitch.⁷ From the 15th century there was also the gradual emancipation of instrumental music, for organ and harpsichord, which eventually made the old system of intonation obsolete. As a result, there was a pressing need to establish a new system of intonation, capable of theoretically justifying musical compositions that could no longer be referred to the traditional Pythagorean and Boethian model.

The Renaissance discovery of the ancient Greek and Latin musical sources dramatized the problem of intonation. How is it possible to accommodate modern music with its theoretical principles in Greek and Latin culture, to which the Renaissance is heir? How can the polyphonic music of the Moderns be reconciled with the theoretical writings of Pythagoras, Boethius and the other ancient theorists, which had turned up in the libraries of the West from Byzantium?⁸ Unlike their medieval colleagues, the problem was acutely felt by Renaissance musical theorists precisely because of the rediscovery of a cultural heritage which besides the authority of Boethius and Pythagoras now ranked that of Aristoxenus and Euclid, Nicomachus and Ptolemy, Plutarch and Aristides Quintilianus, Porphyry, Alypius, and so on. An answer to the dilemma of Renaissance music came from the encounter between an ancient Greek codex recently translated into Latin and a modern reader who combined a Humanistic culture with a knowledge of musical theory and practice. The ancient Greek codex is Ptolemy's *Harmonics*,⁹ the modern reader is Gioseffo Zarlino. Among the various mathematical models of musical scale put forward

⁷ Ibid., p. 38.

⁸ See Section 4 in this Introduction.

⁹ Antonio Gogava, trans., *Aristoxeni Musici antiquiss. Harmonicorum Elementorum libri III. Cl. Ptolemaei Harmonicorum, seu de Musica lib III. Aristotelis de obiecto Auditus...* (Venice: Vincentius Valgrisius, 1562); see Claude V. Palisca, *Humanism in Italian Renaissance Musical Thought* (New Haven and London: Yale University Press, 1985), pp. 133-142.

⁶ H. Floris Cohen, *Quantifying Music. The Science of Music at the First Stage of the Scientific Revolution, 1580-1650* (Dordrecht/Boston/Lancaster: D. Reidel, 1984), pp. 34ff.

by Ptolemy, Zarlino picked out the "diatonic syntonon" (the "right division of tone") as the instrument for his theoretical reform.¹⁰ Ptolemy's diatonic syntonon permitted Zarlino to resolve the dilemma of Renaissance music, both by reforming from within the Pythagorean-Boethian tradition and by adapting it to the musical praxis of the time. Through harmonic and arithmetic proportion it is possible to divide the octave into a fifth and a fourth, the fifth into a major and minor third and the major third into a major and minor tone, then experimentally prove the correctness of the mathematical procedure on the monochord. The mathematical deduction of the new consonant intervals thus affords a different distribution of the intervals within the octave, known today as the scale of 'just intonation':

$$C^{8/9} D^{9/10} E^{15/16} F^{8/9} G^{9/10} A^{8/9} B^{15/16} c$$

Zarlino's just intonation apparently resolved the two limitations of the Pythagorean model. It shifted the consonant borderline, availing itself of thirds and sixths—dissonants in the Pythagorean diatonic scale—on which the modern polyphonic construct was built. Furthermore all the consonances of the scale were just, i.e. defined by ratios between simple whole numbers ranging from 1 to 6 (*senario*): besides octave, fifth and fourth, thirds too, major C-E = $5/4$ and minor A-c = $6/5$, and sixths, major C-A = $5/3$ and minor E-c = $8/5$.¹¹

Without radically changing tradition, Zarlino's *senario* was the true 'sounding number', the archetype of the theory and practice of modern music. With arguments drawn from numerological speculation, the *senario* became the "simulacrum of the world," the symbol of the tripartite harmony of Boethius, found both in *musica mundana* and *humana*, in the macrocosm and in the microcosm.¹² The perfection of the *senario* could moreover be argued using an idea of the Pythagoreans themselves. In their arithmology the category of absolutely perfect numbers is that of the numbers identical with the sum of their own factors, and $6=3+2+1$ is the first of these numbers. In his *Elements* Euclid argued the perfection of 6, showing that it is the result of the sum and of the product of the first three whole

¹⁰ Gioseffo Zarlino, *Sopplimenti musicali* (Venice: Francesco de' Franceschi Sanese, 1588), p. 8: "The forms of the consonances and other intervals that we use in our times in vocal and natural compositions are not products of art nor inventions of man but primarily of nature itself... They are then ordered and rediscovered by art in the species that I call and shall always call natural, named syntonon diatonic by Ptolemy" (trans. Palisca, *Humanism*, p. 272). See, also, Section 6 of the present Introduction.

¹¹ The minor sixth $8/5$, not contained in the *senario*, is perceived by Zarlino as made up of the fourth $4/3$ and the minor third $6/5$, while the embarrassment of the presence of the number 8 is countered by the argument that the 8 is two times 4 and hence potentially, even if not actually, contained in the *senario*.

¹² Palisca, *Humanism*, pp. 178-181, 247-248.

numbers: $1+2+3=1 \times 2 \times 3$; and for Ficino 6 is doubly perfect because it has the perfect ratio 2:1 within itself in that 6 equals 4+2, and 4:2 is the double ratio of 2:1.¹³

In Zarlino's intonation all the consonances are 'just', i.e. given by the 'natural' series of harmonic sounds. The term 'natural' does not mean 'experimentally proven'. In Zarlino it is opposed to 'artificial' and hence a synonym of 'not created by man', the result of a natural poesis ordered by the Mind of the Creator; whence the repeated attempts, from Mersenne to Sauveur, to demonstrate the existence in nature of the mathematical series of consonances of the Zarlinian scale.¹⁴ Furthermore, precisely because of its use of pure intervals, the scale of just intonation is intrinsically unstable: it has a diminished fifth, D-A, as well as a diminished third, D-F, both of which are false by a syntonic comma, and this in the simpler diatonic music, apart from chromatic notes which would increase the number of intervals a comma or a diesis away from the corresponding pure intervals. The compromise reached in the 17th century with the introduction of equal temperament solved the problem by bringing an end to the interdiction of irrational numbers in musical theory, to that date seen as "a solemn and mysterious aspect of mathematics."¹⁵ On the other hand the decision to posit all the consonances as pure implies that it is impossible to keep the original pitch unchanged and certain concessions to the pitch of notes become necessary. What singers do in practice is the object of the 10-year controversy between Zarlino and Vincenzo Galilei. In this controversy the problem of intonation is at the forefront, bringing with it other contradictions pertaining to Renaissance musical culture.¹⁶

2 Music as structure

In her *Inner Music* Jamie Kassler skillfully reconstructs the intellectual attraction and wealth of speculation in Boethius' *musica humana*.¹⁷ The harmony of body and mind and their relationship presents Kassler's reader with a new dimension of the English 'experimental philosophy' of the 17-18th centuries. For the first time natural philosophy of the mind shapes natural philosophy of the musical instrument, which Kassler's thinkers as-

¹³ Michael J.B. Allen, *Nuptial Arithmetic: Marsilio Ficino's Commentary on the Fatal Number in Book 8 of Plato's Republic* (Berkeley: University of California Press, 1994), p. 51.

¹⁴ See Walker's essay in Section 1 of this Collection.

¹⁵ Ibid.; see, also, Cohen, *Quantifying Music*, pp. 38-43.

¹⁶ See Section 6 in this Introduction.

¹⁷ Jamie C. Kassler, *Inner Music. Hobbes, Hooke and North on Internal Character* (London: Athlone, 1995).

sume as a metaphor of human mentation. Musical instruments lie silent, and man as a musical instrument plays another music, 'inner music' as a construct of the mind-body relationship, and of the relationship of the self with the external world and with the mental archetype that encompasses and complicates both. Boethius' *musica humana* is thus the core of a conceptual structure informed by cosmological (Stoic and Neoplatonic), musical (Pythagorean) and medical (Galenic) traditions that the modern philosophers, from Thomas Hobbes to Robert Hooke and Roger North, interpret in the light of recent scientific discoveries: Harvey's theory of blood circulation, Galileo's science of motion and modern musical science.¹⁸

The conceptual structure of *Inner Music* has its roots in the conceptual structure of an ancient tradition, the intellectual tradition of music. In this tradition, which Boethius (ca. 480-526) epitomizes and hands down, *musica humana* communicates with the cosmological level of *musica mundana* (harmony of the cosmos) and with the artistic level of *musica instrumentalis* (harmonics).¹⁹ Boethius, who speaks to the philosophers, aligns music and philosophy: his tripartition is the musical rendering of the Aristotelian tripartition of theoretical philosophy into metaphysics, mathematics and physics, based on the Platonic triadic Being, intelligible, mediate and sensible. *Musicus* is therefore the philosopher who from sensible harmonies can cast back to metaphysical harmonies via intermediate harmonies, while *musica* is the science which investigates the source and foundation of harmony, musical or not, understood as order and proportion between the parts of a whole. That the book of the universe is written in mathematical language, that its characters are numbers, proportions, geometrical figures, and so on, also means that it is written in musical characters, the archetypes of the divine creation of the cosmos. This is what shapes the science of musical characters of the world, the ideal or idealized history of music written by philosophers, above which run the specific histories of music, written by musicians.

The paralleling of music and philosophy lies at the root of the extraordinary fortunes of Boethian *Musikwissenschaft*. The Renaissance inherited from Boethius the conceptual structure of music as an encyclopedia, the image of a universe created according to mathematical-musical archetypes, but it complicated the Boethian model. In the fifth chapter of the First Part of his *Le Istitutioni harmoniche* (1558), Gioseffo Zarlino (1517-1590) questions "What music in universal is, and its division." The questioning goes on to the tenth chapter, where Zarlino asks "What music in particular is, and why it is called thus."

¹⁸ See my review of *Inner Music* in *Annals of Science* 53 (1996): 642-644.

¹⁹ Boethius, *De musica*, I, 10.

"Music in universal," Zarlino writes, "is no other than Harmony..., that quarrel and friendship Empedocles posited, from which he saw everything had perforce to be generated."²⁰ Zarlino mentions here the mixture theory in Empedocles' poem *On Nature*: the opposite universal forces of Love and Strife continually combine and separate the four substances—earth, air, fire and water—which is why each actual mixture is a balance and harmony of two separate cosmogonic forces.²¹ The mediation between cosmogony and musical theory in Empedocles is, as in Zarlino, number and proportion: proportion between the four elements of the cosmos (cosmogony) and proportion between the four tones that represent the Greek tetrachord (harmonics).

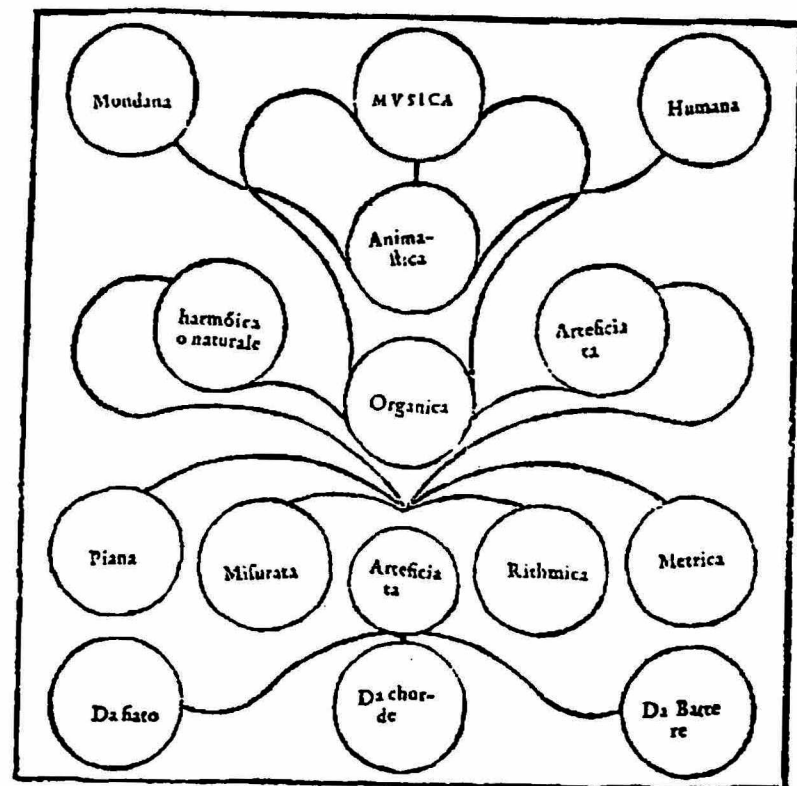
"Music in universal" is then divided by Zarlino into two parts: "animastic" and "organic." "Animastic" is a term that refers to the world-soul in Plato's *Timaeus*, and includes the *musica mundana* and *musica humana* of Boethius: harmony of the macrocosm and harmony of the microcosm, musical cosmology and musical anthropology. The "organics"—from "organo" that refers both to the organs of the human body that produce the voice and to the musical instruments made by man—is Boethius' *musica instrumentalis*. Integral parts of "organic" music are "harmonics, or natural music" and "artificial music:" they are the harmony of natural instruments (Nature) and the harmony of artificial instruments (Art), the former divided into "plain," "measured," "rhythmic" and "metrical" music (applicable also to artificial music), the latter divided according to the nature of the musical instruments: "wind," "string" and "percussion".²² (Figure 3)

Zarlino refashions the Boethian musical encyclopedia, which was addressed to philosophers, aligning it with musical reality and musicians. He combines *musica mundana* and *musica humana* with "animastic" music, distinguishing it clearly from the "organic" music produced by man on this Earth. Zarlino's *musica instrumentalis* has moreover articulations lacking in the Boethian model, that incorporate the musical developments in the centuries separating Zarlino from Boethius: in particular "measured music," which forms the subject of Part Three of *Le Istitutioni harmoniche*, on the rules of contrapuntal composition. Finally, the subject of *Le Istitutioni harmoniche* is *musica instrumentalis*, "music in particular" as distinct from the "music in universal," *mundana* and *humana*, of the philosophers.

²⁰ Gioseffo Zarlino, *Le Istitutioni harmoniche* (Venice: [Francesco de' Franceschi], 1558), p. 10.

²¹ Ibid.; see Kassler, *Inner Music*, p. 32.

²² Ibid., p. 11.



3. The division of music, from Gioseffo Zarlino, *Le Istitutioni harmoniche* (1558)

But what is "music in particular" for Zarlino? His *Istitutioni harmoniche* confirms a belief rooted in the Pythagorean-Boethian tradition: music "is a mathematical speculative science,"²³ one of the mathematical disciplines—along with arithmetic, geometry and astronomy—which in the tripartition of theoretical philosophy occupy an intermediate position between metaphysics and physics. The subject of music is the "sounding number," where number is the form and sound the matter. As number, music is "subordinate" to arithmetic to the extent that arithmetic provides its subject, which is the number; as sound, music is "subordinate" to physics to the extent that sound is a quality of natural bodies. Music is, therefore, a "middle science" between mathematics and natural philosophy,²⁴ but it is

²³ Ibid., p. 20.

²⁴ Ibid., pp. 30-31.

mathematical rather than natural, the form (number) being more noble than the matter (sonorous quality). Musical science also has a practical part which cannot be separated from the theoretical: the distinction points up the difference between those who have an intellectual relationship with music (*musicus*) and those who have a corporeal relationship (composer, singer, player). Finally, unlike the rest of mathematics, music is a speculative science with a moral strain ("*musica non modo speculationi verum etiam moralitati coniuncta est*," "music is tied not only to speculation but also to morals," Boethius says in his *De musica*.) given its power to move the soul to different passions.²⁵

Zarlino's musical encyclopedia is not an isolated case in the Renaissance. In his *De musica* (1577) Francisco de Salinas (1513-1590) revises the Boethian tripartition in his "*musica trimembris*:" at the two extremes, he places music which moves only the sense ("*musica irrationalis*") and music which moves only the intellect ("*musica intellegibilis*," mediated by music that moves the intellect and the sense together ("*musica instrumentalis*,") intimating at the greater perfection of the latter over the two other genres of music.²⁶ Salinas then leaves sensible music to irrational creatures, intelligible music "*philosophis et astronomis*" ("to philosophers and astronomers,") and offers up to the musical theorist '*musica instrumentalis*', split into '*theorica*' and '*practica*', and enriched, vis-a-vis Zarlino's *Istitutioni*, by a substantial part on rhythm (three of the seven books of *De musica*) based on St Augustine's *De musica*.

Zarlino and Salinas are professional musicians and leave it to the speculative musicians—"philosophis et astronomis"—to adapt the new theory of "music in particular" to the "music in universal" engendered by the reformed cosmos of the Moderns. The two musics, '*instrumentalis*' and '*mundana*', are brought together in a book on astronomy, *Harmonices mundi libri quinque* (1619), by Johannes Kepler (1571-1630). The last three treatises of a book God waited six thousand years for, rework the Boethian tripartition for students of astronomy. Boethius' tripartite music becomes in Kepler a single tripartite science of the harmony generated by the movement of voices (*musica instrumentalis*), the movement of Nature (*musica humana* and *astrologica*) and by the movement of the planets (*musica mundana*).²⁷

Boethius' *De institutione musica* provides the Renaissance with another idea, pointed up by Zarlino: the power of music to arouse various passions in man. The obscure, emotional side of music has found an outlet in its long-lasting tie with the literary disciplines, especially poetry and rhetoric,

²⁵ Boethius, *De musica*, I, 1; Zarlino, *Istitutioni*, p. 8 and Part II, pp. 7-9.

²⁶ Francisco de Salinas, *De musica libri septem* (Salamanca: Mathias Gastius, 1577; reprint ed., Kassel und Basel: Bärenreiter, 1958), pp. 1-2.

²⁷ See Section 7 in this Introduction and Dickreiter's piece in this Collection.

bearing witness to the complex articulations of the conceptual structure of musical science. One archetype of the second genre of music is Orpheus, whom Renaissance syncretism places beside Pythagoras. In his *Hebdomades, sive septem de Septenario libri* (1589), Fabio Paolini (1535-1605) includes the two traditions, mathematical and poetical, in a somewhat singular encyclopedia of the contemplative disciplines.²⁸ Paolini unifies the disciplines of the trivium in a single poetical-rhetorical art (Book I *De poetica atque oratoria facultate*), reworks the quadrivium by organizing it around the tripartite music of Boethius (II *De musica*; III *De humani animi sapientia, sive musica et harmonia*; IV *De astrologia*) which he subsumes under arithmetic (V *De arithmetica idealis*), and closes the 'divine septenary' of knowledge with magic (VI *De natura mysteriis*) and theology (VII *De theologia*). The tripartite music mediates the mysteries of theology and of ideal numbers with the power of poetical-rhetorical discourse, and it is this unity which generates the emotional power of music, the extraordinary effects of the song of Orpheus, the most perfect musician (*musicus perfectissimus*).

In the course of the 17th century the 'two musics', mathematical and poetical, which the Renaissance encyclopedia harmonized, start to draw apart. The 'rhetorization' of musical language in Baroque music widened the gap between the two cultures, the scientific and the humanistic, which by the 18th century were well on the road toward the final diaspora. However, the 17th century is not only the age of the mechanical world-view and of the *Affektenlehre*, it is also the age of speculative encyclopedism, of the attempts to construct a systematic encyclopedia of knowledge as a mirror of universal harmony and a means for man's regeneration. The science of the musical characters of the world in the Baroque age is the emblem for absolute knowledge: the universal art of music (*musurgia universalis*) is both the science of sciences (*encyclopedia*) and the technique of combination and calculation applied to musical composition.²⁹ The idea of music as a metaphor of the encyclopedia and as an artificial language runs through the whole of the 17th century. The century opens with the rebirth of Augustinian *harmonie universelle*, which Mersenne links to the plan to reduce music to an "algebra of sounds" and to a "method for composing the best melodies possible," and closes with the pansophic notes of Leibniz's *characteristica* and the universalistic ideals of his encyclopedism.³⁰ For Leib-

²⁸ Fabio Paolini, *Hebdomades sive Septem de Septenario libri* (Venice: Francesco dei Franceschi, 1589); see Daniel P. Walker, *Spiritual and Demonic Magic from Ficino to Campanella* (London: The Warburg Institute/University of London, 1958), pp. 126-144, and Section 6 in this Introduction.

²⁹ See Eberhard Knobloch, "Musurgia Universalis: Unknown Combinatorial Studies in the Age of Baroque Absolutism," *History of Science* 38 (1979): 258-275.

³⁰ See Eberhard Knobloch, "Harmony and Cosmos: Mathematics Serving a Teleological Understanding of the World," *Physis* 32 (1995): 55-89.

niz, founding an encyclopedia capable of uniting all the sciences and arts known to man and defining the universal "characters" of the world are closely linked projects. The characters of the world are for Leibniz prime numbers and musical intervals (tones and semitones), which confer on artificial language the elegance required by the pre-established harmony of signs and meanings, of physical and mental order.³¹ In the second half of the 18th century Kant's work still bears witness to the close relationship between the idea of the cosmos and the encyclopedia, merged in the concept of harmony. "The starry sky above me" (*musica mundana*) and "the moral law within me" (*musica humana, inner music*) are the premise for Kant's architectonics of Reason as harmonious connection between the sciences, which Romantic culture in Germany will link to the idea of the harmony of the world.³² Meanwhile, the dispute between Jean-Philippe Rameau (1683-1764) and the *philosophes* has already decreed the separation between the 'two musics' begun a century before. Rameau still sees the origin and the foundation of sciences in the mathematical laws of harmony engendered by Nature.³³ Rameau's mirror image is Jean-Jacques Rousseau (1712-1778). Rousseau's 'cri animal' mirrors Rameau's 'corps sonore', but instead of generating the musical archetypes of scientific knowledge, it expresses the passions of the soul as the distinctive trait of human nature.

3 Who is a musician?

The idealization of music is mirrored in the idealization of the musician within the tradition of speculative music. The frontispiece of the *Practica musicae* (1496) by Franchino Gaffurio (1451-1522) is graced by an engraving idealizing the musician and his work through the restoration of an ancient tradition. (Figure 4) The engraving seeks to point out the cosmological dimension of musical creation to scholars and all those with a practical relationship with music, to whom Gaffurio's treatise is addressed. Apollo on his throne is the demiurge of a living and harmonic universe, the *Musicus* who infuses his Creation with life and movement. Ministers of the Musagete are the minds, bodies and musical instruments of the Muses, who conduct the vocal motions of celestial bodies from the starry sky on high to the Earth below. The divine Musician communicates to Earth its

³¹ Daniel P. Walker, "Leibniz and Language," *Journal of the Warburg and Courtauld Institutes* 35 (1972): 294-307, also printed in Daniel P. Walker, *Music, Spirit, and Language in the Renaissance*, ed. Penelope Gouk (London: Variorum Reprints, 1985).

³² See Leo Spitzer, *Classical and Christian Ideas of World Harmony: Prolegomena to the Word 'Stimmung'*, ed. Anna Granville Hatcher (Baltimore: Johns Hopkins, 1963).

³³ Thomas Christensen, *Rameau and Musical Thought in the Enlightenment* (Cambridge: Cambridge University Press, 1993).

old tradition is the ideal music history over and above which run the various histories of music in the different countries.



5. The musician, from Franchino Gaffurio, *De harmonia musicorum instrumentorum* (1518)

In the Renaissance, changes in musical language and the rediscovery of Greek and Latin musical sources are the ground for the rebirth and metamorphosis of the Boethian *musicus*. The Renaissance image of the *musicus* is sculpted in two literary masterpieces of Renaissance musical literature: *Fronimo* (1568) by Vincenzo Galilei and *Dimostrationsi harmoniche* (1571) by Gioseffo Zarlino, two musical dialogues set respectively in the bucolic country backwaters of academic painters and men of letters, and in the Venice that in April 1562 was to give a solemn welcome to the corteo of Alfonso II, Duke of Ferrara.

A Franciscan hailing from Chioggia, Gioseffo Zarlino, who had already published the *Istitutioni harmoniche* (1558), ran the Marciana chapel from 1565, after Cipriano de Rore (ca. 1516-1565) and their teacher Adrian Willaert (ca. 1490-1562). The *Dimostrationsi* recount how to the Venetian house of the sick Willaert came Zarlino, Francesco dalla Viola (beginning of 16th century-1568), Ferrarese ducal chapel master, and Claudio Merulo (1533-1604), organist at San Marco: on the one side the *musicus*, on the other the *practici*. The dialogue begins with the unexpected arrival of a “worthy and honoured foreign gentleman,” “Desiderio di Nazione Lombardo da Pavia,” antonomasia of the “natural desire to know” of the *incipit*

to Aristotle's *Metaphysics*.³⁹ *Desiderio* takes “great delight” in music, but is above all interested in theoretical problems, having read, besides the Moderns, “many Greek and Latin authors, who worked with Music.”⁴⁰ The relationship between ancient theory and modern musical practice, engendered by the ‘natural desire to know’, is the *fiat* of the five days of a dialogue that fires the conversation between theorist and practitioners with literary dignity and demonstrative rigour. At the top of the new hierarchy, the *musicus* (Messer Gioseffo) leads the learned conversation: like the *Humanist* (Desiderio) he can read the Greek and Latin authors in the original, like the *practici* (Adriano, Claudio and Francesco) he knows the rules of musical praxis and is able to demonstrate them. The title *Dimostrationsi* underlines the application of the geometric method to music, which the recent editions of the *Commentarii* of Proclus in *primum Euclidis Elementorum* (1560) and of the *Sectio canonis* (1557), attributed to Euclid, made topical. Unlike Boethius' *musicus*, Zarlino is the “perfect musician,” combining as he does both scientific and Humanistic culture and the musical competence of professional musicians.⁴¹

Three years prior to the *Dimostrationsi*, Girolamo Scotto's press in Venice had printed *Fronimo* by Vincenzo Galilei (ca. 1525-1591). Unlike Zarlino, Galilei is neither a member of a religious order nor a musical chapel master. At first, he is a lutenist who becomes a member of the entourage of the Bardi Counts in Florence; they then send him to Venice to complete his musical education on a theoretical level under Zarlino. His encounter with a Humanist, Girolamo Mei (1519-1594), a learned scholar of Greek musical theory, marks the break in the relationship between Galilei and Zarlino and the beginning of the dispute that will separate them unto their deaths.⁴² Unlike the *Dimostrationsi*, *Fronimo*'s characters have no historical background, their names stand for the chief virtue of their activity. *Fronimo*, depicted in the act of tuning his lute in an idyllic countryside,⁴³ is the possessor of *phrónesis*, prudence or temperance, virtue on the calculating side of the rational soul, the object of which is not necessary truths but the general rules for the specific case: the principles of writing musical scores (*intavolatura*) for the lute around which the dialogue is centred. *Fronimo* talks to *Eumatio*, the possessor of *eumátia*, a good disposition towards learning. The rhetoric of the Galileian dialogue confers lit-

³⁹ Gioseffo Zarlino, *Dimostrationsi Harmoniche* (Venice: Francesco dei Franceschi Senese, 1571), p. 2.

⁴⁰ *Ibid.*

⁴¹ See my “Desiderio” in the present Collection.

⁴² See Section 6 of this Introduction.

⁴³ Vincenzo Galilei, *Fronimo... Dialogo sopra l'arte del bene intavolare et rettamente sonare la musica negli strumenti artificiali si di corde come di fiato, & in particolare nel liuto. Nuovamente ristampato...* (Venice: appresso l'Herede di Girolamo Scotto, 1584; first ed., Venice: Girolamo Scotto, 1568), p. 3.

erary dignity on the art of writing scores, not a base mechanical art but a praxis ennobled by reason.⁴⁴ The quarrel between Zarlino, the 'rationalist', and Galilei, the 'empiricist', between the Euclid and the Pericles of Renaissance music, has as its premise the variety of roles of the *musicus* on the Renaissance scene: on the one hand, the post-Boethian theorist, who reforms from within the speculative tradition which was born of sacred vocal polyphony with the Humanist and mathematical paradigm; on the other, the practical musician, who reappraises the knowledge and experience of instrumentalists, becoming the theorist of a new musical language, the expression of academic culture and the taste of courtly society.

In the course of the 17th century the gestation of modern musical theory (the *Seconda Prattica*), which succeeds Zarlino's perfection of the theory of vocal counterpoint (the *Prima Prattica*), once again brings to the fore the break between the philosopher and musical practitioners. A variant of the Boethian *musicus* is now the mathematician and natural philosopher: Descartes, who relegates Zarlino to practitioner in his *Compendium musicae*; Kepler, who ennobles the polyphony unknown to the Ancients with the reformed astronomy of the Moderns; Galileo, who reinterprets Gaffurio's engraving on the discovery of consonance and recycles it in his mechanics of elastic bodies.⁴⁵ This separation of the competences in music exists alongside the contemporary image of the *musicus* in the age of speculative encyclopedism. Mersenne's ideal of the *musicus* as universal man, someone who must know all the sciences in order to be able to interpret the secret relationship God has established between sounds and the soul,⁴⁶ is the mirror image of the Baroque encyclopedia as expression of *musurgia universalis*. The 17th century conception of the *musicus perfectissimus* can be seen in the polyhedral knowledge of the "Complete Musician" that William Brouncker (1620-1684), future President of the Royal Society, lists in his Preface to Descartes' *Compendium of Musick* (1653):

... to a Complete Musitian (please you, to understand Him to be such, as hath not only Nibbled at, but swallowed the whole Theory of Musick, i.e. haveing profoundly speculated the Pythagorean Scheme of the various Sounds arising from Various Hammers, beaten on an Anvill, respective to their different Weights, doth clearly and distinctly understand as well the Arithmetical, as Geometrical [sic] Proportions of Consonances, and Dissonances: for, it is not the mere Practical Organist, that can deserve that Noble Attribute) is required a more than superficial insight into all kinds of Humane Learning. For, he must be a Physiologist, that He may demonstrate the Creation, Nature, Properties, and Effects of a Natural Sound. A Philologer, to inquire into the first Invention, Institution, and succeeding Propa-

⁴⁴ Ibid., pp. 1, 8.

⁴⁵ See the Section 'Reconceiving music' in this Introduction.

⁴⁶ Robert Lenoble, *Mersenne ou la naissance du mécanisme* (Paris: J. Vrin, 1971²), pp. 522-531.

gation of an Artificial Sound, or Musick. An Arithmetician, to be able to explaine the Causes of Motions Harmonical, by Numbers, and declare the Mysteries of the new Algebraical Musick. A Geometrician; to evince, in great variety, the Original of Intervalls Conson-dissonant, by the Geometrical, Algebraical, Mechanical Division of a Monochord. A Poet; to conform his Thoughts and Words, to the Lawes of praecise Numbers, and distinguish the Euphonie of Vowells and Syllables. A Mecanique; to know the exquisite Structure or Fabrick of all Musical Instruments, Winde, Stringed, or Tympanous aliàs Pulsatile. A Metallist; to explore the different Contemperations of Barytonous and Oxytonous, or Grave and Acute toned Metals, in order to the Casting of tuneable Bells, for Chimes, &c. An Anatomist; to satisfie concerning the Manner, and Organs of the sense of Hearing. A Melothetick, to lay down a demonstrative method for Composing, or Setting of all Tunes, and Ayres. And, lastly, He must be so far a Magician, as to excite Wonder, with reducing into Practice the Thaumaturgical, or admirable Secrets of Musick: I meane, the Sympathies and Antipathies betwixt Consounds and Dissounds; the Medico-magical Virtues of Harmonious Notes (instanced in the Cure of Sauls Melancholy fitts, and the prodigious Venome of the Tarantula, &c.) the Creation of Echoes, wether Monophone, or Polyphone, i.e. single or Multiplied, together with the Figure of Buildings, and arched Rocks, neer Rivers, Dales, or Woods, requisite to the multiplyed Reverberations of Sounds; the Artifice of Otocoustick Tubes, or Auricular Meanders, for the strengthening, continuation, and remote transvection of weake sounds, and the mitigation of strong; the Model of Auto-phonous, or speaking Statues; and finally, the Cryptological Musick, whereby the secret Conceptions of the mind may be, by the Language of inarticulate Sounds, communicated to a Friend, at a good distance.⁴⁷

The list reads as an ideal manifesto for the supposed musical aims of the Royal Society. This 17th century image of the 'Complete Musician' is on the other hand reminiscent of the Boethian primacy of the man of science over the "practical organist;" as such, it is not intended to reform but rather to preserve the rift between modern music scientists and music composers and players. The dismembered parts of the 'perfect musician' were recomposed one last time in the first half of the 18th century in Jean-Philippe Rameau. Then Romantic culture will redraw musical values, replacing the *musicus* of Pythagorean-Boethian inspiration, reassumed by Rameau, with the gifted composer, unwitting demiurge of the musical work of art.

⁴⁷ Renatus Des-Cartes *Excellent Compendium of Musick: With Necessary and Judicious Animadversions thereupon, by a Person of Honour* (London: Printed by Thomas Harper, for Humphrey Moseley, 1653), "The Stationer to the Ingenious Reader;" on this English edition of the *Compendium*, see Descartes, *Abrégé de musique*, Edition nouvelle, traduction, présentation et notes par Frédéric de Buzon (Paris: Presses Universitaires de France, 1987), pp. 37-40.

Recollecting Music

4 Sources and institutions

The recovery of Greek musical sources began not in the Latin West but with the Byzantines who had direct access to the originals. Around the 10th century a circle of learned musicologists grew up in Byzantium, to whom all the Greek musical codices known today can be traced: the *Sectio canonis* attributed to Euclid, the *Harmonica* by Aristoxenus and the fragments of a treatise of his on rhythm, the treatises *De musica* by Aristides Quintilianus and Plutarch, the *Enchiridion* by Nicomachus, the *Introductio harmonica* of Gaudentius and Cleonides, the *Harmonica* by Ptolemy with the comment by Porphyry, the *Introductiones musicae* by Alypius, Baccheius and Dionysius, and finally some anonymous texts (later called *Anonymi Bellermanniani*) and some fragments.⁴⁸ The recovery and reception of this literature by Westerns can be ascribed to learned Byzantines of the 12th, 13th and 14th centuries, such as Maximus Planudes or Manuel Bryennius (whose musical synthesis was later assimilated to ancient writings), and to the Byzantine and Italian collectors of the 15th century. It was in Venice, with its favorable geographical, economic and political position vis-a-vis Byzantium, that at the end of the 15th century all the Byzantine musical codices could be found, which already belonged to the Venetian patrician and collector Francesco Barbaro, the Cardinal Bessarione and Giorgio Valla, the first to translate Cleonides and Euclid (1497).⁴⁹ The library of the San Marco convent in the Florence of Cosimo de' Medici and the Vatican library in the Rome of Pope Nicolas V (1447-1455) and his immediate successors were, like the Marciana in Venice, the first public libraries to house codices of the ancient Greek writers on music.⁵⁰

The Greek and late-Roman musical sources did not include musical examples that could be reproduced by the musicians of the 15th or 16th century. The only *repertoire* of ancient music were a few hymns of Hellenistic times which had passed unnoticed until Girolamo Mei sent a copy in 1579 to Vincenzo Galilei, who published them in their original form.⁵¹ Ancient music was not the instrumental music practiced in Greece, but the intellectual music conceived and written by the philosophers, mathematicians and musical theorists of antiquity, later preserved in the musical codices

⁴⁸ F. Alberto Gallo, "Die Kenntnis der griechischen Theoretikerquellen in der italienischen Renaissance," in *Geschichte der Musiktheorie*, 10 vols., *Italienische Musiktheorie im 16. und 17. Jahrhundert* (Darmstadt: Wissenschaftliche Buchgesellschaft, 1989), 7:7-38, pp. 10-11.

⁴⁹ Ibid., pp. 13-18.

⁵⁰ Palisca, *Humanism*, pp. 23-50.

⁵¹ Ibid., p. 450.

arrived in Italy from Byzantium. *Renaissance music*, i.e. music imbued with Greek musical culture, affected the *music of the Renaissance* via readings and commentaries of the ancient theories of music in the era of modern music.⁵² The paradox may explain the rift between the world of culture and the world of musical professionals which marked the early phase of Renaissance music. At the end of the 15th century the composer, the chapel master or the musical theorist trained in the Scholastic tradition of music theory were not involved in the work of recovering, translating and interpreting the Greek musical treatises undertaken by the humanists, philosophers and men of culture, who saw in music one of the theoretical sciences of the encyclopedia, or a literary discipline to be placed alongside rhetoric and poetry. Franchino Gaffurio—composer, chapel master and then also public lecturer in music at the university of Milan established by Ludovico il Moro—healed this rift by promoting a dialogue between music and culture which left its mark on the second phase of the musical Renaissance.⁵³ Gaffurio was the first musical humanist to try to study the Greek musical texts. Ignorance of the language, which had accounted for the delay of the Latin Middle Age vis-a-vis the Judaic, Arabic and especially Byzantine culture in understanding Greek music, was overcome by Gaffurio's contacts with Humanist circles to whom he entrusted, in the persons of Gianfrancesco Burana and Nicolò Leonceno, the translations from the Greek: Aristides Quintilianus, the so-called Anonymi of Bellermann, Bryennius and perhaps Bacchius (Burana), and Ptolemy (Leonceno). The musical writings of Gaffurio, from *Theorica musica* (1492) to *De harmonia musicorum instrumentorum* (written in 1500, published in 1518), show Gaffurio's increasing familiarity with the ancient theorists: while only mentioned in the First Book of the *Theorica* inspired by Boethius, in the *De harmonia* they put forward the main themes of the treatise.⁵⁴ The Humanistic dialogue between musicians and men of letters marked a turning point in the history of Italian musical culture. The controversy which between the 15th and 16th centuries pitched Ramos de Pareja (ca. 1440-after 1491) and Giovanni Spataro (ca. 1458-1541) against Gaffurio and Niccolò Burzio (ca. 1450-1518) is symptomatic of the intellectual and social upheaval wrought on the world of musicians by the introduction of classical culture: on the one hand the theorists trained in the linguistic and cultural models of Scholastic treatise writing, on the other the musical Humanists who renewed the forms of musical literature to bring it into line with the new literary paradigm.⁵⁵ "To the authority of Franchino Gaffurio," Gioseffo Zarlino himself would appeal in his *Istitutioni harmoniche*. Zar-

⁵² Ibid., p. 5.

⁵³ Gallo, "Die Kenntnis," pp. 19-22; Palisca, *Humanism*, pp. 191-225.

⁵⁴ Gallo, "Die Kenntnis," p. 22.

⁵⁵ Palisca, *Humanism*, pp. 230-235.

lino is credited with having arranged the list of the books on music in the *Summa librorum* (1559), the publishing program of the Accademia Veneziana that "the law giver of music" was a member of. The list associates the ancient musical theorists (Ptolemy, Porphyry, Euclid, Aristides Quintilianus) with the modern theorists (Fogliano, Faber Stapulensis, Francesco Giorgi Veneto), hinting at the unity and continuity of Renaissance musical culture with its ancient past, that had turned up with the Greek musical codices in Venice a century before.⁵⁶

The distinction between speculative and practical music is the premise to the presence of music in cultural institutions. The distinction helps account for the variety of forms music assumed in European medieval universities. The university allowed different levels of musical activity often overlapping: from vocal and instrumental execution to oral teaching and written composition. At one extreme there was music as entertainment: from the instrumental ensemble to dance and the songs of the symposium; at the other extreme there was the *ars musica*, music as quadrivial discipline taught in the Faculty of Arts with arithmetic, geometry and astronomy. Between the two extremes there were other intermediate levels: music in function of the periodical events of the community of *doctores* and *scholares*; oral teaching of the elementary rules of plainchant in the musical chapels annexed to monasteries and cathedrals; finally musical treatise writing oriented more towards the theory of contemporary musical praxis than to the cosmological and mathematical foundation of the science of music.⁵⁷

At the beginning of the 13th century the *ars musica* taught in the European Universities is no different to that taught in the schools of the monasteries and cathedrals: reading the Books, usually the first two, of *De institutione musicae* by Boethius, and *compendia* and *commenta* inspired by it—as later (13th century) the *Musica speculativa* by Jean de Murs (ca. 1290-ca. 1351), widely read throughout Europe and still taught in the 18th century at the University of Cracow. A statute of the Faculty of Arts at the Universitas parisiensis in the mid-13th century records, however, a change in the programs of oral teaching which from 1255 to the beginning of the 14th century consisted primarily of *philosophia naturalis*.⁵⁸ Bearing musical witness to the growing spread of Aristotelianism are the roughly fifty copies of the first Latin translation of the *Problemata* attributed to Aris-

⁵⁶ Ian Fenlon, "Zarlino and the Accademia Venetiana," in *Italian Academies of the Sixteenth Century*, ed. David S. Chambers and François Quiviger (London: The Warburg Institute/University of London, 1995), pp. 79-90, esp. 84-85.

⁵⁷ Michel Huglo, "The Study of Ancient Sources of Music Theory in the Medieval Universities," in *Music Theory and Its Sources: Antiquity and the Middle Ages*, ed. André Barbera (Notre Dame, Indiana: University of Notre Dame Press, 1990), pp. 150-172.

⁵⁸ *Ibid.*, pp. 151-156.

totle, which Bartolomeo da Messina carried out between 1258 and 1266, sections 11 and 19 of which are the only two Greek texts of musical theory translated into Latin in the Middle Ages.⁵⁹ The move from Platonism to Aristotelianism is accompanied in the same period by the introduction of measured-chant treatises into the *curriculum studiorum* of Europe's leading universities: *De mensurabili musica* by Johannes de Garlandia and his successors, the *Anonimo* of 1279, Franco and Anonimo IV, written between 1260 and 1285,⁶⁰ followed in the 14th century by the musical treatises of Philippe de Vitry (1291-1361) and de Murs in Paris, of Marchetto (ca. 1274-1326) and Prosdócimo de Beldemandis in Padua (ca. 1380-1428), whose theoretical production coincides with his teaching in the University of Padua in the second and third decades of the 1400s.

The tripartite harmony of Boethius, however, long remained the main catalyzer of the forms of musical speculation in universities. The anonymous *Questions* on music proposed at the end of the 14th century in a university course of the late Scholastic, attributed to Biagio Pelacani, *magister artium* in Padua, Bologna and Parma, illustrate a recurrent phenomenon in the history of university musical culture: the Boethian system is used to review all the aspects of the discipline and adapt them to contemporary science and philosophy.⁶¹ The second *quaestio* "Utrum sonus sit subiectum in musica" follows Boethian *musica trimembris*, and the comment touches on cosmological, mathematical and natural issues: the structure of the skies, the four elements, the mind-body relation, the action of qualities, the problem of movement, the nature and propagation of sound, the theory of consonance, and the concept of proportion that encompasses all: "musica in ratione numerorum consistit," music is the science of the mathematical proportions between the parts of a whole, natural or metaphysical, sonorous or mental. At the height of the Renaissance Boethius is still a studied author, translated and collected.⁶² The case of the Jesuit schools is significant. The primacy of mathematics in the *ratio studiorum* revised by Christoph Clavius (1537-1612) can be seen in the Renaissance tradition of *compendia* of Boethius' *De institutione musicae*, destined to be taught orally: *Musica demonstrata* (1496 and 1551) by Jacobus Faber Stapulensis (Jacques Le Febvre d'Étaples) and *Musicae traditiones* (1575) by Fran-

⁵⁹ F. Alberto Gallo, "Greek Text and Latin Translation of the Aristotelian Musical Problems: A Preliminary Account of the Sources," in *Music Theory*, pp. 190-196.

⁶⁰ Jeremy Yudkin, "The Influence of Aristotle on French University Music Texts," in *Music Theory*, pp. 173-189.

⁶¹ See Cecilia Panti, "Una fonte della 'Declaratio musicae disciplinae' di Ugolino da Orvieto: quattro anonime 'Quaestiones' della tarda scolastica," *Rivista Italiana di Musicologia* 24 (1989): 3-47.

⁶² Claude V. Palisca, "Boethius in the Renaissance," in *Music Theory*, pp. 259-280.

cesco Maurolico (1494-1575), forerunners of the *Compendium musicae* (1618) by René Descartes.⁶³

The Renaissance complicated the teaching of musical theory in cultural institutions. Alongside and in competition with the Universities, state or private, the Academies grew up as institutions halfway between private and public, designed to culturally educate the noble offspring of the ruling classes in the towns. At the Italian Academies of the 16th century music was usually conceived of as a speculative discipline within the encyclopedia of the liberal arts. Rarely did musical practice alone, vocal and instrumental, justify the setting up of a musical institution created as living metaphor of the Parnassus symbolized by the Muses and by Apollo Musagete.⁶⁴ This nonetheless was the case both of the Accademia degli Unisoni in Perugia⁶⁵ and of the Accademia Filarmonica founded in Verona in 1543.⁶⁶ The latter cultivated musical divertissements leaving Pietro Pontio (1532-1595) the job of arguing in his *Dialogo della Theorica e Pratica di musica* (1595), dedicated to the Veronese Academy, the primacy of active music over contemplative music. However the Accademia Veneta or della Fama, founded by Federico Badoer in 1557 and renowned for its encyclopedic organization of knowledge, gave over one of the four rooms of the "Council of the Sciences," the room "de' Mathematici" ("of the Mathematicians,") to the science of music. It is not astonishing to find Gioseffo Zarlino here in this room. Zarlino's presence in the Venetian Academy is attested by two significant cultural facts: the list of music books, both ancient and modern, which the Academy intended to publish,⁶⁷ and the *Dimostrazioni harmoniche* published by Zarlino after the dissolution of the Fama, whose most singular scientific legacy they are.⁶⁸ Zarlino was the link between the Accademia della Fama and the Accademia degli Uranici, established in 1587 in Venice by Fabio Paolini. Professor of Greek and Latin in San Marco, Paolini is the author of a sophisticated synthesis of the musical Renaissance; his academic orations on music reconcile Greek Arcadia and Virgilian verse, Platonism and Aristotelianism, contemplation and practice, and prescribe a model of musical composition, the monodic song accompanied by simple harmonies, which recalls con-

⁶³ See my "Descartes" in the present Collection.

⁶⁴ Marc Fumaroli, "Academia, Arcadia, Parnassus: trois lieux allégoriques de l'éloge du loisir lettré," in *Italian Academies*, pp. 15-35.

⁶⁵ Allan Atlas, "The Accademia degli Unisoni: A Music Academy in Renaissance Perugia," in *A Musical Offering: Essays in Honor of Martin Bernstein*, ed. Edward H. Clinkscale and Claire Brook (New York: Pendragon Press, 1977), pp. 5-23.

⁶⁶ See Fenlon, "Zarlino," p. 80.

⁶⁷ *Summa Librorum quos in omnibus scientijs in lucem emittet Academia Veneta* (Venice: in Academia Veneta, 1559); see Fenlon, "Zarlino," pp. 84-85.

⁶⁸ See my "Desiderio" in the present Collection.

temporary experiences.⁶⁹ The nostalgic myth of ancient Greek music, academic and literary, was renewed through musical reform in both the Florentine literary and musical academies of the second half of the 16th century—from the Accademia degli Alterati⁷⁰ to the Camerata fiorentina⁷¹ and in the French academies of the late 16th century:⁷² the "maravigliosi effetti della musica antica" became in the Italian and French academies the forerunner of opera and the *musique mesurée à l'antique*.

The work of Marin Mersenne (1588-1648) is the main element in the continuity between Antoine Baïf and Jacques Mauduit's Académie de poésie et de musique (1570-1585) and the modern academies, which have a decidedly scientific outlook later ratified by the foundation of the Académie royale des sciences.⁷³ The 17th century encyclopedic ideal is embodied in the scientific research planned and discussed within the academies, and together with optics, mechanics or astronomy, music was one of the subjects investigated by the natural philosophers at the Cimento, Royal Society and Académie des Sciences. It was as part of the scientific research of the Paris Academy of Science that the problem of the origin and foundation of harmony, with which our history began, was finally tackled in modern terms. The Pythagorean paradox of different sounds engendered by the single string that encapsulates them became the paradox of different vibrating motions in the whole vibrating string, able to engender, with its fundamental sound, the theoretically infinite series of its harmonics, whose frequency is a multiple of the fundamental frequency. This redefinition of the origin and foundation of harmony can be found in the *Mémoires* Joseph Sauveur (1653-1716) presented in 1701 to the Academicians of the French institution.⁷⁴ The *merveille* Fontenelle experienced on

⁶⁹ See Section 6 in this Introduction.

⁷⁰ Claude V. Palisca, "The Alterati of Florence, Pioneers in the Theory of Dramatic Music," in *New Looks at Italian Opera: Essays in Honor of Donald J. Grout*, ed. William Austin (Ithaca, NY: Cornell University Press, 1968), pp. 9-38, also printed in Claude V. Palisca, *Studies in the History of Italian Music and Music Theory* (Oxford: Clarendon Press, 1994), pp. 408-431.

⁷¹ Claude V. Palisca, *The Florentine Camerata. Documentary Studies and Translations* (New Haven and London: Yale University Press, 1989).

⁷² Frances A. Yates, *The French Academies of the Sixteenth Century* (London: The Warburg Institute/University of London, 1947; reprint ed., London and New York: Routledge, 1988).

⁷³ *Ibid.*, pp. 275-316; see, also, Albert Cohen, *Music in the French Royal Academy of Sciences: A Study in the Evolution of Musical Thought* (Princeton, NJ: Princeton University Press, 1981).

⁷⁴ Joseph Sauveur, "Système général des intervalles des Sons, & son application à tous les Systèmes & à tous les Instrumens de Musique," in *Histoire de l'Académie Royale des Sciences. Année 1701. Avec les Mémoires de Mathématique & de Physique, pour la même Année* (Amsterdam: Gerard Kuyper, 1707), pp. 390-482.

seeing and hearing Sauveur's demonstration⁷⁵ anticipated that of Jean-Philippe Rameau, who saw his own mathematical principle of harmony experimentally confirmed in the memoirs presented by Sauveur to the Académie des Sciences. And to the "Messieurs de l'Académie Royale des Sciences" Jean-Philippe Rameau addressed his own *Génération harmonique* (1737), prompted by 'Newtonian' experiments on the properties of sound, while his *Démonstration du principe de l'harmonie* (1750) was "Approuvée par Messieurs de l'Académie des Sciences," thereby bearing witness to the now century-old association of music and the modern academic institution.⁷⁶

5 Musical genre

From the 4th century BC to the mid-18th century the treatise on music is the literary genre that informs the intellectual identity of music, assigns it its place in the encyclopedia of knowledge and sets itself up as the sole repository of the discipline's historical memory. The *Historia musica* (1695) by Angelini Bontempi, perhaps the first book of music to link music and history in its title, is not in fact a history of music but a systematic description of musical theory articulated in theses and corollaries and rooted in the speculative musical tradition.⁷⁷ Bontempi entitles his treatise on musical theory *Historia* because treatises had always dealt with history: from Boethius, who reports the opinions of the Greek theorists, to Gaffurio and Zarlino, who discuss all previous musical treatise writing, through to Rameau who, via Zarlino, Descartes and Mersenne, sums up modern musical writing.

But what is a treatise on music? A student of the Greek musical codices has answered this question by using the metaphor of the onion: the critic continually tears away layers (amendments, additions, interpolations narrating the history of the codex) only to find others beneath; the answer to the question, however, does not lie in reaching the center but in giving each layer its own place in the history of the codex, in its *Rezeptionsgeschichte*.⁷⁸ The warning does not simply apply to the study of musical

⁷⁵ Bernard le Bovier de Fontenelle, "Sur un nouveau système de musique," in *Histoire de l'Académie Royale des Sciences. Année 1701*, pp. 155-175.

⁷⁶ See Christensen, *Rameau*, pp. 159-162.

⁷⁷ Giovanni Andrea Angelini Bontempi, *Historia Musica, nella quale si ha piena cognizione della Teorica e della Pratica antica della Musica Harmonica...* (Perugia: per Constantini, 1695; reprint ed., Bologna: Forni, 1971).

⁷⁸ André Barbera, "Reconstructing Lost Byzantine Sources for MSS Vat. BAV gr. 2338 and Ven. BNM gr. VI.3: What is an Ancient Music Treatise?," in *Music Theory*, pp. 38-67, esp. 65.

codices but extends to the theory of the text,⁷⁹ is therefore an effective antidote to the periodical classificatory temptations inflicted on musical treatise writing, especially in the Middle Ages. From Gerhard Pietzsch to Lawrence Gushee, these classifications answer the question 'what is a musical treatise?' in terms of a 'question of genre': they transform the problem of the tradition of the text into the definition of models. These classifications try to order the extraordinary variety of musical treatises, ancient and medieval, by using different criteria—from the distinction between *musica theoricæ* and *musica practica*⁸⁰ to more complex and sophisticated categories: genre, style, public, and so on.⁸¹ They produce, however, a subtle distortion of the musical treatise: instead of being a live testimony to the culture of an era, the treatise is hemmed into a narrow enclosed space, helpful perhaps for the present-day scholar but foreign to the cultural beliefs of its Author. Music makes no exception to the medieval intellectual's trust in the unitary structure of knowledge, the specificity of the discipline does not exclude its dependence on the principles of knowledge and the aim of understanding the theological truths, common to all the *artes*.⁸²

The same trust is shared by the Renaissance musical theorist who sees the treatise as a synthesis of ancient, medieval and modern musical culture. In Zarlino's *Dimostrazioni*, "the natural desire to know" in the celebrated *incipit* of Aristotle's *Metaphysics* wears the clothes of a foreign gentleman, "Desiderio da Pavia," who in the role of reader of the ancient writers of music wants to resolve a doubt: how to reconcile the science of the Ancients with the music of the Moderns?⁸³ Reconciling theory and practice, reason and experience, is not just a technical problem of a few musical professionals but belongs to the whole of culture. The musical treatise stands witness to the faculty of music to contaminate culture, to change it and be changed by it. The dialogic genre of the *Dimostrazioni* is the rhetorical instrument that opens up the world of music to the Humanist interlocutor, charged with mediating communication between theorists and practitioners, reason and sense.⁸⁴ The Euclidean structure of the *Dimostrazioni*

⁷⁹ Thomas J. Mathiesen, "Ars Critica and Fata Libellorum: The Significance of Codicology to Text Critical Theory," in *Music Theory*, pp. 19-37.

⁸⁰ Gerhard Pietzsch, *Die Klassifikation der Musik von Boethius bis Ugo da Orvieto* (Halle: M. Niemeyer, 1929; reprint ed., Darmstadt: Wissenschaftliche Buchgesellschaft, 1968).

⁸¹ Lawrence Gushee, "Questions of Genre in Medieval Treatises on Music," in *Gattungen der Musik in Einzeldarstellungen. Gedenkschrift Leo Schrade*, ed. Wulf Arlt, Ernst Lichtenhahn and Hans Oesch (Bern-Munich: Francke Verlag, 1973), pp. 365-433.

⁸² Nancy van Deusen, *Theology and Music at the Early University. The case of Robert Grosseteste and Anonymus IV* (Leiden/New York/Köln: E.J. Brill, 1995), xiii.

⁸³ Zarlino, *Dimostrazioni*, p. 2.

⁸⁴ Klaus-Jürgen Sachs, "Boethius and the Judgement of the Ears: A Hidden Challenge in Medieval and Renaissance Music Theory," in *The Second Sense. Studies in Hearing and Musical Judgement from Antiquity to the Seventeenth Century*, ed. Charles Burnett, Mi-

tioni harmoniche is, on the other hand, the contamination of musical theory with the method of scientific demonstration.⁸⁵ Aligning musical theory to the Euclidean paradigm is not imitation of an extraneous model but the updating of a mathematical discipline in the light of the successful geometrical method of the ancient mathematicians and Greek musicologists. These developments set the *Dimostrazioni* and their Author in a precise historical and cultural context. The treatise stands witness to the active participation of Zarlino in the Venetian culture of the 1560s. The "translations from the Greek" commissioned by Franchino Gaffurio are re-born in Zarlino's contacts with the Venetian and Lombard Humanistic circles. The relationships between Gaffurio and his colleague at the Milan university, the mathematician Luca Pacioli, live again in the contacts between Zarlino and "the modern mathematicians" at the University of Padua, open to the renaissance of mathematics by the teachings of Francesco Barozzi (1537-1604).⁸⁶ Zarlino's membership in the Accademia della Fama links music to Federico Badoer's project of cultural and political renewal, which continues in the Accademia degli Uranici via the musical interests of Fabio Paolini, who asks Zarlino for the musical codices of Marciana.

Is the musical treatise not a betrayal by the theorist of musical praxis, of the polyphonic choruses of the Cappella Marciana that Zarlino was Maestro of? Does not the science of the Ancients contradict the practice of the Moderns, or, vice versa, does not modern polyphony falsify the musical theory of the age of ancient monody? Desiderio's doubt is the problem which from Gaffurio to Nicola Vicentino, from Zarlino to Vincenzo Galilei, and from Salinas to Descartes and Kepler runs through the pages of the Renaissance musical treatise. The theorists' response to the unrepeatability of sonorous events and apparent lack of principles of musical praxis is to search for their intellectual archetypes. To Willaert, who can give no explanation for his own compositions, Zarlino answers with the demonstration learnt at the school of the ancient geometers.⁸⁷ The response of the theorist is not a betrayal of the work of men but its idealization: musical praxis *sub specie aeternitatis*, the affirmation of the unity of knowledge as

chael Fend and Penelope Gouk (London: The Warburg Institute/University of London, 1991), pp. 169-198.

⁸⁵ See Michael Fend, "Zarlino's Versuch einer Axiomatisierung der Musiktheorie in den 'Dimostrazioni harmoniche' (1571)," *Musiktheorie* 4 (1989): 100-112.

⁸⁶ See Paolo Gozza, "La musica tra matematica e antica teologia," in *Sapere e/è Potere. Discipline, dispute e professioni nell'Università medievale e moderna. Il caso bolognese a confronto*, 2 vols., *Verso un nuovo sistema del sapere*, ed. Andrea Cristiani (Bologna: Istituto per la Storia di Bologna, 1990), 2:217-238, and Ann Elisabeth Moyer, *Musica Scientia. Musical Scholarship in the Italian Renaissance* (Ithaca and London: Cornell University Press, 1992), pp. 126-134.

⁸⁷ Zarlino, *Dimostrazioni*, p. 5; see my "Desiderio" in this Collection.

a mirror of universal harmony. And the distance that remains between the music produced by men and *the music* of the treatise is not fault of musical theorists alone but also of men of culture, their idea of reason and science, and the role assigned experience in cultural systems.

The musical treatise is not just the object of musicologists alone. Alongside the names of Gaffurio, Fogliano, Glareanus, Vicentino, Zarlino, Salinas, Vincenzo Galilei and Artusi, the Renaissance includes those of magicians, natural philosophers, mathematicians, astronomers: Marsilio Ficino, Faber Stapulensis, Giorgio Valla, Francesco Giorgi Veneto, Francesco Maurolico, René Descartes, Johannes Kepler, Simon Stevin and Marin Mersenne. In the 17th century the musical treatise stands witness to affirmation of the modern scientific paradigm: the *Elucidationes physicae* that Nicolas Poisson published in the margins of his French translation of the *Abrégé de musique* (1668) by Descartes reveals the intention to complete the mathematical demonstrations of the youthful Cartesian treatise with the experimental musical pages of Galileo's *Discourses* (1638);⁸⁸ the *Musica speculativa* (1670) by Pietro Mengoli, despite its traditional title, seeks to deduce musical theory from the mechanistic doctrines of sound and from the anatomy and physiology of hearing;⁸⁹ and the treatise *Del suono, de tremori armonici e dell'udito* (1679) by the Jesuit father Daniello Bartoli, in its very title points to the changes wrought in the musical treatise by modern experimental philosophy.⁹⁰ In the mid-1700s Jean-Philippe Rameau is the epitome of the musical treatise tradition which had begun in the 4th century B.C. If the *Traité de l'harmonie* of 1722 reworks Renaissance models, the *Génération harmonique* (1737) and the *Démonstration du principe de l'harmonie* (1750) speak the language of Newtonian science and are addressed to the *philosophes*, who include music in their scientific agenda.⁹¹ With the Illuminists the musical treatise is clarified, emended and simplified⁹² before being finally set aside and de-

⁸⁸ Nicolas Poisson, "Elucidationes Physicae in Cartesii Musicam," in *Traité de la mécanique composé par Monsieur Descartes. De plus l'abrége de musique du même auteur mis en français avec les éclaircissements nécessaires* (Paris: Charles Angot, 1668), pp. 101-127; see René Descartes, *Abrégé de musique suivi des Éclaircissements physiques sur la musique de Descartes du R.P. Nicolas Poisson*, traduction, introduction et notes par Pascal Dumont (Paris: Méridiens Klincksieck, 1990).

⁸⁹ Pietro Mengoli, *Speculationi di musica* (Bologna: Herede del Benacci, 1670); see Paolo Gozza, "A Mechanical Account of Hearing from the 'Galileian School': Pietro Mengoli's 'Speculationi di musica' of 1670," in *The Second Sense*, pp. 115-136.

⁹⁰ Daniello Bartoli, *Del suono de tremori armonici e dell'udito. Trattati* (Rome: per Nicolò Angelo Tinassi, 1679; 2nd ed., Bologna: P. Bottelli, 1680); see Paolo Gozza, "La musica nella filosofia naturale del Seicento in Italia," *Nuncius. Annali di Storia della Scienza* 1 (1986): 13-47, esp. 31-33.

⁹¹ Christensen, *Rameau*, pp. 209-251.

⁹² Jean Le Rond D'Alembert, *Eléments de musique théorique et pratique suivant les principes de M. Rameau, éclaircis, développés et simplifiés*. Nouvelle édition, revuë, corri-

stroyed: the venerable container of musical science is shattered and the parts of the treatise freed from their container start to live an independent life, generating new musical genres.

The musical treatise is not only theory, it is also the history of music. The "perfect knowledge of Music," Zarlino says, "is acquired from two sources, one of which we will call *Historica* & the other *Methodica*."⁹³ History and method are for Zarlino the sources of musical knowledge. They are not, however, independent genres but a different way of expressing the same principles: indirect and direct, via the comments of the ancients and the path of reason, or method. The distinction has to do with the ordering of materials in musical theory, a science rooted in the past which has always made history: from Boethius, who records the opinions of the Greek theorists, to Gaffurio and Zarlino, who recycle the whole of the tradition that precede them. Zarlino sets out the historical part of musical theory from the very frontispiece of his *Istituzioni harmoniche*: "in which, besides the material belonging to music, are mentioned many places of Poets, Historians & Philosophers, as can clearly be seen in reading them."

The historical part of musical theory found its expression in a centuries-old rhetorical genre, encompassed within the systematic structure of the treatise: the praise of music. The Zarlinian variant of the *encomium musicae* extends from the Proem to the first eleven chapters of the First Part of *Le Istituzioni*, and forges a unitary and coherent theme: the comparison between ancient music and modern music (Proem); the origin of music and the certainty of the discipline (chapter 1); the praise of music through the *exempla* of its fabulous effects (chapter 2); the aim of music (chapter 3); the usefulness of music (chapter 4); the definition of music and its divisions (chapters 5 to 10); the distinction between speculative music and practical music, and between *musicus* and *singer* (chapter 11). *Le Istituzioni harmoniche* then deals with the methodical part of the musical edifice: the remaining chapters of the First Part, 12 to 44, set out the mathematical doctrines on which musical theory bases the manipulation of consonances; Part 2, in 51 chapters, describes the basic musical concepts: sounds, intervals, genres, modes, and so on, and brings to an end the speculative section. The practical section of *Le Istituzioni* also has two parts: Part 3, the 80 chapters on the art of counterpoint, and Part 4, the 36 chapters on the musical modes.

The musical treatise is therefore an articulated organism with multiple functions. It ideally encompasses the whole of the discipline: from the nar-

gée et considérablement augmentée (Lyon: J.-M. Bruyset, 1766); see Thomas Christensen, "Music Theory as Scientific Propaganda: The Case of d'Alembert's *Eléments de Musique*," *Journal of the History of Ideas* 50 (1989): 409-427.

⁹³ Gioseffo Zarlino, *Supplimenti*, p. 10.

ration of its noble past and its present day 'renaissance' to the enunciation of its theoretical principles (*musica speculativa*) to their concrete application to compositional praxis (*musica practica*). It can therefore be read at different levels, by readers and scholars of different cultural extraction: music professionals interested in the solution of the concrete problems of their art, music theoreticians concerned with the systematic nature of musical concepts, mathematicians interested in applying numbers and geometrical figures to sonorous events, natural philosophers looking for the physical causes and psychological effects of sound, grammarians and scholars of rhetoric involved in investigating the rhythm and rhetorical clauses of the musical period.

Of the various divisions of the musical treatise, the historical part is the least specialistic, easily accessible to the reader not directly interested in the systematic sections. It traditionally precedes the other divisions of the treatise, fulfilling the role of musical protreptic, of an introduction exhorting to the study of music; and, given its vocation to communicate, it borrows from epideictic discourse the narrative style and thematic structure that can be easily memorized. The praise of music belongs to the genre of introductions to the liberal arts in Hellenistic and Roman culture inherited by Christian thought.⁹⁴ The Scholastic culture then sorts the *encomium musicae* into the taxonomic divisions responsible for the organization of matters in musical treatise writing. Preceding the modern musical protreptic is the 15th century dispute on the arts which redraws the epideictic parameters for singing the praise of arts in Humanistic civilization. From the 15th century the praise of music suddenly becomes vital: a petrified organism, transmitted without significant variants, is the most widespread and widely read musical genre of the Renaissance. Sensitive to the changes in culture and general public, the *encomium musicae* is a genre practised by humanists and men of letters in the academic prolusions and celebratory descriptions of performances by celebrated artists;⁹⁵ in the general introductions to mathematical writing designed to praise the *mathemata*, which regularly included music;⁹⁶ in the books of Renaissance magic, from Marsilio Ficino to Giovambattista Della Porta, written to point up the pneumatological theories on the power of music and to illustrate the physical

⁹⁴ See James Hutton, "Some English Poems in Praise of Music," *English Miscellany* 2 (1952): 1-63, also printed in James Hutton, *Essays on Renaissance Poetry*, ed. Rita Guerlac (Ithaca and London: Cornell University Press), 1980, pp. 17-73.

⁹⁵ See F. Alberto Gallo, "La musica in alcune prolusioni universitarie bolognesi del XV secolo," in *Sapere e potere*, 2:205-215, and his *Music in the castle: troubadours, books, and orators in Italian courts of the thirteenth, fourteenth, and fifteenth centuries* (Chicago and London: The University of Chicago Press, 1995).

⁹⁶ Gozza, "La musica tra matematica e antica teologia," in *Sapere e potere*.

'effects' of sounds;⁹⁷ in the texts of the encyclopedic tradition, from Angelo Poliziano to Giorgio Valla to the encyclopedism of the 17th century;⁹⁸ and in certain Humanistic-pedagogic literature,⁹⁹ in the writings of the heurmatologists,¹⁰⁰ in Renaissance poetry.¹⁰¹

In time the encomium of music also experiments with its own metamorphosis and dissolution. Its classical topics desert their traditional rhetorical model and are contaminated by other cultural traditions, undermining historical narration and its epistemologic premises and generating new forms and traditions. The most extraordinary example is the topos of the *conditores* of the discipline, the Biblical and Pythagorean legend of the discovery of consonances. Transmitted by Boethius, who borrows it from Nicomachus and Aristides Quintilianus, passed on by later musical treatise writing until Zarlino, the legend had been visually encapsulated in the engraving of the *Theorica musice* by Gaffurio, taking root in the imagination of men of culture up to the 18th century. In the second half of the 18th century the ancient origin of musical theory was set aside and replaced by the modern origin of music, language, projected back into the past of human history by the nascent esthetical paradigm.¹⁰² But already long before its radical metamorphosis, the *encomium* had been reinterpreted by Vincenzo Galilei in the light of experience, "mother of all things." In his 1589 *Discorso* and the *Discorso particolare intorno alla diversità delle forme del diapason*,¹⁰³ Galilei is the first to discredit the mythical *conditores* of music, pointing up the mistake of Pythagoras and cracking one of the pillars of the musical tradition transmitted by the *encomium*: experience shows that the weights of the hammers in Gaffurio's plate are not defined by the relationships between simple whole numbers but by the relationships between numbers inverse to the square.¹⁰⁴ The crisis of the epistemological

⁹⁷ Walker, *Magic*; Gary Tomlinson, *Music in Renaissance Magic. Toward a Historiography of Others* (Chicago and London: The University of Chicago Press, 1993).

⁹⁸ Fiorella Brancacci, "L'enciclopedia umanistica e la musica: il 'Panepistemon' di Angelo Poliziano," in *La musica a Firenze al tempo di Lorenzo il Magnifico*, ed. Piero Gargiulo (Florence: Olschki, 1993), pp. 299-316.

⁹⁹ Palisca, *Humanism*, pp. 14-17, 100-106.

¹⁰⁰ Brian P. Copenhaver, "The Historiography of Discovery in the Renaissance: The Sources and Compositions of Polydore Vergil's 'De Inventoribus Rerum', I-III," *Journal of the Warburg and Courtauld Institutes* 41 (1978): 192-214, pp. 199-201.

¹⁰¹ See Hutton, "English Poems;" John Hollander, *The Untuning of the Sky: Ideas of Music in English Poetry, 1500-1700* (Princeton, NJ: Princeton University Press, 1961); and Ludke Gretchen Finney, *Musical Backgrounds for English Literature: 1580-1650* (Westport, Conn.: Greenwood Press, 1976).

¹⁰² See Downing A. Thomas, *Music and the Origins of Language. Theories from the French Enlightenment* (Cambridge: Cambridge University Press, 1995).

¹⁰³ See Palisca, *Florentine Camerata*, pp. 180-197.

¹⁰⁴ See Claude V. Palisca, "Scientific Empiricism in Musical Thought," in *Seventeenth Century Science and the Arts* (Princeton, NJ: Princeton University Press, 1961), pp. 91-137, also printed in Palisca, *Studies*, pp. 200-235.

archetype of the praise of music thus gives rise to the modern experimental science of sound. Galilei's observation is confirmed by Marin Mersenne who reformulates the law of tensions, or the inverse of the square, in the first acoustic-mathematical law of the vibrating string;¹⁰⁵ Isaac Newton would on the other hand see in the legend of Pythagoras his own law of universal gravitation, deliberately concealed by the ancient sage in the "error" of the legend passed down by Boethius and later tradition.¹⁰⁶

In the course of the 18th century the musical treatise is shattered, and the different parts of the organism engender new forms. Even the topics of the *encomium musicae*, freed of their container, give birth to new genres: for example, the entry "Effets de la musique" in the *Encyclopédie*, drawn up by Rousseau, is based entirely on the *Tentamen de vi soni et musicae in corpus humanum* (1758) by Joseph-Louis Roger, the leading 18th century treatise of *musica iatrica*, a medical specialization of the topos of the extraordinary effects of ancient music.¹⁰⁷ But perhaps the most vivid legacy of the *encomium musicae* is the 18th century development of the historiographical genre: it is no coincidence that the first histories of music occur with the final separation of the two sources of musical knowledge included in the genre of the treatise, *historica* and *methodica*.¹⁰⁸

6 Nature and Art

In their *Mathematical Models of Musical Scales* Mark Lindley and Ronald Turner-Smith ground the theory of mathematical models of musical scales on two premises: first, *conventionalism*, the model should not be confused with the thing represented; second, *historicism*, the model should include pieces of the past: notation, "habits of musical thought," and so

¹⁰⁵ See Sigalia Dostrovsky, "Early Vibration Theory: Physics and Music in the Seventeenth Century," *Archive for History of Exact Sciences* 14 (1975): 185-187, and Peter Dear, *Mersenne and the Learning of the Schools* (Ithaca and London: Cornell University Press, 1988), pp. 158-159.

¹⁰⁶ See Daniel P. Walker, *Studies in Musical Science in the Late Renaissance* (London: The Warburg Institute/University of London, and Leiden: E.J. Brill, 1978), pp. 23-26, and Penelope Gouk, "The Harmonic Roots of Newtonian Science," in *Let Newton Be! A new Perspective on His Life and Works*, ed. John Fauvel, Raymon Flood, Michael Shortland, and Robin Wilson (Oxford: Oxford University Press, 1988), pp. 101-125.

¹⁰⁷ Cp. Joseph-Louis Roger, *Traité des effets de la musique sur le corps humain, traduit du latin et augmenté de notes par Etienne Sainte-Marie* (Paris: Brunot, 1803).

¹⁰⁸ See Warren D. Allen, *Philosophies of Music History. A study of general histories of music* (New York: Dover Publications, 1962), and Philippe Vendrix, *Aux origines d'une discipline historique. La musique et son histoire en France aux XVII et XVIII siècles* (Liège: Bibliothèque de la Faculté de Philosophie et Lettres, 1993).

on.¹⁰⁹ In fact the premise in their Introduction, "that mathematics can be treated as a matter of formal logic not inherently related to anything else," makes it difficult, if not impossible, to understand musical models historically: for example, it makes "it easy to see what is wrong with 'Pythagorean' music theorists: they confuse a mathematical model of a thing with the thing itself."¹¹⁰ According to the Authors, Vincenzo Galilei's experiment of the weights applied to the strings undermined the authority of Pythagoras and destroyed the Pythagorean conception of music as 'sounding number'.¹¹¹ Against the image of Vincenzo Galilei, mentor of Galileo and modern experimental science, the Authors depict the champion of Renaissance Pythagoreanism as an old fashioned 'metaphysicist': "The most eminent 16th century theorist, Gioseffo Zarlino ... adhered to the Pythagorean theory that music is "sounding number," even in the face of Vincenzo [sic] Galilei's neo-Aristoxenian attack."¹¹² If singers without musical accompaniment did not sing just intervals, Zarlino had said, "the sounding number would be completely in vain and superfluous in Nature." "It was a sad day for Pythagoreanism, the Authors comment, when its champion in the field of music theory was reduced to such an a priori argument."¹¹³ The sad day for Pythagoreanism is, in fact, dictated by its original sin: confusing number with reality, the model with the thing represented.

Seeing things in the light of 'conventionalism' versus 'metaphysics' makes it impossible to understand historically the musical controversy between Zarlino and Vincenzo Galilei. The confusion between ideas and reality that Lindley and Turner-Smith accuse Zarlino of is unfair because "splendid Nature" (as he calls it) is for Zarlino the basis of his mathematical model of musical scale, the very possibility of music as science of 'sounding number.' And the criticism of Vincenzo does not have simply epistemological reasons but 'practical' ones too: in his *pars construens* he leans towards a recognition of music as art that Galilei perceives as compromised by the Zarlinian distinction of "natural" and "artificial"—it is better seen as part of the Renaissance debate on the contemplative and the active life rather than the argument between 'constructionists' and 'deconstructionists'.

What do we sing today? Zarlino's and Galilei's question is not naive; it springs from the conviction that music is not the same throughout history, that modern music is different from ancient music. Whence the search for

¹⁰⁹ Mark Lindley and Ronald Turner-Smith, *Mathematical Models of Musical Scales. A New Approach* (Bonn: Verlag für systematische Musikwissenschaft, 1993), p. 12.

¹¹⁰ *Ibid.*, p. 11.

¹¹¹ *Ibid.*

¹¹² *Ibid.*, p. 232.

¹¹³ *Ibid.*, p. 232. On Lindley's and Turner-Smith's a-priori anti-'Pythagoreanism,' see, also, Knobloch, "Harmony and Cosmos," pp. 55-56.

continuity, the desire to find in the culture of the Ancients some of the characters of the music of the Moderns. For some it is trying to find the principles of modern music in ancient science, for others it is trying to reduce "ancient music to modern practice."¹¹⁴ Reducing ancient music to modern practice for Vincenzo Galilei means making modern music by capturing the expressiveness of ancient music, compromised by polyphony. Finding the principles of modern music in the science of the Ancients means for Zarlino deducing the rules of counterpoint from unchangeable mathematical-musical laws. In Galilei and Zarlino two ancient musical myths rediscovered by the Renaissance are at work: in Vincenzo, the humanistic myth of the 'marvellous effects of ancient music'—music to be heard; in Gioseffo, the renaissance myth of 'harmony'—music as perfect, absolute work.

What music do we sing today? Zarlino replies, "making no bones about it (as they say), that we sing [sang] the above-mentioned Natural species, or Ptolemy's Diatonic Syntonon, and not the Ancient Diatonic or other species."¹¹⁵ Galilei concedes to Zarlino that "what we sing today agrees more than any other Distribution with Ptolemy's own Syntonon;"¹¹⁶ the controversial point for Vincenzo is the word "natural" and its opposite "artificial," which Zarlino uses in relation to voices and instruments.¹¹⁷

Nature is the source of Zarlino's musical theory. Zarlino borrows from the Peripatetic tradition the conception of the natural object as *poiesis*, nature as intrinsic principle of things (*natura naturans*). But Zarlino also takes on board another conception of nature, nature as object of the creating power of the divine mind (*natura naturata*): "Nature is the outcome of divine Art imposed on things, whereby they move towards their end."¹¹⁸ In brief, Zarlino superimposes on the Aristotelian concept of *physis* as a poetic system the Platonic-Christian idea of the divine Demiurge, the geometer and architect God who orders natural reality on the basis of intelligible forms.¹¹⁹

The syncretism between Aristotelianism and Christian Platonism explains Zarlino's remark that the music we sing today is "the Natural spe-

¹¹⁴ Nicola Vicentino, *L'Antica musica ridotta alla moderna pratica* (Rome: Antonio Barre, 1555; reprint ed. by Edward E. Lowinsky, Kassel: Bärenreiter, 1959).

¹¹⁵ Zarlino, *Sopplimenti*, p. 9.

¹¹⁶ Vincenzo Galilei, *Discorso intorno all'opere di messer Gioseffo Zarlino da Chioggia, et altri importanti particolari attenenti alla musica* (Florence: Giorgio Marescotti, 1589), pp. 124-125.

¹¹⁷ See Walker, *Studies*, pp. 14-26, and Cohen, *Quantifying Music*, pp. 79-85.

¹¹⁸ Zarlino, *Sopplimenti*, p. 20.

¹¹⁹ See Jürgen Mittelstrass, "Nature and Science in the Renaissance," in *Metaphysics and Philosophy of Science in the Seventeenth and Eighteenth Centuries*. Essays in Honour of Gerd Buchdahl, ed. Roger S. Woolhouse (Dordrecht/Boston/London: Kluwer, 1988), pp. 17-43.

cies or Diatonic Syntonon of Ptolemy." The music that Zarlino has in mind is "vocal and natural melodies," the sacred polyphonies without instrumental accompaniment, called 'a cappella'. This music is "natural" because it is produced by the voice, a living unity of matter and form: the voice as matter of singing intones the "Forms" which "Mother Nature, Instrument of the great God," has placed in our bodies so that the work of Creation is perfect. Every created thing possesses for Zarlino "its Form and its determined Figure" which in sonorous bodies is consonance, form "according to a certain and determined reason or proportion."¹²⁰ The two postulates, that the universal forms of consonance exist in Nature and that "God and Nature never make anything in vain," are to Zarlino the basis of knowledge and science.¹²¹ Ptolemy's 'diatonic syntonon'—i.e. the 'right division of tone'—stands at the end of a complex scientific procedure based on the analogy between sound and extension, the pitch of the sound and the length of the string that generates it: "On a fully taut string, [divided] in two parts, the proportion found between one space and the other is the same as that to be found between one sound and the other."¹²² Matter and form are separated, and sounds lose physical reality to acquire the status of 'sounding numbers': the 'interval' between the string and its half, $2/1$, is the mathematical form of the musical octave interval, the Greek diapason, "Mother and source of all Intervals;"¹²³ from this "Sounding whole divisible in parts" Zarlino mathematically deduces, and verifies through experience, that the "natural forms" of the consonances ordered in the scale of just intonation are defined by ratios between the first six integers, the *senarius*, the perfect number.¹²⁴

The continuity between nature and science paves the way for the continuity between nature and art. The musical universals in nature, exhibited by the *senarius* and ordered in the 'syntonon', are the building-blocks of music, the premises of the practical rules of counterpoint that the theorist offers up to the composer for musical creation. Artistic creation, the *opus perfectum*, is imitation of natural poesis; the art of the divine Demiurge hidden in Nature is the paradigm of human art which assumes Nature as its own ideal norm. Zarlino's reply that the music we sing today is the "natural syntonon" affirms the affinity between Nature and Art, in its double meaning of science (theoretical music) and of composition and song (practical music): the perfection of music as the imitation of the divine creation of the world.

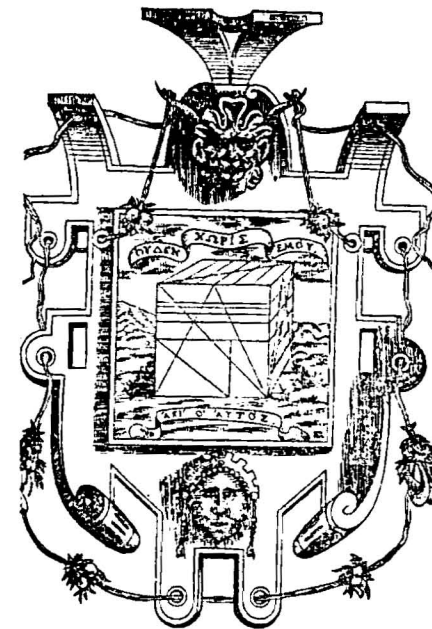
¹²⁰ Zarlino, *Sopplimenti*, p. 88.

¹²¹ *Ibid.*, p. 27.

¹²² Zarlino, *Dimostrazioni*, p. 147.

¹²³ Zarlino, *Sopplimenti*, p. 98.

¹²⁴ *Ibid.*, pp. 27-28.



6. Zarlino's emblem, from Giovanni Maria Artusi, *Impresa del molto R.M. Gioseffo Zarlino* (1604)

Zarlino's firm belief in harmony (Figure 6) is contrasted with the scepticism of Vincenzo Galilei, who upsets Zarlino's ordered synthesis. There is no single part of Zarlino's theoretical edifice that his "loving disciple" does not try to turn upside down. Gioseffo idealizes "stupendous Nature," in which he sees a system of forms that man tries to comprehend by reason and imitate by art; for Vincenzo Nature proceeds "without any cognition,"¹²⁵ and provides no laws or models to follow. Gioseffo believes that music is a science, for Vincenzo science worries pointlessly about numbers and figures to "regulate and proportionate" music which is sung. Zarlino's *senarius* is for Galilei merely one of the many "Zarlinish impertinent innovations,"¹²⁶ and the 'natural syntonon' is neither perfect nor natural: it has dissonant intervals on the various levels of scale, is instable, and, Galilei adds, is a product of art, which does not imitate nature but follows its own designs. For Zarlino the aim of nature and art is the perfect work, for Galilei music is communication ("the aim of Music is that it be heard,")¹²⁷ so that "the rules of the modern contrapuntists observed as inviolable

¹²⁵ Galilei, *Discorso*, p. 94.

¹²⁶ *Ibid.*, p. 98.

¹²⁷ *Ibid.*, pp. 116-117.

laws... will all be directly contrary to perfection."¹²⁸ If at the end of this systematic demolition he is ready to concede "that what we sing today is more fitting to Ptolemy's own Syntonon than to any other Distribution," this does not mean that Galilei is a practical musician without any principles, a 'grandchild of Rameau': if Nature withdraws, the space is filled by Art, and the criterion of perfection gives ground to the demands of communication.

As regards the nature-art relationship, Vincenzo Galilei pays less heed to *physics* and more to the *ps.* Aristotelian *Quaestiones mechanicae*: nature follows the same course without deviating, human art changes constantly—it is projecting and making things that may or may not be, the origin of which lies in the person who actually produces. Nature and art, therefore, have different goals and in the pursuit of their own particular goals art is superior to nature. Characteristic professional pride leads Vincenzo at times to identify nature with matter, to which human art adds form from without: nature gives "the sound both of voices and of strings," art gives "the form of the interval whether consonant or dissonant."¹²⁹ The philosophical premise of this approach is the separation of the theory of the instrument from the theory of nature, of mechanics from *physis*: Galilei contrasts nature, minister of the natural motions of bodies, with mechanical art, the theory of instruments designed by man to pursue an end that is different from nature, or that nature cannot pursue.¹³⁰

The aim of art is expression—"to express with greater efficiency the ideas of the soul"—and communication—"to impress them secondarily with equal force in the minds of mortals."¹³¹ Against Aristotle's *Physics* or *Posterior Analytics* and the *Commentarius* of Proclus in *primum Euclidis Elementorum*, the mathematical texts close to Zarlino, Vincenzo juxtaposes the Eighth Book of *Politics*, the *Poetics*, the *Rhetoric* and the *Problemata*, the Aristotelian texts of the Florentine humanists and of the mentor of the Camerata dei Bardi, Girolamo Mei (1519-1594).¹³² In his letter to Vincenzo of 8 May 1572 Mei takes up the arguments in the *Problemata* on the human voice, distinguished from the voice of animals by "its meaningful speech:" the human voice brings to the animal cry, manifestation of pleasure and pain, articulated sounds capable of express-

¹²⁸ Vincenzo Galilei, *Dialogo della musica antica et della moderna* (Florence: Giorgio Marescotti, 1581; reprint ed. New York: Broude Brothers, 1968), p. 81.

¹²⁹ Galilei, *Discorso*, p. 79.

¹³⁰ *Ibid.*, pp. 73-74.

¹³¹ Vincenzo Galilei, *Dialogo*, p. 81.

¹³² See Claude V. Palisca, *Girolamo Mei (1519-1594): Letters on Ancient and Modern Music to Vincenzo Galilei and Giovanni Bardi*. Musicological Studies and Documents, 3 (Rome: American Institute of Musicology, 1960; 2nd, corrected edition, with Addenda, Rome: American Institute of Musicology, 1977).

ing the soul's motions and impressing them on the listener.¹³³ In his *Dialogo* Galilei takes up Mei's line of thought, and makes of it the premise to his antimodern musical argument in support of the expressiveness of ancient music.¹³⁴ In other words, music in Galilei and in Mei is discourse, no science of the necessary but art of the possible. It is music from the rhetorical and anthropological perspective of communication and fruition, in contrast to music from the perspective of the *opus perfectum et absolutum*.

The debate between Zarlino and Galilei is the turning point of the Renaissance. The 'nature' of Zarlino and the 'technics' of Galilei are the opposites of a synthesis bequeathed to posterity. Reconciling Gioseffo and Vincenzo, harmonizing nature and man, science and art, classical harmony and modern hearing: these are the themes music has to concern itself with in the next decades. How to reconcile arithmetic and poetry, number and word, Pythagoras and Orpheus?—this is Fabio Paolini. How to reconcile celestial and vocal motion, harmony of the spheres and musical composition, tracing *musica mundana, humana et instrumentalis* back to the same archetypes?—this is Kepler. How to reconcile reason and sense, geometry and musical hearing, mental order and sensible pleasure?—this is Descartes. How finally to reconcile Nature and mechanics, mathematical demonstrations and sensate experiences, while turning the sounding number into sound?—this is Galileo.

Paolini's synthesis belongs to the cabalistic, hermetic and neoplatonic tradition of Marsilio Ficino and Francesco Giorgi Veneto,¹³⁵ complicated with Zarlino, Francesco Patrizi and the Humanistic ideal of the expressiveness of music. The cathartic and religious function of music—the 'marvellous effects' of the song of Orpheus—lies for Paolini in the rationale of the number and in the rationale of the word, in arithmetic and rhetoric. As to number, Paolini in his *Hebdomades* draws on the Pythagorean distinction between *numeri numerantes* (ideal) and *numeri numerati* (material): the former archetypes of divine creation, the latter sensible copies in human creation.¹³⁶ As to words, Paolini draws on the syncretism between Plato and Aristotle in the dialogues *Della Poetica* of Francesco Patrizi:¹³⁷ Aristotelian theory of imitation and Platonic doctrine of the divine furor are assimilated in view of the common goal of poetry and music, cathartic and religious. Rhythm is what Paolini bases his arhythmo-poetic musical science on. The concept of rhythm embodies the double status of number,

¹³³ *Ibid.*, pp. 89-117, esp. 113.

¹³⁴ Vincenzo Galilei, *Dialogo*, pp. 79-89, esp. 89.

¹³⁵ See Walker, *Magic*, pp. 126ff., and Cesare Vasoli, *Profezia e ragione. Studi sulla cultura del Cinquecento e del Seicento* (Naples: Morano, 1974), pp. 129-403.

¹³⁶ Paolini, *Hebdomades*, pp. 231-237.

¹³⁷ Francesco Patrizi, *Della Poetica* (Ferrara: V. Baldini, 1586), ed. Daniello Aguzzi Barbagli, 3 vols. (Florence: Istituto Nazionale di Studi sul Rinascimento, 1969-1971); see Palisca, *Humanism*, pp. 402-405.

ideal and material. Ideal rhythm is the vocal kind, found in the metre of poetical verse, ideal because it is vehicle of rational meaning. Material rhythm on the other hand is instrumental, intrinsic to music without poetry, material because it does not transmit rational meanings. Between Aristotle and Plato, Paolini places Saint Augustine's *De musica* revisited by Salinas. Placing music in an intermediate position between mathematics and poetry-rhetoric finds a parallel in the idea of musical composition laid out in the *Hebdomades*, the monodic song accompanied by simple instrumental harmonies: a model similar to that of the Camerata Fiorentina and the Académie de poésie et de musique of Jacques Mauduit and Antoine Baif.¹³⁸

The sophisticated synthesis of Fabio Paolini is 'the swansong' of the Florentine and Venetian, Italian musical Renaissance. Paolini's ideal numbers still live in the motionless and archaic cosmos of Robert Fludd, at a time when the struggle among the symbols of the divine has already given way to geometrical images, closer to God and the moving, musical cosmos of modern astronomy.

Reconceiving Music

7 Harmony

If there were stillness and no movement, there would be silence; and if there were silence and if nothing moved, nothing would be heard. Then if anything is going to be heard, impact and movement must first occur.¹³⁹

The incipit of the Preface to Euclid's *Sectio canonis* identifies sound and motion: a motionless cosmos is a silent cosmos, where nothing is heard, a moving cosmos is a sounding cosmos, alive. To the spatialized sound of Pythagorean cosmology, metaphor for a world at rest, the Euclidean text contrasts temporalized sound, a metaphor for a world in motion animated by sonorous events.¹⁴⁰ The identification of sound and motion in an ancient writing on music rediscovered in the Renaissance¹⁴¹ and attributed to

¹³⁸ Paolini, *Hebdomades*, pp. 149-164; see Daniel P. Walker and François Lesure, "Claude Le Jeune and 'musique mesurée'," *Musica Disciplina* 3 (1949): 151-170.

¹³⁹ "The Euclidean *Sectio Canonis*," in *Greek Musical Writings II. Harmonic and Acoustic Theory*, ed. Andrew Barker, (Cambridge: Cambridge University Press, 1989), p. 191.

¹⁴⁰ See Alan C. Bowen, "Euclid's *Sectio Canonis* and the History of Pythagoreanism," in *Science and Philosophy in Classical Greece*, ed. Alan C. Bowen (New York and London: Garland Publishing, 1991), pp. 164-187.

¹⁴¹ The *Sectio canonis* was first translated into Latin by Giorgio Valla (Venice: Simone Bevilacqua, 1497), then by Johannes Pena (Paris: Andreas Wechel, 1557) and Conradus

Euclid helped determine a new disciplinary statute to musical science. The object of music was still quantity it had in common with the other mathematical disciplines: besides music, arithmetic, geometry and astronomy. But the quantity music dealt with was continuous quantity, not discrete quantity of the traditional quadrivial system. Continuous quantity refers to the geometric magnitudes generated, as indicated by the term 'continuous', by motion: ideal motion of the point on the plane (geometry), material motion both of celestial bodies in cosmic space (astronomy) and of sounds in musical space (music). Discrete quantity refers on the other hand to arithmetical magnitudes, numbers (arithmetic). The analogy between sound and motion took music away from arithmetic, to which it was subordinate, and moved it nearer to astronomy, sister discipline of music since Plato's *Republic*. This repositioning of music determined the new alliance between 'polyphonic revolution' and 'astronomic revolution', both of which from Copernicus to Newton took place under the guise of a reformed Pythagoreanism.

In music the 'reformed Pythagoreanism' was the Zarlilian *senarius*. When in 1540 the natural philosophical community was informed of the Copernican undertaking by Rheticus's celebrated *Narratio prima* (1540), the clear reference to the ancient heliocentric hypothesis attributed to the Pythagoreans was flanked by geometrical, musical and numerological analogies which conferred on the cosmos of Copernicus a harmony that was missing in the ancient astronomers.¹⁴² In calculating the harmony of planetary movements, Rheticus writes, the ancient astronomers should have imitated musicians when they tune their instruments to obtain a perfectly consonant harmony; with Copernicus planetary motion conforms, on the other hand, to a mathematical principle regulated by the arrangement of the planets and their yearly orbits around the Sun, in the same way that the sounds of different musical strings conform to that of a single tuned string.¹⁴³ The Philolaic-Copernican cosmos is in Rheticus' text a dynamic musical cosmos, animated by the Sun, "both choral dancer and choral leader," the heliocentric variant of the Plotinian picture of the cosmos as dancer, taken up by Ficino.¹⁴⁴ And with regard to the number and arrangement of celestial bodies, "who could have chosen a more suitable and more appropriate number than six? By what number could anyone more

Dasypodius (Strausburg: Christian Mylius, 1570); see Gallo, "Die Kenntnis," pp. 16-17, and Palisca, *Humanism*, pp. 67ff.

¹⁴² Georg Jachim Rheticus, "De libris revolutionum Nicolai Copernici *Narratio prima*," in *Three Copernican Treatises: The Commentariolus of Copernicus, the Letter against Werner, the Narratio prima of Rheticus*, translated with introduction and notes by Edward Rosen (New York: Columbia University Press, 1939).

¹⁴³ *Ibid.*, pp. 138-139.

¹⁴⁴ Marsilio Ficino, *Opera, & quae hactenus extitit, & quae in lucem nunc primum prodire omnia*, 2 vols. (Basle: ex off. Henricpetrina, 1576), 2:1746.

easily have persuaded mankind that the whole universe was divided into spheres by God the Author and Creator of the world?... Moreover, the celestial harmony is achieved by the six afore-mentioned movable spheres. For they are all so arranged that no immense interval is left between one and another; and each, geometrically defined, so maintains its position that if you should try to move any one at all from its place, you would thereby disrupt the entire system."¹⁴⁵ When in the Preface to his *De revolutionibus orbium coelestium* (1543), Copernicus reproached astronomers with having lost sight of "the main thing, the shape of the world and the symmetry of its parts," he could not better indicate the theme of the harmony of a universe created by 'God the perfect geometrician' of the Pythagorean and Platonic musical tradition. Chapter 10 of *De revolutionibus*, "The order of the heavenly spheres," underlines the superior perfection of the new astronomical system, the only one able to achieve the true harmony of the world that God the geometrician had created with "admirable symmetry" of the parts and "the precise harmonic relation between motion and size of the spheres."¹⁴⁶

Unlike Copernicus, Johannes Kepler did not limit himself to showing the order and symmetry of the solar system, he wanted to discover the archetypal laws that govern it. These laws are mathematical, more precisely geometrical. Geometrical truths are co-eternal with God and exist as copies in physical reality where the human mind, an image of the Creator, recognizes them.¹⁴⁷ The primacy of geometry is in step with the demolition of the 'sounding number' argued by Kepler. Rheticus is wrong when in his *Narratio prima* he deduces the number of the six moving skies from the sacrality of the *senarius*: according to Kepler, whoever talks of cosmology should not base his reasoning on numbers, which "have obtained dignity from things that came after the Creation."¹⁴⁸ In astronomy Kepler tries to determine the number and the distances of the planets from the five regular polyhedra of the Platonic tradition; in music Kepler traces the origin of consonances to the regular polygons inscribed in the circle. The key to understanding the primacy of geometry in Kepler is the *Commentarii* to

¹⁴⁵ R thicus, "Narratio prima," pp. 144-147.

¹⁴⁶ Nicholas Copernicus, *On the Revolutions*, edited by Jerzy Dobrzycki, translation and commentary by Edward Rosen (London: The Macmillan Press, and Cracow: Polish Scientific Publishers, 1978), pp. 18-22, esp. 22; see Robert S. Westman, "Proof, Poetics, and Patronage: Copernicus' Preface to *De revolutionibus*," in *Reappraisals of the Scientific Revolution*, ed. David C. Lindberg and Robert S. Westman (Cambridge: Cambridge University Press, 1990), pp. 168-205.

¹⁴⁷ See Walker, *Studies*, pp. 34-62.

¹⁴⁸ Johannes Kepler, *Mysterium Cosmographicum, editio altera* (1619), in Johannes Kepler, *Gesammelte Werke*, ed. Max Caspar et al. (Munich: C.H. Beckische Verlag, 1938-), 8:24.

Euclid by Proclus.¹⁴⁹ Proclus identifies perfect geometrical images with divine archetypes and with the mathematical nature of the *anima mundi*, and in Book 4 of his *Harmonice mundi* Kepler cites Proclus, translating word for word the long passage on the cosmogonic myth of Plato's *Ti-maeus*, the other source of Kepler's cosmology.¹⁵⁰

Of the five *Harmonices mundi* Books, the third on harmonics occupies the central position, between the two geometrical Books and the two natural ones. (Figure 7) The original scheme foresaw a different lay-out. Once the consonances ("harmonicas rationes") had been deduced from the regular polygons inscribed into the circle, it was a question of introducing them into the world in the other three books, the first of which attributed harmonics to God the Creator of the heavens, the second to Nature, the minister of motion, and the third to Man, maker of the voice generated by motion: "Harmonicas rationes hactenus descriptas in Mundum introduceremus tribus libris alijs, quorum primus Deo coelorum Conditori, secundus Naturae motuum variorum administratae, tertius Homini, vocis, quae ex motu gignitur, compoti, tribueret Harmonias."¹⁵¹ Kepler not only inverts the order, "initio ab humano cantu facto, transituri inde ad Naturae opera, et sic demum ad Opus Creationis" ("we started from the songs of man, we will then pass on to the works of Nature, and finally to the Work of Creation;") he also, as early as in the Third Book, conjugates the archetypes of consonance with the concrete harmonies of singing: "sed etiam finem speculationis abstractae cum principio concretarum Harmoniarum in Cantu, coniungeremus eodem libro tertio."¹⁵² Book 3 on harmonics is therefore a musical treatise modelled on the *dispositio* of Renaissance musical treatises: to the theoretical part, *musica speculativa*, on the deduction of consonances from the regular polygons inscribed in a circle, Kepler adds a practical part, *musica activa*, devoted to song. Kepler places music at the centre of the book that God has waited six thousand years for: the music of man stands at the threshold to the world, the motions of the human voice are the *introitus* to the sonorities of heavenly motion, to the *musica intelligibilis* centred around the "Sol auditor et choragus." How can we explain the extraordinary position of music in Kepler's cosmology?

¹⁴⁹ Francesco Barozzi, *Procli Diadochi... in primum Euclidis Elementorum librum Commentariorum ad universam mathematicam disciplinam tradentium libri IIII* (Padua: exc. Gratiolus Perchacinus, 1560); see Proclus, *A Commentary on the First Book of Euclid's Element*, translated with Introduction and Notes by Glenn R. Morrow (Princeton, NJ: Princeton University Press, 1970).

¹⁵⁰ Johannes Kepler, *Harmonice mundi*, in Kepler, *Werke*, 6:218-221; see Proclus, *Commentary*, pp. 10-15.

¹⁵¹ *Ibid.*, 6:93.

¹⁵² *Ibid.*

Ioannis Keppleri HARMONICES M V N D I

LIBRI V. QVORVM

Primus GEOMETRICVS, De Figurarum Regularium, quæ Proportionibus Harmonicas constituunt, ortu & demonstrationibus.

Secundus ARCHITECTONICVS, seu ex GEOMETRIA FIGVRATA, De Figurarum Regularium Congruentia in plano vel solido:

Tertius propriè HARMONICVS, De Proportionum Harmonicarum ortu ex Figuris; deque Naturâ & Differentiis rerum ad cantum pertinentium, contra Veteres:

Quartus METAPHYSICVS, PSYCHOLOGICVS & ASTROLOGICVS, De Harmoniarum mentali Essentiâ earumque generibus in Mundo; præsertim de Harmonia radiorum, ex corporibus cœlestibus in Terram descendentibus, eiusque effectus in Natura seu Anima sublunari & Humana:

Quintus ASTRONOMICVS & METAPHYSICVS, De Harmoniis absolutissimis motuum cœlestium, ortuque Eccentricitatum ex proportionibus Harmonicis.

Appendix habet comparationem huius Operis cum Harmonicis Cl. Ptolemæi libro III. cumque Roberti de Fluctibus, dicti Flud. Medici Oxoniensis speculationibus Harmonicis, operi de Macrocosmo & Microcosmo insertis.



Cum S. C. M^{te}. Privilegio ad annos XV.

Lincii Austriæ,
Sumptibus GODOFREDI TAMPACHI Bibl. Francof.
Excudebat IOANNES PLANCVS.

ANNO M. DC. XIX.

7. Title page of Johannes Kepler's *Harmonices mundi libri V* (1619)

How does music mediate geometry and the world? The theme running through the *Harmonice mundi* is harmony, the passage from static geometrical archetypes to harmonic proportions, the so-called 'laws of motion': "à un monde en repos," as Koyré says, it contrasts a world in motion, animated and harmonic. Kepler perceives musical sounds not as numbers, simple collections of individuals, but as highly organized movements of voices through time, carried out by a musical practice that is the extraordinary revolution of the Moderns, a prelude to the astronomic discoveries themselves. In his *Harmonices mundi libri V* Kepler finds the perfect consonances in the properties of geometrical figures: the circle and the line (*musica theorica*: Book 3, chapters 1 to 5;) he then discovers these archetypal harmonies in the motions of voices (*musica practica*, "Hominis seu Artis opus:" Book 3, chapters 6 to 16,) in the motions of nature (*musica astrologica*, "Naturæ opus:" astrological Book 4) and in planetary motion (*musica mundana*, "opus denique Dei Creatoris:" astronomic Book 5.) It is the variant of the tripartite harmony of the Pythagorean and Boethian musical tradition: a science which contaminates geometry, music and astronomy along the lines of the cosmogonic tradition of Plato's *Timæus* and his Neoplatonic commentaries, and which Kepler calls "mathesis physica"¹⁵³—an expression also used by Isaac Beeckman to define a context characterized by scientific-musical interests common to the young Descartes, and that Mersenne relates to his own mechanical musical science within the framework of Augustinian *harmonie universelle*.¹⁵⁴

The concept of harmony as measure of the motion of voices through time, effected by polyphony, offers a glimpse of the "terms," not visible at the time of the *Mysterium Cosmographicum*, of the harmonic proportions of celestial movements:

if therefore we are looking for Harmonies, let us look for them not in these intervals, as semidiameters of Orbits, but in those intervals, as measurements of motion, *i.e.* in the movements themselves.¹⁵⁵

Modern harmony stands thus as "the genuine archetype of cosmic work." In his attempt to reach the place where the secret harmony of the world has been hidden away for thousands of years, Kepler invites musicians to rise with him. It is through the ears of modern musicians that Nature manifested itself, just as it is, to the Mind of man:

¹⁵³ Ibid., p. 100: "... Mathematices Physicesque partem (sc. musicam)..."

¹⁵⁴ See Dear, *Mersenne*, pp. 76-77, 168-169.

¹⁵⁵ Kepler, *Harmonice mundi*, in *Werke*, 6:310: "Ergò si quaerimus Harmonias, quaeramus eas non in his intervallis, ut sunt semidiametri Orbium; sed in illis, ut sunt mensurae motuum, hoc est, in ipsis potiùs motibus."

Follow me, modern musicians, and express your opinion on this matter by means of your arts, unknown to antiquity; Nature, always generous with her gifts, has at last, having carried you two thousand years in her womb, brought you forth in these last two centuries, you, the first true likenesses of the universe; by your symphonies of various voices, and whispering through your ears, she has revealed her very self, as she exists in her deepest recesses, to the Mind of man, the most beloved daughter of God the Creator.¹⁵⁶

The relationship between geometric symbols and musical and astro-nomic reality places Kepler's *Harmonice mundi* in an original position in the centuries-old *musica mundana*, as witness the controversy which on the publication of his book pitted Kepler against Robert Fludd (1547-1637). In the Appendix to Book 5 Kepler discussed the first two parts of the *Utriusque cosmi... historia* (1617-1618) by Robert Fludd. Fludd was interested in the analogy between macrocosm and microcosm, between man and the world, a relationship he examined through musical analogy: the cosmos is a musical instrument, a monochord extending from the highest to the lowest level of creation, from the angelic choirs to the dumb earth. (Figure 2)

The monochord ranges the extension of two octaves, on which the three worlds—elemental, ethereal and angelical—are hierarchically placed. On high the hand of God tunes this *fides mundana* (string of the world). The string of the instrument is divided into 15 musical notes, from bottom G to to middle G, on the sphere of the Sun, to upper G, and includes two octaves (*disdiapason*): material octave, from the Earth to the Sun, and formal octave, from the Sun to the top of the *monochordum mundi*, consisting in form without matter. The two octaves are divided into Pythagorean intervals: fifth (*diapente*) and fourth (*diatessaron*), expressed on the left side by the ratios $3/2$ (*proportio sesquialtera*) and $4/3$ (*proportio sesquitercia*). The material fourth consists in four elements, earth, water, air and fire, and its reflected image is the formal fourth, comprising the angelic region, from the sphere of the fixed stars to the last of the three angelic orders. The region from the fixed stars to the sphere of the Sun coincides with the extension of a formal fifth, symmetrical to the material fifth, the distance of the Sun from the Moon (note the error in the figure: the arc of the *diapente materialis* and the corresponding one of the *proportio sesquialtera* should

¹⁵⁶ Kepler, *Werke*, 6:323 (trans. Walker, *Studies*, p. 39:): "Sequimini Musici moderni, remque vestris artibus, antiquitatis non cognitis, censete: vos his saeculis ultimis, prima universitatis exempla genuina, bis millium annorum incubatu, tandem produxit sui numquam non prodiga Natura: vestris illa vocum variarum concentibus, perque vestras aures, sese ipsam, qualis existat penitissimo sinu, Menti humanae, Dei Creatoris filiae dilectissimae insussurravit."

end in C). The symmetry of the diagram of the world is perfect.¹⁵⁷

Kepler does not comment on Fludd's system, he criticizes him for basing harmony on abstract numbers (*numeri numerantes*).¹⁵⁸ For Kepler numbers have no demonstrative force; they derive from measurement (*numeri numerati*), hence presuppose homogeneous objects, having the same unit of measure. Fludd's harmonies are based on the numerical similarity of incommensurable objects, such as musical intervals and the regions of the cosmos; Kepler's on the other hand are derived from the ratios between the minimum and maximum angular velocities of the planets seen from the Sun. Fludd defends the idea of numerical symbols: without the mystery of occult abstract numbers it is not possible to grasp the intimate nature of things, or the relationship between natural and supernatural things. In brief, a Platonic God intent on geometrizing is the basis for Kepler's and Fludd's cosmology. The difference lies in the fact that Kepler's analogies are ratios between homogeneous quantities that correspond to measurable properties of the physical universe, while those of Fludd are numerical analogies between non homogeneous quantities, outside observed reality. Alongside this basic divergence, there are other substantial differences between the celestial harmonies of Fludd and Kepler. Fludd's harmonies are based on the scales in the traditional Pythagorean-Boethian system of intonation, and presuppose the centrality of the Earth. Kepler's celestial harmonies, on the other hand, are polyphonic, hence in just intonation, as they accept thirds and sixths, and are centered on the Sun.¹⁵⁹ The polyphonic revolution thus came to shape both *musica mundana* and modern astronomy, culmination of the centuries-old relationship between the two "sister disciplines" of Plato's *Republic*.

The 'Pythagorean' or 'Platonic' dream of the protagonists in the 'astro-nomic revolution,' from Copernicus to Kepler to Galileo, was eventually fulfilled by Isaac Newton (1642-1727). Book 3 of his *Philosophiae naturalis principia mathematica* (1687), "De Mundi Systemate," distills in one simple mathematical law, the law of universal gravitation, all previous astronomical observations. After expounding Kepler's three laws, Newton reinterprets them dynamically in the light of the law of universal gravitation. In the subsequent propositions, 4 to 9, the inverse square law is gradually extended to cover all bodies of the solar system and the physical universe. Newton then backs up the propositions 6 to 9, which expound the core of

¹⁵⁷ See Peter Amman, "The Musical Theory and Philosophy of Robert Fludd," *Journal of the Warburg and Courtauld Institutes* 30 (1967): 198-227.

¹⁵⁸ Kepler, *Werke*, 6:374-375; see Judith V. Field, "Kepler's rejection of numerology," in *Occult and Scientific Mentalities in the Renaissance*, ed. Brian Vickers (Cambridge: Cambridge University Press, 1984), pp. 273-296. See, also, Robert S. Westman, "Nature, art, and psyche: Jung, Pauli, and the Kepler-Fludd polemic," in *Occult and Scientific Mentalities*, pp. 177-229.

¹⁵⁹ See Walker, *Studies*, p. 34.

gravitational theory, with numerous proofs from the ancient philosophers.¹⁶⁰ If Copernicus, Kepler and Galilei had sought in the wisdom of the Ancients the sign of a venerable astronomic, harmonic and heliocentric truth to contrast the geostatic model of Aristotle and Ptolemy, Newton now incorporates the proofs of the Ancients in his own mathematical astronomy. And just as Copernicus and the 'Copernicans' had often understood progress in astronomy as a regression towards propositions intuited by the Ancients, so Newton now considers his own heliocentric and vacuist system as an experimental and mathematical retrieval of an ancient truth till then hidden. In the Scholium to Proposition 8, on the law of the inverse of squares, Newton 'reads' in the ancient Pythagorean concept of the harmony of spheres his own theory of universal gravitation expressed in symbolic form.¹⁶¹ By comparing the weights that stretch the strings with the weights (mass) of the planets, and the lengths of the strings with the distances of the planets (*musica mundana*), Pythagoras discovered that the masses of the planets towards the Sun are like the squares of their distances. Pythagoras then obfuscated the law of the cosmos by expressing the musical ratios with simple numbers, something which gives a correct result for the length of the strings but not for the weights. The fables of Apollo, Pan and Orpheus, and the legend of Pythagoras weighing the hammers, provided the key to interpreting authentic celestial harmony which only the initiated like Newton were able to penetrate.

The interpretation of the harmony of spheres is the apex of the theoretical-musical learning that Newton had already applied both to optics and the theory of colours and to his historical and theological studies.¹⁶² Newton's considerations in the last two Scholia of Book 3 of the *Principia* on the writings of Macrobius and the Orphic fragments point to the close tie between the musical ratios underlying the inverse square law and the Newtonian image of God: a God highly expert in mechanics and geometry, along the lines of the Pythagorean-Platonic tradition of "God who eternally geometrizes."

8 Hearing

The object of music is sound, its purpose to give pleasure and arouse in us various

¹⁶⁰ See Paolo Casini, "Newton: The Classical Scholia," *History of Science* 22 (1984): 1-58.

¹⁶¹ Ibid., pp. 24-38; see, also, James Edward McGuire and Piyo Rattansi, "Newton and the 'Pipes of Pan'," *Notes and Records of the Royal Society of London* 21 (1966): 108-143.

¹⁶² Penelope Gouk, "The Harmonic Roots of Newtonian Science," in *Let Newton Be!*, pp. 101-125.

passions.¹⁶³

The incipit to the *Compendium musicae* (first draft 1618 / first ed. 1650) (Figure 8) by René Descartes (1596-1650) sets music, in true Aristotelian fashion, among the objects of hearing: sound, the object of musical theory, encounters the listener who draws pleasure and passions from the music. Pleasure and passions are possible provided the sound is musical—in terms of the Pythagorean paradigm taken up by Descartes, the sound must have a mathematical structure purified by occult timbre qualities that cannot be quantified:

In view of the aim [*i.e.*, to give pleasure and arouse various passions] the means of music are basically two properties of sound: the ratios of duration or tempo, and of pitch in relation to acuteness and loudness. Let the natural philosophers study the quality of sound, *i.e.* from which body sound is produced and under which conditions it may be most pleasing.¹⁶⁴

In the light of these premises Heinrich Bessler's comment, "that in the history of musical theory Descartes is the first to move not directly from the music but from the listener," is only partially true.¹⁶⁵ The Zarlirian paradigm in the *Compendium musicae* structures hearing as a perception of the mathematical ratios immanent to music; only later, in the mature Descartes, does Cartesian hearing free itself from the mathematical ontology of musical theory, and become 'modern'. The two Descartes *vis-a-vis*, the young mathematician of the *Compendium* and the mature philosopher of the *Traité de l'homme* and the *Passions de l'âme*, define a context for musical hearing in the early 17th century that stretches from the 'aesthetic' to the 'pathetic', from pleasure through perceiving ratios to moving the passions of the soul. The context is the *musica humana* of Boethius, the mind-body relationship as conceptual structure of the emotional power of music: a metaphysical rather than rhetorical context, a long way from the *Affektenlehre* which dominates musical historiography.

¹⁶³ René Descartes, *Musicae Compendium* (Utrecht: typis Gisberti à Zjil & Theodori ab Ackersdijck, 1650), in René Descartes, *Oeuvres*, ed. Charles Adam and Paul Tannery. Nouvelle Présentation, 13 vols. (Paris: J. Vrin/CNRS, 1964-1974), 10:89 1-5: "Huius [sc. musicae] obiectum est sonus. Finis, vt delectet, variosque in nobis moveat affectus."

¹⁶⁴ Ibid., 9-13: "Media ad finem, vel soni affectiones duae sunt praecipuae: nempe huius differentiae, in ratione durationis vel temporis, & in ratione intensionis circa acutum aut grave. Nam de ipsius soni qualitate, ex quo corpore & quo pacto gratior exeat, agant Physici."

¹⁶⁵ Heinrich Bessler, *Das musikalische Hören der Neuzeit* (Berlin: Akademie-Verlag, 1959), p. 30.

RENATI
DESCARTES
MUSICÆ
COMPENDIUM.



AMSTELÆDAMI,
Ex Typographia BLAVIANA, MDC LXXXIII.
Sumptibus Societatis.

8. Title page of René Descartes's *Compendium musicae* (1683)

The "premises" (*praenotanda*) of the *Compendium*, the first of which "All senses are capable of some pleasure" represents, according to Besseler, "the new point of view of pleasure present in the soul,"¹⁶⁶ show how the origin of Cartesian pleasure is in fact the Aristotelian doctrine of the affinity between sense and the object of sense with proportion: if sound, the object of hearing, is a consonance and hence a proportion, the

¹⁶⁶ Ibid.

sense of hearing too must be a proportion.¹⁶⁷ That hearing is inscribed in the mathematical-musical, Zarlinian, paradigm can equally be deduced from what is 'missing' in the *Compendium*. Descartes does not say how sound is propagated and how it is perceived by the ear; he does not describe the physiology of hearing, hence the Cartesian ear is mental, not physical; furthermore, the model of auditory perception is not so much hearing as vision, and the geometric examples Descartes sets forth in his *praenotanda* are visual not auditory.¹⁶⁸ Since the *Compendium* does not address the physics of sound and the physiology of hearing, the passions of the soul—the other end of music besides pleasure—are also lacking. In all of this the young Descartes displays a scant propensity towards the Aristotelian themes of auditory perception. For Aristotle, hearing is essentially activity, the sound is transported by the movement of air and the ear is a box full of air—undispersed air, because it is enclosed and its reception of sounds is accurate.¹⁶⁹ In Descartes' *Compendium musicae*, however, there is number not sound, and the aesthetic pleasure of the *sounding numbers* sidelines the pathetic effect, limited to the brief mention of the traditional analogies major mode-glad and minor mode-sad, quick rhythms=vital passions (joy, and so on) and slow rhythms=restless passions (languor, sadness, fear, pride...)¹⁷⁰ The incipit to the *Compendium* "the aim of music is to give pleasure and arouse various passions" finds then only half an answer—*ut delectet*, to give pleasure. We have to take seriously the passage in the *Compendium* where Descartes claims that a close examination of the music-passions relationship depends on a good understanding of the motions of the soul, "de quibus nihil plura," "on which [I will say] no more."¹⁷¹

After the *Compendium* comes the discovery of the body, and the discovery of reality determines dualism and conflict. Dualism means that mind and body are different worlds—that there is no similarity between the vibrations of the sounding bodies outside of us and the motions of the soul inside us which we call passions. Nonetheless, *la maladie de l'âme* is the symptom of its bodily tie, and the passions bear witness to this bond between the mind and its body which only death can undo.

In the *Traité de l'homme* (first draft 1632, first Latin ed. 1662) dualism is the diversity between sonorous sensation and its representation. The mechanistic physiology of the treatise describes the material process through which the vibrations of the air become sounds in the soul. The fi-

¹⁶⁷ Aristotle, *De anima*, III, 2, 426a 28 - 426b 8.

¹⁶⁸ See my "Descartes" in this Collection.

¹⁶⁹ See Alan Towey, "Aristotle and Alexander on Hearing and Instantaneous Change: A Dilemma in Aristotle's Account of Hearing," in *The Second Sense*, pp. 7-18, esp. 16.

¹⁷⁰ Descartes, *Oeuvres*, 10:95 10-15.

¹⁷¹ Ibid., 22-23.

bres that make up the nerves are attached at the periphery to the senses and at the center to a carillon—the brain where the soul is housed. The fibres of the acoustic nerve in the internal cavity of the ear can be easily stimulated by air vibrations from outside which strike the ear drum. Via the nerves the vibrations reach the carillon and stimulate the brain, a soft and elastic matter which predisposes the mind to the idea of sound. The idea conceived in the mind is different from the bodily sensation: the latter is a particular motion of the spirits in certain parts of the brain, the former is a geometrical image similar to those in the *Compendium* on the calculus of consonances.¹⁷² There are as yet still no passions, no conflict. The sonorous vibrations travel straight to the brain without passing through the heart, and the furnace of the machine is not led to overheat the blood producing large quantities of vapours which in the cerebral cavity act on the soul, eliciting passions. If hearing is to be 'pathetic' the brain is not enough, the heart is also needed—the nervous function must be merged with the vital function, by the animal heat generated by the motion of blood. At the apex of this machine, the soul thus endures the action of bodies through the organ which binds it to the body, through the gland suspended in the brain cavity which, like a bell, is sensitive to the slightest tremor of the spirits and receives contrary impulses.¹⁷³ Precisely

...it is only in the repugnance which exists between the movements which the body by its animal spirits, and the soul by its will, tend to excite in the gland at the same time, that all the strife which we are in the habit of conceiving to exist between the inferior part of the soul, which we call the sensuous, and the superior which is rational, or as we may say, between the natural appetites and the will, consists.¹⁷⁴

Here then is the fiat of the passions, of the conflicts mankind imagines between the superior and inferior parts of the soul—different pressures, contrary motions of the gland excited at one and the same time by the will and by animal spirits: by the spirits that pull on the gland, tilting the soul to one side, by the soul, that tilts the movement of the gland in the opposite direction.

¹⁷² Descartes, *Traité de l'homme*, in *Oeuvres*, 11:150; see Kassler, *Inner Music*, pp. 43-48.

¹⁷³ Descartes, *Passions de l'âme*, in *Oeuvres*, 11:337 (art. 12.)

¹⁷⁴ Ibid., art. 47, p. 364: "...en la repugnance, qui est entre les mouvements que le corps par ses esprits, & l'âme par sa volonté, tendent à exciter en mesme temps dans la glande, [que] consistent tous les combats qu'on a coustume d'imaginer entre la partie inferieure de l'âme, qu'on nomme sensitive, & la superieure qui est raisonnable, ou bien entre les appetites naturels & la volonté." See Descartes, *The Philosophical Works*, trans. Elizabeth S. Haldane and G.R.T. Ross, 2 vols. (Cambridge: Cambridge University Press, 1979), 1:352-353.

Between the *Traité de l'homme* and the *Passions de l'âme* (first draft 1645-46) comes the episode of "le petit combat harmonique" thought up by Mersenne.¹⁷⁵ Descartes' contribution to the debate—two letters: one, brief, of December 1640;¹⁷⁶ the other, longer, of uncertain date¹⁷⁷—does not seek to demonstrate scientifically the music-passions relationship, as Bannius (Joan Albert Ban: 1597-1644) believes, anticipating the dogmatics of the *Affektenlehre*. Descartes does not describe music as the decalogue of rules that are sure to musically stir up the passions: he comments on the composition of a French 17th century maestro, Antoine Boesset. Descartes illustrates to Bannius the pertinence of Boesset's compositional choices which enhance the affective content of the literary places set to music. In his account there is no room for the two quantifiable parameters of sound, tempo and pitch, that the *Compendium* had identified as the cause of pleasure-giving; the word holds a prominent position, and with the word the accents emerge, the centrality of which Descartes, following Mersenne, now underlines in the expression of the different passions.¹⁷⁸ In praising the harmony of Boesset's composition Descartes is praising modern polyphonic music, better able than ancient music to represent the different passions of the soul through the composite texture of the voices. In many-voiced compositions, writes Descartes, one is seeking

the expression of different passions that the words themselves can stir up in different listeners, and also the pleasure of variety.¹⁷⁹

Conflict finds here its representation: the 'aesthetic' is born of the 'pathetic', the pleasure of variety out of the variety of the passions that the various voices move in the different listeners, each with their own history. In the *Compendium* Descartes had written that sad or joyful melodies provide equal pleasure, arguing that the more the elegiac and tragic move us, the more pleasing they are. In the *Passions de l'âme* he once more takes up

¹⁷⁵ Marin Mersenne, *Correspondance*, ed. Paul Tannery et alii, 17 vols. (Paris: CNRS, 1933-1988), 9:450. See Daniel P. Walker, "Mersenne's Musical Competition of 1640 and Joan Albert Ban," in Walker, *Studies*, pp. 81-110.

¹⁷⁶ Mersenne, *Correspondance*, 10:325-326; Descartes, *Oeuvres*, 3:255.

¹⁷⁷ See Frédéric de Buzon, "L'esthétique de Descartes dans la correspondance: à propos de la Lettre à Bannius," an unpublished paper that I owe to Prof. De Buzon's kindness. De Buzon convincingly argues for postponing Descartes' letter to Bannius ("ma lettre musical") to 1646 instead of 1640, as hastily stated by the Editors of Descartes' *Correspondance*, Charles Adam and Gérard Milhaud, 8 vols. (Paris: Presses Universitaires de France, 1947; reprint ed., Nendeln/Liechtenstein: Kraus Reprint, 1970), 4:226-236.

¹⁷⁸ De Buzon, "L'esthétique de Descartes."

¹⁷⁹ Descartes, *Oeuvres*, 3:832-833: "[...] aliud quaeri ex concentu quàm facilitatem perceptionis verborum;] nempe quaeritur expressio diversorum affectuum qui ab iisdem verbis in diversis hominibus possunt excitari, simulque ex varietate delectatio." See Walker, "Mersenne's Musical Competition," p. 105.

his ancient idea of the coexistence of contrasting passions in the soul. Article 147 "Des emotions interieures de l'ame" claims that these passions are aroused in the soul exclusively by the soul itself: while they are often elicited by like passions, they are also often engendered by opposing passions:

For example... when we read of strange adventures in a book, or see them represented in a theatre, which sometimes excite sadness in us, sometimes joy, or love, or hatred, and generally speaking all the passions, according to the diversity of the objects which are offered to our imagination; but along with that we have pleasure in feeling them excited in us, and this pleasure is an intellectual joy which may as easily take its origin from sadness as from any of the other passions.¹⁸⁰

Our imagination elaborates the passions aroused in us by the events represented, conjuring up other different, even contrary, passions, and this counterpoint of affectivity is the source, according to Descartes, of profound joy. The sensible music finds an echo in inner music, in the mental theatre of the affections where the 'I' represents itself in the alternate motions of the soul. The gland excited by the spirits in the cavity of the brain is in its turn the inner image of the vibrating string which in the outside world is excited and vibrates, engendering by its contrary motions harmony, a synthesis of opposites.

The emotional power of music, its power to move the soul in a controlled way, as desired by Descartes' correspondent, Bannius, finally found its 'scholastic' in the Baroque idea of affections, theoretically argued by Athanasius Kircher (1602-1680) along iatro-mechanic and physiological lines, and by Andreas Werckmeister (1645-1706) along mathematical lines. Eggebrecht turns Kircher's *musica pathetica* into a physiological and mechanistic theory, but after Descartes, Galileo and Mersenne, Kircher is somewhat an epigone of Renaissance humoral theory. In the same way, the musical mathematics of Werckmeister is a late legacy of the Renaissance mathematical-musical model, outdated by the mechanistic musical science of the Moderns.¹⁸¹

Despite the claims of the 'theory of affections,' the music of Descartes is not so foreign to 17th century culture as is generally imagined. The cir-

¹⁸⁰ Ibid., 11:441: "Et lors que nous lisons des aventures estranges dans un livre, ou que nous les voyons représenter sur un theatre, cela excite quelquefois en nous la Tristesse, quelquefois la Joye, ou l'Amour, ou la Haine, & généralement toutes les Passions, selon la diversité des objets qui s'offrent à nostre imagination; mais avec cela nous avons du plaisir, de les sentir exciter en nous, & ce plaisir est une Joye intellectuelle, qui peut aussi bien naître de la Tristesse, que de toutes les autres Passions." See Descartes, *Philosophical Works*, 1:398.

¹⁸¹ Hans H. Eggebrecht, *Musik in Abenland. Prozesse und Stationen vom Mittelalter bis zur Gegenwart* (Munich: R. Piper GmbH & Co. KG, 1991), pp. 352-360.

ulation of the manuscript of *Compendium musicae* between 1619 and 1650, and, after the *editio princeps* in 1650, its numerous reprintings and translations, ensured that the small Cartesian treatise became widespread in Europe.¹⁸² The English translation of 1653 introduced the culture of the British isles to the music of a continental philosopher famous, for better or for worse, for his dualism and his mechanicism.¹⁸³ The Cartesian 'solution' to the 'mind-body relationship' became the subject of much scientific and metaphysical debate in the second half of the 17th century. As Jamie Kassler has shown, the cognitive metaphor of man as a musical instrument proper to Hobbes, Hooke and North wanted to reaffirm a unitary vision of man and contrast their instrumental realism to Descartes' dualistic approach to man. The problem of how the two substances, mind and matter, interact, threw up new anatomical and physiological explanations on just how, e.g., a particular motion of the air becomes emotion and conscience. In Italian culture such attempts are witnessed by the two major treatises on speculative music in the 17th century in Italy: *Speculationi di musica* (1670) by Pietro Mengoli, and *Del suono, de tremori armonici e dell'udito* (1679) by Daniello Bartoli.¹⁸⁴ In 1668 the French translation of the *Compendium musicae*, published by Nicolas Joseph Poisson (1637-1710) in a miscellaneous volume containing *Dioptrique*, *Meteores* and *Traité de la Mécanique* of Descartes, as well as *Elucidationes physicae in Cartesii musicam* by the same Poisson,¹⁸⁵ presented the music of Descartes as example of his logical method, whereas Poisson's 'physical demonstrations' sought to prove experimentally the mathematical musical theories of the young Descartes. "Enlightened by Descartes' method," states Jean-Philippe Rameau of himself.¹⁸⁶ He had already in the first Book of his *Traité de l'harmonie* (1722) reported the passage of Descartes' *Abregé de musique* translated by Poisson on the guiding principle for the deduction of consonances. Descartes' "perception des rapports," though now referred to the relations between the harmonic sounds demonstrated by Joseph Sauveur,¹⁸⁷ would again find support in Euler and Diderot.¹⁸⁸ And the idea of the

¹⁸² See de Buzon's Présentation to his edition of Descartes' *Abregé*, pp. 20-44.

¹⁸³ See note 47.

¹⁸⁴ See notes 89 and 90.

¹⁸⁵ See note 88.

¹⁸⁶ See Frédéric de Buzon, "La réception du *Discours de la Methode* dans les écrits théoriques de Jean-Philippe Rameau," in *Problématique et réception du "Discours de la Methode" et des "Essais"*, ed. Henry Méchoulan (Paris: J. Vrin, 1988), pp. 277-282.

¹⁸⁷ See note 74.

¹⁸⁸ Leonhard Euler, *Tentamen novae theoriae musicae* (St. Petersburg: Ex Typographia Academiae Scientiarum, 1739), pp. 26-43; Denis Diderot, "Principes généraux d'acoustique," in *Mémoires sur différents sujets de Mathématiques* (Paris: Durand, 1748), edited in Denis Diderot, *Oeuvres Complètes*, 33 vols. (Paris: Hermann, 1975), 2:257.

"musical hieroglyphic," that Diderot launched against the baroque dogmatics of the affections, was not so indebted to 18th century linguistic theories as not to recall the function of the imagination that Descartes had introduced in the *Compendium* and in the musical letters on the Bannius-Mersenne affair.¹⁸⁹

9 Number to sound

Missing in the *Compendium musicae* of Descartes is one fundamental aspect of sound: "de ipsius soni qualitate, ex quo corpore & quo pacto gratior exeat, agant Physici."¹⁹⁰ The 'quality' of sound, sound as a natural reality, subject of the natural philosophers, remains outside the bailiwick of the mathematician, interested as he is in the quantifiable aspects of sound, "nempe huius differentiae, in ratione durationis vel temporis, & in ratione intensiois circa acutum aut grave." The passage from number to sound entails on the other hand looking harder into the labyrinth of nature; it means giving up on the 'qualities' that inhabit and animate the Aristotelian and Renaissance natural world, and the will to explain nature for what it is or appears to be, matter and motion, re-establishing on its laws, mathematical and physical, the ancient science of the sounding number. *Terminus a quo* towards the modern epistemology of music is still the controversy between Vincenzo Galilei and Zarlino. Against Zarlino's "well ordained Nature," which whispers into the ear of man "the consonances in their true and natural Forms," and has claimed that "by means of human art these Forms should be found as if they were recorded in the natural things, to everlasting memory, well ordained in their own places according to their own degrees; so that Man could know that they were not created by chance, but ordained with great wisdom and not without great mystery,"¹⁹¹ Vincenzo had contrasted the idea of a nature that proceeds "without cognition," with principles and ends foreign to man, and against Zarlino's Nature he had set human poesis, the mechanical art devised by

¹⁸⁹ See Béatrice Durand-Sendrail, *La musique de Diderot. Essai sur le hiéroglyphe musical* (Paris: Kimé, 1994).

¹⁹⁰ See note 164.

¹⁹¹ Zarlino, *Sopplimenti*, p. 97: "Questa Sapientia d'ordinare, non d'altri s'impara, che dalla ben'ordinata Natura, la quale hà sempre in tal modo collocate le cose, che non si trovò mai alcun Sapiente, per grande ch'egli fusse, che meglio le ordinasse di lei. Laonde hauendo essa Natura prodvtrice delle cose del mondo fatto noto al Senso dell'udito ne i Suoni & nelle Voci le Consonanze nelle lor vere Forme & natvrali; volse anco, che col mezo dell'arteficio cotali Forme si trouassero, come registrate nelle cose naturali, à perpetua memoria, collocate per ordine, secondo i gradi loro ne i loro proprii luoghi; accioche l'Huomo conoscesse, che non fussero state fatte à caso; ma ordinate con gran sapientia & non senza gran misterio."

man to pursue an end that is different from nature, or that nature cannot achieve.¹⁹² Vincenzo's son, Galileo Galilei (1564-1642), combined the principles of nature and the principles of mechanics that his father had separated, and for the first time mechanics became the physical and mathematical science of the movement of bodies, natural and artificial.¹⁹³ It was precisely this reformed mechanics that banished the 'qualities' and unveiled the "great mystery," forcing Nature to bring forth the sounding numbers concealed in its womb through Vincenzo's 'sensate experiences' and Gioseffo's 'mathematical demonstrations'.

The science of the 'sounding number' begins with the discovery of consonances in the blacksmith's workshop of the 6th century in the pagan age. Even the modern musical paradigm has its own apologue, the mirror image to that of Pythagoras where our story began. It is the warm apologue of the bird-catcher in *The Assayer* (1623) Vincenzo's son uses to represent the condition of the man of science. A man, with no other experience of sonorous events but that of the song of his birds (*musica irrationalis*), hears the sound of melodious notes in the middle of the night, and thinking it to be a bird makes to capture it; to his surprise, the man discovers a shepherd blowing on a whistle (*musica instrumentalis*). Impressed, the man ventures out into the world in search of other unknown sonorous events, and just when he thinks he has come to know everything (*musica intelligibilis*),

... he suddenly found himself once more plunged deeper into ignorance and bafflement than ever. For having captured in his hands a cicada, he failed to diminish its strident noise either by closing its mouth or stopping its wings, yet he could not see it move the scales that covered its body, or any other thing. At last he lifted up the armor of its chest and there he saw some thin hard ligaments beneath; thinking the sound might come from their vibration, he decided to break them in order to silence it. But nothing happened until his needle drove too deep, and transfixing the creature he took away its life with its voice, so that he was still unable to determine whether the song had originated in those ligaments.¹⁹⁴

Pythagoras enters the workshop knowing already what he will find, the universal archetypes of musical sounds; the modern experimenter mistrusts however his knowledge, "so that when asked how sounds were created he used to answer tolerantly that although he knew a few ways, he was sure that many more existed which were not only unknown but unimaginable."¹⁹⁵

¹⁹² See Section 6 in this Introduction.

¹⁹³ Jürgen Mittelstrass, "Nature and Science in the Renaissance," pp. 27-30.

¹⁹⁴ Galileo Galilei, *Discoveries and opinions of Galileo... including excerpts from the Assayer*, trans. Stillman Drake (New York: Doubleday, 1957), pp. 257-258.

¹⁹⁵ *Ibid.*, p. 258.

Galileo was to remember Pythagoras at the end of the first day of his *Discourses and Mathematical Demonstrations Regarding Two New Sciences* (1638). In justly famous pages, Galileo recycles the traditional theory of sounding numbers in his new science of motion.¹⁹⁶ In the second half of the 16th century, Giovanni Battista Benedetti (1530-1590) had already applied the Aristotelian concept of time as a measure of movement to the vibrations produced in the air by the string; the ratios between the times of vibrations quantified the musical consonances, which were explained physically through the periodic movement of sounds.¹⁹⁷ The attack on the 'musical universals' was then continued by Vincenzo Galilei. Experience had shown him how the 'sonorous number' depended on the material conditions of the 'sonorous body': tension of the strings, transversal section, mass of the material, volume of the pipes, and so on. The primacy of motion and matter over number became the premise of Galilean and modern musical science. In his *Discourses* Galileo recasts the physical theory of Benedetti and the experimental observations of the father in a mechanistic theory of consonance, which in the following decades becomes the starting point and the theoretical model for the study of music in the framework of mechanical philosophy.¹⁹⁸ Galileo assimilates the simple harmonic motion in an ideal pendulum to the swinging of the vibrating string, and proves experimentally that the frequency, understood as the number of periodic oscillations of the string in unit time, is the physical cause of the pitch of the consonant sounds. The kinematics of the consonance then becomes the premise for a physiology of auditory perception, limited in the *Discourses* to the behaviour of the tympanic membrane, assimilated to a deformable elastic body capable of oscillating in synchrony with the periodic impulses transmitted into the air by the sonorous body.¹⁹⁹ Musical science is simply a chapter of the mechanics of elastic bodies, and the new paradigm transforms the lexicon and content of the discipline, and its standing in the encyclopedia of knowledge: the ancient science of the sounding number, whose principles were rooted in arithmetic and geometry, is now a physico-mathematical discipline set like optics or astronomy in the modern system of the mechanical laws of nature. After Galileo,

¹⁹⁶ Galileo Galilei, *Two New Sciences*, trans. Stillman Drake (Madison, Wisc.: University of Wisconsin Press, 1974), pp. 99ff; see Walker, *Studies*, pp. 27-33, and Cohen's piece in this Collection.

¹⁹⁷ Giovanni Battista Benedetti, *Diversarum speculationum mathematicarum et physicarum liber* (Turin: N. Bevilacqua, 1585), pp. 277-283; see Palisca, *Scientific Empiricism*, pp. 219-223, and *Humanism*, pp. 257-265; see, also, H. Floris Cohen, "Benedetti's Views on Musical Science and their Background in Contemporary Venetian Culture," in *Giovanni Battista Benedetti e il suo tempo* (Venice: Istituto Veneto di Scienze, Lettere ed Arti, 1987), pp. 301-310.

¹⁹⁸ See Cohen's piece in this Collection.

¹⁹⁹ Galilei, *Two New Sciences*, p. 104.

Mersenne can announce the definitive passage from number to sound: the sounding number is not what mathematicians abstractly consider, "absque materia" ("without matter:") the number does not produce sound. For Mersenne and Galileo the sounding number denotes the number of periodic vibrations of the air "by which the hearing can be affected and moved."²⁰⁰

Paradoxically, not so much hearing as vision is the paradigm for the musical reasoning in the *Discourses*. Galileo's problem is to visualize frequency, to set beneath his Reader's eyes the physical images of Nature capable of sensibly showing the ratios of frequency among consonant sounds. Today as then the Reader 'sees' the experiments which Galileo recounts with sovereign rhetoric within the context of a 'natural history of sound', stemming from its generation to its auditory perception. Having opened with the definition of the laws of the swinging pendulum, the musical pages of the *Discourses* close through the image of three pendulums oscillating together, visual metaphor of the pleasure produced by the vibrations of the sounds in the air which regularly strike the ear-drum. At the core of his natural history of sound Galileo introduces some musical experiments, depicting them with extraordinary realism, in a way more impressive than actually seeing them—*enargeia* as a synonym of 'sensate experience', visual demonstration. When thirty years later Poisson would try to 'demonstrate' Descartes' *Compendium musicae* with the musical experiments of Galileo's *Discourses*, he will use the expression 'physical demonstrations' (*elucidationes physicae*) in the sense of the Galilean 'sensate experience', *repraesentatio quae se ostendit*. In his own rhetorical and experimental structure Galileo has in mind Gaffurio's plate and Boethius' story on the Pythagorean discovery of consonances. At least one of the images of Gaffurio's plate, that of the glasses filled by water, is the model to one of the experiments in the *Discourses*. Galileo describes the ripples of water on the surface of a resonating glass, which show us the ratios of frequencies of two sounds at the distance of an octave: the waves regularly divide into half, the sounding numbers are visualized through the vibrations of the two sounds on the surface of the water.²⁰¹ Together with the Pythagorean reminiscence, Galileo also recollects here the Stoic analogy between propagation of sounds in the air and circular waves engendered on the surface of the water in the pond by a small stone. The expression "the invention was by chance" ("l'invenzione fu del caso") Galileo chooses to introduce the second experiment, recalls the expression "for a divine chance" ("divino quodam casu") Boethius uses with regard to Pythagoras' encounter with the mythical blacksmiths.²⁰² Like the hammers and anvils, Galileo's experimental tools—chisel and plate of brass—are of metal and

²⁰⁰ Marin Mersenne, *Cogitata Physico-mathematica* (Paris: Bertier, 1644), p. 261.

²⁰¹ Galilei, *Two New Sciences*, p. 100.

²⁰² *Ibid.*, p. 102; Boethius, *De musica*, I, 10.

common usage, and like Pythagoras' hammers they reveal the ratios of consonances (here of two sounds a fifth apart) as recorded in Nature. The symmetrical lines the chisel etches into the brass in concert with the two sounds show permanently to Galileo's eyes and ours the numbers of frequencies as recorded in the metal, and these images of Nature can win out against the unrepeatability of sonorous events. Chipping off matter from a metal surface using a chisel, as with the Pythagorean hammers, generates sonorities that hold within them profound truths, manifest only to the enlightened to whom a random event becomes meaningful. The cymbal in the room where Galileo handles his metals bears living auditory and visual witness to the experiment with the vibrations of its string that is tuned up to the fifth Galileo has engendered 'by chance'. It is hardly surprising that such a lively tale, which throws the mental eye and ear of the Reader into Galileo's work room, resisted the wear and tear of time for about over three centuries until Walker noticed the mistake in Galileo's report.²⁰³

Between the end of the 16th and the first years of the 18th century the 'experimental philosophy' showed that a string can vibrate in many way at the same time, generating with its fundamental sound the series of its concomitant harmonic sounds: Zarlino's 'perfect harmony' existed in nature as a physical law of resonance. The discovery of the 'natural principle' of harmony became part of the culture of musical theorists only later. For more than a century from the acceptance of the physical-mathematical paradigm, the search for the 'natural principle' of harmony had been separated from the search for its 'musical principle', and it was only in the first half of the 18th century that the two parts of musical science met. When in the Preface to his *Traité de l'harmonie* Rameau states that he wants to reclaim in music the rights that reason has lost to mere practice, he is lamenting the decline of a musical theory that has ignored the lesson of the Ancients, renouncing its ties with science.²⁰⁴ In the *Traité*, Rameau traces musical theory back "à ses principes naturels," reproducing the traditional model of mathematically deducing consonances: he cuts out the ties of music with natural philosophy and, following Descartes, deduces the chords from the successive divisions of the string.²⁰⁵ It is as if between Rameau and Zarlino or Descartes there has been no 'modern science'. Only with his *Génération harmonique* (1737) does Rameau contaminate musical theory with Newtonian science, reformulating the harmonic con-

²⁰³ Walker, *Studies*, pp. 29-30; see also Cohen's piece in this Collection, and Thomas B. Settle, "La rete degli esperimenti galileiani," in *Galileo e la scienza sperimentale*, ed. Milla Baldo Celin (Padua: Dipartimento di Fisica "Galileo Galilei", 1995), pp. 11-62, esp. 35-45.

²⁰⁴ Jean-Philippe Rameau, *Traité de l'harmonie réduite à ses principes naturels* (Paris: Jean-Baptiste-Christophe Ballard, 1722), reprint ed., Jean-Philippe Rameau, *Complete Theoretical Writings*, ed. Erwin R. Jacobi, 6 vols. (Rome: American Institute of Musicology, 1967), 1:1-3.

²⁰⁵ *Ibid.*, pp. 33-34.

cept of "fundamental bass" with the physical one of "fundamental sound."²⁰⁶ Rameau's synthesis coincides with the conversion to experimental philosophy of an epigone of the speculative musical tradition, begun more than two thousand years before with the Pythagorean discovery of the consonances. Blending musical theory and experimental philosophy, Rameau brings music to the fore in 18th century European science: he wins for himself and for musical science the praise of d'Alembert in his *Discours préliminaire* (1751) of the *Encyclopédie*, and launches the musical dialectics of the Enlightenment, which leads to the final primacy of the aesthetic paradigm on the ruins of the ancient science of the 'sounding number'. The historiographical conscience of the winning paradigm wastes little time in liquidating the speculative musical tradition born 'by chance' in an artisan's workshop in the 6th century B.C.—"these vain enquiries," writes Charles Burney, which have held back the progress of music.²⁰⁷

²⁰⁶ Jean-Philippe Rameau, *Génération harmonique* (Paris: Prault fils, 1737), in Rameau, *Complete Theoretical Writings*, 3:15-29; see Matthew Shirlaw, *The Theory of Harmony. An Inquiry into the Natural Principles of Harmony, with an Examination of the Chief Systems of Harmony from Rameau to the Present Day* (London: Novello & Company, 1917; reprint ed., New York: Da Capo, 1969), pp. 155-161, 164-181.

²⁰⁷ Charles Burney, *A General History of Music. From the Earliest Ages to the Present Period* (London: 1789², reprint ed. 2 vols., New York: Dover, 1957), 2:136.