

7351 pdf
BARKER, A.D.

2002

p. 88-102

Barker, A. D. Words for sounds p 22-35

In: Science and mathematics in ancient Greek culture / ed. by Christopher J. Tuplin and Tracey E. Rihll Publication : Oxford ; New York : Oxford University Pr., **2002**

Résumé : Early scientists' linguistic and conceptual inheritance enmeshed them in difficulties of at least three sorts : 1) the poets rarely use adjectives to give colorful descriptions of sounds ; most often the colorful work is done by nouns or verbs. 2) When adjectives are applied to sound, they are rarely used with empirical intent to give descriptions of the way sounds sound. 3) Few of the adjectives used to designate the attributes of sounds belonged primarily to the acoustic domain.

Examination of Aristotle, de An. 2, 8, 420 A 28-B 4 ; of Archytas (cited by Porphyry, in Harm. 56, 21-57, 14) ; and of Ptolemy, Harm. 1, 3 shows that since much of the words' significance in acoustic contexts is grounded in metaphor, it is on the character and content of these metaphors that the argument that seeks to persuade us of their connections depends.

Notice n° : 80-14402 Une notice est liée : Type de notice : monographie Titre(s) :

Description matérielle : XVI-379 p. ill. 2 index Compte(s)-rendu(s) : Phronesis 2003 48 (1) : 85-88 Keimpe A. Algra ; AJPh 2004 125 (1) : 140-144 Philip Thibodeau ;

BMCRev 2004 (3) : non paginé William Wians ; CR 2004 N. S. 54 (1) : 82-84 George L. Huxley ; LEC 2004 72 (3) : 260-262 Michael Federspiel ; CW 2004-2005 98 (2) : 223-225 Mary Knight ; Eos 2002 89 (2) : 378-382 Joanna Komorowska ; Gymnasium 2005 112 (1) : 85-88 Markus Asper ; Nuncius 2004 19 (1) : 432-434 Fabio

Acerbi Notice n° : 73-16572

Science and Mathematics in Ancient Greek Culture

EDITED BY

C. J. TUPLIN

and

T. E. RIHLL



OXFORD
UNIVERSITY PRESS

Words for Sounds

ANDREW BARKER

THIS paper is a very modest contribution to the project of 'placing' ancient science in its relation to the society in which it was embedded. Scientific enquiry, for all its pretensions to objectivity, inevitably has roots in the culture from which it springs, and in its concepts, assumptions, aims, and procedures carries more or less visible traces of its ancestry. These traces and their influence are the subject of the present study; I shall be considering some of the ways in which the pre-scientific assumptions and thought patterns of a culturally inherited tradition can live on in the minds of scientists and significantly colour their work. But that topic is enormous.¹ All I can do is to glance at a very small number of the conceptual stowaways that are concealed in one small cabin aboard one little boat of no pretensions and questionable seaworthiness, bobbing on the fringes of the Greek scientific fleet: that is, the science of physical acoustics.

I shall take two principles as axiomatic without attempting to explore or justify them, though I recognize that the interpretations under which they are true are legitimate matters of debate. The first is that no scientist can be a purely neutral or transparent receiver and reporter of objective data.² What we seek to explain, and how, depends on what we take the phenomena to be, what we see them *as*; and that depends in turn on the conceptual resources we bring to bear on them. The casual visitor to a scientific laboratory does not see the images presented through the lens of a microscope *as* a trained scientist sees them; in a loose but acceptable sense they see different things, since the ways in which 'things' are conceived by the microbiologist, for example, are very different from those available to the uninitiated. Nor are

¹ In the Greek context the author who has tackled it most vigorously and from the most diverse range of perspectives is G. E. R. Lloyd. See particularly his *Magic, Reason and Experience* (Cambridge, 1979); *The Revolutions of Wisdom* (Berkeley, 1987), whose ch. 4 is especially relevant to the present paper; *Demystifying Mentalities* (Cambridge, 1990), ch. 1; *Methods and Problems in Greek Science* (Cambridge, 1991), 392-4. A stimulating earlier study is N. Goodman, *Ways of Worldmaking* (Hassocks, 1978).

² Versions of this principle have been endlessly discussed in the philosophical literature of the last century. For a few examples see P. K. Feyerabend, 'How to be a Good Empiricist', in B. Baumrin (ed.), *Philosophy of Science: The Delaware Seminar*, ii (New York, London, and Sydney, 1963), 3-39; A. F. Chalmers, *What is This Thing Called Science?*, 3rd edn. (Buckingham, 1999), ch. 3; A. Musgrave, *Common Sense, Science and Scepticism* (Cambridge, 1993), ch. 3 (esp. pp. 54-9); D. Gillies, *Philosophy of Science in the Twentieth Century* (Oxford, 1993), ch. 7; E. G. Zahar, 'The Problem of the Empirical Basis', in A. O'Hear (ed.), *Karl Popper: Philosophy and Problems* (Cambridge, 1995) 45-74 (esp. 50-5).

they necessarily even identifying the same things but conceiving them in different ways, since the dividing-lines between 'same thing' and 'different thing' may themselves be differently located in the two conceptual fields.

My second axiom is that something of the character of the conceptual spectacles a scientist is wearing, and of the relations between concepts in his or her repertoire, can be detected through an examination of the idiosyncrasies of the language in which they represent the phenomena. In the modern context we would look first, no doubt, at the behaviour of terms in the technical vocabulary of the scientific tradition in which our scientist was working. But at the point where we shall pick up Greek acoustics, no inherited technical vocabulary existed. The relevant conceptions are those embedded in the language of ordinary educated Greeks, the language that formed, expressed, and transmitted their shared cultural baggage. At the end of the fifth century that meant, inescapably, a language resonating with the usages of poetry, above all those of the Homeric epics. In that case students of this science need to examine rather carefully the behaviour, in the imaginative literature of the preceding period, of the words and word patterns which the scientists subsequently adopted to describe phenomena in their field of operations; and if we neglect that task we may seriously misconstrue the problems they faced and the solutions they offered. If we too casually assume that they conceived their initial data exactly as we would, and that the terms by which they are designated do not matter, we may quite literally fail to grasp what they were talking about, and why their enquiries followed the sometimes curious trajectories that they did.

The two main tasks that Greek acoustics set itself can be stated easily enough. The first focuses on the phenomenon of sound in general. It seeks to explain what sounds are, how they are caused, how they behave, how they are transmitted to the ear and perceived by it. The second concerns itself with what constitutes and what causes the various perceived attributes of sounds, how a sound that is high-pitched or quiet or rough or muffled differs in itself and in its causal antecedents from one that is low-pitched or loud or smooth or clear. Or at least that is how *we* would put the questions: if my preliminary remarks were on the right track, the attributes that the Greeks were investigating may not map altogether directly onto those designated by the English words standardly offered to translate them.

It is on matters to do with the attributes of sounds that I propose to concentrate. I want to suggest that the early scientists' linguistic and conceptual inheritance enmeshed them in difficulties of at least three sorts. The roots of the first problem are in what we might call 'customary syntax'. The poets use adjectives to give colourful descriptions of sounds surprisingly rarely. It is possible to read hundreds of lines of Homer—the whole of the first book of the *Odyssey*, for instance—and large tracts of fifth-century drama without coming across a single example. The point is not that the poets are

uninterested in sounds and their qualities: the *Iliad*'s battle-scenes, to take only the most obvious case, are a veritable brouhaha of clangs and thuds and screams and bellows. But most often the colourful work is not done by adjectives, but by nouns—*κλαγγή*, *ῥαυδος*, *δοῦπος*, *στοναχή*, *πάταγος*, *ἰαχή*, *ἀλαλητός*—or by verbs, as in *δοῦπησεν δὲ πεσών*, *ἀράβησε δὲ τεύχε' ἐπ' αὐτῷ*, or *χαμαὶ βόμβησε πεσοῦσα*, or *λίγξε βίος*, *νευρὴ δὲ μέγ' ἴαχεν*, or *ὥς ὅτε κύμα πολυφλοίσβοιο θαλάσσης | αἰγιαλῷ μεγάλῳ βρέμεται*, *σμεραγεί δέ τε πόντος*.³

This familiar way of speaking becomes a problem for the scientists simply because it could not be transferred directly into their own analyses. On pain of multiplying classes of entity and classes of activity or process absurdly, they could not treat a *δοῦπος* and a *κλαγγή* as distinct and independent types of thing, or treat *βρέμειν* as an activity different in kind from *βομβεῖν*. They needed something for which the inherited patterns of discourse made only scanty provision: that is, a way of referring neutrally to a sound of any sort, or to any activity of sounding, together with a rich vocabulary of adjectives to indicate the special attributes associated with each class of instances. The poets' colourful nouns and verbs had to be recast in substance-and-attribute terms, where the subject, sound or sounding, remained constant and relatively neutral, and the various kinds of qualitative colouring were conveyed attributively. The former requirement was quite easily fulfilled. The noun *ψόφος* could do duty as 'sound' generally, for example, while *φωνή*, *φθόγγος*, and *ἦχος* could be hijacked, relatively harmlessly, for more specialized purposes.⁴ The difficulty lay in the adjectives. Because the work of characterization had overwhelmingly been borne by nouns and verbs, the collection of adjectives provided by the tradition was too small to allow room for much picking and choosing by the scientists; and the adjectives it did contain posed additional problems of the two other kinds I want to mention.

The second problem is that when adjectives are applied to sounds by pre-scientific writers, they are rarely being used with merely empirical intent, just to give descriptions of the way sounds sound. A poet who describes a

³ Translations of the 'sound' words here can only be impressionistic, and *κλαγγή*, the first noun on the list, is an unusually versatile word even by Homer's standards. See LSJ s.v. Rough equivalents for the other nouns, in at least some Homeric contexts, might be 'hubbub', 'thud', 'groan', 'clatter', 'yell', and 'shout' respectively. The sentences containing the relevant verbs mean, approximately, 'he *thudded* as he fell, and his armour *clattered* [not, I think, the time-honoured 'rang'] upon him'; 'it *rang resonantly* [a sort of hollow humming noise] as it fell' [the subject is a helmet]; 'the bow *twanged* and the string *cried out* loudly'; 'as when a wave of the noisy sea *roars* on a great beach, and the ocean *crashes*'.

⁴ They are used in various ways. *φωνή* is often reserved for the human voice, sometimes extended to the 'voices' of instruments, but this is by no means invariable; not infrequently it means simply 'sound'. *φθόγγος*, in technical writers, is regularly 'musical note'. *ἦχος* can be used as a vague designator of sound, but has special applications to echo (along with its familiar relative *ἠχώ*), and to a sound's secondary 'resonance' (e.g. that in a stringed instrument's soundbox or arms, or in the metal or horn 'bell' of a wind instrument; see e.g. [Arist.] *De aud.* 802^a17 ff.).

sound as *ὀξύς* is not normally *just* characterizing it as high in pitch; such words seem primarily intended to indicate the special kind of psychological or emotional impact that a sound makes on its hearer, not to register the objective sound quality that would be detected by an uninvolved observer. Homer and the archaic lyricists, I believe, do not even have words that just mean 'high-pitched', 'low-pitched', and so on; and one would be hard pressed to find cases where one could confidently claim that as the full sense even in Euripidean drama. Hence the adoption of this terminology into the language of the empirical scientists, who evidently were aspiring to the detached observer's perspective, is unlikely to have been smooth or conceptually unproblematic.⁵

The third difficulty is the most striking. Very few of the adjectives regularly used to designate the attributes of sounds belonged exclusively or even primarily to the acoustic domain. Leaving aside compounds formed with acoustic indicators like *-φωνος* or *-φθογγος* as suffixes,⁶ there is, I think, only one common exception, the adjective *λιγύς*;⁷ and this plays no significant part in scientific discourse, not even as the name of an attribute whose nature and causal antecedents call for investigation. All the rest, like so many of our own, have important applications elsewhere. Whether it is altogether accurate to label the acoustic uses of *ὀξύς*, *βαρύς*, *λείος*, *τραχύς*, *μεγὰς*, *μικρός*, *σύντονος*, *ἀναιμένος*, and the rest as 'metaphorical' is an issue I shall not

⁵ *ὀξύς* always retains in Homer the sense 'piercing', sometimes carrying the idea of psychological or perceptual 'penetration', as in the recurrent phrase *ὀξὺ νόησε* (e.g. *Il.* 5. 312), usually with the overtones of something hostile, bringing grief or pain. This is obvious in non-acoustic applications (e.g. *ὀξὺν Ἄρεα*, *Il.* 4. 352; *ὀξεῖ χαλκῷ*, 5. 132; *ὀξεῖαι δ' ὁδύναι*, 11. 268), but carries over into acoustic ones, e.g. *ὀξεὰ κεκλήγων* of Thersites at *Il.* 2. 222, *ὀξεὰ κεκλήγοντες* of the Trojans at 12. 125. Similarly, when *βαρύς* is applied to sounds, its force seems as much psychological ('heavy' in the sense 'sad' or occasionally 'threatening') as directly descriptive. Not every hero who weeps *βαρὺ στενάχων* is to be thought of as the possessor of a bass voice; and it is no coincidence that the occurrence of this expression at e.g. *Il.* 9. 16 is immediately followed by Agamemnon's reference to the ἄτη . . . *βαρεῖν* sent upon him by Zeus (9. 18). The difficulties that beset any attempt to give the poets' sound-adjectives clearly defined fields of acoustic reference are broadly parallel to the better-known difficulties afflicting adjectives of colour: see e.g. E. Irwin, *Colour Terms in Greek Poetry* (Toronto, 1974).

⁶ These suffixes, attached to adjectival stems, form adjectives meaning explicitly 'such-and-such sounded', or 'such-and-such voiced', and so on. Thus *μεγάλω-φωνος*, for instance, means 'big-voiced', and the suffix serves to establish unambiguously that the intended conception of 'size' is an acoustic one, consisting in sonorous, not spatial 'volume'.

⁷ The sense of this term is slippery, but the main element in it seems to be 'clear', 'carrying'. The Peripatetic treatise *De audibilibus* has an interesting paragraph (804^a22-32) on the attribute designated by the related word *λιγυρός*. It associates being *λιγυρός* with being slender and compact (*λεπτός* and *πυκνός*), with lack of bulk and weight, and with distinctness or precision (*ἀκριβεῖα*). It comments that this is an attribute of the sounds of instruments without resonating horns (or 'bells'); the earlier discussion of such horns (802^a17-^b1) indicates that their function is to produce resonances that partially obscure the principal sound of the instrument, and so make it less hard and penetrating. The passage and others related to it are discussed in my paper 'Telestes and the "Five-Rodded Jointing of Strings"', *CQ*, NS 48 (1998), 75-81.

pursue; for most purposes the term will serve.⁸ What is perfectly clear is that the acoustic senses of these terms are not independent of their uses in other domains. It is from their wider uses that they derive the special, descriptive meanings they acquire when applied to sounds; and we can reasonably anticipate that the Greeks' conceptions of the sonorous attributes they name were in some degree affected by the ways they thought about their non-acoustic counterparts. The specialized conceptual apparatus of modern science and philosophy has immunized us somewhat to the allure of the trans-sensual analogies that our language tempts us to make. We can stand back from our antique metaphors and objectify them instead of thinking with and through them; we are not much inclined, for instance, seriously to suppose that a 'high' sound is somehow 'up there'. But our ability to do this depends on our possession of an allegedly neutral scientific vocabulary through which the phenomena can be designated without apparent detours into metaphor. There is no good reason to believe that the Greeks of this period were capable of similar feats of detachment, lacking as they were in the linguistic resources through which the inherited metaphors could have been translated into literal terms.

Even if the gist of what I have been saying is true, I have done nothing so far to support my insinuation that any of it made an important or interesting difference to the character of acoustic science in the fourth and subsequent centuries; and we are plainly unlikely to uncover persuasive reasons for accepting or abandoning that claim without exploring examples of the scientists' work in some detail. I shall place at centre stage, as they did, the small group of adjectives that have to do with a sound's pitch and its volume, leaving more slippery qualitative attributes aside.⁹

⁸ These adjectives form pairs: lit. 'sharp/heavy'; 'smooth/rough'; 'big/small'; 'tense/relaxed'. Of these, both the first pair and the last function as approximate counterparts of our 'high/low', and the third provides the normal Greek way of referring to volume. The pairing 'rough/smooth' is applied to sounds in ways not unlike those we use ourselves.

The modern literature on metaphor is of course vast. Works I have found particularly useful in the present context include the well-known studies by G. Lakoff and his colleagues, especially G. Lakoff and M. Johnson, *Metaphors We Live By* (Chicago, 1980), and G. Lakoff and M. Turner, *More than Cool Reason* (Chicago, 1989); essays in A. Ortony (ed.), *Metaphor and Thought*, 2nd edn. (Cambridge 1993), especially D. Gentner and M. Jeziorski, 'The Shift from Metaphor to Analogy in Western Science', 447–80, R. Boyd, 'Metaphor and Theory Change', 481–532, and T. S. Kuhn, 'Metaphor in Science', 533–42; essays in D. S. Miall (ed.), *Metaphor: Problems and Perspectives* (Brighton, 1982), especially F. C. T. Moore, 'On Taking Metaphor Literally', 1–13, and J. Martin and R. Harré, 'Metaphor in Science', 89–105. For the study of metaphors in Greek literature, the work of W. B. Stanford, *Greek Metaphor* (Oxford, 1936), though inevitably dated in some respects, is still indispensable. In the present context, see particularly appendix A to ch. 3 (47–62), on 'Synaesthetic or Intersensual Metaphor'; cf. Irwin (n. 5), 205–13.

⁹ The fullest Greek studies of attributes of this latter sort are in the Peripatetic *De audibilibus*. For the distinction, and a quantitative scientist's attitude to it, see also Ptol. *Harm.* 1. 3, esp. pp. 6. 24–7. 21 Düring; a different approach and a wide range of additional sources appear in the discussion of this chapter by Ptolemy's commentator, Porphyry (*In Harm.* 29. 27–78. 2 Düring).

(The fact that pitch and volume received the bulk of these scientists' attention is due of course to the close historical, theoretical, and practical connections that existed between physical acoustics and the musical sciences, particularly mathematical harmonics;¹⁰ but I shall say nothing of that here.)

My first witness is Aristotle. Aristotle, of course, is quite unusually sensitive to the linguistic forms in which ideas are expressed, and his analyses of *τὰ λεγόμενα*, 'what people say', regularly provide him with the groundwork for substantial philosophical and scientific constructions.¹¹ We might expect him to offer some reflections on the peculiar features of terms like *ὀξύς* and *βαρύς*, 'sharp' and 'heavy', when they are used in an acoustic context; and so he does. The major passage is at *De an.* 2. 8, 420^a28–^b4, in the course of his general account of the nature of sound, *ψόφος*. The terms *ὀξύς* and *βαρύς*, he says, 'are said by way of transference from tangible things', *κατὰ μεταφορὰν ἀπὸ τῶν ἀπτῶν*. In his opinion, then, the tactile uses and senses of the words are primary, the acoustic derivative and metaphorical. But he does not for that reason dismiss as illusory the implications about pitch that the metaphors appear to offer. On the contrary. 'For the sharp [*τὸ ὀξύ*]', he continues,

moves the sense much in a short time, and the heavy [*τὸ βαρύ*] a little in a long time. It is not that *τὸ ὀξύ* is swift and *τὸ βαρύ* slow, but the movement of the one is as it is *because* of swiftness and that of the other *because* of slowness. And it seems to be analogous to the sharp [*τὸ ὀξύ*] and the blunt [*τὸ ἀμβλύ*] in the field of touch. For *τὸ ὀξύ* as it were pierces, while *τὸ ἀμβλύ* pushes, because one moves things in a short time and one in a long time, so that one of them turns out to be swift and the other slow. (420^a30–^b4)

I want to extract just two main points from this complex passage. First, it is obvious that Aristotle is quite deliberately developing his account of these attributes of sound on the basis of implications 'transferred' with the terms from one domain of reference to another. Despite his explicit recognition of the 'metaphorical' status of these usages, he seems confident that they can guide us to a reliable understanding of the modifications of sound which they designate. His confidence is apparently not diminished by the fact (surely an obvious one) that different metaphors could have been used for this purpose, and indeed sometimes were¹²—though if *their* implications

¹⁰ For a sketch of these connections see A. Barker, *Greek Musical Writings*, ii (Cambridge, 1989), 3–11.

¹¹ See e.g. the classic paper by G. E. L. Owen, 'Tithenai ta Phainomena', first published in S. Mansion (ed.), *Aristote et les problèmes de méthode* (Louvain, 1961), 83–103, and often reprinted, e.g. in J. Barnes, M. Schofield, and R. Sorabji (eds.), *Articles on Aristotle*, i (London, 1975), 113–26.

¹² The alternative metaphorical axis of tension and relaxation (cf. n. 8) recurs quite frequently in Greek texts from the early 5th cent. onwards. I shall say a little more about it towards the end of this paper (pp. 33–5).

were taken as seriously as Aristotle takes these ones, the conclusions drawn would necessarily be different.

The second point I want to make is that, even given this approach, the story Aristotle tells here is in certain respects embarrassingly unpersuasive. The expressions are derived from discourse concerned with tangibles, and what is sharp, $\tau\acute{o} \delta\acute{\epsilon}\xi\acute{\upsilon}\varsigma$, moves the senses—whether of touch or of hearing—a lot in a short time. This seems provisionally acceptable, and it helps to mediate his progression towards a theory of the causation of pitch which associates it with *speed*. Here he is tapping into a model already developed to some degree by his predecessors, and this family of theories proved serviceable, despite some awkwardnesses, for many centuries.¹³ But the companion attribute, $\tau\acute{o} \beta\alpha\rho\acute{\upsilon}$, is less amenable to Aristotle's treatment. What is $\beta\alpha\rho\acute{\upsilon}$, he says—which as he understands it here means literally 'heavy'—moves the sense a little in a long time. But why on earth should any reader accept that? No doubt what is heavy is more resistant to *being* moved; but once a heavy thing is in motion, it is most likely to be thought of as impinging on our senses with speed and force.¹⁴ The trouble, of course, is that in their allegedly literal uses $\delta\acute{\epsilon}\xi\acute{\upsilon}\varsigma$ and $\beta\alpha\rho\acute{\upsilon}\varsigma$ are not true opposites. Aristotle recognizes the fact, implicitly here and explicitly in the *Topics* (I. 15, 106^a9 ff.; cf. 107^a11 ff.);¹⁵ but it throws into question the status of his whole analysis, dependent as it is on drawing out the implications of these words in their 'primary' uses and applying them to cases where they are used metaphorically.¹⁶ If the words in their primary uses are not strict opposites, the wholesale transportation of their implications there into the metaphorical context will bring that lack of strict opposition with it; but in the new context, of course, they *are* opposites. What Aristotle in fact appears to do is to take seriously the literal implications of $\delta\acute{\epsilon}\xi\acute{\upsilon}\varsigma$ and transfer them to the acoustic domain, while not doing the same with the literal implications of $\beta\alpha\rho\acute{\upsilon}\varsigma$. But the choice seems arbitrary, and if he had taken the alternative tack, privileging the implications of $\beta\alpha\rho\acute{\upsilon}\varsigma$ while suppressing those of $\delta\acute{\epsilon}\xi\acute{\upsilon}\varsigma$, the resulting analysis would surely have had to be different. Aristotle is tangled in a confusing and inconsistent web of words. He is, I suspect, conscious of his predicament, but powerless to extricate himself. The attributes *are* what the words say they are, but the story they tell is incoherent.

¹³ Aristotle's main precursors are Archytas fr. 1 (discussed below) and Pl. *Ti.* 67 A–C, 79 E–80 B. Later examples include [Arist.] *Pr.* 11. 3, 899^a9–14 (and elsewhere; but other theories too are canvassed in this collection), *De aud.* 803^a6 ff., Adrastus ap. Theon Smyrn. 50. 2 ff., 60. 12 ff. Hiller, Ael. ap. Porph. *In Harm.* 33. 16 ff. Düring, *Nicom. Harm.* 4. For an important variant see the introductory paragraph to the Euclidean *Sectio canonis*, and for a vigorous attack on such theories Theophr. fr. 716 FHS&G.

¹⁴ Compare Arist. *Ph.* 7. 5, 249^b27 ff., with 4. 8, 216^b11 ff.

¹⁵ It is a pity that he failed to consider the problems raised by this example in the context of his remarks on 'contraries' in *Cat.* 11, esp. 14^a19 ff.

¹⁶ Some related difficulties are discussed in *Ph.* 8. 4, particularly at 248^b4 ff.

My second witness is Archytas of Tarentum, perhaps half a century earlier. His first fragment, if it is genuine, as I believe,¹⁷ is the first trace we have of sustained investigation in this field. Archytas stands at the head of the scientific tradition I mentioned above. The fragment identifies the cause of sound as the impact of bodies on one another and on the air, analyses sound itself as a special kind of movement in or of the air, and relates the pitch of a sound to the speed or vigour of this movement. In various versions and at various levels of sophistication, theories of sound recognizably related to this one remained dominant for the rest of antiquity.

The passage that primarily concerns us here comes after Archytas' initial statement that sounds are produced by impacts, and his exploration of some of the conditions under which impacts of the relevant sort occur. It runs as follows:

τὰ μὲν οὖν ποτιπίπτοντα ποτὶ τὰν αἴσθασιν, ἃ μὲν ἀπὸ τὰν πλαγῶν ταχὺ παραγίνεται καὶ ἰσχυρῶς, ὀξέα φαίνεται· τὰ δὲ βραδέως καὶ ἀσθενῶς, βαρέα δοκοῦντι ἤμεν. αἱ γὰρ τις ῥάβδον λαβὼν κινῶι νωθρῶς τε καὶ ἀσθενέως, τῇ πλαγῇ βαρὺν ποιήσει τὸν ψόφον· αἱ δὲ κα ταχὺ τε καὶ ἰσχυρῶς, ὀξύν. οὐ μόνον δὲ κα τοῦτω γινώμεν, ἀλλὰ κα ὅκκα ἄμμες ἢ λέγοντες ἢ αἰεῖδοντες χρῆζομέ τι μέγα φθέγγασθαι καὶ ὀξύ, σφοδρῶ τῷ πνεύματι φθεγγόμενοι. ἔτι δὲ κα τοῦτο συμβαίνει ὥσπερ ἐπὶ βελῶν· τὰ μὲν ἰσχυρῶς ἀφιέμενα πρόσω φέρεται, τὰ δ' ἀσθενῶς ἐγγύς. τοῖς γὰρ ἰσχυρῶς φερομένοις μᾶλλον ὑπακοῦει ὁ ἀήρ, τοῖς δ' ἀσθενέως ἦσσαν. τῶντῶ δὲ κα ταῖς φωναῖς συμβήσεται· τῇ μὲν ὑπὸ [τῷ] ἰσχυρῷ τῷ πνεύματι φερομένα μέγала τε ἤμεν καὶ ὀξέα, τῇ δ' ὑπ' ἀσθενέως μικρὰ τε καὶ βαρέα. ἀλλὰ μὰν κα τοῦτω γὰ κα ἴδοιμες ἰσχυροτάτῳ σαμείῳ, ὅτι τῷ αὐτῷ φθεγγαμένῳ μέγα μὲν πόρσωθέν κ' ἀκούσαμεν· μικρὸν δ' οὐδ' ἐγγύθεν. (Archytas ap. Porph. *In Harm.* 56. 21–57. 14 = 47 B 1. 24–41 DK)

Now when things fall upon our sense, those that arrive swiftly and (strongly) from the impacts appear sharp [ὀξέα], while those that arrive slowly and weakly seem to be heavy [βαρέα]. Thus if someone takes a stick and moves it sluggishly and weakly, he will make a heavy sound with the impact, but a sharp one if he moves it swiftly and strongly. We can grasp the fact not only from this example, but also when we want to utter something big [μέγα, i.e. 'loud'] and sharp, either in speaking or in singing, since we utter with a vigorous breath. The following also happens, as it does with missiles: the ones that are thrown strongly travel to a distance, while those thrown weakly fall nearby. For the air yields more to those travelling strongly, less to those travelling weakly. The same thing will happen to voices too, that a voice travelling under the agency of a strong breath is big and sharp, whereas one travelling under the agency of a weak breath is small [μικρὰ, 'quiet'] and heavy. We can also see the fact in this most powerful piece of evidence, that when a person utters loudly [lit. 'big'] we can hear them from far away, but when they utter quietly ['small'] we cannot hear them even from nearby.

¹⁷ Its authenticity was called in question by W. Burkert, *Lore and Science in Ancient Pythagoreanism* (Cambridge, Mass., 1972), 379 n. 46, but has been defended, with some reservations and qualifications, by A. C. Bowen, 'The Foundations of Early Pythagorean Harmonic Science', *Ancient Philosophy*, 2 (1982), 79–104, and by C. A. Huffman, 'The Authenticity of Archytas fr. 1', *CQ*, NS 35 (1985), 344–8.

It is not surprising, perhaps, that Archytas' pioneering expression of these notions is less than satisfactory as it stands; later writers found in it a number of significant problems which Archytas seems to have overlooked.¹⁸ But the oddest of the passage's apparent shortcomings seems not to arise from an oversight. It is well known that in enunciating his theory of pitch, Archytas fails to disentangle the determinants of pitch from those of volume. He tells us several times that what makes a sound high-pitched is the swiftness, strength, and vigour of the impact causing it and of the movement constituting it; but he also asserts, twice, that a sound whose movements are caused by impacts of that sort is loud as well as high, *μεγάλα τε . . . καὶ ὀξεῖα*, whereas one caused by weak or sluggish impacts is quiet as well as low-pitched, *μικρὰ τε καὶ βαρέα*. He offers a single recipe for uttering a vocal sound that is simultaneously 'big' and 'sharp'—we do it by uttering with a vigorous breath. The theory seems to imply, then, that a sound which is high is inevitably loud, and one that is low is inevitably quiet; and that seems patently false.

Scholars have been fond of pointing out that this deficiency in Archytas' theory is detected and corrected first by Plato (*Ti.* 67 B–C), and then, more elaborately, by Aristotle (*De an.* 2. 7, 419^b4–420^b4; *Gen. an.* 5. 7, 786^b8–787^a23; and elsewhere): the sequence offers a neat example of the way in which science can progress through careful, critical attention paid to problems inherent in an inherited theory. But these scholars seem to have been less inclined to ask why the mistake, if such it is, should have been made in the first place.¹⁹ Archytas was no fool, and this fragment itself (especially in its later parts, not quoted above) shows that he was capable of at least ordinarily acute observation. He cannot possibly have just failed to register the fact that sounds can be both high-pitched and quiet or both low-pitched and loud. Little birds cheeped and thunder roared as much, presumably, in Archytas' Tarentum as in Plato's Athens. What is more, his insistence on coupling the attributes of pitch and volume seems unnecessary as well as perverse. In introducing this passage he claims no more than that he has an explanation of the fact that some sounds present themselves to us as high and others as low, and the rest of the surviving argument is concerned exclusively with high and low pitch, *ὀξύτης* and *βαρύτης*. Volume is not introduced as an issue for discussion at all; we merely get these two additional adjectives, 'big' and 'small', attached to 'high' and 'low' in a couple of sentences along the way. In a closing sentence that Porphyry describes as summarizing his whole discussion (*συγκεφαλαιοῦται τὸν λόγον*, *In Harm.*

¹⁸ See e.g. Arist. *Gen. an.* 5. 7, 786^b8–787^a23; *Sens.* 7, 448^a20 ff.; [Arist.] *Pr.* 11. 3 (899^a9–10), 6 (899^a22–3), 14 (900^a32 ff.), 19–20 (901^a20–1), 34 (903^a27–8); *De aud.* 803^a6–7, where pitch (caused by swiftness) is distinguished from 'hardness' of sound (caused by force).

¹⁹ I have made such observations myself, and been guilty of this omission; see Barker (n. 10), 41 n. 48, 61 n. 68, 81 n. 48. For a more complex account (differing significantly from mine) and further references see Bowen (n. 17), esp. 92–4.

57. 25=47 B 1. 56 DK), Archytas again refers only to *ὀξεῖς φθόγγοι* and *βαρεῖς*, 'sharp' and 'heavy' notes, and makes no claims whatever about 'big' and 'small' ones.²⁰ The offending pair of sentences seem, then, to throw these hostages to fortune needlessly. Archytas is simply not writing about the causation of volume. So why does he insert these adjectives where they could cause nothing but trouble?

We must also give full weight to the fact that the confusion of which he is accused is not extracted from some remote implication of his theoretical position. It is plainly there in the text. Given *that* fact, along with the fact that his explicit association of pitch and volume is evidently not pressed on him willy-nilly by the course of his argument, the reasonable conclusion seems to be that it struck him as altogether natural and harmless. But how could that impression possibly have survived confrontation with the cheeping of chicks and the squeaking of mice?

The answer lies as before, I suggest, in the earlier history of the pivotal words, and especially, once again, in that of *ὀξύς*. In the fourth-century and later acoustic tradition this word comes to be used of high-pitched sounds regardless of their other features. But I do not think that this is so in earlier literature. A sound that is *ὀξύς* is not just 'high'. It is *piercing*; it attacks the ear with vigour and force. Though high-pitched sounds can indeed be soft, no writer from Homer to Euripides and his non-technical contemporaries will describe them as *ὀξεῖς*: that word names an attribute which they simply do not have.²¹ The adjective that seems to have struck Greek authors as most appropriate for such sounds, for the voices of children, for instance, is not *ὀξύς* but *λεπτός*, 'fine' or 'thin'.²² Both *λεπτός* and *ὀξύς* name attributes which from our perspective are complex. Both imply height of pitch, but *λεπτός* implies thinness and delicacy in addition, while *ὀξύς* implies penetration and power.

Now I do not wish to deny that when Archytas wrote this passage he could fairly have been described as setting off to write about pitch, and about nothing else. Musicians had long been able to abstract pitch differences from others; theorists had already gone some distance in their various projects of comparing and quantifying them; and it is likely that the word *ὀξύς* had already been co-opted as one of the regular terms to designate *simply* high pitch in the context of these researches. But so far as we know these harmonic theorists pursued no investigations into the question that interests Archytas here, the question what pitch *is*, or, more precisely, what exactly the attribute is that the adjective *ὀξύς* names. When that question *was* asked, the deep resonances of the language inevitably made themselves felt. What pierces our senses cannot be feeble or weak. I suggest, then, that

²⁰ ὅτι μὲν δὴ τοὶ ὀξεῖς φθόγγοι τάχιον κινέονται, οἱ δὲ βαρεῖς βράδιον, φανερόν ἀμὴν ἐκ πολλῶν γέγονεν.

²¹ Cf. n. 5 above.

²² The attribute is examined at *De aud.* 803^b18 ff.

this is a case falling squarely under my thesis, that certain oddities in the theories proposed by scientists derive from their sense of the meanings and semantic implications of the inherited terms through which they described, and as it were 'saw', the phenomena.

The two cases I have been discussing are not isolated examples, even if we restrict ourselves to the topic of pitch and the environs of the words *ὀξύς* and *βαρύς*. In Peripatetic sources one finds, for example, a number of apparently perverse attempts to replace theories of pitch which referred to speed of movement or frequency of impact with ones representing a sound's pitch in terms of its 'shape'. High-pitched sounds are described as 'pointed', 'acute-angled', or linear and uni-directional, while low-pitched sounds are obtuse-angled, or move on a broad front, or travel all around. Such theories have no apparent scientific advantages comparable to those of the 'speed' hypotheses. They are motivated solely, I think, by an impulse to give a physical interpretation to the implications of the words *ὀξύς* and *βαρύς*.²³

Cases like that provide obvious but rather uninteresting examples of the phenomenon I have been discussing. I want to finish with one that is emphatically neither. Centuries after the period on which we have been focusing, Claudius Ptolemaeus, author of the *Almagest*, wrote his own magnificent work on mathematical harmonics. By way of a preliminary, he sets out to establish that pitch is a quantitative variable, amenable to mathematical treatment, and the long third chapter of book 1 of the *Harmonics* is a highly condensed essay in physical acoustics. Little of the early part of the chapter is original, and as he enters on the passage that deals directly with pitch, any informed reader expects him to offer a version of the 'speed' hypothesis that had served his predecessors so well. The observations from which he starts could easily have been harnessed to that purpose. But the reader is in for a surprise. Ptolemy announces no such theory. We naturally look around for a theory that he *is* offering; and in the past my reading of this chapter has led me to credit him with a new account of his own (though it might be related to ideas current among the Stoics), according to which pitch is correlated with or constituted by the degree of tension imposed on the air by a blow from an agent. That curious but intelligible suggestion I now retract. Though it is not straightforwardly false, it misrepresents what Ptolemy is doing.

He is not primarily concerned, in fact, to offer a physical analysis of what pitch *is* at all, though such an analysis perhaps emerges as a secondary product along the way. His primary concern is simply to establish the credentials of *ὀξύτης* and *βαρύτης* as *quantitative* attributes of sounds; and so long as it is agreed that they are indeed quantitative rather than qualitative, other

²³ For some examples see [Arist.] *Pr.* 19. 8 (918^a19–21); Theophr. fr. 716. 78–103 FHS&G; cf. *Pr.* 11. 20 (901^a20–9); *De aud.* 800^a2–3; Ptol. *Harm.* 1. 3, p. 7. 10 ff. Düring.

aspects of their nature, in the present context, are of no particular interest to him.

But the route that Ptolemy takes in pursuit of this goal is very curious. He notes first, as a matter of observation, that two attributes of an agent which can cause high pitch, *ᾠξύτης*, in sounds are *πυκνότης* and *λεπτότης*, a body's density and its thinness or fineness (*Harm.* 1. 3, p. 7. 23–5 Düring). Evidently we want to know how these attributes are connected with the relevant sort of *ᾠξύτης*; and to explain that, Ptolemy sets off on what looks like a detour. In other domains too, he says—that is, in wholly non-acoustic contexts—*λεπτότης* and *πυκνότης* do entail or involve *ᾠξύτης*. What is finer, *λεπτότερον*, is sharper, *ᾠξύτερον*, because it strikes *ἁθρούτερον*, more compactly, and so penetrates more quickly; while what is *πυκνότερον* is *ᾠξύτερον* because it penetrates more, or perhaps 'more vigorously', *μᾶλλον*; and he offers various concrete examples to convince us that these claims are true (pp. 7. 25–8. 2 Düring).

What Ptolemy seems to have shown so far, then, is that certain features of an agent, its being denser or finer, somehow involve also its being 'sharper', *ᾠξύτερον*, when it goes into action as an agent. Notice that we are still talking about the agent, not the sound caused; nothing has yet been said about *ᾠξύτης* in an acoustic sense. But at this stage Ptolemy seems to feel the need to reduce these two alternative modes of *ᾠξύτης* in the agent to a single, inclusive one. He immediately names it: it is *τὸ εὐτονον*, 'well-tensedness' or 'high tension' (p. 8. 2–3 Düring). Things are *ᾠξύτερα*, he says, not fundamentally (*κυρίως*) *qua* denser or thinner but *διὰ τὸ εὐτονον*, 'because of the well-tensedness'; and he adds an extraordinarily abbreviated, not to say impudent, piece of reasoning to support the claim. It is a fact, he flatly asserts, that things which are denser or finer *are* thereby *εὐτονώτερα*, more highly tensed; in its impacts what is *εὐτονώτερον* is *σφοδρότερον*, more vigorous; and that is *ἁθρούτερον*, more compact; and that is *ᾠξύτερον*, sharper (p. 8. 3–5 Düring). That is the whole argument.

Ptolemy's commentator, Porphyry, dissects the shortcomings of this bewildering chain of connections with ghoulish enthusiasm (*In Harm.* pp. 50. 13–51. 14 Düring, particularly the final paragraph). But the general strategy is after all clear enough. Ptolemy's remarks are not a summary of the results of scientific experiments designed to establish facts about the constitution of materials, or even reports of a series of observations. They draw attention, rather, to a set of semantic connections between words in the language: when we call an impact 'tense' we thereby implicitly ascribe to it the associated attributes of vigour, compactness, and 'sharpness'. In so far as such distinctions survive the loosely post-Quinean treatment I have been giving them, what Ptolemy has done is to delineate a network of broadly 'conceptual' (rather than 'empirical') linkages between the attribute of *εὐτονία*, which he takes to be quantitative and in at least some manifestations measurable,

and the attribute of $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$. If something is $\epsilon\ddot{\upsilon}\tau\omicron\nu\omicron\nu$ it thereby *is* $\delta\acute{\xi}\acute{\upsilon}$ in its action—that is, when it goes into action and strikes something else.

But how does an agent's being $\delta\acute{\xi}\acute{\upsilon}$ in this sense establish the thesis—as Ptolemy immediately claims—that the $\epsilon\ddot{\upsilon}\tau\omicron\nu\omicron\nu$ in which this *tangible* (or dynamic) $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$ is implicated is the cause of *acoustic* $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$ in a resulting sound? At one level the answer could hardly be simpler. Ptolemy works more or less consistently in this chapter with a rather naïve theory of causation in general, inherited along with much other material from the Peripatetic treatise *De audibilibus*, according to which the attribute of an effect must be caused by an attribute of exactly the same sort in the agent: rough sounds arise from rough objects, and so on.²⁴ Hence an agent's $\epsilon\ddot{\upsilon}\tau\omicron\nu\omicron\nu$ can be held responsible for a sound's $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$ only if it can itself be shown somehow to incorporate the attribute of $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$. That is all well and good, but of course it presupposes that the $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$ of the agent and the $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$ of the sound are indeed the *same* attribute—that whatever it is that constitutes an object's 'sharpness' in its role as an agent also constitutes the 'high pitch' of the sound arising from its action. A good deal of the character of this shared $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$, as Ptolemy conceives it, can be inferred from the nexus of other concepts in which it is embedded. Being $\delta\acute{\xi}\acute{\upsilon}\varsigma$, acoustically as well as tactually, has intimate affinities with being $\acute{\alpha}\theta\rho\acute{o}\varsigma$ and $\sigma\phi\omicron\delta\rho\acute{o}\varsigma$ and $\pi\upsilon\kappa\nu\acute{o}\varsigma$ and $\lambda\epsilon\pi\tau\acute{o}\varsigma$, compact and vigorous and dense and fine, and in the last resort is an aspect or mode of being $\epsilon\ddot{\upsilon}\tau\omicron\nu\omicron\nu$, well-tensioned. It also follows from his position—Ptolemy half-admits this and Porphyry (pp. 51. 4–52. 3 Düring) rubs it in with malicious satisfaction—that any sound caused by a 'highly tensed' agent will derive from it not just one but all of the attributes implicated in being 'tense'; it will not only be $\delta\acute{\xi}\acute{\upsilon}\varsigma$ but compact and vigorous as well. Plainly the term $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$ is not being used just as a handy label for something perceived independently of linguistic constructions. Ptolemy's conception of it is avowedly dependent on the implications of the *word*, and specifically on its resonances outside the acoustic sphere. As a result, the old poetic associations of acoustic $\delta\acute{\xi}\acute{\upsilon}\tau\eta\varsigma$ with piercing penetration are alive and well; and the concept is still as far from behaving as a concept of pure pitch, as we would understand it, as was that of Archytas, five centuries earlier.

The extraordinary manoeuvres that Ptolemy goes through in this passage are all the more remarkable for the fact that—like Archytas' alleged mistake—they seem on the face of it quite unnecessary. What Ptolemy wants is a way of representing $\epsilon\ddot{\upsilon}\tau\omicron\nu\omicron\nu$ in the agent as the fundamental cause of high pitch in sound; and he must do so within the constraints of the metatheory requiring that cause and effect be identical in character. But locutions involving 'tension' had been used to refer to pitch at least from the time of Pratinas, early in the fifth century. They had been copiously drawn on by Plato in the third and fourth books of the *Republic*, and are exploited by

²⁴ The principle is enunciated at *De aud.* 803^b27 ff; cf. *Ptol. Harm.* 1. 3, p. 7. 5 ff. Düring.

very many writers on music.²⁵ Describing a high-pitched sound as *εὐτονος* or *σύντονος* was never as common as calling it *οξύς*, and calling a low-pitched sound *ἀνειμένος*, 'relaxed' or 'slack', was never as common as calling it *βαρύς*, 'heavy', but these alternative metaphors were fully available and comprehensible. Why, then, could Ptolemy not argue, straightforwardly, as follows? The term *εὐτονία* designates high pitch; so does the term *ὀξύτης*. Hence in an acoustic setting, regardless of the nuances of the associations transferred with them from their primary contexts, these words are simply alternative labels for the same thing; in effect they are synonyms. Hence we can see at once that there is no obstacle to our treating *εὐτονία* in the agent as the cause of *ὀξύτης* in the sound.

But the convolutions of Ptolemy's tortured reasoning make it all too clear that this route was not open to him. He does not and cannot regard *εὐτονος* and *ὀξύς* as merely giving differently coded references to the same phenomenon. The attributes the words name are determined by their meanings, and these include everything in the metaphorical penumbra that each carries with it. Since their meanings are different, the attributes they designate are also different, and semantic connections between them have to be laboriously constructed in order to make the causal story admissible. Since so much of the words' significance in acoustic contexts is grounded in metaphor, it is on the specific character and content of these metaphors that the argument that seeks to persuade us of their connections most crucially depends. To rerun a point I used earlier in my discussion of Aristotle, if the Greeks had happened to use a different range of metaphors in their locutions for designating high pitch, an entirely different argument would have been needed; this one would have been merely irrelevant. It is one of the most striking instances I know of argumentation, in a scientific context, which hangs wholly on the assumption that the phenomena *are* what the words of the traditional, pre-scientific language say that they are.

²⁵ See e.g. Pratin. 712(a) Page; Pl. *Resp.* 398 E, 410 D-E, 411 E-412 A; *Leg.* 800 D; Arist. *Pol.* 8. 7. 4 (1341^b41), 10-11 (1342^b21-3); [Euc.] *Sect. can.* 149. 3 ff.; Aristid. *Quint.* 6. 28 ff.