

1744

BARKER, A.D.

1991

IN: SCIENCE AND PHILOSOPHY
IN CLASSICAL GREECE

9

Aristoxenus' Harmonics and
Aristotle's Theory of Science

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It is agreed on all sides that Aristoxenus was the giant of Greek musicology. His work in musical history and criticism was the point of departure for a host of informal essays on music by philosophers, antiquarians, and men of letters. Almost all the technical harmonic treatises of later antiquity drew heavily on the analyses set out in his writings: this is true even of authors in the distinct scientific tradition of 'mathematical' harmonics, writing under the banner of Platonism or Pythagoreanism. Aristoxenus himself insists loudly and often that nothing comparable in scope and sophistication had been attempted before his *Harmonica elementa*;¹ and though his reiterated claims to originality become irritating, they are undeniably true. It is not just that he was thoroughly acquainted with musical practice, acute in his observations, and tireless in the pursuit of detail. The crucial task of harmonics, as he conceived it, is to go beyond the essentially preliminary compilation of facts to their systematic coordination in a scheme of scientific understanding. He discussed, self-consciously, polemically and at length, the methods by which this understanding is to be achieved and the form it must take if harmonics is to be truly a science. His importance lies as much in his meta-musicological reflections and in the way he brought them to bear on the organisation of his material, as in any of his substantive doctrines about the musical facts.

Aristoxenus' conception of science and its methods exercised no noticeable influence in antiquity outside specifically musical studies. So far as I know, mathematicians, astronomers, medical writers, students of mechan-

¹ For the text I have used, see Da Rios 1954: all my references are by Meibom's [1652] pages and lines. See also Macran 1902.

ics, and the rest paid him no special attention.² This is not surprising, since—taken abstractly—his ideas were not new. They were borrowed almost without exception from Aristotle; and though modifications of Aristotelian positions can be found in Aristoxenus, it is principally his interpretation and application of his teacher's ideas that should earn him the attention of historians of science.

The influence of Aristotle on Aristoxenus has been studied from a number of angles in a recent book by Annie Bélis [1986].³ Here I shall consider issues that arise out of just one aspect of the relationship, one in which, I suggest, Aristoxenus might be of considerable help to our understanding of Aristotle himself. It is notorious that none of Aristotle's own treatises offers itself, *prima facie*, as an example of the sort of science painstakingly described in the *Posterior Analytics*. It is sometimes argued that the *An. post.* should not be construed either as proposing a framework for scientific research or even as describing the form which a complete science should ideally take, but more modestly as articulating a blueprint for pedagogy, a way of organising scientific results so that they can effectively be taught [see esp. Barnes 1969, 1975]. But the *Harm. elem.* shows, I believe, that Aristoxenus drew directly on Aristotle's essay when discussing the methods by which his subject is to be investigated: hence, it was indeed possible for an associate of Aristotle to conceive the *An. post.* as offering a sound framework for something that can fairly be called a research programme.

Aristoxenus also treated the *An. post.* as conveying a description of the form of understanding that constitutes science, one at which the harmonic scientist, like any other, must aim; and the *Harm. elem.* seeks to articulate its harmonic truths in the pattern that the *An. post.* proposes, not just for pedagogic purposes, but because scientific understanding must itself have the structure that the shape of the treatise reflects. A careful study of the *Harm. elem.* will show that this treatment of the *An. post.* makes sense, and will clarify the notions of scientific discovery and scientific understanding that underlie the latter. At the same time it will be instructive to consider certain ways in which Aristoxenus found it necessary to modify the ideas of the *An. post.*, and certain difficulties that his project appears to encounter. The most important stumbling-blocks, I shall suggest, are not of his own making but are in fact inherited from Aristotle.

² An exception is Vitruvius, who announces his debt to Aristoxenus at *De arch.* v 4.

³ Bélis' book reached me at a late stage in the preparation of this paper, and I have not been able to incorporate many reflections on it here. There are substantial points on which we differ, but it is a work from which much can be learned.

At the centre of our investigation will be a pair of closely linked Aristoxenian positions, one positive, one negative. I shall outline them briefly here and discuss them more fully in what follows. On the negative side is one of his rare departures from Aristotle's views. In the *An. post.* and elsewhere Aristotle identifies two sorts of harmonics, one empirical and one mathematical, and treats the former as subordinate to the latter. Empirical harmonics discovers only certain facts available to perception, and a list of unexplained and uncoordinated facts is not yet a science. The explanations, but not the data, are provided by mathematical harmonics. In more Aristotelian language, the empirical approach distinguishes and perhaps classifies the phenomena, but finds no ἀρχαί and generates no ἀπόδειξις. The ἀρχαί that stand as principles essential to the explanatory demonstration of statements describing the phenomena are principles proper to the mathematical branch of the subject.⁴ This may well be an accurate transcription into Aristotelian terms of contemporary mathematical theorists' own view of their project. But Aristoxenus will have nothing to do with it. The ἀρχαί of his science, its coordinating and explaining principles, must—so he insists—be intrinsic to the domain of musical perception itself and not imported from the foreign territory of mathematics or quantitative physical acoustics. Aristotle, of course, engages in no very careful study of the two kinds of harmonics: he merely notes their existence for the sake of an example of the way in which one science may be subordinate to another, and apparently accepts the mathematical theorists' own estimate of their

⁴ Mathematical harmonics, in Aristotle's sense, is exemplified in the pioneering work of Archytas [see Diels and Kranz 1951, i 428.15–430.12, 435.15–436.13; Bowen 1982], in a highly specialised application at Plato, *Tim.* 35b–36b, and later in such treatises as the Euclidean *Sectio canonis*. It treats pitch-relations as ratios between numbers (which may be conceived as attaching to physical variables such as speeds of movement: cf. Bowen 1982, and chapter 8 in this book). It represents harmonic structures, for instance, the octave-scale, as organised complexes of ratios, whose coordination may be explained by reference to a theory of proportions or to some other purely mathematical set of principles. In its application to acoustics, a focus of some interest in the Lyceum, such conceptions were used to account for phenomena including the correspondence of notes an octave apart and the concordance of octaves, fifths, and fourths: they are concordant because their ratios are of certain sorts. Aristotle accepts these accounts as giving at least a sketch of an appropriate explanation [see *An. post.* 90a18–23: cf. *De sensu* 439b31–440a3], even though it is not clear what reasoning is concealed in this 'because' [see n5 below].

relative ranking.⁵ Aristoxenus rejects this view, as we shall see, for reasons drawn from the *An. post.* itself. He argues, in effect, that a consequence of taking the pronouncements of that treatise seriously is that the two existing forms of harmonic science cannot genuinely stand in the relation that Aristotle imagines. His intention is not, however, to elevate the work of previous harmonic empiricists from the humble station to which Aristotle had consigned it: their conception of the science, he believed, was as inadequate as that of their rivals was irrelevant. Nor had Aristotle failed to discern the merits of some other existing harmonic project. The real implication of the *An. post.*, for Aristoxenus, was that an entirely new harmonic science had to be framed which would absorb both the descriptive and the explanatory functions.

The positive side of the coin is Aristoxenus' insistence that harmonics must find its ἀρχαί through reflection on the phenomena revealed to musical perception, seeking forms of order intrinsic to the phenomena themselves as they are perceived (not in the ordering of an unperceived realm of 'causes', movements of the air, or the like, which physical acoustics might investigate). The ἀρχαί proper to harmonics articulate a φύσις, a nature or essence, that exists and is expressed in groups of heard sounds themselves in so far as they are melodically attuned, and qualify as instances of τὸ ἡρμοσμένον. These ἀρχαί describe the structures within which sounds are necessarily organised if they are correctly heard as melodic, since to hear a sequence as melodic is just to hear it as exemplifying the φύσις that the harmonic scientist seeks to describe. If a hearer is sufficiently attentive and carefully trained, he will come to realise that what the scientist articulates does indeed express the form a sequence of sounds must have when he

⁵ Aristotle may have been persuaded by the apparent analogies between harmonics and his two other examples, optics and astronomy, particularly the latter. The Pythagorean treatment of harmonics and astronomy as 'sisters', articulated by Archytas [see Bowen 1982, 79–83] and reported in Plato, *Resp.* 530d6–9, derives from a conception of them as parallel studies of different forms of movement, audible and visible, or so I would argue. (Huffman [1985] gives reasons for rejecting a sentence in the text of Archytas which is important for my interpretation: I think his arguments can be answered but this is not the place to pursue the issue.) The achievements of Eudoxan astronomy may have encouraged the view that Archytan harmonics, already much the most impressive form of musical science, could be developed to rival it. In both these cases, and in optics, an abstract mathematical description of the phenomena, allied to purely mathematical principles, might plausibly be construed as constituting their explanation, as it is for a harmonic example at *An. post.* 90a18–23. Aristotle's antipathy to Pythagoreans is directed at their metaphysics and their use of harmonic theory in non-musical contexts: he does not criticize their development of it in its own sphere.

himself hears it as melodic or as being of a given melodic type. Similarly, the rules apodeictically derived from the $\acute{\alpha}\rho\chi\alpha\iota$ are also ones to which every alert listener would subscribe, on the ground that these rules make explicit criteria that were already implicit in his own experience. They are not surprising, unexpected constraints on what can count as melody: still less do they impose restrictions derived from principles in another realm, such as that of pure mathematics. The task of harmonics is to clarify and organise what educated perception implies, not to prescribe things that it will not autonomously accept. The apodeictic phase of the science serves to explain the rules that are implicitly accepted in ordinary practice by showing that they are not arbitrary or haphazard, but are coordinated expressions of a single nature or essence.

The immediate consequence of this approach is that Aristoxenus' harmonic science turns out to be a sort of musical phenomenology. It describes and classifies the phenomena according to the distinguishable ways in which they present themselves to perception, not according to classes whose members cannot be directly identified as such by the musician's ear. The audible appearances are not explained by reference to inaudible physical causes or mathematical principles, but by being displayed as aspects of a coherent nature that exists just in its audible instances. Audible melodicity is not an echo or a consequence of some other form or order that holds among the inaudible precursors of sound. The melodic is an autonomous form inhering in certain sequences of sounds under their aspect as objects of hearing and in nothing else. It is to be defined through a coordinated array of principles abstracted inductively from the audible appearances; and the rules governing what is and what is not an acceptable melody are accounted for when they are shown to be implicit in the pattern of organisation in which that form consists. In neither its descriptive nor its explanatory phase should harmonics call on data that are not presented to the musical ear or on categories that divide up the data on other than musical principles. Aristoxenus' reasons for taking this position, its implications, and certain problems it brings with it, will be explored in more detail below.

The *Posterior Analytics* and the structure of Aristoxenus' harmonic treatise

I have said that Aristoxenus' conception of a science corresponds closely to that set out in the *An. post.* A thorough evaluation of this claim would have to focus on the fine detail of what Aristoxenus does, in order to see how well the propositions of his treatise correspond to Aristotle's descriptions of the propositions of a science and their mutual relations. I shall do little at that level here. A more compassable project is to compare the explicit

remarks made by each author on the subject of scientific method and on the conditions that an adequate science must fulfil, and here I shall draw attention to some obvious parallels. But the central investigation into which these closer ones must feed concerns the overall match between the designs proposed in Aristotle's essay and exemplified in that of Aristoxenus. This creates a difficulty, since the *Harm. elem.* as we have it is not a complete work, nor even, in my view, the remains of a single treatise. Issues about the relations between the parts of the surviving text have raised a good deal of scholarly dust;⁶ I shall not attempt to sift it, but I must at least state the opinion on which what follows is premised.

This is that books 2 and 3 belong together; that while the work of which they are parts was originally a good deal longer, and while the two books are not perfectly preserved even as parts, nevertheless they are enough to give a reasonably clear picture of the form which that treatise took. Book 1, on the other hand, is evidently in many respects (not in all) an alternative treatment of the project undertaken in book 2.

I must pursue these preliminaries a little further. Books 1 and 2 perhaps contain fewer genuinely equivalent passages than is sometimes assumed, but there are enough parallels and approximate repetitions to ensure that they cannot originally have been parts of the same finished work.⁷ I take them to have performed roughly equivalent tasks in two different treatises. Further, though the first and second books differ little in what they claim to be facts about music, they do differ significantly in the conceptual resources which they bring to bear on the interpretation and organisation of these facts. Those deployed in book 2 are subtler and richer than those of book 1, and its author shows a markedly higher degree of methodological self-consciousness. (Some considerations that support these claims will be mentioned later.) For these and other reasons I have little hesitation in treating book 2 as the later essay, reworking in the light of greater maturity, and perhaps for rather different purposes, much of the material of book 1. The same criteria indicate that the affinities of book 3 are with book 2, not book 1, and hence encourage the belief that books 2 and 3 belonged to the same treatise. In what follows I shall be concerned mainly

⁶ For a summary of opinions, see Da Rios 1954, cvii-cxvii.

⁷ There are also several striking inconsistencies which cannot easily be resolved. But other scholars have taken different views, some fragmenting the work much more radically than I do, others declaring for its overall unity. See the survey mentioned in the previous note, and for a vigorous defence of a unitarian view, see now Bélis 1986, particularly 24-48; her position was already sketched in Bélis 1982, 450-451.

with the presumably later work represented by books 2 and 3, and shall draw only occasionally on book 1.

According to the *An. post.* [esp. 71b10–73a20] a science consists on the one hand of principles (*ἀρχαί*), and on the other of conclusions explained and deductively secured in the light of these principles. The pursuit of science, then, involves first the establishment of *ἀρχαί*, and secondly the demonstrative derivation of subordinate propositions. The establishment of *ἀρχαί* is not itself a matter of demonstrative proof (*ἀποδείξις*): the scientist works his way up to principles from a starting-point in perception by a process that is in one sense or another inductive, and whose stages are outlined, rather enigmatically, in the last chapter of *An. post.* ii. The *ἀρχαί* include, beside the so-called common axioms, both what Aristotle usually calls *ὑποθέσεις* (and which I take to be propositions asserting that this or that exists or is the case), and definitions of primary entities or kinds within the relevant domain [see, e.g., 72a14–24]. Having arrived at these *ἀρχαί* through ‘epagogic’ reflection on perceptual experience, we then set them to work as *ἀρχαί* by identifying the special relations in which they stand to other propositions of the science, propositions which are not primary and which are scientifically understood only when they have been derived apodeictically from the appropriate *ἀρχαί*. The *ἀρχαί*, then, must be grasped as epistemologically and metaphysically prior to the facts expressed in these subordinate propositions, and as providing the explanatory ground for them (these points are summarily sketched at 71b19–22).

The *ἀρχαί* must also fulfil certain other conditions. Notably, they must be true and they must be immediate, not requiring explanation or demonstration in terms of anything else [see particularly *An. post.* i 2–3]. It is less than clear, epistemologically, how we can be sure in a particular case that either of these conditions holds: but the latter should be taken to mean that the *ἀρχαί* represent what belongs to the essence of things in the relevant domain, expressing what it is to be such and such. In the case of a class of perceptible things it is reasonably clear why, in Aristotle’s view, the things that hold essentially of members of the class as such are not capable of being demonstrated from any higher considerations but must be grasped through a process of abstraction and coordination, a process directed at the data which our perceptual experience of them provides.

We have an understanding of the subordinate truths of a science only if we have demonstrated them: that is, we must not merely prove them by logical derivation from propositions known to be true, but we must derive them from principles that explain why they are true [see particularly *An. post.* i 2–3, 13]. The Aristotelian content of the notion of explanation is of course complex and takes us beyond the scope of the *An. post.* But

in a general and abstract way, ‘explaining why property *P* holds of subject *S*’ here means ‘showing that *P* holds of *S* because the essence of *S* (as expressed in some *ἀρχή* or *ἀρχαί*) logically requires it’. As a consequence, Aristotle argues, the conclusion of an *ἀπόδειξις* must hold of its subject as such in virtue of the essential nature of that subject (and not of some other thing or of the same thing differently conceived: see, e.g., *An. post.* i 4 and 6). And it is as a consequence of this proposition that Aristotle maintains the impossibility, except in certain very special kinds of case, of demonstrating *ἐξ ἄλλου γένους μετέβαντα* [75a38: cf. 71b22–23, and below]: a single science is delimited by a kind (*γένος*) that constitutes a single domain whose contents stand as the subjects of both the primary and the subordinate propositions. This requirement, as we shall see, has crucial work to do in determining the shape of Aristoxenus’ harmonic theory.

But let us postpone consideration of that issue for the present and concentrate first on the general adequacy of fit between the *Harm. elem.* and the framework that Aristotle proposes. That there is some sort of rough correlation is reasonably clear: the two books we are principally considering seem to fall quite neatly under the two categories that the Aristotelian scheme demands. Book 2 articulates and discusses the *ἀρχαί* of the science: book 3 sets out a series of formal derivations from these *ἀρχαί*, demonstrations that this is a melodic sequence (while that is not) or that a melodic sequence in some one genus is subject to such and such conditions; and these demonstrations are at the same time explanations of why these things are so. Aristoxenus calls his derivations *ἀποδείξεις* and his use of the expressions is undeniably Aristotelian in intent.⁸ He also makes several methodological declarations that distinctly echo the *An. post.* in both language and content. He alludes scathingly to other theorists who have

⁸ Aristoxenus also refers twice to a section of his work as ‘elements’ or as ‘concerned with the elements’. In i 28.34–29.1, a proposition *ἐν τοῖς στοιχείοις δευχθήσεται*: in ii 43.27–30, after introducing the main topics of harmonics but before elaborating his treatment of them, he says, *μέλλοντας δ’ ἐπιχειρεῖν τῇ περὶ τὰ στοιχεῖα πραγματείᾳ δεῖ προδιανοηθῆναι τὰ τοιαῦτα*; and goes on to present methodological reflections that insist on a distinction between *ἀρχαί* and what follows from *ἀρχαί*. In the former passage, the *στοιχεῖα* evidently constitute part of the treatise: in the latter they seem to be the ‘elements’ of *μέλος* itself, some part of the harmonic scientist’s project being designated by the expression *τῇ περὶ τὰ στοιχεῖα πραγματείᾳ*. It is not clear whether these parts of the treatise, or of the investigation, include the whole of its ‘scientific’ content (that is, everything after the discursive introduction), or whether they are restricted to the ‘demonstrations’ alone (that is, to the contents of book 3). Bélis [1986, particularly 34–48] takes a clear and strong line in identifying book 1 of the *Harm. elem.* as *ἀρχαί* and the other two as *στοιχεῖα*, but the problems are, I think, more complex than this treatment suggests.

asserted their propositions *ἀνευ αἰτίας καὶ ἀποδείξεως*: he himself, by contrast, will seek both to adopt (*λαβεῖν*) suitable *ἀρχαί* and to demonstrate (*ἀποδεικνύναι*) τὰ ἐκ τούτων συμβαίνοντα [32.29–33.1]. The *ἀρχαί* themselves, of course, cannot be demonstrated: τὸ γὰρ πῶς ἀπαιτοῦν ἀπόδειξιν οὐκ ἔστιν ἀρχοειδές [44.14–15]. Again, every science that consists of several propositions must adopt (*λαβεῖν*) *ἀρχάς*... ἐξ ὧν δειχθήσεται τὰ μετὰ ἀρχάς [44.3–7]. In passages like these Aristoxenus' debt to the *An. post.* could hardly be more obvious. He believed that he had succeeded in a task whose character his predecessors had not understood and whose necessity to harmonic science they had not even noticed, that of drawing the harmonic facts into an Aristotelian system of *ἀρχαί* and *ἀποδείξεις*. On this achievement he rests one of his major claims to originality and importance.

As in Aristotle's scheme, some of the *ἀρχαί* take the form of definitions: each of the seven μέρη of the science outlined in the early sections of book 2 involves a subject to be defined, and various other items are also defined along the way. The definitions initially offered, however, are explicitly schematic,⁹ requiring more detailed articulation and differentiation as well as an enumeration of the more specific types of item falling under the subjects outlined. Not all Aristoxenus' elaborations of detail have survived: some that he promised may never in fact have been given.¹⁰ What we do find are close accounts of some specific types of structure falling under the broader kinds that certain definitions sketch, notably his descriptions [i 21.37–24, ii 46.19–52.33] of tetrachordal divisions in the three melodic genera and some of their subordinate *χρῶα* (nuances or shades). But this phase of Aristoxenus' project raises serious questions about his method. Though the analyses of these divisions might, not unreasonably, be given the status of definitions (definitions of species falling under a broader kind rather than more detailed definitions of the kind itself), the terms in which they are set make it very difficult to construe them as *ἀρχοειδῆ*, as principles proper to the science. On the other hand they are plainly not demonstrated in the technical sense, nor did Aristoxenus think they could be. There are problems here to which we shall return.

In addition to definitions, the *ἀρχαί* include what Aristotle calls *ὑποθέσεις*. Aristoxenus uses no corresponding noun; but he sets out a series of principles whose importance and primacy he vigorously underlines, each asserting that something is the case and each introduced by such words as

⁹ See, for instance, Aristoxenus' engaging appeal to his hearers at *Harm. elem.* 16.2–16.

¹⁰ Thus, at 36.17 he raises the question, What is a *δύναμις*?, as one that urgently demands an answer. But if he gave an answer, it left no trace in the writings of his successors and epitomisers.

ὑποκείσθω [in book 1, esp. 29.1–34], *λαμβάνετω* or *θετέον* [in book 2, esp. 54.7, 19]. As is appropriate to such primary propositions, they are quite ostentatiously presented with no attempt at proof or derivation. One of them he describes as 'the first and most indispensable of the conditions that bear upon the melodic combination of intervals' [τὸ πρῶτον καὶ ἀναγκαϊότατον τῶν συντελούντων πρὸς τὰς ἐμμέλεις συνθέσεις τῶν διαστημάτων: 53.33–54.1]. A little later he says of it, 'Let this, therefore, be posited as first in the order or principles: if it is not fulfilled, the harmonic attunement is destroyed' [θετέον οὖν τοῦτο πρῶτον εἰς ἀρχῆς τάξιν οὐ μὴ ὑπάρξάντος ἀναιρείται τὸ ἡρμουςμένον: 54.19–21]. It cannot be over-emphasised that the οὖν (therefore) in this sentence does not mark the conclusion of any sort of argument. The Aristotelian thesis that principles cannot be demonstrated is one that Aristoxenus wholeheartedly endorses: 'Anything that requires demonstration (*ἀποδείξις*) is not *ἀρχοειδές*' [44.14–15].

To the extent that it deals with principles, then, it is no criticism to point out that book 2 contains hardly anything in the way of arguments to support the musicological assertions it makes. (The same could be said of book 1.) There are arguments in book 2, but virtually all of them are methodological, and have to do with the way in which the subject is to be approached; they are not designed to establish substantive propositions of the science. The impressive and elaborate typology of melodic genera, the principles governing melodic succession, the enumeration of concordant intervals, the definitions of an array of harmonic concepts, these and all the rest are flatly asserted, not argued, rarely even supplied with supporting considerations. This is not a sign of either arrogance or incompetence: it is a necessary consequence of Aristoxenus' determination to take seriously the distinction between what can be demonstrated and what cannot [see 43.34–44.1].

The only proper approach to the latter is inductive, and it is important to be clear about what this implies. It implies that they cannot be established by any argumentative device capable of being presented in a written treatise. The function of the treatise, so far as they are concerned, is to systematise and draw to our attention what is implicit in our own experience, that is, in the perception by carefully trained and attentive listeners of certain phenomena as melodic. If we attend to our experience we shall recognise the authority of the principles that Aristoxenus articulates and the cogency of the distinctions marked by his definitions, as accurately mapping the framework within which our perception of melodies takes place.¹¹

¹¹ Each of the primary propositions must be both *ἀληθές* and *φαινόμενον*: it must also be such as to be grasped (*συνοπᾶσθαι*) by *αἰσθητής* as being among the *πρῶτα* of the various parts of harmonics [44.9–13; cf. 32.31–33.1].

The principles of harmonics are not recognisable as such except through an individual's reflection on his own perceptual experience.¹² No amount of reading treatises can give such experience and, hence, any attempt to establish their truth through the written (or spoken) word would be out of place and futile.

Similar considerations explain why Aristoxenus tells us nothing of particular examples of melody drawn from his own experience, on which his inductive generalisations might be founded. We might expect a treatise in empirical science to offer case studies or experimental reports at least by way of examples: Aristoxenus does not provide such data, though he occasionally mentions what he would expect his readers' experience to be under certain conditions. Whatever may be true of the other ancient sciences, I suggest that there are good reasons for the omission here. In most empirical sciences we typically assume—unless we affect a hyperbolic form of scepticism—that what the researcher observed at some time would have been observed also, other things being equal, by anyone else who had been there. Hence, the researcher's experience can stand proxy for our own, as a basis for the inductive extraction of principles. In Aristoxenian harmonics this is not so, not because Aristoxenus supposes that the assumption would be false but precisely because it is part of the task of harmonics to show that it is true. Little purpose would be served by descriptions of individual cases that Aristoxenus has observed, since we must not assume that we would experience them in the same way. Hence, he states his principles without supporting evidence: we ourselves must provide the grounds for believing that they hold universally, by finding that they are indeed implicit in our own perception of individual cases. To present examples in evidence, or any form of argumentation, would be to offer the illusion of support for the principles without the reality: that is something that the written word cannot provide.

Aristoxenus' text contains one superficially anomalous case, his 'argument' to the conclusion that the concord of the fourth is an interval spanning exactly two and a half tones [56.13–58.5]. But in fact this helps to prove the rule, since it is not offered as an argument in the relevant sense at all. That is, it does not seek to establish anything without recourse to the listener's own perception: it explains a practical method by which the student can satisfy *himself* of the truth of the proposition. He must work through a specified musical construction in practice, not on paper or in his head, and *listen carefully* to its results [see esp. 56.31–33]. If and only if the results are heard in a certain way, the proposition will have been

¹² See especially the contrast with geometry at 33.10–26.

established [56.33–57.3]. The method which Aristoxenus describes has its flaws,¹³ but these do not affect the point I am trying to make. The intention of the passage is not to establish a musical proposition by argumentative means, but to show how perception may be used in order to judge whether the proposition is acceptable or not. To repeat: in a science based on the ideas of the *An. post.* it cannot be the function of a treatise to establish the truth of ἀρχαί. It can only *identify* them, on the basis of the author's own experience, in a form that allows us to recognise them in our own; and it can organise and coordinate them so as to bring out their interconnections and to make them available for use in ἀπόδειξις.

These reflections suggest something important about the way in which an Aristotelian scientist's work is to be construed. There is a sense in which Aristoxenus' writings do not by themselves constitute the science, the body of knowledge, of which he spoke. This is not to deny that these writings were, in their original form, as complete and accurate an account of their subject as any treatise could be: on this issue we do not need to pronounce. The point is that the treatise, no matter how finished a product it is, cannot itself be the knowledge which its author possesses and to which its readers may aspire. The thesis that knowledge is a property of minds, not of books, is not just a tendentious *a priori* dogma. There are good grounds here for saying that the book cannot even be a written representation of its author's knowledge, since there can be no such representation of the conditions that constitute it as knowledge. A treatise may enunciate the laws and principles on which its demonstrations rest, but it cannot incorporate the grounds that give them the status of scientific truths objectively established. The task of the written or spoken exposition is to guide others towards understanding, by articulating the truths that they must recognise if they are themselves to master the science of harmonics. Scientific understanding *establishes* these truths and the treatise does not. Then a science is not something that can exist in a book or a library or a data-bank: there is no impersonal corpus of scientific knowledge. A science must satisfy conditions that can be satisfied only by a mind that can draw on its own experience in confirmation of its claims: it is a δύναμις θεωρητική, a mental capacity or disposition, something that can be neither contained nor represented in the written or spoken word [cf. *Harm. elem.* 41.6–24].

Such a conception of a science is closely related to that of a τέχνη or practical skill (though there are differences, emphasised in 41.6–24.) The principles of such a skill may have been fully discovered and developed

¹³ Exposed with acid precision by Ptolemy, *Harm.* 21.21–24.29.

long ago: they may even have been written down in works entitled, 'The art of such and such'. But plainly the art or skill does not exist in anything written: it is not even the sum of the propositions enunciated there, but consists of the capacities and dispositions of individuals who have mastered it. Similarly, a science is a mind's organised and systematic grasp of a determinate domain. What a treatise expresses can be knowledge only in so far as its principles are grasped by a mind that has recognised their truth; and that recognition depends on the mind's own experience, since their truth cannot be established by anything independent of that. Aristotle himself says something in this vein:

Demonstration is not directed to external discourse, but to that in the soul... for it is always possible to raise objections against the external discourse, but not always against the internal.

οὐ γὰρ πρὸς τὸν ἔξω λόγον ἡ ἀπόδειξις, ἀλλὰ πρὸς τὸν ἐν τῇ ψυχῇ
... ἀεὶ γὰρ ἔστιν ἐνστήναι πρὸς τὸν ἔξω λόγον, ἀλλὰ πρὸς τὸν ἔσω
λόγον οὐκ ἀεὶ. [*An. post.* 76b24-27]

In that case it seems misleading to treat the *An. post.* as offering only a framework for teaching, if this implies that it is not also designed to describe the form of a finished science and to commend certain approaches to research. In describing the conditions of ἀπόδειξις and the ways in which the ἀρχαί must be established, Aristotle is analysing the structure of a system of understanding that can exist only in a mind, not in a teacher's presentation of his material.

Again, since our grasp of a domain of experience becomes knowledge only when it is systematically ordered and grounded in the appropriate way, research in that domain must be, at least in part, a search for ways in which the phenomena of experience can be so ordered. Aristoxenus' success in finding principles and categories under which an empirical grasp of musical facts can be converted into an Aristotelian science is the core of his achievement; and it would be curmudgeonly to refuse his endeavours the title of research merely because they did not necessarily involve the discovery, or even the pursuit, of hitherto unsuspected first-order facts. The expression of the results of this research in writing ceases to be science and becomes pedagogy. No doubt it is appropriate to teach students who seek to become knowers by a method that brings out, as clearly as possible, the system of relations that must hold between propositions in their mind and between these propositions and their experience if knowledge is to be achieved. The treatise or lecture should therefore mirror the structure of the science so far as it can. But the structure of pedagogy, like that of research, is derived from that of the science itself as it may exist in a

knowing mind and not the other way round; and as we have also seen, there are crucial aspects of the science, as Aristotle describes it and Aristoxenus pursues it, that the teacher's pronouncements have no power to represent.

2. The 'same domain' rule and Aristoxenian phenomenology

A scientifically perspicuous description of what I heard when I heard some sequence of sounds as a melody would draw attention to properties and relations that contributed essentially to its being heard as melodic or as being of some determinate melodic kind. The ἀρχαί of harmonic science are abstracted inductively from observations of phenomena to which such descriptions could be attached, clarifying, generalising, and coordinating them, but not introducing new matter from elsewhere. Subordinate rules are derived from principles deductively. It is considerations like these that underpin Aristoxenus' enthusiastic endorsement of what I shall call Aristotle's 'same domain' rule, according to which no ἀπόδειξις of what belongs to a subject in one domain can be derived from principles proper to subjects in another. In short, as Aristotle says, one cannot demonstrate ἐξ ἄλλου γένους μετάβαντα [cf. *An. post.* 75a38].

Aristoxenus lays great stress on this rule. To break it is ἀλλοτριολογεῖν [32.20: cf. 32.27] or εἰς τὴν ὑπερορίαν ἐμπέπειν [44.17-18], and scientific understanding cannot come that way. In so far as a statement belongs to harmonics, it mentions nothing that falls outside the domain defined by the essence of the kind with which harmonics is concerned, τὸ ἡρμοσμένον and its species. Crucially, no laws describing the regular behaviour and properties of what is melodic as such can be demonstrated from principles expressing what is essential to things of another kind. Each principle of harmonic science, we are told, must be both true and φαινόμενον: it must be such as to be accepted as a primary principle by αἰσθησις [44.9-14].¹⁴ That is, it must express what is essentially involved in something's presenting itself to our hearing as melodic, not offer descriptions referring to entities of another sort or even to sounds conceived under an aspect which is not that presented to musical αἰσθησις. It may not, then, impose rules based on a conception of sounds as movements of the air, differing in the rapidity of their transmission or in the frequency of the impacts that initiate them, since it is not as patterns of relative speeds or frequencies that sequences of sounds present themselves to the ear as melodic or

¹⁴ Compare for instance *An. post.* i 6, particularly 74b24-6: the ἀρχή of a demonstration is τὸ πρῶτον τοῦ γένους περὶ ὃ δέικνυται· καὶ τάλῃθες οὐ πᾶν οἰκεῖον. See also 81a38-b9.

unmelodic. Nor, for the same reason, can harmonic rules be founded in a representation of pitch-differences as ratios of numbers.¹⁵ The entities, properties, and relations mentioned in the ἀρχαί must be exclusively ones to which precisely articulated observation-statements would already need to refer—statements saying just what it was about an experienced set of sounds that constituted it as melodic or as an instance of some specific melodic kind.

Aristotle grounds his 'same domain' rule in considerations of just these sorts, though of course without reference to the special domain of harmonics. The reasoning is essentially simple. Any putative demonstration that broke the rule would not display its conclusion, which asserts that some property belongs to entities of a given kind, as flowing from the nature of the entities themselves and, hence, as being explained by reference to that nature. The link between any entity's possession of that nature and its possession of that property would remain merely contingent, even if the pseudo-demonstration showed in the light of something else that the conclusion was indeed true.¹⁶ If in fact the inherence of certain properties in things of kind *K* cannot be demonstratively explained from ἀρχαί expressing the φύσις of that kind, then either there is no such φύσις and *K* is an arbitrarily designated class of accidental aggregates, or else the properties in question do not belong to things of kind *K* as such but only under some description that applies to such things contingently (κατὰ συμβεβηκός).¹⁷

But Aristotle allows exceptions to the 'same domain' rule in cases where one science falls under another in a specified manner. There are cases where it is the task of one science to describe the perceived properties of phenomena in a specific domain and the relations between these properties, but that of another to explain why the properties belong to them and why they are so related [see *An. post.* 75b14–20, 76a9–15, 78b32–79a16]. The situation seems to be this. The 'empirical' version of a science identifies a range of properties that perception finds attached to subjects of a given sort. The 'explanatory' version then identifies these properties as special instances of a more generalised class of forms, instances whose perceptible character derives from the inherence of the forms in the kind of perceptible

¹⁵ These issues are mentioned several times in book 1 in ch. 8–12, esp. 9.2–11, 12.4–32: see also ii 32.19–28.

¹⁶ The statement at *An. post.* 75a38 that one cannot demonstrate ἐξ ἄλλων γένους μετάβατα is introduced with the particle ἀρα, indicating that it is the conclusion of an argument and not a new assertion. The argument is contained in the whole of i 4–6. What I have said here is not even a summary or a paraphrase of those chapters, but may serve to indicate their general drift.

¹⁷ See the forceful statement at *An. post.* 75a28–34: cf. for instance, *Phys.* 192b28–32.

matter under investigation, though they can, at least in principle, occur as forms organising matter in other perceptible domains. These forms remain what they are independently of the genus of matter on which they are imposed, and their nature and relations can be studied in abstraction from any such matter (though of course they cannot exist in separation from matter of some determinate sort). The prime examples of forms that are properly studied at this abstract level are the objects of mathematics, and in each case the explanatory version of the sciences that Aristotle mentions is a mathematical one.¹⁸

We can extract the skeleton of an example from *De sensu* 439b19–440a6, where Aristotle compares certain properties of colours and of sounds. He offers the view (though it is not clear whether he endorses it) that the same numerical ratios which characterise the relation between sounds that are perceived jointly in certain special ways, also express the relation between instances of the basic colour-types, dark and bright, when they are so related as to produce jointly certain perceptible results. He seems to suggest that the acoustic and visual phenomena explained in terms of the same numerical ratio may themselves be somehow analogous. The perceived property is of course different in each case, since one is seen and the other heard: but within its own perceptual domain, each is the analogue of the other.

For the colours that are in the most well-ratioed numbers, like the concords in the other case, appear to be the pleasantest of the colours, ones like purple and scarlet and a few others of that sort (for which reason the concords too are few), while those that are not in numbers are the other colours.

τὰ μὲν γὰρ ἐν ἀριθμοῖς εὐλογίστοις χρώματα, καθάπερ ἐκεῖ τὰς συμφωνίας, τὰ ἥδιστα τῶν χρωμάτων εἶναι δοκοῦντα, οἷον τὸ ἀλουργόν καὶ φοινικοῦν καὶ ὀλίγ' ἄλλα τοιαῦτα, δι' ἣν περ αἰτιάιν καὶ αἱ συμφωνίαι ὀλίγαι, τὰ δὲ μὴ ἐν ἀριθμοῖς τὰλλα χρώματα. [*De sensu* 439b32–440a3]

In each case, then, the subordinate, empirical science classifies the properties by the way they appear to eye or ear. They appear as colours or as sounds because of the character of the matter in which they are present. But the reason why they have their special perceived characteristics within

¹⁸ For valuable accounts of Aristotle's views on these paired sciences, see Lear 1982 and Lennox 1986, particularly 31–44, which builds on Lear's approach. But while they give substantial help with the question how mathematics makes contact, in Aristotle's view, with the empirical subject matter of physics, I would argue that Aristoxenus' grounds for resisting Aristotle's position with respect to harmonics remain untouched. I discuss this resistance below.

any domain, and are related in their own special ways to other properties in that dimension (e.g., as concords stand to discords, or as primary and attractive colours stand to muddy intermediates) is revealed through some branch of mathematics. It is revealed when the perceived properties and relations are shown to be instances, in particular types of matter, of mathematical properties and relations, quantitative forms that can be abstracted in the same way from each.

It is striking that when Aristotle needs an example of such pairs of sciences, he finds it natural to turn to harmonics in its perceptual and mathematical guises (explicitly twice, and by implication in a third passage).¹⁹ Yet Aristoxenus rejects with the utmost vehemence the suggestion that this relation holds, that the *αλτία* of the phenomena which 'perceptual' harmonics classifies can be provided by mathematics or by mathematical acoustics [ii 32.18–28: cf. i 9.2–11, 12.4–32].

He does so not because he disputes Aristotle's theory of scientific explanation, but precisely as a good Aristotelian. The phenomena harmonics describes and classifies are the properties of groups of sounds heard as forming a melodic sequence: 'being melodic' is a property of sounds presented to the ear and exists nowhere else, and the properties that a melody has as such are necessarily and essentially those grasped *κατά τὴν τῆς αἰσθήσεως φαντασίαν* [8.23, 9.2–3: cf. 48.22]. It may be true, Aristoxenus seems to concede [cf. i 9.2–11, 12.4–32], that the pitches of sounds are in fact determined physically by their velocities, or by some other quantitative variable. It might even be open to him to accept, for instance, that the movements causally responsible for sounds an octave apart stand to one another in the ratio 2:1, those generating sounds a fourth apart are in the ratio 4:3, and so on, as the Pythagoreans had proposed, and both Plato and the acoustic scientists of the Lyceum agreed.²⁰ But facts like these, in Aristoxenus' view, could in principle do nothing to explain why certain sequences of intervals and not others present themselves to the ear as melodic. There are no mathematical reasons, or reasons within the province of physical acoustics,

¹⁹ *An. post.* 78b32–79a16, 87a32–4: cf. 90a18–23. The other passages mentioned above [75b14–20, 76a9–15, 78b32–79a16] are also relevant. It is only at 79a1–2 that the two sciences are described as ἀρμονική ἢ τε μαθηματική καὶ ἢ κατὰ τὴν ἀκοήν: elsewhere they are ἀριθμητική and τὰ ἀρμονικά (or ἀρμονική).

²⁰ But to accept this would invite difficulties. Notably, since there is no mean proportional between terms in superparticular ratio, that is, in one of the form $(n+1):n$ [see Boethius *De mus.* iii 11; *Sect. can.* props. 3, 16, 18], it would be impossible to specify ratios of velocities belonging, for example, to notes an exact half-tone apart. Aristoxenus insisted, but mathematical theorists denied, that the tone and other superparticular intervals such as the fourth (4:3) can be divided into equal parts.

why there can be, for example, at most two notes between given notes a fourth apart in a single scale-system, or why no more than two *dieses* can be sung successively in the course of a melody, or why the lowest interval of a tetrachord between fixed notes is always smaller than the highest, and so on. Nor can such sciences explain why the boundaries of the genera lie where they do, or why the melodic structure called the *πυκνόν* cannot span an interval equal to or greater than half the magnitude of a concordant fourth. It is true that the boundaries of the genera and the limits of the *πυκνόν* can be quantitatively specified (a fact that raises difficulties of its own, to which I shall return). But the boundaries marked in this way correspond to no distinctions that are mathematically significant: from a mathematical point of view their placing seems quite arbitrary; and mathematical principles cannot show why melodically significant boundaries should lie there, rather than somewhere else. Thus, it is a fact of musical experience, according to Aristoxenus, that the sequence of two quarter-tones is heard as generically different from that of two intervals of one third of a tone, while the latter sequence differs only in *χρόα*, not in *γενος*, from a sequence of two semitones [see, e.g., 50.22–51.1 with 48.21–26]. Nothing in mathematics would lead us to expect this result nor can mathematical laws explain it.

Indeed, *nothing* can explain it outside principles generalising or abstracting from the perceived data of harmonics itself. For Aristoxenus, harmonic truths are not to be explained by reference to something external to our perception of melodies. Rather, they are to be organised and understood solely in terms of the system in which they themselves appear. The task of harmonics is to reveal the structure of phenomena taken as phenomena, to show that for something to be melodic is for it to fit within a certain orderly system, and to describe that system's anatomy. It is not to show how the structure of the system is determined by something else, mathematical or physical, because there is nothing that so determines it. It is an independent essence, existing only in the realm of audible musical sound. It is not an ordering of entities that 'really' exist in some more fundamental domain, of which the heard sounds are just one aspect; nor is the ordering one that can be abstracted without loss from the 'material' of sound and transferred, even in principle, to another domain. The crucial relations can no more be abstracted from the domain of the audible than can the relation of sweet to bitter, for example, from the domain of taste.

Even among authors who espoused mathematical harmonics in Aristotle's sense, there were those who recognised a problem to be solved in this connection. It could not just be assumed that the forms which appear as properties of melodic phenomena are the very same forms as those with

which the mathematics of ratio and proportion concerns itself: in hearing sounds as melodically related we plainly do not hear them as standing to one another in certain classes of ratio. That they are indeed the same forms is something that must be shown, a task that the writer of the *Sectio canonis* at least undertook, however unsuccessfully, in the introduction to the treatise [Menge 1916, 148–149: but see chapter 8 in this volume].

I do not mean to imply, of course, that Aristoxenus' stand on these matters is impregnable. Several points could be urged against him, of which two are worth mentioning here. First, he may have misconstrued the Pythagorean conception of the relation between audible phenomena and their mathematical counterparts. I shall not argue this question (though for what it is worth, I do not think that he was wrong), since some of his criticisms are in fact quite independent of the subtler nuances of interpretation that these relations may be given. In particular, he claims as a plain fact that there are significant differences between melodic systems, scalar systems, and so on, to which no comparably significant mathematical distinctions correspond, and that there are rules of melodic sequence whose mathematical counterparts could be derived from no rationally compelling principle: from the mathematician's point of view the rules must seem merely arbitrary. Now the Pythagorean ratios might be conceived as analyses of relations between physical events distinct from the sounds they cause. Alternatively, they might be conceived in various ways as characterisations of the mathematical form of the melodic relations between musical notes themselves. To Aristoxenus, however, such details are unimportant. Any audible relation between sounds, or any relation between the 'physical' causes of the component pitches, could no doubt be described in the language of ratios. But if the rules of melodic progression turn out to be purely accidental with regard to the principles of mathematics, or if in distinguishing between the mathematical counterparts of perceptually distinct melodic forms we are making classifications that are mathematically arbitrary and unintelligible, these translations into mathematical terminology will have achieved nothing. They will have brought us no nearer to the goal of explaining the musical phenomena or of elucidating the grounds of their coherence and order: this orderliness will, if anything, have been obscured under the 'accidents' to which mathematical descriptions draw attention.

Secondly, however, it might be argued that Aristoxenus is mistaken in supposing that the Pythagoreans intended, as he did, to analyse and coordinate the rules and distinctions implicit in ordinary musical experience: their real project was prescriptive rather than descriptive, concerned primarily with the excogitation of mathematical or metaphysical ideals. There

would probably be some truth in this accusation if, for example, Aristoxenus' main targets were theorists of a more or less Platonist persuasion. But not all mathematical theorists were concerned solely with rational paradigms. I would argue that Archytas, for one, was deeply interested in the description, analysis, and coordination of the systems implied in current musical practice, as were such writers as Didymus and Ptolemy in later antiquity. Others, it appears, were not: examples would be Plato himself, at least in some of his moods, and later commentators such as Theon of Smyrna. Certain mathematical writers—Eratosthenes, for instance, and Theon's main source, Adrastus—seem to show traces of both approaches. There was no uniform 'Pythagorean' project with a single, unambiguous goal: mathematical analyses were offered by different authors for different purposes. But in so far as mathematical theorists did share Aristoxenus' ambition to describe and explain the credentials of melodic systems in familiar contemporary use, there can be little doubt that he had the better of the argument, for the reasons given above. His approach enabled him to identify and coordinate a far richer collection of musical forms and distinctions than the Pythagorean scheme of concepts could even describe, let alone subsume under mathematical principles. Even if Pythagoreans and Platonists could offer a mathematical account—an analysis and an explanation—of some properties essential to melodic systems, still a vast storehouse of properties and relations remained untouched.²¹

²¹ The representation of pitch-relations as ratios was flexible enough to express many different forms of attunement or scalar series. In the fourth century, three distinct 'generic' versions were described by Archytas [Ptolemy, *Harm.* 30.9–31.18 = Diels and Kranz 1951, i 428.15–37], and these differ again from the 'Pythagorean diatonic' of Philolaus (if we accept as genuine the disputed fragment from Nicomachus, presented as the second paragraph of Diels and Kranz 1951, i 408.11–410.10) and Plato [*Tim.* 35b–36b], which is the same as that implied in *Sect. can.* props. 19–20. Different ones again were later offered by Eratosthenes and Didymus, and with impressive sophistication by Ptolemy: for all these, see Ptolemy, *Harm.* 70.5–74.3. But their mathematical principles, even Ptolemy's, could cope with relatively few tasks in the field of explanation. Attempts were made to account for the perceived difference between concord and discord [e.g., Porphyry, *In harm.* 107.15–108.21 = Diels and Kranz 1951, i 429.1–27; Menge 1916, 149.11–24: cf. [Aristotle] *De aud.* 803b26–804a9]. More importantly, the Archytan theory of means [Porphyry, *In harm.* 93.5–17 = Diels and Kranz 1951, i 435.19–436.13] was held by some authors to provide a rational basis for the construction of well coordinated systems; and it could then be used to explain one feature of a legitimate attunement that distinguishes it from improper ones—the former and not the latter divides the octave proportionally (most clearly Plato, *Tim.* 35b–36b: the same principles are also at work in Archytas' own divisions). Other authors found different principles to do similar work. Those adopted by Ptolemy have features that arise from reflection on the special characteristics of

Aristoxenus' concept of these essentially melodic properties and relations is closely linked to what he calls *δύναμις*. He has no corresponding adjective, but we can reasonably use 'functional' or 'dynamic' to describe the relevant properties of notes, intervals, and sequences. The notion of melodic *δύναμις* is the central pivot of Aristoxenus' approach to his subject in books 2 and 3. (The fact that it appears nowhere in book 1 constitutes the most significant difference between its ideas and those of the presumably later treatise.) It is too large a subject to be explored fully here, but a sketch is essential. The subject is best approached through the contrasts Aristoxenus draws between *δυνάμεις* on the one hand and purely quantitative features of notes and intervals on the other, particularly what he calls the *μεγέθη* (magnitudes) of intervals. A pitched sound may take its place in a melody by being perceived, for example, in the character of the note called *λιχανός*—that is, the note immediately below the note *μέση* which is the principal focus of the system. To be *λιχανός* is not to be a sound of any particular pitch. Nor is it even to be a sound standing at an interval of some definite size (*μέγεθος*) below *μέση*. That is, perceiving a note as *λιχανός* is not identical with perceiving it as a note at such and such a distance below *μέση*. Our perception of a note's melodic function, its *δύναμις*, is distinct from and may not even include a perception of the magnitudes of the intervals between it and other notes: in fact the note *λιχανός* may stand, according to Aristoxenus, at any distance from a tone to a ditone (inclusive) below *μέση*. Its being *λιχανός* and so its finding a genuinely melodic role depends only on its being perceived within the prevailing system as the note between which and *μέση* no other note can melodically be inserted.²² (*Μέση*, of course, is also dynamically determined, and so is every other note in the system: all notes exist in their relations to one another, relations constituted partly by their sequential order, partly

superparticular ratios [see esp. *Harm.* i 7], whose privileged status was recognised before Archytas, though he gave it new emphasis [cf. *Harm.* i 13]: but they do not depend on the Archytan theory of means, relying instead on applications of several subtle and distinct conceptions of mathematical 'equality' [see *Harm.* i 7, 15, 16]. But none of the other essential features of melodic systems as Aristoxenus identified them could be accounted for by such purely mathematical expedients. Ptolemy is commendably frank about this, despite the 'rationalistic' ambitions declared in *Harm.* i 2. The point is most explicit in *Harm.* i 15, where he distinguishes sharply between 'principles of reason' and 'theses based on agreed perception', and insists that these are independent and equally indispensable starting-points for the derivation of properly ordered systems of attunement. On Archytas' own conception of the relations between mathematical principles and the data of experience, see Barker 1989.

²² Aristoxenus discusses and defends his position elaborately in 46.24–50.14.

by relations of concordance between certain fundamental notes, and partly by the ways in which the actual locus of one note, within the boundaries of these concords, carries implications for the positioning of the others.)

To take another example, a chromatic sequence is not to be defined as an ordering of some particular set of intervallic magnitudes nor even as a disjunction of such orderings. A chromatic sequence is essentially one heard as having a certain melodic character, which it is the business of trained musical perception to recognise. That character is preserved no matter which of indefinitely many different sets of magnitudes its intervals may possess within determinate ranges: it is this character that constitutes its *δύναμις* as a form of melody, and it is only when we have recognised this character as definitive of the chromatic that we can begin to enquire which sets of intervallic magnitudes, in which melodic contexts, in fact present it to the ear [see 48.15–49.2]. Again, the so-called *πικνόν* is not in essence a pair of intervals of such and such a size, or even one with a determinate range of magnitude. In fact all *πικνά* do fall within a determinate range [50.15–19] but it is not this fact that defines them as such, nor is it in that character that they are perceived as *πικνά*. A *πικνόν* is to be defined as a pair of intervals that presents to perception a certain character of sound [*πικνου τυπὸς φωνή*: 48.30], and it is in having that sort of sound, not in being of some size or other, that a *πικνόν* plays its dynamic part in melody and affects the melodic character of what we hear. Conversely, two intervals of equal size may differ in *δύναμις* by differing in their locus within the system or in the genus of the system to which they are heard as belonging [see, for instance, 47.29–48.6]: this difference will determine distinct melodic roles for each of them and different possibilities for melodic continuation from them.

In general, if we identify the absolute pitches of sounds in a sequence or spell out the sizes of the intervals between them, we are not thereby giving an explication or analysis of the fact that they form a melodic series or that they possess some specific melodic character [see 40.11–24]. In hearing pitches as melody it is not these features as such that we attend to. Rather, their melodic character depends on their being heard in determinate dynamic roles that form a consistent pattern of reciprocal relations, relations which cannot be described in other than dynamic terms. The language of harmonic *δυνάμεις* cannot be translated into that of *μεγέθη*. A basic task of the student of harmonics is to learn to identify the melodic relations he hears under their dynamic categories, since it as *δυνάμεις*, not as *μεγέθη*, that they constitute the data that he must come to understand. Harmonics seeks to articulate the system in which the dynamic relations exist; to explore the implications, for the structure in which it occurs, of a note's being

heard as *λιχανός*, a sequence's being heard as chromatic, a pair of intervals' being heard as a *πικνόν*, and so on; and to show how these implications arise from a unified set of *ἀρχαί* that express the *φύσις* of melody. That dynamic relations have these specifically melodic properties involves and arises from their existence as elements in that *φύσις* which is articulated by the theorist as a systematically integrated relational structure.²³

In the context of Aristoxenus' insistence on the primacy of perception, this entails that individual instances of the *δυνάμεις* with which he is concerned are themselves objects of perception. The *δυνάμεις* must be present as such to ordinary melodic experience and cannot exist only as concepts of reflection or theoretical constructs of the harmonic scientist. Harmonics studies the melodic: being melodic is a property only of sounds as heard, and to be melodic is to fall under dynamic descriptions of the sorts I have sketched. This raises problems of two sorts. First, is the claim the *δυνάμεις* are objects of perception an intelligible and plausible one? And secondly, is Aristoxenus consistent in maintaining it? One passage, at least, suggests otherwise.

The first question is perhaps tangential to an exposition of Aristoxenus' ideas, but it is worth a moment's attention. One might argue that the directly perceived character of a sound must be limited to such features as its pitch, timbre, and volume, that is, to features determined by the physical processes through which it impinges on the ear. The intricate pattern of dynamic relations that Aristoxenus conceives cannot exist in the physical event of sensory reception and, hence, a note's melodic *δύναμις*—which consists, precisely, in its place within that network of relations—cannot be part of our perceptual experience of it. The large issues raised by such argument cannot be pursued in any depth here. So I shall be dogmatic.

The restriction of direct perception to a grasp of the so-called proper objects of each sense, though traces of it may be found in philosophers as eminent as Aristotle, seems to me quite without foundation. We hear sounds as standing in certain relations to one another, and these include relations of melodic implication just as surely as they include relations of pitch and loudness: similarly, we see things in visual relations, not just of colour and size, but also of symmetry and pattern. Of course, our reception of these relational properties is a complex matter, and it would be legitimate to set aside the expression 'indirect perception' to describe it just so long as this description does not serve surreptitiously to insinuate that it is

²³ The striking orderliness (*τάξις*) of *μέλος* is emphasised at 5.23–4: compare the description of the *φύσις* τοῦ συνεχοῦς at 27.17–33. References to the *φύσις*, of *μέλος* and of *μελωδία* and of τὸ ἡρμωσμένον recur frequently in this connection throughout the *Harm. elem.*

not really perception at all. In the case of sequences of sounds, such perception is conditioned by (at least) short-term memory, generating a complex within which the relations are grasped. Again, our capacity to engage in it can be heightened and sophisticated by training. Both of these are facts about which Aristoxenus is clear and emphatic [see 38.31–39.3, 33.1–26]. But there is no reason why they should impugn the status of these relations as inhering in what is perceived. A melody is something heard: its character as melody is not something intellectually constructed and imposed from outside our perceptual resources onto what is given to us only as a set of differently pitched sounds. To say that it is would imply that what makes something melodic is a structure discernible only by the intellect, a set of *νοηταὶ αἰτίαι*: such a Platonist or Pythagorean approach leaves it wholly mysterious how we can tell that something is a melody without the least recourse either to measurement and mathematical analysis or to the sophisticated investigations of Aristoxenian musicology. It would also fail to explain how Aristoxenian or similar conceptualisations can be recognised as accurate or inaccurate articulations of what we ourselves experience.

Whatever the truth about these issues may be, Aristoxenus is plainly committed in most of books 2 and 3 to the thesis that melodic *δυνάμεις* are indeed given to perception, and that it is in hearing sounds as related in these 'dynamic' ways that we hear them as forming a melody. But one passage can be read as denying this:

The project depends on two things, hearing and reason. Through hearing we assess the magnitudes of the intervals, and through reason we study their functions.

Ἀνάγεται δ' ἡ πραγματεία εἰς δύο, εἰς τε τὴν ἀκοὴν καὶ εἰς τὴν διάνοιαν. τῇ μὲν γὰρ ἀκοῇ κρίνομεν τὰ τῶν διαστημάτων μεγέθη, τῇ δὲ διανοίᾳ θεωροῦμεν τὰς τούτων δυνάμεις. [33.4–8: Macran emends τούτων το τῶν φθόγγων, but unnecessarily]

This suggests that only the quantitative aspects of intervals are detected by the hearing, while all grasp of *δυνάμεις* lies in the province of *διάνοια* (intellectual reflection). Now if that is what Aristoxenus meant and if anything in his procedures hung on it, it would be the ruin of his science. If the hearing can discriminate only intervallic *μεγέθη*, it can have no grasp of any of the major distinctions that are said to determine melodic form. But the immediate continuation of our passage makes such an interpretation impossible. At 33.32–34.10 it is said that we perceive (*αἰσθανόμεθα*) such things as the differences between genera, the differences between intervals of the same size lying in different parts of the system, the difference between two placings of an interval such that one, but not the other, creates a

modulation; and all these are differences of *δυνάμεις*, not of *μέγεθος*, or of anything reducible to the quantitative.

So what do the sentences quoted mean? I think the answer is clear enough. Aristoxenus is not concerned here with the way in which we standardly perceive melody and melodic relations. He is discussing the special resources we must deploy in order to generate the analyses characteristic of harmonic science (*πραγματεία*, the project). To hear a melody is to hear sounds in certain dynamic relations: but to articulate what these relations are and how they fit together demands reflection (*διάνοια*). That seems clear and unobjectionable. On the other hand, we do not hear something as melody by hearing its notes as standing to one another at certain intervallic distances. But there are certain distances at which, as a matter of fact, they stand in any given case; and the identification of these distances has a part to play in harmonic analysis. Now *this* is not something that can be achieved by *διάνοια*: to say that it is would again be to lapse into Platonism or Pythagoreanism by supposing that given melodic relations *must* be associated with specific quantitative values for mathematical or other intellectual reasons.²⁴ We can discover what quantitative relations hold between melodically related notes only through perception, by devising a technique of auditory measurement that enables us to find what the quantities in fact are. But it must be emphasised—and Aristoxenus underlines it repeatedly—that though the ear is capable of these quantitative discriminations, and though their results help in the scientific articulation of harmonic structures, they are no part of the original perception of a sequence as melodic. Here is Aristoxenus in full flow:

The fact that the perceptual discrimination of the magnitudes as such is no part (*οὐδὲν ἐστὶ μέρος*) of the complete understanding [of μέλος] was stated in outline at the start, but is easy to see from what I shall say next: for neither the *δυνάμεις* of the tetrachords, nor those of the notes, nor the differences between the genera, nor, to put it briefly, the differences between the composite and the incomposite, nor the simple and the modulating, nor the styles of melodic composition, nor one might say anything else whatever, becomes known through the magnitudes as such. [40.11–24]

²⁴ See in particular Aristoxenus' contrast between harmonics and geometry [33.10–26] which he seems to have developed out of considerations like those discussed by Aristotle in *An. post.* i 12, *Phys.* ii 2. Aristoxenus' position is analysed, with this comparison in mind, by Didymus in Porphyry, *In harm.* 27.17–28.26 (esp. 28.9–19).

The knowledge and understanding of which Aristoxenus speaks depend on principles abstracted from what is essential to our perception of the melodic character of given sequences. Perception of magnitudes contributes not at all to this understanding. Hence, the perceptions that do so contribute are exclusively qualitative and dynamic. The perception of magnitudes as such, which we might call calculative perception, is a scientific resource that enables us to identify quantitatively the ranges within which given dynamic properties are found. It thereby gives some help in mapping the interrelations of *δυνάμεις*, but it has nothing to offer to the project of discovering and articulating the nature of these *δυνάμεις* themselves. Perceiving melodic *δυνάμεις* and perceiving intervallic *μεγέθη* are entirely distinct operations.

Let us review the gist of this part of our discussion. To hear a set of sounds as a melody is to hear its constituent notes as standing in certain intrinsically melodic relations, relations of the sort we are calling dynamic. Harmonics seeks to articulate precisely the nature of the melodic *δυνάμεις* and the ways in which they are related, to describe fully the anatomy of the system of relations that they compose, and to spell out the principles of behaviour by which these relations are governed. These principles express the nature of μέλος as such: from them follow special and subordinate rules such as those demonstrated in book 3. As a matter of method, the principles are abstracted inductively from a careful survey of perceived instances: they must be such that perception, not just the abstract intellect, will recognise their appropriateness and authority as ἀρχαί [44.11–13]. As a matter of metaphysics, it is because the principles are as they are, because the essence of μέλος is as it is, that we hear certain sequences and not others as melodic and discriminate perceptually in the way we do, for example, between the various generic forms. It follows from Aristoxenus' phenomenism, which is grounded in his rigid adherence to Aristotle's 'same domain' rule, that nothing can stand as an ἀρχή and assert for instance that every melodic sequence necessarily has such and such a property unless an instance of the inherence of that property in a sequence would be recognisable as such by perception. More than that, it must be recognisable as such by *melodic* perception, not just by the sort of perception that I have called calculative: it must be recognisable as one of the properties we discriminate in the act of hearing something as a melody.

Now these properties, as I have tediously repeated, are dynamic properties: they are not, as such, quantitative features of intervals. In hearing melody, we may hear, for example, a sequence presenting the character of the enharmonic *πικρόν*: and it is no part of such hearing to notice that

its constituent intervals span exactly a quarter-tone each. Indeed, as Aristoxenus emphasises, the subintervals may not always be of just that size: the enharmonic character on which attention focusses is preserved so long as the pair of intervals falls somewhere within a certain range of quantitative variation. The half-tone *πικρόν*, broken down into two quarter-tones, is merely his favoured instantiation of this enharmonic sequence [see, for instance, 49.10–21].

It would be natural to draw the conclusion that the relation between a sequence's perceived quantitative features and its melodic ones is wholly contingent. Further, if melodic properties are neither constituted by nor inferable from quantitative ones, then by the 'same domain' rule the latter should apparently not even be mentioned in any of the classes of proposition proper to the science—not in the observation-statements from which the *ἀρχαί* are inductively abstracted, nor in the *ἀρχαί* themselves, not in either the premisses or the conclusions of the apodeictic demonstrations. In that case assessments of the magnitudes and statements about them seem to have no place in the science. The fact is, however, that in Aristoxenus' actual text they recur continually. What role can such propositions have?

We shall look at his treatment of them in a little more detail shortly. But first we must consider briefly a stratagem that promises to provide a route between dynamic and quantitative propositions, a way of showing that they are after all essentially and not merely contingently related. I have tried to make sense of this stratagem elsewhere [Barker 1984, esp. 52–62], but I am increasingly doubtful about its credentials. The main effort is to persuade us that even if some of Aristoxenus' statements about magnitudes are methodologically anomalous, still there remains a large group that can be intelligibly accommodated into his science. Let us assume two things: (a) that the relations of concord and discord are properly functional or melodic (that, I think, is uncontroversial); and (b) that though melodic perception does not identify magnitudes as such, it nevertheless does have within its scope the relations 'larger than', 'smaller than', and 'equal to', as applied to intervals.

These assumptions will get us a surprisingly long way. I shall not describe the route in detail. But (i) they allow us to distinguish the three primary concords, the octave, the fifth, and the fourth, as respectively the third-smallest, the second-smallest, and the smallest of the concords presented to perception; moreover, (ii) they enable us to identify the octave as the sum of the fourth and the fifth; and (iii) to draw attention to the interval by which the fifth exceeds the fourth, and which is called the *τόνος* or tone. Finally (iv) Aristoxenus offers a method [*Harm. elem.* 55.8–58.5: cf. Euclid(?), *Sectio can. prop.* 17], proceeding through the construction of concordant

fourths and fifths, for determining the size of the fourth relative to the tone (it is, allegedly, exactly two tones and a half); and by further, similar steps, we can assign magnitudes measured by the tone to all intervals that are a half-tone or its multiples.

Propositions correlating melodic phenomena with sequences involving intervals other than these remain anomalous. But *something* seems to have been achieved, for we have established links of a non-contingent kind between melodic properties on the one hand and magnitudes on the other: for instance, if an interval presents itself to perception as an instance of the smallest perceptible concord, then it is an interval that 'calculative' perception will assess as spanning two tones and a half. Some quantitative propositions are after all derivable from functional ones.

But this comforting conclusion cannot be allowed to stand, since it rests on an assumption whose methodological status is itself open to question. The assumption is made explicit by Aristoxenus at 55.3–11: this passage states that the magnitude of each kind of perceived concord, though not that of each kind of discord, is fixed and determinate, or so nearly so that it makes no difference. That is, there may be some variation in the size of interval capable of instantiating a given perceived type of discordant relation, but a given concordant relation can be instantiated in an interval of only one size or something very close to it indeed.

The development of artificially tempered tuning systems since the sixteenth century strongly suggests that this proposition is false.²⁵ But let us suppose that it is true and that we can check its truth against our experience. The trouble is that if it is true, it seems to be a truth of a wholly contingent sort. It is not implicit in our perception of something as a concord that this concord admits no variation in magnitude, nor, certainly, would Aristoxenus have supposed that it was: his statement of the proposition

ἐπεὶ δὲ τῶν διαστηματικῶν μεγεθῶν τὰ μὲν τῶν συμφώνων ἦτοι ὅλως οὐκ ἔχειν δοκεῖ τόπον ἀλλ' ἐν μεγέθει ὀρίσσει [55.3–6]

is noticeably tentative—it is no kind of necessary truth. The alleged fact might be verifiable through experience, but that experience must be built out of presentations that are not exclusively those of melodic properties as such.

²⁵ The problems that led to the development of tempered systems and the theoretical controversies that surrounded them are clearly and vividly described in Walker 1978.

Aristoxenus faces a dilemma. Either his propositions about tones, half-tones, and so on are genuinely concerned with determinate magnitudes (in which case they stand in no essential relation to our perceptions and conceptions of melodic phenomena as such) or they are shorthand expressions of relations that are properly melodic (in which case they only pretend to say something about determinate intervallic distances). Even in these most favourable cases, the attempt to build a necessitating bridge between functional and quantitative propositions must fail.

Quantitative propositions appear in Aristoxenus' work in various roles, but their task is primarily to establish correlations between specific melodic properties and particular magnitudes or ranges of magnitude. This is exactly what Aristoxenus' own principles seem to make methodologically suspect. Before we pursue the matter further, there are three preliminary points that need some emphasis. First, the problem is not (or not only) that quantitative propositions cannot be demonstrated from functional ones, or the converse. It would be entirely within the rules to establish their correlations inductively, as Aristoxenus generally seems to do. The problem is that the necessary information about magnitudes is drawn from observations that are not essentially melodic: they introduce facts drawn from a different domain.

Second, we are not concerned here with magnitudes that are problematic because they are not given to perceptual experience: they are not relative rates of vibration or anything of that sort. They are heard and identified by ear, but not as intrinsically melodic properties. Quantitative relations are never such that a set of notes perceived as standing in some such relation is thereby perceived as making melodic sense or sense of some specific melodic sort.

Third, I must underline the fact that Aristoxenus' deployment of quantitative propositions is far from being just incidental to what he is doing. The claims I have drawn on about the centrality of *δύναμις* and the irrelevance of *μεγέθη* to an understanding of it can be exemplified in a number of passages from about the middle of book 2 onwards. Yet this is hardly what we would expect from the way book 2 set out, after a short discursive introduction: here Aristoxenus seems to go out of his way to emphasise how crucial the ear's quantitative judgements are to the conduct of the science and how important it is that the student should be trained to make them accurately.

Thus, in the passage beginning at 32.18 we find those scathing remarks about people who try to proceed from *αἰτίαι* foreign to the domain (described as *ἀλλοτριολογούντες* and *ἀλλοτριωτάτους λόγους λέγοντες*), and about others who neglect the need for proper *ἀπόδειξις*. Aristoxenus, by

contrast, will adopt *ἀρχαί* for his demonstrations that are all *φαινόμενα τοῖς ἐμπείροις μουσικῆς*. Given all I have said, we would be surprised to find much emphasis on *μεγέθη* here. Yet he goes on at once, in another passage we have already reviewed, to assert that the practice of the science depends on two things, *ἀκοή* and *διάνοια*: through *ἀκοή*, he says, we assess (*κρίνομεν*) the magnitudes of the intervals, and through *διάνοια* we apprehend (*θεωροῦμεν*) their *δυνάμεις*. I have argued that this does not imply that *δυνάμεις* are inaccessible to perception, nor that hearing a sequence's melodic properties involves hearing as such the magnitudes instantiating it: but plainly it does assign some crucial role in harmonic science, if not in ordinary musical listening, to the identification of *μεγέθη*. By way of an example of the role in which such assessment appears, we may take his remark a page or so later [35.10–17] to the effect that his predecessors had neglected the task of identifying the point at which chromatic divisions of the tetrachord begin and enharmonic ones end. No sense can be made of this task unless it is that of picking out the magnitude of the smallest chromatic *πικρόν*, a task that Aristoxenus does indeed undertake [see 50.25–51.1].

We cannot solve the problem by arguing that Aristoxenus changed his mind half-way through book 2. Propositions concerning magnitudes continue to appear throughout that book and in book 3. I have argued [Barker 1984, esp. 62] that the quantitative form of many propositions in book 3 can be taken *exempli gratia* and their import reinterpreted functionally, but even so the difficulty remains. Towards the end of the third book, in a long and ill-tempered digression, he argues [68.13–69.28] that harmonic science must be concerned in the first place with *δυνάμεις*, not *μεγέθη*, since its objects must be determinate.²⁶ In this sense *δυνάμεις* are determinate and *μεγέθη* are not: that is, there is a unique set of dynamic relations, but not of quantitative ones, by which any given kind of melodic phenomenon is to be defined. But in almost the same breath [69.22–28] he draws the conclusion that progressions of melodically successive intervals must be identified for just one *χρῶα* at a time; and that claim makes sense only if the identification is quantitatively conceived. The dynamic properties he has in mind are common to sequences in more than one *χρῶα*: that indeed is why they are determinate, in that definite general rules concerning them can be formulated. It is the magnitudes of intervals instantiating them that

²⁶ The emphasis on the determinacy of the object of scientific understanding and the terms in which the discussion is couched may echo Plato, *Phil.* 16c–17c: relations between Aristoxenus' treatise and the *Philebus* are discussed in Kucharski 1959. But the immediate source here may be Aristotle, specifically *An. post.* 86a3–7.

vary from *χρόα* to *χρόα* and cannot be specified for all, or for several, at once.

Despite all I said earlier, irreducibly quantitative propositions are as deeply embedded in the treatise as are dynamic ones. They apparently describe two different domains of perceptual experience. Now the ways in which harmonics can approach these domains are not parallel. Let us consider them first separately, and then in relation to one another.

First, *δυνάμεις* are objects of melodic perception. By reflection on them we proceed inductively to definitions of the *δυνάμεις* and rules governing their interrelations.

Second, quantitative assessments of intervals are also made by ear. But perceptions of intervallic magnitudes are not as such intrinsic to our experience of melody or melodic form. Hence, no rules of melodic progression or the like can be derived (inductively or otherwise) just from remembered perceptions of strings of *μεγέθη*. Quantitative hearing as such does not discriminate the melodic from the unmelodic at all.

But third, what Aristoxenus apparently thinks we can do is to establish, inductively, correlations between specified dynamic relations and the quantitative relations in which they are materially instantiated. It may turn out, and indeed it does, that a given dynamic relation can appear only in notes standing at distances within a determinate range of magnitude: yet there is nothing in the dynamic relations as such to ensure that this must be so.

Then, if we can formulate rules governing such correlations, what standing have they in the science? They form no part of a definition of the essence or *φύσις* of melody: they are neither *ἀρχαί* proper to the science nor propositions derivable demonstratively from *ἀρχαί*, precisely because they serve to span the gap between one domain, one experienced 'kind', and another. We may appropriately call them bridging rules but that is just a name: it should not be allowed to disguise the fact that Aristoxenus himself has no equivalent terminology, nor that they constitute an uncomfortable irregularity in the smooth surface of the scientific structure as he conceives it.

There are some slight signs, I think, that Aristoxenus was himself half-aware of a distinction between proper *ἀρχαί* and the propositions I am calling bridging rules. He does not articulate it; but the language in which he expresses propositions of the two sorts does something to encourage the belief that he approached them in rather different frames of mind, whether he knew why or not. If the distinction did indeed have an influence on his modes of expression, we would expect it to appear most clearly in his handling of such notions as necessity and necessary connection. We would anticipate that necessity-terms would appear in propositions dealing

with relations between melodic *δυνάμεις*, but would be absent or modified in those correlating *δυνάμεις* and *μεγέθη*. Unfortunately, a survey of cases does not give unambiguous results, and I place little weight on the statistics reported below. In many cases relevant propositions are introduced only with unilluminating indicative verbs. In others there might well be dispute about the class—domain-bridging or purely dynamic—into which a given proposition falls: the differences are not always as clear-cut as my remarks may have suggested. Since I do not want to over-emphasise the significance of my findings, I shall present them very briefly.

First, we might anticipate that uses of the verb *συμβαίνειν* indicate something less than full-blooded necessity. There are some twenty-nine occurrences in books 2–3, of which five are casual and irrelevant. Of the rest, I would construe nineteen as expressing relations between *μεγέθη* and *δυνάμεις*. Only three plainly concern essential links between dynamic properties: two are doubtful.

Turning to the words most obviously expressive of necessity, *ἀνάγκη* and *ἀναγκάιος*, these appear twenty-six times. Ten cases are irrelevant (three being quite informal, two mathematical, and five representing logical relations). None expressly links *μεγέθη* with *δυνάμεις*, though one may be accounted doubtful. Fifteen seem to indicate relations between *δυνάμεις* themselves.

These results look straightforward, but the amount of interpretation behind them is such that they must be treated with extreme caution. Nevertheless, they give a little tentative and provisional support to the hypothesis that Aristoxenus was not wholly unaware of the distinction I have made. To draw attention to the distinction, however, is not to answer the question how the domain-bridging rules are to be accommodated smoothly into Aristoxenus' enterprise: the problem is re-described rather than eliminated.

But perhaps we may get more help from Aristotle than from our own unaided wits. The problems we have encountered in Aristoxenus are already implicit, I suggest, in authentic Aristotelian views concerning the relation of matter to form; and Aristoxenus' two major categories, the quantitative and the dynamic, do seem to invite representation under these Aristotelian headings.

Thus, the melodic, defined dynamically, is evidently a formal essence. As such it requires matter of some specific kind for its instantiation and this must be the movement of the voice in the dimension of pitch. (Aristides Quintilianus helpfully describes *κινήσις φωνῆς* as the *ἔλη μουσικῆς* [*De mus.* 108.18].) Further, it turns out that any particular species of melodic sequence requires for its instantiation a set of magnitudes within some determinate range in this dimension, if not ones that are uniquely fixed at

definite values. But the thrust of Aristoxenus' remarks about *δυνάμεις* is plainly that the definition of such a species of melodic sequence does not as such import any reference to the magnitudes that are its 'matter'—which is not, of course, to deny the Aristotelian view that there are some sorts of things which do demand such reference in their definition [see, e.g., *Meta.* viii 2–3]. The best statement of the sort of relation that may be conceived as holding between melodic essences and the appropriate *μεγέθη* is perhaps Aristotle's account of relations between form and matter in *Phys.* ii 9. The existence of suitable matter is necessary for the instantiation of a given form but is not sufficient for it, nor even a part or an aspect of it.

But what kind of necessity is this? Not, at any rate, one that can be displayed through the logical connections of apodeictic demonstration: Aristoxenus, at least, could certainly not regard it so, whatever may have been true of Aristotle. It is a sort of material, even contingent necessity. But what can that mean?

The matter of which a thing of a determinate natural kind is constituted is as such only potentially an instance of the kind. But though it is only potential, its being potentially *that* sort of thing marks it off from matter of other varieties or in other types of arrangement. Not just any type of material complex can be a tree or a bird or a thunderstorm: there is some sort of necessity in the fact that only *this* kind of matter is potentially *that* kind of thing.

Let us consider, briefly and impressionistically, how this relation is handled in Aristotle's reflections on organisms. An organism's body, conceived materially, is potentially an organism: its actually being a living organism, its possession of soul, is the appropriate 'actualisation of a body possessing organs'. The student of the soul, the person who investigates the activities in which only living things engage, may choose to study them in the abstract, in their essence and their relations to one another. His analysis of sensation, for example, may bring out the fact that it is the reception of form without matter, that a perceiver's various senses are not independent perceivers, that sensation is a precondition of *φαντασία* and *φαντασία* of thought, and so on.²⁷ But his enquiry will be incomplete if it fails to consider also the material conditions under which sensation is possible, to ask what organs are needed for seeing, hearing, and the rest, and to consider what material constitutions they require. No organism can see if it lacks eyes and nothing can be an eye unless it fulfils *inter alia* certain material conditions.

²⁷ These examples are all taken, of course, from *De an.* ii–iii.

In cases like this we are faced once again with a kind of natural necessity that cannot properly be presented as a necessity of logic, unless of course an account of an entity's matter is intrinsically involved in the definition of its essence along with the account of its form. We have noted that Aristotle recognises cases where this last condition is met, but in ones of the sort we are facing here the possibility is unhelpful. No doubt we could just stipulate that an account of the eye's material constitution must be included in what we are prepared to call its complete definition. Similarly, we could decide to include in a definition of the note *λχανός*, along with its formal, dynamic properties, an account of the ranges of magnitude within which a *λχανός* must stand in relation to other notes in order to be capable of playing the melodic roles that the dynamic properties identify. But the problem would only be disguised: the definition would merely place two sorts of description side by side without revealing how the kind so defined is one kind and not two whose classes of instances just happen to coincide or overlap [see, e.g., *An. post.* S7a38–b4].²⁸

Aristoxenus' difficulty can then be stated adequately in Aristotelian terms; and if it threatens the coherence of his enterprise, Aristotle's own scientific projects in biology and elsewhere must be similarly at risk. It is all very well for Aristotle to say that the natural scientist must treat a thing's nature as comprising its matter as well as its form, though the latter is more important; or that the relation between matter and form is such that the form is essence and end, while the matter is what is necessary if the end is to be attained [see *Phys.* ii 1 and 9]. The fact remains that this necessity cannot be a matter of logic, and that the relation between a form and its material conditions cannot be the object of scientific *ἀπόδειξις*. It is open to Aristoxenus to treat his *δυνάμεις* as the correlate of Aristotelian formal essences and his *μεγέθη* as the correlate of matter. Hence, he can stand by his thesis that no contribution towards an understanding of the essence of *μέλος* is made by the perceptual grasp of intervallic magnitudes. Equally, since his science is a study of a class of perceptibles, not of abstract

²⁸ Lennox [1986, 34] puts the point clearly:

The problem with offering a purely functional account of (say) man is that it gives the impression that his soul is only incidentally related to his body. But this is a false impression—a man is an animal of a certain sort, a specific perceptive being, requiring precisely structured organs to function properly. His psychological and physiological activities are simply the actual realisation of his specific bodily structure.

But the last sentence quoted is not a solution to the difficulty I am indicating, only a different way of expressing it. What is it, in point of scientific method, that can show the truth of such a claim?

or purely intelligible objects, it will be incomplete if it fails to discuss the ὕλη required for this essence's instantiation both in general (where it is the κινήσις φωνῆς κατὰ τόπον) and for each type of dynamic property that a melodic sequence can as such display (where it is a range of magnitudes or distances in the τόπος within which the voice can move). Essence and material condition, δυνάμεις and μεγέθη, can be correlated in a law-like way by inductive generalisations from experience. The accusation that this procedure either breaks the 'same domain' rule, or more simply just places the results of two different scientific programmes side by side without demonstrative justification, can be met if and only if δυνάμεις and μεγέθη are not after all two kinds (γένη), the inhabitants of two distinct domains, but are complementary aspects of just one. The study of muscle and bone, after all, seems to belong to the same science as does the study of animal movement; and so would the matter and the form of natural entities of any kind that are the subject of a coherent programme of investigation. If this is the direction in which we should be led, the result will be Aristotelian without a doubt; but it is one that leads to further difficulties. The 'same domain' rule, on which Aristoxenus takes so firm a stand, is no longer the clear and justifiable injunction that it seemed to be. In the case of domains, what is sameness?²⁹

3. Essence and history

It is easy to accuse Aristoxenus of presenting prejudice in the guise of science. His conservative leanings are well known: in insisting that μέλος has a fixed nature, from which it follows that certain sequences are melodic while others are not, is he merely trying to shore up established practices against the perversions of modernism with the impressive but empty paraphernalia of pseudo-scientific argument? Can there be any justification for his thesis that τὸ ἡρμοσμένον is a real and objective φύσις, not just the invention of arbitrary human taste or whim? After all, it seems implicit in his procedure that what is perceived as melody is melody: Can he properly insist that some sequence is intrinsically non-melodic, if someone else asserts that to his ear it is part of a perfectly acceptable melody?

These difficulties can probably not be neutralised completely. It is striking, however, that while Aristoxenus is free with his abuse of predecessors who have failed in point of scientific method or who have given faulty

²⁹ This is a question I shall leave unresolved. If it has an answer, an extension of the analyses offered in Lennox 1986 may offer the best approach. The remainder of this paper is by way of a coda: it has something to say about the issues aired in this section but does not continue the argument directly.

quantitative assessments of certain intervals, and while he disparages performers who play out of tune and of connoisseurs who prefer saccharine, quasi-chromatic versions of the enharmonic to the 'noble' one that he himself admires, nowhere does he suggest that there are those whose ears perversely accept as melodic something that in fact is not. On the contrary, he goes to great lengths to accommodate all aesthetic preferences, including ones that he himself finds distasteful. There is a best form of the enharmonic, for example, but its excellence is not demonstrated within harmonic science (though Aristoxenus believes that its merits will gradually become clear to people who attend to it carefully and often): the nature of μέλος as such is neutral between melodies in good and in bad taste. It discriminates only what is a melody, whether good or bad, from what is not, and sequences of one melodic form or species from those of another [cf. 40.8–18 and 23.3–22].

Aristoxenus' overall enterprise, therefore, involves from the start two levels of judgement, distinguishing first what is melodic and secondly, within that class, what is admirable or fitting for given musical purposes. The sphere of harmonics, as he makes clear on several occasions, is restricted to the former [see esp. 1.18–2.2, 31.16–32.8: cf. [Plutarch] *De mus.* 1142f–1143e, 1144c–e]. Further, as we have already seen, there are at least two sorts of judgement associated with harmonics itself: there is the properly 'harmonic' investigation of dynamic relations and there is the assessment, by 'calculative' perception, of the magnitudes in which these relations are instantiated. Since each dynamic relation is capable of several different quantitative instantiations, which Aristoxenus shows signs of wanting to designate as aesthetically better or worse, it would seem that breaches of taste can occur in at least two ways. Legitimate harmonic relations can be instantiated in the less admirable of the magnitudes available to them as 'matter': alternatively (and this introduces a new dimension, beyond harmonics altogether), legitimate harmonic patterns may be combined and used in contexts and for purposes to which they are not suited. Deciding what is and what is not legitimately harmonic, however, involves no judgement of taste of either kind. But we may still ask what the grounds are on which Aristoxenus bases his confidence in the harmonic principles he asserts. If they stand on induction from his own experience and nothing else, the ground is exceedingly weak.

In the *Harm. elem.* we can detect hints of another source of confidence, the agreement of practical experts in the musical arts. It is fair to imagine that Aristoxenus exchanged views with such people and in particular that he took the trouble to find out how far the kinds of melody they aimed to produce corresponded, in their intention as well as in his ears, to the rules

he believed he could discern. His purpose, after all, was not to enunciate a set of laws that prescribed obedience, but to articulate those that were presupposed by current practice.

But the core and the grounding of his ideas are most clearly revealed, I suggest, in his attitude to musical history. Very little of this appears in the *Harm. elem.*, but long fragments and paraphrases of his extensive writings on the subject have been preserved elsewhere, notably in the Plutarchan *De musica*. Here the manner in which his conservative prejudices are articulated is highly instructive. His aim was apparently to demonstrate the superiority of the music of an earlier period (up to and including the first decades of the fifth century), not just by asserting the excellence of the musical forms adopted by composers of those times, but by arguing that it was by deliberate policy that they restricted themselves to those forms.³⁰ The proliferation of elaborate new styles in the later fifth century and the passion for chromaticism in the fourth drew Aristoxenus' scorn. But his central thesis is that the melodic possibility of such styles was already implicit in the systems of the reputable ancient composers: it was by choice, not through ignorance, that they left them unused.

There are two points to be drawn from this. The first is the simple one that in proceeding by 'induction' to the articulation of ἀρχαί Aristoxenus did not start merely from his experience of contemporary practice. He took into account also what he knew—or thought he knew—of practices throughout Greek musical history. That by itself adds some weight to his findings. The second is the implication that even the earlier and simpler practices carried within themselves the seeds of later and more sophisticated ones: that is, even if earlier conventions restricted melodies to those based, for example, on the diatonic genus of scale, these conventions could not be understood except against the background of a system that embraced equally the possibility of the other genera. The nature of μέλος as a whole is then implicit in the simplest tune: for no ἀρχαί acceptable to perception can be found which would allow it to be understood, and

³⁰ This, at any rate, is the position taken by the speaker at [Plutarch's] dinner-party: it is a principal theme of *De mus.* 18–21, and of much of the discussion from ch. 28 to the end. But it seems safe to infer, from the nature of the Aristoxenian material he cites, that the theme was already there in his source. Thus, it seems likely, for instance, that the form in which the information on the σπονδειαζών τρόπος is presented [ch. 19] reflects that given it by the source: the line of argument in ch. 20 is plainly that of a fourth-century commentator: similar conclusions will apply in many other places. Notice also how the theme, still explicit in ch. 32, is merged without any sense of discontinuity into a wholly Aristoxenian discussion of the relation between harmonic science and other modes of judgement [in ch. 33–39].

its functional relations articulated, in isolated from the rest.³¹ It is in this sense that the φύσις τοῦ ἡμιοσμένου, as expressed in the complex web of propositions that Aristoxenus sets out, is an objective and permanent reality. The musical conventions of particular times and places are partial exemplifications of it and can be made comprehensible only through an understanding of the whole.

This approach gives Aristoxenus' polemics against 'modern' composers a particular pungency. They have broken no laws of melody: they write tunes that are heard as melodies and so are melodies, and that are indeed much applauded by the vulgar. But their cheap and popular taste does not even have the merit of originality, of daring experiment. What they did was always there to be done: their achievement was only that of working out in practice and putting on display those aspects of melodic nature that earlier composers had deliberately and rightly avoided, deeming them to lack nobility or to be unsuitable for the social context in which their performances took place [cf. [Plutarch] *De mus.* 20–21, 28–30].

It was not Aristoxenus' intention, then, to use his technical writings on harmonics to defend his own conception of musical excellence. If it had been, we would no doubt have found in them 'proofs' that practices adopted by the composers he disliked are melodically improper, in breach of the principles of melody. In fact his attitude is the reverse: the legitimacy of these second-rate practices is implicit in the principles that underlie good melody. When he defends μέλος against the charge of being disorderly, of having no determinate nature, he does not do so by showing that modern manifestations of such disorder are outside the proper definition of μέλος: he argues that in fact they depend, for all their superficial confusion, on the same underlying system of order as does music of more traditional sorts. The discrimination of noble melody from meretricious rubbish is not within the scope of harmonics, though harmonics may provide some distinctions in terms of which judgements of taste may be set. What makes noble music melodic is no different from what makes a mere jingle so; and the melodic legitimacy of the individual instance or type, whether good or bad, can be understood only through its relation to the whole nature of μέλος which accommodates both [see [Plutarch] *De mus.* 30–34].

This brings me to my final point, which is in a way the upshot of the whole discussion. The *Harm. elem.*, in my judgement, shows the principles of the *An. post.* at work, and brings out very clearly the conception of a

³¹ See, for instance, [Plutarch] *De mus.* 34 (esp. 1143e–f), a passage that is certainly derived from Aristoxenus.

science which that treatise implies. Its task is not conceived as the discovery of truths of fact hitherto unknown, but as the articulation of what is known and its ordering in relation to truths already implicit in what is known. A domain of experience is held together and shown to be intelligible as a unity through the formulation of principles whose truth can be recognised by inductive reflection on experience. These, related to one another (not related by derivation from something standing outside of and 'explaining' the experienced content of the domain) form a description of a single essence or nature. From the principles expressing this nature subordinate truths are derived, but not as surprising new discoveries. Surprises, in fact, would be quite out of place. The *προδείξεις* are designed to illuminate the known, not to uncover the unknown. They show how particular and familiar facts in the domain are implicit in the web of relations constituted by the primary essence, rather than being essentially disconnected items of experience related only casually to one another. Harmonics, as Aristoxenus envisages it, does not expel from the melodic domain anything we supposed that it included or import any novelties on theoretical grounds: it seeks to display the pattern within which our actual melodic experience falls and so to draw our experience into the sphere of our understanding.³²

³²I should like to express my gratitude to the organisers of the IRCPS conference in Pittsburgh for the opportunity to present an earlier version of this paper. Comments made by participants on that occasion have been very valuable: my thanks are due especially to Alan C. Bowen, James G. Lennox and Alexander P. D. Mourelatos. The shortcomings of the product are of course my own.