

Francis Bacon and the Aristotelian Tradition on the Nature of Sound

Claudia Dumitru

Department of Philosophy, Princeton University
1879 Hall, Princeton, NJ 08544, USA; cdumitru@princeton.edu

Abstract: Centuries II and III of Francis Bacon’s posthumous natural history *Sylva Sylvarum* are largely dedicated to sound. This paper claims that Bacon’s investigation on this topic is fruitfully read against the background of the Aristotelian theory of sound, as presented in *De anima* commentaries. I argue that Bacon agreed with the general lines of this tradition in a crucial aspect: he rejected the reduction of sound to local motion. Many of the experimental instances and more theoretical remarks from his natural history of sound can be elucidated against this wider concern of distinguishing sound from motion, a theme that had been a staple of Aristotelian discussions of sound and hearing since the Middle Ages. Bacon admits that local motion is part of the efficient cause of sound, but he denies that it is its form, which means that sound cannot be reduced to a type of local motion. This position places him outside subsequent developments in natural philosophy in the seventeenth century.

Keywords: Francis Bacon, natural history, sound, acoustics, perception, Aristotelian psychology, sensible quality

Introduction

Acoustics as a modern science is said to have had its start in the seventeenth century, in the context of a shift from “number to sound,” from a focus on music and on harmonic numerical ratios to a focus on sound as a physical entity suitable for empirical investigation and quantification.¹ There is one figure that is distinctively Janus-like in this story (as he is in many other stories

¹ This is a story that has been told in more detail about music, with some references to acoustics, see Paolo Gozza (ed.), *Number to Sound: The Musical Way to the Scientific Revolution*, Dordrecht: Kluwer Academic Publishers, 2000.

having to do with the development of seventeenth-century natural philosophy): Francis Bacon. Bacon was among the first to emphasize the importance of investigating “the nature of sounds in general” (what he calls “Acoustica”), as opposed to the nature of sound with respect to music.² His observations and experiments on sounds from his posthumous natural history, *Sylva Sylvarum*, were read carefully in England and on the Continent, and provided considerable inspiration to the acoustical experiments conducted by the Royal Society later in the seventeenth century.³ Meanwhile, Bacon’s own conception of sound was indebted to a traditional Aristotelian theory that was soon to be superseded.

The purpose of this paper is to place Bacon’s discussion of sounds in Centuries II and III of his *Sylva Sylvarum* against this Aristotelian background. I argue that Bacon agreed with the general lines of the Aristotelian tradition on sound in a crucial aspect: he rejected the reduction of sound to local motion. Many of the instances and remarks from his natural history of sound can be elucidated against this wider concern of distinguishing sound from motion, a theme that had been a staple of Aristotelian discussions of sound and hearing since the Middle Ages. Agreeing with this tradition places Bacon outside subsequent developments on the subject in the seventeenth century. As the familiar story goes, the new philosophy drew a sharp distinction between primary and secondary qualities, between features such as size, shape etc. and features such as color, sound, taste etc. Whereas the former were assumed to be really in bodies, the latter were not. They were seen as the result of—or outright identified with—certain motions and textures in bodies that observers perceive as colors, sounds etc. Contra Bacon and the scholastics, sound could be reduced to local motion.

That Bacon’s considerations about sound are Aristotelian is not a new claim.⁴ Still, Bacon’s debt to the Aristotelian background has been explored

² “Perspective hath been with some diligence inquired; so hath the nature of sounds, in some sort, as far as concerneth music. But the nature of sounds in general hath been superficially observed. It is one of the subtilest pieces of nature.” in Francis Bacon, *Sylva Sylvarum* (henceforth SS) in *The Works of Francis Bacon*, ed. by James Spedding, Robert Ellis and Douglas Heath, 7 vols. (henceforth SEH), London: Longman et. al., 1857–1861, vol. II, p. 390. See also SEH I 542 for the term “Acoustica.”

³ For Bacon’s influence in England see Penelope Gouk, *Music, Science and Natural Magic in Seventeenth-Century England*, New Haven: Yale University Press, 1999, pp. 157–192. Marin Mersenne, author of some of the most important work in acoustics and music science in the seventeenth century, was also a reader and translator of the sound experiments from *Sylva Sylvarum*, see Claudio Buccolini, “Mersenne Translator of Bacon?,” *Journal of Early Modern Studies* 1 (2013), pp. 33–59.

⁴ See Penelope Gouk, for whom Bacon, “while adding nothing in the way of theory, implicitly proposes that the classical ideas be regarded not as authoritative fact but as working hypotheses for an extensive programme of acoustical research” (Penelope Gouk, “Some English

more in relation to natural magic applied to sounds (where the Peripatetic *Problemata* is one of his main sources)⁵ and in relation to the science of music (where Bacon falls in line with a tradition that emphasizes the empirical properties of musical sounds over abstract numerical ratios).⁶ I think this connection could be fleshed out further as regards the science of sound by examining some central topics it owes to *De anima*, the principal source for the Aristotelian account of sound and hearing. The relation between sound and motion is one of them.

I begin with a brief outline of the Aristotelian theory of sound in *De anima* and its associated commentary tradition. While I will not be able to do justice to the rich landscape of scholastic debates in these commentaries, I aim to draw attention to two key aspects of sound as theorized there: that sound is a sensible quality irreducible to motion, but that, unlike other sensible qualities, sound is always accompanied by motion, because its immediate efficient cause is a motion of the medium. I take these two elements to be an important part of the received tradition in Bacon's time, although individual commentaries might vary in the argumentative weight they place on them.

In the second section, I turn to Bacon's remarks about sound and motion in his *Sylva Sylvarum* and in the unfinished Latin history *Historia soni et auditus*, which most likely functioned as a draft for centuries II and III of the

Theories of Hearing in the Seventeenth Century: Before and After Descartes," in Charles Burnett, Michael Fend, and Penelope Gouk (eds.), *The Second Sense: Studies in Hearing and Musical Judgement from Antiquity to the Seventeenth Century*, London: Warburg Institute, 1991, p. 91).

⁵ This is not to say that the *Problemata* itself is natural magic, but only to point out that some of this traditional material is of interest for natural magic as well (e.g. the material about echoes). For a partial enumeration of the experiments Bacon takes from the Pseudo-Aristotelian *Problemata*, see Penelope Gouk, "Music in Francis Bacon's Natural Philosophy," in Marta Fattori (ed.), *Francis Bacon: Terminologia e fortuna nel XVII secolo*, Rome: Edizioni dell'Ateneo, 1984, p. 144, notes 24, 26.

⁶ This is in reference to Italian music theorists, like Vincenzo Galilei, who traced their inspiration back to the works of Aristoxenus and Aristotle (see Gouk, *Music, Science and Natural Magic in Seventeenth-Century England*, p. 160). But discussing intellectual traditions may be beside the point here, as Bacon's failure to acknowledge even the basics of existing musical theory has frequently opened him to charges of ignorance. For a seventeenth-century critique, see Mordechai Feingold and Penelope Gouk, "An Early Critique of Bacon's *Sylva Sylvarum*: Edmund Chilmead's Treatise on Sound," *Annals of Science* 40/2 (1983), pp. 139–157. For a taste of more recent indictments, see H.F. Cohen, *Quantifying Music: The Science of Music at the First Stage of the Scientific Revolution, 1580–1650*, Dordrecht: D. Reidel, 1984, p. 207 ("The simple reason why his name does not occur in the history of ideas on the problem of consonance is that he was not aware of it. Whereas from Pythagoras' time onwards the problem had been to account for the ratios of consonance, for Bacon it was to find them. [...] Clearly from such ignorance of elementary musical theory no direct contribution to it is to be expected.") and D.P. Walker, *Studies in Musical Science in the Late Renaissance*, London: Warburg Institute, 1978, p. 120 ("Since this dark cause and great secret had been common knowledge for two thousand years, Bacon's failure to even mention musical ratios seems to me surprising and perverse.").

Sylva.⁷ I show that many of the experimental instances Bacon discusses are shaped by an explicit interest in decoupling sound from motion. In particular, his investigation into the cause of sound revolves around building a case against elision of the air (i.e. a local motion) being the true cause of sound. Bacon admits that local motion is part of the efficient cause of sound, but denies that it is its form, which means that sound cannot be reduced to a type of local motion.

In my third and final section, I suggest that, while Bacon's position might end up coming close to the Aristotelian account, there are a number of significant differences at play as well. The greatest difference is, of course, a methodological one: Bacon is not starting from a full-fledged theory, but collecting experimental instances that could be used as the basis for induction. As we will see, this general point holds even if Bacon's natural history of sound contains significant theoretical elements as well. His theoretical conclusions, such as they were, are tentative and provisional. Rejecting local motion as the form of sound is just one negative step in the process of finding the true form of sound, a process that relies on collecting more experimental instances. Yet once that form is found, sound might be reduced to motion—not to local motion, but to one of Bacon's myriad of motions or active virtues of matter. This would ultimately place Bacon at odds with both the scholastic tradition and seventeenth-century mechanical philosophy.

Aristotelian Sounds

When discussing the nature of sound in his *Traité de physique* (1671), Jacques Rohault enlists Aristotle on this topic against the Aristotelians:

Aristotle has [...] a Chapter particularly upon this Subject, wherein he asserts, *that Sound is nothing else but the local Motion of certain Bodies, and of the Medium applied to the ear*; and that we may be sure that this is his Notion, he repeats it above twenty times. [...] I take particular Notice of that extraordinary Care which Aristotle took, to make us understand the Notion he had of the Nature of Sound. For though he repeated it so often, that it may seem troublesome to some Readers; yet I find, he has not said it often enough for some others, who professing to follow his Opinions in other things, do notwithstanding believe that Sound is a Quality different from local Motion.⁸

⁷ Here, I follow Spedding, who places *Historia soni* before *Sylva Sylvarum* chronologically, on account of the fact that it is not mentioned by Rawley in the list of things Bacon was working on during the last five years of his life. Spedding also indicates that *Historia soni* might be part of the tables of sound that Bacon was working on in 1608, according to an entry in *Commentarius solutus* (see SEH III 655).

⁸ This is John Clarke's English translation of Samuel Clarke's Latin translation of Jacques Rohault; see *Rohault's System of Natural Philosophy: Illustrated with Dr. Samuel Clarke's Notes*

While appealing to the writings of Aristotle to refute his commentators' claims is not an uncommon rhetorical strategy in the early modern period, the discussion of sound offers uncommonly rich fodder for such a move. As Robert Pasnau has nicely argued, sound posed something of a dilemma for commentators of Aristotle.⁹ On the one hand, sound seems to be more intimately connected with local motion than other sensible qualities, since it is often accompanied by visible vibrations in the sounding objects or the medium. Aristotle himself seems to identify sound with motion (κίνησις) explicitly on at least a few occasions in *De anima* II.8.¹⁰ On the other hand, the Aristotelian theory of perception relies on a distinction between things that are perceived by only one sense (color, sound etc.) and things that are perceived by more than one sense (size, motion etc.) Identifying sound with motion might seem to threaten this theory, and so it is something that medieval commentators are at pains to avoid.

In what follows, I will sketch very briefly the Aristotelian picture of the external senses and their objects, and then turn to questions pertaining to the nature and generation of sound. As concerns the latter, I rely on an influential strand of the Latin commentary tradition, one that stretches from Albertus Magnus and Thomas Aquinas to Suárez and the Coimbra commentators at the end of the sixteenth century. My goal here is not to chart the intricacies of various internal debates within the *De anima* commentary tradition, but rather to isolate a few core elements that might plausibly be said to be part of the accepted theory of sound in Bacon's time.¹¹

*Taken Mostly Out of Sr. Isaac Newton's Philosophy. Done into English by John Clarke, 3rd edition, London: James, John, and Paul Knapton, 1735, p. 183. The French goes: "Aristote en a traité dans un Chapitre particulier, où il enseigne que le son n'est autre chose que le mouvement local de certains corps, & du milieu qui s'applique à nos oreilles; Et afin qu'on ne doutast pas que ce ne fust son sentiment, il l'a repeté plus de vingt fois. Je remarque expressement le soin extraordinaire qu'Aristote a pris pour nous faire comprendre la pensée qu'il avoit touchant la nature du son; Mais quoy qu'il l'ait repetée tant de fois, que cela semble importun à quelques-uns de ses lecteurs, je trouve qu'il ne l'a pas encore assez fait pour quelques autres, qui faisant d'ailleurs profession de suivre sa doctrine, croyent encore que le son est une qualité différente du mouvement local." (Jacques Rohault, *Traité de physique*, Paris: Jean Cusson, 1671, p. 245).*

⁹ See Robert Pasnau, "Sensible Qualities: The Case of Sound," *Journal of the History of Philosophy* 38/1 (2000), pp. 27–40.

¹⁰ See e.g. *De anima* II.8, 420a21 (ἔστι γὰρ ὁ ψόφος κίνησις τοῦ δυναμένου κινεῖσθαι) or 420b11 (ἄερος κίνησις τίς ἐστὶν ὁ ψόφος), following the Ross edition: *Aristotelis De anima*, Oxford: Clarendon Press, 1956. While κίνησις encompasses other kinds of change as well, it is at least *prima facie* reasonable to take it to refer to local motion in this context, given the phenomena described and the language used to describe them (the issue is debated; see Mark Johnstone, "Aristotle on Sounds," *British Journal for the History of Philosophy* 21 (2013), p. 634). The subsequent Latin commentary tradition will also make explicit reference to local motion.

¹¹ Here, like in the case of musical theory, one would be wise not to assume that Bacon had detailed knowledge of scholastic debates, beyond a basic theory of sound.

In *De anima*, the external sense faculties are distinguished by reference to their objects: color for sight, sound for hearing, odor for smell, flavor for taste, tangible qualities for touch.¹² These objects are called proper sensibles and have at least two important features: they are tied exclusively to one sense faculty and they are perceptible in themselves. By contrast, the common sensibles (such as size, shape, number, motion) and the various accidental objects of the senses can be perceived by more than one sense, but are only perceived through the mediation of other sensibles. Common sensibles are perceived through the mediation of proper sensibles: you perceive an object's size or motion only through perceiving its color. Accidental sensibles are perceived through the mediation of proper and common sensibles: you perceive that something is a horse or the son of Diaries through perceiving its color, shape etc.

Sound, the proper sensible of hearing, is said to occur as the result of an impact between two solid objects that takes place in a medium.¹³ While this aspect is sometimes smoothed over in general presentations of the Aristotelian tradition, collision itself is not the immediate cause of sound. Instead collision produces a cleavage or breaking up of the medium caught between the two bodies and violently expelled, which cleavage is the immediate efficient cause of sound. This point is underscored in Aristotelian-inspired treatments of sound in the medieval period. It appears explicitly in Albertus Magnus' *De homine*, where sound is said to arise from a specific, breaking motion of the air.¹⁴ It appears in Aquinas' commentary to *De anima* as well, though somewhat de-emphasized, as Aquinas only describes the process through which air is caught between the two bodies and moved without talking explicitly of a cleavage or breaking motion of it.¹⁵ By contrast, in two very different

¹² The objects of sense are presented in *De anima* II.6, 418a7–25. See also Richard Sorabji, "Aristotle on Demarcating the Five Senses," *The Philosophical Review* 80/1 (1971), pp. 55–79.

¹³ Aristotle, *De anima* II.8, 419b10. Two relatively brief but good overviews of the Aristotelian theory of sound and hearing and its medieval reception are: Charles Burnett, "Sound and Its Perception in the Middle Ages" in Charles Burnett, Michael Fend, and Penelope Gouk (eds.), *The Second Sense: Studies in Hearing and Musical Judgement from Antiquity to the Seventeenth Century*, London: Warburg Institute, 1991, pp. 43–69, and Pasnau, "Sensible Qualities." Both of them inform my reading here. Apart from these, the most useful resource on this topic is Michael Wittmann, *Vox atque sonus: Studien zur Rezeption der Aristotelischen Schrift "De anima" und ihre Bedeutung für die Musiktheorie*, Pfaffenweiler: Centaurus, 1987 (whose second volume collects Latin sources from 1200 to 1600).

¹⁴ "Dicimus ergo, quod sonus est qualitas sensibilis, proueniens ex fractione aëris, & ens cum illo. Dico autem qualitas sensibilis propter sensum auditus. Et dico ex fractione motus: quia non quilibet motus aëris facit sonum, sed motus frangens aerem antequam divisibilis sit per naturam. Et dico ens cum illo: quia sonus non habet esse nisi quandiu durat motus ille." (Albertus Magnus, *Summa de creaturis* II.23.1, in *Opera omnia*, ed. Pierre Jammy, 21 vols., Lyon: Prost, Rigaud, De la Garde & Huguëtan, 1651, vol. XIX, p. 128).

¹⁵ "Et propter hoc videmus, quod si aliquid tardo motu tangat alterum, non facit sonum, quia prius recedit aer et dissolvitur, quam contactus solidorum corporum fiat. Sed si percussio sit velox et

sixteenth-century commentaries to *De anima*, *fractio aëris* is flagged almost as an entity onto itself. The Coimbra commentaries state that sound does not follow immediately from a collision of bodies, but from the intermediary *fractio aëris*.¹⁶ Melanchthon's very popular commentary focuses almost entirely on this element in the short paragraph it dedicates to the object of hearing, by saying that sound arises from the cleavage of air caused by the collision of two bodies, a disturbance he compares with the waves made by a stone thrown in water.¹⁷

Insisting on the importance of the medium in the generation of sound is not accidental. Unlike colors, sound is in objects only potentially—it requires a collision of bodies and a disturbance in the medium to become actual. And when it comes to deciding to which of the three elements involved in its production (the striking object, the struck object or the medium) sound belongs, the medium often emerges as the best candidate. While the best and thus most discussed medium for the generation of sound is air, the Aristotelian tradition allows that other media can be suitable as well, such as water and even fire.¹⁸

But what is sound? At a distance of four hundred years, Albertus Magnus and Melanchthon converge on this point. *Sonus est qualitas sensibilis*,

fortis, tunc fit sonus; quia ad hoc quod fiat sonus, oportet quod motus percutientis praeveniat divisionem aëris, ut aer adhuc adunatus sive collectus percuti possit, et in eo sonus generari." (Thomas Aquinas, *Sententia libri de anima*, lib. 2, l. 16, n. 8, in *Opera omnia*, vol. 45/1, ed. R.-A. Gauthier, Rome: Commissio Leonina; Paris: J. Vrin, 1984, p. 137).

¹⁶ "*Sonus non sequitur immediate collisionem corporum, sed fractionem aëris intermedii.*" Collegium Coimbricense, *Commentarii in tres libros de anima Aristotelis Stagiritae*, II.8, question I.1.3, Coimbra: Antonio de Mariz, 1598, p. 202.

¹⁷ "*Est autem sonus qualitas orta ex aëris fractione, quae fit collisio duobus duris corporibus, latitudinem aliquam habentibus. Haec fractio perinde in aëre spargitur, ut lapillo in aquam coniecto, videmus gyros ea agitatione proferri.*" Philipp Melanchthon, *Commentarius de anima*, Lyon: Sebastian Gryphius, 1542, p. 177. Comparing sound with the waves made by a stone thrown in water is a motif that crops up in a number of traditions (see Burnett "Sound and Its Perception in the Middle Ages," p. 56, note 101).

¹⁸ The discussion of media in Suárez's *De anima* commentary gives us a nice view of the interplay between conceptual arguments and appeals to common experience in the Aristotelian discussions of sounds. Suárez summarizes two positions regarding the suitability of water as a medium. One invokes the fact that fish do not make any sound travelling through water, together with the conceptual justification that the density of water is not suitable for the sort of divisions and collisions that can take place in air, to claim that water cannot be a medium for the production of sound. The other replies that fish can hear boats and oars under water and run away from them, and as a general argument, that water has all the qualities necessary for the production of sound. Suárez sides with the latter opinion, but he also takes the opportunity to expand the discussion to include fire as a medium. Experience shows us, he says, that sound can be produced by striking two hard bodies together inside a flame, which makes sense conceptually, considering that flame is rarer than air and easily divided. (See Francisco Suárez, *De anima* III.19.10–12, in *Opera omnia*, ed. Michel André, Charles Berton, 26 vols., Paris: Luis Vivès, 1856–1866, vol. III, pp. 678–679).

proueniens ex fractione aëris, says Albertus.¹⁹ *Est autem sonus qualitas orta ex aëris fractione*, says Melanchthon.²⁰ That sound is said to be a quality is significant, as is the language indicating that sound arises from the breaking motion of the air. Both of these elements underscore that sound is not to be identified with the disturbance in the medium, i.e., with the breaking or cleavage of the air. The disturbance in the medium associated with sound is a kind of motion. On the classification of sensible objects I have sketched above, motion would be a common sensible (perceivable by more than one sense), while sound is a proper sensible (perceivable only by hearing). Reducing a proper sensible to a common one would throw a spanner in the strategy of *De anima*, where sense faculties are individuated by their proper objects. It is within this framework that Aristotelian commentators reject the identification of sound to motion, seemingly going against language Aristotle himself employs.

This rejection is implicitly made in defining sound as a sensible quality. When it is made explicitly as well, as some commentators do, it relies on two types of arguments. First, there are what one might call conceptual arguments. These can be appeals to the wider Aristotelian framework that needs to be upheld: invoking the proper/common sensibles distinction (sometimes as elaborated by Aquinas into a distinction between sensible qualities and sensible quantities) or the fact that sound is also said by Aristotle to be caused by motion and nothing can be its own cause.²¹ There are also more elaborate arguments against the reduction of sound to motion, such as Avicenna's argument that if sound and motion were the same, knowing the motion would mean that we know the sound as well, but that this is not always the case.²²

The second type of argument is based on appeals to common experience. For good examples of this type we can turn again to the Coimbra commentaries.²³ There we see a distinction between the issue of sound's generation or production (which happens with a motion) and the issue of sound's transmission through the medium (which can happen without a motion). Sound can be transmitted to parts of the medium where motion has not or cannot spread. A much-invoked example from Aristotle tells us that fish can hear even in still pools. Similarly, people sealed up in a place completely protected from move-

¹⁹ Albertus Magnus, *De homine* II.23.1, p. 128.

²⁰ Melanchthon, *Commentarius de anima*, p. 177.

²¹ Collegium Conimbricense, *Commentarii in tres libros de anima* II.8, question I.1.1, p. 201.

²² See Pasnau, "Sensible Qualities," p. 33.

²³ Or, indeed, to a source closer to Bacon's own context: the student notebook of Sidney Sussex alumnus, George Palfrey, compiled around 1623. Palfrey's overview of the scholastic curriculum includes the Jesuit arguments about the reduction of sound to motion, with a particular accent on these experiential arguments. See *The Palfrey Notebook: Records of Study in Seventeenth-Century Cambridge*, ed. by C.J. Cook, Woodbridge: Boydell Press, 2011, pp. 355–356.

ments in the air can nonetheless hear sounds produced from far off. If sound needed motion in order to be transmitted to the ear, then sound heard at great distance would entail a massive disruption of the air, which is not true. People shouting could not hear one another, because the contrary and opposite motions of their voices would prevent it, and this is also not true.²⁴

We have seen that arguments against the reducibility of sound to motion are a distinct topic in some prominent Aristotelian commentaries, and would have been available to an educated person engaging with this tradition. The more casual reader would have at least been acquainted with the definition of sound, which included details about the generation of sound and about its classification under sensible qualities, as these were standard fare across commentaries.

Baconian Echoes

So far, I have emphasized two aspects of the Aristotelian theory of sound that would have been familiar to Bacon, though perhaps somewhat unequally. First, the generation of sound was taken to involve both a collision of bodies and a cleavage of the air, with the latter being the immediate cause of sound. Second, sound was taken to be a sensible quality and distinguished from motion. This background illuminates many of Bacon's remarks and experiments collected in *Sylva Sylvarum* and in the Latin *Historia soni et auditus*.

Let us start with the generation of sound and its underlying causal picture, which is one of the central topics of investigation in the Baconian natural history of sound. In a key passage from the *Sylva*, we find Bacon inveighing against the traditional picture sketched above, where *fractio aëris* was the immediate efficient cause of sound:

The cause given of sound, that it should be an elision of the air (whereby, if they mean anything, they mean a cutting or dividing, or else an attenuating of the air) is but a term of ignorance; and the notion is but a catch of the wit upon a few instances; as the manner is in the philosophy received. And it is common with men, that if they have gotten a pretty expression by a word of art, that expression goeth current, though it be empty of matter.²⁵

What are the problems Bacon identifies with the elision of air as a cause of sound? This question is slightly obscured by the fact that Bacon sometimes seems content to challenge this concept with reference to air, rather than as a subspecies of the more general concept "cleavage of the medium." His list of

²⁴ Collegium Conimbricense, *Commentarii in tres libros de anima* II.8, question I.2.6, p. 204.

²⁵ SS 124 (SEH II 393).

instances against elision of air as the cause of sound ends with the observation, “that which convinceth it most of all is, that sounds are generated where there is no air at all,” and indeed we soon find him discussing water and fire as possible media for the production and transmission of sounds.²⁶

This should not lead us to believe, however, that it is just the idea of air as the unique medium of sound that Bacon is objecting to. It is clearer perhaps in *Historia soni*, but can be discerned in the *Sylva* as well, that Bacon uses the elision of air to mean a kind of local motion to which sound cannot be reduced. To support this assertion, we can find various passages where he seems to talk of the two interchangeably. For example, in *Historia soni*, he talks of the “elision or manifest local motion of the air,”²⁷ with virtually all of the arguments then focusing on local motion. Insofar as we can assume an internal logic to the *Sylva*, I take the transition from denying that elision is the cause of sound (in SS 124) to immediately saying (in SS 125) that “sound is not produced at the first but with some local motion of the air, or flame, or some other medium,” though we should not confuse that motion with the sounds themselves, to be in the same vein.²⁸

However, if we take talking of the elision of air to be a way of talking about the relation between sound and motion, Bacon seems to be saying more than that we should distinguish between the two. He says that the elision of air is not the *cause* of sound. By contrast, the Aristotelian tradition sketched above held the cleavage of the air to be the efficient cause of sound. Yet the distance between the two is not as great as it might seem, for Bacon has a precise type of cause in mind here. We see this in *Historia soni*, where we are offered a series of instances in which sound occurs against the perceptible motion of the air (e.g. whistling by drawing air into one’s mouth or having air rush back into a receptacle from where it had been forcibly sucked out, so that the motion of the air is clearly directed inward, while the sound is emitted outward). These cases are offered as evidence for the claim that the first impulsion of the air is “the remote efficient and not part of the form of sound.”²⁹

²⁶ SS 124 (SEH II 394). This experiment belongs to a group of “experiments in consort touching production, conservation and delation of sounds; *and the office of air within*” (italics mine), so the focus on air is not surprising.

²⁷ “*Elisionem vel motum manifestum localem aëris*” (Bacon, *Historia soni*, SEH III 659). In *Sylva I* take SS 125 to be an example of this type of identification (SEH II 394).

²⁸ SS 124 and 125 (SEH II 394).

²⁹ “*Quod dignum admodum notatu videatur: quia sonus generatur in contrarium motus manifesti aëris, ut prima aëris impulsio videatur plane efficiens remotum, nec sit ex forma soni*” (Bacon, *Historia soni*, SEH III 660). Talking about a remote efficient might be due to the fact that Bacon is strictly referring to the first impulsion of the air. However, as the discussion of causes sketched below makes it clear, Bacon also holds that traditional efficient causes are remote from their effects, because they are not investigated at the proper level. A proper investigation would look at the latent processes and schematisms of matter that lead immediately to the form.

I propose that we take Bacon to be saying that the elision of air is not the true cause of sound in the sense that it is not its form, although it might be part of the efficient causal chain leading up to it. Some explanation of the Baconian picture of causality is in order here. At the beginning of the second book of the *Novum organum*, Bacon discusses the four causes of the Aristotelians. They are not wrong, he says, when they establish four causes, except that the final cause is “so far from being beneficial that it actually corrupts the sciences, except insofar as it relates to the actions of men,” and that the material and efficient causes “(as they are investigated and received, i.e. as remote causes distinct from the latent process leading to the form) are slipshod and shallow things” that “contribute practically nothing to a true and active science.”³⁰ Instead, what one should inquire into are the forms.

The Baconian concept of “form” is a difficult one to pin down. I will have more to say about it in the concluding section, but for now we can restrict ourselves to a few observations about the role it plays in Bacon’s system relative to other types of causes. Material and efficient causes are “fluctuating causes and nothing but vehicles which in certain cases carry the form.”³¹ In other words, material and efficient causes do not produce the effect: they facilitate something else which does (the form). I take it that they are called “fluctuating causes” (*causae fluxae*) because different causes could produce the same effect; there is not a strict one-to-one correspondence between them and their effects. We might illustrate this with examples drawn from Bacon’s investigation of heat: heat could be the effect of friction, sunlight, burning etc. Forms, however, are uniquely tied to their effects. You cannot have one without the other. “The form of the thing,” Bacon says, “is the very thing itself, and the thing does not differ from the form in any other way than appearance from existence, external from internal, or that relative to man from that relative to the universe.”³² The form of heat is present whenever heat is present.

Keeping this picture in mind helps us make sense of Bacon’s saying that we must “attentively distinguish between the local motion of the air (which is but *vehiculum causae*, a carrier of the sounds) and the sounds themselves conveyed in the air.”³³ We have seen him call efficient causes mere vehicles for the real causes above, so we can take this sentence to say that the local motion of the air is the efficient cause and thus has to be distinguished carefully from sound itself. Yet if we had the form of sound, sound would be reducible to it. After

³⁰ Francis Bacon, *Novum organum* (henceforth NO) II 1, in *The Oxford Francis Bacon* (henceforth OFB), vol. XI: *The Instauration Magna Part II: Novum organum and Associated Texts*, ed. by Graham Rees and Maria Wakely, Oxford: Clarendon Press, 2004, p. 201.

³¹ NO II 3 (OFB XI 203).

³² NO II 13 (OFB XI 237).

³³ SS 125 (SEH II 394).

all, once Bacon famously gives us the form of heat in the *Novum organum* as being motion, he says that what he means is that heat simply *is* a kind of motion.³⁴ This reading is largely consistent with Bacon's claim that "sound is not produced at the first but with some local motion of the air, or flame, or some other medium."³⁵ The fact that local motion is the efficient cause of sound does not mean that it is the form of sound or that sound can be reduced to it.³⁶

While the discussion about the elision of air is the source for the most sustained and explicit remarks Bacon makes about the relation between sound and motion, an interest in decoupling these two entities runs throughout the natural history of sound. Thus, SS 115 opens with a list of "great motions" in nature that happen with "a percussion and division of the air" but without being accompanied by sound.³⁷ It then moves on to examine other kinds of motions, including "the motion in the minute parts of any solid body (which is the principal cause of violent motion, though unobserved)," that are similarly found to happen without any sound.³⁸ For readers familiar with Bacon's methodology, these instances might recall the tables of presence and absence from the *Novum organum*.³⁹ The thrust here seems to be towards distinguishing

³⁴ NO II 20 (OFB XI 263).

³⁵ SS 125 (SEH II 394).

³⁶ Note that Bacon does bring one instance in support of the view that sound is a kind of local motion: "*Potest sumi in argumentum, quod sonus sit plane genus quoddam motus localis in aere, quod ita subito pereat*" (Bacon, *Historia soni*, SEH III 663). This might be a case where the genre of natural history, collecting instances regardless of their theoretical implications, is legitimately resistant to theoretical generalizations of the kind I am attempting here. This instance gets reworked in SS 221 (SEH III 417) as an argument that "sound participateth of some local motion of the air (as a *causa sine qua non*)." In context it seems that he really means the local motion of the specific medium air (as opposed to water, for example), which is another view he had rejected earlier.

³⁷ SS 115 (SEH II 390): "It is first to be considered, what great motions there are in nature which pass without sound or noise. The heavens turn about in a most rapid motion, without noise to us perceived [...]. So the motions of the comets, and fiery meteors (as 'stella cadens,' &c.) yield no noise. [...] We see that lightnings and coruscations, which are near at hand, yield no sound neither. And yet in all these there is a percussion and division of the air. The winds in the upper region (which move the clouds above, which we call the rack, and are not perceived below,) pass without noise. The lower winds in a plain, except they be strong, make no noise; but amongst trees, the noise of such winds will be perceived." See also SS 118 (SEH II 392): "The flame of tapers or candles, though it be a swift motion and breaketh the air, yet passeth without sound."

³⁸ See SS 115 (SEH II 390–391).

³⁹ See NO II 11–13 (OFB XI 217–237). Bacon holds that in order to draw any conclusions about the causes of a quality or phenomenon, one must start by drawing up a natural history organized in three tables: a table of essence and presence (with all the instances in which the quality is present), a table of divergence or absence in proximity (with all related instances in which the quality is absent), and a table of degrees (with all the instances in which the quality varies). This would allow us to eliminate the causes which are not invariably associated with the quality under investigation.

between sound and violent motions that strike and split the air (i.e. the kind of motions that were traditionally thought to produce sound), by cataloguing instances where this kind of motion is present, but sound is absent.

What I am suggesting is that large swaths of centuries II and III of the *Sylva* can be productively read as investigating the relationship between sound and motion. Part of the impetus for this inquiry comes from the traditional Aristotelian definition of sound, which thematizes a connection between sound and local motion. The way Bacon seems to interpret this connection ends up fairly close to the way the Aristotelians had (and sometimes by appealing to very similar phenomena). This is mainly a point about conceptual similarities; it does not require that Bacon be intimately familiar with the arguments of this tradition (and he frequently writes as if he is not).

Points of Dissonance

We have seen that, like the Aristotelians, Bacon seems to accept local motion as (part of) the efficient cause of sound, while rejecting the idea that it is the form of sound and thus something sound can be reduced to. There are, however, also important differences between his position and that of the scholastic tradition, both at the level of theory and at the level of methodology. I would like to discuss two of them by way of conclusion.

The first and most obvious difference is the methodological one. The Aristotelians resist the identification of sound to motion within the framework of a larger theory about perception and its objects, which they hope to preserve. An appeal to experience is instrumental in some of their arguments for the irreducibility of sound to motion, coming by way of a fairly limited stock of natural observations that support various theoretical points regarding sound. Bacon might appeal to some of the same classical natural observations, but the weight he places on them is completely different. They are part of a larger and much more varied collection of observations and experiments on the topic that are supposed to provide the material for constructing a larger theoretical framework, via a long process of induction. For Bacon, experience is supposed to come first.

Yet one might worry about the proposed relation between theory and experience in Bacon, given that we have seen him propose hypotheses for refutation and draw theoretical conclusions on the basis of just a few instances. Some care is needed here to balance two competing claims. On the one hand, there is Bacon's methodological commitment to assembling collections of natural particulars as a basis for the future development of an adequate theoretical framework. On the other, there are his theoretical pronouncements interspersed in these natural histories, many of which do not seem tentative at

all. That Bacon's natural histories contain theoretical material that his general methodological position seems to disallow is a fact that has attracted both criticism and friendly reconstructions over the years.⁴⁰ Without entering into this larger debate, I think there are a couple of points that we can make about Bacon's investigation of sound in particular.

First, many of the instances he collects in this investigation are clearly informed by an existing theory where the relation between sound and motion was salient. Second, most of his theoretical interventions in the text are negative pronouncements: instances show that local motion is not the form of sound. As regards the positive account, he stresses repeatedly that we do not yet have one: we do not know the true cause of sound. That we are told so early in the investigation that the true cause of sound is not local motion might be seen as an illicit anticipation of later steps in the inductive process. But equally we might see it as a theoretical step that facilitates further experimentation instead of closing it off, as a signal that one can and should look beyond experimental instances that have to do with the relation between sound and local motion.⁴¹

The second important difference between Bacon and the Aristotelians has to do with motion. When Bacon and the scholastics discuss the generation of sound and try to distinguish sound from motion, the kind of motion they are referring to is local motion. But that is not the end of the story for Bacon. Sound is not reducible to local motion, but that does not mean that it will not be reducible to some other kind of motion, once we have discovered its true form. As the example of the form of heat already indicated, Baconian forms seem to be combinations of natural motions.⁴²

Bacon recognizes at least nineteen basic motions of nature, which could also combine to give rise to complex motions. Among the motions presented in the *Novum organum*, one is of particular interest to us: the motion of impression, which is said to be a diffusive motion that reveals itself in "light rays,

⁴⁰ On this topic, see Peter Anstey, "Francis Bacon and the Classification of Natural History," *Early Science and Medicine* 17/1–2 (2012), pp. 11–31; Dana Jalobeanu, "Core Experiments, Natural Histories and the Art of Experientia Literata: The Meaning of Baconian Experimentation," *Society and Politics* 5 (2011), pp. 88–103; Daniel Schwartz, "Is Baconian Natural History Theory-Laden?," *Journal of Early Modern Studies* 1 (2014), pp. 63–89.

⁴¹ The way Bacon describes the traditional cause of sound in SS 124 (SEH II 393) as "a term of ignorance," "a catch of the wit upon a few instances," "empty of matter" makes it sound like the kind of illicit generalization that would hinder the progress of knowledge. Rejecting it by means of empirical instances might be akin to purging an Idol and could thus be beneficial to the progress of the experimental investigation.

⁴² Guido Giglioni nicely calls them "structural patterns determined by natural motions," see Guido Giglioni, "Mastering the Appetites of Matter. Francis Bacon's *Sylva Sylvarum*," in Charles. T. Wolfe and Ofer Gal (eds.), *The Body as Object and Instrument of Knowledge: Embodied Empiricism in Early Modern Science*, Dordrecht: Springer, 2010, p. 153.

percussions of sounds, and magnetic forces in respect of their transmission.”⁴³ The main feature of this motion is that it requires the persistence of the cause that initiated it and disappears immediately if that is withdrawn. This is illustrated for the case of sound with the observation that stopping the ringer of a bell makes the sound stop immediately too (a feature of sound that Bacon highlights in a few places in the natural histories as well).⁴⁴ This motion of impression presumably would be part of the true form of sound and thus one of a combination of motions that sound could be reduced to.

If the endgame of his inquiry into the form of sound might place Bacon a long way from the Aristotelian tradition, it would equally separate him from the mechanical philosophy. His proliferation of motions contrasts with the stark whittling down of motion into local motion in the seventeenth century. His most important legacy for this tradition remains his insistence that one could and should experimentally investigate different features of sounds and their degrees. And this applies to the connection between sound and local motion as well. For, as he says in *Historia soni*:

[O]f this matter altogether (*videlicet*, what relation and correspondency sound has to the local motion of the air) let inquiry be more diligently made; not by the way, whether? (which sort of question in matters of this kind has ruined all,) but by the way how far?, and that not by arguments discursive, but by opposite experiments and crucial experiences.⁴⁵

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⁴³ NO II 48 (OFB XI 407).

⁴⁴ See e.g. SS 124 (SEH II 394).

⁴⁵ This is the Montagu translation from *The Works of Francis Bacon, Lord Chancellor of England*, ed. by Basil Montagu, 7 vols., Philadelphia: Carey and Hart, 1848, vol. III, p. 543. The original runs: “*Verum omnino de hac re (videlicet, quam relationem & correspondentiam habeat sonus ad motum localem aëris) inquiratur diligentius; non per viam utrum (quod genus quaestionis in huiusmodi rebus omnia perdidit), sed per viam quatenus: idque non per argumenta discursiva, sed per apposita experimenta and instantia crucis*” (SEH III 679).

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