THE HARMONIOUS PULSE

Gell. *NA* 3.10.13 citing Varro's *Hebdomades uel de imaginibus*, reports:

Venas etiam in hominibus, uel potius arterias, medicos musicos dicere ait numero moueri septenario, quod ipsi appellant τὴν διὰ τεσσάρων συμφωνίαν, quae fit in collatione quaternarii ⟨et ternarii⟩ numeri.

He also states that doctors who make use of music theory declare that the veins, or rather arteries,[1] in human beings move in accordance with the number seven; they call this motion 'the consonance of the fourth', which is produced by the proportional relation of the numbers four and three.

Bernardi Perini's supplement (*AIV* 137 [1978–9], 264) is clearly right: the ratio 4:3 generates the perfect fourth and $4+3 = 7$.[2] However, neither he nor anyone else has explained what the consonance of the fourth is doing in this context: the pulse is not a source of musical pitch. We expect the language not of pitch but of rhythm, whether numerically defined as a ratio or likened to metrical feet as by Herophilus and his followers;[3] commentators have recognized the underlying doctrine of a 4:3 rhythm for the pulse.[4] The resemblance between rhythm and interval, as being both based on ratios, was recognized in antiquity;[5] but we lack an ancient parallel for the designation of a rhythm by a name belonging to an interval.

Yet in the Middle Ages it was known to any educated physician that *al-šayḫ al-ra'īs* Abū Alī Ibn Sīnā (980–1037), in the West called Avicenna, in his *Canon of Medicine* (*al-Qānūn fī 'l-ṭibb*), had interposed, within a tenfold classification of the pulse adapted from Galen, between the accounts of the last two categories, respectively order/disorder (*al-niẓām wa-ġayr al-niẓām* = τάξις καὶ ἀταξία) and rhythm (*al-wazn*, rendered *pondus* by Gerard of Cremona), the following digression:[6]

You should know that there is in the pulse a musical nature, for as the art of music is realized in the melody (*ta'līf al-niġam* 'composition of sounds') according to the relation between them as to high pitch (*al-ḥidda* = ὀξύτης) and low (*al-ṯiql* = βαρύτης), and in the rhythmical

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[1] Cf. *NA* 18.10 and my remarks at *Aulus Gellius* (London, 1988), 224 and n. 50.

[2] Cf. *Theol. Arith.* 55.4–5 De Falco ὁ ζ' λέγεται τῆς πρώτης συμφωνίας ἀριθμὸς εἶναι τῆς διὰ δ' δʸ [4:3].

[3] See now Heinrich von Staden, *Herophilus: The Art of Medicine in Early Alexandria* (Cambridge, 1989), 276–84, 346–61, 391–3.

[4] Both W. H. Roscher, *Die Hebdomadenlehre der griechischen Philosophen und Ärzte* (Abh. K. Sächs. Ges. Wiss., ph.-hist. Kl. 24/6 [1906]), 139 and von Staden 279 n. 136 refer the text to rhythm without more ado. To be sure extant Greek authors offer no support and Herophilus likened the healthy adult pulse to the spondee, in even rhythm (διὰ ἴσου): 'Ruf. Eph.' *Syn. puls.* 4.5–6, p. 225.2–6 Daremberg–Ruelle—cf. *Aulus Gellius* 234 n. 4, where for '2/2' read 'even minims in 4/4' and correct the Ar. Quint. reference to 2.14 (p. 82.25–8 W.-I.). But it is no objection that Aristoxenus did not recognize 4:3 as rhythmical (*El. Rhythm.* 2.35), since medical writers were not bound by his pronouncements; he equally rejected 5:2, which Galen allowed (see below). The extent of Herophilus' debt to Aristoxenus is unclear (von Staden 278–9, but cf. 391).   [5] See M. L. West, *Ancient Greek Music* (Oxford, 1992), 244 with nn. 64–5.

[6] Bk. 1, *fann* ('fen') 2, *ta'līm* ('doctrina') 3, *jumla* ('summa') 1, *faṣl* ('caput') 1; ed. Institute of History of Medicine and Medical Research (New Delhi, 1982–), i.202–3; Gerard, e.g. Padua, 1476 edn., sigs. e4ᵛ–e5ʳ. French trans. by Amnon Shiloah, '"Ên-Kol"—Commentaire hébraïque de Šem Tov ibn Šaprût sur le Canon d'Avicenne', *Yuval: Studies of the Jewish Music Research Centre*, 3 (1974), 267–87 at 272–3; for this reference and that in n. 12 I am indebted to Dr Bonnie Blackburn, and for helpful comments to Dr Charles Burnett and the anonymous referee for this journal.

recurrence of time-intervals between the strikings (of strings), so it is with the pulse: its temporal relation in respect of swiftness (duration of movements) and frequency (duration of pauses) is a rhythmical relation, and its qualitative relation as to strength or weakness (of the impact on the finger) and size (of dilation) is a relation like that of melody (*nisba ka-'l-ta'līfiyya*). And as the time-units of rhythm and the durations of notes may be concordant (*muttafiqa*) or inconcordant (*ġayr al-muttafiqa*),[7] so the variations of the pulse may be orderly and may be disordered, and the qualitative relation of the pulse as to strength or weakness and size may be concordant or inconcordant, indeed uneven. This lies outside the consideration of order.

Now Galen holds that the observed values of metrical proportions are in accordance with one of these musical relations mentioned:[8] either in the relation of the octave and fifth (*nisbat al-kull wa-ḥamsa*[9] = διὰ πασῶν καὶ διὰ πέντε), which is triple (3:1), being the relation of the double (2:1) compounded with the relation of that which adds a half (3:2), i.e. the fifth (*bi-'l-ḥamsa* = διὰ πέντε); in the relation of the octave (*bi-'l-kull* = διὰ πασῶν), which is double (2:1); or in the relation of the fifth, which is that which adds a half (3:2); in the relation of the fourth (*bi-'l-'arba'a* = διὰ τεσσάρων), which is that which adds a third (4:3); or in the relation of that which adds a quarter (5:4).[10] No further ratios can be observed.[11] I am amazed that these relations should be detected by touch; but it is easier for one who executes the progression of rhythm and the proportion of sounds in (practising) the 'art (*bi-'l-ṣinā'a*), and then has the opportunity to become acquainted with music theory (*al-mūsīqī*), so as to correlate the art with the discipline (*fa-yaqīs al-maṣnū' bi-'l-ma'lūm*). Such a man, should he turn his attention to the pulse, would be enabled to identify these relations by touch.

These remarks, much discussed by medieval and Renaissance commentators,[12] have no counterpart in the extant works of Galen: the nearest approach is the discussion at περὶ διαφορᾶς σφυγμῶν 1.9 (viii.516–17 Kühn), according to which the relation of contraction may be 1:1; or rational, whether multiple, e.g. 2:1, 3:1, 4:1, or 'of number to number (ὡς ἀριθμοῦ πρὸς ἀριθμόν), when to two time-units of dilation correspond five, seven, nine, or eleven of contraction'; or irrational, with irrational time of dilation, contraction, or both. However, they may well have some basis in lost Greek writings, developed from the simpler doctrine in Varro's source that the healthy pulse beat in a ratio of 4:3,[13] interpreted as the generating ratio of the perfect fourth.

The assimilation to pitch of strength and size will have been mediated by the intensity and length of strings in the 'ūd or lute, the basic instrument of Arabic music

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[7] *muttafiq* = 'consonant', but is also used more loosely; here applied to rhythms of even periodicity (Shiloah, 279–80, §16 n. a). The antonym is *mutanāfir*; Avicenna's privative corresponds to ἀσύμφωνα. Dr Burnett points out that elsewhere dissonance may be *iḫtilāf*, which in this text denotes the variation of pulse (category 8), itself either orderly or disordered.

[8] *al-madkūra*; but Gerard of Cremona renders '…nominatarum aut non nominatarum. nominatarum uero…'.

[9] Lit. 'the relation of the whole and five', a blend of *nisbat al-kull wa-ḥums* ('relation of the whole and a fifth [part]' = 6:5) and *al-nisba 'llatī bi-'l-kull wa-'l-ḥamsa*, 'the relation that is through the whole and five'.

[10] This proportion generates the major third of just intonation, of little account in ancient music theory; 'que proportio non est proprie musicalis', Peter de Abano, *Conciliator differentiarum philosophorum et precipue medicorum* (Pavia, 1490), sig. [r6]ra (note that 'Ga. in de pulsuum compendio', ibid., sig. r4ra, is 'Ruf.' Eph.' *Syn. puls.*), but see Ptol. *Harm.* 1.13, p. 31.1 Düring; 1.15, pp. 35.3–4, 36.31–2 (10:9 × 9:8); 2.13, p. 68.20–22.

[11] *ṯumma lā yaḥuss* = *postea non sentitur* (Gerard), cf. μετὰ ταῦτα similarly used at Ptol. *Harm.* 1.15 (p. 34.3 Düring). Ibn Šaprût, in his commentary though not his translation, declares that 5:4 cannot be perceived 'à cause de sa grande subtilité' (*lərôb daqqôtô*).

[12] Nancy G. Siraisi, 'The Music of Pulse in the Writings of Italian Academic Physicians (Fourteenth and Fifteenth Centuries)', *Speculum*, 50 (1975), 689–710, esp. 693–4, 699–700.

[13] It is uncertain whether we should measure dilation against contraction, dilation and pause against contraction and pause, or dilation against contraction and both pauses: see Galen, περὶ διαγνώσεως σφυγμῶν 3.3 (viii.911–13), but cf. below, n. 19.

theory; the Greek sources will have thought of the kithara, or the monochord.[14] In addition, since our concern is with Varro's *medici musici* and not with the Šayḫ al-Raʾīs, we may find suggestive the explanation given by Jacopo of Forlì (Giacomo della Torre, d. 1414) for an assimilation of speed or frequency of pulse to pitch of note that Avicenna does *not* make but Hellenistic writers may have done:[15]

Secundo nota ut mihi uidetur notandum, quod uelocitas et spissitudo in pulsu acuitati uocis aliqualiter assimilatur. uox enim acuta uelociter mouet auditum, grauis uero tarde.[16] ita pulsus uelox cito imprimit in tactum et praeterit, et similiter spissus respectu rari ceteris paribus. unde pulsus ueloces et spissi possunt dici metaphorice acuti. proportio ergo pulsuum in uelocitate et tarditate est sicut proportio uocum in grauitate et acuitate.

But more important was the long-standing association of ἁρμονία with the soul, the body, and even the universe: it was in that tradition that Censorinus, having reported Asclepiades' cures of phrenetics and Herophilus' doctrine of rhythms, commented (12.4–5): 'itaque si et in corporis et in animi motu est harmonia, procul dubio a natalibus nostris musica non est aliena', and Cassiodorus declared (*Inst.* 2.5.2): 'quicquid enim loquimur uel intrinsecus uenarum pulsibus commouemur, per musicos rithmos armoniae uirtutibus probatur esse sociatum'.[17] Moreover, whereas in the macrocosm writers who describe planetary distances as musical intervals rather than as their generating ratios measure them in the Aristoxenean manner by tones and semitones,[18] in the microcosm the pulse could not be measured in such terms, but if expressed as a ratio might be assimilated by a Pythagorean to the corresponding interval. Hence, since the fourth is generated by the ratio 4:3, its name was applied to this ratio even as a rhythm.

A similar assimilation is reported by Aristeides Quintilianus, *De musica* 3.8 (p. 106.8–18 Winnington-Ingram): palpitations and fevers are divided into three classes according to their periods, ὧν οἱ μὲν τοῖς συμφώνοις ἀναλογοῦντες λόγοις, διπλασίῳ τε, ὡς ὁ ἀφημερινός, ἡμιολίῳ τε, ὡς οἱ διὰ τρίτης, ἐπιτρίτῳ τε, ὡς οἱ διὰ τετάρτης ἐπισημαίνοντες, οὐ πάντως κινδύνους ἐπιφέρουσιν. The relations between the inclusive count of days from one fit to the next, and the exclusive count of the first fit and the intervening days,[19] are the ratios respectively of the octave and its

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[14] Nicomachus, *Ench.* 4; Boeth. *Inst. mus.* 1.3; the former also considers how the sound of wind-instruments is affected by intensity of breath and the dimensions of bore and holes.

[15] *Iacobi Foroliuiensis medici singularis expositio et quaestiones in primum Canonem Avicennae* (Venice, 1547), fo. 132[va], a misconstruction of Gerard's 'proportio suorum temporum in uelocitate et spissitudine est sicut proportio sonorum eius'.

[16] Arist. *De anima* 420[a]29–[b]4; for other views Archytas 47 B 1 DK *sub fin.*; Pl. *Tim.* 80A; Thphr. *Sens.* 85; Ps.-Arist. *Probl.* 899[a]27–8, 900[b]7–14; Nicomachus and Boethius locc. citt. Cf. Alan Towey, 'Aristotle and Alexander on Hearing and Instantaneous Change: A Dilemma in Aristotle's Account of Hearing', in Charles Burnett, Michael Fend, and Penelope Gouk (edd.), *The Second Sense: Studies in Hearing and Musical Judgement from Antiquity to the Seventeenth Century* (Warburg Institute Surveys and Texts, XXII [London, 1991]), 7–18; Burnett, 'Sound and its Perception in the Middle Ages', ibid. 43–69 at 64–5.

[17] Whence Isid. *Etym.* 3.17.3; cf. Siraisi 702. Whereas Aug. *De musica* 6.3.4 speaks only of rhythm, the speaker of Mart. Cap. 9.926 is called *Harmonia* (cf. Serv./DS *Aen.* 12.394, 397) rather than *Musica* to show her cosmic significance (cf. Cristante, edn. of bk. 9, pp. 13–18).

[18] Alex. Eph. *SH* 21, Plin. *NH* 2.84, Cens. 13.3–5, Fav. Eul. 25.1–2, Mart. Cap. 2. 169–98. The Romans follow Varro, who apparently assigned the doctrine to Pythagoras; the additive conception of intervals is not the only ground for disbelief: T. L. Heath, *Aristarchus of Samos* (Oxford, 1913), 113–15.

[19] Applied to the pulse, this would entail comparing the time from the beginning of one contraction to the end of the next with that from the beginning of the first to that of the second.

fundamental divisions the perfect fifth and perfect fourth, being hence described as consonant even though ῥυθμός, not μέλος, is at issue (cf. 2.7, p. 66 W.-I.). Similarly, those fevers that bear some resemblance to them[20] are dangerous but leave room for hope; for example semitertians, with a fit every day, but alternately stronger and milder. No ratio is stated, but by allowing 1 for the strong fits and $\frac{1}{2}$ for the mild, we obtain on the same principle $2\frac{1}{2}:1\frac{1}{2} = 5:3$, superpartient but still rational.[21] Utterly inconsonant fevers (οἱ δὲ παντελῶς ἀσύμφωνοι), such as the continuous, are fearful and fatal; they are inconsonant because it is impossible to find in them any ratio whatsoever.

In both cases the equation of rhythm and interval is made in the interests of corporeal ἁρμονία; it is not a mere figure of speech as it would become in the musical terminology of the later Middle Ages, when the note-values of mensural music were often subjected to proportional changes. These were normally known by the Latin names inherited from Cicero and Boethius; however, one musician called the proportion 3:4 'subdiatessaron' instead of *subsesquitertia* and 3:2 'diapente' instead of *sesquialtera*, another defined 'diapason', 'diapente', and 'diatessaron' not merely as the intervals, harmonic and melodic, of octave, fifth, and fourth, but as the proportions 2:1, 3:2, and 4:3, properly *dupla*, *sesquialtera*, and *sesquitertia*.[22] Not knowing that the *dia-* names, with their subintended χορδῶν, referred specifically to intervals, writers understood them of the corresponding proportions in any musical context.[23]

The proportional names *sesquialtera* and *sesquitertia* invite a further reflection. Gellius asserts (18.14.3), probably following Varro, but in ignorance of Cicero, that ἡμιόλιος and ἐπίτριτος cannot be rendered into Latin;[24] nothing in his chapter betrays any awareness of these ratios' musical significance—not of course in respect of mensural proportions, unknown in ancient music, but in the generation of the fifth and fourth.[25] Music theory did not interest him;[26] even if Varro could explain what

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[20] Retaining αὐτούς against Jahn's αὑτούς, cf. τῶν ἡμιτριταίων οἱ τούτοις παρακείμενοι, with Thomas G. Mathiesen, *Aristides Quintilianus: On Music, in Three Books* (New Haven, CT, 1983), 65, 172, and Andrew Barker, *Greek Musical Writings*, ii: *Harmonic and Acoustic Theory* (Cambridge, 1989), 506.

[21] In Ptolemy's syntonic diatonic, though not in Pythagorean tuning nor in Didymus', a major sixth ($3:2 \times 10:9$).

[22] Respectively Johannes de Sarto, in the canonic inscription to the tenor of his motet *Romanorum rex* (composed for the death of Albrecht II in 1439, and previously thought to be by Johannes Brassart), and Johannes Tinctoris, in his *Terminorum musicae diffinitorium* (written c. 1473, published at Treviso, c. 1495; facs. Leipzig, 1983), sigs. [A5]ʳ, [A5]ᵛ, [A6]ᵛ. See now Bonnie J. Blackburn, Edward E. Lowinsky, and Clement A. Miller, *A Correspondence of Renaissance Musicians* (Oxford, 1991), 658 with nn. 19–20, 663–4, and for the resulting ambiguity ibid. 695 with n. 28. (The proportions refer to the overall time-relation, e.g. 'three breves in the time of four/two'; hence 3:4 makes the music slower, 3:2 faster.)

[23] Cf. Jacopo of Forlì, fo. 132ᵛᵇ: 'in musica proportio dupla uocatur dyapeson [*sic*], sexquialtera uero diapente, sexquitertia uero diatessaron.'

[24] Cf. *Aulus Gellius*, 169 n. 26; J.-Y. Guillaumin, 'La terminologie latine de la série des épimores', *RPh*³ 53 (1989), 105–9; see too Aug. *De mus.* 2.10.18. Evidently Gellius had not read Cic. *Tim.* 22–3; for *subsesquitertia* = ὑπεπίτριτος see Boeth. *Inst. arith.* 1.24 (p. 49.24 Friedlein).

[25] Of the examples given, 15:10, 30:20; 12:9, 40:30, only 12:9 is of musical interest, being part of the intervallic formula 12:9:8:6. Some commentators refer 18.15.2 to a division of the octave into 5+7 semitones, representing respectively the 4:3 and 3:2 relations of the preceding chapter; but even if the coarse blend of Aristoxenean and Pythagorean conceptions were no objection, cf. n. 18, 'ratione quadam geometrica' suits better with the 3, 4, 5 triangle of Aug. *De mus.* 5.12.26. See my 'Parva Gelliana', *CQ* (forthcoming).

[26] Cf. *Aulus Gellius*, 233–4.

the consonance of the fourth was doing in a discussion of the pulse, Gellius in all likelihood could not. Nevertheless, it is the commentator's duty to do so for him.

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