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The Analogies of Light and Sound in
Athanasius Kircher's *Phonurgia Nova*
(1673)

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Chapter 1

Introduction

Viewed against the background of the Scientific Revolution, Athanasius Kircher has often been found to be an ambivalent figure: too conservative to be counted among its heroes, yet too experimental and open to new knowledge just to be counted as a counter-revolutionary; spiritual concerns are too prominent in his writings for them to be taken seriously, yet they also contain too much obvious erudition and honest experimental curiosity to be discounted as irrelevant to its history. His *Phonurgia Nova* might very well be the first book devoted solely to acoustics, and thus avant-garde in its time, but Kircher is also known for his harmonical world-view, interpreting harmony as a fundamental principle of the universe, and explicitly considering analogical thinking as one of the fundamental ways to understand it.

In analyzing the analogies between light and sound in Kircher's acoustical writings, I try to assess how deeply his acoustical writings were marked by his adherence to analogical thinking, and thus to grasp his position between modern and occult science more precisely. Through an examination of the intertextual links between the *Phonurgia* and those of his earlier writings that contain acoustical material I look for developments over time. Although much of his oeuvre was planned years in advance and is homogeneous in character¹ with the goal of presenting one unified universal science, he was working in a time during which acoustics was undergoing intensive growth

¹As shown by the fact that many of his books were announced in his earlier works years before they were published. The *Phonurgia* though is not one of them.

and the proper uses of analogies in science were intensely discussed (a discussion that, when it was over, consigned his cherished analogical thinking into the dustbin of obsolete ideas). Well-informed as he was, this begs the question as to whether any of these developments left their mark on his acoustics or his use of analogies.

1.1 Science, magic and occult qualities in the 17th century

In trying to understand the relationship of an author of the 17th century to science and occult thinking there are at least two problems: a) that of definition, of what exactly science and occult thought are, or more precisely, were; and b) that of their distance, overlap or influence. It is impossible to position any historical actor between magic and science without clarity on these issues. But the latter in particular continues to be subject of debate, while the former, apparently a necessary first step in solving the latter, is often skipped altogether. It appears that the definition of science is often neglected because science is taken for granted with the meaning it has for us today, which itself is taken for granted as well, leaving the understanding of science then and today, as well as the possibility of an essential difference between them (as opposed to a simple relationship of development or expansion), clouded in the mystery of the seemingly obvious.² This points to a problem. Betty J. T. Dobbs has described it (without providing a definition of science) in “Newton as Final Cause and First Mover” as the assumption that the thought-patterns of those figures considered part of the Scientific Revolution “were fundamentally just like ours.”³ In her article this is presented as a fallacy. In the response by Richard S. Westfall in the same volume, “The Scientific Revolution Reasserted,” this idea reappears as one of the cornerstones of the continued significance of the Scientific Revolution, expressed positively as:

²For example Osler (2000) and Vickers (1984b).

³Dobbs 2000, 34.

Scientists of today can read and recognize works done after 1687.

It takes a historian to comprehend those written before 1543.⁴

The problem as I see it is to recognize the continuing relevance of some procedures, ideas and norms created in the 17th century, to see things shine out that are so very common to us that they might seem like laws of reason itself, while remaining acutely aware that they weren't necessarily as common or evident to "everybody" back then. But a large part of the appeal of the 17th century for the history of science lies without a doubt in the desire to watch the birth and development of ideas and ways of scientific thinking we still accept today. To paraphrase and rewrite Westfall: yes, the goal of the historian can certainly be "to help the present understand itself by understanding how it came to be," but the description and understanding "of that past on its own terms" is a necessary step in doing so.⁵ In order to understand how today's science came to be we need to understand what science was before, and not simply to make a collection of everything we can find that looks like "our" science.

The term "science" (or rather *scientia*) around 1600 "chiefly denoted a body of theoretical knowledge or doctrine about a specified subject."

The sciences were individual branches of knowledge acquired by study, and were concerned with systematic truths embodied in texts; hence it was mostly in the context of the schools (i.e. including universities) that such knowledge was generated. But the category of "scientist" did not exist, and the idea of *practising* science would have been utterly incomprehensible to anyone in this period.⁶

By the time the Royal Society was founded in 1660, "natural philosophy" as that part of science concerned with a systematic understanding of the natural world

⁴Westfall 2000, 44.

⁵Westfall 2000, 42.

⁶Gouk 1999, 9. She also notes that although "the distinction between the arts and sciences was . . . totally different from that familiar today," "this distinction is rarely spelled out, even by historians attempting to engage with the arts-science dichotomy."

was coming to be understood in England not so much as a theoretical system but as a *practice*: that of experimental philosophy. The production of this new kind of natural philosophical knowledge was recognized as a process which required the accumulation of data by means of observation and experiment. It was generally considered to be superior to, and distinct from, traditional modes of scholarship within the universities.⁷

Magic, on the other hand, was from the beginning of our period seen as an *art*, that is, a practice and the knowledge needed for it, “which causes particular effects on things or people by occult, that is, hidden, or insensible means.”⁸ A consequence of the Renaissance “boom” of magical publications⁹ was the wide range of attempts to provide a classification of the forms of magic and a coherent theoretical framework for it.¹⁰ A basic distinction was commonly made between magical effects produced through the intervention of supernatural beings, considered to be *demonic* magic, and natural magic which exploited hidden but natural—that is *occult*—properties of things. At the time, those phenomena which occurred in the usual course of things or most of the time were considered *natural*, while rare or astonishing phenomena were considered to be *unnatural*. Likewise, occult forces or unknown properties of things were counted among the *unnatural* phenomena.¹¹ Coming from an Aristotelian background, the term *occult* denoted anything not directly accessible to the senses, which was also excluded from the proper realm of scholastic physics.

Within this intellectual framework gravity, magnetism and musical sympathy... were all occult forces which acted at a distance in just the same way the more obviously “magical” techniques

⁷Gouk 1999, 10.

⁸This is close to the definition of *stregoneria* or witchcraft by the Venetian Inquisition, denoting every attempt to “manipulate supernatural forces to one’s own end,” only leaving out the intentionality. Martin 1989, 3.

⁹Unverzagt 2000, 22.

¹⁰Gouk 1999, 11.

¹¹Gouk 1999, 12.

of witchcraft such as fascination and binding exerted their influence.¹²

In the framework of natural magic it was possible to manipulate and use these hidden forces to produce predictable effects. Gouk stresses that while

this active, manipulative approach to nature is now accepted as characteristic of experimental science and technology. . . in the sixteenth century it was most often recognized as a feature of magic

and practitioners of medicine and the arts were among those most routinely making use of occult means, in ways that were often “closely guarded secrets known only to initiates.”¹³

What she does convincingly show is that experimental science increasingly came to inhabit a space of entertaining and astonishing practice which had previously been the domain of natural and mechanical magic; that many of the British heroes of the Scientific Revolution were interested in both natural magic and experimental science;¹⁴ and that they adopted both topics and aims from the realm of occult thought to that of what was to become modern science. But even in conventional universities, in spite of their Aristotelian outlook, typical magical topics were debated in this time, such as transmutation, sympathies and antipathies, astrology and amulets.¹⁵ And although they were committed to Catholic doctrine, so intimately connected to scholastic Aristotelism, even the Jesuits’ specific brand of Aristotelism and general philosophical foundation parted from certain theories in the face of new problems, such as for example the theory of the four elements, while retaining an Aristotelian “mentality” or epistemology, and the view of nature as a *Zusammenhang* of beings of certain qualities as opposed to the Cartesian view of an ensemble of material bodies moved in space. But this body

¹²Gouk 1999, 13.

¹³Gouk 1999, 13.

¹⁴She considers among others Francis Bacon (pp. 158–171), Robert Hooke (pp. 193–222), and Isaac Newton (pp. 224–259), without losing sight of the political and social developments of their time that they were part of (Gouk 1999).

¹⁵Unverzagt 2000, 27.

of doctrine was also supposed to stay in touch with current developments outside of the Society of Jesu.¹⁶

1.1.1 The differing uses of analogies

The idea of sympathetic magic played an important role in the framework of natural magic.¹⁷ It is at the most general level the notion that things that are similar in some aspect share an occult connection and can influence one another, such that manipulating the one has an effect on the other as well. Under this category fall for example the connection between metals and planets, protecting charms such as the use of red coral for babies and young children (where the link lies in the color of blood, and thus of life), the idea that there is not just a resemblance between microcosm and macrocosm, but that they also influence each other (as for example when an influence on certain organs is ascribed to a planet), and also phenomena such as musical resonance, referred to as “musical sympathy” by Gouk above and in Kircher’s writings as well.¹⁸ This concept was one of the main tools Giovanni Battista della Porta used to develop his *Magia naturalis*, which eschewed ghosts and demons, and portrayed occult forces, sympathies and antipathies as the true workings of nature.¹⁹ Della Porta’s book is one of the few that Kircher openly quotes in his *Phonurgia*.²⁰ The doctrine of signatures, the belief that natural objects carry outward signs of their occult powers is intertwined with the magical notion of sympathy, as these outward signs were often considered to be some kind of similarity to the power they were supposed to signify.²¹ From this doctrine and the idea of sympathetic powers a wealth of metaphors and analogies springs up in writings of the occult tradition, claiming meaningful connections from to modern eyes superficial similarities and sometimes building long chains of objects connected in such ways.

¹⁶Unverzagt 2000, 15–19.

¹⁷Gouk 1999, 88–111, Unverzagt 2000, 22–25.

¹⁸As for example in the *Phonurgia*, p. 151.

¹⁹Unverzagt 2000, 23.

²⁰Among them are also Marin Mersenne’s *Harmonie Universelle* (1637), Vitruvius’ *De architectura* and Giuseppe Biancani’s *Sphaera mundi* (1619).

²¹Gentner und Jeziorski 1993, 464.

Withholding the question if these occult analogies were actually confined to magical writings or not, diverse analogies were also used in authors that are commonly considered part of the tradition of modern science. Writing specifically about analogies between light and sound in the early modern period, Olivier Darrigol states that

[a]nalogies between hearing and seeing occurred at phenomenal, metaphysical, mathematical, physical, and physiological levels... the various levels of analogy are historically entangled... analogies at the physical or mathematical levels often derived from analogies at the other levels. Besides, the distinction between different levels of analogy depends on the period considered and on the general philosophy of the actors. For example, in Galen’s philosophy the physiological and physical levels are intertwined; in Kepler’s, a mathematical analogy is de facto a physical analogy; in Francis Bacon’s, a phenomenal analogy indicates a physical analogy.²²

He insists that they were not always constructive for the ideas of their authors, but could also stem from the author’s desire to present a comprehensive yet homogeneous philosophy of nature.²³

But while these various ways of analogizing may or may not conform to modern notions of a sound analogy, those springing from the doctrine of signatures and sympathetic powers contrast sharply with it. Today, analogy can be defined as the pointing out of a highly selective similarity that focuses on common relational abstractions, in which knowledge from one domain (here called the base) is mapped onto another (called the target), “such that a system of relations that holds among the base objects also holds among the target objects,” with one object or element from the base being mapped onto exactly one element from the target, thus creating a one-to-one-correspondence.²⁴ The objects that thus correspond to each other need

²²Darrigol 2010a, 118.

²³Darrigol 2010a, 118.

²⁴Gentner und Jeziorski 1993, 448–449.

not resemble each other, but their respective roles in their relation to the other objects in the relational structures that make up the analogy have to:

Thus, an analogy is a way of aligning and focusing on relational commonalities independently of the objects in which those relations are embedded.²⁵

According to Dedre Gentner and Michael Jeziorski, building on several investigations of Gentner and others,²⁶ structural analogies, or what today are considered to be sound analogies, follow six principles, some of which have already been hinted at:

1. **Structural consistency.** Elements from base and target correspond to each other on a one-to-one basis, and the respective relational “roles” of the elements match.
2. **Relational focus.** Of significance are the relations, while the attributes of the elements that are not relevant to the structure being mapped are not relevant to the analogy.
3. **Systematicity.** Among several relationships of an element that can be detected in either base or target, the one that can best be mapped to the other is preferred.
4. **No extraneous associations.** Other connections between base and target, or properties that are not part of the relational structure being mapped, do not strengthen the analogy.
5. **No mixed analogies.** Only one base is mapped onto one target. If several bases are mapped onto the same target, each analogy is coherent without the others—that is, independent.
6. **Analogy is not causation.** If the relational structure of one phenomenon can be mapped to a certain degree on another phenomenon, it “does not imply that one causes the other.”²⁷

²⁵Gentner und Jeziorski 1993, 449.

²⁶Particularly the study of models and analogies in science by Hesse (1966).

²⁷Gentner und Jeziorski 1993, 450.

They find examples that defy one or more of these principles in the alchemist tradition,²⁸ especially a failure to preserve a one-to-one correspondence and the tendency to fuse two interpretations of an analogy rather than to choose one over the other,²⁹ and conclude that

... the alchemists lacked a sense that *analogy* in the modern sense had any advantage over surface similarities or over metonymic, richly interconnected but unclarified forms of similarity and metaphor.³⁰

Gentner and Jeziorski note a striking contrast in analogical style between the alchemical texts from around 1600 they analyze and the scientific texts from later in the 17th century. Also relying on the account of the discussion of the proper uses of analogy by Vickers³¹ they locate a “shift in the rules of reasoning by similarity” between 1570 and 1640.³²

Vickers himself locates this shift rather between 1580 and 1680. Moreover, he claims that the occult and experimental scientific tradition “differ in goals, methods, and assumptions,”³³ and implies they always have done so. He goes on to analyze one of these differences, namely their respective assumptions about the relationship between language and reality. The occult tradition would not, according to Vickers, accept the arbitrary character of this relationship, but would posit an essential connection between word and thing. As a result, its adherents used analogies not only as heuristic or didactic devices, but as real explanations of things; furthermore the things between

²⁸[Names, texts! Refs to Vickers?] They use this term almost synonymously to Vickers’ “occult tradition.”

²⁹Gentner und Jeziorski 1993, 466.

³⁰Gentner und Jeziorski 1993, 475.

³¹Although they keep their distance to Vickers’ central claim about the “collapse into identity” (Gentner und Jeziorski 1993, 464).

³²Gentner und Jeziorski 1993, 475. Genter and Jeziorski acknowledge that this might be rather considered a “rediscovery” of analogy because it was already used in the modern way in Greek Antiquity, but that does not seem to make them rethink their periodization, nor does the fact that Brian Vickers, from whom they take so much, considers this to be a victory of the scientific tradition over the occult one, although the two coexisted for a while. Moreover, what he mentions but they fail to are the rigorous rules for the uses of analogy in Aristotelian science, which of course predates the alchemical texts they analyze. Which is to say that a more precise delineation of the area of validity of their argument would have been useful.

³³Vickers 1984a, 95.

which the analogy was drawn would become interchangeable—analogy would “collapse” into identity. Or, as he concludes, the difference can be described as the experimentalist saying about an analogy “this is not reality, but only a trope,” while the occultist says “this is not just a trope, but reality.”³⁴ Thus analogies in the occult tradition would “reify, rigidify, and ultimately come to dominate thought.”³⁵ He makes this argument mostly by analyzing the use of analogies in some occult writers, such as Agrippa, Boehme, Webster, Paracelsus and Fludd, and quoting and paraphrasing contemporary experimental critics of these writers, such as Ward, Locke, Kepler, van Helmont and Mersenne. Because he finds that these contemporary critics agree with his own criteria for the proper use of analogies in science, such as viewing analogies as rhetorical or didactic devices, but not a means of proof, and denying any essential connection between word and thing, he asserts that those same distinctions were already made in the 17th century (and, quoting Plato, in fact since antiquity).³⁶ This leads him to deduce a quasi-eternal deep gulf between experimental and occult science. In his introduction to the same volume he sums up his view of the relationship between them and its historiography that more or less follows the lines laid down by Frances Yates, as follows: “The error, as I see it, lies in arguing that the occult sciences in the Renaissance were productive of ideas, theories, and techniques in the new sciences.”³⁷ Following in the footsteps of Frances Yates is of course Penelope Gouk, whose whole monograph on the development of acoustics in 17th century England could be summed up as an attempt to prove that yes, indeed, they were.³⁸

³⁴Vickers 1984a, 136.

³⁵Vickers 1984a, 95.

³⁶Without analyzing how they actually *used* analogies. [†berprŸfen. If true, put in in the text proper.]

³⁷Vickers 1984a, 44. Yet that begs the question: How could they not? And what would it say about experimental science if it didn’t at least look at what the occult might have to offer in terms of things to find out or phenomena to explain better?

³⁸Sadly many of the points on which Vickers has criticized this research tradition do apply to her, even though she writes many years after both Yates’ and Vickers’ work was published, and acknowledges both. Vickers’ criticism mostly focused on the alleged blurring of “fundamental distinctions,” “assertion not argument,” “such rhetorical tricks as repetition” and the insinuation of ideas “without ever adequately exploring them” (Vickers

As a case in point, there are numerous parallels between Kircher and Isaac Newton (or, in modern perception, the nutcase and the genius): they were both deeply religious,

committed to the study of nature as a sure path toward the revelation of divine wisdom, who began their academic careers as professors of mathematics. Both valued the learning of the ancients, searching ever further into the pagan and Christian past in hope of illumination. For significant portions of their respective careers, that knowledge was found in occult sciences.³⁹

Findlen even speculates that the catholic Kircher would have been highly critical of the protestant (and anti-trinitarian) Newton's version of action at a distance, and would have described its use in explaining physics as both philosophically and religiously unsound, thus rhetorically reversing the roles of the scientist and the mystic.⁴⁰

1.2 The role of analogical thinking in Kircher's conceptions of science and knowledge

As both a Jesuit, and hence to some degree bound to an Aristotelian frame of thought, and a natural philosopher with an interest in hermetic texts,

1984b, 5). At least the last three of these criticisms could be harnessed against Vickers himself just as well; when Gouk in her conclusion fails to acknowledge the difference between Pythagorean numbers *being* the building blocks of the universe and Newtonian mathematical physics *describing* the universe, uses the word "symbolic" in a rather loose and undefined understanding, seems to neglect the possibility that even between "similar views" sometimes crucial differences can be observed, or simply fails explain how exactly Newtonian mechanics made the powers of the heavens "manipulable," she makes it harder to trust her general judgement; when she fails to provide documentation for some of her most programmatic claims (as for example her summary of Robert Hooke as an occultist (Gouk 1999, 194), she leaves one hanging with charming statements but on insecure ground. This is a pity, as without these flaws in the grand conclusions her research, much more diligent in the details, could be a welcome corrective to the oversimplifying texts of Vickers, whom she nevertheless puts into perspective, criticizes and at least partially refutes (Gouk 1999, 266f).

³⁹Findlen 2000, 221.

⁴⁰Findlen 2000, 225.

Athanasius Kircher is a highly ambivalent figure.⁴¹ His “universal science” was at least according to his own description characterized by analogies and combinatorial art, an “analogical thinking where the fundamental notion was number,”⁴² based on the underlying belief that “there is an analogical structure to the universe and the world contained therein: everything is to be found in everything.”⁴³ [Vorname] Vermeir has noted that there is a continuous ambiguity in Kircher’s descriptions that

allows him to integrate different traditions in what I would call a “unity without unification”, and it also allows him to draw schemes of correspondences, without having to worry much about consistency.⁴⁴

This wealth of “metaphors, analogies and characterisations of God and the universe” connects everything with everything. Vermeir concludes that

In the abstraction of his metaphysics, and by means of its powerful analogical and combinatory tools, different kinds of knowledge and divergent religions could be reconciled and merged. Ultimately, this made his metaphysics the focal point of all his other activities.⁴⁵

Both because he is the only author I have encountered with a believable claim to have worked his way through the majority of Kircher’s oeuvre, and because his monograph *Mundus combinatus* [Full title] is the most in-depth study of the philosophy underlying Kircher’s works, I am taking Thomas Leinkauf as my authoritative guide through this maze.

Leinkauf has looked in detail at the role Kircher ascribes to analogy in the structure and understanding of the world. He distills a philosophical framework from Kircher’s oeuvre that unifies his seemingly disparate objects of

⁴¹Even without the accusations of sorcery that some of his “amazing” shows are supposed to have drawn, as Vermeir states without providing a source. [Vermeir 373].

⁴²Knobloch 334.

⁴³Knobloch 343.

⁴⁴381

⁴⁵382

study, from magnetism to philology, a framework that also provides a consistent description of the relationships between God, his creation, and human knowledge of his creation. According to Leinkauf, this system integrated Kircher's theological and hermetic sources with methods and knowledge from the new science in a new synthesis, a synthesis that had space for God as an active principle in the world as well as a significant emphasis on experiment and observation.

The general expectation inspired by Vickers' article would be that Kircher, who places himself squarely in the natural magic tradition, both by the sources he quotes (as for example De la Porta), as well as through the titles or subtitles of numerous parts of his works,⁴⁶ should be hostile to the idea of experimental tests for scientific theories, ought not to care much about such data or general observations, and possibly also be hostile to a quantifying approach to natural phenomena, and cannot have had any influence on or contributed anything to "real" experimental science. His analogies can be expected to be arbitrary and liable to turn into identity at some point. They could not possibly transport much rationally meaningful information, while at the same time they are presented as real explanations rather than merely heuristic or didactic devices. Kircher's analogies would be rigid and dominate his thought (as he is working during the high time of the period Vickers describes). And indeed Leinkauf explains the Lullist principles which Kircher adopts as the elements which combine to make up the world as follows: "Grundzug dieser absoluten Prinzipien ist ihre Realidentität mit Gott und ihre auf Realidentität untereinander basierende Konvertibilität"⁴⁷ Yet these absolute principles are not *words*, and this convertibility is not the simple identity as which it might appear.

For Kircher the "ars analogica" was a central key to understanding the world. In his view, the world consisted of a vast number of combinations of a limited number of elements. These elements were predicates of God, thus referring back to him while being his unfolding. Because they all refer back to God, they are essentially exchangeable. This is the analogical structure

I need to clarify how this matters for the magic/science debate and for my question.

⁴⁶[Examples]

⁴⁷Leinkauf 1993, 152.

of being, an expression of the divine intellect, and thus the truly intelligible aspect of the world, “das, was die Summe der Dinge überhaupt erst zu einer ‘Welt’, zu einem geordneten, strukturierten Zusammenhang macht...”

Denn: die Substanz von Analogie besteht für Kircher darin, daß sie paradigmatisch das *Verhältnis von Einheit und Vielheit* bzw. Identität und Differenz im *Horizont von Vielheit* ontologisch begründet.⁴⁸

Things are defined through the dialectic of identity and difference, especially the positive-negative reference to everything else, which they are not, in which reference their being becomes clear as the not-being of the other in a complete, universal sense.⁴⁹ God is to the world as the basic unit is to numbers.⁵⁰ The central aspect of any analogy for Kircher was not one or the other of the things the analogy was made between, but rather the relationship that the analogy puts these things into.⁵¹ But although analogy is for Kircher a very real aspect of reality, man can only approximate these real analogies hypothetically, and needs additional evidence to legitimize his hypotheses. Yet because of its fundamental general legitimacy, as well as the mathematical roots of the term in antique Greek thought, analogy gives these conjectures a form that is quantifiable and thus appropriate for science.⁵² ⁵³ The real qualitative complexity of the world which actually relates the things to each other can only be grasped hypothetically and imprecisely by man, but the projection of the analogical structure from the domain of the speculative discussion of the predicates of God into the domain of the concrete being gives man a starting point from which to gain scientific, that is secure, knowledge about this being.⁵⁴

Kircher was not alone in his attempts to correlate our ways of knowing with the structure of the world or ultimately with God’s intellect. According

⁴⁸(Leinkauf 1993, 164).

⁴⁹Leinkauf 1993, 275.

⁵⁰This is a structurally sound analogy according to the criteria by Gentner and Jeziorski.

⁵¹Leinkauf 1993, 166.

⁵²Leinkauf 1993, 167.

⁵³“Die Konstanz der Natur in ihrer inneren Organisation gestattet begründete Konjekturen von analysierten und interpretierten Teilbereichen auf das Ganze.” Leinkauf 1993, 129.

⁵⁴Leinkauf 1993, 168.

to Leinkauf, both those working in the deductive-geometrically proceeding natural science and those in the broader Lullist tradition⁵⁵ (such as Kircher himself) increasingly made the form of knowledge or ways of knowing (“Form der Erkenntnis”) a criterium for the scientific worth of this knowledge, legitimizing their procedures through *methodus* that were taken to be infallible, because they were structurally the same as God’s own thought.⁵⁶ But while Kircher obviously gives great weight to speculative thoughts and ideas, that does not in itself make him an irrationalist. In fact, in his *Mundus subterraneus* he contrasts the metallic and chemical arts against magic and alchemy, and tries to put up rational, if speculative, criteria for these disciplines especially threatened by irrationalism.⁵⁷ More generally, Kircher tries to bring the as yet undisclosed “dark” aspects of nature into the “light” of divine order, to turn that which used to be understood irrationally as *secretum* or *miraculum* into an expression for the not-yet-understood or the as-of-yet—but not forever—exceeding human capacity for understanding, an essentially intelligible complexity and variety of nature.⁵⁸

From the imprecision of human understanding follows the necessity to test and correct these conjectures through experimental data. In fact, in the interpretation of science as part of the human *ascensio* to a better understanding of God, the fundamental first step is the analysis of empirically observed natural processes, and the internal structure of things as well as their external relations of things to one another. This analysis has to be testable through experiment.⁵⁹ The imprecise and discursive nature of human understanding is for Kircher a consequence of the Fall; this view of the theological necessity of the imprecision of human understanding saves science from the hubris of aiming to understand the world from universal principles

⁵⁵Rebohm Fußnote

⁵⁶Leinkauf 1993, 133–134. [Who exactly is he talking about?] “Wie die Form für den Künstler bei Nietzsche, so wird hier die dynamische Struktur der Methode vom Organon, das den Zugriff auf etwas von ihm Unterschiedenes eröffnen soll, zum integralen Bestand der Sache selbst.” Leinkauf 1993, 15.

⁵⁷Leinkauf 1993, 32.

⁵⁸Leinkauf 1993, 42–43.

⁵⁹Leinkauf 1993, 283.

alone without referring to experimental data.⁶⁰ So while Kircher positively receives the mathematical-geometrical method as developed for example by Kepler, Galilei and Descartes, and shares the idea that the behaviour of things is determined through their geometrical structure, he connects this approach with an undiminished regard for the dignity of the particular.⁶¹ Thus he defends the peculiarity of the individual structure against the idealizing mathematizing discussion of the world. For him, the only possibility for science to deal productively with the discrepancy between divine precision and the human demand for it is to note the gap between the scientific formula and the actual instance, and to try to reconcile them under the heading of his Lullist universal combinatorics.⁶² The experiment thus both supports and extends limited human rationality, and mediates between reason and experience.⁶³ Discussing the shared convictions between Kircher and Marin Mersenne, Leinkauf writes that the experimental and quantifying procedures of the “new physics” can only grasp the surface of natural phenomena, so to say, for reason; the “inner,” substantial action of the forces remains hidden, and the mathematical grounds of explanation do not coincide with the nature of things.⁶⁴ For Kircher and his contemporaries it became increasingly clear that this assumption of general, metaphysical or at least spiritual active principles in nature particularly necessitated the analysis of their action or presence in the particular empirical case through the analysis of the immediate manifest special forces.⁶⁵

Although these “active principles” seem to point straight at conceptions of natural magic, the category of magic does not figure as prominently in Leinkauf’s account of Kircher as it does in other, less expansive works. Theurgical or demonic magic were clearly not acceptable to Kircher, but natural magic, defined as “alle Magie, die nicht satanisch ist, und die wundersame Wirkungen durch verborgene Effekte hervorbringen kann und doch immer

⁶⁰Leinkauf 1993, 289.

⁶¹Leinkauf 1993, 194.

⁶²Leinkauf 1993, 295.

⁶³Leinkauf 1993, 300.

⁶⁴Leinkauf 1993, 296.

⁶⁵Leinkauf 1993, 301.

natürlichen Ursprungs ist”⁶⁶ clearly occupied both at times his attention and space in his writings.⁶⁷ But Leinkauf does repudiate, at least for the 17th century in general, the clean distinction between “naturalism” and “magic” that William L. Hine claims for Marin Mersenne,⁶⁸ emphasizing that the reality of the discussion in the 17th century was largely to ignore this clean separation of domains.⁶⁹ More convincingly, and more importantly, he analyzes the importance for Kircher of authors from the Neo-Platonist, hermetic and natural magic tradition, especially Cusanus, but also Ficino, della Porta, and others.⁷⁰

So how to locate Kircher’s notion of analogy in this web of experimental science and occult thought? He seems to be saying that his analogies might actually describe the fundamental structure of the world, thus clearly being more than a trope, but in such a way that we post-lapsial humans are unable to tell for sure. He is clearly drawing on both traditions, and possibly even more on science, both scholastic and experimental, than on occult and magical thought. This is not just science that has been influenced by magic; this is science that proudly proclaims this inheritance and, as we will see, now considers the wonderful as a hallmark of matters of science. On the one hand, in Kircher, science is fitted into a spiritual worldview (mostly religious and not necessarily magical), on the other hand it appropriates natural magic to the extent of almost becoming synonymous. But even though Kircher ascribes paramount importance to the principle of analogy in the world, taking it not just to be a phenomenon of speech but an actual property of the structure of being, this does not mean that he accepts that what you do to one part of the analogy actually affects the other. Just because he relates stories of magical charms etc. that work that way does not mean that his actual physics works

⁶⁶Englmann 2006, 39. Englmann’s further explanation “Mit natürlicher Magie beschrieb Kircher das Ausnutzen aller Kräfte, die Naturwissenschaftler als Kräfte der Natur ansehen, etwa Newton die Gravitation” is not quite as helpful, as it neglects the distinction between occult and ‘classical’ forces (in this view, motive force would also fall into the domain of magic, and with it all of mechanics, which is clearly not the case) and too readily accepts that Newton and Kircher fall into completely different categories.

⁶⁷[Examples]

⁶⁸Hine 1984, 174.

⁶⁹Leinkauf 1993, 39.

⁷⁰[Discuss in more detail.]

that way.⁷¹

There are many things Kircher and Gouk's examples have in common, most importantly their adherence to a harmonical world-view.⁷² Compared to the more and more public nature of the scientific undertakings of these Englishmen, who emancipated their practice from court culture under the influence of the Interregnum among other factors, Kircher's studies still have a more courtly touch to them, with princes and noblemen and -women being the guests he entertained in his museum, while everything took place under the auspices of his order, not a public club like the Royal Society, and firmly embedded in Catholicism. One consequence of this might be the openness with which he refers to natural magic (even while veiling the influence of heretical authors), using the aura of the wonderful and miraculous as an advertisement. It is not necessary to search for the magical influence on Kircher's writings in allusions and private diaries, they are obviously right there on the printed page, in headings and explicit citations.⁷³

While Leinkauf has described Kircher's instance of this harmonical world-view in detail, traced its consequences for his theory of knowledge, and described its application to Kircher's writings on numbers and language, he has left open the matter of whether Kircher actually practiced the natural sciences according to his own theory. Did he use analogies as exploratives in physics, for example? Did he make conjectures from them, and then test them in experiment?

How Kircher actually used analogies in his writings on acoustics is the topic of this paper. I have chosen to focus on his uses of the light-sound analogy because he uses it copiously, and in different ways, and because the rational and the spiritual interpretation of analogy are especially close to each other in this case, a pair that combines the heavy metaphysical and spiritual associations of light and harmony.

⁷¹[Many claims in this paragraph that I have yet to make plausible.]

⁷²[Rebohm cite?]

⁷³For a detailed comparison between Newton and Kircher see Findlen (2000).

1.3 The development of acoustics in the 17th century and the analogy between light and sound

Although the *Phonurgia* is a marginal text with regard both to Kircher's oeuvre as whole (in contrast to the opus magni he published, the *Phonurgia* was not planned in advance as an integral part of his universal science) and to its reception (apparently it did not productively influence later works on the subject, especially not innovative ones),⁷⁴ it is an especially interesting one for observing the distance or lack thereof between a new experimental science and occult thought. The material of the *Phonurgia* developed over about three decades, from Kircher's first echological passages in the *Ars Magna Lucis et Umbrae* in 1646 (but probably worked on some years before) to the publication of the *Phonurgia* itself in 1673. This was after the experiments of Galileo and Mersenne on sound, contemporary to the experiments by the Accademia del Cimento and a wave of experiments with and without air pumps about the vacuum as well as the speed of sound,⁷⁵ and before the publication of Newton's *Principia* with the derivation of the speed of sound from the properties of air as a gas.⁷⁶ This was a time when acoustics as a discipline of its own was just developing, and before it had a fixed name. Between the year 1600 and the publication of the *Phonurgia*, thinking about sound overcame Aristotelian conceptions of sound, the understanding of consonance became physical and largely independent from scholastic musical theory, and the theory of sound caught up with established practices of sound manipulation by the engineers.⁷⁷ All of these developments have

⁷⁴Reilly describes the tube controversy in which the *Phonurgia* took part, noting that at least in regard to England Kircher lost this battle, and notes the waning of his influence after his death (Reilly 1974, 143–144, 182–185).

⁷⁵For example in the Florentine Accademia del Cimento (Hunt 1978, 100–108), the Royal Academy and the Académie des Sciences. Specifically about vacuum experiments, see Hunt (1978, 112–120).

⁷⁶Even if the adiabatic aspect of sound was only recognized later, making Newton's value too small.

⁷⁷For an overview of the general development of acoustical knowledge up to and including the 17th century, the best work is still Hunt (1978). For a more in-depth study of the

What ideas?

bearing on the perception of similarities between light and sound.

The new mechanical ideas about sound replaced the Aristotelian conceptions of sound, based on the notion of sensible qualities and violent motion. Before the understanding of vacuum phenomena became more sophisticated, these new ideas were largely based on the analogy between optics and acoustics, epitomized in the treatment of sound propagation as rays in straight lines like light.⁷⁸ This optical approach to acoustics was first put forth by Biancani [Vornahme, Buchtitel, Jahr]. Later, Mersenne gave a new explanation for the perception of different sounds, rendering obsolete the explanation of sound as a “sensible quality,” and Gassendi [Vornahme, Buchtitel, Jahr, Entdeckung] superseded the interpretation of sound as violent motion.⁷⁹

Either this development of acoustics made it possible to think about sound, and issues relating to musical theory, especially the problem of consonance, in new ways, or conversely, because the rise of poly*Phonurgiai* in the late Middle Ages made new consonances felt that did not fit into the Pythagorean ratio system, “a physical justification of harmonious ratios now became necessary” (Darrigol 2010a, 119). Leaving the question of historical causality aside, the strictly arithmetical scholastic notion of consonance based on simple ratios, and explained or even caused by these ratios without physical explanation, was replaced by a physical theory as to the nature of consonance, and ultimately of sound.⁸⁰ “Der zweite und endgültige Grund für den

concepts of sound propagation from antiquity to the Enlightenment, see Baskevitch (2008). For the development of acoustics as a separate discipline of natural knowledge and its relations to other disciplines of science and art in 17th century England, see Gouk (1999). For a case study exploring specifically the relationship between practical knowledge of sound manipulation and its relationships to the evolving concepts of sound in natural philosophy in the case of the hearing trumpet, see Valleriani (2011).

⁷⁸Yet not every philosopher who put forth mechanical theories agreed with this increase in “likeness” between light and sound; René Descartes, for example, did not (Darrigol 2010a, 120).

⁷⁹Valleriani 2011.

⁸⁰“Galiée a clairement établi, sans doute le premier - mais est-ce bien important ? -, que la hauteur du son dépendait uniquement du nombre de vibrations dans un temps donné, et que les autres paramtres, tels que les longueurs de cordes ou leur tension, n’étaient que des corollaires de cette loi. Cette approche, qui annonce la théorie ondulatoire malgré un modle dominant encore largement corpusculaire, est novatrice et constitue une ébauche de l’autonomie de l’étude physique des sons par rapport à la musique et au dogme de l’harmonie scolastique.” Baskevitch 2007, 409.

Untergang der Proportionslehre in der akustischen Wissenschaft liegt in der Möglichkeit zur absoluten Frequenzmessung und Mersennes empirischer Feststellung der Bandbreite menschlicher akustischer Wahrnehmung... weil die Mathematik nun zu einer Physik wird... So antizipieren Mersennes Arbeiten Sauveurs folgerichtige Aufteilung der Musiktheorie in eine Akustik und eine Musiklehre: ‘Mersenne quote, aber nicht nach Original’ [Volmar, Seitenzahl]. This independence of physical theories of consonance from scholastic music theory slowly dissolved the previously intimate connection between thinking about sound and notions of harmony, musical and otherwise.

Acoustical instruments were not really integrated into theories about sound at the beginning of the 17th century. In Francis Bacon, Leurechon and della Porta [Bücher, Jahre] the functioning of the ear trumpet is explained through an analogy to the telescope, *not* a theory of sound, and in their description does not change the sound itself as much as it changes its perception. Moreover, even as acoustical effects in architecture became better known and exploited by engineers, lacking the mechanical notion of sound their workings could not yet be explained to the satisfaction of contemporary natural philosophy:

Because of the increasing diffusion of contemporary architectonic solutions, which made more and more use of ‘surprising [acoustic] effects,’ such as those used in the Boboli Gardens of Florence, or in Salomon de Caus’ Palace Gardens in Heidelberg, engineers like Galileo naturally focused their attention on such contrivances [acoustical devices]... Although Aproino and Galileo foreshadowed the results later obtained by Morland and Cassegrain, their theoretical background in this field in 1613 could not have bridged the gap between acoustic devices in the fields of architecture, engineering and medicine and the natural philosophers and engineer-scientists since the new mechanics of sound was not yet at their disposal.⁸¹

Although it does not provide a systematic analysis of how Kircher used

⁸¹Valleriani 2011.

analogies in general (which would not be within the scope of this text), the light-sound analogy can be expected to be a fruitful point of focus. On the one hand, light and sound both bear a heavy load of spiritual connotations, but on the other hand this analogy did have a lot to offer on a structural level to investigators of sound in the 17th century, and played an important role in the development of acoustics. [Vorname] Darrigol gives the most comprehensive account of the role of this analogy in the history of science, providing an orientation, even if he is looking from the other direction, asking how the analogy with acoustics influenced the development of optics from antiquity to [Newton?]. He explains that the proliferation of such analogies in the 17th century stems from the parallel development of the mechanization of optical theories and the physicalization of theories of sound, which produced conceptions of both light and sound that were more alike than the classical ones [Beispiele]. He also asserts that

the ambition of a few philosophers to erect a new natural philosophy on the ruins of Aristotle's favored reflection on the connections between various departments of knowledge,⁸²

contrasting this to medieval authors, who tended to consider sound in the context of music and in special relation to arithmetic, and light in the context of optics with its diverse relations to physics, physiology, and geometry. Kircher can certainly be considered one of these philosophers striving to build a new natural philosophy, and the *scientia universalis* he was aiming for was indeed held together by all kinds of connections between different areas of knowledge he could discover. Moreover

[The largely mechanical character of early modern optical theories] made light more similar to sound, because since Greek antiquity the propagation of sound was most often regarded as a mechanical process (with the exception of the scholastic theory of immaterial sound species). This circumstance and the rise of physical approaches to sound and music explain why fruitful

⁸²Darrigol 2010b, 246.

analogies between light and sound only began to occur in the 17th century. More attention to individual cases is needed to understand the motivation and nature of such analogies, or their occasional exclusion.⁸³

[Integrate this better, this almost makes for some kind of dialectics in the literature.]

Darrigol, however, focuses exclusively on the structural analogies between the two domains, on those that could in the modern sense be scientifically productive, and ignores any metaphysical implications, allusions and metaphors. Among the analogies he leaves out there are those with a primarily aesthetickal bearing, like Galileo's comparison between musical consonance and pleasing patterns among multiple oscillating pendulums.⁸⁴ More importantly in the context of this paper, he leaves out the considerable amount of spiritual significance that both sound and light command in some of the intellectual traditions in the 17th century, both occult and religious, classical and hermetic. The role of sound and phenomena related to it for a harmonical world-view have already been described above; the impact of a certain kind of metaphysics of light on the history of medieval science has famously been charted by Alistair Crombie [Title, year, specifics]. Both sets of connotations, although in the process of becoming dated, were very much relevant for Kircher, who was steeped both in the hermetic and the Neoplatonist tradition [Rebohm, Leinkauf ref]. At the same time, the *Phonurgia* was to a considerable extent simply the most detailed account of the new (well, by that time not *that* new anymore) ray-theory of sound and its application to acoustical devices of all kinds at the time of its publication.

It is exactly this relationship between the old and the new, and between the occult and the experimental, that I set out to understand better by analyzing the light-sound analogies in Athanasius Kircher's *Phonurgia Nova*.

⁸³Darrigol 2010b, 206.

⁸⁴"Galileo observed that a set of pendulums of different lengths set oscillating about a common axis and viewed in the original plane, presents to the eye (at least it did to his eye) a pleasing pattern if their frequencies are simply commensurable, whereas it forms a complicated jumble otherwise. One must admit that this was a kinematic observation of great ingenuity and formed the basis of a suggestive analogy." Lindsay 1973, 6.

Chapter 2

The Analogies between Light and Sound in the *Phonurgia Nova*

As I have described above, the scholarly convention is that Kircher was a prominent exponent of the occult tradition and natural magic. As such he can be expected to conform to Vickers' analysis of the occult tradition's use of analogy, in which analogies are seen as modes of perceiving real relationships between things, to the extent that the one can be substituted for the other, or manipulating the one also has an effect on the other. This assumption is strengthened by the pivotal role that Kircher ascribes to analogy, both as a principle of the structure of the world and as a means of understanding it, as well as his peculiar notion as to the nature of analogy. In the *Phonurgia*, there are quite a number of instances of the light-sound analogy that seem to fit the "collapse into identity" that Vickers has described. For example, Kircher states that "light is nothing but a certain consonance and dissonance to the eyes,"¹ that "nothing can occur to the eyes, that according to a certain analogical reason cannot get itself up for the ears," that light was like a certain movement of the air, and sound the same;² he freely transfers state-

¹ *Phonurgia*, first page of the preface to the reader, unpaginated.

² *Phonurgia* 6–9.

ments made about light from the *Ars Magna Lucis et Umbrae* to sound³ and equates the laws of sound reflection with those of the reflection of light;⁴ he compares optical and acoustical instruments with regard to their tube-form, disregarding that this is an essential part of some acoustical instruments only, while in optical instruments the tube usually accomodates the truly functional lenses;⁵ and last but not least he states that sound perfectly imitates the rays of light in every respect.⁶ All of these instances seem to fit the assumption that Kircher is a typical exponent of the occult interpretation of analogy, insofar as they give a great weight to analogy, apparently taking for granted that this weight is justified, exaggerating its potency (“nothing but” etc.), and apparently heaping analogies onto each other without regard for consistency.

But looking in detail at Kircher’s light-sound analogies in context, these expectations turn out to be misleading.⁷

2.1 Examples

1. The first of these analogies appears on the first side of the “Preface to the Reader.” The preface itself starts off with a reference to the *Ars Magna Lucis et Umbrae*, explaining how it was well received by the Republic of Letters, and stating the perpetual pregnancy of Kircher’s mind with strange and wonderful ideas, and his desire to produce new and wonderful devices. One of these ideas is the conjunction of acoustics to its loyal partner optics through a variety and abundance of arguments:

Because if one draws up the parallels between the one with the other, one finds that there are so many as to be a marriage, so that light is nothing but a certain consonance and dissonance for the eyes, and the ‘lightshade’ to the ears he will conclude nothing

³*Phonurgia* 18, 66.

⁴*Phonurgia* 22.

⁵*Phonurgia* 111.

⁶*Phonurgia* 136.

⁷[Summary/overview of the *Phonurgia*]

but a not inconsistent combination, and from these everything that is worthy of admiration in the world results, especially what renders the minds of mortals so very astonished.⁸

He goes on to describe the relationship of acoustics and optics as bound together in a firm marriage with this analogy functioning as bridesmaid. The next paragraph is mostly about how much work he has expended in writing this book, and how “the *Phonurgia*, or the practical science of sound stretches its tricky boundaries no less long and wide than the Photurgia, that is, the science of light, and recedes as to be practically hidden and inaccessible.”⁹

By proclaiming this marriage, Kircher effectively makes his optical expertise ‘count’ in this new area of acoustics. If optics and acoustics are connected so tightly, his reputation in optics makes him competent to tackle acoustics as well. The quoted extract itself mingles poetic analogy with the motif of combinatorics. Kircher likens light to consonance and shade to dissonance, and then sound itself, via the explanation of consonance put forward by Mersenne, to harmony, or as he puts it, “a not inconsistent combination,” which in turn becomes the cause of everything admirable in the world. This is a classic example of how in an occult context an analogy starts out with a limited scope, but ends up explaining the whole world. What Kircher does not mention here is a combination of *what* exactly light, sound, or the admirable things in the world are. Light and sound might both be combinations, but can still be combinations of fundamentally different elements.

⁸“Acusticam facultatem Opticae fidae Sociae pari argumentorum varietate & opulentia conjungendi, ardentissimum insedit desiderium; siquidem parrallela quadam comparatione unius cum altera constituta, certe tantam harum ad invicem affinitatem inveni, ut lucem nihil aliud, quam consono-dissonum quiddam oculis; auribus vero lucidumbre quidpiam esse, haud in consentanea combinatione concluderim, atque adeo ex harum miscella, quicquid in Mundo admiratione dignum, quodque mortalium animos tantopere attonitos reddit, resultare videatur.” *Phonurgia*, unpaginated.

⁹His itaque prob praecognitis, non adeo difficile arduumque videbatur, utramque paranymph rerum analogi connubio junctam firmo unionis faedere stabilire.

Habet enim Phonurgia, sive soni practica scientia non mins, quam Photurgia, id est, scientia Lucis longe lateque exporrectos [Greek term] suae terminos, recessusque prorsus reconditos atque inaccessos, quos ut superarem, dici vix potest, quantum in doctrina subtili & ardua, [Greek term] in sua principia resolvenda mihi laborandum, quam meus hic animi sudarit & alserit ausus. *Phonurgia*, unpaginated.

Light, sound, and the admirable aspects of the world do not necessarily collapse into identity.¹⁰

2. The second analogy is part of a whole section titled *Sonus Lucis Simia Est*, “Sound is the ape of light.” The comparison between light and sound is thus considered to be a topic on its own. Furthermore, this section is used as an explanation of what exactly sound is, not necessarily always in comparison with light. This part is four pages long, and reaches the comparison with light like this:

just as the ray of light in a denser medium, in which it is broken, is made dull, so is the ray of sound broken in a denser medium. Thus the species of sound are made dull and blunt by the thickness of the water, like the visible species in a thicker medium. Thus we hear less in times of rain and when the air is misty than when it is purified.¹¹

He goes on to describe the sound absorbing-qualities of fabric. Sound would be the ape of light, and imitate it in all things/aspects. The first aspect he mentions is the “sound sphere,” inside which the sound from a specific sounding object/subject can be heard, but not outside it. From this he deduces that sound, like light, travels in straight lines in all directions from the sounding subject. Thus the radiation of sound would closely imitate the “luminous flow.” But not completely: He mentions that sound is not propagated instantly through the air like light, and that light is not amplified through curved tubes the way sound is. Still, nothing could occur to the eyes that could not set itself up for the ears according to a certain analogical

¹⁰This passage also hints at the role of dissonance or shade in Kircher’s concept of harmony, who is writing at a time when dissonance in music was emancipating itself as necessary contrast to consonance, and the line between the two categories was being redrawn. In Kircher’s world-view the negative and the positive are both necessary elements of the harmonical combination that makes up the world.[Rebohm Ref!]

¹¹Sicut neim se habet lucis radius ad medium densius, in quo refringitur, hebetaturque, ita radius sonorus in medio densiori quoque refringitur. Hebetaaturque igitur, obtundunturque sonorae species aquae crassitudine, ut species visibiles medio densiore. Hinc tempore pluvio, & aere vaporoso minus, quam eo defaecato audimus. Praelusio I, 6–7. For a facsimile of the complete “Praelusio”, see the appendix.

relation. Just as light would present the different colors of bodies, and the angles of incidence and reflection of rays on surfaces to the eyes, so too would sounds represent different qualities of bodies

through the movement of the air that hits and strikes their surfaces; so that we can not unsuitably say that colours are nothing other than the different immersion and reflexion of rays in a medium; in the same way sounds are nothing but different motions of the air: if namely somebody discerns the subtle movements of the air, while any instrument resonates, it is surely nothing different from when he sees some picture sketched out with a variety of colorful marks, where through the eyes he puts up for himself different qualities of the sounding bodies, as it is said.¹²

Furthermore, he states that abstractly light would be in itself invisible, and all we could see would be the illuminated bodies. From this he proceeds to a short general statement that no *accidens* could itself be perceived if not through the bodies by which it is supported, and ends by stating that light without air would be invisible, as would sound without air be inaudible. He goes on to describe light as a certain movement of the air, and sound the same, but carrying with it different qualities from its source. He then doubles back and reformulates this comparison as “just as light without a body from which it flows forth cannot keep on actually flowing, so it is for sound without the movement of the air.” His next point of comparison is the way in which vision and hearing are produced similarly in men: just as the optical species of things affect the eyes and optical nerve in certain hidden ways (*occulta*

¹²Siquidem nihil oculis occurrere potest, quod sub Analogica quadam ratione auribus sese sistere non possit. Sicuti igitur luminis proprium est, repraesentare differentes colores corporum, juxta differentes nunc radiorum incidentium, nunc reflexorum directiones in superficies, & hinc ad oculos factas; ita sonorum proprium est, repraesentare differentes corporum qualitates ope moti aeris eorum superficies impingentis, ferientisque; ita ut haud incongrue pssimus dicere, colores nihil aliud esse, quam differentem immersionem & reflexionem radiorum in medio; quemadmodum soni nihil aliud sunt, quam differentes aeris motiones: Si enim quispiam subtilissimas aeris motiones, dum aliquod Instrumentum resonat, cerneret, certe is nihil aliud, quam picturam aliquam insigni colorum varietate adumbratam videret, qua oculis sese diversae sonantium corporum qualitates, uti dictum est, sisteret. 7–8.

ratione) in order to produce through the work of the spirit an image in the mind similar to that of the thing seen, so too would air transport an image of the sound-source, which would affect the air in the ear or the aural nerve in the same way that optical *species* affect the eyes. And lastly, taking up the topic of sound-absorption from the beginning of this section, just as light is broken in a denser medium, so too sound be, and the effect of a soft and porous body which mutes or at least diminishes sound would be like a shadow on sound, and this body like an obstacle “meeting with which it [the sound] cannot extend further.” In the following *consectarium* he expands on the question of the muting of sound in water as a denser medium, and concludes that the cone of sound operates in parallel to the cone of light, except for the instant motion of light compared to the successive motion of sound, and that sound could not just travel in straight lines, but also in curves, which could be seen when sound would go through channels or tubes.

Most of these analogies are structural in the sense described above, comparing similar aspects in the behavior of sound and light: the different effects of water as a medium in contrast to air, the model of the sound-sphere, the dependence of the *accidentia* on the bodies through which they are supported, and the comparison of the respective physiology of perception are fully rational, given Kircher’s Aristotelian framework. He points out important differences between light and sound, thus limiting the scope of this analogy. The aspects of sound are mapped almost one to one on those of light. This whole section is in fact a single expanded analogy, and not a list of functionally unrelated superficial similarities and metaphors, as might be expected from the alchemist’s “more is always better” approach to analogies and metaphors, and which the sheer length of this section seems to indicate.¹³

Bring in the criteria from the introduction.

But Kircher also compares different aspects of sound and light in a disorderly manner: in one instance sound travels in rays like light, in another the rays of light are *like* the movement of air that is sound (which is not the same as writing they *are* movement of the air), only later to make a comparison that would give air in relation to sound the role that the light source has in relation to light. That is, air would be the sound-source, whereas before it was

¹³?, 471.

the medium for both light and sound. In the *consectarium*, the parallelism between the cone of light and the cone of sound is substantially weakened by the acknowledgement of their differences. If the sound can travel in curves as well as straight lines, how does it still qualify as a cone? After all, the cone-form had been deduced from sound traveling in straight lines in the first place. Kircher clearly violates the criteria described by Gentner and Jeziorski, yet he does not touch occult territory: To use Vickers' words, it is not so much that he is used by his analogy as that he abuses it. He clearly wants it to explain more than it really can, but he stays clear of anything resembling sympathetic magic, or proclaiming actual identity of light and sound.

3. The third analogy takes up the motif of the parallelism of sound and light again in the first proposition of chapter three, stating that everything said in the *Ars Magna* about the bending of light could be repeated here, because the actions of sound are, with only few exceptions, parallel to the actions of light. First of all it would have to be proven that the angle of reflection is equal to the angle of incidence;¹⁴ the following proof is a deduction from the axiom of sound always acting in the way with the shortest distance [correcte Formulierung nachschlagen], concluding that nature always arranges her operations under the same angle of incidence and reflection, as has been shown abundantly in the *Arte anacamptica parte 2. Proposita* (implying the *Ars Magna*), to which the curious reader is referred. Given the statements from example two above, this adaption of knowledge about light taken from the *Ars Magna* makes sense as a transfer from a better-known area to the one being explored here. Check!

4. The fourth repeats this a few pages later, stating that the art of bending sound, that is, of echo, follows in every respect the laws of bending sound,¹⁵

¹⁴“Quaecunque in Arte Anacamptica Lucis & Umbra [sic] de reflexione Lucis ostendimus, hęc revocari possunt, sunt enim soni operationes Lucis operationibus in omnibus, si pauca excipias, parallelae; Primo igitur ostendum est Angulum *Phonurgia*optotum aequalem esse Angulo *Phonurgia*ocamptico, quod ita facimus.” *Phonurgia* 18.

¹⁵A term he often uses for echo or 'of bending sound' is 'phonocamptica', put together from the classical Greek terms ΕΙΝΦΥΓΕΝ for 'sound' and 'bending'.

or those of the reflection of light. He uses the formulation of the reflexiones “anophonae, vel catophonae” in an obvious allusion to optics, or rather, catoptrics, according to his habit of forming neologisms based on classical Greek. Both refer to the reflection of sound or echo, literally the “sounding back.” He closes with a remark about reflexions in general, and refers to his *Ars Magna* “as we have proven in the Arte anacamptica Lucis.”¹⁶

These neologisms liken acoustics even more to optics, they are a representation of the optics/acoustics analogy, which is not taken up or used again later. These are not terms Kircher actually needs. The new words are more about style and rhetoric than anything else; they make acoustics look old and familiar, almost as classical as optics.

5. In the beginning of section three on the construction of tubes and trumpets he explains that those instruments are called acoustical instruments which, in the same way that optical instruments put things that are farther apart before our eyes as if they were near, bring remote sound that are usually inaccessible to the acoustical sense to the ears. He announces that the first part of this section deals with the fabrication of halls, chambers and galleries in such ways, that in certain spots princes can hear everything amplified that is uttered (in their palace), and that the second part deals with the fabrication of acoustical instruments for the use by the hard-of-hearing, as well as an acoustical and secret cryptology of communication through sound, and more.¹⁷

¹⁶ *Phonurgia* 22.

¹⁷ “Acustica instrumenta ea vocamus, quibus, uti opticis instrumentis, remoota nobis objecta & sensui visivo prorsus impervia, veluti vicina & propinqua oculis sistimus, (de quibus fuse in *Arte magna Lucis & Umbrae lsb. ult. egimus*) ita acusticis instrumentis sonos remotos, & sensui acustico impervios intra Organa ad naturae exemplar fabricata mira industria & solertia coarctos auribus repraesentamus; continetque *Primo* Aularum Conclavium, & Porticuum fabricam eo ingenio dispositam, ut in iis certo & determinato puncto omnem etiam quantumvis submissam verborum prolationem Principes audire possint; *Secundo*, acusticorum instrumentorum in usum surdastrotum fabricam, una cum *Cryptologia Acustica* sive de occulta mutuorum conceptuum per sonos communicatione, aliisque novis & abditissimis inventionibus; Verum antequam rem aggrediamur Tuborum Tubarumque proprietates, & experimenta ipsa, quibus in operis Architectura utemur, praemittenda duximus.” *Phonurgia* 58.

Here, the comparison between acoustical and optical instruments is used to make plausible the workings of the often novel and strange acoustical instruments Kircher is about to introduce. He has already established the fundamental parallelism between sound and light, and now he uses it to recreate the known effects of optical instruments for sound, or rather, makes it plausible that those effects should in principle be possible with sound as well.

6. The motif of sound reflection following the laws of light reflection recurs in the beginning of his third ‘experiment,’ dealing with the question why sound is amplified more in bent than in straight tubes. Everyday experience, as well as history, for example the horn of Alexander the Great, would teach that this is so, and it would have to be noted that just as light and heat are multiplied through reflection, as shown in the AMLU, just as much would sound be multiplied by the reflections in concave and circle-shaped tubes. Because straight round tubes would only focus the sound, and thus achieve some amplification, but circular tubes would additionally amplify it through reflection, he concludes that the latter would be superior for sound amplification.¹⁸

So what he does is to use the analogy to light in order to explain one of his stated differences between light and sound, namely that sound would travel not just in straight but in bent lines as well (see example 2 above). On the other hand, this explanation is built on the assumption of straight sound rays to be reflected. He uses the analogy to explain something that contradicts it. He also refers to something already shown about light to show the direction in which to look for an answer, it can be said in an explorative fashion. The peculiar aspect of this instance is that the knowledge transferred is his ‘big

¹⁸“Experientia quotidiana docet, sonum vehementius in tubo contorto quam recto intendi, monstrant id imprimis tubae, monstrat cornu Alexandri *Magni*, quo integrum exercitum cogere solebat, in circulum contortum, ut in *Historia sonorum prodigiosorum* dictum est. Quaeritus autem huius rei causa. Notandum igitur, quod sicut multiplicatio luminis & caloris fit multiplici lucis reflexione, ut in *Arte magna Lucis & Umbrae* docuimus, ita vehementia soni fit multiplici soni in concavo circulari reflexione; Nam tubo recto soni tantummodo coarcti & in unum collecti propagatio fit, in circulari vero non tantum colligitur, sed & ex infinita quadam linearum sonorum reflexione plurimum augetur & intenditur.” 66.

mistake' in acoustics, to assume that sound gets amplified when it is reflected, and thus the more reflections it undergoes the stronger it becomes.¹⁹

7. This example, again in the beginning of section VI, builds on the established analogy between light and sound in a description of how Kircher acquired his knowledge of (that is in his account, invented) acoustical instruments. Mentioning the known similarity and analogy, he comes back to the thought to do for sound what the opticians are already used to be doing for light when they are constructing *tubos helioscopos*. Thus following the Ariadne thread of Catoptrics, which would consist of the development of different kinds of lenses and their well-proportioned placement in a tube, he had tried to find out if he could not achieve a true amplification of sounds. He explored various set-ups for embiggening sound, and thought long and hard about it according to theoretical knowledge [gr] and confirming through experiments. Especially tubes and organ pipes proved important for this, both those with simple forms like cylinders, cones, and ellipses, and those wound like spirals.²⁰²¹

That is, here he is emphasizing the use of tubes both with light and with sound, as a bridge between the two 'arts'. Since the tube is not actually the essential part of a telescope, which Kircher must have known, this seems to be a comparison and emphasis for the sake of making the comparison. After all, there are no acoustical lenses in Kircher's understanding of sound amplification, but still he feels like he can use the tubes of telescopes, which do not actually embiggen anything, as a plausible starting point for his exploration

¹⁹Kircher does not consistently propound this assumption about sound, but sometimes claims the opposite as well. See for instance example 8.

²⁰"Intuitus autem magnam lucis & soni in specierum visibilium, audibiliumque diffusionem similitudinem, & analogiam, idem Ego, quod Optici, per tubos helioscopos catoptrica arte constructos peragere solent, per sonos praestandum censui. Filum itaque *Ariadneum* Catoptricae . . . secutus, num quid in specierum acusticarum transmissione, nec non valida sonorum multiplicatione efficere possem, dum exploro, varii mihi quidem in concinnando [Greek] seu sonorum multiplicandorum modi, & rationes occurrerunt, at cum periculosum aleae opus esse cernerem, huic unice incubui, ut quos [Greek] conceperam rerum peragendarum modos, eos per experimentum prius comprobarem; unde nullum non lapidem movi, ut per organa, tubosque partim simlices eosque cylindricos, conicos, ellipticos, partim per cochleatos ad finem tanquam per media proportionata pertingerem." 111.

²¹[recheck that translation!]

of an area where all the action actually does happen in the tube. While the reference to the already established similarities between light and sound makes it plausible that acoustical instruments could exist just like optical ones, the emphasis on the tubes does not really make any 'real' sense. For somebody knowing a bit about the construction of telescopes it should rather undermine Kircher's credibility. Kircher here seems to be too much in love with his own analogy, and carries it way past the point where it is useful. He is grabbing at a superficial similarity and trying to make a functional analogy from it. This is definitely an unordered analogy, but it is not an anti-rational one in Vickers' sense, because it is not based on the assumption of an occult connection between optical and acoustical tubes, nor does it deduce such a connection from their superficial similarity.

8. Another one is to be found in the beginning of the Chapter 'De conici tubi proprietate.' Kircher starts this chapter stating that it has been found through experiment that conical tubes have a greater power of sound amplification than cylindrical or prismatical ones, but that this fact had so far been scarcely explained. Many would believe that it [the amplification] was made by the real reflections of the acoustical species at the sides of the tube (apparently forgetting that he has explained sound amplification in general like that himself before), but in a conical tube the reflection of the voice would not be possible as the sound ray, being a straight line just like light, would be scattered about in its long conical diffusion. There would thus have to be something else in a tube to explain its sound amplifying power.²²

Here the comparison to light is made in a very 'on the side' manner, and it does not illustrate what Kircher is trying to show, but rather one of his fundamental properties of sound which it has illustrated before already. This section describes an aspect in which the comparison to light does not ade-

²² " Sit tubus conicus A B. ex arcto A. in amplam latitudinem B. extensus, fiet vocis elatio in A. quae non secus ac lucis actinobolismus in B. conica radiorum diffusionem, extra, qua data porta in remota spatia propagatus radiabit, ubi tamen nullo prorsus ad latera tubi facta reflexio continget, & consequenter nulla multiplicatio soni, praeter eum, quem conicum radiorum acusticorum effluvium causat, assignari potest; erit itaque aliud quidpiam in conico tubo, quod vehementiam soni efficiat, absconditum, quod paucis explicandum duxi." 117. [MORE]

quately or exhaustingly explain the behaviour of sound according to Kircher. He goes on to explain how he thinks the amplification of sound in a conical tube actually works, namely the trembling of the whole tube caused by the movement of the enclosed air and the reciprocal reflections of the sounds and their reverberations producing a strong multiplication of the initial sound, as *Proposition 9* would show. He likens this to the workings of a stretched string, where all the parts are made to resonate through nothing but a light touch.

Kircher thus suddenly distances himself, at least for this case, from the “amplification through reflection” thesis, ascribing it now to unnamed somebodies, and instead puts up this resonance theory of sound amplification in conical tubes, without explaining why this does not also apply to straight cylindrical tubes, for example. It is interesting that the light/reflection analogy is here used to describe the insufficient explanation, only to be replaced by another analogy, this time that of the vibrating string, which is even less well founded through arguments etc.²³

9. The last of the above mentioned analogies occurs in the Chapter ‘De augmento audibilium specierum.’ This chapter starts with a description of various ways how light can be ‘augmented’ (in reality focused), referring to the more extensive discussion in the AMLU, for example if a lamp is put inside a tube, its unified rays would illuminate a wall more fully. Then it goes on in the second paragraph to say that he wants to do the same for sound, which in everything perfectly imitates the rays of light, as has already been said in the preceeding text. Again, the reference to light seems to have a mostly rhetorical character, reminding the reader of phenomena he already knows in the context of light, and then introducing ideas how to do similar things with sound.²⁴

²³The importance of the phenomenon of acoustical resonance as an example of sympathetic magic actually working, and its influence as a model on many early modern scientists in England has been analyzed at length in Gouk (1999) SEITENZAHL.

²⁴“Quemadmodum lumen lumini additum, illud pro ratione appositi alterius luminis mirifice auget; quae ut explicem: Sit lampas quaequam, quae proximum parietem plene illuminet; si lampas tubo inclusa accesserit, illa per actinobolismi, sive luminosae radiationis unionem, dictum parietem plenius illuminabit; si praeterea speculum concavum

10. Again very explicit becomes this kind of comparison in the marginalium to *Technasma I*, which says that like the optical tube would lead in the visible species, so the acoustical tube would lead in the sounding species.²⁵ In the text itself this is developed in more detail, stating that just as people nowadays produced optical tubes that showed in a chamber whatever might be done by people outside of it, and presented this right, left, under or above, all by the means of reflection of the things outside, as they fall into the tube, etc. In just the same way would he want to teach how to make an acoustical tube, through which in a chamber anything spoken by the people on the street or in a courtyard might be understood quite distinctly.²⁶ It is important to note here that 'in the same way' does not necessarily mean that the actual construction of the tube is like that of a telescope, but might rather convey that its function is similar.

2.2 Summary

Kircher's use of light-sound and optics/acoustics analogies seems in some instances to fit neatly into Vickers' analysis, especially the claims to the almost absolute parallelism between light and sound and the way how the scope of the analogy suddenly expands to explain something about the whole world in the first example. Furthermore, a lot of his analogies are definitely unorderedly, freely jumping from compared aspect to compared aspect without much regard for consistency or functionality, as when he compares optical

lampadi, situ proportionato praeposueris, videbis parietem una cum figuris ei inscriptis, quam plenissime illuminatum iri, quemadmodum in 10. libro AMLU, de Lucerna Magica adornanda fuse docuimus. Quod itaque de luminis augmento dictum est, de augmento soni intra tubos coarctati pariter dictum velim, cum soni radiosae species, luminis actinobolismos in omnibus perfectae imitentur, uti in praecedentibus dictum fuit." 136.

²⁵ "Sicut tubo optico introducuntur species visibiles, ita acustico species sonorae."

²⁶ "Quemadmodum hodie tubi optici conificiuntur, qui intra cubiculum exhibent quicquid foris ab hominibus agitur, dextre, finistre, inferne, superne repraesentatum, totumque artificium constitit in varia reflexione specierum extrinsecarum in speculum pro motu tubi facta, ut si quis nosse cupiat, quid in foro aut platea peragatur, is tubum primo egregia arte instructum vertat, unacum speculo cistulae ad lucem superfluam impendiendam incluso... Haud secus tibi tubum acusticum parabimus, quo intra secretum cubiculum omnia ea, quae sive in foro, sive atrio alicuius palatii homines garriunt, audias." (158. [Direkte Anrede!])

and acoustical instruments on the point of their tube form, or explains the claimed superior sound amplification capabilities of bent horns through the analogy to light reflection, after having claimed that in contrast to light sound could also travel in curved lines, not just in straight ones. But none of them actually undergoes the collapse into identity that Vickers claims as typical of the occult and natural magic tradition, nowhere can sound be manipulated through the manipulation of light, or the respective words. There is a clear line between words and things. Manipulating the one does not have an effect on the other. Nor do they play such an important role in the text as a whole, or bear so heavy consequences, that it could be said that instead of using these analogies, Kircher is used by them.

Quite the contrary, they usually appear in the Prefaces, Introductions, and beginnings of sections, not to be taken up again in the real meat of the argument, like the Greek inspired neologisms of 'ana*Phonurgia*ae vel cato*Phonurgia*ae' which he coins without needing them, or ever using them again after their introduction. So instead of being keys to unlocking the mysteries of the world, Kircher's light-sound analogies in the *Phonurgia* are rhetorical devices: He uses them to underscore his competence to tackle acoustics (example 1), and to familiarize his reasonably novel topic by making it appear as much like optics as possible. And while his general emphasis with regard to his technical devices is indeed on their novelty, comparing them to what is already commonly done in the realm of optical instruments helps him to make it at least plausible that something like them could work. So while the Preface to the reader makes the impression that analogical thinking is indeed extremely important to Kircher, this almost qualifies as lip service: apparently, at least in the *Phonurgia*, he wanted analogy to be important much more than it actually was in leading his thinking or explaining acoustical phenomena.

Chapter 3

The Development of Kircher's Acoustical Material and the Light/Sound Analogy over Time

Even if the example of consonance as light and dissonance as shadow might seem to imply otherwise, the close relationship between light and sound is for Kircher not a sign for the analogy of the science of music and optics, but of the “acoustical science” and optics. Not only is this analogy used almost exclusively in passages of an acoustical nature, but it is also acoustics, and not music, that makes a precocious appearance in Kircher’s treatise on light, the *Ars Magna Lucis et Umbrae*, even before publication of the *Musurgia*. In all of these cases light and optics are used as models for the understanding of sound, and not the other way around. By looking into the relationships between the acoustical material of those three books, the *Ars Magna* (1646), *Musurgia* (1650) and *Phonurgia* (1673), I also hope to uncover possible changes over time both in Kircher’s treatment of this analogy, and in his conception of acoustics.

3.1 In what form appears acoustical material in the *Ars Magna Lucis et Umbrae*, and where and how does it resurface later?

Without combing all of the *Musurgia* for analogies and comparing them (which would exceed the dimensions of this work) the special connection of acoustics to optics can be confirmed by a look at the index of the *Ars Magna*; it is striking that there are ten entries for sonus, *sound* in general, and none for terms such as tonus, musica, harmonia etc.¹ What is more, nine out of these ten entries refer to the acoustical chapters, the only exception (“Sonum edens”) to a chapter of mechanical nature (a musical automaton, and how to make it produce sounds). On the other hand, both references to light in the index of the *Musurgia* refer to its acoustical sections, specifically the comparisons between light and sound in those sections, and not to anything of a musical or harmonical character.²

The *Ars Magna* contains three chapters focusing on sound, two of which contain material that reappears in one form or another in the *Musurgia*. The chapter that does not reappear is about how to judge certain characteristics of animate and inanimate objects by the sounds they make, as well as which kind of sound corresponds with which color. It is presented as “divination” and explicitly follows the model of the “chromocritical art” previously described by Kircher, “so that the immense riches of light and shade may

¹“Soni refractio, & reflexio. 132

Sonum edens. 889

Sonus duplex. 141

Sonus imitatur lucem. 131

Sonus in aula tapetibus ornata, cur non ita sincerus. 133

Sonus intra aquam gravior eodem extra aquam. 132

Sonus naturam lignorum, assium, mineralium indicat. 142. Temperamentum cuiusvis corporis propositi. 141

Sonus non semper exigit collisionem corporum solidorum. 132

Sonus quid sit. 132

Sonus quomodo per medium propagetur; per esse reale, an per esse intentiona[e]le. 133”

Both indices without page numbers themselves.

²“Luminis parallela comparatione ad sonum. fol. a 240

Lumen eadem ratione oculis, ac sonus auribus allabatur. a 241”

become clear to the curious reader.”³ It is not clear why he later omitted this *Phonurgia*ognomia, but it is a somewhat confused and incoherent chapter, does not have an obvious connection to his general theory of sound, and contains such notions as which kind of sound signifies what kind of element (water, air, fire, earth) or temperament, argued through to my eyes superficial similarities. There is here a very clear kinship to alchemical writings as described by Vickers and Gentner and Jeziorski.

The first chapter in the *Ars Magna* with acoustical content proper in the modern sense, “On the actinobolismus, or the radiation of sound, and its parallel comparison to light”⁴ is the first appearance of the passage later titled *Sonus Lucis Simia Est* in the *Musurgia* and *Phonurgia*.⁵ In the *Ars Magna* it starts with the paragraph about how sound imitates light because of its spherical propagation, proceeds to discuss how both light and sound present properties of objects to the senses, how no *accidens* is perceptible in and of itself, compares eyes and ears, and closes with a note about how sound absorbed by a soft and porous body is akin to what shadows are for light. There then follows a “consectarium” about sound in water, the nature of sound as a “fraction” of air or water, and an exploration of those notions and comparisons in more detail. The sequence partially differs from the later versions, particularly in the opening, but the contents, containing Kircher’s most fundamental views on the nature of sound,⁶ and its relationship to light,⁷ remain the same.

³“CAPUT VIII. *Phonurgia*ognomia, sive De divinatione circa cuiusvis corporis propositi temperamentum ex sono, et voce eiusdem perficienda. “Quemadmodum in preecedentibus ex colorum unicuique rei inditorum inspectione, Chromocriticam artem instituimus, ita hoc loco parallela quadam ratione *Phonurgia*ocriticam, seu *Phonurgia*ognomiam instituendam duximus, ut Lectori curioso immensae lucis, & umbrae divitiae clarius paterent.” *Ars Magna* 141–147.

⁴CAPUT VI. De Actinobolismo, sive raditatione soni, eiusque ad lucem comparatione parallela : item de natura, medio, et subiecto soni. *Ars Magna* 131–133.

⁵Compare chapter 2.1, page 30.

⁶“Sonus igitur nihil aliud est, quam qualitas sensibilis, qua auditu percipi potest, neque est motus, ut quidam opinantur, corporum se collidentium: consequitur tamen motum corporum se collidentium sonus, non quidem immediate, sed mediante fractione aeris intermedii;” *Ars Magna* 132.

⁷Again, compare chapter 2.1, page 30.

This is an interesting analogy in itself. How exactly does it relate to the ray image of sound? It doesn’t quite make sense. How so? Relate to general development/Valleriani.

The following chapter, “The art of bending sound, or the echologia,”⁸ concerns the reflection of sound and its material is a precursor to the more expanded treatment of this subject in *Musurgia* and *Phonurgia*. It begins with a list of definitions:

1. Defines the *φωνοκαμψις* as the reflexion of the voice commonly called “echo,” and the “Artem *Phonurgiaocamptica*” as the discipline that teaches how to produce various echoes. It corresponds with definitions 1 and 2 in the *Musurgia*,⁹ the former defining the “Magia sive Ars *Phonurgiaocamptica*” as the science of sounds that are reflected and amplified, the latter repeats the definition of *φωνοκαμψις*.
2. Defines the “linea sonora” as the line along which the sound goes and comes back. It corresponds with definition 7 in the *Musurgia*, which makes the same point in more complicated words.¹⁰
3. Defines the “linea sonora recta” as the line which describes the way by which a sound travels and is reflected back to its source. It corresponds with definition 8 in the *Musurgia*, which calls this the “Linea [Greek: ortho*Phonurgiaes*]” and in general uses new and more wording.
4. Defines the “linea sonora obliqua” as the line which describes the way of sound as it is reflected to an opposite point or place. It corresponds to definition 9 in the *Musurgia*, here being called “linea [Greek: loxo*Phonurgiaes*].”
5. Says that air or water are the “medium *Phonurgiaocampticum*,” through which the species of sound are propagated. It corresponds with definition 6 in the *Musurgia*.
6. Defines the “obiectum *Phonurgiaocampticum*” as that object, which, if the voice strikes against it, reflects it. It corresponds to definition 5 in the *Musurgia*.

⁸CAPUT VII. Ars *Phonurgiaocamptica*, sive Echologia. *Ars Magna* 134.

⁹*Musurgia* II, 238.

¹⁰Many of the reformulations center around an illustration which is added in the *Musurgia*. [Appendix]

7. The line of action of sound is defined as the whole length of the line as far as the sound can be heard. It reappears unchanged as definition 10 in the *Musurgia*.
8. Defines the corpus “*Phonurgiaoclasticum*” as that body in which sound is refracted. It reappears as definition 19 in the *Musurgia*.

All of these definitions are kept in strict analogy to optics, and make use of the ray-conception of sound. The *Musurgia* repeats this—most of the eleven additional definitions it gives introduce more specific terms for certain kinds of angles,¹¹ except definition number 18:

Acoustical tools are instruments which, if applied to the ears, possess the power to greatly multiply the voice.¹²

This addition is ambivalent with regard to the optics/acoustics link: On the one hand, the introduction of “organa acustica” or acoustical instruments is reminiscent of the well-known optical instruments. On the other hand, the use of the verb “multiplicare,” if meant to indicate that the strength of the sound itself is manipulated, would contradict contemporary explanations of what happens to light in a telescope or microscope, which do not posit a change or amplification of the light itself but rather one of its perception.¹³ In several cases the versions from the *Musurgia* substitute “sonus” where the *Ars Magna* says “vox.” This may indicate a tendency to a more abstract notion of acoustical knowledge, but the quote from the *Musurgia* above makes it hard to generalize, except if the use of “vox” in this definition is meant to indicate that these acoustical instruments are intended more for the magnification of the voice than for the magnification of sounds in general.

There follows an extensive description of what echo is and how it works, which keeps the comparison to light and its reflection close throughout.¹⁴ The majority of the propositions and other elements of this second sound-centered

¹¹[Examples.]

¹²Organa Acustica sunt instrumenta, quae auribus applicata, magnae vocis multiplicandae vim habent. *Musurgia* II, 239.

¹³Valleriani 2011.

¹⁴*Ars Magna* 134.

chapter can be mapped onto the *Musurgia*: The first proposition, about the spherical propagation of sound and its implications,¹⁵ reappears with new wording as Problema I,¹⁶ and the corollary explaining why in a valley echo is more likely to be perceived on top of a tower in that valley than on the ground reappears with the same illustration as a consecarium.¹⁷ The illustration to the second proposition¹⁸ is most similar to the one used in the definitions.¹⁹ The second proposition itself about the oblique reflection of sounds is related to proposition III on page 249,²⁰ which is more differentiated and detailed than the version from the *Ars Magna*. The proposition about the distance needed for the reflexion of one recognizable syllable²¹ is expanded in the *Musurgia* into the Praelusio III,²² which deals with the speed of sound in more general terms, but also comes back to that particular question about the reflexion of recognizable syllables, and refers back to the *Ars Magna*. The illustration and the idea of the consecarium about the construction of walls that produce multiple echoes²³ are taken up again in Propositio VII,²⁴ but here explained in more detail and in a more geometrical manner (although some examples are omitted). They are expanded on even further in the *Phonurgia*.²⁵

The propositions of this chapter on echo are followed by “experiments.” First come “various experiments about the nature of the reflexion of the voice and wonderful operations”²⁶ which describe how to transmit sound through wood and other solid bodies, and explain this transmission as an effect of the air enclosed in the porous wood. At the end of that passage, branching out into how a prince might communicate in secret through built-in channels in

¹⁵ *Ars Magna* 135.

¹⁶ *Musurgia* II, 261.

¹⁷ *Musurgia* II, 262.

¹⁸ *Ars Magna* II, 136.

¹⁹ *Musurgia* II, 238.

²⁰ *Musurgia* II.

²¹ *Ars Magna* 136.

²² *Musurgia* II, 243–244.

²³ *Ars Magna* 137.

²⁴ *Musurgia* II, 252–253.

²⁵ *Phonurgia* 45–47.

²⁶ Experimenta varia circa reflexae vocis naturam, & mirificas operationes. *Ars Magna* 137–138.

his palace, Kircher refers to Della Porta:

Whether it is possible however, to enclose the voice in some kind of canal, in order for it to really remain in there, in the way that Ioannes Baptista Porta has related.²⁷

I cannot identify a corresponding passage in the *Musurgia* or *Phonurgia*. Next is an experiment “about the acoustical mirror, or auditorium”²⁸ about the effect of parabolical reflecting surfaces on sound, with extravagant examples culled from the historical literature in a consectorium. It becomes Pragmatia III.–V. in the *Musurgia*.²⁹ The next experiment expands on this, discussing the “elliptical acoustical mirror.”³⁰ It first partially resurfaces in the *Musurgia* in the form of the illustration titled “Ellipsis otica”³¹ and then later much expanded in the first paragraph of a chapter of the *Phonurgia* on the horn of Alexander the Great.³² This experiment does *not* correspond with Pragmatia VI. which describes how to use elliptical devices for private conversations between different rooms.³³ Lastly, a separate paragraph about *φωνοκλασις* or the breaking of the voice in a denser medium surprisingly gets dropped or at least reduced to the notes in “Sonus Lucis Simia Est” in the later works.³⁴

What I hope has become clear is that there is a significant amount of acoustical material in the *Ars Magna*, while music is conspicuously lacking, that this material largely reappears in the *Musurgia*, and that it keeps its description of sound remarkably close to optics. What these appearances of sound in the *Ars Magna* never do, though, is to use sound to explain something about light. Light is always the model for sound, and not the

²⁷ “Utrum autem quis canali vocem includere possit, ut realiter ibi permaneat; quemadmodum Ioannes Baptista Porta tradidit,” *Ars Magna* 138.

²⁸ Experimentum I. De Speculo Acustico, seu Auditorio. *Ars Magna* 138.

²⁹ *Musurgia* II, 297–301.

³⁰ Experimentum III.[sic] De Speculo Elliptico Acustico. *Ars Magna* 139–140.

³¹ *Musurgia* II, 304.

³² *Phonurgia* Lib. I Sect. VII. Caput VII. De cornu Alexandri Magni. 132–134. This chapter also takes over the respective passage from the *Musurgia*.

³³ *Musurgia* II, 301.

³⁴ *Ars Magna*. Paragraph III, *φωνοκλασις*, sive de fractione vocis in medio densiori. 140.

other way around.

All of these reappearances in the *Musurgia* happen in the fourth part of the ninth book, which is the basis for the *Phonurgia*, and they all get carried over into it. So...

3.2 What is new in the *Phonurgia*, and what is taken over from the *Musurgia*?

We have already seen some text elements and passages carried from the *Ars Magna* to the *Musurgia*, and some further to the *Phonurgia*. In the *Phonurgia* Kircher is open about presenting material taken from the *Musurgia*, and announces that he does so as well as adding new material in his preface.³⁵ Its full title is

The new sound art, and mechanico-physical union of art and nature, prepared by the bridesmaid philosophy of sound; through which the universal nature of sounds, their properties, and the powers of their effects and the causes of their wonders are explained in detail through the exhibition of new and many experiments. The method and rule of acoustical instruments and machines is delivered, which are to be fitted to the prototype of nature, for the propagation of sound to remote places as well as for conversing in the hidden recesses of houses hidden from the public through devices with tricks even more secret; and finally the unique use of instruments of this kind in the confusion of wars, and the procedure according to the new science of sound,

³⁵“Quod tametsi in vasto Musurgiae Opere quam uberrime praestiterimus, in hoc tamen praesenti opusculo praeter ea, quae in Nono *Musurgia* Libro exposita sunt, hic repetita complurium novarum inventionum augmento cumulata stabilire conabimur, praesertim hoc tempore, quo occasione Tubae Mecologiae, quam Trombam sive Trombonem vulgo vocant, quam ante vicennium ego primus inventam, & in *Musurgia* impressam, nec non multiplici experimento comprobata hic Romae publici juris feci; quae tandem praeterlapso Anno primum in Anglia a clarissimis & solertissimis Regiae Academiae choragis resuscitata, atque in praxin deducta, non Britanniam tantum, sed & Galliam Italiamq;” *Phonurgia*, Praefatio ad lectorem.

is described.³⁶

But what exactly is new or old in the *Phonurgia* he does not say. It is divided in two books, Liber I. which is devoted to the “philosophy of sound and reflection”³⁷ (and is the more interesting one in the context of this text) and Liber II. which is devoted to the “new philosophy of sound.”³⁸ As is typical for Kircher, each of them is then further divided into sections, chapters and insertions of various kinds (for example “experiments,” “corollaria” etc.).³⁹ Most of these parts can be traced to passages of the *Musurgia*: The first five sections of the first book of the *Phonurgia* are a mostly directly taken over from the Pars Quarta of the ninth book of the *Musurgia*, sometimes with modified wording, but the same content in mostly the same order. Sections VI. and VII. on the other hand are almost completely new material, focusing on the various kinds of sound amplifying tubes. explain what this is about.

Regarding Liber II. of the *Phonurgia*, its first section is taken from the first part of the ninth book of the *Musurgia*⁴⁰, the second section from the second part,⁴¹ and the third section from the third part.⁴² I did not find any light-sound analogies or comparisons in the material of Liber II., which is why I do not treat it in the detailed manner in which I treat Liber I. in the following.

Additionally, before Liber I. begins, there are 27 pages of a new dedication to the emperor Leopold I., an exegesis of the frontispiece and laudations, and

³⁶*Phonurgia Nova sive Conjugium Mechanico.physicum ARTIS & NATURAE PARANYMPHA PhonurgiaOSOPHIA Concinnatum; qua UNIVERSA SONORUM NATURA, PROPRIETAS, VIRES effectuumque, prodigiosorum Causa, nova & mulitplici experimentorum exhibitione enucleantur; Instrumentorum Acusticorum, Machinarumque ad Natura prototypum adaptandarum, tum ad sonos ad remotissima spatia propagandos, tum in abditis domorum recessibus per occultioris ingenii machinamenta clam palamve sermocinandi modus & ratio traditur, tum denique in Bellorum tumultibus singularis huiusmodi Organorum Usus, & praxis per novam Phonurgiaologiam describitur.*

³⁷“*Phonurgiaosophia Anacamptica.*” *Phonurgia* 1–170.

³⁸“*Phonurgiaosophia Nova,*” “Qua recondita et abstrusa sonorum rationes per numeros exponuntur.” *Phonurgia* 171–229.

³⁹[Wald]

⁴⁰De Physiologia Consoni, et Dissoni, in qua arcana vis in Consono et Dissono latens manifestatur. *Musurgia* II, 200–212.

⁴¹De Magia Musurgo Iatrica, sive Medicina corporum per Musicam sanandorum. *Musurgia* II, 213–230.

⁴²De Teratologia Musica, seu de sonis prodigiosis. *Musurgia* II, 230–236.

testimonials and quotes of texts from other authors.⁴³ The testimonials focus on bolstering Kircher's position in the priority dispute: The poet Jacobus Albanus Ghibbesius, writing "About the first invention of this art,"⁴⁴ mentions the claims to the invention of the speaking tube coming from Samuel Morland via the Royal Society by the name of "tuba Stentoro-Phonurgiaica" and insists that Kircher has already written about it in the *Musurgia* twenty years earlier, and thus has priority, as well as describing a recent public experiment by Kircher on mount Vulturellum using such a tube to call people to mass. Next comes a long quote from Gaspar Schott's *Magia universalis*⁴⁵ describing the device Kircher had built in the Collegio Romano between the doorman and his study, basically a conical sound tube, with the big opening at the doorman's end, and the small one in his study, enabling them to communicate (and Kircher to greet guests at the door) without the doorman having to go up to Kircher's room or having to shout.⁴⁶ The next quote is from Franciscus Echinardus' *In Discursu de Sono Pneumatico* Fol. 10., claiming that many had acquired the construction of sounding tubes (Tubae Phonurgiaicae) from Kircher, which he had published in his *Musurgia* in the year 1648 [*sic*], and that Kircher had built a conical sound tube 21 palms long,⁴⁷ a famous object in the Collegio Romano. After that Joannes Philipus Hardofferus is quoted testifying in his *Libro de Recreationibus Mathematicis* that this invention was already publicly announced in Rome by Kircher twenty years ago.

A full quote from page 271 of the second volume of the *Musurgia* follows, describing what acoustical instruments are, as well as a reference to the Corollarium describing the differences between conical and cylindrical tubes, the description and analysis of the alleged horn of Alexander the Great, and the description of arced and spiraled tubes and their special power of

⁴³All without pagenumbers.

⁴⁴De prima huius Artis inventionione.

⁴⁵Parte II. Fol. 156.

⁴⁶Supposedly confirmed on Libro secundo Folio 145. Although there is a digital facsimile of this publication available, I was not able to verify either of these references to Schott's *Magia universalis*.

⁴⁷1 palm = 22 cm (Ullmann 2002, 74).

sound amplification.⁴⁸ Referring to and paraphrasing or quoting those bits of the *Musurgia* that are most important in bolstering Kircher's priority claim, the text goes on to the passage of the *Musurgia* about the secret communication through tubes built between chambers⁴⁹ and mentions an additional experiment with those tubes in the Collegio Romano in the year 1649. Somewhat surprisingly, the last of the testimonials and quotes comes from a text that was published considerably earlier than the *Musurgia* in 1604 by P. Sebastiano Beretario about the peoples of the mountain region of America and the province of Peru,⁵⁰ in which he writes that they have tubes and pipes into which they blow according to a certain *ratione*, which could be heard far, through which they would express themselves as if they were talking with their voices etc.⁵¹ This part ends with the claim that many more authors could have been quoted, but that the testimony of these few suffices.

The testimonials thus emphasize Kircher's priority in the invention of the acoustical tube, describing some of his acoustical feats in detail, as well as in some cases their public character or "well-knownness," implicitly enlarging the number of possible witnesses. They highlight public performances of these feats. Together with the quoted passages from the *Musurgia*, here, before even the table of contents, all the most relevant material for the priority dispute is collected. Anyone reading the *Phonurgia* primarily because of the dispute would not have to read any further. As an intervention alone, the material from the *Phonurgia* proper seems scarcely necessary.

The first of the sections of the content proper consisting of new material, section VI about "the architecture of instruments"⁵² starts with a chapter on

⁴⁸ *Musurgia* 275ff.

⁴⁹ *Musurgia* II, 303.

⁵⁰ [Source!]

⁵¹ "Tubis enim tibiisve certa inflatis ratione, ita quod volunt significant ut & longe audiantur; & perinde ac si expressis vocibus loquerentur, intelligantur, neque tamen ab iis, qui eorum linguam norunt, quae significantur percipiuntur; nisi diu apud eos versati sint." *Phonurgia*, without page number. [MAKE A PROPER TRANSLATION OF THIS!!!]

⁵² SECTIO VI. ARCHITECTONICA INSTRUMENTORUM. Acusticorum, quorum ope per sonos qua articulatos, qua inarticulatos ad maximam locorum distantiam quemlibet reciproco coresponso mentem suam alteri quantumvis diſito manifestare posse, experientia

the origin of the acoustical art, which highlights Kircher's acoustical achievement in the *Musurgia*, especially his understanding of the similarity between the visible and audible species, and even more so in actually building acoustical devices, beginning with his aforementioned sound tube in the Collegio Romano, while the marginalium to this paragraph claims that this is "When and on what occasion the acoustical tube was first invented."⁵³ This gives the impression that Kircher does not so much view the date of describing the acoustical tube, or the date of publication of that description, as the cornerstone of invention, but rather the time when it was first put into practice. The following chapters describe various types of sound tubes in detail, namely cylindrical, polygonal and conical tubes (claiming that the longer the tube, the greater its sound amplifying capabilities), the sound transmission in an old Roman aqueduct, the use of oblique echoes in communicating even if the communicating parties do not have eye contact, and the role of noise in war. This leads directly to an experiment investigating the speed of sound, or, as Kircher puts it, how much sound is slower to be heard than light reaches sight,⁵⁴ to be conducted by having a gun fired in the distance and observing by means of a pendulum the time between seeing the explosion and hearing the shot, explicitly referring to the experiments done in this manner by the Accademia del Cimento.⁵⁵ While he acknowledges that nothing certain can yet be said about this matter, he believes (and writes) that factors such as wind, vapors, rain, times of year and times of day might have an influence on the speed of sound.⁵⁶

The second section of mostly new material is dedicated to the fabrication or construction of various instruments or tools⁵⁷ and deals with them in a more practical manner than Kircher has done before. The first chapter mentions dimensions that work if the instrument has to be carried from place

demonstratur. *Phonurgia* 111–122.

⁵³ *Phonurgia* 112.

⁵⁴ *Phonurgia* 122.

⁵⁵ In his words the "Florentina Academia."

⁵⁶ *Phonurgia* 123.

⁵⁷ SECTIO VII. DE FABRICIS DIVERSORUM ORGANORUM, ad producendum longißime sonum apte construendis. *Phonurgia* I, 124–168.

to place, suitable materials etc.⁵⁸ The second chapter treats of different kinds of tubes, starting with two problems of conical tubes, namely that they are not suitable to two-way communication (or as Kircher puts it, it is not possible to give an answer), and that nothing communicated through them can be kept secret or hidden;⁵⁹ it describes the conditions under which he thinks the former problem can be solved considering factors such as the distance between tube and second sound-source, the size of the tube and the direction in which it is pointed (all centering on the tube's ability to "collect acoustical species" and thus function not just as a speaking tube, but also as hearing tube), and the latter later in chapter IX. through the use of codes.⁶⁰ Chapter III. adds the spherical form to the repertoire of sound enhancing tubes,⁶¹ chapter IV. the elliptical tube,⁶² and chapter V. the screwed or snail-shell-like tube.⁶³ Chapter VI. mentions instruments that are able to make a loud sound, but not to propagate sounds already made and articulated by the voice, such as musical instruments in the widest sense, like horns, trumpets, drums, flutes etc.⁶⁴ Chapter VII. attempts to explain the properties and powers of several famed instruments from the historical tradition,⁶⁵ namely the horn Alexander the Great allegedly used to communicate with his troops, which in Kircher's representation becomes a contorted tube-ring hung on a large tripod,⁶⁶ a combination of a drum with a conical tube attached supposed to maximize the drum's noise for use in war,⁶⁷ and a tube instrument supposedly widely used in Gaul, called the

⁵⁸Caput I. De tubi conici structura. *Phonurgia* 124–125.

⁵⁹Caput II. De tubis ita accomodandis, ut sine altera tuba, sola voce quis ad quaesita respondere possit. *Phonurgia* 125–128.

⁶⁰Caput IX, De secreto per sonum inarticulatum alteri correspondenti significando. *Phonurgia* 138–141.

⁶¹Caput III. De multiplici augmento soni in dictis Tubis, sive de Tubis prodigiosi soni, variisque speciebus, et formis eorum. *Phonurgia* 128.

⁶²Caput IV. De tubo elliptico. *Phonurgia* 129–130.

⁶³Caput V. De tubo cochleato. *Phonurgia* 130–131.

⁶⁴Caput VI. De tubis qui solummodo sonum vehementem, sed articulatam vocem dare non possunt. *Phonurgia* 131.

⁶⁵Caput VII. De immensa sonorum multiplicatione in instrumentis hucusque expositis, per solam impositionem, seu insertionem organorum ordine exponendorum. *Phonurgia* 132–135.

⁶⁶*Phonurgia* 132–134.

⁶⁷*Phonurgia* 134–135.

snake or serpent, and formed accordingly, which according to Kircher would without a doubt emit a sound equal to the sound of the screwed tube.⁶⁸ Chapter VIII. refers back to the similarities between acoustical and optical species in order to propose a combination of spherical and conical elements in a sound tube.⁶⁹ The aforementioned chapter IX. describes the use of signals and codes in order to communicate secret messages over big distances with the help of acoustical instruments.⁷⁰ Chapter X. consists of several *Technasmata*, the first one explaining how to transmit music over two or three miles (milliaria) without anybody between the place where the music is played and where it is *supposed to be heard* able to hear it;⁷¹ the second gives instructions how to combine tubes with a wind chime in order to transmit the resulting harmonies further;⁷² the third describes another form of wind chime,⁷³ and is then lead⁷⁴ through an experiment and a corollarium to the conclusion, that one and the same chord, struck by the wind in different places, would be able to produce an infinite number of different sounds, and thus the previously wind chimes would need only one chord to produce a multitude of harmonies.⁷⁵ Technasma IV. continues the topic of music and harmony at a distance; ⁷⁶ Technasma V. introduces the concept of musical

⁶⁸*Phonurgia* 135.

⁶⁹Caput VIII. De augmento audibilium specierum per varia instrumenta orificie Tubi, cuiuscunque tandem forma fuerit, applicata dando. *Phonurgia* 136–137. [Backref, Abgleich!]

⁷⁰Caput IX. De secreto per sonum inarticulatum alteri correspondenti significando. *Phonurgia* 137–141. One of the first examples he refers to is the alleged practice of the Turks in this.

⁷¹Technasma I. Amaenissimam musicam tum vocibus, tum omni instrumentorum genere instructam, ad duo, aut tria milliaria exhibere, ita ut nemo, unde veniat, concipere queat. *Phonurgia* 142–143.

⁷²Technasma II. Tubum conicum ita adornare, ut novam, peregrinam, et omnibus incognitam harmoniam in remota spatia exhibeat. *Phonurgia* 143–145.

⁷³Technasma III. Aliam machinam harmonicam automatam concinnare, qua nullo rotarum, follium, vel Cylindri phonotactici ministerio, sed solo vento et aere perpetuum quendam harmoniosum sonum durante vento excitet. *Phonurgia* 145–148.

⁷⁴Or rather mislead.

⁷⁵Corollarium. *Phonurgia* 149. In the sense of a string tone having overtones that sound simultaneously this is true, but even looked at in this light the harmony produced is constant and does not change depending on where the string is plucked. What Kircher here describes is impossible.

⁷⁶Technasma IV. Phonologia harmonica ad 1. 2. 3. et amplius milliaria instituenda. *Phonurgia* 150.

sympathy, and is worth quoting:

We call those sympathetical experiments, which, without having been touched resound to the sound of others, in wonderful proportion and similarity of the sounding bodies, which is to say that at the sounding of the one the other is moved as well without being touched; which proportion does not have its place only in homogeneous, but in heterogeneous bodies as well.⁷⁷

Chapter XI. goes on to exploit phenomena of sympathy (or, in modern words, resonance) for experiments and the construction of entertaining musical devices, as for example a statue that moves on the sound of a certain tone.⁷⁸ After seven “experiments”⁷⁹ this chapter returns to *Technasmata* that have already been described in the *Musurgia*.⁸⁰

3.2.1 The appearances of the main light-sound analogies

Examples nine and ten from the previous chapter have no direct precursor in the *Musurgia* whatsoever.⁸¹ Five of the examples are taken over without modifications from the *Musurgia*: example two, “Sonus Lucis Simia Est,”⁸² example three,⁸³ example four,⁸⁴ example five,⁸⁵ example six.⁸⁶ Because the respective sections I–III are taken over in their entirety, these examples are

⁷⁷Sympathica experimenta vocamus illa, quae ad sonum aliorum resonant intacta, mira quadam sonorum, corporum proportione & similitudine, qua fit, ut ad sonitum unius altera quoque moveatur intacta: quae quidem proportio in corporibus non tantum homogeneis, sed & in heterogeneis locum habet. Technasma V. Omnis generis experimenta harmonica sympathica exhibens. *Phonurgia* 151.

⁷⁸Caput XI. De reconditioribus machinis. *Phonurgia* 151–165.

⁷⁹These are things Kircher assumes could be done, complete with the results he expects. They are not necessarily experiments he has actually performed. In fact, most of them assume results they could not possibly have if actually performed.

⁸⁰*Phonurgia* 158–165.

⁸¹[Backref, summary.]

⁸²*Musurgia* II, 239–241; *Phonurgia* 6–9.

⁸³*Musurgia* II, 248; *Phonurgia* 18.

⁸⁴*Musurgia* II, 250; *Phonurgia* 22.

⁸⁵*Musurgia* II, 271; *Phonurgia* 58.

⁸⁶*Musurgia* II, 274; *Phonurgia* 66.

not only remain themselves, but preserve the same order and context they have in the *Musurgia*.

Three examples do have precursors, but have undergone some modification between the *Musurgia* and the *Phonurgia*: In example number one⁸⁷ some paragraphs are reordered, and it spends fewer words on consonance and dissonance. A reference to the *Ars Magna Lucis* is replaced by a reference to the *Musurgia*, the “haud inconsistentanea combinatione” bit is new, as is the “paranympa.” In one instance it uses “Phonurgia” instead of “scientia soni.” It also announces to present some of the material of the ninth book of the *Musurgia*. Significantly even in the version from the *Musurgia* he already writes about joining *acoustics* to its friend optics, not music.⁸⁸

The precursor to example seven⁸⁹ might easily be overlooked because it is much shorter and differently worded, but in the preface to the chapter on the “echotectonical magic” in the *Musurgia*⁹⁰, the reference to catoptrics has the same function as later in the *Phonurgia*’s section on the architecture of acoustical instruments.⁹¹ They both proclaim to do for sound what catoptrics is already doing for light, namely to make sounds audible that usually would not be, but they make it in mostly different wording and focusing on different points, with the example from the *Phonurgia* emphasizing sound-amplification, and the passage in the *Musurgia* stressing how microscopes make the composition of things visible, a topic omitted in the passage in the *Phonurgia*. Interestingly, in the *Musurgia* both telescopes and microscopes or the connected activities are mentioned by name (“telescopiorum” and “smicroscopia” respectively), and are omitted to be replaced by “tubos helioscopos” in the *Phonurgia*.⁹²

The passage from which example number eight⁹³ was taken has a direct

⁸⁷Chapter 2.1 page 28.

⁸⁸Praefatio ad lectorem, *Musurgia* I; Praefatio ad lectorem, *Phonurgia*. Both without pagenumber.

⁸⁹Chapter 2.1 page 36.

⁹⁰*Musurgia* II, 283.

⁹¹*Phonurgia* 111.

⁹²[QUOTES]

⁹³*Phonurgia* 117–118. Compare chapter 2.1 page 37.

precursor in a corollarium from the *Musurgia*.⁹⁴ Both attempt to explain the greater power of sound amplification of conical versus cylindrical tubes, but they offer *completely different explanations*. Compare the paraphrase of this example offered in the last chapter with this translation of the corollarium from the *Musurgia*:

From this it is obvious that the conical tube stretches the voice more than the cylindrical tube does, because it is better fit to reflect the sounding species. From which [it follows] that if both a conical and a cylindrical tube are contorted to form a circle, the contorted conical [tube] will be more powerful than the cylindrical contorted [tube]; for in the conical [tube] the sounding species come together to circulate from the wide into the narrow [sic!], and are thus fit closely and pressed together, and more strongly stretched, [because] not otherwise the wind acquires a greater strength when constricted in a narrow spot. In the cylindrical [tube] sound circulates everywhere equally and is clogged. This is why the horn of Alexander was constructed in such a way that it opened from the narrow to the wide.⁹⁵

Apparently Kircher felt that this explanation was not in fact satisfying when he replaced it with the one from the *Phonurgia*, which likens the behavior of a conical tube to that of a stretched string. How he came to this opinion, by himself or maybe prompted by feedback from others, I do not know. It is intriguing though, since the new explanation does not make much more sense than the old one, but introduces an element of analogy that the older one is lacking.^{96 97}

⁹⁴ *Musurgia* II, 275.

⁹⁵ Hinc patet, quod tubus conicus plus vocem intendit, quam tubus cylindraceus, ille enim reflectendis speciebus sonoris, hoc aptior est; Unde si umtrumque tam conicum, quam cylindraceum in circulum controqueas, conicus in circulum contortus plus poterit, quam cylindraceus in circulum contortus; nam conico circulari ex amplo in angustum coeunte, species sonorae coarctatae constipataeque vehementer intenduntur, non secus ac ventus locis angustis constrictus maiorem vim obtinet. In cylindraceo vero circulari equalis ubique soni est constipatio. Hinc Cornu Alexandri Magni ita constructum erat, ut ex angusto in amplum dilaretur. *Musurgia* II, 275.

⁹⁶ They are both wrong, of course, from the viewpoint of today's knowledge of acoustics.

⁹⁷ *Musurgia* T2 (Liber IX) 256/261. That passage in the *Musurgia* is parallel (identical)

3.3 Summary

Obviously Kircher did revise his acoustical material for the *Phonurgia*, and not just add additional material. He was also aware of acoustical experiments going on both in Italy and elsewhere in the meantime. Yet he was not up-to-date with the development of the *theory* of sound, and his revisions weren't necessarily improvements. Some of the most confused and inconsistent ideas and analogies are actually later additions. He contradicts himself even more in the new material than he did before. I can only speculate about the reasons for this—did he lose sight of his material in the meantime? Were his intellectual capacities already waning? Perhaps more importantly, his later additions emphasize even more practical and wonderful or entertaining applications of his (old) theory of sound. There are no longer any occult arguments here, but many invocations of magic and wonder in general. They serve mostly to advertise his fancy devices, both real and imagined—the devices constructed to entertain with automatic harmonical sounds lead over to a treatment of musical sympathy or resonance in which it mostly appears as a gimmick rather than a principle of the world or a statement about its structure.

to *Phonurgia* 32/74, which is a very interesting passage and I have apparently overlooked so far.

Chapter 4

Conclusion and Outlook

Kircher's uses of the light-sound analogy in his acoustical writings do not fit the expectations set by his programmatic statements about analogical thinking and his proximity to the occult tradition. Instead of heaping multifaceted analogy upon analogy to in the last consequence explain the whole world, he uses structural analogies in a mostly rhetorical manner. Over time, although there is an elimination of more occult acoustical material between the *Ars Magna* and the *Musurgia*, this analogy becomes *more* confused; yet this development cannot convincingly be mapped as a movement between the poles of experimental and occult science. When his writing becomes confused it seems to happen because he himself is confused, and not in any systematic manner or because of hermetic or magical beliefs.

Moreover, allusions to the magical and wonderful in the *Phonurgia* are remarkably void of truly occult or irrational content. They are invocations of the fascination magic and the occult might command, rather than occult writing. These invocations devoid of magical content combine with the prominent, but lonely place in the preface to the reader of the most classically occult of his light-sound analogies¹ to produce the impression of a nostalgia for the occult, rather than a belief in magic, sympathetic or otherwise. They are placed in a context concerning the manipulation of sound through numerous devices and advertising their virtues. There they have the function of

¹Chapter 2.1, page 28.

an entertaining gimmick rather than a statement about the inner workings of the universe. Even in their marginal role, they confirm the connection between occult leanings, even if only on the level of style, and manipulative approaches to nature for Kircher, without compromising the essentially rational, if sometimes less than lucid, character of his acoustical discourse. This is an important qualifier: At this point I do not know, and don't feel confident to make estimates, how my findings relate to Kircher's use of analogies in general. Particularly because the *Phonurgia* is decidedly not representative for his publications with regard to her very limited scope, and lacking the metaphysical and holistic ambitions that characterize most of his opus magni, such as the *Musurgia*, *Ars Magna*, and the *Magnes*. It would not be surprising if the kind of expansive, world-explaining analogies marked as typical for the occult tradition were to be found in expansive, world-explaining works, rather than specialised treatises, and it could be mere chance that this particular analogy between light and sound does not follow the occult pattern. The fact remains that either way, Kircher's acoustics, with all its faults, does not fall prey to occult analogies.

The largely rational character of his use of the light/sound analogy may also be related to the fact that it often appears as an element of passages of acoustical material largely taken over from Marin Mersenne, usually without mentioning his source, and always without indicating the extent to which he has made use of Mersenne's *Harmonie Universelle*. The view of Mersenne's "Table des Propositions" makes the *Phonurgia* look like an excerpt:

XXV. Enquoy le son et different de la lumiere, & enquoy il luy est semblable. 44.

XXV. Comme se fait l'Echo, ou la reflexion des sons. 48. Traité de l'Echo. 50.

XXVII. Quelles sont les distances, & longueurs de la ligne vocale de l'Echo: si l'on peut cognoistre le lieu d'o il repsond, & de quelle longueur doit estre ladite ligne, pour faire l'Echo de tant de syllabes que l'on voudra. 56...

XXVIII. Expliquer toutes les figures propres pour faire les Echos

artificiels, les sectiones Coniques, & leurs principales proprietiez.
59...

XXIX. Determiner si les sons se rompent, c'est à dire s'ils endurent de la refraction, comme la lumiere, quand ils passent par des milieux differens. 63.²

To quote just a few. The most extensive example of the light/sound analogy, the passage titled “Sonus Lucis Simia Est,”³ is one of those passages that are largely taken over from Mersenne, namely from proposition XXV, “Enquoy le son et different de la lumiere, & enquoy il luy est semblable,” as is example three, which claims that sound reflection follows the laws of the reflection of light, starting with the equality of the angle of incidence to the angle of reflection.⁴ This is a transformation and explication of a corollary to Mersenne’s proposition XXVII, which states

Ceux qui entreprendront de donner la science de l’Echo, doiuent determiner la maniere dont toutes fortes de surfaces reflechissantes reflechissent le Son, particulierement les regulieres, . . . et pour ce sujet il faut considerer si les Sons gardent l’egalité d’angles tant d’incidence, & de reflexion avec le plan reflechissant, . . . Enfin il est necessaire de considerer dans la reflexion des Sons tout ce que l’on a coustume d’establit pour celle de la lumiere. Mais la vie d’un homme tres-scauant n’est pas trop longue pour accomplir cette science, c’est pourquoy il suffit d’en auoir icy touch quelque chose; à quoy i’adiouste ce qui suit des surfaces concaues, & conuexes reflechissantes, afin que ceux qui auront la commodité et *faire les experiences necessaires pour refoudre cette difficulté*, augmentent la Physique par une nouuelle cognoissance.[Emphasis by me.]⁵

Where Mersenne suggests possibilities that should be inquired through further experiments, Kircher states and deduces laws without mentioning

²*Harmonie Universelle*, “Table des Propositions,” unpaginated.

³Example number 2, chapter 2.1, page 30.

⁴Chapter ??, page ??.

⁵*Harmonie Universelle* 59.

any doubts about their validity or any necessity for experimental confirmation. And while “Sonus Lucis Simia Est” is in large parts a direct translation of the passage by Mersenne, what Kircher minimizes in his version is Mersenne’s much more extensive discussion of the differences between light and sound, partially even rewriting differences as similarities, as for example in his formulation that

just as light without a body from which it flows forth cannot keep on actually flowing, so it is for sound without the movement of the air.

Mersenne had written:

qu’il [the sound] ne depend pas tant des corps par lesquels il est produit, comme la lumiere depend du corps lumineux.⁶

Kircher simplifies Mersenne’s nuanced and careful treatment, and writes from a position of certainty where Mersenne writes of explorations still to be done (without actually having done the further experiments etc. Mersenne calls for). In Mersenne the analogy between light and sound is an explorative, constructive modern analogy par excellence; it leads some of his investigations and helps him to formulate hypotheses, without ever substituting for their testing. It is only in Kircher’s rewriting of them that it becomes reduced to rhetoric and a sign of certainty itself that does not need any more scrutiny or investigation to be confirmed. It may be exactly this lack of doubt on Kircher’s part that marks the deepest lingering of occult thought in the *Phonurgia*.

⁶*Harmonie Universelle* 44.

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