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CONTACT INFORMATION
aefstath1@gmail.com,
rhetoricandscience@gmail.com

COVER DESIGN
www.johnstefou.com

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Department of History and Digital Humanities
Ionian University
72 Ioannou Theotoki str., 491 00 Corfu
Tel: 26610 87330, 87331

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The Rhetoric of Infertility and its Cure: *Iamata* and the Delphic Oracles on Having Children

Polyxeni Strolonga

Abstract

This paper compares the oracles provided to childless men at Delphi with the *iamata*, inscriptions of the 4th c. BCE, found in Epidaurus, which record, among others, the miraculous cures of women's fertility problems. Both *corpora* share similarities in the rhetoric that they apply, while they also implicitly propose as a cure for fertility problems the change of one's sexual partner, a remedy that is concealed under the ambiguous oracular rhetoric and the rhetoric of the supernatural physical healing. Despite the different nature of requests and healing practices which are adjusted to the gender of the patient, the rhetorical similarities in the oracles and the *iamata* indicate that childless men may approach Delphi as patients, in the same manner that women visit Epidaurus in order that they will be healed. The similar diction also reflects a strong belief in the capacity of the gods to intervene in order to provide progeny and shows the juxtaposition of the cults of Apollo and Asclepius.

Introduction

In ancient Greece failure to reproduce, when it is regarded as a treatable medical condition, is associated mainly with women. With the rise of the Hippocratic medicine, specific treatments were designed for sterile women so that they regain their fertility.[1] While the Hippocratic corpus and Aristotle acknowledge that the causes of sterility lie in both men and women,[2] when it comes to remedies for infertility, there is little to no evidence for medical treatments for men and the focus of the medical writers lies almost exclusively on women, especially since the Hippocratic doctors had thoroughly studied the female reproductive system.[3]

However, valuable information about how sterility was treated in antiquity, especially when men are concerned about progeny, is detected in the realm of religious medicine that involves healing which is conveyed through the intervention

[1] For the Hippocratic gynecological recipes, see Totelin (2008) ch. 5.

[2] Arist. *HA* 10.633b13–14, *GA* 2.7.746b16–747a22. For the Hippocratic corpus, see *Airs Waters Places* 21; *Aphorisms* 5.62–63 (causes of both female and male infertility). Notice that even though the moistness of the body is a common denominator for the infertility of the Skythians, nevertheless different reasons are offered for men's infertility (lack of intercourse or weakness in intercourse) compared to women's (physiology of the uterus).

[3] Flemming (2013) 571 and n. 23. See e.g., the Hippocratic treatises *On the Sterile Women* (Περὶ ἀφόρων), *Diseases of Women* (I, chs. 8–24), *Nature of Woman* (ch. 35). Hippocratic *aphorisms* (*Aph*. 4.174–76; 5.62–63 Loeb) offer reasons for female and male infertility implying (but not stating) a cure, by overcoming dryness and wetness. There are also examples of advice on diet for would-be-fathers (see e.g., *On Superfetation* 30). These pieces of advice, however, do not constitute remedies for male infertility. See Bourbon (2016) on the notion that infertility was a symptom of a woman's disease and not a disease itself.

of gods.[4] It turns out that childlessness, ἀπαιδία, is a condition that concerns both men and women, who consult περὶ παίδων ('about children') the Delphic oracle and the Asclepieion at Epidaurus.[5] This paper compares the oracles which are provided to childless men at Delphi, with the *iamata*, inscriptions of the 4th c. BCE, found in Epidaurus, which record, among others, the miraculous cures of women's fertility problems.[6] Both *corpora* adopt a certain rhetoric, which, despite the supernatural miraculous themes and mythical patterns, presents each case in a systematic way, including the name of the patient (or the inquirer) and his/her origin, the disease/request, and the cure that is provided either in a descriptive manner in the case of the *iamata* (i.e. how the cure was achieved) or in a prescriptive manner in the case of the Delphic oracles (i.e. how the cure would be achieved if the patient followed the oracle).[7] Also, the immediacy of the cure, as soon as the petitioner leaves the sanctuary, is a common denominator of both *corpora* which often share similar mythical motifs.

Despite the different healing practices that apply in Delphi and Epidaurus, these rhetorical similarities in the oracles and the *iamata* indicate that childless men may approach Delphi as patients in the same manner that women visit Epidaurus in order that they will be healed. The rhetoric of the cure of infertility obviously differs since, as the case is in the Hippocratic corpus, inability to reproduce for women is considered a somatic state that requires physical healing, which does not apply to men. While the Delphic oracles show that men are also anxious about their own infertility, the stereotypical view that women are the main responsible for a sterile marriage prevails.[8] Finally, it appears that in both *corpora* a common cure for fertility problems is the change of one's sexual partner, a remedy that is concealed under the ambiguous oracular rhetoric and the rhetoric of the supernatural physical healing. In the case of men, this remedy is achieved through (unwanted and unavoidable) adultery, but in the case of women, it takes the form of incubation with the divine. Moreover, the Delphic prophecies reveal certain male anxieties about lineage. In some

[4] On the interrelation between religious and scientific medicine, see Edelstein and Edelstein (1945) II, 139; Jouanna (2012) 112–18. I consider the Delphic oracles with respect to infertility as constituents of religious or temple medicine. Graf (2015) 505 argues that the dichotomy should not be seen between religious and scientific medicine, but between illness caused by gods and sickness which is generated according to some natural law. In either case, gods could be asked to intervene.

[5] Lenfant (2020) 12 rightly notices that lack of children is not synonym to infertility. This is clear in Euripides' *Ion* (304–305) when Ion asks Creusa who states that she and her husband are childless, whether she did not give birth before and therefore she is without descendant. Ion wants to clarify that the problem of childlessness is sterility. The cases that I will explore suggest that those who seek assistance with respect to having children fear that they face reproductive problems.

[6] The Delphic oracles about children date from circa 705 BCE to 360 BCE. Scott (2018) 323 notices that the oral and material records that the priests collected in the *iamata* go back to the end of the 6th c. BCE during the rise of the cult of Asclepius.

[7] Pausanias (2.27.3 Spiro) who visited the shrine at Epidaurus in the 2nd c. ACE noticed the structure of the *iamata*, that is the name of the patient, the disease, and the way of healing: ταύταις ἐγγεγραμμένα καὶ ἀνδρῶν καὶ γυναικῶν ἐστιν ὀνόματα ἀκεσθέντων ὑπὸ τοῦ Ἀσκληπιοῦ, προσέτι δὲ καὶ νόσημα ὅ τι ἕκαστος ἐνόσησε καὶ ὅπως ἰάθη; Scott (2018) 333 describes the corpus of the *iamata* as 'rhetorically subtle'.

[8] Both Senkova (2015) and Lenfant (2020) argue convincingly, based on various Greek sources, that a barren marriage could be attributed to men and that men acknowledged that they could have reproductive problems. For the stereotypical view that women are the main responsible for the lack of children, see Scott (2018).

cases, the oracle appears to be unable or unwilling to cure infertility, especially when progeny is rendered dangerous, since the heir will also be the father's murderer. Thus, childless men, unlike sterile women, are provided with alternatives to progeny, such as the foundation of colony or military victories. The healing, therefore, of infertility appears to be gendered.

The following investigation of the Delphic oracles and the *iamata* needs to start with a caveat. Both *corpora*, since they are unrealistic, seem, at first sight, unreliable sources for actual social attitudes. Most of the prophecies, which I discuss, are rendered by Fontenrose as quasi-historical, mythological and legendary,[9] and the corpus of the Epidaurian *iamata*, which contains radical and miraculous cures to impossible diseases, could not apply to real patients. Nevertheless, the oracular responses and the miraculous treatments reflect a strong belief in the capacity of the gods to intervene in order to provide progeny. Moreover, as I will show, they offer some evidence for actual attitudes and mentalities towards infertility that we find in medical and philosophical writings.[10]

A. The Rhetoric of Requests for Children

The ancient rhetoric about infertility and its cure is largely gendered, since women appear to be the ones who have to be treated physically, when a couple is childless.[11] In the Hippocratic *corpus*, the infertility of women is presented as an often curable condition while there are few references to male impotence.[12] To this end, there is no abstract noun to describe the condition of infertility and the adjectives for the sterile, *aphoros* and *atokos*, are reserved only for women, who had to endure a treatment in order to regain their fertility.[13] In the Hippocratic *corpus* a specific treatise is devoted to the barren women (Περὶ ἀφόρων). The term *agonos* is used as well primarily for sterile women (*Aphorisms* 5.59.4; *Epid*emics 2.5.6A 5.130 L.; *Diseases of Women* 228A1 L. 8.438) but it also describes the infertile semen (*Airs Waters Places* 22A8 2.76 L.; *On Generation* 2.9 7.472.12–13 L.) in the case of men who suffer an ear incision, an untreatable case.[14] The idea that sterility was mainly a disease of women is also reflected in a passage by Herodotus, where he discusses the impotence of the Skythians. The historian notices that they were afflicted by Aphrodite with the feminine disease (θήλεαν νοῦσον, 1.105) as a punishment for robbing the goddess' temple.[15]

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[9] See Fontenrose (1978) ch.1, on the division of the Delphic oracles.

[10] See Johnston (2004) 465: 'even when partly fictitious, these inscriptions remain valuable documents for ancient attitudes to divine intervention in illness and other problems'. Maurizio (1997) 312 argues about the status of the Delphic oracles as oral compositions, which were transmitted orally and were re-created as they were remembered and interpreted in 'communities of believers', establishing the efficacy of Apollo's prophecies.

[11] See also Scott (2018) 330–32.

[12] See the case of the Skythians in *Airs, Waters and Places* 17–22 (cf. *Aph*. 5.63), and *On Diseases* 4. Cf. the case of eunuchs in Aristotle *GA* 2.7.746b.20–25. For a discussion of these passages, see Fallas (2016) 114–17. There is a reference to male impotence as a reason for divorce for an *epiklēros* in Plutarch, *Solon* 20.2.

[13] Flemming (2013) 576–77.

[14] On all terms for the infertile in the Hippocratic *corpus* see Fallas (2016) 55–72. Cf. the term ἀπαιδία (e.g. Eur. *Ion* 306).

[15] On the interpretation of the feminine disease as impotence, see Asheri (1988) 333. Notice that the infertility of the Skythians is discussed and explained in a rationalized way in the Hippocratic *corpus*.

Such a gendered approach to infertility is reflected in the segregation, albeit to a small extent, between male and female petitioners of children. It appears that when it comes to fertility problems, the petitioners/patients who visit Delphi are usually men. But cases of couples and even women alone who visit Delphi are also attested.[16] In Euripides' *Ion* Creusa is asked whether she came with her *kyrios* or alone to the oracle (299), and she responds that she arrived with her husband.[17] On the other hand, it is shown in the Epidaurian inscriptions that women with reproductive problems visit the sanctuary of Asclepius, in order that the god would heal their infertility by incubation.[18] From the fifty-two eligible *iamata*, thirteen relate to female suppliants, of which six refer to women who face problems with prolonged pregnancy or infertility (A1, A2, B11, B14, B19, B22). Andromache, a royal, one of the patients mentioned in the *iamata*, travelled a long distance from Epirus in Northwest Greece to Epidaurus in Peloponnese, motivated by her desire to get pregnant. According to Dillon, women of high rank could have male or female chaperons for a pilgrimage.[19] Men appeal to Asclepius in Epidaurus for other illnesses or private concerns but not for childlessness. Even in the instance when an old childless man consults the Asclepieion at Lebena, Asclepius heals the petitioner's wife, not the male visitor.[20] There is only an implication to impotence problems in one cure inscription. In A8 a male patient requests healing, because he has a stone in his membrum. After he sleeps in the *abaton*, he dreams that he lies next to a young boy, and while he ejaculates, he forces out the stone. Such a problem that relates to the patient's sexual performance presumably affects his fertility, although this is not stated as his concern.

Regardless the gender of the petitioner, the wording of the request for children at Delphi and at Epidaurus is similar and it reflects oral and fixed diction.[21] The formula 'about children' (περὶ παίδων) and its variants are found in both *corpora*.[22]

Delphic Oracles[23]
περὶ ἄρσενος παιδὸς (L23/PW156)
περὶ παίδων (L5/PW111, L82/PW 322, L28/PW190)

In these cases, it is the Skythians' lifestyle (i.e. excessive horse riding) and the cold climate that cause impotence. These factors lead to absence of desire or strength for intercourse.

[16] Dillon (1997) 184: 'Several pilgrimage sites, especially healing sanctuaries, attracted female pilgrims, and women seeking to become pregnant not only sought the assistance of Asklepios at Epidauros, but could also consult Delphi about the possibility of having a child'. Plutarch (*Mor.* 385c) notices that women could not consult the Delphic oracle. The practice may have stopped in his time in the 2nd c. ACE. Also, it could be the case that as with Xuthus and Creusa in *Ion*, it would be the man who would enter the *adyton* in order to ask Pythia.

[17] Notice, however, that the couple visits the oracle with different inquiries and for this reason Creusa reaches the oracle a little bit before the arrival of her husband (Eur. *Ion* 330). To this end, she arrives on her own. Creusa wants to find out what happened to her exposed child, whose father is Apollo, while Xuthus asks the oracle about his desire for having children.

[18] Cole (2004) 174 pointedly notices: 'Apparently, under the impression that for males sexual performance was equivalent to fertility, husbands anxious to produce progeny sent their wives instead [to Epidaurus]'.

[19] See Dillon (1997) 185.

[20] Dillon (1997) 190 notices that if the woman is of the same age with her husband, something quite unlikely though, there would be a concern about menopause.

[21] See Maurizio (1997), on Delphic oracles as oral performances.

[22] Cf. E. *Ion* 303: καρποῦ δ' ὕπερ γῆς ἥκετ', ἢ παίδων πέρι (Martin).

[23] L = Legendary, Q = Quasi-Legendary (Fontenrose), PW = Parke and Wormell.

περὶ παίδων γονῆς (L4/PW110)
περὶ τέκνων γενέσεως (Q28/PW43)
περὶ γόνου (PW 107)

Iamata[24]
Ἀνδρομάχα ἐξ Ἀπείρο[υ] περὶ παίδων (B11)
[…]νία ὑπὲρ τ[έ]κνων (B14)
ἐκ Κέου. αὖτα περὶ παίδων (B19)
Νικασιβούλα Μεσσανία περὶ παίδων (B2)

A variant of this request at Delphi, which has the form 'how shall I have X or become X', is always reserved, according to Fontenrose, for questions on how to have children or how to become a parent.[25] The question is phrased in the third-person plural of the verbs γίγνεσθαι or εἶναι, with the dative of the first-person pronoun for the petitioner (e.g. πῶς ἐμοὶ ἔσονται παῖδες).[26] The use of the adverb πῶς shows that the oracles which are elicited are prescriptive, unlike the *iamata* that describe the method of a cure, enacted by the god or his attendant. The rhetoric of the Delphic request implies the patient's personal involvement in the interpretation and the execution of the proposed solution by the oracle.

In some cases, both at Delphi and at Epidaurus, even the gender of the child is requested. Men at Delphi ask specifically for sons, and it has been argued that even the generic word παῖς refers to a male child.[27] In the *iamata* as well, it is recorded that a female inquirer at Epidaurus had a similar request (B14). In this case, a woman from Troezen approaches the Asclepieion asking initially for children (ὑπὲρ τέκνων). During the incubation, the woman sees in a dream the god who announces to her that she will have a family (ἔσσεσθαι γενεά). He asks her whether her wish is for a male or a female child and she responds that she wishes for a boy. The prophecy is fulfilled and within a year a son is born to her. In contrast, Ithmonika of Pellene (*iama* A2), who visits the sanctuary for the sake of a family, has a dream in which she requests from the god a daughter – a wish that Asclepius grants. These examples show that the gods can even determine the gender of the child and thus the request is modified accordingly.

In the *iamata*, in addition to the request περὶ παίδων, we have two examples of a request about birth (ὑπὲρ τόκου) – a gendered appeal.[28] In these cases, two women

[24] Edition by LiDonnici (1995).

[25] Fontenrose (1978) 36.

[26] A similar question ('how will I have children by X?' or 'will I have children by X?') is found often in the lead tablets at the oracle of Dodona, which date from the 6th to the mid-4th c. BCE. The inquiry becomes specific, since the man asks whether he will have children from a particular woman, who is either named or unnamed (i.e. his wife). On these requests, see Eidinow (2007) 87–93, and Dakaris, Vokotopoulou, Christidis (2013) (e.g. 1036A, 2493A, 3034B).

[27] Buck (1955) *ad* παῖς. In this light, specific requests at Delphi for male progeny (e.g. Apollod. *Library* 2.34 (Wagner): Ἀκρισίωι δὲ περὶ παίδων γενέσεως ἀρρένων χρηστηριαζομένωι), like those in the tablets at Dodona (e.g. 313A: γενιά κἀνδρογένεια, 542A), aim to avoid any misunderstanding that would lead to the fulfilment of the request with a daughter. Alternatively, the inquirer already has a daughter and seeks for a son. In my view, the most common request for παῖς is not probably gender specific, and the petitioner is childless.

[28] Cf. another gendered appeal in Euripides' *Ion* (303). Ion asks Creusa the reason for Xuthus' visit to Delphi. He gives two alternatives for his inquiry, either for the fertility of the land or for children. These seem to be the main concerns for a man.

experience prolonged pregnancies (A1, A2) for five and three years respectively. This condition constitutes a peculiar type of childlessness and infertility by means of restrained childbirth. The rhetoric of these requests about giving birth indicates gendered anxieties, since women should also be preoccupied with giving birth to healthy children, not only with conception, while men at the oracle are anxious in general about progeny and succession.[29]

In the case of Kleo (A1), the child is born after a prolonged five-year pregnancy, and is miraculously able to walk and wash himself at the fountain of the shrine. The pattern of a baby's miraculous growth, which is common in oracles and *iamata,* is characteristic of mythological narratives as well, such as the case of the prince Demophoon in the *Homeric Hymn to Demeter*, who grows up quickly, 'equal to a god', with the aid of his nurse, Demeter (h. *Dem.* 235).[30] Hermes and Apollo, in their respective *Homeric Hymns* that describe their birth, are born as infants (h. *Ap.* 127–132; h. *Herm.* 21–23). A baby, either divine or mortal, when it is born (or raised) with the assistance of a god, has miraculous attributes.

A similar miracle is recorded in an inscription at Delphi (H34).[31] Several diseases prevented a woman from getting pregnant. In this case, the wife is responsible for the barren marriage. Her husband visits the oracle in order to request a child, and Apollo asks for a lock of hair from the girl who is to be born. The woman is indeed cured and after eleven months a girl is born with full hair, an atypical trait for a newborn.[32] A lock is then dedicated to the god, so that the divine request is fulfilled in reciprocation for the cure of sterility. The girl was named Delphis, and three years later the couple had another girl, which means that the woman was not cured just temporarily.

The reference to a fast-grown baby shows that, as with the Epidaurian *iamata*, the rhetoric of myth is adapted for the purposes of oracular medicine. In the latter example, despite the mythical elements, it is clearly stated that healing by the gods' intervention is more successful than traditional medicine, since it is mentioned that the woman got pregnant without facing the diseases (νούσοις) she used to have, and without even having labor pains. The healing aspect of the prophecies is acknowledged, since Apollo provides progeny through prophecies (γενεὰμ μαντεύμασι δῶκεν).

Another prolonged pregnancy, recorded at *iama* A2, recalls as well a mythical motif. As already mentioned, Ithmonika had requested initially to conceive a daughter during an incubation, but she forgot to ask for the actual birth of the child. Thus, she was pregnant for three years until she visited the sanctuary again, where Asclepius granted her request, and she gave birth to her daughter. The motif of a wrong request to a god is common in mythological tales such as, for example, in the myth of Eos and

[29] See e.g. Xuthus, who, thrilled about Apollo's prophecy and the son he would encounter, forgot to ask who the mother was (541: τερφθεὶς τοῦτο, κεῖν᾽ οὐκ ἠρόμην), apparently an unimportant information for a man who seeks a successor.

[30] See also Prêtre (2018) 21–22.

[31] *FD* 3.1.560. The inscription is of the same date with the *iamata*. See Weinrich (1924/1925), who calls the tale recorded in the inscription a miracle, due to the length of the pregnancy and the full hair of the newborn. Fontenrose (1978) 19 n. 7 argues against its miraculous content, since both events are not atypical. Similarly, Bousquet (1956) 552.

[32] It is not clear whether the pregnancy lasted eleven months or that eleven months passed by after the father's initial visit.

Tithonos, according to which Eos asked Zeus to grant immortal life but not eternal youth, with the result that Tithonos was forever aging (h. *Aphr*. 218–238). Medicine and myth are intertwined in the miraculous *iamata* to the point that the wrong appeal by the patient reflects the common theme in myth of the miscommunication between gods and mortals, but it also alludes to analogous confusion in the interactions between doctors and patients. Rhetorical ambiguity in the phrasing of the request or in the wording of the prescribed therapy is typical in religious medicine. This is a dominant theme in Delphic oracles as well.

The inquiries at Delphi 'about children' could stem from the petitioner's general desire for learning about posterity. Considering that the same questions are articulated at the Asclepieion by women, who apparently have reproductive problems, it can be argued that some of the consultants at Delphi could also be motivated by their personal anxiety (although not admitted openly) about their own fertility. To this end, the request 'about children' or 'about the birth of children' functions almost as euphemism for infertility. The preposition περὶ presents the topic of the inquiry, but it also defines the problem for which the worshipper requests assistance from the god. The petitioner visits Delphi at the time when it is apparent that there is a problem regarding bearing children. All examples of visits by childless husbands or couples (e.g. Aegeus, Laius, Xuthus) in literature show that, when they visit the oracle, they have already faced a long marriage without children.[33] If the oracular rhetoric is perceived in this way, the posing question is equivalent to making a request but it also implicitly points to the disease of the petitioner who seeks personal assistance from the divine.

To this end, the oracular rhetoric coincides with the religious-medical rhetoric, if we define as such the diction of the *iamata*.[34] For example, in the case of the *iamata* the prepositional phrase περὶ παίδων is placed at the spot where the disease is usually mentioned, often right after the name and the origin of the petitioner. The propositional phrase reflects the purpose of the visit at the sanctuary, the problem that the suppliant faces, but also the healing that is requested (i.e. the provision of children). The inquiry encompasses the cure. In the *iama* 8 it is mentioned that a voiceless child came to the sanctuary 'for the sake of voice' (παῖς ἄφωνος [...] αφίκετο ὑπέρ φωνῆς B8), pointing to the healing that is requested (i.e. speech). Such formulaic questions indicate the oral performance of the process and precipitate the standard, technical and scientific diction of the Hippocratic corpus, where the prepositional phrase is the title of treatises on diseases. The parallel formulaic discourse in the Delphic inquiries and the *iamata* indicate that the consultant at Delphi approaches Apollo with expectations like those of a supplicating patient.[35]

[33] e.g. E. *Phoen*. 13–16.

[34] Cf. Dillon (2017) 287: 'many of these *iamata* are couched with prophecy'. Dillon (288) notices the *iama* (B14) where the god during incubation predicts in a dream that the female inquirer will have a boy, according to her wish, and the prediction is fulfilled.

[35] Naiden (2005) 72 shows that the visitors at the shrines of Asclepius were treated as suppliants (even though no human being executed the cure). The process, as Naiden shows, is the same: the approach to the shrine is long and difficult, a request is made, and upon reception of the supplication the god provides the cure, while, if the supplication is rejected, the worshipper leaves untreated. My examples from the Delphic oracle in comparison with the *iamata* strengthen this view.

The intersection between prophecy and medicine is reflected as well in other private requests for a remedy, such as the ones concerning incurable conditions, e.g. the muteness of Croesus' son (PW 55), or the untreatable wounds of Leonymus (PW 77) and Phormio (PW 78). These are examples where prophecies substitute supposedly unsuccessful medical treatments. Apollo was also requested to heal lovesickness (PW 468), to restore the power to laugh (PW 129) or to treat the inability to abstain from laughter (PW 328). Considering that, as we will see in the next section, men consult Delphi after many years of a barren marriage, childlessness is also considered a difficult case for treatment.

B. The Rhetoric of Therapies for Infertility

The rhetoric on curing infertility is also formulaic to an extent when it comes to *iamata*. After the disease is described, it is mentioned that the patient sleeps in the *abaton* and has a dream, which includes the mode of therapy, and then the outcome of the incubation is stated. The use of the verb ἐδόκει that introduces the dream shows the subjectivity of the experience. Finally, a prepositional phrase ἐκ τούτου, after the description of the dream and the procedure that the patient endures, shows the cause-effect relation. This phrase stresses the efficacy of the practice of incubation and thus it provides confidence about the cure to other patients who read the *iamata* presumably before their entrance into the *abaton*. The description of the incubation process helped the visitors to envision their own therapy and to be prepared psychologically for the cure.[36]

Therapies, on the other hand, which are proposed at Delphi, while they varied in phrasing, are framed by an imperative, which encompasses the mode of action that the petitioner should follow, even though it is expressed in a riddle. Some oracles strengthen the stereotype that men are less likely to be responsible for infertility. Such is the case of the King Erginus of Orchomenos, who reached old age without having married and without heirs (ἄγαμος καὶ ἄπαις ἀφικόμενος ἐς γῆρας) (L5/PW 111, Paus. 9.37.4).[37]

> Ἐργῖνε Κλυμένοιο πάι Πρεσβωνιάδαο,
> ὄψ' ἦλθες γενεὴν διζήμενος· ἀλλ' ἔτι καὶ νῦν
> ἱστοβοῆι γέροντι νέην ποτίβαλλε κορώνην.
>
> Erginus, son of Klymenus, who is the son of Presbon,
> You came late seeking for children; but even now
> put a new tip on the old plow tree.

His visit to Delphi showcases his personal concern about his capacity to be fertile considering his age. Old age in the Hippocratic *corpus* is treated as one of the causes of female sterility due to the lack of menses (*On Diseases of Women* 1.1), but Aristotle acknowledges that this factor relates to male infertility as well (*GA* 725b18–25), due to the lack of semen in senility. The Delphic response verifies male attitudes

[36] On the function of the *iamata*, see LiDonnici (1992), Dillon (1994), LiDonnici (1995), King (1998).

[37] Texts for the Delphic oracles come from Parke and Wormell (1956). Translations for the Delphic oracles by Fontenrose (1978).

to sterility, as it suggests a young partner for securing progeny. Erginus indeed had two sons after marrying a young woman. The fact that he first went to Delphi to find out whether he would ever have children, being an unmarried old man shows the trust Greeks had that the oracle can securely not only predict progeny, but also advise on how to achieve it, even when old age may be an obstacle. Erginus' case shows that men as well are concerned about their own fertility, at least when they reach old age. The outcome of the story, the fact that Erginus had children after all, appears to verify the notion that men (unlike women) can retain their fertility, presumably with the assistance of Apollo, even when they age.[38]

A similar example from an inscription at Asclepius' sanctuary at Lebena in Crete (1.7.9; 2nd c. BCE) showcases a different cure but the same belief, that a man, even when he has surpassed the prime of his youth, is not necessarily responsible for the lack of children.[39]

IC I xvii 9 (Lebena, Crete, 2nd c. BCE)
Φαλάρει Εὐθυχίωνος Λεβη[να]-
ίωι οὐ γινομένω τέκνω ἰόντος ἐν π[εντή]-
[κ]οντα ἤδη ϝέτεθι προσέταξε τὰν γυ[ναῖ]-
κα ἐφευδησίονσαν ἀποσστῆλαι καὶ [ἐπ]-
ευθ<όνσ>αν ἐς τὸ ἄδυτον ἐπέθηκε τὰν σικ[ύαν]
[ἐ]πὶ τὰν γαστέρα κὴκέλετο ἀπέρπεν [ἐν]
[τά]χει κὴκύσατο.

To Phalaris, the son of Euthychnion, from Lebena, who had no children even though he was fifty years old, the god commanded him to send his wife to incubation and as she came to *adyton*, he put a *sikya* on her belly and bade her to leave quickly, and she became pregnant.

The inscription relates how a childless man in his fifties achieves progeny. The god asks that the man's wife be sent to the sanctuary and sleep in his temple. During the incubation, the god places a cup instrument on the patient's belly, and she gets pregnant. As with the Hippocratic *corpus*, it is the woman who must endure a physical treatment, so that she will restore the health of her reproductive system, and the couple will be able to have children.[40]

Similar somatic cures for women through physical contact with the divine or his instruments are recorded in the *iamata*. In one example, a female suppliant is touched by Asclepius' snake (B19) on her belly, and she gives birth to five children.

Iama B19
_δα ἐκ Κέου. αὗτα περὶ παίδων ἐγκαθεύδ[ουσα ἐνύπνιον εἶδε· ἐδό]κει οἱ ἐν τῶι ὕπνωι δράκων ἐπὶ τᾶς γαστ[ρὸς κεῖσθαι· καὶ ἐκ τούτου] παῖδες οἱ ἐγένοντο πέντε.

[38] Cf. the case of Menecles in Isaeus' speech (2.7–9, 7: καὶ ἔφη τήν τε ἡλικίαν ὑφορᾶσθαι τὴν ἑαυτοῦ καὶ τὴν ἀπαιδίαν Forster). He acknowledges his ἀπαιδίαν due to old age and he convinces his wife to divorce him and to remarry to have children. See also 6.22–23.

[39] Female visitors to Lebena in Crete are well attested. See Dillon (1997) 191 and n. 35.

[40] Cf. *On regimen* 2.54, which lists food that, if eaten, affects the fertility of the semen. On this topic, see Fallas (2021) ch. 4.

> _da from Keos. This woman, sleeping here concerning children. It seemed to her that in her sleep a snake lay down upon her stomach. And from this, five children were born to her.[41]

In another case the female patient has intercourse with the snake (4cB22).

> *Iama* B22
> Νικασιβούλα Μεσσανία περὶ παίδω[ν ἐγκαθεύδουσα]
> ἐνύπνιον εἶδε· ἐδόκει οἱ ὁ θεὸς δράκοντα μεθ[----------]
> φέρων παρ' αὐτὰν, τούτωι δὲ συγγενέσθαι αὐτά· [καὶ ἐκ τούτου] παῖδες οἱ ἐγένοντο εἰς ἐνιαυτὸν ἔρσενες δύ[ε].
>
> Nicasiboula of Messene, concerning children. Sleeping here she saw a dream. It seemed to her the god came bringing a snake creeping beside him and she had sex with it. And from this children were born to her within a year, twin boys.

As is the case with the Hippocratic School, the remedy which is provided by Asclepius constitutes a body cure for female infertility, which is perceived as a reversible somatic state.[42] Asclepius' treatment does not heal the woman's fertility problems for a single time. It rather leads to multiple progenies.[43]

In the case of Andromache from Epirus, who also supplicates for children (B11), the *iama* describes another instance of a miraculous, healing touch.

> Ἀνδρομάχα ἐξ Ἀπείρο[υ] περί παί-
> δων, αὔτα ἐγκαθεύδουσα ἐνύπνιον εἶδε· ἐδόκει αὐτᾶι π[α]ῖς τις ὡραῖ-
> ος ἀγκαλύψαι, μετὰ δὲ τοῦτο τὸν θεὸν ἁψασθαι οὐ τᾶι [χη]ρί· ἐκ δὲ τού-
> του τᾶι Ἀνδρομάχαι υ[ἱ]ὸς ἐξ Ἀρύββα ἐγένετο.
>
> Andromache from Epirus concerning children. When she was sleeping here she saw a dream. It seemed to her that a handsome young boy uncovered her, and after that the god touched her with his hand. From this a son was born to Andromache by Arybbas.

The god's touch of the woman's naked body (B11), just like the lay of the snake on the belly (B19), has presumably sexual connotations. These are stronger in the case of the patient's intercourse with the snake that Asclepius holds (B22). In these cases, it is implied that the suppliant is provided with a child, after she is erotically involved with a partner other than her husband, Asclepius or even a priest who poses as Asclepius.[44] This cure suggests that the suppliant's husband is infertile and thus the woman can be impregnated by another partner. The naming of the child's father in B11, nevertheless, pointedly strengthens the legitimacy of the progeny, especially since it concerns a

[41] Translations for the *iamata* come from LiDonnici (1995).

[42] Flemming (2013) 580.

[43] It is not clear in B19 whether the god provides quintuplets or five children collectively during the woman's childbearing years. In the latter scenario, the inscription functions as a thanking offering after the woman's childbearing age ends.

[44] For male doctors taking advantage of female patients in antiquity, see Scott (2018).

king's heir, and it objects the notion of divine parenthood.[45] Unlike mythical narratives about demigods, in the context of religious medicine the intervention of the healing god constitutes therapy. Women need a physical cure, which is emphasized by the repetition of words of touch, such as the ones the rationalized medicine prescribes, but there are also strong implications of an atypical intercourse with the divine. The *iamata* stand between myth and medicine.

The remedies that the women receive at Epidaurus through intercourse with the divine echo analogous cases at Delphi where the change of sexual partner, an involuntary act, seems to be the cure to infertility. The inquiry about children in these cases is answered with a prophecy that orders a course of action, which is not followed accurately, with the result that the petitioner procreates but outside marriage.

In Euripides' *Medea*, Aegeus, like the women at Epidaurus, consults Delphi because he is concerned about his own fertility (669). The oracle, which is provided to Aegeus, (L4/PW 110, Apollod. 3.15.6, Plut. *Thes*. 3.5, Σ Eur. *Med*. 679)[46] is ambiguous, and needs interpretation by the petitioner who receives, in the manner of a medical prescription, an order for a certain course of action in a set time frame.

> ἀσκοῦ τὸν προύχοντα ποδάοντα, φέρτατε λαῶν,
> μὴ λύσῃς, πρὶν ἐς ἄκρον Ἀθηναίων ἀφίκηαι.
>
> Do not untie the wineskin's foot, strongest of the people, until you reach Athens.

Considering that the wineskin's foot is a slang for membrum, according to the ancient scholia (Σ Eur. *Med*. 679), the oracle advises that Aegeus on his way home should refrain from intercourse.[47] This is a peculiar cure for childlessness, but apparently the oracle not only provides the capacity to procreate but also directs Aegeus to exercise it in Athens, presumably with his legitimate wife. According to Apollonius and Plutarch, Aegeus, being perplexed by the oracle, goes to Troezen where Phitheus, who understood the oracle, tricks him, turns him drunk, and offers him his daughter, Aethra. Parke and Wormell argue that Aegeus' inability to interpret the oracle meant that 'he brought about his own death through his son's agency, because he begat him elsewhere than the Pythia prescribed'.[48]

In a similar story from the oracle at Didyma, Lyrcus (Parthenius, *Love Romances* 1) received a prophecy about his childlessness, according to which he should mate with the first woman he would encounter after he left the oracle.

> Χρόνου δὲ πολλοῦ προϊόντος ὡς τῷ Λύρκῳ παῖδες οὐκ ἐγίνοντο, ἦλθεν εἰς Διδυμέως χρησόμενος περὶ γονῆς τέκνων: καὶ αὐτῷ θεσπίζει ὁ θεὸς παῖδας

[45] Andromacha's visit had political motivations according to Dillon (1997) 189, since she is 'in search of pregnancy clearly to have children for the sake of the dynasty'. See also Paus. 2.10.3, 4.14.5, for the case of Aristodama, the mother of Aratos, the commander of the Achaeans, born in 270 BCE, who was considered by Sikyonians as the son of Asclepius.

[46] The hexametrical versions in Apollodorus and Plutarch are regarded as earlier than the one found in Euripides. Against this view see Keen (2009) 628, who regards the oracle as Euripides' invention, since the tragedian was accused of using vulgar language.

[47] Cf. Dillon (1997) 187 on abstention from sex on the day of the visit to the oracle (for marital sex) or a day before (for extra-marital sex).

[48] Parke and Wormell (1956) vol.1.301.

> φύσειν, ᾗ ἂν ἐκ τοῦ ναοῦ χωρισθεὶς πρώτῃ συγγένηται: ὁ δὲ μάλα γεγηθὼς ἠπείγετο πρὸς τὴν γυναῖκα πειθόμενος κατὰ νοῦν ἂν αὐτῷ χωρήσειν τὸ μαντεῖον. Ἐπεὶ δὲ πλέων ἀφίκετο ἐς Βύβασσον πρὸς Στάφυλον τὸν Διονύσου, μάλα φιλοφρόνως ἐκεῖνος αὐτὸν ὑποδεχόμενος εἰς πολὺν οἶνον προυτρέψατο, κἀπειδὴ πολλῇ μέθῃ παρεῖτο, συγκατέκλινεν αὐτῷ Ἡμιθέαν τὴν θυγατέρα. Ταῦτα δὲ ἐποίει προπεπυσμένος τὸ τοῦ χρηστηρίου καὶ βουλόμενος ἐκ ταύτης αὐτῷ παῖδαςγενέσθαι.
>
> So a considerable period of time passed, but Lyrcus and his wife had no children: and accordingly he made a journey to the oracle at Didyma to ask how he might obtain offspring; and the answer was that he would beget a child upon the first woman with whom he should have to do after leaving the shrine. At this he was mighty pleased, and began to hasten on his homeward journey back to his wife, sure that the prediction was going to be fulfilled according to his wish; but on his voyage, when he arrived at Bybastus, he was entertained by Staphylus, the son of Dionysus, who received him in the most friendly manner and enticed him to much drinking of wine, and then, when his senses were dulled with drunkenness, united him with his own daughter Hemithea, having had previous intimation of what the sentence of the oracle had been, and desiring to have descendants born to her.[49]

Lyrcus, just like Aegeus, gets drunk by another king (Staphylus) and impregnates his daughter (Hemithea), against his wish, since he originally was planning to go straight home and have intercourse with his own wife. Both Aegeus and Lyrcus engage in an illegitimate liaison after they are intoxicated by means of trickery. The way in which the oracles are executed appears to reinforce the social belief that in the case of childlessness, a change of the husband's partner can be the solution. Even though the Delphic oracle does not openly prescribe adultery for the purpose of procreation (on the contrary it tries to prevent it), in myth this practice is always successful. The change of one's sexual partner as a remedy for infertility echoes the diagnostic method proposed by Aristotle. When Aristotle (*HA* 10.636b11–13) discusses the possibility that the cause of infertility lies with the male, he notes: 'if you want to find out whether the man is to blame, just let him have intercourse with another woman and see whether that produces a satisfactory result'.[50]

Male petitioners at the oracle at Dodona often ask whether there will be a child from a certain woman, their current wife, implying that they need to know, whether they should seek another consort.[51] The therapy of infertility by changing one's sexual partner is also implied in an inquiry from Dodona in which a woman asks whether she would have children from her husband (1318A: ἐξ ἄνδρὸς). In another question, finding another partner is suggested to the god, since the female petitioner (Kleunika) asks whether she will have children from another husband/man (2552B: ἐξ ἄλλω [ἀ]νδρὸς).[52] As is the case in many tablets, she also asks to which god she should

[49] Translation by Edmonds (1916).

[50] van der Eijk (1999) 490. See also Arist. *HA* 10.637b23–4.

[51] See n. 27.

[52] There are 14 inquiries from women who ask for children, which are dated from the 5th to the 3rd c. BCE. See Katsadima (2017) 133 on a review of all these cases. In some inquiries the name of the wife

sacrifice in order that she may have children. Thus, there is an implication of the double cause of lack of children: because of the partner's sterility and because of the gods' intervention.[53] The fact that a woman employs the same request that most often men address in Dodona suggests a change in mentality, unless the inquirer is a woman of low status and questionable morality.[54]

Alternatively, it could be argued that the petitioner in the cases of Aegeus and Lyrcus is the one who is indeed infertile, and not his wife. In this case, the sterile suppliant is presumably cured once, since Apollo fulfills the request for children and heals the presumed fertility problem only in the first intercourse after the visit at the oracle. Neither Lyrcus nor Aegeus had more children with their legitimate wives at the time.[55] According to Mastronarde, the oracle promises potency, which is used up by Aegeus not for his legitimate wife but for Aethra.[56] Regardless of whether Aegeus or his wife is the sterile, the healing of Aegeus' childlessness with an illegitimate son turns into a cautionary story about the dangers of procreation outside marriage.

As the two prophecies to Aegeus and Lyrcus show, a prominent feature of oracular medicine is the immediacy of the cure, a wish of every patient.[57] The immediate enforcement of the cure can also be found in the *iamata* especially in the case of the two women with prolonged pregnancies who give birth to their children as soon as they leave the *abaton* in Epidaurus.

Another prophecy that carries similar immediacy in its enforcement and relates as well to an illegitimate son is the oracle which is given to Xuthus (L28). Xuthus visits with his wife the oracle after many years of infertile marriage even though he was able to perform sexually (64–65). He asks the oracle about his desire for children, and Apollo announces that the first child he will see will be his son (Eur. *Ion* 534–536).[58]

Ἴων: ὁ δὲ λόγος τίς ἐστι Φοίβου;
Ξοῦθος: τὸν συναντήσαντά μοι —
Ἴων: τίνα συνάντησιν; 535

is mentioned next to that of her husband. Katsadima (140) notices that 'in a total of over 4460 inscriptions on the Dodona's tablets, the women's inquiries represent roughly only 2,33% of the material that has been published'.

[53] The petitioner knew perhaps that she was fertile, maybe because of previous childbirths. See Cole (2004) 146–158 on male reproductive anxiety, especially expressed in Dodona tablets. Also, von Straten (1981) 98–100.

[54] Dillon (1997) 185 notices, however, that women of upper class, who had the money and leisure to travel, could consult the oracles.

[55] The fact that Aegeus has a son later with fertile Medea can be explained by Medea's capacity to create and use drugs. She promises to Aegeus in Euripides' *Medea* (718) a cure with her *pharmaka*, a type of healing reserved for women. On women and sorcery through *pharmaka* (drugs), see Dillon (2002) 169–77.

[56] Mastronarde (2002) 54. Kovacs (2008) 300 argues that in Euripides' version, there are signs that Aegeus fulfills the prophecy and has intercourse with his legitimate wife named Aethra. Later mythographers changed the original version turning Aethra into a foreign woman so that they would explain the saga of Theseus' special tasks.

[57] Notice that in the case of Phormio (PW 78), his doctor, according to the prophecy, would be the first person who would invite him to dinner. Similarly, Pythia orders that the person who would first invite the kings/petitioners, as soon as they leave the sanctuary, would be taken to their country as an *oikist* (60PW, Hdt. 6.34.2).

[58] Notice that the purpose of his visit to the oracle is described as 'desire for children (ἔρωτι παίδων Eur. *Ion* 67; cf. 1227)', which, in a way, glosses the oracular 'περί παίδων'. Similarly, Archel. fr. 2.19–21 Austin; Eur. *Med*. 714–15 (Aegeus).

Ξοῦθος: δόμων τῶνδ᾽ ἐξιόντι τοῦ θεοῦ
Ἴων: συμφορᾶς τίνος κυρῆσαι;
Ξοῦθος: παῖδ᾽ ἐμὸν πεφυκέναι.
Ἴων: σὸν γεγῶτ᾽, ἢ δῶρον ἄλλως;
Ξοῦθος: δῶρον, ὄντα δ᾽ ἐξ ἐμοῦ.

Ion: What were the words of Phoebus?
Xuthus: That the one who met me—
Ion: What meeting?
Xuthus: As I came out of the temple—
Ion: What would be the result?
Xuthus: That he would be my son.
Ion: Your own by birth, or a gift from some other?
Xuthus: A gift, but born from me.[59]

This is a variation of the prophecy**,** which prescribes that the first sexual encounter is fertile and that the cure of infertility takes place as soon as the petitioner leaves the oracle. Xuthus assumes that Ion, whom he sees first, is the product of one of the affairs he had in his youth (545–48), since the possibility that he could have been infertile does not seem likely to him. The audience knows that it is Xuthus who is infertile, since Creusa was impregnated by Apollo who raped her, and perhaps Euripides criticizes the male standard view on infertility.[60] Alternatively, it could be argued, as Calame does, and as it is implied in the chorus' *stasimon* (456ff.), that the birth of Ion caused Creusa's subsequent infertility.[61] As was the case with Aegeus and Lyrcus, Xuthus becomes a father by means of an illegitimate child, as the chorus notices (815, 1095). Apollo's cure of Xuthus' childlessness strengthens the efficacy of the Delphic oracle in the context of temple medicine, since Xuthus first consulted the Trophonius' oracle, which only predicted that neither Xuthus nor Creusa would return from Delphi childless, but it is Apollo's oracle that provided the cure.[62]

In the examples of Aegeus and Xuthus, an illegitimate son is the solution to the problem of lack of children. But complications arise by such practices since they violate social norms. Procreation for the sake of procreation is problematic; a legitimate offspring is to be sought after. The sociopolitical aspects of infertility are at least implied in the Delphic oracles.

In the context of oracular rhetoric, a prophecy, defying the purpose of medicine, may even warn against progeny or predict a dangerous progeny. Laius' visit to Delphi is matched with a grim prophecy about his heir, who will become his murderer.

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[59] Translation by Potter (1814) slightly modified.

[60] Similarly, Herodotus (6.61) criticizes the Spartan king Ariston who had married twice without having children and then married a third time, because Ariston did not think that he was responsible (αἴτιος) for the lack of children. Moreover, there was a rumor in Sparta that Ariston's sperm was not παιδοποιὸν (ὅ τε λόγος πολλὸς ἐν Σπάρτῃ ὡς Ἀρίστωνι σπέρμα παιδοποιὸν οὐκ ἐνῆν; 6.68). Herodotus expresses perhaps a progressive view of his time. Notice that the third wife gives birth to a child seven months after the wedding and after she has intercourse with a demigod, Astravakos (6.69), and Ariston, rightly so, was skeptical that Demaratus was his son. In this story, we see the pattern of the remedy for childlessness through the change of one's sexual partner (for the wife) and the divine intervention.

[61] Calame (1997) 132.

[62] On double consultation, see Martin (2018) 216 and 299–302.

Laius (L17/PW148)
Λάιε Λαβδακίδη, παίδων γένος ὄλβιον αἰτεῖς.
δώσω τοι φίλον υἱόν· ἀτὰρ πεπρωμένον ἐστὶν
σοῦ παιδὸς χείρεσσι λιπεῖν φάος. ὡς γὰρ ἔνευσε
Ζεὺς Κρονίδης, Πέλοπος στυγεραῖς ἀραῖσι πιθήσας,
οὗ φίλον ἥρπασας υἱόν· ὁ δ'ηὔξατο σοι τάδε πάντα.

Laius son of Labdakus, you request a blessed line of children. I will give you a son; but it is fated that you will lose your life at the hands of you son. For this is how Zeus the son of Cronus decided, obeying to the harsh curses of Pelops, whose dear son you abducted. And he wished all these for you.[63]

In Euripides' *Phoenissae*, according to Jocasta, the oracle, which was given to Laius when he consulted Delphi after being childless for many years (13–14), prescribed abstinence (18–20).

μὴ σπεῖρε τέκνων ἄλοκα δαιμόνων βίᾳ:
εἰ γὰρ τεκνώσεις παῖδ',ἀποκτενεῖ σ' ὁ φύς
καὶ πᾶς σὸς οἶκος βήσεται δι' αἵματος;

Lord of Thebes famous for horses, do not sow a furrow of children against the will of the gods; for if you beget a son, that child will kill you, and all your house shall wade through blood.[64]

The Delphic oracle, serving the interests of the petitioner, tries to thwart away the opportunity to have a child and instead of giving advice on how to become fertile, it prescribes a course of action against it, using a negative command as was the case with Aegeus. Although Apollo can provide progeny, he can withhold this offering to protect a man's (and a king's) interests. The Delphic oracle therefore treats childless men according to male anxieties towards parenthood, succession, and lineage.

Laius violated the order of the god and yielded to his desire under the influence of intoxication (E. *Phoen*. 20–21: ὃ δ' ἡδονῇ δοὺς ἔς τε βακχείαν πεσὼν/ἔσπειρεν ἡμῖν παῖδα; Apoll. 3.5.7: ὁ δὲ οἰνωθεὶς συνῆλθε τῇ γυναικί).[65] Just like Aegeus, who violated unwillingly the oracle due to heavy drinking, Laius did not follow the prescription of Apollo for the same reason. Both kings had sons who nevertheless caused their demise. To this end, these myths about the childless kings work as stories that comfort infertile couples, since progeny against the god's orders can be dangerous.

Despite the violation of the oracle, the cure of infertility, as we saw before, relates to intoxication, which reduces any resistance to intercourse. Apparently, in myth and medicine there is an interrelation between the consumption of wine and procreation. In the Hippocratic *corpus*, for example, it is advised that a man should not be

[63] See also Eur. *Ph*. 18–20; Apollodorus 3.5.7. For all sources see Parke - Wormell (1956), vol. 2, 65–66.
[64] Translation by Coleridge (1938).
[65] Cf. Aesch. *Seven against Thebes* 750.

intoxicated in order to be fertile, but he should drink strong, undiluted wine before intercourse.[66]

Moreover, in accordance with the oracles, according to which the first liaison after someone visits the oracle will lead to progeny, the first time that Laius sleeps with Jocasta, after receiving the oracle, he impregnates her. Since Jocasta had four children with Oedipus, it can be argued that it was Laius who was infertile, and that the oracle operated as in the other cases, according to which the infertile petitioner has a single opportunity for procreation, and the change of partner, on the wife's part this time, leads to greater progeny. It appears then that in Greek tragedy there are clearer indications that infertility could also lie in men.

In contrast with the immediate cures after the petitioner leaves the oracle, a Delphic prophecy predicts procreation as a conditional gift.

> Q 28/ PW 43
> Μύσκελλε βραχυνώτατε, φιλεῖ σ' ἑκάεργος Ἀπόλλων,
> καὶ γενέαν δώσει· τόδε δὲ πρότερόν σε κελεύει,
> οἰκῆσαί σε Κρότωνα μέγαν καλαῖς ἐν ἀρούραις.
>
> Myskele, Apollo the far shooter loves you and he will give you children. But first he orders you this, to settle great Croton among fair fields.

In this case, Apollo promises children to Myscellus only after he founds a colony, implying that the *oikist* may first 'beget' an infant colony before he is granted children. This type of healing from childlessness is gendered, appropriate only for men, and comes in the manner of gift exchange, since it is implied that as long as the petitioner founds a colony, he will be rewarded with progeny. In the case of Xuthus, Ion is provided by Apollo as a δῶρον and in one of the versions of Aegeus' prophecy progeny is presented as a gift.[67]

In the context of oracular (and ambiguous) rhetoric, in addition to referring progeny to a later time, other oracles do not just delay the provision of children but in fact they fail to cure childlessness. For example, in response to a question about children, a victory in five contests, that is military victories, is predicted.

> Q160/ PW107 (Hdt. 9.33.2)
> Τισαμενῷ γὰρ μαντευομένῳ ἐν Δελφοῖσι περὶ γόνου ἀνεῖλε ἡ Πυθίη ἀγῶνας τοὺς μεγίστους ἀναιρήσεσθαι πέντε.
>
> For when Tisamenus was inquiring the oracle at Delphi about offspring, Pythia prophesied to him that he should win five great victories.

The response seems irrelevant to the question, but it constitutes a type of healing as an alternative to parenthood. Military prowess is a source of pride and enduring fame, comparable to that which is generated from children. In other cases of failure to fulfill the request for children or male heirs, the oracle responds with a prophecy about the

[66] See *On Sterile Women* 218, 8.422, 18–20 Littré.
[67] See Eur. Archel. fr. 2.24 Austin: Ζεὺς σ[οι] δίδωσι παῖδ', ἐγὼ μαντεύομαι.

birth of a daughter (H34) or a grandson, who yet will kill the grandfather and petitioner.[68]

Conclusion: Overlapping Rhetoric-Overlapping Cults

Both types of remedies at Epidaurus and at Delphi, by incubation and by means of prophecies respectively, display a similar sentiment as substitutes to medical treatments.[69] The petitioners seek miraculous divine therapies probably after years of infertile marriage and perhaps even when other procedures to cure sterility fail.[70] The Hippocratic treatise 'Περὶ Τέχνης' acknowledges that the doctors should not treat patients whose diseases are incurable or, even though they are curable, the patient came too late to the doctor to be cured. The diseases mentioned at *iamata*, e.g. blindness, paralysis, but also the ones recorded at Delphi are incurable and chronic. Among these, infertility is included, a commonly chronic disease, which sometimes when the condition is by birth cannot be cured (Ar. *GA* 2.7, 746b21–35).

The similarities between the rhetoric of oracles and the rhetoric of the *iamata* stem from the intersection between the realms of Apollo and Asclepius.[71] Apollo is worshipped as *iatros* and many stock epithets reserved for Apollo define his healing capacity, like *eriounios* and *alexikakos*.[72] Asclepius' cult started in Epidaurus, around 500 BCE, while it entered Athens in 420/19 BCE. His worship was incorporated peacefully along with other healing cults especially that of Apollo, and there was no competition between them. Both gods are named by Aeschylus (*Eum*. 62, *Agam*. 1623, *Suppl*. 263) as *iatromanteis*. Also, there was the cult of Apollo Maleatas before that of Asclepius in Epidaurus, with both flourishing alongside, and there are records of an Asclepieion which was operating at Delphi.[73] To this end, it comes as no surprise that the Epidaurian *iamata* are dedicated to both Asclepius and Apollo.

The rhetoric of infertility and its cure in the divine remedies at Delphi and at Epidaurus presents common features, such as the phrasing of the inquiry about children, the mythical motif of fast-grown newborns and the immediacy of the cure. Both *corpora* share a non-scientific, but formulaic, diction. Overall treatments of infertility are adjusted to the gender of the inquirer, the practices of the oracle and the social implications of curing barrenness. To this end, the cure of infertility is gendered to an extent, since on one hand oracular responses concern mostly childless men who are offered children or are provided with alternatives to legitimate heirs (i.e. a son outside wedlock, military victories, and a colony), and on the other hand, the

[68] See the case of Acrisius in Apollod. *Library* 2.4.

[69] On the term 'fertility incubation' as a subcategory of the incubation process and its description in Greek and Egyptian sources, see Renberg (2016), vol. 2, 603–13. Renberg aptly notices the preeminence of the employment of incubation for healing fertility problems.

[70] See Eidinow (2007) 89; Wickkiser (2008) 58–61; Flemming (2013) 569; Renberg (2016), vol. 1, 23, and n. 69 for bibliography. See Wickkiser (2008) 61: 'The relationship between the cult of Asklepios and medicine was one principally of complement, not competition'. The same can be stated for the cures at Delphi and at Epidaurus.

[71] On a list of rhetorical similarities between the Delphic oracles in general and the *iamata*, see Naiden (2005) 90.

[72] See Paus. 1.3.3, 6.24.5, 8.41.5, Plut. *On the Ei at Delphi* 21, *On the Failure of Oracles* 7, Aesch. *Eum.*. 62. Apollo in some versions is the father of Asclepius and he is even identified with Paieon, the god of the healing art in Homer.

[73] Petridou (2016) 440.

Asclepieion sanctuary cures physically women who carry genuine children. Nevertheless, the healing of men and women carries some similarities. The somatic therapies for women through physical contact with the divine may equate therapy by acquiring a different partner, and this practice solves the problem of childlessness of kings, even though the Delphic oracle tries to prevent it. These tales about childless men and women, and how they overcome their fertility problems have obviously an impact on their audience. The legendary Delphic oracles function as cautionary tales about illegitimate children (thus potency which is a gift from Apollo must be exercised in the marriage) and as comfort-myths for barren couples by showcasing the negative implications of progeny (e.g. Laius' heir). Asclepius' mythical therapies, however, provide hope to childless couples, since they fortify the belief that women with fertility problems can be successfully treated by the god.

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Ionian University

Therapeia and *Therapeuein* in Greek Forensic Speeches

Eleni Volonaki

Abstract

The present study examines the use and connotations of the words *therapeia* and *therapeuein* in Greek forensic speeches, denoting the provision of medical care and treatment as well as any kind of service offered to assist and protect an Athenian citizen in need or the whole of the citizen group when facing threat or danger. Thus, as it appears, the terms occur both in medical and non-medical contexts, even though they are not often used in the corpus of the Attic orators. Our interest lies in the medical contexts, where the connotations of the words *therapeia* and *therapeuein* involve the medical treatment and healing of a patient or a victim of wounding and physical abuse. These occurrences are quite infrequent, perhaps reflecting the reservation of the orators to employ actual proof of a medical condition, with the exception of a doctor's report. The rhetoric of the medical connotations appeals to the dramatization or character assassination of one's opponent as an effective means of persuasion in court.

1. Introduction: Therapy as Medical Treatment

In general terms, therapy involves the treatment of a disease (*nosos*) aiming at the remediation of a health problem, usually following a medical diagnosis. The dictionary defines 'therapy' as the 'treatment of an abnormal state of the mind or body'.[1] The process of treatment normally involves medication and/or a surgery. Diet does play an important role to the restoration of health and a patient needs to follow a certain lifestyle concerning not only his dietary habits but also the requirements for exercise and physical movement. It is a common view that the Hippocratic medicine embraced a holistic therapy of body and mind when treating a health problem. The ancient proverb 'healthy mind in healthy body' reflected exactly this approach of holistic therapy. The healing of the body can be successfully done when the *psychē* is taken care of; as in modern times, the good psychology of a patient contributes significantly to the therapy of his physical condition.

As Totelin (2018) 202–203 explains, scholars have tended to believe that ancient Greek therapeutics encompassed the treatment related to the diet (dietetics) rather than medicines (pharmacology) and surgery, the latter being somewhat less advanced. It is true that dietetics was the most dynamic branch of medicine at the time of the Hippocratic physicians, but it was not, however, so clearly distinguished from pharmacology; pharmacology in other terms was subsumed under the heading of dietetics by the Hippocratics. However, Totelin has argued[2] that dietetics was a "work in progress" whereas pharmacology was initially borrowed from "laypeople (who

[1] MWD (Merriam-Webster Dictionary), s.v. therapy (Available online at https://www.merriam-webster.com/dictionary/therapy. Access date: September 7, 2024)

[2] Totelin (2018) 200–16.

knew the properties of common plants through cooking) and from experts (who may have specialised in dangerous substances)"[3]; the treatments borrowed from these people were transformed and stripped away from references to prayers and invocations, and as such they constituted a kind of new medicine used by the Hippocratic physicians, who considered it a professional art (*technē*). Thus, it can be presumed that therapy involved the right medical treatment for the cure of a health problem based firstly and essentially on the use of the right dietetic guidelines and secondary on the supplementary use of drugs (*pharmakon*), which could be part of the dietetic prescription.

2. The Notions of *Therapeia* and *Therapeuein* in Forensic Narratives

The present study explores the use of the noun *therapeia* and the verb/ verbal forms of *therapeuein* in forensic speeches, focusing on the medical connotations and aiming at the explanation of the medical context as well as the notion of treatment implied. In such a context, it is significant to examine the rhetorical effect of the medical treatment and cure of a victim upon the incrimination of one's opponent.

The noun is found in 25 occurrences whereas the verb and verbal forms are used 77 times in forensic speeches. As noted in the ancient Greek lexicon (*LSJ*), both the noun and the verb involve the general notion of offering service and attendance. In particular, the noun denotes service of persons (*LSJ* I), medical or surgical treatment of cure (*LSJ* II), care of animals (*LSJ* III) and service in a collective sense (*LSJ* IV). Similarly, the verb has the general meaning of 'doing service' to the gods (*LSJ* II), of one's person (*LSJ* II.4), of things (*LSJ* II.3), of animals 'train' (*LSJ* II.8), to treat medically (*LSJ* II.7), to 'pay court to' (*LSJ* II.2), to 'foster' (*LSJ* II.5), to 'observe a day' (*LSJ* II.6), to 'cultivate' land (*LSJ* II.9), to 'prepare food' (*LSJ* II.10) and to 'mend' (*LSJ* II.11). The occurrences found in forensic speeches deal either with the abstract connotations of 'serving' in relation to persons, gods and public matters, and more rarely with the meaning of 'medical treatment' and 'cure'.

In non-medical forensic contexts, the noun *therapeia* is rarely used and it denotes the 'assistance', particularly the assistance employed by someone to make praise (Aesch. 1.157), to establish a tyranny (Isoc. 3.22) or by a *pallakē* to offer physical services of the body ([Dem.] 59.122). In these cases, the word *therapeia* is simply employed to narrate or describe an action rather than a kind of behaviour or an element from *ēthos*.

The noun is also associated with the 'service' or 'assistance' offered to weak or persons in need, such as a grandfather while still alive before his death (Isae. 17.37). Such a usage functions as an appeal from *pathos*, arousing the judges' empathy and frustration. Thus, for example, in Lysias *Against Agoratus* (13.45), the most shameful death of Agoratus' victims brought terrible misfortunes upon members of their families, since elderly parents were left behind with no support in their old age, sisters were left unwedded and little children who still required much care were left with no assistance (οἱ δὲ παῖδας μικροὺς πολλῆς ἔτι θεραπείας δεομένους). For the connotation of one's getting assistance from his children, the infinitive is also used in Lys. 19.37 (βούλονται γὰρ πάντες ὑπὸ τῶν παίδων θεραπεύεσθαι ἔχοντες χρήματα

[3] Totelin (2018) 215.

μᾶλλον ἢ ἐκείνων δεῖσθαι ἀποροῦντες), and in Lys. 24.6 the verb denotes the assistance offered to a disabled man by his slaves (παῖδες δέ μοι οὔπω εἰσὶν οἵ με θεραπεύσουσι). In all the cases where *therapeia* or *therapeuein* is employed in association with persons of vulnerable status, such as disabled men, old men and young children, these terms attain an emotional tone to arouse the sympathy of the audience.

Therapeia and *epimeleia* ('care') constitute an emphatic pair, when they involve the service of people and the management of public affairs, as reflected in Isocrates' speech *Antidosis* (15.131):

> Ἐκεῖνος γὰρ οὔτε μισόδημος ὢν οὔτε μισάνθρωπος οὔθ' ὑπερήφανος οὔτ' ἄλλ' οὐδὲν ἔχων τῶν τοιούτων κακῶν, διὰ τὴν μεγαλοφροσύνην τὴν τῇ στρατηγίᾳ μὲν συμφέρουσαν, πρὸς δὲ τὰς χρείας τῶν ἀεὶ προσπιπτόντων οὐχ ἁρμόττουσαν, ἅπασιν ἔδοξεν ἔνοχος εἶναι τοῖς προειρημένοις· **οὕτω γὰρ ἀφυὴς ἦν πρὸς τὴν τῶν ἀνθρώπων θεραπείαν ὥσπερ δεινὸς περὶ τὴν τῶν πραγμάτων ἐπιμέλειαν**.
>
> [131] He did not hate the common people, nor was he a misanthrope, or arrogant, and he did not have any other such vice. But because of his greatness of mind, which was suited to generalship but inappropriate to day-to-day demands, everyone thought he was guilty of all the faults I have mentioned, **for he was as unsuited by nature to the cultivation of other men as he was talented in his management of public affairs.**[4]

The phrase οὕτω γὰρ ἀφυὴς ἦν πρὸς τὴν τῶν ἀνθρώπων θεραπείαν suggests that the encouragement and support of human beings is closely associated with human nature; moreover, the noun *therapeia*, here, involves the idea of protection rather than the notion of service and works complementarily with the word *epimeleia* concerning not the taking care of but the management of public affairs. In the context of character assassination, the word *therapeia* enhances a moral dimension aiming at the representation of the person involved as displaying an unsuited behaviour toward the other men.

In the same speech of Isocrates, the speaker employs again the pair *therapeia* and *epimeleia* to advise Timotheus how he can win the Athenian citizens' good will so that his reputation will expand (Isoc. 15.137):

> Ἀλλ' οἱ μέν, οἶμαι, ποιητῶν ἔτυχον καὶ λογοποιῶν, οἱ δ' οὐκ ἔσχον τοὺς ὑμνήσοντας. Ἢν οὖν ἐμοὶ πείθῃ καὶ νοῦν ἔχῃς, οὐ καταφρονήσεις τῶν ἀνδρῶν τούτων οἷς τὸ πλῆθος εἴθισται πιστεύειν οὐ μόνον περὶ ἑνὸς ἑκάστου τῶν πολιτῶν, ἀλλὰ καὶ περὶ ὅλων τῶν πραγμάτων, **ἀλλ' ἐπιμέλειάν τινα ποιήσει καὶ θεραπείαν αὐτῶν, ἵν' εὐδοκιμήσῃς δι' ἀμφότερα, καὶ διὰ τὰς σαυτοῦ πράξεις καὶ διὰ τοὺς τούτων λόγους**.
>
> The latter, I think, had poets and speechwriters to sing their praises, but the former had no one. If you trust me and have any sense, you will not despise such men, whom the common people generally trust in matters concerning both

[4] The translation of all extracts from Isocrates' speeches are from Mirhady and Lee Too (2000).

> citizens and overall affairs of state. **Rather, you will make them your concern and cultivate them so that you will have a good reputation with regard to both your deeds and their words**.

There is a correspondence between ἐπιμέλειάν τινα ποιήσει καὶ θεραπείαν and those involved, περὶ ἑνὸς ἑκάστου τῶν πολιτῶν, ~ περὶ ὅλων τῶν πραγμάτων, as well as the well known Greek pair words and deeds (διὰ τὰς σαυτοῦ πράξεις καὶ διὰ τοὺς τούτων λόγους), which suggests that *therapeia* and *epimeleia* obtain a political tone, since they are both necessary for a citizen to contribute positively to the common good and obtain a good reputation in the city.

In a similar political framework, Isocrates, in his speech *To Nicocles*, offers advice to the monarch how to treat public and private interests as interrelated;[5] particularly, he encourages Nicocles to accept a good counsellor most useful and the verb *therapeuein* stresses the way he ought to cherish and value such a person (Isoc. 2.53: τοὺς δὲ νοῦν ἔχοντας καὶ δυναμένους ὁρᾶν πλέον τι τῶν ἄλλων περὶ πολλοῦ ποιοῦ καὶ θεράπευε). In the same speech, Isocrates refers to the 'greatest therapy' (Isoc. 2.20):

> **Τὰ [μὲν] πρὸς τοὺς θεοὺς ποίει μὲν ὡς οἱ πρόγονοι κατέδειξαν, ἡγοῦ δὲ θῦμα τοῦτο κάλλιστον εἶναι καὶ θεραπείαν μεγίστην, ἂν ὡς βέλτιστον καὶ δικαιότατον σαυτὸν παρέχῃς· μᾶλλον γὰρ ἐλπὶς τοὺς τοιούτους ἢ τοὺς ἱερεῖα πολλὰ καταβάλλοντας πράξειν τι παρὰ τῶν θεῶν ἀγαθόν**. Τίμα ταῖς μὲν ἀρχαῖς τῶν φίλων τοὺς οἰκειοτάτους, ταῖς δ' ἀληθείαις αὐταῖς τοὺς εὐνουστάτους.
>
> With regard to the gods, do as your ancestors showed; and regard it the finest sacrifice and the greatest service to show yourself as the best and the most just possible. There is more hope that such men will gain some benefit from the gods than those who discharge many sacrifices. Honor with positions of responsibility the friends who are closest to you and those most kindly disposed to the truth itself.

According to Isocrates' view, *therapeia* constitutes the greatest service showing the best and most just behaviour of a person; here, however, this kind of service is associated with the respect toward the gods and the traditional views and customs of the ancestors. Thus, *therapeia* has an ancestral and divine origin in its notion and content, which makes it the greatest and most just action offered within a city.

With reference to the democratic constitution the verb is used to denote the service of the people in contrast to the respect toward the king, as reflected in Isocrates *To Demonicus* 1.36:[6]

> Πείθου μὲν καὶ τοῖς νόμοις τοῖς ὑπὸ τῶν βασιλέων κειμένοις, ἰσχυρότατον μέντοι νόμον ἡγοῦ τὸν ἐκείνων τρόπον**. Ὥσπερ γὰρ τὸν ἐν δημοκρατίᾳ**

[5] Mirhady and Lee Too (2000) 169–170. The speech is included among Isocrates' political speeches, particularly the Cyprian speeches, and it is used here to show the political dimension of the word *therapeia* as most suitable to the context.

[6] As stated in the previous note, the speech is a political one included together with the Nicocles' speeches in the Cyprian political speeches; for the authenticity and content of the speech, see Mirhady and Lee Too (2000) 19.

> **πολιτευόμενον τὸ πλῆθος δεῖ θεραπεύειν, οὕτω καὶ τὸν ἐν μοναρχίᾳ κατοικοῦντα τὸν βασιλέα προσήκει θαυμάζειν.**
>
> Obey also the laws set down by the kings, but consider their conduct the strongest law, for just as someone practicing politics in a democracy must serve the multitude, so it is also fitting for someone living in a monarchy to respect the king.

From the parallelism θεραπεύειν ~ θαυμάζειν, it can be presumed that the service of the Athenian demos designates respect and support of the democratic constitution. As such, the verb has a symbolic connotation in clear political context.

On the whole, it appears that both the noun and the verb/ verbal forms are used in the forensic speeches either to denote the assistance of persons (including weak and under age) and the service of the gods or to signify a political connotation emphasising the role and position of an Athenian citizen or those who take care of them as political figures and officials. It is also to be noted that most examples derive from forensic and political speeches by Isocrates, a fact which may indicate firstly that the specific words are most common toward the mid-fourth century and secondly that they enhance a philosophical and political significance in accordance to the orator's moral and political agenda.

3. The use of *therapeia* and *therapeuein* with medical connotations

As medical terms, the words *therapeia* and *therapeuein* denote the medical care needed for someone who suffers from an illness or the cure of a disease. In Apollodorus *Against Neaira* [Dem.] 59.55–56, Frastor, the ex-husband of Neaira's daughter is said to have fallen ill and was in need of assistance and help:

> (55) Φέρε δὴ ὑμῖν καὶ ἑτέραν μαρτυρίαν παράσχωμαι τοῦ τε Φράστορος καὶ τῶν φρατέρων αὐτοῦ καὶ γεννητῶν, ὡς ἔστι ξένη Νέαιρα αὐτή. οὐ πολλῷ χρόνῳ γὰρ ὕστερον ἢ ἐξέπεμψεν ὁ Φράστωρ τὴν τῆς Νεαίρας θυγατέρα, **ἠσθένησε καὶ πάνυ πονήρως διετέθη καὶ εἰς πᾶσαν ἀπορίαν κατέστη. διαφορᾶς δ' οὔσης αὐτῷ παλαιᾶς πρὸς τοὺς οἰκείους τοὺς αὑτοῦ καὶ ὀργῆς καὶ μίσους, πρὸς δὲ καὶ ἄπαις ὤν, ψυχαγωγούμενος ἐν τῇ ἀσθενείᾳ τῇ θεραπείᾳ <τῇ> ὑπό τε τῆς Νεαίρας (56) καὶ τῆς θυγατρὸς αὐτῆς (ἐβάδιζον γὰρ πρὸς αὐτόν, ὡς ἠσθένει καὶ ἔρημος ἦν τοῦ θεραπεύσοντος τὸ νόσημα, τὰ πρόσφορα τῇ νόσῳ φέρουσαι καὶ ἐπισκοπούμεναι· ἴστε δήπου καὶ αὐτοὶ ὅσου ἀξία ἐστὶν γυνὴ ἐν ταῖς νόσοις, παροῦσα κάμνοντι ἀνθρώπῳ) ἐπείσθη δὴ τὸ παιδίον, ὃ ἔτεκεν ἡ θυγάτηρ ἡ Νεαίρας ταυτησὶ ὅτ' ἐξεπέμφθη ὑπὸ τοῦ Φράστορος κυοῦσα, πυθομένου ὅτι οὐ Στεφάνου εἴη θυγάτηρ ἀλλὰ Νεαίρας, καὶ ὀργισθέντος ἐπὶ τῇ ἀπάτῃ, πάλιν λαβεῖν καὶ [57] ποιήσασθαι υἱὸν αὑτοῦ, λογισμὸν ἀνθρώπινον καὶ εἰκότα λογιζόμενος,** ὅτι πονήρως μὲν ἔχοι καὶ οὐ πολλὴ ἐλπὶς εἴη αὐτὸν περιγενήσεσθαι, τοῦ δὲ μὴ λαβεῖν τοὺς συγγενεῖς τὰ αὑτοῦ μηδ' ἄπαις τετελευτηκέναι ἐποιήσατο τὸν παῖδα καὶ ἀνέλαβεν ὡς αὑτόν·
>
> (55) Now, if you wish, I will present another testimony from Phrastor, together with the members of his phratry and genos, that Neaira here is an alien. Not

> long after Phrastor divorced the daughter of Neaira he fell ill and was in a very bad way, and became totally helpless. As there was an old feud with his family and a lot of anger and hatred, and he was childless besides, while Neaira and her daughter were comforting him in his illness (56) (going to his house when he was unwell and had no one to nurse his sickness, bringing along what was good for his condition and keeping an eye on him – you know yourselves how valuable a woman is in sickness, looking after an invalid), he was finally persuaded to take back and acknowledge as his legitimate son the baby that Neaira's daughter had after she had been sent away by Phrastor, while she was pregnant, once he had found out that she was not Stephanos' daughter but Neaira's and was furious at the deceit. (57) His reasoning was human and natural: he was unwell and there was little hope that he would survive, so he acknowledged the boy as his legitimate son and took him back with him, in order to stop his relatives from inheriting his property and to avoid dying childless.[7]

As becomes obvious, Apollodorus purposely presents Frastor as being in such a bad condition that he became totally helpless to indicate that he had no choice but to accept the help from his ex-wife, Neaira's daughter, Phano; on the other hand, the emphasis placed upon his weakness serves to present rather persuasively how Phano took advantage of the whole situation in order to get her son recognized by Phrastor as his own. Phrastor's physical weakness to such an extent that it was not certain if he would survive is manipulated to victimise him so that the acknowledgment of the boy as his legitimate son appears to be an action from scheming and deceit, even though Phrastor is said to have sent Phano away while she was pregnant. As Kapparis (1999) 278 points out, the orator wishes to stress the point that if the son of Phrastor was rejected from the genos and the phratry on the grounds that Phano was an alien, by implication Phano's mother, Neaira was an alien too. Nevertheless, the legitimacy of the son of Phrastor is not disputed, even though Apollodorus attempts to insinuate that the son was from an alien woman; nowhere, Phrastor implies that he has a *nothos* son.[8]

In terms of vocabulary, the phrase ψυχαγωγούμενος ἐν τῇ ἀσθενείᾳ τῇ θεραπείᾳ <τῇ> ὑπό τε τῆς Νεαίρας (56) καὶ τῆς θυγατρὸς αὐτῆς indicates that *therapeia* denotes the comfort to be offered as both a kind of assistance and medical cure. One needs to bear in mind that both Neaira and Phano were there to help Phrastor and that Phrastor was almost dying (57: οὐ πολλὴ ἐλπὶς εἴη αὐτὸν περιγενήσεσθαι, τοῦ δὲ μὴ λαβεῖν τοὺς συγγενεῖς τὰ αὐτοῦ μηδ' ἅπαις τετελευτηκέναι ἐποιήσατο τὸν παῖδα καὶ ἀνέλαβεν ὡς αὑτόν) and that he was suffering from a very bad illness (55: ἠσθένησε καὶ πάνυ πονήρως διετέθη καὶ εἰς πᾶσαν ἀπορίαν κατέστη). Beyond the rhetorical hyperbole in the description of Phrastor's condition, it seems that he needed someone to take care of the illness, which would imply a treatment to cure him (56: ὡς ἠσθένει

[7] The translation is from Kapparis (1999) 119, 121.

[8] Further, on the argument here, see Kapparis (1999) 285–86. The sequence of the events is described by Kapparis (1999) 288 as follows: "1. Phrastor fell ill shortly after the divorce. 2. Neaira and Phano looked after him and persuaded him to acknowledge the child. 3. Phrastor acknowledged the boy as his legitimate son and received him in his oikos. 4. His health improved. 5. He married again. 6. He eventually enrolled his son with his genos and phratry".

καὶ ἔρημος ἦν τοῦ θεραπεύσοντος τὸ νόσημα). What would then be the role of Phano and Neaira? What kind of treatment was expected to be offered by them, and how would they help Phrastor to get well and survive? It appears that the women's help to an invalid was widely known as reflected in §56: τὰ πρόσφορα τῇ νόσῳ φέρουσαι καὶ ἐπισκοπούμεναι· ἴστε δήπου καὶ αὐτοὶ ὅσου ἀξία ἐστὶν γυνὴ ἐν ταῖς νόσοις, παροῦσα κάμνοντι ἀνθρώπῳ. One may assume that women served as nurses for ill men, as in the case of Phrastor, and were considered to be valuable in sickness. The phrase τὰ πρόσφορα τῇ νόσῳ φέρουσαι implies that they brought what was needed for the medical treatment and care, which must have been widely known to an Athenian audience and may have included medicines, medical preparations and ingredients for the right and suitable diet to strengthen the ill person's condition. For rhetorical purposes, however, the phrase is rather vague which simply denotes the women's general care of the ill man. As it appears, any specific detail about medical condition is avoided since the whole story may be deliberately distorted or even invented in order to present the women's motivation for personal profit, and subsequently their guilt. On the other hand, Phano is purposely presented by Apollodorus as Neaira's own daughter and, as such, non-citizen, whereas Phano was most plausibly Stephanus' daughter from his wife.

On balance, it is to be noted that an Athenian woman had the reputation of being capable to serve and cure and ill man as his nurse.[9] The medical care offered by a doctor involved the treatment needed to prevent from death, as reflected in Antiphon's *Tetralogy* 4.2.4, where a man's death results from mistaken cure provided by a bad doctor:

> [4] νῦν δὲ πολλαῖς ἡμέραις ὕστερον μοχθηρῷ ἰατρῷ ἐπιτρεφθεὶς διὰ τὴν τοῦ ἰατροῦ μοχθηρίαν καὶ οὐ διὰ τὰς πληγὰς ἀπέθανε. προλεγόντων γὰρ αὐτῷ τῶν ἄλλων ἰατρῶν, εἰ ταύτην τὴν θεραπείαν θεραπεύσοιτο, ὅτι ἰάσιμος ὢν διαφθαρήσοιτο, δι᾽ ὑμᾶς τοὺς συμβούλους διαφθαρεὶς ἐμοὶ ἀνόσιον ἔγκλημα προσέβαλεν.
>
> [4] But as it was, he was entrusted to the care of a bad doctor and died many days later not from the blows but because of the doctor's incompetence. Other doctors warned him that although he could be cured, he would die if he followed that course of treatment. But you his advisers caused his death, which has led to this unholy charge against me.[10]

It becomes clear that for rhetorical purposes a medical treatment could be presented as suitable to cure a patient or as wrong causing his death, on the grounds that there were good and bad doctors. In any case, as Gagarin (1998) 42 n. 5[11] notes, a doctor could not be regarded as responsible for a man's death in case he had provided a treatment after he had been injured. The specific piece of medical information concerning a doctor's treatment derives not from a forensic speech but from a

[9] For the social role and groups of women in Athens, see Kapparis (2021) 186–215.
[10] The translation is from Gagarin (1998) 42–43.
[11] For the doctor's immunity, cf. Gagarin (1997) 166.

rhetorical treatise, and as such it may not reflect a common use of *therapeia* denoting the medical treatment.[12]

There is, however, another instance where both the verb *therapeuein* and the noun *therapeia* are repeatedly employed to refer to the doctor's treatment for a heavily injured woman, who eventually died. In [Dem.] 47, *Against Evergus and Mnesibulus*, a speech ascribed to Apollodorus and delivered by a trierach at a trial for false testimony, the speaker recalls a series of invasions against his own house by his opponents; during the last invasion, the triererch's old nurse was severely beaten and abused to such an extent that she was bleeding while she was defending to keep a cup in her arms.[13] In [Dem.] 47.67, the speaker describes how the nurse was not taken any care by the opponents and he had to bring his own doctor to treat her injuries:

> **[67]** Ἐπειδὴ τοίνυν, ὦ ἄνδρες δικασταί, ἐπαγγείλαντός μου αὐτῷ θεραπεύειν τὴν ἄνθρωπον ἣν συνέκοψαν καὶ ἰατρὸν εἰσάγειν οὐκ ἐφρόντιζον, ἐγὼ αὐτὸς εἰσήγαγον ἰατρὸν ᾧ πολλὰ ἔτη ἐχρώμην, ὃς ἐθεράπευεν αὐτὴν ἀρρωστοῦσαν, καὶ ἐπέδειξα ὡς εἶχεν, εἰσαγαγὼν μάρτυρας. ἀκούσας δὲ τοῦ ἰατροῦ ὅτι οὐδὲν ἔτι εἴη ἡ ἄνθρωπος, πάλιν ἑτέρους μάρτυρας παραλαβὼν τήν τε ἄνθρωπον ἐπέδειξα ὡς εἶχεν, καὶ ἐπήγγειλα τούτοις θεραπεύειν. ἕκτῃ τοίνυν ἡμέρᾳ ὕστερον ἢ οὗτοι εἰσῆλθον εἰς τὴν οἰκίαν, ἐτελεύτησεν ἡ τιτθή. ὡς δὲ ἀληθῆ ταῦτα λέγω, τούτων ὑμῖν ἀναγνώσεται τὰς μαρτυρίας.
>
> **[67]** Since, then, gentlemen of the jury, they paid no attention when I required him to provide treatment for the woman they had beaten and call in a doctor, I myself brought in a doctor whom I had used for many years, and he treated her in her ailing state, and I showed him her condition, bringing witnesses. On hearing from the doctor that nothing could be done for the woman, I again took witnesses, other ones, and showed them her condition, and told them to provide treatment. But on the sixth day after these men entered the house, the nurse died. And to prove that I am telling the truth in this, the clerk will read you the depositions about it.[14]

The old woman was not under the speaker's ownership, since she had been freed long ago, got married, left the house and had only recently returned after her husband had died. Here, the speaker depicts the brutal and reckless character of Theophemus and Evergus in order to incriminate them not only for the wounding but also for neglecting the old woman's treatment and causing her death. Therefore, the speaker appeals to the common view that the person who is responsible for someone's wounding should take care of him. The dispute allegedly involved the nurse and her attackers and thus the speaker asked for a doctor of their choice (ὃν αὐτοὶ βούλοιντο), underlining that the responsibility for her care lay with them. Moreover, a doctor accepted by them would be a suitable witness and the negligence in producing one falls upon the assailants.[15]

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[12] For the *Tetralogies*, see Gagarin (1997) 32–35; Gagarin (1998) 17–18.

[13] For a detailed presentation of the case, see Volonaki (2023) xlvii–l.

[14] For the translation, see Edwards (2023) 30.

[15] For the rhetorical presentation of a doctor's deposition in court, cf. Dem. 54.8–10. Further, on the analysis of this chapter, see Volonaki (2023) 198.

Here, the words *therapeuein* and *therapeia* clearly denote the medical care to be provided by a doctor; the nurse's case involves severe wounding and the treatment would necessarily require the use of medicines. The role of the doctor is rhetorically manipulated to provide evidence for the opponents' maltreatment to the degree of homicide. As it appears, the treatment offered by the trierarch's personal doctor could not save the patient from the severe injuries. In this context, the terms *therapeuein* and *therapeia* may also denote the medical care and relief rather than cure. A medical treatment at such a stage would involve the use of medical materials for the wounding and possibly a surgery but surely not a diet.

4. Conclusions

Generally, in political contexts the words *therapeuein* and *therapeia* denote the service offered to the Athenian demos or the politicians and officials. Toward the mid-fourth century the specific terms obtain a more philosophical and moral connotation referring to the care and support. In forensic contexts, the terms are used in connection to the assistance provided to weak persons, such as young children, elderly persons and women. In all these instances, the specific words have a more abstract meaning of helping and assisting a person in need either in private or in public life.

There is, however, the use of the specific terms *therapeuein* and *therapeia* in medical contexts referring to the actual treatment of an injured person or a patient by a woman, a nurse or a doctor for cure. The occurrences are only a few and involve the medical care required for wounding and severe injuries with bleeding and bruises causing even the death of the victim. The care provided includes medicines, medical substances and surgery and more rarely dietary practices. As a whole, this kind of medical use is not common in forensic oratory and it is striking that two instances are found in two speeches ascribed to Apollodorus 54, *Against Neaira*, and 47, *Against Evergus and Mnesibulus*, both of which include extensive dramatic narrative sections aiming at the emphatic depiction of the opponent's *ēthos*. Another instance that has not been included in this study since it does not include the use of the specific terms in discussion is Demosthenes 54, *Against Conon*, where a very detailed medical description is employed to maximise the beating and injuring of the victim.[16]

Orators seem to avoid using medical terms or details about injuries and wounding and by consequence the use of the terms *therapeuein* and *therapeia* with a medical connotation is rather exceptional in forensic narratives. Wherever they are actually used in this meaning the rhetorical effect is very impressive, since the presentation of the persons accused of wounding becomes much more dramatic and persuasive. The avoidance of medical terms in Greek oratory may be explained by the fact that orators rely more on other means of description and persuasion, which are not easy to be proven, and not on medical and scientific elements which themselves provide a valid evidence and may not be always available. In other words, orators usually describe one's persona without giving adequate evidence of their character, but include persuasive means of narrative and dramatisation for their purposes. The portrayal of the litigants is achieved through their words and deeds in private and public life,

[16] For a full discussion about the wounding in Demosthenes 54, see Volonaki (2021) 16–18.

offering many examples of behaviour and attitudes taken from social and political interactions. Moreover, orators attempt to describe through one's words, the *logos*, and leave a scope for a personal interpretation and imagination of the audience.

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University of the Peloponnese

Cloudy Rhetoric: Biology as an Anchor in the Presentation of Meteorological Knowledge in Aristotle, Lucretius and Seneca

Giouli Korobili[*]

Abstract

This paper investigates how ancient philosophers explained meteorological phenomena, tracing the transition from mythological to naturalistic accounts. Focusing on Aristotle, Lucretius and Seneca, it examines how clouds, hail, rain, rivers, thunder and lightning were understood through analogies with the human body. Biological imagery – encompassing digestion, circulation, and exhalation – served both explanatory and rhetorical purposes, linking microcosm and macrocosm. Aristotle's concept of *antiperistasis* and his condensation-based theory of river formation illustrate shared causal principles between physiological and atmospheric processes. Lucretius and Seneca employ affective and sensory metaphors to confront fear, portraying storms as natural rather than divine phenomena. Overall, the study argues that bodily analogies not only clarified natural processes but also functioned therapeutically, guiding readers toward intellectual understanding and emotional tranquillity.

Introduction

The ancients displayed a profound interest in observing and describing the weather and natural phenomena. In Greek antiquity, phenomena such as winds, clouds, and thunder already occupy a significant place in the Homeric epics, although systematic meteorological theories emerged only later, beginning gradually with the pre-Socratic philosophers. Prior to this development, weather phenomena were primarily interpreted as manifestations of divine presence or as vehicles of divine communication.[1]

One of the earliest natural philosophers who appears to have challenged these popular beliefs was Xenophanes of Colophon (6th ce. BCE). According to Aetius, Xenophanes explained the rainbow in purely naturalistic terms:

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[1] Such interpretations continued to emerge in later periods; see, e.g., Lucretius, *On the Nature of Things* (*DRN*) VI 379–422; Seneca, *Natural Questions* (*NQ*) II 42; and Hall (2023) 30, on Cleanthes. Cf. Aristophanes' humourous depiction of the Clouds as the 'gods' of Socrates and his pupils (ταῖς ἡμετέραισι δαίμοσιν, 252). In *Clouds* 328–330, Aristophanes reverses the expected roles of Socrates and Strepsiades: Socrates presents the Clouds as goddesses, whereas Strepsiades characterizes them in purely physical terms as mist, dew and smoke.

> What they call Iris [the rainbow goddess] that too is in reality a cloud[2]: one that appears to the eye as purple, red, and green (Fr. DK 21B32).[3]

Yet voices such as Xenophanes' were not widely heeded in antiquity, at least not by the general public. Terrifying natural events – especially thunder and earthquakes – continued to inspire dread. This motivated later natural philosophers, including Aristotle, Epicurus and Seneca, to conceptualise such phenomena and to devote substantial attention to their possible causes. Aristotle authored the earliest extant treatise on meteorology in his attempt to explain the natural causes of sublunary phenomena. Epicurus, in his *Letter to Pythocles*, insists that the ultimate purpose of meteorological science – as of all science – is to secure freedom from anxiety through a firm understanding of the real causes of phenomena (Diog. Laert. 10.85). Following him, Lucretius in *DRN* presents natural explanations of celestial and terrestrial events as a way to liberate humankind from ignorance and fear:

> <... I will now explain how the storms> of winds come into being, are appeased, so that everything that exists is transformed, its madness placated. I will also explain the other things which men gaze on as they happen in earth and sky, men in suspense with minds filled with dread, making their hearts grovel with fear of the gods, pressing their hearts crushed against the ground because their ignorance of the real causes of things compels them to attribute matters to the power of the gods and acknowledge their kingly authority. [They are not in any way able to see the causes of these doings and they believe them to be done by divine power.] For if those who have learnt well that the gods enjoy a life free from cares can still be amazed at how all the different things are done – especially in those matters which are seen above our heads in the shores of aether – then they slip back into their outmoded superstitions, engaging for themselves harsh masters whom the wretched men believe are capable of anything, being ignorant as they are of what can and what cannot be, how the power of each thing is limited and its boundary-stone sticks buried deep: and so all the more do they go wrong and are carried along by reasoning which is blind to the truth (*DRN* VI 48–67).[4]

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[2] Ancient thinkers conceived of clouds as either female or male, though this distinction was not based on references to specific anatomical parts but rather on the functions or 'activities' they were thought to perform. In some pre-Socratic accounts, for instance, clouds are described as 'giving birth' to weather phenomena (see further fn. 25 and 26 below), in which case they must be understood as female entities. Another common depiction presents clouds as fighters – sometimes attacking, at other times being defeated – so in such cases they were probably conceived as male. Cf. Aristophanes, *Clouds* 335–340, where Strepsiades notes that dithyrambic poets describe clouds as impetuous beings, before he himself asks: 'So tell me, if these really are Clouds, how is it that they look like mortal women?'. (trans. Henderson [1998])

[3] Trans. in Mourelatos (2008) 136. Fr. DK 21B32 and its reading *kai touto* ('that too' in the translation) imply that Xenophanes offered the reductivist explanation on more than one occasion (so Mourelatos [2008] 136). Comets, stars and the sun seem to be substantially related to clouds in an attempt to be explained as natural and not associated with the divine; see Mourelatos (2008) and Hall (2023) 77.

[4] Translations of *DRN* I–V are from Smith (2001), while the translation of *DRN* VI is from Godwin (1991). For the text of book VI, I follow Godwin (1991). Cf. *DRN* I 150ff., where the principle that

At first glance, such passages might suggest that weather phobias were confined to the uneducated. Seneca, however, demonstrates otherwise. In the *NQ*, he both criticises philosophers (perhaps Epicureans) for assimilating gods to meteorological phenomena such as lightning, clouds and storms, and ridicules entire communities, such as the citizens of Cleonae, who responded to approaching hail-clouds with sacrifices of animals – or even their own blood:

> I cannot stop myself from going on to expose all the follies of our people. They declare that some people are expert at observing clouds and predict when hail is going to occur. They could have learned this by experience, when they noted the cloud color that was always followed by hail. What is incredible is that at Cleonae there were publicly appointed χαλαζοφύλακας, people who watched out for hail coming. When they had given a signal that hail was imminent, what do you suppose? That people ran for their cloaks or their waterproofs? No, they all performed their own sacrifices, one person with a lamb, another with a chicken. Instantly those clouds turned away, once they had tasted a bit of blood. That makes you laugh? Listen to what will make you laugh even more. If anyone had neither a lamb nor a chicken, as an inexpensive alternative he turned on himself, and, so that you do not think clouds are greedy or cruel (*avidas aut crudeles*), he pricked his finger with a really sharp stylus and performed a sacrifice with the blood. The hail turned away from his tiny farm no less than from those where it had been appeased with larger victims (*NQ* IVb 6.1–3).[5]

According to Seneca, the Cleonaeans appointed official 'hail-wardens' (*chalazophulakes*) to observe the skies. When hail threatened, citizens resorted to sacrifices in the belief that such offerings would appease the clouds. Seneca both mocks these practices and anthropomorphises the clouds themselves, presenting them as animate, bloodthirsty beings (*avidus, crudelis*). Such anthropomorphism, rooted in mythological traditions, was gradually absorbed into philosophical and scientific discourse as an explanatory tool. While detached from its context such imagery might appear as a mere cultural remnant, in fact it often functioned as part of a broader rhetorical strategy. Alongside metaphors, similes, and analogies, anthropomorphism provided authors with a means of rendering obscure and unobservable natural processes intelligible to their audiences. Consider, for example, Lucretius' description of cloud shapes in *DRN* IV:

> You must not imagine that the only images of things straying about are those that withdraw from objects. There are others that are spontaneously produced and self-created in the part of the sky that is called the air; these, formed in countless ways, are swept along on high. Compare how sometimes we see clouds effortlessly massing together in the lofty heaven, marring the serene countenance of the firmament and fanning the air with their motion. Often the

'nothing comes from nothing' undercuts divine causation: fear arises from ignorance of natural causes, but once this principle is established, phenomena can be explained independently of the gods.

[5] See also *NQ* I Praef. 14–15 and cf. Aristophanes' depiction of the Academy's scholars in *Clouds* 92–101. Cf. Hall (2023) 149 for Senecan passages where imaginary interlocutors question meteorological hypotheses about clouds. Translations of *NQ* are taken from Hine (2010); the Latin text follows Hine (1996).

> faces of giants[6] seem to glide by, trailing a massive shadow; sometimes a procession of mighty mountains and rocks wrenched from mountains appears to pass before the sun, followed by some monstrous beast leading another string of storm clouds. They constantly melt away and transform their appearance, assuming the contours of forms of every kind (*DRN* IV 129–141).

Here, clouds are metaphorically depicted as animate (monstrous beasts), inanimate (mountains,[7] rocks), or mythological forms (giants). The imagery not only conveys their shifting contours but also communicates the emotions of fear, awe and insecurity experienced by observers.[8] Moreover, this figurative passage participates in a wider analogy between clouds and *simulacra* (tenuous images), drawing on the language of spontaneous generation (*sponte gignuntur, ipsa constituuntur*) to emphasise processes of perpetual motion, change, and transformation as principles pervading both the natural world and atmospheric phenomena.

This paper examines selected passages from Aristotle, Lucretius and Seneca in which analogies between the human body and nebular formations are employed. In addition to clouds, related phenomena such as the rain cycle, thunder and lightning are also considered in order to build a more comprehensive picture of the functions attributed to clouds. My analysis focuses on the rhetorical effects of biological language: how it shapes readers' perceptions, mediates fear and operates within broader philosophical conceptions of care for the self. Methodologically, the use of biological analogies serves to render unfamiliar ideas more familiar. This suggests that obscure processes associated with atmospheric phenomena could be clarified through reference to the living body. However, as is to be expected, technical knowledge of anatomy and physiology was not a prerequisite either for studying the meteorological works of the three natural philosophers under examination or for understanding their doctrines. How, then, are we to evaluate the impact such descriptions may have had on audiences who were not expected to possess biological expertise?

In my view, the principal advantage of these analogies, which enables them be effective for diverse types of readers, lies in their capacity to operate 'homeopathically': the reader, conceived as a patient, is directed to reflect upon their own body in order to understand phenomena that affect both body and soul. Fearful events, when explained through equally – or even more – unsettling biological imagery, could thereby be normalised or 'de-demonised'. This rhetorical strategy constitutes a therapeutic tool within philosophy, designed to heal body and soul simultaneously. Its rhetorical power lies precisely in its care for the reader: the author writes to be understood, advises with authority and philosophises with the reader's needs at the centre.

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[6] Cf. Aristophanes *Clouds* 346–347 and Aristotle *On Dreams* 3.461b19–21.

[7] For a detailed analysis of the analogy between mountains and clouds, and the notion of *montes nimborum*, see Beltramini (2021).

[8] See also VI 249–255, where the poet employs vivid and evocative imagery to express the fear inspired by storm-clouds, piling up ominous and shadowy metaphors; cf. West (1969) 57–59 on *DRN* I 62–79.

1. The Anatomy and Physiology of Clouds

Across literary genres, the most common representation of clouds is as containers. Ancient authors liken them to cavities, caves, vessels, pipes, bodily parts such as bladders and veins, organic substances such as sponges and wool, and even to whole living bodies – human and animal alike. Although most containers are by nature solid and firm, clouds are often depicted defying the usual properties of vessels: plastic, inflatable, or permeable. Despite being three-dimensional bodies, ancient accounts frequently reduce clouds to their vertical axis, conceived as a boundary separating the phenomena above from those below. Their density, determined by the compactness of their contents, is a common indicator of type: the denser the cloud, the more likely it is to bring rain or storm. At the same time, clouds are often depicted as porous, traversed by internal channels through which air or water can travel. This implies that their hollow parts contain an internal structure, varying in complexity, the 'anatomy' of which remains difficult to discern. A further complication is the widespread assumption that clouds are composed from the very elements they contain – air and/or water – making their substance at once a product and a container.[9]

These aspects are well illustrated in a lengthy passage from Seneca's *NQ* (III 15.1–8). Seneca elaborates an analogy between the human body and the earth's body, before extending it to the region of clouds (III 15.7). The reader is thus encouraged to construct the analogy step by step, first between human physiology and the subterranean world, and only then between the subterranean and the atmospheric:

> I think that the earth is controlled by nature, and on the model of our own bodies, in which there are both veins and arteries; the former are receptacles for blood, the latter for breath. In the earth too there are some passages through which water runs, others through which breath does; and nature has created such a resemblance to the human body that our ancestors too spoke of 'veins' of water. (2) Now, in us there is not just blood but many kinds of fluid, some essential (*necessarii*), some corrupted (*corrupti*) and rather too thick; in the head there is the brain, mucus, saliva, and tears; in the bones, marrow and something added to the joints as a lubricant so that they can bend more readily. In just the same way in the earth as well there are several kinds of fluid: (3) some that harden when fully developed (from them comes the entire harvest of metals – from which greed seeks out gold and silver – and substances that turn from liquid to stone), and some that are formed from the decay of earth and moisture (such as bitumen and other things of that sort). This is the explanation for the kinds of water that come into being according to the law and will of nature. (4) But, as in our bodies, so in the earth liquids often go bad: either a blow, or some upheaval, or the old age of the location, or cold, or heat corrupts their nature; a festering process forms a liquid, which may be either long-lasting or short-lived. (5) Now, in our bodies, when a vein has been severed, the blood runs until it has all flowed out, or until the cut in the vein <has healed> and the bleeding has

[9] Ancient attempts to explain thunder and lightning often provoked scepticism, since they required clouds to possess properties – such as solidity or frictional heat-production – that seemed incompatible with their observed moist, porous nature; Seneca (*NQ* II 25 and 27–28) and the *Syriac Meteorology* preserve such objections, even while offering replies, revealing the tension between explanatory ambition and the physical indeterminacy of clouds. See Hall (2023) 72 and 148.

> subsided and been staunched, or some other factor has checked the flow of the blood; and in just the same way in the earth, when veins are unsealed and opened, a stream or river runs out. (6) The size of the vein that is opened makes a difference: sometimes it gives out when the water is exhausted; sometimes it is blocked by some obstacle; sometimes it heals over with a scar, as it were, and seals off the path it had opened up; sometimes the earth, which we have said is subject to change, loses its ability to convert its nourishment into moisture. (7) But on occasion what is exhausted can be renewed: sometimes it recovers its own strength; sometimes strength is transferred from elsewhere. For empty things placed next to full ones often divert moisture to themselves; often earth, if it putrefies easily, is itself dissolved and liquefied. The same occurs below the earth as in the clouds, that <the air> is condensed, and, when too heavy to remain in its natural state, it produces moisture; often a thin, dispersed liquid collects like dew, and trickles from many directions into one place (water-diviners call it sweat, because drops are either extruded by the pressure in the region or are extracted by heat)[10]. (8) This feeble trickle is scarcely sufficient for a spring. But from large caverns and large reservoirs there emerge rivers, sometimes issuing gently, if the water just flows downhill under its own weight, sometimes violently and noisily, if breath is mixed in with it and forces it out (*NQ* III 15.1–8).

Behind Seneca's discussion of rivers lies a parallel account of rainwater in clouds: just as water emerges from subterranean veins, so raindrops form when airy clouds condense. Yet the passage offers more than explanation: the biological analogy provides vivid imagery for conceptualising the interconnectedness of subterranean and atmospheric processes. The human body – with its veins, arteries, organs, fluids, health and disease – serves as a model for understanding the hidden structure and activity of the natural world.

Seneca presents both earth and clouds as structured regions, full of cavities comparable to bodily vessels. Subterranean 'veins of water' mirror human veins carrying blood, while airy cavities correspond to arteries carrying breath. Veins and arteries, in this reading, may represent different kinds of clouds: the former heavy rain-clouds, the latter lighter, brighter formations. To emphasise multiplicity and variety, Seneca enumerates bodily fluids – brain matter, mucus, saliva, tears, marrow, synovial fluid – each located in its proper container and serving a distinct function (cf. *necessarii*). By analogy, natural cavities, whether subterranean or atmospheric, also contain diverse substances, each with unique properties.

Seneca also extends the analogy to disease.[11] First he refers to corrupted (*corrupti*) bodily fluids, which are thickened and therefore symptomatic of disorder. No parallels

[10] Cf. pp. 51–52 below.

[11] Cf. *DRN* VI 1090–1102, where particles producing disease are to be found both in the sky (in the form of clouds and mists) and in the underground: 'Now I will explain the principle behind diseases and the source from which the silky power can suddenly arise and breathe deathbringing destruction for the race of humans and the herds of cattle. First of all I have shown above that there are atoms of many things which are life-enhancing to us and on the other hand there must be many flying around which are a cause of disease and death. When these happen to have arisen by chance and have disturbed the sky the air becomes infected. And so the whole force and infection of diseases either comes from outside through the sky above, like clouds and mists, or they often arise and come up from the earth

are provided for such unusual fluids in nature; the formation of metals or bitumen in the earth is treated as an 'accepted natural outcome', even though these too result from processes of condensation – processes that, in the human body, would signal corruption. Seneca then turns to discuss causes of corruption in nature, such as the old age of a location or thermal instability. Such conditions can disturb the expected 'life-span' of certain materials, which may now endure either longer or shorter than is appropriate to their nature.[12]

Building on the biological analogy, Seneca turns to the nature of containers. Their porosity or piercing determines whether they can hold their contents. His ancestors had already compared torn veins to subterranean channels, from which blood or water escapes once opened; he himself adds the image of communicating vessels, where liquid flows from full to empty. In all such cases, according to the passage cited above, the contents serve as nutriment that sustains the container, yet they are never secure: veins may be drained, obstructed, or sealed, and the earth itself may lose its power to convert nourishment into moisture. What is depleted, however, can be replenished, either by its own renewal or by transfer from elsewhere. The same logic governs clouds: they retain their airy[13] substance only so long as it remains light, but once thickened and heavy, it breaks free as rain.

Seneca later develops this view in more explicitly ontological terms, insisting that clouds exist even in subterranean regions:

> Although down there no light reveals differences in the air, I shall nevertheless state that in the darkness there are clouds and mists (*nubes nebulasque*). For even in the case of those above the earth, they do not exist because they are seen, but they are seen because they exist: below ground too, they do not exist any the less because they are not seen. You may be sure that down there rivers as big as our own are flowing, some of them moving gently, others crashing noisily over rocky rapids. And tell me, will you not equally grant that there are some lakes beneath the earth as well and some stagnant waters without an outlet? (*NQ* V 14.2)[14]

In a distinctly rhetorical mode, Seneca invites his addressee to accept the claim that clouds exist within the earth, whether or not they can be directly observed.[15] Here the underground world becomes a mirror-cosmos, complete with rivers, lakes and mists. While this may seem fanciful to modern readers, it is consistent with ancient

itself when it has become rotten through being wet and being struck with rainstorms and sunbeams out of proportion to the season'.

[12] On vitalistic language and analogical models applied to stones, metals and gems in Greco-Roman thought, see Korobili (2024).

[13] Although the term in the text is air, the underlying concept is that of exhalation, i.e. a mixture of air and water.

[14] Cf. *DRN* VI 249–255 and n. 8 above. In *NQ* VI 9.1, Seneca attributes the idea of underground clouds to Anaxagoras.

[15] Lucretius, by contrast, would have regarded such a view as absurd: 'Again, a tree cannot exist in the sky, or clouds in the depths of the sea; fish cannot live in fields; blood is not found in timber, or sap in stones. The place where each thing may grow and exist is fixed and determined' (*DRN* III 784–787). Cf. *DRN* VI 251 and Godwin's (1991) comment ad loc.

cosmological imagination, in which the sub-surface was envisaged as full of cavities resembling those above the earth.[16]

Seneca is not alone in employing the biological analogy for meteorological explanation. Aristotle and Lucretius likewise employ it in their accounts, using the language of physiology, reproduction and digestion to conceptualise cloud formation.

Aristotle defines cloud (νέφος) twice in his extant works: once in his *Topics* as the 'condensation of air' (πύκνωσις ἀέρος, 146b29),[17] and again in *Meteorology* (*Mete*) in a more informative context. Below the fiery region, he claims, there lies a second place (τόπος), which extends to the surface of the earth and is common to air, water and the phenomena attending the formation of water in the upper region (I 9.346b16–19).[18] This is the place where clouds form[19] and the rain cycle takes place – the region in which the vaporous exhalation operates. In *Mete* I 9, after a carefully structured opening[20] in which Aristotle reiterates that the sun and its course influence the phenomena occurring in this region, he writes:

> The exhalation of water is vapour: air condensing into water is cloud. Mist is what is left over (περίττωμα) when a cloud condenses into water, and is therefore rather a sign of fine weather than of rain; for mist might be called a barren (ἄγονος) cloud (I 9.346b32–35).[21]

Condensation, then, is the transformative process through which air becomes cloud. Aristotle presents it as a formative process:[22] just as digestion and reproduction are

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[16] See *NQ* III 9.1–3 and 16.4. In VI 15.1, holes in the earth are described as breathing passages (*spiramenta*), a mirror-image in reverse of Lucretius' *spiracula* (VI 493), the 'respiratory channels' of the earth and the upper air. The language of mirroring is not merely metaphorical: elsewhere, following Aristotle, Seneca also describes clouds as natural mirrors reflecting solar light, reinforcing a broader cosmological imagination structured by specular analogy (see *NQ* I 3–13 and Le Blay [2010] paragr. 10–16: https://books.openedition.org/pur/38573).

[17] In the 6th ce. BCE, Anaximenes defined cloud as dense air (DK 13A5). The 5th ce. BCE Hippocratic treatise *On the Nature of the Child* – which, according to Craik (2015) 118, may even predate Aristophanes' *Clouds* – describes clouds as a continuous volume of water suspended in air (25 = VII.522 Littré). Metrodorus of Chios (5th or 4th ce. BCE) held that clouds form from watery matter rising into the air (DK 70A16). Plato, in *Timaeus* 49c, explains cloud and mist as a stage in the transformation of air into water.

[18] As Wilson ([2013] 147–48) explains, by 'common place' Aristotle designates the region of the rain cycle specifically, not other phenomena such as rivers or winds.

[19] Cf. *Mete* I 11.347b12, where Aristotle refers to this region as 'the place associated with clouds' (ὁ περὶ τὰ νέφη τόπος). The text of *Mete* is taken from Louis (1982).

[20] Cf. Wilson (2013) 146: '[Aristotle] deliberately obscures at the beginning of chapter I.9 the distinction between the daily passage of the sun and the annual cycle that produces the seasons'.

[21] Translations of *Mete* are taken from Barnes (1984). A similar conception of fertility appears in ps. Aristotle, *On the Cosmos* 4.394a27–28, where cloud is described as a dense, vaporous formation, productive (γόνιμον) of water. The notion that clouds are generative of weather phenomena (e.g. lightning) and even of celestial bodies such as the sun and stars seems already to be attested in Xenophanes (DK 21A32; DK 21A38; DK 21A40; DK 21A43–45). In *DRN* VI, Lucretius likewise speaks of clouds as pregnant (e.g. 259, 296, 440; cf. 210 and Godwin's [1991] comment ad loc); see Beltramini (2020) 88 n. on 246–247 and 89–90 n. on 258–259, and cf. discussion below.

[22] Anaximenes held that clouds result from a process of generation (γεννᾶσθαι, DK 13A7, lines 22–23). Xenophanes probably invoked a similar transformative process (cf. γενέτωρ in DK 21B30) to explain the formation of clouds, which, like all other celestial phenomena, have the heat of the sun as their primary cause (ἀρκτική αἰτία), forcing sea water to evaporate, separate, and form clouds (DK 21A46). Anaxagoras likewise maintained that clouds are generated (according to Aristotle, *Mete* I

vital for living beings, so too condensation produces primary products (clouds) and secondary, residual by-products (mist). Clouds are fertile bodies, capable of producing a wide range of watery phenomena – rain, snow, dew, frost and hail – as well as other meteorological events such as lightning. Mist, by contrast, is directly related to clouds in the way residues (περιττώματα) are related to the digestive or generative processes of living beings: residues appear only after transformation has ended, are produced in small quantities relative to the material originally subjected to change, and, above all, are superfluous and therefore useless to the organism. Not all residues are necessarily useless – seed, for example, is a fertile and valuable by-product – but in this passage Aristotle employs the term περίττωμα specifically to emphasise uselessness, as made clear by his description of mist as a barren cloud and a sign of fine weather. His discussion can therefore be fully appreciated once the reader recognises that the processes of condensation producing clouds and mist are analogised to digestion and reproduction within a living body.

Such an interpretation would have been anticipated by an ancient reader (and, I suggest, not only by the most sophisticated one). It exemplifies Aristotle's broader idea, found elsewhere in *Mete*, that comparisons between microcosm and macrocosm shape the way we contemplate the world: 'We must suppose, then (to compare great things with small), that what happens in the earth is just like that' (τὸ αὐτὸ δεῖ νοεῖν γιγνόμενον καὶ ἐν τῇ γῇ, ὡς εἰκάσαι πρὸς μικρὸν μεῖζον, II 8.366b29–30).[23] Both this passage and I 9.346b32–35 (cited above) exemplify Aristotle's strategy for broadening his audience by employing a mixed vocabulary. On the one hand, he relies on concepts from physics, such as the condensation of air and the role of air in earthquakes; on the other, he draws upon medical and biological terminology, such as *perittōma*, tremors, and throbbing. This interplay of languages offers the reader a multidimensional understanding of meteorological phenomena, encouraging them to discern common principles operating both in the heavens and in living organisms, and to situate meteorology within a wider investigation of nature that encompasses life itself.

A similar tendency to use biological language in describing nebular activity appears in Lucretius' account of cloud formation in *DRN* VI. This account forms part of a broader discussion (vv. 80–535) that includes thunder, lightning, *prester* and rainwater – most of which we will return to later. The self-referential veil of the opening is impossible to miss: by invoking his polished verses (*ornanda politis versibus*, 82–83), Lucretius signals his sense of duty toward humanity and reminds the reader that the ultimate purpose of his poem is to guide people toward happiness through knowledge. Storms, dazzling lightning flashes, their causes and effects – these are fitting subjects for a 'glorious song' such as the *DRN* (83–89).[24]

12.348a14 [= DK 59A85]; the name of Anaxagoras is not attested in this passage, but has been restored on the basis of Alexander of Aphrodisias). Lucretius adopts a similar view, as we shall see below.

[23] In the context of this passage (366b2ff.), the action and force of *pneuma* in earthquakes is compared to bodily tremors and throbbings, while the affection of the earth is likened to the state of the body after urination. Cf. II 9.369a25–b4, discussed below.

[24] The reader-oriented, therapeutic framing of meteorological explanation is made explicit by Lucretius at *DRN* VI 48–89. Cf. Tutrone (2012) 85: 'I believe the *De rerum natura* is a rare masterpiece of physiological synthesis. In its didactic structure we … can find a balanced mixture of *physics* and *biology*, macroscopy and microscopy. It is often said that Epicureanism founded a

In his account of cloud formation (VI 451–493), Lucretius draws upon reproductive vocabulary to present clouds as products of generation.[25] An increasing accumulation of particles (*corpora*, 451) floating in the air first produces thin, wispy formations that gradually develop into thick, dark clouds.[26] The particles 'copulate' (*coiere*, 452), and thanks to their rough surfaces (*asperiora*,[27] 453) they achieve unions (*coniungendo*, 457) that yield *nubila*. Smaller clouds collect into a 'flock' (*inter se… gregantur*, 456). Mists and vapours (*nebulas aestumque*, 477), emitted from rivers and the earth as breath (*halitus*, 478), gather together (*conveniundo*, 480) and obscure the sky. The mass of clouds is continuously augmented by particles from the sea and even from beyond this world.[28] Thus, clouds inherit the properties of water, air and heat, as indicated by Lucretius' terminology (*umoribus*, 475; *nebulas*, 477; *aestum*, 477). This recalls the four-element theory of earlier natural philosophy, but Lucretius' repeated use of *umor* also points toward humoural theories, familiar from the Hippocratic corpus.[29] Biological resonances intensify in his emphasis on the kinship of sea and air humours, which are described as consanguineous – 'brothers and sisters' (*consanguineast*, 475). In short, a chorus of warm, moist breaths, reminiscent of sexual intercourse, rises into the sky and generates humoural masses that, through stages of condensation, become heavy rain-clouds (*cf. tempestas saeva*, 458).[30]

"biological atomism", but it has recently been correctly pointed out that this kind of eclectic orientation belongs instead to Lucretius' careful exposition'. (emphasis in the original)

[25] As Johncock ([2016] 66–67) observes, although birth terminology is less frequent in book VI than in earlier books of the *DRN*, its use becomes more conceptually focused. The marked rise in compounds such as *coorior* and *concresco* signals an emphasis on generation through atomic combination. Natural phenomena ranging from clouds and storms to disease and magnetism are unified under this model of 'birth', which operates at both microscopic and macroscopic levels. Sedley ([1998] 38) argues that in the proem to book I, Lucretius introduces atomistic terminology (e.g. *rerum primordia*, *materies*, *semina*) that foregrounds not the smallness of these entities but their generative function. These terms emphasise atoms as dynamic, procreative starting points and underpin his argument against *ex nihilo* generation, linking macroscopic biological regularity to fixed microscopic seeds. See also Solmsen (1951) 20–21 on σπέρματα/ *semina* 'which, although a technical or semi-technical term, had not become entirely divorced from its biological origins'.

[26] In *DRN* IV 1233–1277, Lucretius attributes infertility to two main causes, one being the excessive thickness or thinness of the seed. The term he uses for thick seed is *crassus* (IV 1240), the same adjective employed in his description of heavy rain-clouds (VI 461). Beltramini ([2020] 88 n. on 246–247) has already gathered several parallel passages. For a comprehensive survey of possible medical and philosophical sources influencing Lucretius' views on infertility, see Brown (1987) 337–40.

[27] Cf. Epicurus' view that clouds may be formed παρὰ περιπλοκὰς ἀλληλούχων ἀτόμων, 'through the entanglement of mutually linked atoms' (*Letter to Pythocles* 99); Hall (2023) 25 adds that this presumably implies hook-shaped atoms.

[28] In explaining particles coming from outside the sky (VI 483–494), Lucretius employs verbs in the first person singular twice – *docui* (486) and *ostendi* (487) – to signal that he has already taught and shown details from which this idea can be inferred (cf. *DRN* I 1035–1041). In doing so, he anticipates potential objections from his addressee while simultaneously reinforcing the coherence and tight structure of *DRN*.

[29] See Tutrone (2012) 87–88; Pigeaud (2010) paragr. 23: https://books.openedition.org/pur/38572.

[30] Godwin ([1991] 127 n. on 457–458) questions the relevance of Lucretius' reference to storms as a necessary outcome of dark clouds, observing that clouds may gather and exist without producing storms. One might nevertheless interpret the passage as describing a climactic transformation, whereby the cloud develops into – and thus generates – a heavy rain-cloud – the extreme opposite of a barren cloud. On this possible progression, see also the discussion below on the transition from *nubila* to *nimbi*.

To substantiate this theory, Lucretius deploys a variety of Latin terms to classify different types of clouds.[31] The most general is *nubila*, which in *DRN* usually refers to light, wispy formations akin to modern cirrus clouds.[32] With condensation, *nubila* become *nubes*: thicker, often darker clouds that may or may not produce heavy showers. Lucretius typically uses *nubes* when stressing density and sluggish movement, while *nubila* describes formations driven by winds (recurring as *nubila portabunt venti* or *venti nubila portant*).[33] *Nubes* is the standard term used in descriptions of violent phenomena such as thunder and lightning (e.g. VI 246–248), where clouds are depicted as containers whose walls are gradually weakened by trapped winds (VI 121–131, 438–442). The most enigmatic type of cloud is *nimbus*. Predominantly used in the plural, the term designates dark clouds that obscure the sky and herald a tempest, or that advance rapidly and menacingly. More broadly, it may signify a thundercloud, heavy rainfall, or a storm in general.[34] Notably, however, Lucretius also employs *nimbus* to describe clouds appearing in an otherwise clear sky (e.g. IV 445, VI 482). Finally, *nebula* refers not to clouds but to fog, characterised by lightness, porosity, and fineness. In *DRN*, it often appears alongside smoke (*fumus*) and/ or other delicate, dissolvable substances (II 457, 436, III 428).

The transformative progression – from particles to *nubila*, from *nubila* to *nubes* and from *nubes* to *nimbi* – together with Lucretius' reproductive imagery, creates a model of generation distinct from that alluded to in IV 130ff. (cited above), where spontaneous generation seems implied. As Godwin notes, however, the term *sponte* there signals not divine intervention but natural causality, consistent with the poem's didactic aim of eliminating fear of the gods' involvement in meteorological events.[35] On the other hand, in our passage, VI 451–493, it seems that Lucretius aims at a naturalistic explanation of cloud generation; in this sense, a description based on the model of animal reproduction appears more fitting. The flexibility with which Lucretius applies these analogies – sometimes spontaneous, sometimes reproductive – reveals not inconsistency but rather his imaginative strategy. He opts not for a rigid

[31] For an overview of the semantic range of Latin terms for clouds (*nebula*, *nimbus*, *nubes*), see Wolff (2010): https://books.openedition.org/pur/38575.

[32] In modern cloud classification, the two main criteria are altitude and texture (https://www.weather.gov/lmk/cloud_classification). Lucretius does not employ altitude as a systematic criterion, although he distinguishes clouds forming at the tops of mountains from others; these are usually called *nubes* (VI 459–469, 729–734). Cf. also VI 189–203, where the roles of *nubila* and *nubes* seem reversed. This may result from the structure of the sentence: the passage opens with a metaphor comparing clouds to mountains and the same subject (*nubila*) continues into a subsequent, non-metaphorical description of clouds piled up like a mountain range, so that the initial metaphor appears to influence the following clause. Cf. n. 7 above.

[33] At VI 132–136, Lucretius describes a frequent type of *nubila*, rough and heavily branched, allowing air to pass through, produce noise and move the clouds. These could resemble cumulus clouds, large, vertically developing clouds that sometimes form secondary bulges or 'tendrils'. The text does not suggest that these clouds are associated with an impending storm, which is why I take them not to correspond to modern cumulonimbus clouds. As noted by Garani ([2007] 111), Lucretius rhetorically assimilates the form of certain clouds to trees with branching limbs; this crafted comparison between clouds and forests not only shapes the visual imagery but also explains the perceived similarity in the quality of the sound produced.

[34] A characteristic example occurs at VI 256–261, where *nimbus* appears to correspond closely to a modern cumulonimbus cloud, with a dark base, vertical development and the capacity to produce thunder, squalls and heavy rainfall.

[35] Godwin (1986) 101 n. on 131; cf. Godwin (1986) 95 n. on 47.

explanatory system but for suggestive, poetically enriched accounts that illuminate nebular phenomena otherwise inaccessible to the senses.

2. Hail: The Exceptional Product of Clouds

As noted above, ancient authors attributed to clouds the capacity to generate diverse meteorological phenomena such as rain, snow, hail, dew, thunder and lightning. This section focuses on hail and its peculiar status in Aristotle's meteorology. Seneca's views on hail are largely lost,[36] while Lucretius offers no detailed account. He mentions hail only briefly, at the close of his treatment of cloud formation, rain and the rainbow, where the reference serves a rhetorical rather than explanatory purpose:

> The other things which grow and are formed up above and which gather together in the clouds, all of them, absolutely all of them, snow, winds, hail, cold frosts, and the great power of ice the great hardener of waters, the hindrance which everywhere reins back the eager rivers – it is still very easy to find out and to see mentally how all these things are made and why they are brought into being when you have fully grasped the characteristics with which their atoms are endowed (*DRN* VI 527–534).

Here hail appears as one of the atmospheric phenomena *grown* (*crescent*, VI 527) and *created* (*creantur*, VI 527) in the sky. Lucretius directly addresses Memmius in the second person singular, inviting him to advance to the highest stage of learning: independent inquiry into natural phenomena. Hail thus serves, along with other meteors, as a case-study for Memmius to practice abstract reasoning and causal explanation, thereby reinforcing the teacher-student bond.[37]

Turning now to Aristotle, hail presents a unique case of an exceptional meteorological phenomenon arising from clouds and the rain cycle. Its exceptionality lies partly in its peculiar nature, but also in the fact that, unlike other aqueous phenomena, it has no analogue near the earth's surface. In Aristotle's framework, dew corresponds to rain and frost to snow, differing only in degree and quantity (διαφέροντα τῷ μᾶλλον καὶ ἧττον καὶ πλήθει καὶ ὀλιγότητι, *Mete* I 10.347b15–16). Rain and snow form in the upper atmosphere, while dew and frost occur at lower levels of the same region. Hail, however, has no such counterpart and is examined in *Mete* I 12.

From the outset, Aristotle acknowledges that the study of hail is beset with difficulties, for prevailing explanations appear paradoxical (τὰ δοκοῦντ' εἶναι παράλογα, 347b35–36).[38] By using the participle *dokounta*, he signals to the reader that he has already devised a solution to these puzzles. His strategy is to ground his

[36] Seneca's discussion of hail appears at the beginning of *NQ* IV, though much of this section is lost. In the extant portion, he examines the shape of hail through doxographical reports, without recourse to biological analogies. Seneca's account of the behaviour of the people of Cleonae when hail-clouds approach is analysed at the outset of this paper. For earlier views, see Hall (2023) 145–47.

[37] Hence, I suggest that Lucretius deliberately abbreviates his treatment here, rather than merely being 'impatient', as Godwin ([1991] 131 n. on 527–534) proposes.

[38] A little further on, Aristotle presents a doxographical report that likely reflects Anaxagoras' account of hail formation. Although he refers generally to the 'opinions of others' (τοῖς μὲν οὖν δοκεῖ, 12.348a14), he leaves them unnamed, thereby implicitly disparaging their attempts to explain the phenomenon.

account in earlier theories while introducing a new explanatory principle: the concept of mutual replacement between hot and cold (*antiperistasis*), which he deploys to account for this unique phenomenon requiring a special efficient cause.[39]

Aristotle introduces *antiperistasis* – aptly, in this context[40] – in opposition to theories positing that hail forms at great heights where, owing to diminished solar reflection, the air is colder. According to this view, hail clouds rise during summer heat; their water then freezes, producing hail (348a14–18). Aristotle finds it absurd (ἄτοπον, 348a4) to believe that rainwater freezes in the upper air, since exhalation has already condensed into water in the lower region where clouds are formed, as established earlier in *Mete* I 3, and water cannot remain suspended in the air (348a4–6). Moreover, hail clouds are often observed near the earth, sometimes moving with terrifying noise, and even when silent, producing violent hailstorms with unusually large hailstones – a fact better explained by their proximity to the ground (348a20–36). Thus, 'things are not as others claim' (οὐχ ὥσπερ ἐκεῖνοί φασιν, 348a30).

He instead posits:

> Now we see that warm and cold react upon one another (γίγνεται ἀντιπερίστασις τῷ θερμῷ καὶ τῷ ψυχρῷ ἀλλήλοις). Hence in warm weather the lower parts of the earth are cold and in a frost they are warm. The same thing, we must suppose, happens in the upper region, so that in the warmer seasons the cold is concentrated by the surrounding heat and causes the cloud to go over into water suddenly. (348b2–8)

On this account, there is no need to posit water freezing at high altitudes or clouds forming and moving upward. Instead, *antiperistasis* explains thermal inversion in nature: in autumn and spring, the atmosphere above the earth is colder than the surface, yet still warmer than the region near the celestial sphere.[41] Clouds, laden with moisture, sink into the warmer lower air, where sudden compression by the surrounding heat causes the moisture to freeze.

This theory recalls Aristotle's biological account of digestion, specifically the upward and downward movement of nutritive exhalation in the torso. In *On Sleep* 3, warm exhalation ascends to the brain, where it is cooled, before sinking back to the warm heart (456b20–28, 457b26–31). After meals – when exhalation is most abundant, as also during fatigue, illness, or youth – this cycle fosters the conditions for sleep (456b32–457a5). This meeting of the cooled exhalation with the heat concentrated in the region of the heart produces a thermal inversion: the heat is driven inward under the pressure exerted by the colder exhalation. Consequently, the outer and upper parts of the body become cool, while the inner and lower parts remain hot

[39] The concept of *antiperistasis* is introduced for the first time in chapter 10 to account for an unusual phenomenon – dew produced in Pontus when a north wind is blowing. See Wilson (2013) 154.

[40] Cf. Wilson (2013) 154 n. 18: '… *antiperistasis* is used twice among forms of condensation in order to increase its utility and its credibility as a generic cause'.

[41] The concept of thermal inversion is first attributed by ancient sources to Oenopides of Chios, as part of his explanation of the flooding of the Nile (Bodnár [2007] 11–13). Outside this context, and apart from its attestation in Aristotle, the idea appears again in a medical work, the Hippocratic *On the Nature of the Child* (chapters 24–26). For further discussion, see Korobili (2022) 228–30.

(457b4–6). Sleep is thus described as a 'natural *antiperistasis*' (ἀντιπερίστασις φυσική, 457b2), a necessary affection for maintaining life (σωτηρίας, 458a31–32).[42]

This parallel invites the question: would ancient readers of *Mete* have recognised *antiperistasis* as a common principle underlying both meteorological processes and bodily functions, each mediated by exhalation, internal or external? Certainty is elusive. Aristotle himself advises that his biological works on animals and plants should follow the study of meteorological science (*Mete* I 1). Still, readers of the biological treatises could hardly miss the analogy, since Aristotle explicitly links digestive exhalation to rain formation in both *On Sleep* 3 (457b31–458a10) and *On the Parts of Animals* (*PA*).[43] For reasons of space, I will examine here only the *PA* passage. This text conveys the same view as *On Sleep* 3, but in a more eloquent and elaborated form, and thus serves as a representative witness for both accounts.

In *PA* II 7, immediately after the well-known claim that nature devised the brain to counterbalance the heat of the heart – part of his broader discussion of the brain's usefulness in blooded animals – Aristotle turns to the pathological case of fluxes:

> We can now understand why fluxes (ῥεύματα) have their origin (ἀρχήν) in the head, and occur whenever the parts about the brain have more than a due proportion of coldness (ψυχρότερα τῆς συμμέτρου κράσεως). For when the nutriment steams (ἀναθυμιωμένης) upwards through the blood-vessels, its refuse portion (περίττωμα) is chilled by the influence of (δύναμιν) this region, and forms fluxes of phlegm and serum. We must suppose, to compare small things with great (ὡς μεγάλῳ παρεικάζοντα μικρόν), that the like happens here as occurs in the production of showers (τὴν τῶν ὑετῶν γένεσιν). For when vapour steams up from the earth and is carried by the heat into the upper regions, so soon as it reaches the cold air that is above the earth, it condenses again into water owing to the refrigeration, and falls back to the earth as rain. These, however, are matters which may be suitably considered in the *Principles of Diseases* (ἐν ταῖς τῶν νόσων ἀρχαῖς), so far as natural philosophy has anything to say to them. It is the brain again – or, in animals that have no brain, the part analogous to it – which is the cause of sleep. For either by chilling the blood that streams upwards after food, or by some other similar influences, it produces heaviness in the region in which it lies (which is the reason why drowsy persons hang the head), and causes the heat to escape downwards in company with the blood. It is the accumulation of (ἀθροιζόμενον) this in excess in the lower region that produces sleep, taking away the power of standing upright from those animals to whom that posture is natural, and from the rest the power of holding up the head (652b33–653a19).[44]

Fluxes of phlegm and serum, Aristotle explains, are by-products of the digestive exhalation, specifically that portion (περίττωμα) superfluous to the organism which

[42] Notably, *antiperistasis* is employed in a different sense in *Physics*. According to Golitsis ([2018] 80–81), it denotes 'a round displacement of bodies until the last displaced body occupies the place of the first displaced body'. As he explains, this concept is of Platonic origin, corresponding to the action of *periōthein* in *Timaeus* 79a–e, where it describes the process of respiration.

[43] Note, however, that the term *antiperistasis* does not appear in either passage.

[44] The text of *PA* is taken from Louis (1993).

fails to cool properly upon reaching the brain. This residual element upsets the delicate balance of hot and cold required in the cerebral region. Strikingly, Aristotle compares this condition to the formation of rainwater – an analogy that at first glance seems disproportionate, yet is methodologically deliberate. Both processes share essential features: the alternating upward and downward movement of exhalation and the external force that triggers condensation and subsequent descent. In the case of fluxes, however, the principle of *antiperistasis* is deployed with particular force, operating twice: first in the brain, before the exhalation descends, and again in the heart, where the cooled, heavier exhalation collides with concentrated heat. This double application not only underscores the explanatory power of *antiperistasis* but also reinforces Aristotle's broader strategy of reading the body and the atmosphere as governed by the same causal dynamics.

Aristotle explicitly signals the use of this analogy with a phrase akin to that in *Mete* II 8.366b2–30 ('to compare small things with great'), thereby legitimising it both methodologically and explanatorily. He even promises to return to the subject – perhaps to the analogy itself – in a work on the *Principles of Diseases*, adding, in his characteristic fashion, the caveat of methodological caution: 'so far as natural philosophy is permitted to examine these issues'. While this remark directly concerns the incorporation of medical ideas into natural philosophy, it also performs a broader function. It encourages the reader to recognise that such analogies, when used with due caution, can illuminate processes across different domains: not only meteorology and biology, but also pathology, psychology, and even broader questions of natural philosophy where the dynamics of heat and cold, balance and inversion, are at stake. In the continuation of the cited passage, Aristotle goes on to explain the physiology of sleep in terms of the incapacity of the digestive exhalation to cool the heart – a process we have already examined.

3. Rainwater and River Formation

In *Mete* I 13 Aristotle sets out to examine the nature of winds and the causes of river and sea formation. He begins with a survey of how his predecessors understood winds, but soon turns to rivers, since rivers 'serve as a heuristic introduction to the winds'.[45] At the opening of the chapter he introduces a striking river-wind analogy, plausibly prompted by the idea that both rivers and winds 'flow' (ῥέουσι, 349a28). This analogy leads to sharp criticism of unnamed predecessors who, wishing to sound clever (τῶν σοφῶς βουλομένων λέγειν τινὲς), claimed that all winds are one single wind (349a20–22), just as if all rivers were one and the same river (349a25–26). By means of this analogy Aristotle quickly shifts his focus to rivers, with the explicit aim of 'restoring the truth' that has been obscured by ingenious but plainly false ideas (349a28–32). Such views provoke Aristotle's lament: those who have scrutinised the matter (τῶν μετὰ ζητήσεως οὕτω λεγόντων, 349a27) produce explanations inferior to popular belief (διὸ βέλτιον οἱ πολλοὶ λέγουσιν ἄνευ ζητήσεως, 349a26–27), or ideas that anyone 'off the street' could have proposed (περὶ τούτων οὐδὲν παρειλήφαμεν λεγόμενον τοιοῦτον ὃ μὴ κἂν ὁ τυχὼν εἴπειεν, 349a15–16).[46]

[45] Wilson (2013) 156.

[46] For a discussion of the problematic methodological approach of these thinkers, see Korobili and Stefou (2021), esp. 57–59.

Traditional views, which Aristotle here targets, held that rivers originate from rainwater stored in subterranean cavities:

> We find analogous views about the origin of (γενέσεως) rivers. It is thought that the water is raised by the sun and descends in rain and gathers below the earth and so flows from a great hollow (ἐκ κοιλίας μεγάλης), all the rivers from one, or each from a different one. No water at all is generated (οὐ γίγνεσθαι), but the volume of the rivers consists of the water that is gathered into (συλλεχθὲν) such reservoirs (ὑποδοχάς) in winter. Hence rivers are always fuller in winter than in summer, and some are perennial, others not. Rivers are perennial where the hollow is large (διὰ τὸ μέγεθος τῆς κοιλίας) and so enough water has collected in it to last out and not be used up before the winter rain returns (μὴ προαναλίσκεσθαι πρὶν ἐπελθεῖν τὸ ὄμβριον ἐν τῷ χειμῶνι πάλιν). Where the reservoirs are smaller there is less water in the rivers, and they are dried up (φθάνειν ξηραινομένους) and their vessel empty (κενουμένου τοῦ ἀγγείου) before the fresh rain comes on (πρὶν ἐπελθεῖν τὸ ἐκ τοῦ οὐρανοῦ) (I 13.349b2–15).[47]

Aristotle's main objection to these 'reservoirists'[48] is that their theory explains only a *passive* storage of water underground, not the *generation* (γένεσις) of water. Cavities function merely as receptacles (ἀγγεῖα), overflowing in winter and drying up in summer, without playing any active role in processes of change. In this sense they resemble Aeolus' bag of winds,[49] which was simply emptied when opened.

Aristotle counters with his own account of condensation, which is explicitly a theory of coming-to-be:[50]

> Though it is evident that many reservoirs of this kind do exist in many parts of the earth, yet it is unreasonable for anyone to refuse to admit that air becomes water in the earth for the same reason as it does above it. If the cold causes the vaporous air to condense into water above the earth we must suppose the cold in the earth to produce this same effect, and recognize that there not only exists in it and flows out of it actually formed water (τὸ ἀποκεκριμένον ὕδωρ), but that water is continually forming in it too (349b19–27).

Malcolm Wilson has argued that Aristotle's appeal to condensation is a redundant solution: why should rainwater need to evaporate into vapour, only to condense back into water underground before feeding rivers? On Wilson's reading, the vapour theory here functions only as a superfluous explanatory layer introduced for polemical reasons against the reservoirists.[51] While Wilson is right that Aristotle does not supply decisive evidence for the *necessity* of condensation, I suggest that we can make sense of this account if we approach it through Aristotle's habitual use of biological analogy. River formation, I propose, mirrors digestion:

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[47] The language in the second half of this passage recalls that of *On Youth and Old Age, On Life and Death, On Respiration* 5, where Aristotle describes the motion of exhalation.

[48] The term is borrowed from Wilson (2013) 157.

[49] Wilson (2013) 160 mentions the example in a different context.

[50] Wilson (2013) 161.

[51] Wilson (2013) 162–63.

> Liquid nutriment entering the stomach (pre-digestion) : Rainwater
>
> Production of digestive exhalation : Condensation of rainwater in underground cavities
>
> Digestive exhalation cooled by the brain : Riverwater

The digestive model helps clarify the evaporation-stage. Food, once liquefied in the mouth, enters the stomach in a form still unconcocted and hence dissimilar to the body it is to nourish. It becomes *true* nutriment only through digestion. Similarly, rainwater must be transformed in underground cavities before becoming riverwater. As food becomes blood in the blood vessels and then nutritive exhalation rising to the brain, so rainwater undergoes a process of condensation and cooling, generating a new substance: riverwater.

Immediately after, Aristotle concedes that some rivers may also derive from water merely stored in subterranean cavities. To rule this out completely would be untenable, and he admits that collected water can contribute to river formation, just as small drops gather in the air and add to rainfall (349b27–35). He illustrates this point through another analogy:

> This is proved by facts. When men construct irrigation works (ὑδραγωγίας) they collect the water in pipes (ὑπονόμοις) and trenches (διώρυξι), as if the earth in the higher ground were sweating the water out. Hence, too, the head-waters of rivers are found to flow from mountains, and from the greatest mountains there flow the most numerous and greatest rivers. Again, most springs are in the neighbourhood of mountains and of high ground, whereas if we except rivers, water rarely appears in the plains. For mountains and high ground, suspended over the country like a saturated sponge (οἷον σπόγγος πυκνὸς), make the water ooze out and trickle together in minute quantities but in many places (349b35–350a9).

The comparison with sweating is particularly telling. It emphasises that earth has an *operation* similar to that of a living organism, with mountains functioning like saturated sponges.[52] Here again the biological analogy is crucial. Sweat, for Aristotle, is a περίττωμα – a residue of digestion rather than its true product. Likewise, water that merely collects underground is not the *genuine product* of the rain cycle, but rather a by-product. Still, just as sweating presupposes proper nutrition, collected underground water testifies to the ongoing generative processes of condensation.

This analogy between the *operations* of the earth and those of the living body appears to belong to a broader ancient explanatory framework. Seneca (III 15.1–8, discussed in section 1), for instance, describes a thin, dispersed liquid collected beneath the earth, called ‘sweat’ by water-diviners, exuded by pressure or drawn out

[52] The example of irrigation works (ὑδραγωγίαι) recurs in *PA* III 5.667b34–668a33, where Aristotle uses it to illustrate how blood circulates throughout the body via the blood-vessels. The comparison underscores that blood-vessels are distributed across the entire body and that all regions are nourished because blood is continuously available (cf. the repeated use of πᾶς in the passage). Thus, *Mete* and *PA* are linked through the interconnected notions of irrigation works, blood-vessels and underground ‘veins’ of water.

by heat. The image recalls Aristotle's 'sponge-like' mountains exuding water. Seneca likewise distinguishes two types of underground water: one generated and the other merely collected, the latter being insufficient to explain springs. He also insists, as Aristotle does, that in some cases – such as rainwater – water is not merely gathered but actually produced in the cloud (*NQ* II 26.1). As in Aristotle, the language of nutrition is used to clarify the different stages of subterranean processes.[53] Thanks to this shared biological imagery, the tacit dialogue between Aristotle and Seneca becomes visible.

Analogies of this kind were also central to Lucretius:

> Come now (*Nunc age*),[54] and I will explain (*expediam*) the way in which rainy water (*umor*) condenses high in the clouds (*nubibus*) and then drops as a shower (*imber*) sent down onto the earth. First of all I will not be refuted if I argue (*vincam*) that many particles of water rise up with the clouds (*nubibus*) themselves from all manner of things and thus both the cloud (*nubis*) and whatever water is present in the clouds (*nubibus*) grow together just as in the case of ourselves the body grows at the same pace as blood, sweat and (in a word) whatever moisture is in the limbs at all. The clouds (*nubila*) also often take up a lot of sea-moisture, like fleeces of wool hanging up,[55] when the winds carry the clouds over the great sea. On the same principle moisture is lifted up into the clouds (*nubis*) from all rivers. When the many particles of water, swollen on all sides have gathered to this place in many ways, then the clouds (*nubes*) are stuffed full and strive to emit the water in two different ways: for the force of the wind shoves them together and also the very plenitude of the clouds (*nimborum*) when they have formed a larger crowd than usual exerts pressure and squashes down from above, forcing the showers to poor out. Besides this, when the clouds (*nubila*) thin out with the force of the winds or disintegrate when struck from above the heat of the sun, they discharge their wet rain and drip like wax melting over a hot fire which turns into liquid at a great rate. A violent shower happens when the clouds (*nubila*) are violently assaulted both by the force of their own accumulation and by the attack of the wind. Yet rain tends to hold on for a long time and persist when many particles of water are stirred up and clouds and storm clouds one on the top of another (*aliis aliae nubes nimbique*) are borne along from all directions everywhere showering down from on high and the whole of the smoking earth breathes the moisture back up (*DRN* VI 495–523).

Lucretius here develops a familiar idea already encountered in section 1: particles of water rise into the air and augment the mass of the clouds. As one would expect, he primarily uses *nubes* when discussing rainfall, but he shifts to *nubila* when describing

[53] Seneca similarly draws on the analogy with the living body when explaining his view of the nourishment of the heavenly bodies; see Korobili and Hoffmann (2025).

[54] For the rhetorical use of this phrase, cf. Godwin (1991) 130 n. on 495: 'For the peremptory *nunc age* cf. 1.265, 921, 953, 2.335, 731, 4.110 etc. It is used when passing onto a new topic and is often the prelude to a syllabus such as this one'.

[55] For depictions of clouds as fleeces of wool in Aratus, Varro Atacinus and Vergil, see Godwin (1991) 130 n. on 503–504; Cf. *Syriac Meteorology* 1.25–28.

clouds acted upon by external forces (wind or sun) and to *nimbi* when referring specifically to storm-clouds. This lexical variety mirrors the plurality of forms, colours and functions that ancient observers would have discerned in a cloudy sky.

The progression from *nubila* to *nubes* and then to *nimbi* might suggest to such observers the approach of something fearful or threatening. Yet Lucretius deliberately forestalls such interpretations. He frames his account rhetorically, insisting that the causes of rainfall are entirely natural and should inspire no fear of the supernatural. In this way he casts himself as a skilled expositor whose reasoning cannot be refuted.[56]

The central argument rests on an analogy with the living body: clouds, together with the moisture they constantly absorb, grow just as the body grows together with its humours – blood, sweat, and the moistures that permeate its limbs. On this view, the collection of moisture in clouds is not itself a formative process. However, if the analogy with bodily humours is pressed more strictly, the growth of clouds and the water they contain must imply a formative process analogous to the assimilation of blood and humours in bodily growth – a manifestation of digestion. In meteorological terms, this formative process may be represented by the serial transformation of clouds into storm-clouds, already suggested at the outset of the passage in the transition from *umor* to *imber*.

For Lucretius, then, the living body offers a model for the natural world as a whole. Just as the body functions and grows through the continual incorporation and transformation of humours, so too the cosmos – sea, rivers, winds, sun, earth, and sky – forms an integrated system. The production of rainwater thus reflects a network of natural processes as varied and interconnected as those that govern the body's internal economy.

4. Thunder and Lightning

In *Mete* II 9 Aristotle attributes thunder and lightning to the ejection of the dry exhalation from within clouds. Yet, as he explains, the *efficient* and moving cause of these and other violent phenomena is the moist exhalation.[57] Thunder arises when the dry exhalation, having ascended to the upper region and become confined within a cloud, is expelled under pressure and strikes against adjacent clouds (369a25–29). The ensuing impact produces the sound of thunder, while the fiery ignition of the expelled wind accounts for lightning (369b4–8).

Aristotle's description of thunder and lightning emphasises their sensory manifestations – their audibility and visibility. To clarify the causes of these phenomena, he turns to examples drawn from everyday perception; in the case of thunder, he illustrates his account with the familiar sound of crackling wood. His explanation of thunder reads:

> Now the heat that escapes disperses to the upper region. But if any of the dry exhalation is caught in the process as the air cools, it is squeezed out as the clouds contract, and is forcibly carried on and collides with the neighbouring

[56] Through *vincam* (VI 498) Lucretius evokes the forensic sphere familiar to his contemporaries: his explanation is presented almost as a case to be argued and judged. His meteorological views may thus become a matter of debate, yet he expresses confidence that his argument will ultimately prevail. Cf. Godwin ([1991] 130 n. on 498): '*vincam* is the language of the lawcourts'.

[57] Wilson (2013) 227.

> clouds, and the sound of this collision is what we call thunder. This collision is analogous, to compare small with great (ὡς παρεικάσαι μείζονι μικρὸν πάθος), to the sound we hear in a flame which men call the laughter or the threat of Hephaestus or of Hestia (οἱ μὲν τὸν Ἥφαιστον γελᾶν, οἱ δὲ τὴν Ἑστίαν, οἱ δ'ἀπειλὴν τούτων). This occurs when the wood dries and cracks and the exhalation rushes on the flame in a body. So in the clouds, the exhalation is projected and its impact on dense clouds causes thunder: the variety of the sound (παντοδαποὶ δὲ ψόφοι) is due to the irregularity of (διὰ τὴν ἀνωμαλίαν) the clouds and the hollows that intervene (διὰ τὰς μεταξὺ κοιλίας) where their density is interrupted. This, then, is thunder, and this its cause (369a25–b4).

Once again, Aristotle illustrates the meteorological phenomenon through psychosomatic expressions – such as laughter and threat – associated with the living, active body. He employs the same phraseology we have encountered before in his analogical comparison between the microcosm and the macrocosm, drawing a parallel between the sound of thunder and the cracking of ignited wood.[58] This, in turn, he elucidates by referring to what people say when they hear such sounds – namely, that they identify them as 'the laughter or the threat of Hephaestus or of Hestia'. The fact that this saying originates in popular opinion cautions us not to press the discussion too far. We do not have much contextual evidence to work with. To Aristotle's readers, however, such a reference might have been readily familiar. Both Hephaestus and Hestia were widely venerated among the Greek deities, despite not being highly esteemed by the other Olympians – for different reasons. At the same time, both are directly associated with fire: the former as the divine blacksmith, and the latter as the guardian of the hearth – the vital centre of household and family life – in the Olympian order. To the modern ear, however, this reference may seem of limited value for identifying the sound of thunder.

Thunder was regarded primarily as a fearful phenomenon. Thus, the text likely refers to a type of laughter that provokes fear – either mocking laughter or cruel laughter. The former, in particular, is one of the most commonly attested forms of laughter among the Olympian gods and an expected response to reproachful behaviour – one that evokes the fear of public derision within the early Greek society of shame.[59] The subsequent explanation in the text, likening the sound to a 'threat', follows the same interpretive path, suggesting sounds that elicit fear. There is no indication of gender differentiation here: both male and female laughter – boisterous

[58] Both Lucretius and Seneca make use of the sound of cracking when describing thunder. In a passage where Seneca reports different kinds of thunder according to the classifications of others (*NQ* II 27), he refers to a type that is harsh (*acre*) and sharp (*acerbum*), like the sound produced when a bladder is burst over someone's head; he adds that it should be called a crack (*crepitum*) rather than a mere noise. Here *crepitus* is associated with the sound of a bursting bladder rather than with the sound of burning wood, which appears in Aristotle's explanation. Lucretius likewise uses *crepito* to describe the sound of the blazing laurel of Phoebus and, correspondingly, the 'terrible' (*terribili*) sound of thunder (*DRN* VI 150–155). Godwin ([1991] 106 n. on 154–155) draws attention to the Lucretian structure of the passage: 'The word order in 155 is deliberate and effective: the fear then the immediate cause of it (the sound), then the cause of the sound (the flame), then a wonderfully onomatopeic word to describe the crackling itself and finally the alliterative *crematur* to round off the line with a touch of finality'. Cf. Garani (2007) 143–44.

[59] See e.g. Brown (1989); Dillon (1991); Lomiento (2021).

and resonant – are portrayed as equally suited to convey the pitch and loudness of thunder. How, then, are we to evaluate this popular denomination within Aristotle's scientific framework?

It is important to observe that, according to this passage, it is Aristotle – not ordinary people – who establishes the connection between the collisions of clouds and the laughter or threat of the two deities, mediated through the example of burning wood. What purpose does this serve? Is it merely an instance of learned display? I would argue that Aristotle's reference to this aspect of popular understanding is both strategic and didactic. It serves an anchoring function: it incorporates a familiar, traditional analogy – linking the sound of burning wood to divine laughter or threat – into a new, natural-philosophical context, thereby enabling Aristotle to repurpose its implications for his readers. The aim, in my view, is to draw the reader's attention to a widespread yet mistaken belief – that meteorological phenomena manifest divine presence or the wrath of the gods. Aristotle is intent on dispelling this interpretive tendency by demonstrating that natural phenomena have natural causes, explicable through reason and observation rather than supernatural agency. Natural philosophers of later times who engaged with meteorological topics – such as Lucretius and Seneca – shared similar concerns and adopted the same methodological approach.

The folk saying under examination is attested once more in the extant literature – as far as we know – this time in Theophrastus' *On Fire* 69:[60]

> ὡσαύτως δὲ καὶ τὰ ξύλα καιόμενα τὰ μὲν ῥήγνυται καὶ πηδᾷ, τὰ δὲ συνεχῆ ποιεῖ τινα ψόφον (καλοῦσι δ'οἱ μὲν γελᾶν τὸν Ἥφαιστον, οἱ δ'ἀπειλεῖν).
>
> The same happens in burning wood: in some case they burst forth and leap, in other case they produce a continuous sound (hence some call this Hephaestus' laughter while others Hephaestus' threat).

Formulated upon an antithesis between two opposing psychosomatic expressions – *laughter* and *threat* – of the same god, Hephaestus, and reinforced by Theophrastus' chosen linguistic structure, the parenthetical folk saying now appears slightly more informative. First, it occurs outside a meteorological context. This constitutes further evidence that Aristotle deliberately selected this familiar example to anchor his own meteorological explanation of thunder, thereby introducing a novel connection. Second, by omitting any mention of Hestia, the Theophrastean version directs the reader's attention not toward the individual deities themselves, but rather toward the *sound* – the acoustic analogy between psychosomatic manifestations (such as non-verbal vocal expressions) and natural phenomena, specifically the sound of cracking. Finally, although burning wood may produce a variety of sounds – a parallel, once again, with Aristotle's remark on the diverse sounds of thunder in the passage cited above – Theophrastus' audiovisual image clearly distinguishes between two types: one, a leaping sound identified with laughter; the other, a continuous, monotonous sound identified with threat. If we assume that Aristotle had these two types of sound in mind when formulating his account of thunder, we can appreciate the explanatory

[60] The text of *On Fire* is taken from Coutant (1971), the translation is my own.

power of a familiar expression once it is recontextualised within a new verbal and theoretical framework.

Let us now turn to the example Aristotle introduces in order to explain lightning and discuss it briefly. This passage immediately follows his description of thunder quoted above:

> It usually happens that the wind that is ejected is inflamed and burns with a thin and faint fire: this is what we call lightning, where we see as it were the exhalation coloured in the act of its ejection. It comes into existence after the collision and the thunder, though we see it earlier because sight is quicker than hearing. The rowing of triremes illustrates this: the oars are going back again before the sound of their striking the water reaches us (369b4–11).

Even without knowledge of the Presocratic accounts (Empedocles, Anaxagoras) that interpreted lightning as the cause of thunder – and therefore as preceding it – the reader of this passage could infer that detail independently, given Aristotle's (erroneous) insistence on the actual sequence of the two phenomena.[61] As evidence for his claim, he appeals to the temporal difference between human auditory and visual perception, which he corroborates through a vivid analogy drawn from the rowing of triremes: the eye perceives the oars moving backward before the ear registers the sound of their striking the water.[62]

Although this example is neither strictly technical nor purely biological, it is instructive in two important respects. First, it challenges readers unfamiliar with Aristotle's theories of sight and hearing to explore them further; in this sense, the analogy serves a didactic function. Second, it introduces a dynamic image that centers on the active, healthy, and coordinated movement of human bodies – the oarsmen in motion.

In *DRN* VI 96–422, Lucretius displays his mastery in portraying what appear to be the most terrifying celestial phenomena: thunder, lightning and thunderbolts. At the opening of book VI, Epicurus is exalted as the liberator of souls – the one who dared to dissolve the thick clouds of fear that shroud the human mind. Lucretius echoes the Epicurean proclamation: the observation of nature and the flame of reason are the only weapons capable of dispelling the poison of dread (VI 39–42).

Although after v. 47 the reading becomes difficult due to a lacuna in the manuscripts, the truncated passage that follows still bears the mark of Epicurean consolation. Here, Lucretius' poetry functions as a form of catharsis: in nature, the storm subsides into calm (VI 48–49; see p. 36 above). Likewise, the reader of the poem may infer that the turmoil of the soul can give way to serenity. Whoever contemplates this natural harmony and grasps its meaning will no longer yield to irrational terror, nor attribute the violent workings of the sky to divine wrath.

In his accounts of thunder, lightning and thunderbolts, Lucretius refrains from employing elaborate biological analogies. Yet, as will soon become evident, the living

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[61] See Irby (2021) 94.

[62] Lucretius also adopts the traditional view that visual stimuli reach us before auditory ones and illustrates it with a different analogy from that found in Aristotle, namely the cutting of a tree trunk (*DRN* VI 167–170). Seneca, by contrast, maintains that thunder is produced simultaneously with lightning flashes and lightning bolts, but is heard later than either phenomenon (*NQ* II 12.1).

body remains a crucial hermeneutic instrument. When the poet begins his presentation of these three dreadful phenomena, he programmatically announces his pedagogical intent: he will sing of them, and through his verse – an embodiment of reason itself – he will cast light upon the darkness of ignorance. As it turns out, this didactic journey is by no means an emotionally tranquil experience for the reader. Lucretius seems to pursue quite the opposite effect: to expose his audience to overwhelming, visceral depictions of natural forces, with the ultimate aim of neutralising their existing fear before impending cosmic upheavals. The emotional transition from terror to *ataraxia* can occur only through direct exposure to images brimming with energy and awe – images even more fearsome than those encountered in the natural world. In doing so, Lucretius seeks to shake both body and soul. From his verses arise skies torn asunder, thunders that shake the earth, flames that pierce the heavens. His sounds are sharp and almost inhuman – a music of terror that does not dispel fear by denial, but rather exorcises it through confrontation.[63] Thus, Lucretius transforms reason into aesthetic experience: poetry itself becomes both the instrument of liberation and the site of humanity's confrontation with the dreadful face of nature.

The language describing clouds, winds and thunder is saturated with corporeal and affective vocabulary: clouds 'run together' (*concurrunt*, VI 97) and align 'in battle order' (*agmine*, VI 100) as the winds 'fight against each other' (*contra pugnantibus*, VI 98). The sky becomes a living organism whose movements are not mechanical but animated by conflict and emotion. This rhetoric of vitality reaches a striking intensity in VI 108–113, where the poet compares the tearing sound of clouds to the rending of a theatre awning flapping in the wind. The simile, as noted by Godwin, evokes the imagery of human frenzy and lamentation: terms such as *furit* and *petulantibus* convey rage, madness and the violent gestures of grief.[64] Through this anthropomorphic lexicon, Lucretius transforms a meteorological process into a scene of bodily suffering and affective excess – an instance of what has been aptly termed his pathetic fallacy. The same rhetoric of conflict and violence reappears later in the description of thunderbolts, which can set houses on fire like an invading enemy who storms a building and makes himself master within (VI 223–224). The destructive force of the thunderbolt is further elaborated in VI 239–245. Lucretius depicts thunderbolts as capable of shattering towers with a single blow, unseating houses, tearing out beams and timbers, opening tombs and striking down humans and flocks alike.

This persistent recourse to imagery drawn from warfare and bodily devastation also prepares the ground for Lucretius' emphasis on the embodied experience of the observer. Verbs of perception such as *videntur* (VI 121), *videas* (168), *cernas* (169) and *cernimus* (170) anchor the cosmic spectacle within human sensorial experience. Thunder and lightning are not abstract phenomena but events apprehended through sight, sound and fear – Lucretius' visual metaphors dramatise the cognitive gap between enlightened understanding and the terrified imagination of the unlearned. The same logic governs his account of the lightning's violence, where 'wet clouds act as slaughterers' (*continuo magno clamore trucidat*, VI 147): the collision of fire and

[63] See e.g. *DRN* VI 217–218, 223–224, 254, 256–268, 269–270, 286–289 and Godwin's (1991) comments ad loc.

[64] Godwin (1991) 102 n. on 111; cf. 120 n. on 367.

moisture evokes Homeric scenes of bodily pain, such as the blinding of Polyphemus in *Odyssey* 9.391–393.[65] Finally, in his description of the 'vaulted halls' of the sky (VI 196–200), the winds themselves acquire animal vitality: they growl, pace, and search for escape like beasts confined in a cage.[66] Through this recurrent strategy of bodily analogy, Lucretius' cosmic theatre fuses physical explanation with the rhetoric of affect, transforming natural processes into a drama of animated matter and emotional resonance.

Seen from this perspective, the discussion of thunder and lightning in Seneca invites comparison with that of Lucretius.[67] Both philosophers produce remarkably vivid descriptions that combine natural explanation with highly evocative language capable of holding the reader's attention and engaging the emotions. At the beginning of book II of *NQ*, Seneca introduces a distinctive rhetorical framework that establishes the conceptual basis for his subsequent investigation of these phenomena. Before turning to meteorological explanation, he articulates a vision of the cosmos structured according to the biological analogy: the world is conceived as an integrated body whose components relate to one another as parts and matter within an organism (II 3–6). This conceptual move is not merely explanatory but programmatic, preparing the reader to accept atmospheric phenomena as integral elements of the cosmic system.

Seneca begins by distinguishing between those things that are parts of the world and those that function as matter. To clarify this distinction, he draws on the human body: eyes, hands, bones and nerves are parts, whereas the nutritive substance derived from recently consumed food represents matter that will become part of the organism. Blood, occupying an intermediate position, is described as a quasi-part because it both constitutes the body and continuously renews it. The biological analogy is further extended through Seneca's discussion of quasi-parts, such as individual animals and trees. While particular organisms may perish, the genera to which they belong remain integral to the universe as a whole. The analogy emphasises processes of nourishment, integration and internal coherence, presenting the cosmos as a dynamic and unified body rather than a collection of discrete elements.

Within this framework, air occupies a crucial position.[68] Seneca identifies it as a necessary part of the world that simultaneously separates and connects heaven and earth. The language he employs – air links, divides and transmits forces – underscores its mediating function within the cosmic organism. This perspective becomes especially significant for the study of thunder and lightning. If air is a constitutive part of the cosmic body, then the events that occur within it must likewise belong to that body. In other words, thunder and lightning are not accidental disturbances but manifestations of the functioning of one of the universe's essential components. Seneca's rhetorical strategy thus expands the scope of natural inquiry: phenomena that

[65] Godwin (1991) 105–106 n. on 148–149; *id.* 6–7.

[66] Cf. Godwin (1991) 109 n. on 197–200 with bibliographical references; Garani (2007) 104–105. Similarly, Seneca explains (*NQ* II 27.1) that one kind of thunder occurs when wind trapped within a cloud produces a roaring noise reminiscent of an animal.

[67] See the particularly helpful discussion in Althoff (2005).

[68] 'Der Grund dafür ist night nur, dass die betrachteten meteorologischen Phänomene sich im Luftraum abspielen (wie Seneca selbst 11, 3 sagt), sondern auch das Faktum, dass die Luft für das physikalische Weltverständnis der Stoa ein zentrales Element ist' (Althoff [2005] 24).

might otherwise appear episodic or marginal are reinterpreted as integral expressions of cosmic structure.

As he moves into the detailed discussion of thunder and lightning,[69] Seneca continues to employ biological analogies to clarify and illustrate his points. In a playful vein, he describes lightning flash as 'a threat and an attempt that fails to strike home' and lightning-bolt as 'a throw that does strike home' (12.1). This recalls Aristotle's innovative description of the sound of thunder (discussed above), although the two philosophers use the notion of a 'threat' to describe distinct, if related, meteorological phenomena. After reviewing earlier theories, Seneca reports Aristotle's account (*NQ* II 12.4–6), including the example of burning woods, while omitting Aristotle's illustration involving laughter.[70] This selective adoption suggests that Seneca does not accept Aristotle's double-level analogy – linking the sound of thunder to both the sound we hear in a flame and the divine threat – either because it complicates his account unnecessarily or because it lacks scientific relevance.[71]

In II 15, Seneca compares clouds to a hand assisting a blade in cutting, thereby evoking a model of differentiated agency projected onto the sky. Just as the hand enables the action without being the primary agent, the clouds and their resistance (cf. *pugna*, 15.1) function as contributory elements in the production of fire (lightning), while the decisive power lies in the nature of air itself. This example of hands also informs his explanation of the difference between a lightning-flash and a lightning-bolt (II 16). The image of water held in two cupped hands and forced out by pressing the palms together introduces a quasi-physiological model of pressure and expulsion: the hands form a temporary cavity and the force produced by compression drives the fluid outward. Seneca transfers this bodily mechanism to the sky, imagining two clouds pressed together so that the breath trapped between them is violently expelled and ignited. The comparison with military machines (ballistas and scorpions) further intensifies the imagery of force and propulsion, yet the bodily analogy remains central, grounding the phenomenon in familiar experience.

The example of hands, together with that of a bladder, is Seneca's favourite for explaining the sound of thunder as well. In II 27.3–4 and 28.1–2, he repeatedly turns to familiar bodily actions – hands clapping and a bladder bursting – to illustrate how noise is generated in the sky. The analogy with hands is particularly instructive: just as a clap occurs only when palms strike each other in a certain manner, the production of thunder depends on the specific way clouds collide and compress the air within them. Similarly, a bladder inflated with breath and then burst rather than cut demonstrates that the sudden release of compressed air produces a loud sound.

The second book of *NQ* closes as strikingly from a rhetorical point of view as it begins. This is not only due to the choice of the concluding theme, in which Seneca addresses the ever-relevant issue of the fear of death. More importantly, in my view, it lies in the way he introduces this thematic conclusion by addressing his interlocutor: 'I know what you have long been waiting for'. Seneca shows his interlocutor that he

[69] For the structure of the book and its division into two 'scientific sections', see Hine (2012).

[70] According to modern scholarship, Aristotle's theory is presented with reasonable accuracy in most of its details (Hall [1977] 410–12; Williams [2012] 299, 301, 309–11).

[71] Notably, he introduces the explanation of the flame-analogy, despite it being readily intelligible to a lay person.

is not merely offering philosophical advice; rather he demonstrates his ability to place himself in the addressee's position, indicating that he understands what his reader needs. 'I would rather', Seneca says in the voice of the addressee, 'not be afraid of lightning-bolts than understand them'. […] 'I want to have my fear of them dispelled, not their nature explained' (II 59.1).

At the end of an extensive discussion of thunder and lightning – one that encompassed theory, empirical observations, doxographical accounts and Seneca's own position – Seneca attempts, more rhetorically than theatrically, to incorporate even the most reluctant addressee, to engage even the most impatient or superficial reader and to convey his message even to those who may not have fully grasped his preceding analysis. He does so first by expressing sympathy, without reproaching his addressee for possible ignorance or haste. Even specialists capable of understanding the teachings of natural philosophy and of pursuing such investigations themselves, he suggests, still need to strive for tranquillity of mind and moral strengthening:

> I obey your summons; for every topic, every conversation, should contain something that furthers our well-being. […] our mind must be set free from its ills and constantly strengthened. This is essential even for experts who devote themselves exclusively to this pursuit (II 59.2).

Not by chance, shortly thereafter this sympathy turns into irony: 'How foolish you are, how forgetful of your fragility, if you fear death only when there is thunder!' Yet the irony here does not signal malice or condescension toward the addressee. Rather, Seneca is playing his final card, attempting to shake his interlocutor as if struck by a thunderbolt. Dispelling fear of natural phenomena will bring us one step closer to the contempt of death; but this requires, first, that we recognise our fragility and accept out mortal and limited nature.

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Academy of Athens

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Aristoxenus and the Rhetoric of *Pragmateia*

Konstantinos Stefou

Abstract
Among the Peripatetics, Aristoxenus occupies a distinctive place as a philosopher and music theorist. While best known for his *Harmonics*, his surviving works reveal a complex awareness of method, rhetoric, and pedagogy. Central to his intellectual project is the notion of *pragmateia*, a term that straddles both the process of systematic treatment and the subject matter of inquiry itself. Aristoxenus deploys this concept not only descriptively, but also polemically and pedagogically, in ways that serve to construct his intellectual authority, distinguish him from his predecessors, and guide his students or readers. This paper argues that Aristoxenus' *Harmonics* can be read as an extended exercise in the rhetoric of *pragmateia*.

Introduction: The Concept of *Pragmateia*

In modern Greek, the word πραγματεία is usually defined as any original, mostly formal, written and extensive scientific work or research on a subject, distinguished by its systematic exposition and thorough analysis. Certainly, this understanding can already be traced back to Plato, for instance in the *Gorgias*, where πραγματεία is used to denote serious or sustained engagement with rhetoric. Nevertheless, the ancient Greek word πραγματεία has a broader semantic range than its modern equivalent. In Classical and Hellenistic usage, it can refer not only to a written treatise but also to the very act of engagement or pursuit, whether intellectual, political, or practical. In Aristotle, the term increasingly functions as a technical marker for the systematic treatment of a subject, appearing in self-referential and methodological reflections across his corpus. For the Peripatetics, πραγματεία thus acquired both descriptive and programmatic force: it named the orderly exposition of a science and simultaneously prescribed the standards by which such exposition should be judged. By the time of Aristoxenus, the concept had accumulated significant semantic and methodological weight, ready to be redeployed in new contexts. What follows will argue that Aristoxenus' *Harmonics* offers a distinctive version of this tradition: a rhetorical performance of *pragmateia* that blends Peripatetic method with polemical and pedagogical strategies.

Part I – Aristoxenus: Life, Importance, and Rhetorical Competence

Aristoxenus of Tarentum (fl. late 4th century BCE) occupies a central place in the history of ancient musical thought. A native of southern Italy and initially formed within a cultural milieu shaped by Pythagorean musical theory, Aristoxenus later became a pupil of Aristotle in Athens and was closely associated with the Peripatetic school.[1]

[1] On Aristoxenus' biography and intellectual background, see Macran (1902) 86–93; Laloy (1904) 1–42; Barker (1989) 119–25; Pöhlmann (2020).

This intellectual background gave him a distinctive vantage point: on the one hand, he engaged critically with the speculative and mathematical concerns of earlier harmonicists, especially the Pythagoreans; on the other, he absorbed from Aristotle a commitment to systematic inquiry, perceptually grounded investigation, and methodological rigor. The convergence of these traditions is most clearly evident in his *Harmonics*, the earliest surviving systematic attempt to present music theory as a coherent scientific discipline rather than as a collection of ad hoc observations or isolated doctrines.[2]

Aristoxenus' importance as a musical theorist lies not only in the technical details of his system – such as his treatment of the genera, intervals, and scales – but also in his methodological stance. Unlike many earlier harmonicists, especially those working within the Pythagorean mathematical tradition, Aristoxenus insisted that the starting point of harmonics must be perception (*aisthēsis*), guided but not dominated by reason (*logos*).[3] This orientation did not entail abandoning theory; rather, it involved rethinking the proper relationship between observation and explanation. In doing so, Aristoxenus effectively redefined what it meant to engage in a *pragmateia* of music: a sustained, systematic, and pedagogically effective inquiry that balanced descriptive adequacy with rational structure. His influence was considerable, shaping later Greek musical theory and, indirectly and through mediation, aspects of medieval and Renaissance thought.[4]

At the same time, Aristoxenus deserves attention as a stylist and rhetorician of scientific prose. His *Harmonics* is not a neutral repository of facts but a carefully crafted discourse that addresses an audience of students and critics alike. He frequently situates himself against earlier writers, exposing their errors in order to justify his own approach, and he draws attention to the clarity, adequacy, and fittingness of his exposition. In adopting these rhetorical strategies, Aristoxenus reveals his awareness that scientific writing is not merely about transmitting knowledge but also about legitimizing a method and securing assent to its principles. His competence as a rhetorician thus forms an integral part of his contribution as a theorist: by shaping harmonics into a genuine *pragmateia*, he not only reoriented the study of music but also demonstrated how scientific discourse itself could function as a medium of authority, persuasion, and intellectual identity within the Peripatetic tradition.

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[2] Cf. Macran (1902) 89; Barker (1978) 9–16; Barker (2007) 229. On the structure of this work and the question whether the whole of the surviving text originally belonged to the same treatise, see da Rios (1954) cvii-cxvii; Barker (2007) 113–35; Bélis (1986) shows that Aristoxenus' *Harmonics* should be understood as a coherent treatise with a deliberate structure, not merely a set of later-bound fragments.

[3] Cf. Barker (1978); Mathiesen (1999) 321–22; Barker (2007) 167–75; Levin (2009) 241–95; Rocconi (2020) 158–66.

[4] See e.g. Mathiesen (2002) 109–35, who notes that Greek technical harmonics continued to be read and valued because parts of the tradition – including Aristoxenian material – were carried into the Latin West by medieval writers, and that interest was sustained throughout the Middle Ages; Bower (2002) 136–67, who discusses the wider integration of Greek music theory (including harmonic concepts) into medieval intellectual life; and Palisca (1993), who specifically focuses on how Aristoxenian concepts were rediscovered, interpreted, debated, and often reintegrated into Renaissance music theory.

Part II – The Semantics of *Pragmateia*

The Greek term *pragmateia* bears a productive ambiguity in Aristoxenus' usage. On the one hand, it refers to the process of treatment – the methodological unfolding of an argument or discipline; on the other, it denotes the object of treatment itself, a particular science or subdivision of knowledge. Aristoxenus moves fluidly between these senses, allowing procedure and object to illuminate one another. This oscillation sharpens his critique of earlier approaches while presenting his own *pragmateia* as at once more comprehensive and more rigorously articulated than those of his predecessors.

Part III – Book I: What is the Harmonic *Pragmateia*?

In the opening sections of Book I Aristoxenus establishes what is called the *harmonic pragmateia* – the systematic treatment (πραγματεία) of harmony – as a distinct and necessary part (μέρος) of the broader science concerned with melody (*peri melous*).

> Τῆς περὶ μέλους ἐπιστήμης πολυμεροῦς οὔσης καὶ διῃρημένης εἰς πλείους ἰδέας μίαν τινὰ αὐτῶν ὑπολαβεῖν δεῖ τὴν ἁρμονικὴν καλουμένην εἶναι πραγματείαν, τῇ τε τάξει πρώτην οὖσαν ἔχουσάν τε δύναμιν στοιχειώδη.
>
> The science concerned with melody has many parts and is divided into several species, of which the study called Harmonics must be considered one: in order it is first, and its character is like that of an element (1, 5.4–7 da Rios). (trans. Barker [1989])

The *harmonic pragmateia*, then, is not an isolated manual or collection of observations but a constituent form within a more comprehensive intellectual enterprise. It occupies, within the science concerned with melody, a place analogous to that of a species within a genus: it has its own subject matter, purpose, and method, yet it remains defined by its relation to the total science of melody.

For Aristoxenus, to be proficient in the harmonic science means not simply to have familiarity with musical practice, but to possess a distinct and specialized form of knowledge – one that concerns itself precisely with the theory of *systēmata* and *tonoi*.

> […] ταῦτα[5] δ' ἐστὶν ὅσα συντείνει πρὸς τὴν τῶν συστημάτων τε καὶ τόνων θεωρίαν. προσήκει γὰρ μηθὲν πορρωτέρω τούτων ἀξιοῦν παρ' αὐτοῦ τοῦ τὴν εἰρημένην ἔχοντος ἐπιστήμην.
>
> […] which include whatever is relevant to an understanding of *systēmata* and *tonoi*. The man who is proficient in this science should not consider anything beyond these as falling within his province (1, 5.8–11 da Rios). (trans. Barker [1989])

The goal (*telos*) of the harmonic *pragmateia* is therefore limited and clearly defined: it is to grasp, and to articulate, what pertains to the understanding of musical structures and tonal relations. Any further knowledge lies beyond its proper scope, and should not be demanded of one who possesses this science. Consequently, the reader should

[5] Following Macran's 1902 text here rather than da Rios (ταύτης). Cf. Barker (1989) 126 n. 2; Gibson (2005) 185 n. 49.

not expect the harmonic *pragmateia* to encompass domains that belong to higher or more comprehensive forms of musical understanding.

> τέλος γὰρ τοῦτό ἐστι τῆς πραγματείας ταύτης. τὰ δ' ἀνώτερον ὅσα θεωρεῖται χρωμένης ἤδη τῆς ποιητικῆς τοῖς τε συστήμασι καὶ τοῖς τόνοις οὐκέτι ταύτης ἐστίν, ἀλλὰ τῆς ταύτην τε καὶ τὰς ἄλλας περιεχούσης ἐπιστήμης, δι' ὧν πάντα θεωρεῖται τὰ κατὰ μουσικήν. αὕτη δ' ἐστὶν ἡ τοῦ μουσικοῦ ἕξις.
>
> For that is the end of this branch of study. Matters investigated at a higher level, where the science of composition makes use of *systēmata* and *tonoi*, no longer belong to this science, but to the one which includes both this and the others through which all musical matters are investigated: and that is the science whose possession makes a man a musical expert (1–2, 5.11–6.5 da Rios). (trans. Barker [1989])

In articulating this restriction with exemplary precision, Aristoxenus does not merely describe a thematic limitation but formulates a methodological principle: each inquiry must remain within the bounds of its proper object. This disciplinary restraint stands in contrast to those earlier theorists who, while claiming to treat harmony, confined themselves to a single genus and neglected the rest. Such inquiry, Aristoxenus suggests, is partial and therefore inadequate to the nature of the whole.

Part IV – Aristoxenus' Critique of Earlier Thinkers and the Ideal of Complete Treatment

From the outset of his *Harmonics*, Aristoxenus defines his project in relation to a past he simultaneously inherits and repudiates. His predecessors, he observes, had produced only fragments of what should have been a complete and coherent *pragmateia*, pursuing questions in isolation and without order. This lack of completeness is not a trivial shortcoming but a failure of method and disciplinary rigor. For Aristoxenus, the integrity of a *pragmateia* depends on its wholeness: it must extend from first principles to conclusions, linking every stage of reasoning in an ordered and continuous discourse.[6]

At several points, he insists that no serious treatment can begin from chance assumptions or arbitrary starting points.[7] Every inquiry must possess its own *archai* – its proper foundations. The true harmonic scientist, therefore, must be capable of defining what his predecessors could not[8]: he must identify the first principles that underlie the structure of melodic systems and intervals. These principles are not secured through authority or unexamined postulation, but through systematic

[6] Cf. Arist. *Physics* I 1.184a12–14; Mathiesen (1999) 303.

[7] See e.g. I.7, 12.12–16 da Rios: 'Certain of the harmonicists have briefly touched on this part of the science, quite accidentally, while not actually addressing themselves to this matter, but seeking to compress (*katapyknōsai*) the diagram; but to put it generally, not one of our predecessors has left us a clear account of it' (trans. Barker [1989]); and I.10–11, 15.18–16.2 da Rios: 'It might seem odd to those who consider these matters superficially that we are positing four items here and not two: most people, at any rate, say that tension is the same as height and relaxation the same as depth. Hence it is perhaps worth one's while to be shown that their views about these things are confused. We should seek to understand this by looking at what exactly the occurrence is that we bring about when, in the process of tuning each of the strings, we relax or tense them' (trans. Barker [1989]).

[8] See e.g. I.3, 7.16–8.5; I.27, 35.9–10; II.35, 44.12–14 da Rios.

reasoning continuously supported and tested by perception (*aisthēsis*)[9]. Aristoxenus repeatedly stresses that harmonic theory, although grounded in hearing[10], is nonetheless a rational science that demands logical coherence and methodological rigor.

Against this background, Aristoxenus' critique of earlier theorists takes on the character of a programmatic intervention. He charges them not only with technical errors but with serious methodological shortcomings. Their inquiry was inadequate to the nature of the subject, because they failed to treat it as a whole and thereby fell short of providing a comprehensive understanding of the discipline. Their writings consisted of isolated remarks rather than a continuous discourse – some having written about one part of the subject, others about another, but none having composed a complete *pragmateia*.

This critique closely parallels Aristotle's own rhetorical prefaces in the biological works, especially *Parts of Animals* I.1, where he reproaches previous investigators for having produced a patchwork of disconnected observations rather than a systematic study. By framing his project through a similar rhetorical strategy, Aristoxenus signals his intention to present harmonics as a rigorously organized scientific inquiry. His treatise, like Aristotle's zoological writings, thus combines theoretical exposition with polemical correction: the author situates himself within an established lineage of investigation while defining his originality through a claim to methodological completeness.

The ideal of completeness thus functions as a regulative standard within Aristoxenus' rhetoric of *pragmateia*. It defines, for him, what it means to write scientifically within the domain of harmonics. Only a discourse that proceeds from

[9] Strong textual evidence for the importance of perception as a criterion in Aristoxenus is attested in the following passages: 'Let us not be disturbed by the opinions of those who reduce notes to movements, and who say quite generally that sound is movement, as though we should be obliged to say that it sometimes happens that movement does not move, but is stationary and at rest […] We shall say, none the less, that the voice stands still when perception exhibits it to us not setting off towards the high or the low; and all we are doing is attaching this name to that sort of qualification of the voice' (I.12, 17.4–8 and 17.10–14 da Rios; trans. Barker [1989]); 'We try to give these matters demonstrations which conform to the appearances, not in the manner of our predecessors, some of whom used arguments quite extraneous to the subject, dismissing perception as inaccurate and inventing theoretical explanations […] Their accounts are altogether extraneous, and totally in conflict with the appearances; Others delivered oracular utterances on individual topics, without giving explanations or demonstrations, and without even properly enumerating the perceptual data; We, on the other hand, try to adopt initial principles which are all evident to anyone experienced in music, and to demonstrate what follows from them' (II.32–33, 41.17–21 and 42.2–7 da Rios; trans. Barker [1989]). With regard to this latter passage, cf. also Barker (1989) 150 n. 12: 'This neatly summarises Aristoxenus' methodological outlook. The initial principles must be accepted without demonstration (this is often insisted on in Aristotle's *Post. An.*, e.g., 72b5ff.). They are abstracted from perceptual experience ("evident" in this sentence translates *phainomenas*, whose full sense here is probably "perceptually evident"), not however that of just anybody, but of people whose perceptual discrimination has been trained to accuracy. (Cf. 33.9–26. On the process of abstraction or "induction" see Arist. *Post. An.* 99b15ff., cf. 88a2–5.) Their truth is also to be checked against perceptual experience, not against metaphysical postulates or scientific hypotheses about the causes of experience. What can be demonstrated from them, however, must be so demonstrated, and thus displayed in its proper relation to the unified nature of melodic attunement, if it is to count as scientifically understood: cf. Arist. *Post. An.* 71b16ff., 76a33–4'.

[10] See e.g. II.33, 42.10–11 and II.34, 44.5–6 da Rios. On the roles to be assigned to perception and to reason, see Barker (1989) 150 n. 13.

proper principles to their consequences, that orders its topics in a continuous sequence, and that avoids fragmentary treatment can claim the title of a genuine *pragmateia*. To fall short of this is to fail the subject itself, and – by implication – the reader, who is deprived of a full and transparent account of the reasoning involved. In this way, Aristoxenus appears to align methodological rigor with a notion of intellectual justice: completeness of treatment becomes not merely an epistemic demand but a normative requirement governing how inquiry ought to be conducted.

This Aristoxenian ideal aligns closely with broader Peripatetic conceptions of scientific writing. The notion that a scientific discipline must be articulated through a continuous and ordered *logos* reflects a philosophical conviction shared with Aristotle[11]: that genuine knowledge requires systematic exposition rather than the accumulation of isolated claims. In his critique of predecessors, Aristoxenus thus enacts the performative dimension of *pragmateia*. By denouncing partial and disordered approaches, he simultaneously models the rhetorical and logical order that, for him, defines legitimate scientific authorship.

Part V – On Method: Definitions, Precision, and the *Epagōgē*

At the core of Aristoxenus' *Harmonics* lies an explicit concern with method[12]. Unlike his predecessors, Aristoxenus insists that every inquiry must begin with properly established definitions and proceed by ordered reasoning.[13] Method, for him, is not a formal accessory but the very criterion of scientific legitimacy. A discourse that lacks method is, strictly speaking, not a *pragmateia* but an assemblage of opinions.

This methodological orientation is visible throughout the *Harmonics.* For Aristoxenus, inquiry begins from what is immediately evident to perception and musical experience, and proceeds toward systematic explanation. This structure is fundamental to his scientific rhetoric. Aristoxenus rejects the view that harmonics consists merely of empirical rules drawn unreflectively from musical practice. Instead, he conceives it as a systematic science that must proceed from clearly articulated definitions of its fundamental concepts – such as tone, interval, system, and genus. Without such definitions, grounded in and answerable to perception, no genuine demonstration (*apodeixis*) is possible.

Aristoxenus insists on two forms of precision (*akribeia*): the accuracy of perception and the rigor of reasoning.[14] Both are indispensable. Hearing provides the material of harmonic inquiry, while reasoning confers order, coherence, and necessity. This dual demand closely parallels, though it does not simply replicate, Aristotelian accounts of scientific knowledge in which perception supplies the data that reason organizes into systematic understanding. In harmonics, Aristoxenus thus treats *aisthēsis* and *logos* as complementary rather than opposed faculties.

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[11] On the idea that Aristoxenus' *Harmonics* is best understood as a consciously Aristotelian scientific project, even though it departs in important ways from Aristotle's own model of demonstrative science, see Barker (1991). Cf. also Bélis (1986).

[12] For the claim that Book II is more 'methodological' in character, in that it is largely concerned with methodological matters, see Barker (1989) 148 n. 1, and passim.

[13] See n. 8 above.

[14] See e.g. II.33, 42.22 da Rios (accuracy of perception); I.3, 7.21–22 and I.27, 35.9–10 da Rios (rigor of reasoning).

For Aristoxenus method involves both the correct use of the senses and disciplined reasoning. He insists that one must first learn to hear correctly, stabilizing perceptual judgment of intervals, before proceeding to theoretical articulation. The transition from perceptual discrimination to general harmonic principles is described by Aristoxenus as an *epagōgē*[15], a guided and ordered progression that leads the learner from experience to systematic understanding, without invoking a noetic grasp of universals.

Aristoxenus differs from his Peripatetic background in one crucial respect. Whereas Aristotle denies perception any principial role in scientific knowledge, assigning first principles to intellect (*nous*), Aristoxenus grants hearing a quasi-principial status within harmonics. The *archē* of harmonic science is not a formal axiom but a trained perceptual faculty. Knowledge of musical phenomena thus depends on cultivating the *aisthētikon* as an organ of judgment. Reason operates not as an abstract, autonomous faculty but as a corrective and articulating structure that systematizes what perception reveals. This epistemological stance – neither empiricist nor rationalist in the modern sense – situates Aristoxenus in a distinctive position within the Peripatetic tradition.

Precision (*akribeia*) in method, for Aristoxenus, also entails precision in language. He repeatedly admonishes his readers to employ terms in a consistent and unambiguous manner, insisting that each name be fixed to a single meaning so that discourse may remain clear and reasoning continuous. This linguistic discipline serves both logical and rhetorical ends: by stabilizing terminology, Aristoxenus ensures that the scientific *logos* remains transparent and persuasive. His attention to verbal exactness closely parallels Aristotelian methodological precepts – such as those articulated in *Metaphysics* Δ and *Posterior Analytics* I.2–4 – where the avoidance of equivocation is presented as a condition of philosophical clarity.

The Aristoxenian method thus unites perceptual experience, rational organization, and linguistic exactness into a single intellectual ethos. To engage in *pragmateia* is to exercise disciplined responsibility toward one's subject: to define properly, to reason rigorously, and to speak clearly. These virtues of method – precision, order, and clarity – constitute not only the marks of scientific writing, but also the habits of mind expected of the serious investigator.

Part VI – On Demonstration, Justice, and the Proper Limits of Inquiry

Throughout Book I, Aristoxenus presents the harmonic *pragmateia* not merely as a descriptive or classificatory enterprise, but as a discipline that aspires to demonstrative rigor. His concern is not only what we know about musical systems, but how such knowledge is acquired and how it must be communicated through a reasoned and orderly *logos*. Within this framework, demonstration (*apodeixis*) acquires a methodological and normative significance. To demonstrate properly is, in Aristoxenus' terms, to proceed justly[16]: to give each element its due place within the

[15] I.4, 8.14; I.23, 29.12–17; II.53, 66.14–15 da Rios.

[16] Cf. I.7, 12.4–8 da Rios: 'The practitioner of the present science must therefore discuss regions of the voice both in general and in detail, so far as this is appropriate – that is, to the extent that the nature of the *systēmata* themselves indicates' (trans. Barker [1989]).

argument, to establish necessary connections between propositions, and to ensure that no claim is advanced without adequate grounding.

In this sense, Aristoxenus can be read as extending the Aristotelian logic of demonstration into a normative principle of authorship. To demonstrate properly is not merely to reason correctly, but to act justly toward one's material and one's reader, by presenting the subject in a proportionate and orderly manner. When Aristoxenus criticizes earlier theorists for having failed to demonstrate, the charge is not simply logical inadequacy, but methodological injustice: their inquiries were disproportionate to the nature of the whole, treating isolated parts without regard for their place within a complete science. The harmonic *pragmateia*, by contrast, aspires to *sufficiency*: it provides precisely the reasoning required to render its subject intelligible, neither exceeding its proper scope nor falling short of it. From this perspective, excess, digression, and deficiency emerge as modes of *adikia* – not moral faults, but failures of disciplinary justice.

Aristoxenus is frequently concerned with delineating the limits of legitimate inquiry. These limits are both methodological and disciplinary in character. Methodologically, they define how far reasoning may extend beyond perception; with respect to subject matter, they demarcate what properly belongs to harmonics and what does not. To transgress these limits is to err twice – once by method and once by scope. Thus, when Aristoxenus insists that the harmonic theorist must speak only of what belongs to the harmonic *pragmateia*, he reaffirms that justice consists in confining one's discourse to the proper domain of the science. This deliberate self-limitation distinguishes *pragmateia* from rhetorical display: the aim is not persuasion through excess, but understanding through proportion.

The ethical undertone of Aristoxenus' methodological discourse can be illuminated by comparison with Aristotle's treatment of justice as a virtue of proportion (*Eth. Nic.* V.3, 1131a10–b15). Just as distributive justice assigns to each person what is due according to proportion, so methodological justice assigns to each subject matter its proper degree and mode of analysis. Aristoxenus' repeated insistence that each science confine itself to what properly belongs to it recalls this conception in a disciplinary register, reframed within the context of scholarly conduct rather than civic life. To exceed the legitimate scope of one's inquiry – to speculate, for example, on metaphysical causes of musical phenomena – is thus presented not merely as a technical mistake, but as a failure of proportion analogous to injustice in the political domain.

Demonstration, therefore, may be understood as having a dual significance within Aristoxenus' methodological framework. On the one hand, it functions as a logical process by which reasoning proceeds from what is already grasped to what remains to be established. On the other, it carries a normative dimension: to demonstrate well is to exhibit moderation, proportionality, and respect for the subject matter. Aristoxenus' use of verbs such as σημαίνειν ('to indicate', 'to make clear') reflects his concern that the structure, scope, and progression of an argument be rendered fully intelligible. The reader should be able to trace both the origin and the limits of each claim. Such transparency of reasoning, as Aristoxenus repeatedly suggests, is the defining mark of a properly conducted and just *pragmateia*.

Moreover, Aristoxenus emphasizes that demonstration must be didactic rather than merely assertive. The true author of a *pragmateia* does not simply pronounce conclusions, but guides the reader so that the necessity of each step becomes evident. This requires not only the technical capacity to reason demonstratively, but also the ability to present that reasoning with clarity and order. In this respect, Aristoxenus operates within a broadly Peripatetic conception of scientific discourse, according to which proof and teaching are inseparable. The most successful scientific *logos* is one that teaches while it proves, persuading not through ornament or display, but through intelligibility and precision.

In sum, Aristoxenus' theory of demonstration encapsulates the ethical, logical, and pedagogical dimensions of his intellectual project. A just and complete *pragmateia* is one that demonstrates in proportion to its subject, neither exceeding nor falling short of what is due. This close alignment of demonstration and justice confers on Aristoxenus' work a distinctive form of authority within the Peripatetic tradition. His treatise does not simply communicate information about harmony; it models a normative form of reasoning – a *logos dikaios* – in which the pursuit of truth is inseparable from the cultivation of intellectual virtue.

Part VII – The Voice of the Author: Instruction, the Plural 'We', and Scholarly Practice

One of the most distinctive features of Aristoxenus' *Harmonics* is the tone of its authorial voice. The treatise is not written in the detached, impersonal idiom of a technical manual, but in a voice that is at once instructive and inclusive. Aristoxenus frequently employs the first person plural – ἡμεῖς ('we') –[17]when guiding the reader through definitions, distinctions, and lines of reasoning. This rhetorical choice is far from casual. It reflects a Peripatetic conception of scientific communication in which knowledge is not merely transmitted but cultivated through shared discourse, and in which the *pragmateia* itself functions as a medium of intellectual formation.

The use of 'we' situates the reader within the process of discovery. Aristoxenus does not present his reasoning as a series of finished conclusions; instead, he leads the reader step by step through the logical movements by which understanding is achieved. Formulations of the type 'we must begin', 'we shall now examine', or 'let us establish first' recur throughout the treatise. Such expressions do not merely soften the author's didactic authority; they enact the pedagogical ethos of the Peripatetic school, in which scientific knowledge was transmitted through guided instruction rather than mere assertion. The *pragmateia* thus becomes an extension of the *scholē* – the philosophical classroom rendered in written form.

At the same time, this inclusive voice carries a normative implication. The *we* of Aristoxenus presupposes a community bound by shared standards of inquiry – precision, fairness, and respect for perceptual and rational evidence. To participate in the harmonic *pragmateia* is thus to enter a collective pursuit of ordered knowledge, one that demands the cultivation of intellectual excellences rather than mere technical familiarity. In this respect, Aristoxenus' rhetorical stance may be compared, at a structural level, to Aristotle's conception of virtue in the *Nicomachean Ethics*: just as

[17] Cf. I.9–10, 13.22–15.5; I.12, 17.4–23; I.13–14, 18.1–19.7; I.26, 34.8–13 da Rios.

ethical action is intelligible only within a framework of shared rational norms, so scientific inquiry presupposes a community governed by common methodological commitments. The harmonic scientist, accordingly, does not reason in isolation but contributes his labor to a shared enterprise aimed at truth.

Aristoxenus' authorial voice is thus inseparable from his normative conception of scholarly practice. He consistently contrasts his own demonstrative and orderly mode of exposition with the procedures of earlier writers, whom he criticizes for methodological inadequacy rather than for the substance of their claims. Their failure, as he presents it, lies not in holding false views but in advancing positions without completing the requisite demonstrations or treating the subject as a coherent whole. By contrast, the proper author of a *pragmateia* proceeds step by step, confines his claims to what belongs to the discipline, and makes explicit both the grounds and the limits of his reasoning. In this context, the recurrent use of the first-person plural does not signal authorial self-assertion but functions as a rhetorical device of inclusion, emphasizing that scientific knowledge emerges through shared rational procedures rather than through the authority of isolated assertion.

This inclusive and non-assertive mode of exposition does not weaken the strength of Aristoxenus' authorial presence; on the contrary, it reinforces it. By positioning himself simultaneously as instructor and co-inquirer, Aristoxenus exemplifies a Peripatetic ideal of philosophical authorship in which teaching consists not merely in stating results but in guiding the reader through the processes that generate understanding. The author's task, on this view, is not only to communicate technical knowledge but to shape the reader's intellectual dispositions – to train both perception and reasoning. Aristoxenus repeatedly emphasizes that harmonic understanding cannot be acquired through theoretical exposition alone: one must learn to hear correctly and to think in an ordered way. The *pragmateia* thus functions as a structured exercise in disciplined perception and rational organization, cultivating the capacities required for genuine scientific comprehension.

We may therefore discern in Aristoxenus' narrative voice a synthesis of the didactic and the normative: his instructional rhetoric not only conveys knowledge but also exemplifies the disciplined modes of inquiry it prescribes. To write a *pragmateia*, on this view, is not merely to present results but to guide the reader in the correct practice of investigation. Each definition, distinction, and demonstration functions as a localized application of ordered reasoning (*orthos logos*) within the domain of harmonics. The repeated use of the first-person plural continually reintegrates the reader into this process, emphasizing that knowledge in the Aristoxenian sense is generated through shared procedures, sustained attention, and adherence to common standards of rational inquiry.

In this way, Aristoxenus' authorial self-fashioning transcends mere stylistic choice. It articulates a normative vision of scholarly practice, one in which the manner of exposition is inseparable from the discipline of inquiry itself. Drawing on broadly Peripatetic assumptions about order, proportion, and rational control, Aristoxenus' prose consistently avoids both assertive dogmatism and ornamental display. The proper tone of the *pragmateia* is thus one of measured authority: firm in reasoning, restrained in claim, and inclusive in address. Through this balanced rhetorical posture, Aristoxenus constructs the harmonic treatise not only as a scientific achievement but

as an exemplary instance of disciplined inquiry – an ordered discourse that models the intellectual virtues it seeks to cultivate in its reader.

Part VIII – On Familiarity, Experience, and the Gradual Acquisition of Knowledge

A recurring motif throughout Aristoxenus' *Harmonics* is that of familiarity – of what is initially unfamiliar becoming progressively recognizable (*gnōrimon*)[18] through disciplined engagement with the subject matter. Aristoxenus employs this notion not in a moral sense but to describe an epistemic process by which the student gradually becomes acquainted with melodic phenomena. Knowledge of melody, he insists, cannot arise from abstract reasoning alone. It requires a sustained training of both hearing and intellect, through which perception is educated to discern the order and continuity inherent in musical structures. Harmonic science is thus presented not as a discipline grounded in purely theoretical postulates, but as a systematic form of inquiry that integrates sensory experience with rational articulation.

The language of gradual acquaintance structures the entirety of Book I of the *Harmonics*. Transitional formulations such as τούτων ὄντων γνωρίμων λεκτέον and τούτων οὕτως ἀφωρισμένων signal moments at which certain points have been sufficiently established for the inquiry to advance. These expressions mark successive stages in the unfolding of the argument, indicating that each definition or clarification provides the necessary basis for what follows. The pedagogical rhythm is thus cumulative: each step prepares the conditions for the next, and no stage of inquiry can be bypassed without compromising the coherence and integrity of the whole.

This epistemic sequencing closely parallels Aristotelian method. Just as Aristotle argues in *Posterior Analytics* II.19 that learning proceeds from what is more familiar to us (*gnōrimōtera pros hēmas*) toward what is more familiar by nature (*gnōrimōtera tēi phusei*), Aristoxenus structures his *pragmateia* around a progressive relation between perceptual acquaintance and theoretical articulation. The student must first see and hear the phenomena before their underlying structures can be grasped; yet perception, left unorganized, cannot by itself yield understanding. The task of the harmonic *pragmateia* is therefore to guide this progression, integrating trained *aisthēsis* with ordered reasoning so as to produce systematic comprehension of melodic phenomena.

Aristoxenus repeatedly emphasizes that the level of comprehension attained by the student depends on the degree of prior familiarity and preparation brought to the inquiry. Those 'not wholly inexperienced with instruments' (τοῖς γε μὴ παντελῶς ἀπείροις ὀργάνων)[19] will immediately recognize what is meant by tension and relaxation, while those accustomed to the musical practices of earlier generations will grasp features such as the ditone lichanos more readily than those acquainted only with contemporary compositions.[20] Familiarity here is not mere prior exposure but a cultivated capacity, formed through repeated engagement with musical phenomena and disciplined reflection. In Aristotelian terms, this condition may be described as

[18] Cf. e.g. I.13, 19.1–3; I.15, 20.15–16; I.22, 29.1–2 da Rios.
[19] I.11, 16.3 da Rios.
[20] I.23, 29.14–30.4 da Rios.

analogous to a *hexis*: a relatively stable ability to perceive and recognize ordered structures.

Hence Aristoxenus' recurring appeal to *epagōgē*, understood not as a formal theory of induction but as a practical recourse within instruction. When conceptual understanding falters, the inquiry must return to perceptible instances, guiding the learner back through the phenomena until recognition is secured. This appeal to examples is not an anticipation of later empirical science but a pedagogical strategy rooted in the disciplined use of perception. Harmonic understanding emerges gradually, through repeated engagement with audible structures under the guidance of *logos*. In this respect, Aristoxenus' account of learning harmony can be fruitfully compared – by analogy – to the Aristotelian account of ethical formation: knowledge is not simply transmitted but cultivated through habituated perception ordered by reason.

In this light, Aristoxenus' instructions concerning the proper reception of his definitions[21] acquire their full significance. The student is expected to approach difficult and sometimes indeterminate formulations with benevolence, recognizing the inherent constraints involved in articulating first principles. Precision (*akribeia*) is not an all-or-nothing achievement but an ideal gradually approached in proportion to the subject matter. To demand a level of exactness that exceeds what the phenomena allow is to misconstrue the aims of scientific inquiry itself. The reader's disposition thus becomes indirectly implicated in the epistemic process: patience, receptivity, and fairness of judgment are tacit conditions for genuine understanding.

Moreover, Aristoxenus' frequent insistence on speaking only about what is useful for the purposes of the present study[22] reveals a refined sense of proportionality in discourse – what one might call the justice of exposition. To speak only to the extent required by the subject is to respect the order of learning, neither anticipating nor delaying what belongs to its proper place. The *pragmateia* thus enacts an ethics of measure: intellectual moderation as a principle of method.

Through this complex interplay of perception, habituation, and intellectual discipline, Aristoxenus transforms what might seem a purely technical investigation into a profound meditation on the formation of scientific understanding. Knowledge, for him, is neither innate nor merely transmitted; it is cultivated gradually through practice, experience, and ordered reasoning. The harmonic scientist thus emerges as a figure of philosophical training: one who listens rightly, reasons justly, and advances step by step toward clarity.

Conclusion: Aristoxenus and the Rhetoric of *Pragmateia*

The *Harmonics* of Aristoxenus stands at the intersection of philosophy, science, and rhetoric. Far from being a merely technical treatise on pitch and scales, it presents

[21] Cf. I.16, 21.7–16 da Rios ('The student should try to accept each of these in the right spirit, without quibbling over whether the account offered of each is exact or only rather approximate. Rather, he should try to grasp it sympathetically, on the assumption that enough has been said for the purpose of instruction when the account has the capacity to put him on the road to understanding the thing that is spoken of. For it is difficult, perhaps, in all cases where we are dealing with things that stand at the beginning, to articulate an account that contains an exhaustive and accurate interpretation, and not least in the case of these three, the note, the interval and the *systēma*', trans. Barker [1989]).

[22] Cf. I.16, 22.2 da Rios.

itself as a reflection on the nature of scientific discourse – on what it means to 'treat' (*pragmateuesthai*) a subject scientifically, that is, in a manner that is systematic, just, and complete. In this respect, Aristoxenus' work is a meditation on *pragmateia* itself: not only on the content of harmonic science but on the normative and intellectual virtues that govern its exposition.

Across the preceding sections, we have seen that Aristoxenus redefines *pragmateia* as a complex rhetorical-epistemic activity. To compose a *pragmateia* is not simply to write about a subject, but to engage in a disciplined form of inquiry that integrates perception, reasoning, and methodological self-restraint. The good author, much like the good citizen in Aristotelian political thought, performs his proper function: he speaks of what lies within his domain, neither exceeding nor neglecting it. In this sense, Aristoxenus transforms the structure of the treatise into a normative paradigm – an enactment of justice in discourse. The order of exposition is presented as consonant with the order of the phenomena, both governed by a single principle of proportion.

This conception of discourse as a norm-governed practice situates Aristoxenus firmly within the Aristotelian tradition, even as his treatment of *pragmateia* marks a distinctive development. Aristotle employs the term across his scientific corpus – especially in works such as the *Physics* or *Metaphysics*, or in his biological treatises – to denote a determinate field of inquiry structured by methodological order and oriented toward causal explanation. Aristoxenus retains this basic framework but infuses it with explicit pedagogical and rhetorical dimensions. His *pragmateia* is not merely a rational schema but a pedagogical performance – a discourse that shapes the reader's intellectual dispositions as it conveys knowledge. In this respect, Aristoxenus may be said, in retrospect, to anticipate elements of the later Hellenistic ideal of *didaskalikē lexis*, a teaching style that instructs by modeling clarity, proportion, and disciplined restraint.

The normative tone of Aristoxenus' authorial voice – most notably his consistent use of the plural 'we' and his expectation of a receptive and charitable reader – further underscores the pedagogical orientation of the *Harmonics*. The treatise does not address an abstract or anonymous audience but a pupil engaged in a shared process of understanding. Through this inclusive rhetoric, Aristoxenus constructs a community of inquiry grounded in disciplined attention, proportional judgment, and mutual intellectual commitment. His *pragmateia* thus takes on the character of an educational exchange rather than a mere exposition of results, reflecting the pedagogical ethos of Peripatetic instruction. In this sense, the *Harmonics* may be read as philosophy written in the mode of education.

Equally central is Aristoxenus' insistence on gradual learning – the cultivation of *familiarity* through practice and repetition. This emphasis on experiential knowledge reflects the Peripatetic conviction that understanding emerges not from isolated abstraction but from progressive engagement with the phenomena. In Aristoxenus' hands, the auditory domain becomes a microcosm of the philosophical one: hearing rightly is akin to thinking rightly. The trained ear, capable of discerning order in sound, exemplifies the intellectual dispositions of proportion, patience, and attentiveness that define the philosopher-scientist.

The *Harmonics*, then, is not only about harmony but also an act of harmony – a *logos* whose form enacts the very principles it studies. Its definitions, divisions, and

demonstrations unfold with the balance and clarity of a musical composition, each part resonating with the others in measured proportion. The treatise embodies what it teaches: the unity of precision and order, of method and normative rigor, of knowledge and justice. To read Aristoxenus is to witness a Peripatetic science become rhetoric – not rhetoric in the pejorative sense of persuasion divorced from truth, but rhetoric as the ethical and pedagogical shaping of reason.

In a broader historical perspective, Aristoxenus' rhetoric of *pragmateia* represents an early and sophisticated reflection on scientific discourse as a normatively structured practice. Later thinkers – from the Hellenistic commentators to Galen and even to the rhetorical theorists of the Roman Empire – would continue to explore how style, method, and virtue intertwine in the act of writing about knowledge. Aristoxenus stands as one of the first to give this intertwining a systematic form. His *Harmonics* thus bridges the Aristotelian conception of science with a later tradition that conceives the learned author as precise in reasoning, moderate in speech, and conscious of the ethical weight of teaching.

In the end, the rhetoric of *pragmateia* is Aristoxenus' philosophical legacy. By transforming the structure of technical discourse into a reflection of normative order, he establishes a model that would deeply influence later conceptions of scientific writing – a model in which *logos*, *ethos*, and *technē* converge. His treatise reminds us that to speak truly about the world is also to act justly within it; that every science, if it is to deserve the name, must be not only demonstrative but humane.

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Ionian University

The Rhetoric on Clouds in the Ancient Star Catalogue

Susanne M. Hoffmann

Abstract
For many people mathematical texts are characterised by numbers but, in fact, the language is much more important in modern and ancient mathematics because it aims to provide sharp arguments. The casual understanding of mathematics makes us focussing on the deeper sense instead of the rhetoric in which it is presented. In this contribution, I will change this perspective and focus on the language in the ancient star catalogue(s).

Introduction

Astronomy is a rather optimistic science: Within the huge and vast darkness of the night sky, it focusses on the few and tiny dots of light. However, this focus often leads to a neglection of anything not point-shaped which I attempt to overcome herewith.

The ancient star catalogue[1] has been analysed back and forth as a source of data in number format. Since Tycho Brahe (1546–1601 CE) had discovered a systematic shift of coordinates and measured the whole star catalogue again, historians of science analysed the errors in the data, compared them to errors in Hipparchus' data and astronomers have improved their methods of measurement. This technical and mathematical method of history only deals with the numbers in the table and totally neglects the language that Ptolemy used to describe the stars and other objects. For the same reason of mathematics, the textual description of the position and appearance of the cloud-like phenomenon of the Milky Way has been neglected so far. Ptolemy's star catalogue is a list of point coordinates mapped to the descriptions of parts of the constellation figures (e.g. 'star at the left elbow of Andromeda, coordinates x, y') but the Milky Way is not a point and cannot be described mathematically with point coordinates. Speaking in terms of mathematics, it is often reduced to a perfect circle[2] which is not an appropriate approximation. The rhetoric Ptolemy uses for the description in this part of mathematical astronomy will be explored in this contribution. Additionally, I will analyse Ptolemy's descriptions of cloud-like phenomena in the star catalogue and compare all these descriptions to the rhetoric in Aratus' didactic poem (*Phaenomena*) and Hipparchus' Commentary on Aratus, whose rhetoric makes clear that it is also a didactic text.

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[1] Speaking of 'the ancient star catalogue' is a wording that leaves authorship consciously open and refers to the long history of this document. It is preserved only in Ptolemy's *Almagest* (*Alm*. VII–VIII), dating 137 CE, but it is proven that this catalogue partially goes back to Hipparchus in the 2nd century BCE (Grasshoff [1990]) although the data is not directly copied from him. It was reworked in the 260 years between these two authors (Hoffmann [2017]), at least by Ptolemy himself (as he testifies) and perhaps by others.

[2] In modern astronomy, where yet another coordinate system was defined with the Milky Way as the fundamental plane, this circle is called the Galactic equator. Historically, the term is not used to designate a line but a band in the sky.

The astronomical information

In the night sky, we can see stars (points of light) in random distributions: some stars form star clusters[3] and associations[4] while others seem to stand lonely in the dark background. Occasionally, there are some fuzzy[5] and irregular[6] phenomena in the night sky: the most prominent one being the view of our Galaxy from inside which causes the impression of a broad stream-like shine. Under a dark sky, the shimmer of the Milky Way appears bright while terrestrial clouds in contrast appear darker. Still, the varying brightness of the Milky Way has frequently been associated with clouds of varying density – a mind image that is still used today. Since the introduction of the telescope to astronomy it is observable that the cloudy appearance is caused by a huge number of stars close together but the visual appearance for the naked-eye observer is a rather smooth mighty stream or a band of clouds that surrounds the observer in a great circle[7]. As the local horizon is also a great circle, always the half of the band of the Milky Way is visible (no matter where the observer is located on this planet: it's always a half), although the exact part (what half) might vary from place to place. The fact that this whitish band seems to be attached to the fixed stars (or to the heavenly sphere which they are attached to) caused various imaginations by ancient people. They invented stories of the milk of a goddess, a trace of a fiery chariot, or a path of souls before birth or after death.

As it is hard for accurately observing astronomers to describe these nebulous and cloudy phenomena in the sky,[8] they are not represented on two of the three globes that survived from antiquity (Hoffmann 2024): neither are they represented on the Farnese Globe nor on the Kugel Globe.

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[3] Modern astronomy distinguishes globular star clusters and open star clusters. As the designations suggest, globular clusters have a rather compound appearance while open clusters appear like loose groups of stars.

[4] In modern astrophysics, the term 'star cluster' is used for a group of stars that are physically bounded and roughly at the same distance to the observer. In most cases, the stars in these clusters are roughly of the same age. A group of stars that occurs like a group or cluster in our night sky but is not physically bounded but only by chance is visible in the same area in the sky is called 'association'. As the physics of these objects have not been known until the 19th or 20th century, historical terminology did not distinguish between physical and apparent clusters of stars.

[5] The globular star cluster called Omega Centauri appears like a fuzzy star. The globular star cluster M13 in the constellation of Hercules is not bright enough to appear like a star but it looks like a nebulous patch.

[6] The Great Orion Nebula is a star birth region which makes the stars in its vicinity appearing as a nebulous irregular patch in the night sky.

[7] The term 'great circle' is from spherical geometry. It designates a circle of the size of the circumference of a sphere in order to distinguish these largest circles from the so-called small circles that are parallel to them. E.g. on Earth, the equator would be a great circle while all other latitudes are small circles.

[8] The workflow of measurements in astronomy is: a) adjust the armillary sphere, b) draw a bead on the star, read the point coordinates of the star at the scale of the instrument, c) enter these coordinates of longitude and latitude into a table. For nebulous and cloudy phenomena this is not possible: Due to their fuzzy appearance, the observer would not be sure what to focus on in step (b). For 'nebulous stars' a roughly estimated centre might be taken for the measurement but the Milky Way encircles the whole celestial sphere as a broad nebulous band. As it is not a thin line (as drawn with a pencil) but has fuzzy edges, the normal workflow is not applicable; no exact coordinate can be given and the geometrical shape is hard to specify. It is neither a point in the sky nor an accurate line (periphery of a circle) as approximated by Aratus.

Genres and their syntax

The oldest extensive description of the Milky Way that came down to us is the one in Ptolemy's *Almagest*. Hipparchus' star catalogue is not preserved and the only preserved text from his hand is a commentary on Aratus. Aratus' didactic poem is a fully preserved description of the celestial globe but the Milky Way is only mentioned briefly.

The genres, audiences and styles of these three texts are different: As Aratus' poem is designed in aesthetically appealing verses, it is easy to memorise and can be understood by almost everybody. In his introduction, he starts with a prayer:

> Let us begin with Zeus, whom we men never leave unspoken. Filled with Zeus are all highways and all meeting-places of people, filled are the sea and harbours; in all circumstances we are all dependent on Zeus. For we are also his children, and he benignly gives helpful signs to men [...]
>
> Hail, Father, great wonder, great boon to men, yourself and the earlier race! And hail, Muses, all most gracious! In answer to my prayer to tell of the stars in so far as I may, guide all my singing. (*Phaen.* 1–6, 15–18) (trans. Kidd [1997])

Although Aratus' poem contains practical information such as the section on wind directions in connection with the seasons,[9] its layout is rather pathetic.

The reasons for Aratus to write the poem are not preserved but its popularity was regarded as a success. The poem is preserved because it used to be cited and recited frequently which was likely also triggered by its appealing rhetoric. Still, it is not highly accurate and therefore questionable for scientific instrument making. This is the reason for Hipparchus to criticise it and for (him and) Ptolemy to describe an alternative and more accurate method of globe making.[10] However, also Aratus' text gives plenty of information (e.g. that the hands, heads, feet, tails of constellation figures lie on specific lines) that serves to build a rather accurate model of the starry sky.[11] For most practical purposes, e.g. sailing and farming, this might have been sufficient.

For practical purpose and in everyday life, it will hardly be necessary to recite the whole poem but the weather rules, culturally relevant and calendric observations can be extracted. However, the religious context is clearly set. It demonstrates the attempt to relate sacred figures as deified constellations to seasonal weather and the according

[9] In the first section, Aratus lists constellations north and south of the ecliptic; in verses 152–156 he refers to the Etesian winds, in verses 410–436 to the South Wind, North Wind and East Wind in autumn. In the fifth section, he describes the risings of the zodiac and in the sixth section weather signs. The terms 'wind' and 'storm' occur roughly 80 times throughout the text, indicating that this is one of the main topics.

[10] The first step for globe makers is always to engrave the celestial circles (equator, tropics, ecliptic, colures). The first (simple) method would then paint constellation images and attach them to the circles in the way as described in Aratus. The second, more sophisticated method would be to mark stars and later on summarise them (with thin lines) to shape constellations as Ptolemy describes in *Alm.* 8.3.

[11] Cf. Leontius Mechanicus, *On the Construction of an Aratean Globe* (probably 6th century CE).

activities (like farming, sailing and the like) of humans which already had a long tradition in Aratus' time[12] and will be adapted to new religions in the time after him.[13]

For globe makers it might have been more relevant to learn the whole poem by heart when they had to arrange the figures of the constellations with regard to the lines of a rudimentary grid consisting of the celestial equator, the ecliptic, the tropical circles and the colure circles. However, due to its appealing style, the briefly presented mythological tales and the practical knowledge it contains, Aratus' poem is very appropriate for all kinds of public performances: for instance, in schools and theatres.

Hipparchus is an accurate astronomical observer and in his commentary he explains to a student of astronomy that Aratus' information occasionally is not accurate enough for scientific purpose. For his didactic text he chooses the form of a letter beginning with a reply to a request:

> From Hipparchus, to my friend Aeschrion: I was pleased to learn from your letter about your continued acquisition of knowledge. For, both the science of the things you have investigated and also what Aratus says about them in his *Synanatolae* have shown me that you have a rather strong attachment to this area of learning; all the more so, since you have been burdened in your daily pursuits by the untimely deaths of our most honorable brothers. Concerning these other matters, I shall elaborate for you my own feelings afterwards; but, in the present treatise I have endeavored to write for you about what Aratus says in his *Phaenomena*, pointing out absolutely everything that is said correctly or incorrectly in that treatise. And from my writing, especially those issues that have bewildered you will become clear (*Hipparchus' Commentary on the Phaenomena of Aratus and Eudoxus* 1.1.1–1.1.2). (trans. MacFarlane and Mills [2009])[14]

The introduction does not only express the goal of his writing but also the negation of a different interpretation of it. He does not aim to bashing Aratus or anybody else as he himself states in 1.1.6: 'I undertook this not because I chose to enhance my image by refuting others. That is hollow and altogether mean'. In contrast, he praises and honours Aratus 'For as a poet, Aratus is both simple and straightforward; but still those who read even relatively closely will find him clever' (1.1.4). Yet Hipparchus also points out the poem's insufficiency for mathematical science. He also credits the efforts of other contemporary scholars (in particular Attalus) in commenting on the popular poem. However, Hipparchus, speaking in the first person singular, says: 'I decided – for the sake of your learning and the common benefit of others – to write about the things that seem wrong to me' (1.1.5). In his introduction he makes it absolutely clear that he appreciates the work of other scholars including Aratus whose

[12] The Babylonian compendium of astronomical knowledge, MUL.APIN, also starts with a list of constellations associated with deities. This compendium had been copied for many centuries in Aratus' time.

[13] For instance, the saints in Christianity are worshipped on particular days of the year related to the seasons, seasonal activities, seasonal weather or seasonal celestial phenomena (like meteor showers).

[14] The English text is quoted from the unpublished translation by MacFarlane and Mills (2009), kindly passed to me in an unfinished version in 2013.

work is a terrific first approach in learning astronomy. He only aims to point out the inaccuracies that become evident for the learned scholar of mathematical science.

That is why Hipparchus' preserved work has three sections: First, the criticism of the poem verse by verse – possibly (due to the introductory letter) in response to questions of a student of mathematical astronomy. In the second part Hipparchus gives his own version of the rising and setting phenomena described by Aratus. Hipparchus' version is not poetic at all but follows a rather simple schema, always using the same phrases with no variation in wording and syntax of the sentences. This makes the text rather unattractive for philological discourse and only the numbers being regarded by scholars of the history of science. In the third part, Hipparchus adds a list of hour stars and his language is similarly schematic.

Ptolemy, in contrast to both didactic pieces, seems to aim to write a compendium. He starts with an essay to a (possibly fictitious) person named Syrus dealing with the distinction of theoretical and practical philosophy. Afterwards he outlines the structure of his work (*Alm.*1.2):[15]

> In the treatise which we propose, then, the first order of business is to grasp the relationship of the earth taken as a whole to the heavens taken as a whole [...] Secondly, we have to go through the motion of the sun and the moon, and the phenomena accompanying these [motions] [...] Our final task in this way of approach is the theory of stars [...]

He continuous later in this section (H10, Toomer [1984] 38):

> The general preliminary discussion covers the following topics: the heaven is spherical in shape, and moves as a sphere; the earth too is sensibly spherical in shape, when taken as a whole; in position it lies in the middle of the heavens very much like its centre; in size and distance it has the ratio of a point to the sphere of the fixed stars; and it has no motion from place to place. We shall briefly discuss each of these points for the sake of reminder.

This makes clear that Ptolemy does not write for a beginner student like Hipparchus does: He reminds his reader of things that are known already. So, the rhetoric in all his books addresses a learned person. The selection of the coordinate system in his star catalogue in particular shows that he wants his book to be useful not only for contemporary readers (like the letter by Hipparchus) but for scholars in the centuries to follow who are enabled to compute the coordinates of stars in their time in the easiest possible way.

Addressee and presence of the authors in their texts

Aratus addresses the reader and is present as the speaker, while in Ptolemy's text, the reader is not addressed but the authors[16] present themselves in the first person plural. It is an ongoing debate what this means for the interpretation of the texts but a rather

[15] All quotes from Toomer (1984). Here: Toomer (1984) 37, H9.

[16] Some classicists are of the opinion that the *Almagest* that is attributed to 'Claudius Ptolemy' as one author, was actually written by a group of scribes (e.g. 'the school of Claudius Ptolemy') which would be supported by the phrasing in first person plural. I don't want to discuss this question here.

intuitive interpretation might be related to their different audiences: a poem is meant to be used by everybody. It is popular and might be recited orally from the father to the son and from the teacher to the pupil. In oral performance, the statements like 'you too know' (line 752) or '[...] take pains to learn them. And if ever you entrust yourself to a ship, be concerned [...]' (758–59) cause the impression of advice to be taken seriously not because of the authority of the speaker but in order to protect one's life.

Hipparchus and Ptolemy, in contrast, never address the reader. Hipparchus is present in the first person singular as the teacher who expresses his opinion to the best of his knowledge.[17] Ptolemy is present in the first person plural suggesting that his statements are widely accepted – at least in his school or academy or whatever scientific community.

As stated above, Hipparchus in his introductory letter dedicated his work to a student and addresses this student's specific questions. However, in the text he does not get back to him personally but only deals with Aratus' verses in order to make his explanations readable for all contemporary scholars as he explicitly states in 1.1.5: 'for the sake of your learning and the common benefit of others'.

The rhetorical style of the *Almagest*, in contrast, leaves the impression of a justification or an explanation to an unknown person – pretty much as modern research papers are written. Statements like 'when we speak of a star as "in advance of" or "to the rear of" another, we mean [...]' (*Alm.* 7.4, H37, Toomer [1984] 340) are rather typical for a scientific text that is meant to be understood by a wide audience, independent of place, time and cultural background.

The section of the star catalogue is introduced as being made for the successors: those who will use his work as contemporary craftsmen and scholar successor astronomers of the author(s). He shows explicitly that he wants his information to be accurate and useful: the statements that (a) the fixed stars do not change their positions relative to each other, (b) the precession of equinoxes is homogenous and stable over time, and (c) that the precession constant is 1° per century, are carefully derived from the comparison of contemporary observations with historical ones. They allow his reader to understand why he recommends the 'logical order' (structure) of information in the way he does. Finally, it is explained in 7.4 that the ecliptic coordinate system is chosen because (i) 'the latitudinal distance will remain always unchanged' and (ii) the longitude can easily be computed for a later century on the basis of 1° per 100 years that needs to be added to the position given in the book. Additionally, the section following the star catalogue and the description of the Milky Way is the instruction how to make a globe by using the previous information. Evidently, Ptolemy writes for an audience of scholars and their craftsmen who make scientific instruments.

The rhetoric on the Milky Way

Aratus only briefly states that there is a 'star-emblazoned wheel (men call it the Milk) (Γάλα)' and 'no other circle that rings the sky is like it in colour' (469–79). He does not enlist all constellations it passes through but describes it as an observational

[17] As he claims in the introduction he writes 'about the things that seem wrong to me', this modest style reoccurs during the whole text. It makes a difference to state 'it seems wrong to me' or 'this is wrong'.

phenomenon in a clear night when all stars are displayed to men and 'at new moon none in its course is dimmed'. To Aratus, the Milky Way is important to mention but it is regarded as one of the circles that form the basic grid in the sky: subsequently, he describes the celestial equator and the two tropical circles parallel to it. It is not fully clear if this is a contradiction to Ptolemy's interpretation of the Milky Way as a natural phenomenon attached to the stars. On the one hand, the circles of the equator and the tropics are an artificial grid and not directly visible in the night sky whereas the Milky Way is visible, making it more similar to the stars. On the other hand, the narrative in Aratus' poem is not a description of a static sphere but it is based on the perpetual revolution of the sky which is turning in the direction of equator parallels. Therefore, for Aratus the equator and the tropics are observable (as the direction or line of motion) although they are not directly marked in the night sky.

The Milky Way does not occur in Hipparchus' text except in one quotation of Aratus (1.9.14). He does not deal with the Milky Way but only discusses the ratio of the circumferences of the tropical circles and the equator (1.9.15).

In Ptolemy's *Almagest*, the description of the Milky Way follows the star catalogue in Book 7 and 8. It is introduced as the logical next step ('as the logical order demands') after the description of the order of the fixed stars. In this logical order, it is first stated that this circle is rather a belt 'of a sort of milky colour overall' which is 'neither uniform nor regular, but varies in width, colour, density [...] and in one section is bifurcated' (*Alm*. 8.2, H170, Toomer [1984] 400). After this general introduction of some qualities, he describes asterisms[18] within this band and how they vary in colour and density. The end is rather abrupt. After having described all constellations in the great circle and having outlined the gaps in the vicinity of Ara and in Cygnus the chapter in Ptolemy's book ends. Both chapters, the one about the Milky Way and the subsequent one, start with the same phrase 'Such, then, [...]' expressing that they belong together as a systematic step-by-step guide for something. As declared already at the beginning of Book 7,[19] the purpose of the whole inventory of the sky consisting of celestial great circles whose positions are not stable over time due to precession, stars sorted by constellations and the milky band, is the construction of a solid globe as described in 8.3.

Visible mathematics or/ and asterism?

The context and rhetoric of the presentation of the phenomenon of the Milky Way for the two authors (Aratus and Ptolemy) suggests a completely different understanding of it. For Aratus it has nothing to do with clouds or stars but it is a division of the sky. He literally states 'when you observed the sky split all the way round by a broad circle' (474–75), implying that this circle (in contrast to the equator and the tropics) is not a thin line and that its geometrical concept is a so-called 'great circle'. Great circles split the sphere in halves (like the ecliptic and the equator) while small circles like the tropics don't. This is additionally emphasised by Aratus' description of the

[18] 'asterism' is an umbrella term for 'constellation', 'single star', 'star cluster' etc. It designates any significant recognisable star pattern.

[19] *Alm*. 7.4, H36, Toomer (1984) 339: 'In order to display the arrangement of stars on the solid globe [...] we have set it out below in the form of a table in four sections'. With this phrase the purpose of the star catalogue and all subsequent descriptions is clearly defined: instrument making.

first of the two tropics when he mentions that the horizon (another great circle) divides the tropic in two unequal parts (5:3).[20] Due to the laws of geometry great circles are always halved by each other, so the tropic cannot be a great circle and must be a small circle. His statement leaves the impression of a mathematical concept (and is, therefore, criticised as inaccurate by Hipparchus).

This ambiguity of the description of the Milky Way in Aratus is strongly reminiscent of an unexplained statement in the first list of the Babylonian compendium of MUL.APIN. This compendium consists of many lists of different type, e.g. lists of heliacally rising and setting constellations and constellations that can be occulted by the Moon. However, the first list of the whole compendium is a pure inventory of the sky, associating asterisms with deities of the Babylonian pantheon. Line I i 37 reads 'one big MUL – (although) its light is dim – divides the sky in half and stands there: (that is) the asterism of Marduk, the Ford'.[21] The Sumerian term GAL for 'big' can be translated as 'great' but also 'big' in size. In the latter case, it refers to the extension and not to the brightness as later in the Greek tradition because the text explicitly states 'its light is dim'. The Sumerian term MUL designates everything in the sky (stars, constellations, star clusters etc.), pretty much as the English term 'asterism' but in this case the translation with the term 'asterism' sounds strange. While asterisms are typically considered occupying only limited space, a celestial phenomenon that is like stars and constellations but covers a big area in the sky and divides the sky in halves must be a band covering a great circle (due to the laws of geometry). Therefore, the rather old sentence from a Babylonian text that still circulated in Aratus' time, highly likely refers to the Milky Way in the same ambiguous manner as Aratus does: the Milky Way being considered as an exceptional asterism with an unusually big size and the shape of a great circle (or "star-emblazoned wheel" as Aratus puts it).

With regard to many other Graeco-Babylonian ambiguities in Aratus, this rhetorical parallel does not surprise. For instance, the constellations that are called 'The She-Bears' in all other Greek texts are additionally referred to as 'The Wagons' in Aratus. The Wagons do not exist in other Greek literature but they are the only names for these constellations in the Babylonian tradition. These Babylonian reminiscences are completely neglected in the *Almagest*: although there is many Babylonian data in other parts of the book,[22] the star catalogue and the description of the Milky Way are free from these references.

[20] 'If the circle is measured approximately in eight parts, five revolve in the sky above the earth, and the other three below the horizon' (497–99).

[21] Translation taken from Hunger and Steele (2019), multiple times in the book. They use 'star' for 'MUL' but I changed it to 'asterism' because I do not want to reduce and change the meaning by translation.

[22] In earlier books, Ptolemy cites and uses Babylonian observational data, in particular solar eclipses. In the introduction to the star catalogue (Book 7) and other parts of the book, the years are counted after the Babylonian king Nabonassar (8th century BCE). So, there are many references to Babylonian astronomy but not in terms of the constellation tradition – at least not obviously (the newly invented sub-constellation Antinous seems to be a revival of the Babylonian constellation of The Corpse next to The Eagle but this is not stated explicitly).

Terminology 'milk'

Both texts, Aratus and Ptolemy, in general use the term 'The Milk' to refer to the Galaxy. Aratus' mention is rather short, limited to the statement 'men call it The Milk' but Ptolemy, giving a long description of the location of the milky band in the sky, uses the term 39 times and with no exception. This is surprising as the term 'The Milk' originates from a fantastic concept and not from any of more thoughtful views (see below).

The popular narratives of the origin of the term are preserved in Hyginus (cf. Hard [2015] 133): he reports two variants of a baby put next to Hera in sleep for breastfeeding that was pushed away by her, which caused the stream of milk running around the sky. This baby could be either Hermes or Heracles, depending on the narrator. A variant of the latter story says that Heracles suckled too strong and the milk ran out of his mouth. Yet another tale says that it is Rhea's milk that ran out when she replaced her baby with a stone in order to protect it from Cronos. Either way, mythology of goddesses is not a naturalistic approach to interpret this phenomenon.

In contrast, there had been naturalistic approaches in antiquity: Anaxagoras and Democritus (both 5th century BCE) taught the hypothesis that it is a visual impression caused by billions of stars close together.[23] Although without any basis, some scholars speculated that the Sun took a different path in earlier time.[24] It is not said when and why the path changed but with this suggestion, the Milky Way would be the earlier trail alongside which the Sun had lost some glittering material.[25] Thus, the phenomenon that is visible in dark nights would be the afterglow of the trace of the Sun. Apparently, these views were not much supported – neither in common sense knowledge nor in scientific terminology (possibly because they were considered too speculative). Aristotle summarises: 'The milky way is not the path of one of the planets, nor the light of imperceptible stars, nor a reflection' (*Mete.* I 8.345b28–30, trans. Webster [1984]); but he understands the Milky Way as the area where the matter gathers that is exhaled by the Earth. In his view, the Milky Way is made of the same material as comets which is a smoky or gaseous substance emitted by the Earth.[26]

Ptolemy, who considers it 'the logical order' to describe the positions of stars first and the trail of the Milky Way subsequently, seems to imply that the Milky Way is not only attached to the sphere of the stars but also of a semi-transparent material (as

[23] Reported by Aristotle in *Mete.* I 8.345a25–30: 'Anaxagoras, Democritus, and their schools say that the milky way is the light of certain stars. For, they say, when the sun passes below the earth some of the stars are hidden from it. Now the light of those on which the sun shines is invisible, being obscured by the rays of the sun. But the milky way is the peculiar light of those stars which are shaded by the earth from the sun's rays'. (trans. Webster [1984])

[24] Reported by Aristotle in *Mete.* I 8.345a16–18: 'Others say that the sun used once to move in this circle and that this region was scorched or met with some other affection of this kind, because of the sun and its motion'. (trans. Webster [1984])

[25] A mythological equivalent of this assumption was the tale that it is the trace of Phaeton's course with his father's solar wagon. This story is also mentioned by Aristotle and attributed to the Pythagoreans.

[26] It should be mentioned that Aristotle himself witnessed the Great Comet in winter 373–372 BCE. In such a comet's tail stars are visible and the visual impression might be similar to the starry clouds of the Milky Way.

Aristotle describes it). The way Aristotle describes its cause resembles a river bed where water flows but the bed of the river remains somewhat stable. Although Ptolemy uses the term ‘milk’ (an opaque substance) in the colloquial language, he considers this milky stream of varying transparency and similar to terrestrial clouds. Yet, the term ‘cloud’ is only used one time in the whole description: ‘For the star on its ears [i.e. of Canis Major: 9 CMa] is caught by a sort of cloud [...]’[27].

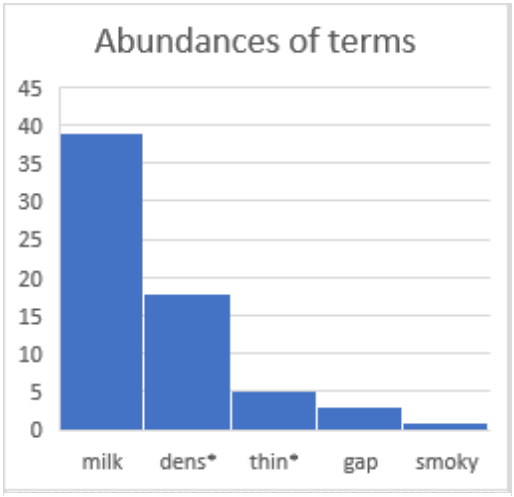

Fig. 1: Abundances in the *Almagest*.

In 23 further cases, the author refers to the density of the Milky Way, e.g. a ‘slightly thinner consistency’ in Auriga (*Alm.* 8.2, H175, Toomer [1984] 402) and ‘less dense’ near the front legs and ‘slightly denser’ near the hind legs of Centaurus (*Alm.* 8.2, H171, Toomer [1984] 400). The terms ‘thin(ner)’ occurs five times and ‘dense’/ ‘density’ 18 times. In Sagittarius a specific area is described as ‘very dense indeed and appears smoky’ (*Alm.* 8.2, H172, Toomer [1984] 401) which supports the view of a cloud-like concept of brighter and darker regions.

However, among the terrestrial clouds there are thin, transparent cirrus clouds that just occur as a veil above the stars dimming the faint ones while there are also dense cumulus clouds that are not transparent. From the terminology and description, it remains unclear whether Ptolemy’s concept of heavenly milk was more like a stream of a gas or fluid substance filling gaps between stars (like Aristotle seems to suggest) or like a separate asterism with an exceptionally huge area (like in Aratus). An explanation is not given because the purpose of the description of positions of the stars and the Milky Way is the creation of their visual representation on a scientific instrument. It is to this end that all his terminology is chosen.

One exception: ‘clouds’ instead of ‘milk’

Although Hipparchus does not deal with the Milky Way as a visual appearance, there is one exceptional occasion where he refers to a part of the Milky Way as clouds:

> Having said concerning the Altar that, whenever it is ‘banked with cloud’ from the north and becomes visible, at that time one must anticipate the southwind, Aratus then goes on to speak about the Centaur in the following fashion: [...] (*Hipparchus’ Commentary on the Phaenomena of Aratus and Eudoxus* 1.8.18.1–4). (trans.MacFarlane and Mills [2009])

These ‘clouds’ north of the Altar might be interpreted as the clouds of the Milky Way in Scorpius and Sagittarius. At other occasion where he mentions clouds, he refers to weather phenomena (or mountains) that might cover the view, but in this case, the pile of clouds north of Ara becomes visible while the terrestrial wind blows from the

[27] *Alm.* 8.2, H176, Toomer (1984) 403; the identification is copied from Toomer in the previous section, the star catalogue.

south. Hipparchus' terminology is exceptional but not unusual because Aratus describes this area in the same way:

> Yet even round that Altar ancient Night, [...] , has set an important sign of storm at sea; [...] So pray, I beg you, that at sea this constellation be not visible in mid-sky overarched by clouds everywhere else, cloudless itself and brilliant, but higher up oppressed by billowing clouds, as they are often packed when an autumn northerly piles them up. (*Phaen.* 408–10, 414–17) (trans. Kidd [1997])

This passage in Aratus is particularly clever because the poet plays with the words and similar appearances of phenomena in the sky that look similar at first glance but are of different nature: the storms of autumn and the north wind who causes them are accompanied by cloudy weather. As this is the rainy season, high cumulus clouds are frequently seen; they carry the rain that is characteristic for the season. Simultaneously, the southernmost constellations of the summer (e.g. Ara, Scorpius, Sagittarius) vanish from the nightly display but among them, Scorpius and Sagittarius happen to contain the brightest parts of the Milky Way. The constellation of Ara, the Altar, is defined just below this area, close to the horizon making the Milky Way appear like smoke emitted by the censer and forming (piling up) cumulus cloud-like structures in the northern adjacent constellations (Fig. 2, 7).[28]

This exceptional case of describing parts of the Milky Way not with the term 'milk' but as clouds terrifically serves the weather rule that it is related to. Additionally, it may or may not imply that the part of the Milky Way north of the Altar is considered a product of the Altar's activity or even part of the constellation.

Fig. 2: The Altar of the Farnese Globe attached to the area in the sky where it belongs: above it, the brightest parts if the Milky Way (modern term: centre of the Galaxy) in Sagittarius and Scorpius. This Altar is drawn upside down but the other two globes show it in an upright position (see Fig. 7).

[28] It should be remarked that the Altar is considered upside down in the sky by Hipparchus and Ptolemy as one can see from their designations of stars. For instance, Hipparchus (3.2.6) states that the double star at the edge (β, γ) sets first and the northern more at the base (α or κ) last, implying that the base is up. Ptolemy calls the southernmost stars β, γ, ε 'in the brazier' and ζ 'at the end of the burning apparatus', while the northern stars σ, θ Ara are described as 'in the base'. The Farnese Globe depicts it this way, but the other two ancient globes, the Mainz Globe and the Kugel Globe, clearly show Ara with its feet in the horizon and the flames and smoke in the Milky Way.

Cloudy and nebulous rhetoric in the star catalogue

Aratus, in general does not refer to single stars (with a few exceptions of very bright ones like Arcturus) but to constellations. Therefore, he cannot be considered in this section.

As Hipparchus only deals with stars on accurate lines, the meridian and the mathematical horizon, he uses the term 'nebulous' or 'cloud-like' only in the description of the visual appearance. In the second part of his commentary, Hipparchus mentions: 'The first star to rise [in Perseus] is the cloud-like one in the sickle' (2.5.15), and this object, the two open star cluster h + χ Persei, occurs again with the same terminology among the stars on the meridian while Bootes and the Water-Pourer set and when the Water-Snake rises.

The nebula in the middle of the Crab for him is only a marker in order to designate the four stars (points) in its vicinity:

> Of the four stars in the Crab lying around the nebula, one is south of the tropic by no less than 1°, and the northern of them is north of the summer tropic by less than 1°. Of the two stars lying on the east side around the nebula, the southern lies nearly right upon the tropic, while the northern is approximately two and a half degree from it to the north (*Hipparchus' Commentary on the Phaenomena of Aratus and Eudoxus* 1.10.12). (trans. MacFarlane and Mills [2009])

This designation again occurs in the second part (2.5.2) when he reports that 'the western stars of those placed around the Crab's nebula' are on the meridian while the Crown rises and (2.6.8) the 'stars lie east of the Crab's nebula' when Cepheus sets. Similar terminology is used to describe the stars for the Crab itself setting (3.4.1) and for the stars in meridian while Pisces set (3.4.9).

Ptolemy's star catalogue does not even have the layout of a text but it is presented as a table with coordinates and a measure of brightness (magnitudes) for each star. For five stars, Ptolemy does not give a number (magnitude) in order to describe their brightness but he calls them 'nebulous', some more are described as 'nebulous mass' but still are given with point coordinates. The ones without a numerical magnitude are:

	Identifications given by Toomer
The nebulous mass on the right hand [of Perseus]	The two open star clusters h+χ Persei
The middle of the nebulous mass in the chest [of Cancer], called Praesepe	The open star cluster M44
[Stars around Scorpius outside the constellation:] The nebulous star to the rear of the sting	The open star cluster M7 or the star G Sco in the Milky Way
The star on the eye [of Sagittarius], which is nebulous and double	The two stars ν_1 and ν_2 Sagittarii
The nebulous star in the head of Orion	The star λ Orionis

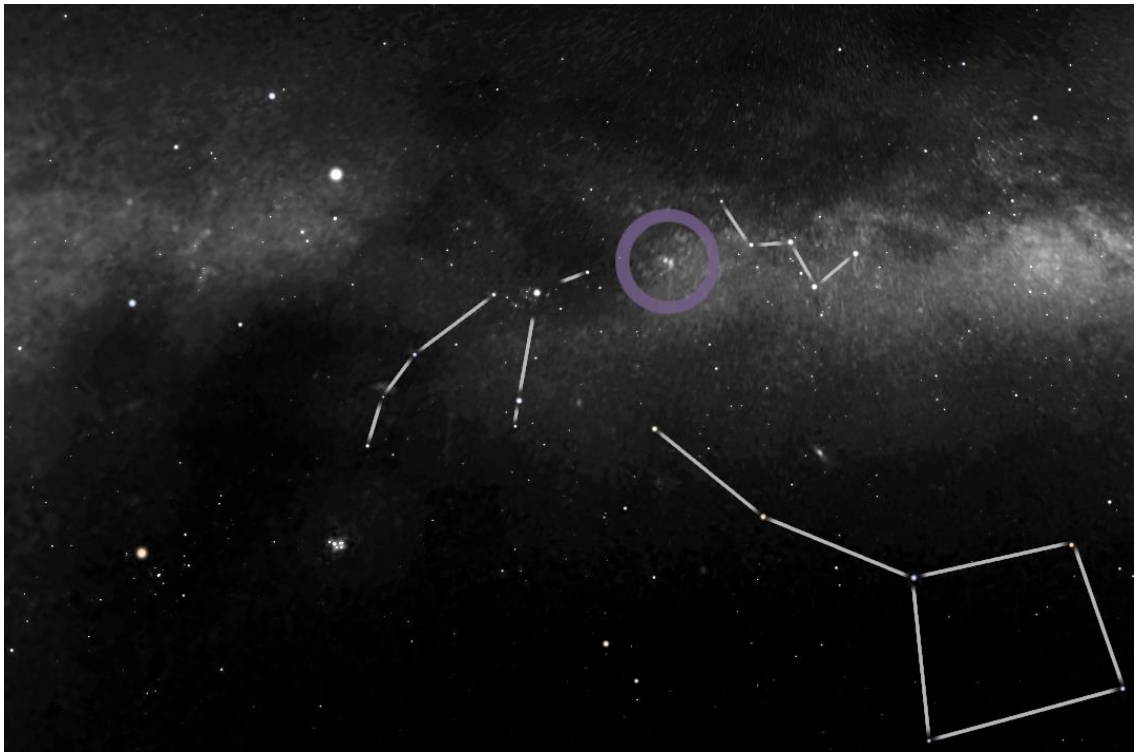

Fig. 3: ‘nebulous mass’ in Perseus, the double star cluster.

It should be pointed out that h+χ Persei (Fig. 3), the ‘nebulous star’ in Scorpius (no matter whether we identify it with M7 or G Sco), and the two stars ν_1 and ν_2 Sagittarii (both Fig. 4, left) are located in the Milky Way and in all three cases, the object is embedded in a bright filament causing the human eye to have difficulty to distinguish the nebula and the group of stars. In particular for elderly observers and in a foggy or humid atmosphere (like the coastal climate of Alexandria), this will cause a fuzzy appearance.

The objects with the term ‘nebulous’ in their description are:

	Identifications given by Toomer
The nebulous star on the right knee [of Cygnus]	The two faint stars ω_1 and ω_2 Cygni
The northernmost part of the nebulous mass between the edges of Leo and Ursa [Major], called Coma	The northernmost part is definitely a star: γ Comae Berenices
The two subsequent star names in the catalogue also refer to the same ‘nebulous mass’ between the edges of Leo and Ursa:	
The most advanced of the southern outrunners of Coma	The star 7 Comae
The rearmost of them, shaped like an ivy leaf	A star is not shaped like a leaf and the point coordinates suggest a dot and not a leaf-like area. The point coordinates suggest the identification with the star 23 Com

Obviously, a sixth object is ‘The nebulous star on the right knee [of Cygnus]’. This case fits the previous explanation because at the given position, Toomer (and others)

finds the two stars ω_1 and ω_2 Cygni in a bright filament of the Milky Way (see Fig. 4, right).

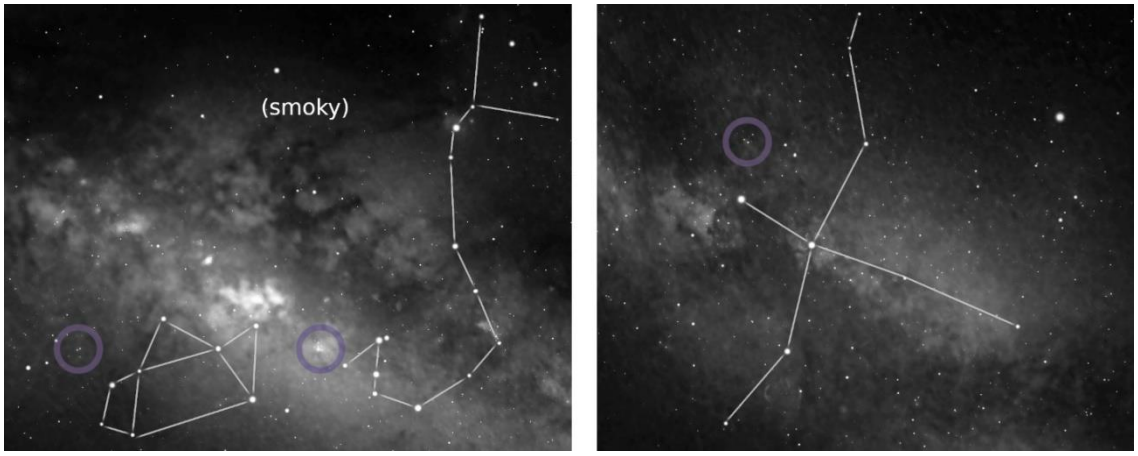

Fig. 4: left the constellations Sagittarius (the remarkable pattern of a tea pot) and Scorpius with two 'nebulous' stars of the *Almagest* star catalogue. Right: constellation Cygnus with another one.

To deduce the meaning of this rhetoric, we should remember the purpose and audience for which the *Almagest* is written. Historians of science throughout the past centuries have compared Ptolemy's coordinates to Hipparchus' and tried to derive (in)dependencies. In all these attempts, the purpose of the star catalogue and the description of the Milky Way were disregarded because they are irrelevant for these research questions. Both catalogues were taken as an inventory of celestial objects causing the impression that their authors were a sort of scientific accounting officers, industriously observing and measuring all night long and afterwards publishing the data.

This is certainly not the case (at least for the author of the *Almagest*): Ptolemy states clearly his purpose of the star catalogue: 'In order to display the arrangement of stars on the solid globe [...] we have set it out below in the form of a table in four sections' (*Alm.* 7.4, H36, Toomer [1984] 339) which also applies to the description of the Milky Way. The order of sections in Books 7 and 8 is certainly not random; these two units belong together. It is necessary to keep the procedure(s) of globe making in mind when reading the rhetoric of the star catalogue: additional to the cloud-like concept of the Milky Way, Ptolemy occasionally calls other appearances 'nebulous' when he wants the globe maker to paint something fuzzy.

Boxed and unframed star clusters

The 'middle of the nebulous mass in the chest [of Cancer]', τῆς ἐν τῷ στήθει νεφελοειδοῦς συστροφῆς καλουμένης Φάτνης τὸ μέσον (*Alm.* 7.5, H94, Toomer [1984] 366), is a description of a star cluster, a group of similarly faint stars that appear as a silverish glow in the corner of the eye, i.e. when not focussed in the middle of the observer's field of view. Ptolemy starts his description of this dark area in the sky with the nebulous area that is most recognisable in indirect view and then continues with the data of four stars (γ, δ, ϑ and η Cancri) forming 'the quadrilateral containing the nebula' (Fig. 5). A globe maker would, therefore, draw the four points

according to their coordinates and then represent the star cluster with a fuzzy area in its centre, surrounded by this box of four stars.

Fig. 5: Constellation Leo is centred in this map. Left (east) of it, the triangle marks the constellation Coma Berenices; right (west) of it, the square marks the core pattern in Cancer.

A similar construction is suggested by Ptolemy for the asterism that is now referred to as the constellation Coma Berenices. In the *Almagest* it is not treated as a separate constellation but as a subgroup within Leo, the Lion: τῆς μεταξὺ τῶν ἄκρων τοῦ Λέοντος καὶ τῆς Ἄρκτου νεφελοειδοῦς συστροφῆς καλουμένου Πλοκάμου τὸ βορειότατον (H100).[29] Again, Ptolemy uses the term 'nebulous mass' to describe a group of faint stars whose appearance in indirect view is a weak glowing or glittering area but in this case, the group is surrounded by three stars: γ Com, 7 Com and 23 Comae Berenices (Fig. 5). As in the case of the four stars around the Praesepe star cluster in Cancer, the globe maker would draw the three stars by coordinates and then fill the space in between with a nebulously looking colour. However, the description of the last star in the list contains the further information that the whole 'nebulous mass' looks like an ivy leaf (φύλλον κισσίνου),[30] so the triangle of the three point coordinates is only the geometrical outline of the rough position and the shape of the 'nebula' (for which the globe maker has to use rather a brush than an accurate ball point or needle) is appended after the accurate points are drawn.

Interestingly, at this area in the sky, the Babylonian compendium MUL.APIN registers a constellation called 'GUB-zu sis-sin-nu $^{d}E_4$-ru_6' (line I i 11) which is a part of the date palm of the goddess Erua. Although the standard Akkadian dictionary, the Chicago Assyrian Dictionary (CAD), gives 'the spadix' as the primary translation, the standard translation in astronomical texts (cf. Hunger and Pingree [1989], Hunger and Steele [2019]) became 'the frond' of the date palm (which might be a rare alternative reading). Thus, Ptolemy's asterism of the Ivy Leaf seen in this nebulous mass might not only describe the shape of the nebula for the globe maker but might also be a

[29] Toomer (1984) 368 translates with many additions: '[Stars around Leo outside the constellation:] The northernmost part of the nebulous mass between the edges of Leo and Ursa [Major], called Coma [Berenices]'.

[30] Literally the Greek text reads: ἡ ἑπομένη αὐτῶν ἐν σχήματι φύλλου κισσίνου (H100).

reminiscence of this Babylonian constellation at the same place as the Graeco-Egyptian asterism of The Lock (or Hair, Coma).

Reading the star catalogue as a working instruction for globe makers returns some new interpretations in details:

1. The term ‘nebulous’ does not imply any statement on the interpretation of the object described. It is only a statement about the visual representation of the spot (or area) in the sky on a scientific instrument.
2. Similarly, the ‘magnitudes’ of stars are not necessarily a measure of any calibrated estimate of brightness of a dot in the sky but they are instructions for the globe maker what template to use for the dot size on the globe in order to help astronomers recognising the relevant patterns. This explains that systematic errors in the magnitudes depending on celestial background brightness, colour of the star and brightness of neighbouring stars as described in Protte and Hoffmann (2020) and (2021) did not bother anybody for almost two millennia.
3. In general, the term ‘nebulous’ refers to a glowing fuzzy area and not to a single point.

This view is supported by the fact that the globular star cluster ω Centauri does not have the qualifier ‘nebulous’ in the *Almagest* although it appears fuzzy to the naked-eye observer. Unlike an open star cluster, a globular star cluster really appears as a (maybe fuzzy) dot of light, and it can be aimed with a front and rear sight.

With this interpretation, it appears evident or at least highly likely that ‘The nebulous star in the head of Orion’ (Fig. 6) that is usually identified with the star λ Orionis does not refer to this star alone but to the whole group of stars around it: λ, ϕ_1, ϕ_2 Orionis and all the fainter 5.6 to 7.6 mag stars in between them. These stars are not a star cluster in the modern sense of the term (i.e. a group of stars that physically belong together) but only by chance appear next to each other in the sky. However, for an ancient globe maker, this does not make any difference: he would draw a point at the given coordinates and blur it to a visual representation of a nebulous appearance. This way, the head of Orion would become a shape instead of being represented with a mere dot.

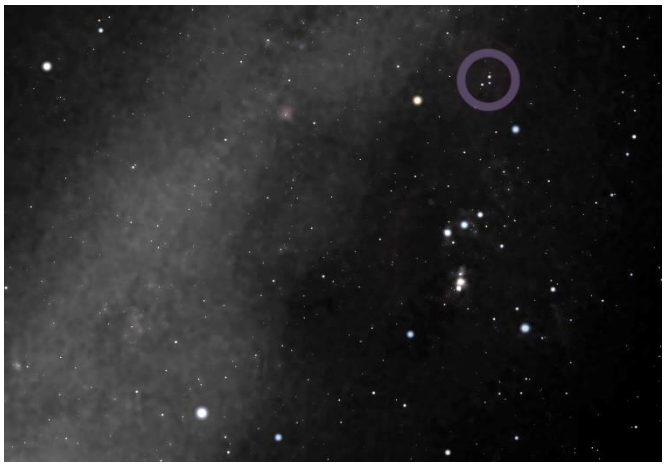

Fig. 6: Constellation of Orion with encircled ‘head’.

Concluding, the term ‘nebulous star’ in Ptolemy’s *Almagest* always refers to groups of stars: either star clusters or associations of stars, eventually embedded in filaments of the Milky Way.

Summary and further conclusions

Analysing the rhetoric of astronomers in their description of the starry sky, we found different audiences and purposes of the three texts:

1. Aratus' text is easily memorisable by everybody but lacks scientific accuracy in the details pointed out by Hipparchus.
2. Hipparchus praises Aratus' poem as an introduction but updates the information for scientific purposes of his contemporaries.
3. Ptolemy lifts the level of information to be useful not only for his contemporaries but also for future astronomers and craftsmen.

With regard to clouds and nebulae, we found the following cases:

1. Ptolemy uses terminology like 'smoky', 'cloud' and 'dense' or 'thin' patch to describe the Milky Way. However, this does not allow any conclusion on his concept of this phenomenon because he only gives instructions to globe makers how to represent it visually.
2. His terminology of 'nebulous stars' designated star clusters and other groups of stars, often combined with filaments of the Milky Way.
3. Similarly, Hipparchus uses the term 'nebula' for the open star cluster in Cancer and the double open star cluster in Perseus.
4. Aratus does not use the terminology of clouds or nebulae to describe the celestial globe as a whole. He sticks to the Babylonian tradition where the Milky Way is described as an asterism (similar to stars but bigger) dividing the sky in halves and star clusters are described as 'scintillating asterisms'[31] which refers to their metallic glittering.
5. Yet, there is one exceptional case for Aratus and Hipparchus to refer to a specific part of the Milky Way with the terminology of clouds, i.e. the brightest parts of the Milky Way as outlet of the constellation Ara, the Altar, south of them (cf. Fig. 7).

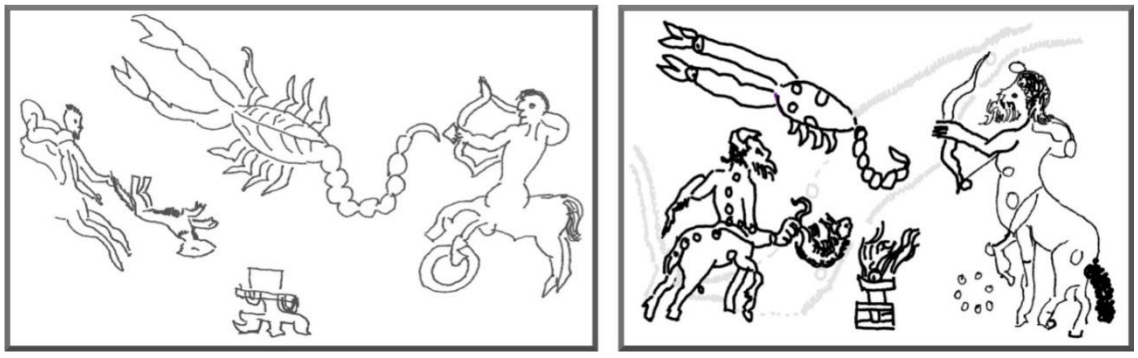

Fig 7: Constellation Ara on the Kugel Globe (left) is positioned 'under' the bright clouds of the Milky Way in Scorpius which are crossed by dark filaments. On the Mainz Globe (right) the Milky Way is even depicted above the fire of Ara (own drawing).

The association of the Milky Way with cloudy appearances in Ptolemy's *Almagest* seems to be new in his time or for his purpose of instructions for globe makers. The structure of his text suggests that he expects the globe maker first to take a needle or engraving tool and make point in the given coordinate system. Then, the globe maker

[31] The term in MUL.APIN would be 'MUL um-mu-lu-tu$_4$', for instance used in I i 10 for Coma Berenices, in I i 32 for an un-identified object (possibly h+χ Per or the Andromeda Galaxy).

would take another tool and 'model' the object: in case of a simple star, he would take a circle template of the given size (according to the magnitude scale) and eventually take a different colour to paint the star at the given position. In case of 'nebulous stars' he would not take a circle template but press a stamp or a sponge or a brush to the marked point or freely paint a cloud (perhaps in the given shape, e.g. of an ivy leaf). The visual representation of the Milky Way would be added after all stars are drawn and again, this structure is painted with a brush but in a semi-transparent way (like chalk drawings) in order to leave the star points (whether sharp or nebulous) visible. The rhetoric of the star catalogue serves the purpose.

Conclusions on the ancient concept of constellations

However, if Ptolemy was the first to describe the star clusters and the Milky Way in the given way, this raises the question what the terminology might have been before this new concept. With regard to the names of constellations in antiquity, I suggest that the constellations were not regarded as patterns of stars (dots of light) only, but they designated the visual appearance of a region in the sky.

For instance, the two small stars in Auriga, the Charioteer, that are called 'Haedi' (young goats)[32] in the *Almagest* (η and ζ Aurigae) are located in a filament of the Milky Way on whose upper rim 'The star at the left elbow' of the charioteer (ε Aurigae) is located. This way, the image of two little white goats that are carried by a man's lower arm is clearly imaginable by considering the stars together with the whitish celestial background making the name Ἐρίφων (Haedi) not only referring to the two little stars (as interpreted from the Almagest star catalogue) but to them plus the adjacent area of the sky. Similarly, the statement 'The area [of the Milky Way] near the three joints [of Scorpius] is somewhat denser, while the area round the point [of the arrow of Sagittarius] is very dense and appears smoky' that describes the area of the Milky Way above Ara, the Altar, might possibly be a hint on the interpretation of these 'clouds' of the Milky Way as being caused by the fire in the censer: in the air above a fire, the smoke of the fire is visible even at some distance of the fire itself. At least this would be compatible with the consciously ambiguous verses in Aratus' poem and the terminology in Hipparchus' commentary when he refers to this area in the sky.

These new suggestions are also compatible with the long-known facts that the double open star cluster in Perseus together with its nebulous Milky Way background causes a silver impression for the naked-eye observer and is therefore interpreted as the metal of Perseus' weapon (a knife or sickle). The same concept is seen in the area of Orion's dagger that is described by six stars in the Almagest star catalogue (η, 42 and 45, ϑ_1 and ϑ_2, ι, 49(d) and υ Orionis) two of which are double and they all are backed by a nebulous ground.

In all these cases, the 'nebulous' appearance of the spot or area in the sky is or could be part of the constellation image.

[32] τῶν ἐπὶ τοῦ ἀριστεροῦ καρποῦ β καλουμένων Ἐρίφων ὁ ἑπόμενος (H66); see Toomer (1984) 353.

Andromeda Galaxy unrecognised?

That said, this new reading of the concept of constellations in the ancient Greek world that is derived from Ptolemy's rhetoric could even explain why the Andromeda Galaxy seems to be unmentioned in the *Almagest*. In fact, there is no stellar point listed at the position of this galaxy although (or because) it is clearly visible to the naked eye as a fuzzy object. However, the visual impression is neither a dot-like appearance like stars, nor is it 'nebulous' in the same way as the star clusters appear that are typically described with that term. To Ptolemy it must have occurred in a similar way as the clouds of the Milky Way, a drop of heavenly milk, so to say.

The star next to the galaxy is ν Andromedae, designated as 'The northernmost of the three [stars over the girdle]'. Thus, the metallic glow of the little galaxy might have been interpreted as part of the chain with which the princess is tight to the rock: it might have been considered part of the constellation image in Ptolemy's data source and therefore not registered as a dot (coordinate) in the star catalogue.

Possibly, even the statement καὶ τὰ μὲν πρὸς ταῖς ἀψῖσιν ἀραιοτέρου χύματός ἐστιν, τὰ δὲ κατὰ μέσην τὴν Κασσιέπειαν παραμήκη τὴν πύκνωσιν ἐμφαίνει (*Alm.* 8.2, H175) at the end of the paragraph describing the Milky Way in the Cassiopeia region does not refer to the Milky Way cloud within the constellation of Cassiopeia but to a spot south of it. The passage reads in Toomer's translation:

> The other stars [of Cassiopeia] and all those round about this [constellation] lie in the milk. The areas near the rims are of thinner consistency, but those at the middle of Cassiopeia display a dense patch running the length. (Toomer [1984] 402)

It is usually interpreted that the 'dense patch' refers to the cloud of the Milky Way in the right part of the 'W', the western part (α, β, γ Cas), equalling the stars Ptolemy considers 'on the breast' and 'over' or 'on the middle of the back of' the Queen's throne. However, these parts of the Milky Way are not at all dense – in Bayer's *Uranometria* (1603) they are even characterized as a gap-like region because of their faintness. There is no star cluster or anything that can be interpreted as a patch in this area and the previous sentences describe the rim of the Milky Way. Therefore, in Ptolemy's source (e.g. the notes of an observer during the night), the 'dense patch' might have referred to the milky appearance of the Andromeda Galaxy beyond the rim of the Milky Way above Cassiopeia's head and the surrounding stars (ν, ξ, ο Cassiopeiae) rather than a part of the Milky Way itself.

A support of this interpretation might be the depiction of Andromeda on the Mainz (Fig. 8) globe that is preserved from the 2nd century CE; the same time as the *Almagest*. It is the only one of the three ancient globes that has the Milky Way clearly marked. At this globe, also the chain is drawn with which Andromeda's arm is attached to the rock. Like for the metal sword of Perseus that is called 'a nebulous mass' by Ptolemy, this might be another hint that the cloudy appearances were interpreted as accessories of the constellation figures.

Fig. 8: depiction of Andromeda on the Mainz Globe; her left arm attached to the Milky Way, the bracelet from the metal chain appearing as possible part of the Milky Way's outer edges (own drawing).

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University of Jena

Cruelty, Commonplace, and the Scientific Gaze. Anatomising Imperial Discourses on Vivisection*

Caroline Petit

Abstract

Some commonplace accusations against physicians are curiously enduring. In every epoch, medicine and physicians have been subjected to mockery, criticism, and attacks. They were often perceived as ignorant, abusive, insensitive or cruel, and greedy. They were also commonly derided for being skilled talkers rather than healers. Stephen Pender cites Petrarch in a letter to the Pope, where, he says, 'while their patients are dying, physicians tie the knots of Hippocrates with Ciceronian warp', indulging in 'the empty elegance of words'.[1]

At the root of this distrust lies the relative amateurism of early physicians, whose knowledge was not always validated by a degree or some other form of scientific recognition. A physician could be an accomplished healer and a scholar, or a simple trickster or charlatan. In popular view then, the profession lacked dignity – just like other professions, such as seers, diviners, and even philosophers.

In antiquity, the critique of medicine assumes many guises and can be found in various forms: in Greek and Roman novels, in philosophical arguments, in Christian apologetics and in epigrams, on the stage, in fables and declamations, and in medical texts themselves. By contrast, and possibly in response, like other arts (*technai*) medicine has developed its own 'scientific' discourse to establish and demonstrate its value as a discipline; my aim, in this study, is to examine to what extent this medical discourse developed around commonplaces, and whether, in particular, this strategy can be described as responding to the well-known commonplaces against doctors which appear in Greek and Latin literature. I will especially focus on the cruelty and ruthlessness they show in their thirst for knowledge.

Introduction

Anatomical endeavours started at Alexandria in the Hellenistic period; their origins and development are shrouded in controversy. It is possible that the bodies of criminals were handed over to anatomists for gruesome exploration as a 'useful' way to end their lives. Galen's silence over this question has been interpreted as casting doubt on the reality of this episode in medical history. But Galen refers openly and without question to other experiments ordered by Hellenistic rulers over criminals sentenced to death, notably on poisons: we should therefore not read too much in his

* This article is a revised version of the paper I gave at the ISHR biennial conference in Nijmegen in August 2022. I am grateful to Kostas Stefou and all the editorial board for accepting this piece in *Rhetoric and Science*. Some of the remarks below expand from Petit (2018) 153–61; cf. Van Mal-Maeder (2007) 78–82. Since I gave my paper in Nijmegen, Claire Bubb published an excellent synthesis on dissection in antiquity (cited below at Bubb 2022) which provides *inter alia* useful background to the rhetorical analysis of ancient literature on vivisection.

[1] Pender (2005) 57.

apparent silence over human vivisection at Alexandria.[2] Be that as it may, anatomy and related activities around living bodies remained, to an extent, frowned upon and became a topic for sarcasm and indignation against medical practitioners. As we will see, medical discourse seems to address the accusation of cruelty levelled at practitioners eager to understand the functioning of the human body. This study focuses on imperial literature, both in Latin and in Greek, at a time when anatomy and public demonstrations of dissection were in fashion. Galen's famous anatomical demonstrations, in Pergamum and in Rome, allowed him to display his skills and whilst playing on his audience's minds, senses, and emotions. Such performances involved not only the cutting open of living animals, but also gestures of spectacular technicality such as cutting and ligaturing an artery, opening the skull to put pressure on various parts of the brain, removing all internal organs of an animal and then replacing them in the abdominal cavity, etc. It was a gruesome business.[3] Beyond such performances, which were intended to instruct and entertain the Roman public, or discredit rivals, doctors also had a reputation (not without reason) for using their patients' bodies and ailments to further their knowledge – a 'dark side' which finds an echo in both Greek and Latin literature, notably the *Major Declamations* attributed to Quintilian, the main focus of our analysis.[4]

Doctors and Cruelty: the Making of a Commonplace

'Cruelty', when applied to physicians, takes on different meanings: doctors are accused of killing their patients (Pliny, Roman satire); of using needlessly painful treatments amounting to torture (cf. Caelius Aurelianus); or (the meaning I am interested in) using ailing, defenceless human bodies to further their knowledge. Such accusations are meant to undermine the famous Hippocratic creed: 'to help, or to do no harm'. They were a serious issue for a practitioner willing to build a relationship of trust with patients. Here I am leaving aside the question of dissecting animals, which did not pose the same ethical problems to the ancients and has been addressed elsewhere.[5]

In one of the *Major Declamations* attributed to Quintilian, *MD* 8 on the sick twins (*gemelli languentes*), the fictitious case concerns a mother, whose husband has sacrificed one of their twin sons to (allegedly) help cure the other. The father has allowed himself to follow the advice of a doctor, who is here accused of following selfish purposes and exhibiting unnecessary cruelty. The father, not the physician, is the main target of the mother's lawyer: for he has cruelly put to death one of his sons, without the mother's consent, and with no certainty that the second son could actually be cured by the doctor's intervention on the first. No matter how fictional, this declamation reflects genuine questions and values that would have been understood by an audience, especially in the classroom. The declamation functions as a

[2] Gal. *On Simple Drugs* 10.1 (12.252 K.).

[3] See Bubb (2022) 92–93.

[4] The recent publication of the *Major Declamations* attributed to Quintilian in the Loeb series (2021) is a game-changer for scholarly engagement with this fascinating group of texts, thanks to the new edition provided by Antonio Stramaglia and the English translation by Michael Winterbottom. All references are to this edition, with occasional reference to Stramaglia's earlier multi-contributor edition in Italian (Cassino project, 1999–2020), as part of which he produced the edition of *MD* 8.

[5] Bubb (2022) 145ff.

practicing, educational space for the young to approach real-life situations and ethical problems beyond the classroom and the often bizarre elements of the exercise. As Antonio Stramaglia puts it in the general introduction to the *Major Declamations*, 'a lack of verisimilitude and a certain distance from the real proceedings of Roman courts, is undeniable in most of the themes preserved in our collection. However, a variety of ethical, social, and legal questions appears beneath the surface of the fictional world conjured up by the rhetoricians: the unrealistic, and even absurd, features of the themes of declamation seem to provide a "safe space" in which a student could confront a wide range of complex issues, so as to attain both the technical knowledge necessary to speak persuasively and the "soft skills" needed to manage the challenges of adult life'.[6] It is thus preferable not to dwell on the apparently excessive emphasis on pathos or the bizarre world of those declamations. At another level, *MD* 8 'concerns the timeless issue of the ethical limits of medicine and is inspired by a debate on vivisection that had gone on in Rome since the early Imperial age'.[7]

This declamation is thought to be datable of the mid to late 3rd century AD, which makes it one of the latest of all the major declamations of the corpus.[8] If correct, this hypothesis makes the declamation neatly posterior (by several decades) to most medical texts of the Antonine and Severan eras, notably the works of Galen (c.129–216 AD), our main medical source for this period. Leaving aside the chronology for a moment, the theme of this declamation does link with earlier medical texts on anatomy. Beyond the obvious point of reference that is Galen, is in fact possible to go back as far as Celsus' *On medicine*, a work of the first half of the first century of our era.

The theme of medical cruelty is not new, but it is put to especially good use by the author of this declamation to inspire pity. The pain of the mother is made all the more apparent that she has been betrayed by her husband, who in turn has allowed a ruthless physician to tear his son's body to pieces. The declamation addresses the father as the main criminal here; but the physician is called 'butcher', and 'executioner'. As Claire Bubb has shown, this is more than a metaphor: anatomists and butchers have much in common in ancient Rome – from butchering techniques to shared spaces and suppliers.[9] But this is also a Latin literary trope and a reminiscence of Pliny the Elder's account of the first Greek physician in Rome, a certain Archagathus whose nickname was 'The Executioner' (*carnifex*).[10] The declamation offers a striking description of the vivisection scene itself:

> *Ut erat iuvenis primo ipso comparationis incerto, mox electione cruciatus, abacta est a perituro prima mater, et modo sedula ministeria servorum repente mutata sunt in mortis officia. Detrahuntur trementibus velamenta membris et, ut grassaturas manus totum corpus admitteret, nudatur miserabilis ac deflenda macies. Toto deinde tenditur toro, et ad immobilem rigidamque patientiam per omnia lectuli spatia duraturus exponitur. Accipet carnifex ille telum, non quo*

[6] (2021), Vol. I, xxv.
[7] *Ibid.* xxii. Cf. Ferngren (1982) and (1985).
[8] *Ibid.*, Vol. II, 114.
[9] Bubb (2022) 94–95.
[10] *Nat. Hist.* 29.6.

> *dextera statim totum vulnus imprimeret, sed quo leviter paulatimque discindens animam in confinio mortis ac vitae librato dolore suspenderet*.
>
> As for that youth, tortured as he was first by the very suspense of the comparison, then by the choice, before anything else the mother was driven away from the doomed man; right after, the solicitous services of the slaves were abruptly changed into preparations for death. The clothes are stripped from the trembling limbs, and, so that the whole body should lie open to the hands that will attack it, the emaciated frame is stripped naked, pitiful and lamentable. Then he is stretched the full length of the bed, and put on display all over it to hold out against what he had to suffer unmoving and stiff. The dreaded executioner takes up his weapon, not to make the whole incision at once with a single stroke, but by light and gradual cuts to regulate the pain and keep the patient's breath on the borderline between life and death.

Once the father's choice is made, the poor boy is handed over to slaves to be prepared for death instead of life; he is stripped naked, revealing his terrifying emaciation, and tied up to a bed or a bench with his limbs stretched out in view of the operation to come, in a setting much reminiscent of Galen's dissections as well as legal torture scenes.[11] But far from a simple operation or incision, the doctor inflicts a protracted death onto the youth, cutting slowly through the flesh so as to maintain life whilst causing an unbearable level of pain. The patient is thus maintained 'at the confines of death and life' while the doctor satisfies his quest for information – we hear nothing of the actual cause of the illness or whether the sacrifice benefited the cure of the other son in any way. Rather, the declamation insists on the uncertainty that remains over the benefit of the deed.[12] Without dwelling on the visual and sensory quality of this scene, it is worth stressing the declamation's emphasis on pathos (*miserabilis ac deflenda macies*). The boy's ordeal conjures up images of slave torture and animal vivisection in a particularly horrific scene.

To compound the gruesome outcome of the pact between the father and the physician, the last words are handed over to the mother, who addresses her dead son. She describes how she gathered his unfortunate entrails, left behind by the doctor and the father, in the folds of her dress, and how she put them back into his mutilated body and brought back together the disjointed limbs, lest he becomes a shocking sight to other souls in the underworld.[13] This theme recalls the myth of Pentheus and many a retelling of mothers piecing back the dismembered body of their child. To readers of Galen, this unexpected deed is also reminiscent of his prowess at putting back in place the entrails of dissected animals: the reversed anatomical skills displayed by the unfortunate mother thus expose the physician's competence as very relative, as well as ironically evoke genuine contexts of medical performance – in which, however,

[11] On the parallels between torture and dissection, see Bubb (2022) 143.

[12] The mother's (and the text's) last words are: *nec tamen umquam constare poterit an tu sanaveris fratrem.*

[13] *Quod solum tamen potui, corpus quod medicus, quod reliquerat pater, hoc sino misera college ac vacuum pectus frigidis abjectisque visceribus rursus implevi, sparsos artus amplexibus junxi, membra diducta composui et de tristi terribilique facie tandem aegri cadaver imitata sum* (*MD* 8, 22.5). Cf. 21.3 above.

animal bodies rather than children are used to showcase a physician's dissection skills.[14]

Although it can be linked with similarly pathetic scenes in other declamations, this pseudo-Quintilianean text is rather unique. Naturally, the medical aspect of this piece calls for comparison: the proem of Celsus' *On medicine* springs to mind.[15] In this long introduction to his treatise in eight books, Celsus exposes the ideas of the two main Greek schools of medicine of the time, the rationalists and the empiricists; the former hold that it is crucial to understand nature to be able to cure patients. On this ground, they defend anatomy as a key formative aspect of medical training. Vivisection of criminals at Alexandria, Celsus reports, were, according to them, a necessary evil, since through the death of a few, much knowledge was gained, to save the many.[16] By contrast, empiricists had decried the practice of anatomy, especially on the living, as cruel, useless, and self-serving. This is the debate echoed in the declamation on the sick twins; arguments put forward by the author of the declamation are in fact closely connected to the empiricists' case as exposed by Celsus.

It is beyond the scope of this article to revisit Celsus' preface in detail, as his argument *pro et contra* is well-known, and covers many pages.[17] Let us focus on some key points. Celsus provides precious information here: first, he gives away that the debate is primarily *internal* to the field of medicine in his time, a quarrel between empiricists and rationalists – with empiricists denying the need for reasoning, eloquence, theory, and anything that does not directly serve healing. Dissection, according to them, falls into that category.

Toward the end of the preface, he also tells us that the debate had been going on for a long time and given rise to many treatises on the question (obviously lost); he also stresses that the discussion is ongoing, at the time of writing.

> *Cum haec per multa volumina perque magnas contentionis a medicis saepe tractate sint atque tractentur, subiciendum est, quae proxima vero videri possint (…)*[18]
>
> Since all these questions have been discussed often by practitioners, in many volumes and in large and contentious disputations, and the discussion continues, it remains to add such views as may seem nearest the truth.

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[14] Gal. *On Examining the Best Physician* 9,6 (*CMG* Supp. Or. IV, p. 104–105 Iskandar). The text is preserved only in Arabic. I cite Iskandar's translation: 'Once I attended a public gathering where men had met to test the knowledge of physicians. I performed many anatomical demonstrations before the spectators; I made an incision in the abdomen of an ape and exposed its intestines: then I called upon the physicians who were present to replace them back (in position) and to make the necessary abdominal sutures – but none of them dared to do this. We ourselves then treated the ape displaying our skill, manual training, and dexterity. Furthermore, we deliberately severed many large veins, thus allowing the blood to run freely, and called upon the Elders of the physicians to provide treatment, but they had nothing to offer. We then provided treatment, making it clear to the intellectuals who were present that physicians who possess skills like mine should be in charge of the wounded'.

[15] Antonio Stramaglia correctly identified this parallel in his 1999 edition.

[16] *(…) neque esse crudele, sicut plerique proponunt, hominum nocentium et horum quoque paucorum suppliciis remedia populis innocentibus saeculorum omnium quaeri* ('nor is it, as most people say, cruel that in the execution of criminals, and but a few of them, we should seek remedies for innocent people of all future ages') (Cels. praef. 26).

[17] See especially the excellent commentary in Mudry (1982).

[18] Cels. praef. 45.

By the time of our declamation then, it was certainly *commonplace* to point out, and use rhetorically the cruelty of anatomical experimentation; but can we trace the origins of this commonplace in time? It may have occurred as early as the Hellenistic period, since Celsus, in his passage on the rationalists, hints at the existence of a widespread condemnation of vivisection in the public.[19] The cruelty of physicians in the specific context of vivisection, as is well-known, is evoked in several Latin texts, including Tertullian's *On the soul* and, much later, Caelius Aurelianus' *Acute and chronic diseases* and Augustine's *City of God*.[20] It ties in well with more general prejudice and attacks against Greek doctors, their theories, and their practice.

The Romans notoriously viewed the arrival of Greek doctors in Rome with suspicion – they have left a vivid picture of their 'reservations', as early as Cato, pointing to their apparent greed, ambition, and ruthlessness.[21] The Greek doctor appears as a talkative, sophisticated charlatan, putting more words than competence into his practice. Traditional Roman medicine being down-to-earth and based on the garden's products and magic, the Greek *technē*, with its emphasis on theory and debate, seemed excessive and out of touch. And their reputation for killing their patients seems widespread enough among Latin poets (notably Martial). But the commonplace of their cruelty in relation with anatomy is certainly something that developed with anatomy as both a practice and a fashion in Rome. As we have seen, public anatomical demonstrations were common practice in the time of Galen, and the debate over vivisection occupied many books, possibly over several generations. It is plausible that this commonplace became established in and with imperial literature.

The efficiency of this commonplace lies in its anchoring in the physician's own arguments. In the description of scientific cruelty offered by *MD* 8, the physician is driven by his own intellectual curiosity and egotism: he is performing a *useless* act, and he is causing the death of the patient he is supposed to save. The professed *philanthrōpia* of ancient physicians is put to the test. The *usefulness* of anatomy and dissection that rationalist physicians advocate is damaged – in fact, the very notion of *useful* (with its double, medical and rhetorical weight) is turned against them, as appears from Celsus' argument. The rhetorical potential of this theme is remarkable: it revolves around a paradox, that of an art and its practitioners made to preserve life, but delivering death. It is therefore not surprising to find an entire Greek *progymnasma* (or preliminary exercise) dedicated to a case against a murderous physician (in this case, poison, not the knife was used).[22]

As proving the usefulness of vivisection turned out to be impossible, at least according to the synthesis provided by Celsus, the trope of the heartless butcher-physician cutting open living human bodies could live on. In the final section of this article, I would like to hypothesise that medical discourse, in turn, addressed those

[19] Cels. praef. 26: *neque esse crudele, sicut plerique proponunt, hominum nocentium et horum quoque paucorum suppliciis remedia populis innocentibus saeculorum omnium quaeri.*

[20] Tert. *On the soul* 10.4; Cael. Aur. *Acute and chronic diseases …* ; Aug. *City of God* 22.24.

[21] See Juvenal, *Sat.* III, 74–78; further references in André (2006) 25–49. It is worth noting that 'bad physicians' are also a trope within medical literature, as in Galen, *On prognosis* or much earlier, Hippocrates' *On the sacred disease*. See also Kudlien (1970) and Ferngren (1985) 500–501.

[22] Libanius, *Progymn.* 8. See Ratzan and Ferngren (1993) (which contains a translation of the text); on Libanius' *Progymnasmata* in general, see Gibson (2014).

caricatural traits and responded through careful anatomical descriptions and narratives.

As we have seen, physicians of the Hippocratic tradition (which would have included rationalists *and* empiricists) believed in the command to 'help, or at least do no harm'. This would have prevented a physician from trying a needlessly painful treatment; as prognostic was the core skill of the physician, diagnosing an incurable disease – and stepping back from the sick room – was always better than try curing it, and fail. In the declamation on the sick twins, emphasis is laid on medicine as an art oriented towards life, not death; and towards treatment rather than murder.[23] This, too, is borrowed from the empiricists' discourse as exposed in Celsus and used to contrast the physician's ruthlessness (certainly a rationalist) with the Hippocratic ideal to 'do no harm'.

Medical texts, in their variety and abundance, offer a privileged insight into anatomy as a discipline and a form of writing.[24] Galen is our most precious source for understanding ancient anatomy in its medical, social and cultural context. He has left us several works on anatomy, including some dedicated to dissection of dead animals and to vivisection (now lost); among the extant works, we have a long treatise on 'anatomical procedures' which is a detailed handbook of dissection.[25] In this work (in fifteen books, part of which being available only in Arabic), Galen focuses on animal dissection and vivisection and provides a luxury of details about how to perform incisions and other procedures efficiently and quickly; he also distinguishes between public procedures and those performed behind closed doors. He is attentive to the emotional aspect that such procedures can produce in various audiences. The choice of animal is therefore guided by the intended effect (loud, etc.); but apes, for instance, are not to be selected for certain public demonstrations, because the way they express pain is too close to that of a human being.[26] There are two anatomists then – the unemotional one behind closed doors, and the public performer, attentive not to hurt his audience. Galen's attitude to the pain of animals, and of humans, is therefore a matter of professionalism and cautiousness. I would argue that this attitude, and the subsequent cautiousness in his writing, including in handbooks for fellow doctors such as the *Anatomical procedures*, is at least partially a response to the public perception of physicians as 'cruel'.[27] In this respect, animal vivisection helps us understand better the attitude of the physician at the bedside.

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[23] *Qualem non salutares medentium manus, non ars inventa pro vita […]*, 21.5.

[24] On this subject, see now Salas (2020) and (2023).

[25] See Bubb (2022), especially chapters 4 and 9.

[26] This has been emphasised many times; see most recently Bubb (2022) 92.

[27] Bubb (2022) 162–63 provides an excellent summary of the thin rope walked by ancient anatomists: 'Just as a dissector would be wise to differentiate himself from butchers, magicians, and priests, he could not be too cautious about disassociating his practice from cruelty, punishment, and death. Public dissections were meant to highlight cutting-edge scientific knowledge and impressive technical skills, and animals provided a familiar, disposable, and uncontroversial medium. The dissection of humans, in contrast, whether done in public or in private, would have sullied the reputation of the doctors who performed it: even if the exposure and maltreatment of human bodies was condoned in certain circumstances, it was in every case an intentional act of desecration'. Cf. Amundsen (1973) and Ferngren (1985) 504, on the liability of doctors in Roman law and the need to maintain a good reputation.

When it comes to human patients, Galen is mindful to stress that he strives to avoid causing any unnecessary pain. True, treating patients provides a physician with a myriad of opportunities to look inside the body (an opportunity which would not have been common in his time in medical training, even at Alexandria). Let us take an example. In a situation vaguely reminiscent of the sick twins, Galen, together with a swarm of other physicians and students, is called to the bedside of patients suffering from 'anthrax': their limbs are laid bare by the illness, which provides an opportunity to examine the tissues, muscles, tendons, veins and arteries.

> ὅσοι μὲν οὖν ἡμῶν ἐτεθέαντο, Σατύρου ἀνατέμνοντος τῶν ἐψιλωμένων τι μορίων, ἑτοίμως τ' ἐγνωρίζομεν αὐτὰ καὶ διηρθρωμένην ἐποιούμεθα τὴν διάγνωσιν, ἐπιτάττοντες τοῖς κάμνουσι, κινεῖσθαί τινα κίνησιν, ἣν ἠπιστάμεθα διὰ τοῦδέ τινος ἐπιτελεῖσθαι μυὸς [...]. τοὺς δ' ἄλλους ἅπαντας ἐωρῶμεν οἷον τυφλοὺς ἀγνοοῦντάς τε τὰ γεγυμνωμένα μόρια, καὶ πάσχοντας ἐξ ἀνάγκης δυοῖν θάτερον, ἢ πολλὰ μέρη τῶν ἐψιλωμένων μυῶν ἐπαίροντάς τε καὶ παρατρέποντας, **ἐξ ὧν ἀνιαροὶ οἱ κάμνοντες ἐγίγνοντο, μάτην ἐνοχλοῦντας**, ἢ μηδὲ τὴν ἀρχὴν ἐπιχειροῦντας θέᾳ τοιαύτῃ· τὸ μὲν γὰρ προστάξαι τῷ κάμνοντι τὴν προσήκουσαν κίνησιν κινῆσαι τὸ μόριον οἱ ἐν ἔθει μᾶλλον ἠπίσταντο. ἔγνων οὖν ἐναργῶς ἐκ τουτωνὶ τὴν τραυματικὴν θέαν τοῖς μὲν ἤδη τι προδεδειγμένοις βεβαιοῦσαν ἃ μεμαθήκασι, τοῖς δ' οὐδὲν προεπισταμένοις ἀδυνατοῦσαν διδάσκειν τὸ πᾶν.[28]
>
> We were all watching, as Satyrus cut into some parts stripped from their skin, and we recognised them straightaway and were able to perform the examination in a structured way, asking the patients to make some movement which we knew would activate a particular muscle [...]. We watched as all the others, in complete ignorance of the bared parts as though they were blind, consequently made either of two errors, lifting and pulling aside the major part of the stripped muscles, **resulting in the patients being left incurable, needlessly aggravated**; or not even attempting any such observation. Those with a habit of doing so did better at asking the patient to perform the movement required to move the part. I knew then clearly that the observation of wounds consolidates the knowledge of those who already have some knowledge, but cannot teach those without preliminary knowledge anything at all.

All in attendance touch and probe the patient's gaping flesh to look and feel inside. Galen however blames the less well-trained physicians who, not knowing anatomy well enough, caused unnecessary pain to the patient by displacing the tissues and inadequately handling the patient's limbs. Other passages like this point to a similar care for the patient's level of pain (although many patients do have a rough ride). In a sharp contrast, Galen and his fellow students combine knowledge and appropriate care, while 'others' all damage the patients to the point of ruining any hope of cure. In this passage, Galen of course doesn't directly address the critiques of physicians that we have discussed; but one may wonder if his insistence on this aspect of the scene

[28] Gal. *On Anatomical Procedures* I, 2 = II, 225–226 K. The translation is mine. Cf. Petit (2018) 157–60.

does not owe to the polemical subtext against the cruel physician. I would venture the idea that it does.

Again, Galen presents himself as a mindful dissector and performer. In other works, he claims to avoid unnecessary emotional distress (audience) when handling animals, notably apes; but this attention is ambivalent. His skilful play on the audience's impressions during public vivisections is no less apparent: when he aims to demonstrate the connection between an area of the brain with the voice, the alternate squealing and silence of the animal under the knife *is* the focal point of the act.[29] The resistance, agitation, nervous reactions and screams of the animals would have had an impact that he could (and would) not ignore. The familiarity of ancient Romans with everyday slaughter of animals in sacrifices and for food may have mitigated the audience's emotional response to such scenes. Torture on the sick bed was, to an extent, another issue. But one may wonder whether Galen is not simply being mindful, in his writing, to construct his own medical *persona* as wildly opposed to the cold, emotionless executioner that the fictional doctor of our declamation is construed to be.

Galen's descriptions and narratives of dissection appear as purged from any emotional language, and any reference to the pain of a patient (the pain of the animal, about which he does not care much, is also usually suppressed in the narrative). In contrast to the twin's dissection by the rhetor (see above, 19.5–7 *MD* 8), Galen's account of a slave whose open chest allowed for his beating heart to be seen shows much control of the language:

> πληγεὶς ἐκεῖνος ὁ παῖς ἐν παλαίστρᾳ κατὰ τὸ στέρνον, ἠμελήθη μὲν τὸ πρῶτον, ὕστερον δ' οὐ καλῶς προὐνοήθη. καὶ μετὰ τέσσαράς που μῆνας ἐφάνη πῦον ἐν τῷ πληγέντι μορίῳ. τοῦτο κομίσασθαι βουλόμενος ὁ θεραπεύων, ἔτεμε τὸν παῖδα, καὶ, ὡς ᾤετο, διὰ ταχέων εἰς οὐλὴν ἤγαγεν. εἶτ' αὖθις ἐφλέγμηνε [...]. ταῦτ' ἄρα καὶ ὁ δεσπότης αὐτοῦ, πλείονας ἀθροίσας ἰατροὺς, ἐν οἷς ἦν κἀγὼ, σκοπεῖσθαι περὶ τῆς ἰάσεως ἐκέλευσεν. ὡς δὲ πᾶσιν ἐδόκει σφάκελος εἶναι τοῦ στέρνου τὸ πάθος, ἐφαίνετο δὲ καὶ ἡ τῆς καρδίας κίνησις ἐκ τῶν ἀριστερῶν αὐτοῦ μερῶν, οὐδεὶς ἐκκόπτειν ἐτόλμα τὸ πεπονθὸς ὀστοῦν· ᾤοντο γὰρ, ἐξ ἀνάγκης ἐπ' αὐτῷ σύντρησιν ἔσεσθαι τοῦ θώρακος. ἐγὼ δ' ἐκκόψειν μὲν ἔφην αὐτὸ χωρὶς τοῦ τὴν καλουμένην ἰδίως ὑπὸ τῶν ἰατρῶν σύντρησιν ἐργάσασθαι· περὶ μέντοι τῆς παντελοῦς ἰάσεως οὐδὲν ἐπηγγελλόμην, ἀδήλου ὄντος, εἰ πέπονθε καὶ μέχρι πόσου πέπονθε τῶν ὑποκειμένων τι τῷ στέρνῳ. γυμνωθέντος οὖν τοῦ χωρίου, πλέον οὐδὲν ἐφάνη τοῦ στέρνου πεπονθὸς, ἢ ὅπερ ἐξ ἀρχῆς εὐθὺς ἐφαίνετο. διὸ καὶ μᾶλλον ἐθάῤῥησα πρὸς τὴν χειρουργίαν ἐλθεῖν, ἀπαθῶν γε τῶν ἑκατέρωθεν ὀφθέντων περάτων, οἷς ὑποπεφύκασιν αἵ τ' ἀρτηρίαι καὶ φλέβες. ἐκκοπέντος δὲ τοῦ πεπονθότος ὀστοῦ κατ' ἐκεῖνον μάλιστα τὸν τόπον, ἐν ᾧ ἐμπέφυκεν ἡ τοιαύτη κορυφὴ τοῦ περικαρδίου, καὶ φανείσης γυμνῆς τῆς καρδίας, ἐσέσηπτο γὰρ ὁ περικάρδιος κατὰ τοῦτο, παραχρῆμα μὲν οὐκ ἀγαθὴν ἐλπίδα περὶ τοῦ παιδὸς εἴχομεν, ὑγιάσθη δὲ εἰς τὸ παντελὲς οὐκ ἐν πολλῷ χρόνῳ.[30]

[29] Cf. Gleason (2009).

[30] Gal. *On Anatomical Procedures* VII, 13 = II, 632–633 K. (my translation).

> As this slave had received a blow to the sternum at the palaestra, the injury was first neglected, then poorly treated. After about four months, some pus appeared in the area that had been struck. As he wanted to remove it from the wound, the healer performed an incision on the slave and believed to have sent him on a quick recovery. But he in turn suffered an inflammation [...]. Then, having gathered many doctors, among whom yours truly, his owner ordered us to make sure he would heal. As everybody thought this was a sphacelus, and as the movement of the heart could be seen on his left side, no one dared to excise the affected bone. Indeed they believed perforation of the thorax would follow. But I said I would excise the bone without the so-called perforation of the doctors. About the complete healing of the patient, however, I made no promises, as what he had suffered and the extent of the damage was unclear. Once the area was laid bare, no further part of the sternum seemed to be affected. Thus I was emboldened to go ahead with the surgery, as the two ends, where veins and arteries are attached, were unscathed. After I excised the affected bone at the precise place where it met the crown of the pericardium, as the heart was laid bare, for the pericardium was putrid at this point, to begin with we did not have high hopes about the slave, but he was cured entirely in no time.

Anatomical language is as sharp and clean as the scalpel it follows. In this narrative, no mention of the pain, the movements, or the horror experienced by the patient. In contrast to the anonymous author of the declamation, or Libanius' exercise cited above, any emotional language or expressivity is banished. This feature of anatomical writing is meant to shift the attention to the scientific gesture: any mention of the effect of the operation on the patient would defeat the purpose of the work. One could argue that this work is aimed at a medical audience – but there is no doubt that Galen's texts circulated beyond a close circle of 'friends'. The restrained form of *enargeia* offered by the anatomist allows for the correct amount of clarity, whilst avoiding any temptation to indulge in pathos – in this passage, he offers a dispassionate take on vivisection that can be contrasted with that of the rhetors. In the domain of anatomy as in other areas of his writing, we can detect an apologetic intention, anticipating on potential attacks.[31]

On another note, but in the same perspective, Galen's heavy insistence throughout his works on 'deeds' as opposed to 'words', on being a practical doctor and not a 'doctor of words', a *logiatros*, is certainly a reflection of the criticism levelled at rationalist doctors in particular, who relied too much on speculation and reasoning as opposed to pure experience.[32]

Conclusion

To medical historians, the pseudo-Quintilian is of little consequence; it may only represent 'an unpretentious piece of rhetorical literature' merely revealing to us the views of the Roman lay audience.[33] As a topic, vivisection here provides 'fodder for

[31] I have suggested elsewhere possible moments of self-censorship in Galen, for example in Petit (2017) 61.

[32] This criticism, too, is voiced in Celsus.

[33] Ferngren (1985) 505.

rhetorical gymnastics'.[34] From the perspective of the history of rhetoric, however, *MD* 8 offers insights into ethical debates in the Empire and demonstrates the importance of medical themes in rhetorical training (and rhetoric altogether). In view of the long Latin literary tradition, from Pliny the Elder to Augustine at least, it is hard to avoid contemplating the theme of medical cruelty as commonplace. This term should be taken in a strong, technical sense: far from being a purely Latin Roman concern, similar cases of murderous physicians appear in Greek literature and more specifically, in the *Progymnasmata* literature in the fourth century with Libanius. As scholars of ancient rhetoric re-discover the importance of *progymnasmata* and declamation as educational tools and ground for moral *exercitatio*, as well as social stability, the role of medicine in the history of rhetoric cannot be overstated. This can be attributed to the weight of medicine in Roman society – but also, in my opinion, to the rich, lively, well-diffused medical literature of the time.

I would thus argue that medicine and rhetoric, from a textual perspective, are in dialogue. Some of the features of medical discourse, as exemplified by Galen, owe much to existing, widespread criticism against physicians, especially their supposed cruelty and selfish thirst for knowledge, usually satisfied at the expense of the patient. The rationalist doctor's emphasis on 'usefulness' (as we can see in Celsus, and Galen) is fundamental in medical writing – a characteristic that, in the case of vivisection and experimentation, is vigorously contested by medical opponents and shunned by society. The core medical values of *philanthrōpia* and benevolence, translating, in practice, into the physician making every effort to preserve life, are jeopardised and questioned in the face of individual criminal behaviour. The careful, often subtle emphasis that ancient doctors put in their anatomical accounts is certainly, if not a response, at least an anticipation of widespread public horror at some aspects of their trade.

A broader enquiry would be needed to assess how such subtexts affect medical writing in, around, and beyond Galen – as we have seen, late antique authors certainly continue to explicitly reject any unnecessary cruelty in therapeutics.[35] Avoiding causing excessive or unnecessary suffering may have become a *commonplace in medical literature*, in response to a widespread and vigorous rejection of 'cruel' attitudes on the part of physicians. Without going as far as suggesting intertextual relations between Galen and the pseudo-Quintilian specifically, I am convinced that there is more intertwining between the two fields of medicine and rhetoric as textual productions than is often thought. The date of *MD* 8, if correct, shows ongoing engagement with the theme, several decades after Galen's death, at a time when we do not have any extant medical sources. What we do see, possibly, is a long-term game in which commonplaces in both medicine and rhetoric mutually impact one another.

[34] Bubb (2022) 113.

[35] Besides, in Petit (2023) I argue in favour of long-term continuity in medical rhetoric, beyond Galen.

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University of Warwick

Late Eighteenth-Century Electricity Literature: The Shifts in the Rhetoric of 'Hypothesis'*

Fengyuan Liu

Abstract

The hypothetical method holds a significant position in contemporary sciences and the philosophy of science. However, early modern scientists did not widely accept the hypothetical method. In the seventeenth and eighteenth centuries, there was a shift in the rhetoric surrounding 'hypothesis'. This study analyses the changes in the rhetoric of the term 'hypothesis' in the late eighteenth century by examining the texts written by natural philosophers working on electricity. This analysis exemplifies how natural philosophers adapted the hypothetical method in an experimentalist context. It uncovers the prehistory of the term 'hypothesis', which has been widely used in scientific writings since the nineteenth century. It also demonstrates the importance of practising natural philosophers in the development of scientific methodology.

1. Introduction

This paper studies the following question: Why did the notion of 'hypothesis' shift from being severely condemned in the natural philosophical writings of the late seventeenth and early eighteenth centuries – and almost falling into a 'virtual eclipse'[1] – to become a standard term for philosophers of science from the nineteenth century onwards? This paper examines the shift in the rhetoric of 'hypothesis' during this period by analysing the arguments relevant to the use of 'hypothesis' in representative late-eighteenth-century works on electricity, which are identified by the 'network of the works of early modern natural philosophy' created by Sangiacomo and others.[2] The works from this network (including works on electricity) are classified as 'average textbooks', representing the consensus reached, at certain periods, on the subjects studied.[3] In this case, the analysis of the works on electricity exemplifies the

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[1] For the use of the phrase 'virtual eclipse', see Anstey (2005) 233.

[2] The statistical data were provided by the ERC Starting Grant project 'The Normalisation of Natural Philosophy: How Teaching Practices Shaped the Evolution of Early Modern Science'.

[3] Sangiacomo and others refer to this type of work as the 'average textbook' of early modern natural philosophy, see Sangiacomo et al. (2022) 37. In some scholarship, the 'textbooks' have been regarded as products of a comparatively stable period of scientific development. Kuhn, for instance, argues that 'the textbooks [...] are produced only in the aftermath of a scientific revolution. They are the bases for a new tradition of normal science', see Kuhn (1970[2]) 144. My study contrasts with Kuhn's view by arguing that although the 'textbooks' on electricity in this study were produced after Newtonian methodology became popular, they contribute to the renovation of the use of hypotheses in natural philosophical writings.

common practices adopted within the study of electricity in the late eighteenth century.

To accomplish its mission, this paper tackles the research question in three sections. Section 2 answers the question: What does 'hypothesis' mean for contemporary scientists and philosophers? It examines the definition of 'hypothesis' as well as its two key characteristics – testability and falsifiability – through the works of Alan Chalmers and Alexander Bird. Through Imre Lakatos and Thomas Kuhn, it draws attention to the use of hypotheses in the rhetoric of science. Section 3 explains the history of hypotheses in the late seventeenth century and early eighteenth century. It examines the development and demise of anti-hypotheticalism during this period, and ends with Hume's critique of inductive reasoning and his proposal of the hypothetical method. Section 4 explicates how the use of 'hypothesis' shifts to a quasi-contemporary definition in the late eighteenth century from the perspective of the most influential English natural philosophers working on electricity. I shall explore the shifts in the rhetoric of hypothesis in three steps: (1) I analyse the methodological reflections upon hypothetical method; (2) I briefly explore the citations of specific hypotheses in these works, which indicates the widespread acceptance of the employment of hypotheses in scientific writing, and (3) I summarise the shifts of the rhetoric of hypothesis by constructing a comprehensive answer to the research question. Section 5 concludes the paper.

2. What is a hypothesis?

In this section, I examine the use of hypotheses in contemporary philosophy of science and its relationship with the rhetoric of science. I shall first lay out two sets of distinctions: one between a hypothesis and a theory, and another between the use and the mention of hypotheses. Secondly, I examine the criteria of establishing a hypothesis through the works of Karl Popper, David J. Glass and Ned Hall, Alan Chalmers, and Alexander Bird. Thirdly, I refer to Thomas Kuhn and Imre Lakatos to show that the falsifiability of a hypothesis operates on a paradigm agreed by the scientific community of a certain period. I argue that the reliance on a paradigm implies the subjectivity of scientific writing. Finally, I demonstrate how the focus on the rhetoric and persuasion of scientific writing by Kuhn and Herbert W. Simon initiated the debate on the rhetoric of science and made the rhetorical study of 'hypothesis' necessary.

Both 'theory' and 'hypothesis' are terms commonly used in contemporary scientific practice. However, a hypothesis is quite different from a theory. A theory is a set of universal statements,[4] usually formed based on empirical data from observations and experiments. A theory must be heavily tested by empirical evidence and not be falsified (otherwise, it can only be called a hypothesis, rather than a theory).

Unlike a theory, a hypothesis can be freely established through either empirical knowledge or merely speculation. It could be constructed by any individual in any form, either being a universal statement or an individual statement of a particular situation. For example, one can very well claim that the moon is made of cheese.

[4] Popper (2005[2]) 37.

Although this hypothesis could be falsified by empirical evidence, it does not prevent it from being a hypothesis. In other words, a hypothesis could exist independently from empirical evidence, while a theory cannot. In scientific investigation, a hypothesis is usually formed prior to experiments to set a point of view for the investigation: 'If we do not come to any decision, and do not accept some basic statement or other, then the test will have led nowhere'.[5] Chalmers, for example, defines science as a set of hypotheses 'that are tentatively proposed with the aim of accurately describing or accounting for the behaviour of some aspect of the world or universe'.[6]

Let us now move to another critical distinction; the one between the mention and the use of a hypothesis. The mention of a hypothesis refers to using the term 'hypothesis' *per se* to refer to certain assumptions. For example, one of Franklin's most famous hypotheses is that lightning is an electrical discharge. Here, the term 'hypothesis' is explicitly used to refer to Franklin's statement. Mentions of 'hypothesis' will occur in my study of early modern works of natural philosophy in the later sections, where 'hypothesis', as a term, was involved in natural philosophy discussions.

The use of a hypothesis implies a broader meaning than the mention of a hypothesis. 'The use of a hypothesis' refers to the 'hypothetical method', which involves constructing scientific theories that rationalise and explain the world through hypothesising.[7] A scientific theory constructed by the hypothetical method may include signs, symbols, and causal explanations,[8] as well as scientific hypotheses. The hypothetical method covers a wider range than the term 'hypothesis' itself. In this section, our discussion will focus on the regulations of the hypothetical method to prepare the stage for a historical analysis of the mentions of 'hypothesis'.

Hypothesising is a procedure widely used in modern science. According to Glass and Hall,

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[5] See Popper (2005[2]) 86.

[6] Chalmers (2013[4]) 57.

[7] See Popper (2005[2]) 38.

[8] Causal explanations are different from hypotheses. Popper (2005[2]) defines a causal explanation as a process of deducing a statement from a combination of universal statements and 'certain singular statements' of the initial conditions. 'To give a causal explanation of an event means to deduce a statement which describes it, using as premises of the deduction one or more universal laws, together with certain singular statements, the initial conditions. For example, we can say that we have given a causal explanation of the breaking of a certain piece of thread if we have found that the thread has a tensile strength of 1 lb. and that a weight of 2 lbs. was put on it. If we analyse this causal explanation we shall find several constituent parts. On the one hand there is the hypothesis: "Whenever a thread is loaded with a weight exceeding that which characterises the tensile strength of the thread, then it will break"; a statement which has the character of a universal law of nature. On the other hand we have singular statements (in this case two) which apply only to the specific event in question: "The weight characteristic for this thread is 1 lb.", and "The weight put on this thread was 2 lbs". We have thus two different kinds of statement, both of which are necessary ingredients of a complete causal explanation. They are (1) universal statements, i.e. hypotheses of the character of natural laws, and (2) singular statements, which apply to the specific event in question and which I shall call "initial conditions". It is from universal statements in conjunction with initial conditions that we deduce the singular statement, "This thread will break". We call this statement a specific or singular prediction. The initial conditions describe what is usually called the "cause" of the event in question. (The fact that a load of 2 lbs. was put on a thread with a tensile strength of 1 lb. was the "cause" of its breaking.) And the prediction describes what is usually called the "effect". Both these terms I shall avoid', see Popper (2005[2]) 39–40.

> 'scientists are commonly taught to frame their experiments with a "hypothesis" – an idea or postulate that must be phrased as a statement of fact, so that it can be subjected to falsification. Hypothesis is constructed in advance of the experiment; it is therefore unproven in its original form. The very idea of "proof" of a hypothesis is problematic on philosophical grounds because the hypothesis is established to be falsified, not verified'.[9]

This definition of 'hypothesis' represents a common understanding of the hypothetical method among practicing scientists. Its reliance on falsification, however, reveals it as being distinctly Popperian. Falsification, in plain words, means that a hypothesis must stand up to observational or experimental tests, otherwise it will be falsified and not qualified to be a (part of) scientific theory.[10] Popper believes that the demarcation of a scientific theory from its non-scientific counterpart (e.g. metaphysics) is realised through the criterion of falsifiability.[11] A scientific theory is always falsifiable if its basic statements, derived from empirical facts, form a hypothesis that is powerful enough to contradict the core of the scientific hypothesis. Popper particularly rejects the view that a theory could avoid being falsified through revisions and reinterpretations; that is, by adding *ad hoc* hypotheses.[12] He believes such revisions could not bring us any new knowledge. Instead, a scientific theory is valuable because it can be falsified and replaced with better functioning theories, which advance scientific discoveries. Popper argues that the falsification of a scientific theory needs a falsifying hypothesis that is formed using basic statements that contradict the theory (a basic statement is a statement of an observed event). Therefore, according to Popper, the falsification process revolves around the falsifying hypothesis:

> 'We say that a theory is falsified only if we have accepted basic statements which contradict it (cf. section 11, rule 2). This condition is necessary, but not sufficient; for we have seen that non-reproducible single occurrences are of no significance to science. Thus a few stray basic statements contradicting a theory will hardly induce us to reject it as falsified. We shall take it as falsified only if we discover a *reproducible effect* which refutes the theory. In other words, we only accept the falsification if a low-level empirical hypothesis which describes such an effect is proposed and corroborated. This kind of hypothesis may be called a *falsifying hypothesis*'.[13]

Therefore, being falsifiable means that there is a possibility that there are facts that form a hypothesis that could challenge the core of a current scientific theory. Here,

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[9] Glass and Hall (2008) 378.

[10] See Chalmers (2013[4]) 73.

[11] See Popper (2005[2]) 10–16. Similarly, Bird highlights the testability of a hypothesis, which focuses on whether the hypothesis could be tested scientifically. Accordingly, supernatural objects such as God, and theological objects such as the faith of creationism from hypotheses, are excluded from being hypotheses because they are not testable, see Bird (2007) 3–4.

[12] See Popper (2005[2]) 59–60. The *ad hoc* hypothesis refers to auxiliary hypotheses that provide supplemental explanation to the contradictions faced by a scientific theory. When there exist basic statements contradictory to the scientific theory, some scientists will eliminate such contradictions by 'suggesting *ad hoc* the adoption of certain auxiliary hypotheses, or perhaps of certain corrections to our measuring instruments', see Popper (2005[2]) 60.

[13] Popper (2005[2]) 66; the italics are original.

the falsifying hypothesis is not, like a scientific theory, established after scientific testing. Instead, Popper's use of this hypothesis is based upon the scattered empirical material that contradicts the present scientific theory. Thus, according to Popper, the process of falsification is to contrast a newly formed hypothesis with another hypothesis based on the core of the current theory. If the new hypothesis falsifies the old hypothesis, it means that the new hypothesis has a stronger explanatory power and can accommodate more empirical facts than the previous one.

Chalmers echoes Popper's account of the falsifiability of a hypothesis. Chalmers explains that 'a hypothesis is falsifiable if there exists one or a set of logically possible statements of observation that are inconsistent with it; and, if established as true, would falsify the hypothesis'.[14] 'Once proposed, speculative theories are to be rigorously and ruthlessly tested by observation and experiment'.[15] Here, the term 'speculative' characterises a theory that is 'freely created by the human intellect'.[16] A scientific hypothesis, if it wants to continue to be scientific, must be able to be tested by empirical evidence and be logically falsifiable.[17] In other words, 'a hypothesis should be falsifiable, the more falsifiable the better, and yet should not be falsified'.[18]

Nevertheless, the Popperian account of falsification cannot resolve all the difficulties of a scientific hypothesis. According to Chalmers, a hypothesis is constructed as a 'theoretical maze' of premises,[19] which practicing scientists working on such a hypothesis might not be aware of.[20] This lack of awareness may cause difficulties when a hypothesis is ultimately proven false. Due to the substantial number of underlying premises, it is challenging to determine whether the test results falsify the hypothesis itself, or the more fundamental premises that underpin it.[21] This uncertainty surrounding falsification may generate scepticism regarding the dependability of scientific knowledge.

Kuhn and Lakatos develop different approaches to avoid the consequences of scepticism. In *The Structure of Scientific Revolutions*, Kuhn distinguishes between 'normal science' and 'revolutionary science' (new science marked by a paradigm shift in thought). He argues that 'a paradigm governs, in the first instance, not a subject matter but rather a group of practitioners'.[22] Thus, Kuhn claims that 'any study of paradigm-directed or of paradigm-shattering research must begin by locating the responsible group or groups'.[23] Kuhn criticises the falsification that Popper relies on in his philosophy. Kuhn argues that Popper's focus on the 'falsifying hypothesis', which Kuhn calls 'anomalous experience', 'is important to science because it evokes competitors for an existing paradigm. But falsification, though it surely occurs, does not happen with, or simply because of, the emergence of an anomaly or falsifying instance'.[24] Kuhn argues that 'if any and every failure to fit were ground for theory

[14] Chalmers (2013[4]) 58.
[15] Chalmers (2013[4]) 56.
[16] See Chalmers (2013[4]) 56.
[17] See Chalmers (2013[4]) 65.
[18] Chalmers (2013[4]) 69.
[19] Chalmers (2013[4]) 82.
[20] Chalmers (2013[4]) 177.
[21] Chalmers (2013[4]) 127.
[22] Kuhn (1970[2]) 180.
[23] Kuhn (1970[2]) 180.
[24] Kuhn (1970[2]) 147.

rejection, all theories ought to be rejected at all times'.[25] Furthermore, Kuhn argues that 'No process yet disclosed by the historical study of scientific development at all resembles the methodological stereotype of falsification by direct comparison with nature'.[26] Therefore, Kuhn replaces Popper's falsification theory with his theory of scientific paradigms. He believes his theory can explain scientific progress in a way that aligns with the historical development of science.

Lakatos echoes Kuhn's position by arguing that a scientific revolution happens because a new 'research program' replaces the previous one.[27] However, during such a replacement, 'the bearing of observation on a hypothesis under test is relatively unproblematic within a research program because the hard core and the positive heuristic serve to define a fairly stable background' within a certain period.[28] Lakatos and Kuhn both emphasise the influence of the contemporary scientific community on the scientific writing of a particular period. The context of the scientific community indicates that between different periods, the standards of scientific writing keep changing. The reason behind the changes is that scientific works are written by certain historical individuals. During the writing process, the author might choose different rhetorical skills to convey scientific knowledge to the readers. Moreover, the author might choose different writing styles for polemical or more personal reasons, which would influence later interpretations.

The focus on scientific writing styles initiates a debate within contemporary scholarship on the rhetoric of science. This debate takes place within a consensus that the rhetoric of science focuses extensively on the evolution of writing style and scientific discourse.[29] Kuhn, as a historian and philosopher of science, is often regarded as one of the initiators and representatives of such a debate.

Kuhn coins a position in the debate on the rhetoric of science that highlights the collective commitments of scientists to their specific scientific communities during a certain period.[30] Kuhn thinks that revolutionary changes happen through the defining notion of rhetoric: persuasion.[31] Kuhn's argument of persuasion starts from his belief in the incommensurability between different paradigms of science. Kuhn argues that

> 'the superiority of one theory to another is something that cannot be proved in the debate. Instead, I have insisted, each party must try, by persuasion, to convert the other. Only philosophers have seriously misconstrued the intent of these parts of my argument. A number of them, however, have reported that I believe the following: the proponents of incommensurable theories cannot communicate with each other at all; as a result, in a debate over theory-choice there can be no recourse to good reasons; instead theory must be chosen for reasons that are ultimately personal and subjective; some sort of mystical apperception is responsible for the decision actually reached. More than any

[25] Kuhn (1970[2]) 146. For a detailed study on Kuhn's rejection of Popper, see Hutcheson (1980), esp. 71–73.
[26] Kuhn (1970[2]) 77.
[27] See Chalmers (2013[4]) 128; see also, Lakatos (1970).
[28] See Chalmers (2013[4]) 128.
[29] See Harris (2002) 164.
[30] See Kuhn (1970[2]) 181.
[31] See Harris (1997) xiv.

> other parts of the book, the passages on which these misconstructions rest have been responsible for charges of irrationality'.[32]

Kuhn argues that a valid mathematical or logical proof would require 'the premises and rules of inference are stipulated from the start'.[33] However, in the case of different paradigms, 'their prior agreement provides no sufficient basis for proof'. Therefore, the debates between supporters of different paradigms could only start with persuasion, since 'that debate is about premises, and its recourse is to persuasion as a prelude to the possibility of proof'.[34] Kuhn briefly describes the process of persuasion as follows:

> 'What one must understand, however, is the manner in which a particular set of shared values interacts with the particular experiences shared by a community of specialists to ensure that most members of the group will ultimately find one set of arguments rather than another decisive'.[35]

However, why would such persuasion be possible given that these two paradigms are incommensurable? Kuhn solves this problem by referring to the common cultural backgrounds that both groups must have shared. The knowledge from different scientific paradigms can be translated into one another by finding out the exact point on which they differ.[36] Kuhn believes that the scientific revolution, or the change of scientific paradigms, will ultimately take place through persuasion rather than mathematical or logical proof.

Since persuasion as a rhetorical skill can only happen in the form of language, it brings our attention to the analysis of scientific writing. Through such an analysis, we could uncover its theoretical and societal implications, which include techniques of persuasion, or the argument and counterargument in a situation when there can be no proof.[37] Here, the writing style implies not only a holistic approach to how scientists structure their theories or experimental reports,[38] but also the rhetorical methods, such as metaphor and analogy, used in concrete scientific arguments. For example, scientists must persuade readers, who cannot witness the scientific experiments, to believe their results.[39] In a case like this, rhetorical skills in writing would help the scientists to gain the recognition of a scientific community.

Simons echoes Kuhn's position by arguing that the scientist is 'a rhetor in disguise':

> 'one who falsely pretends to the status of nonrhetor and thereby renders his rhetoric deceptive; one, moreover, who is not above engaging in such allegedly sophistic practices as masking self-serving motives behind a vocabulary of

[32] Kuhn (1970[2]) 198–99.
[33] Kuhn (1970[2]) 199.
[34] Kuhn (1970[2]) 199.
[35] Kuhn (1970[2]) 200.
[36] Kuhn (1970[2]) 201.
[37] See Kuhn (1970[2]) 151.
[38] Experimental reports or scientific reports are widely used among early modern natural philosophers to document their scientific discoveries either through experimentation or during a journey.
[39] See Bazerman (1988) 77–79.

> legitimating motives or subtly promoting partisan values in the guise of being informative'.[40]

Therefore, scientific writing is not value-free. Instead, it demonstrates an awareness of the scientist and characterises scientific discourses in a way that masks 'self-serving motives'. Moreover, scholars like Bazerman study the rhetoric of science by examining experimental reports. Bazerman argues that examining the reading and writing habits of scientists reveals both methodological and social factors that may have influenced the 'character of rhetoric and writing'.[41]

The rest of this paper echoes the focus on the rhetoric of science-writing by paying particular attention to the mention of hypotheses in natural philosophical works and experimental reports. As mentioned previously, there is subjectivity in scientific writing. A scientific hypothesis should be falsifiable in a certain historical or social context, otherwise it would be a victim of scepticism. This is especially the case during the early modern period when scientists had not yet reached a consensus on the use of scientific terms. Therefore, the next step of this paper is to provide the historical background of the use of hypotheses in the late seventeenth and eighteenth centuries.

3. The use of hypotheses in ancient and early modern natural philosophy

This section reviews the use of hypotheses in the ancient and early modern periods. I first locate the use of hypotheses in ancient philosophy to explain that the hypothesis is a rhetorical skill from the beginning. Second, I illustrate the early modern use of hypotheses under the influence of Aristotle, with a special focus on Bacon's natural history, a predecessor of the distinction between speculative and experimental approaches to natural philosophy in the seventeenth century. Third, I articulate the speculative characteristics of the Cartesian hypothesis of vortexes, and the trend against his speculative approach; hypotheses were regarded as components of speculative philosophy and not welcomed by experimental philosophers. Fourth, I explain the rise of the hypothetical method in the (late) eighteenth century by analysing Newton's shift in his methodology of natural philosophy as well as the scientific journal, *Philosophical Transactions*, published by the Royal Society.

The hypothetical method 'presses beyond the level of a mere description of the real to concern ourselves also with its explanation'.[42] The use of such a method already existed among ancient philosophers and scientists such as Plato, Aristotle, and Archimedes. The earliest use of this method could be found among Presocratic philosophers like Thales of Miletus, and the Pythagoreans. These Presocratic philosophers utilised the hypothetical method to conduct their 'thought experiments', drawing instructions from the hypothesis elicitation process. Rescher notes that such

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[40] Simons (1980) 115.

[41] Bazerman (1991) 13–14.

[42] Rescher (1991) 31. Rescher (1991) contends that Presocratic thought experiments validate the emergence and evolution of ancient natural philosophy. In contrast, Kühne (2009) posits that Presocratic arguments merely mark the genesis of philosophy and do not constitute thought experimentation. For Kühne (2009), Aristotle introduced the standard use of thought experimentation. See Rescher (1991) 31–32, Kühne (2009) 2–3.

thought experiments, founded on hypotheses, are explanatory in nature.[43] Plato later employed the hypothetical method in his two dialogues – the *Meno*, and the *Phaedo* – to establish the connection between 'knowledge' and 'virtue'.[44] The term 'hypothesis' is 'a fortunately close counterpart to the Greek *hupothesis*: literally something one *hupotithêtai* [*sic.*], "sets down <underneath>"'.[45] This term, *hupotithêtai* [*sic.*], was directly adopted by Plato in his dialogues. Although Barney recognises that Plato used the hypothetical method differently in the two dialogues,[46] she manages to summarise six characteristics of the hypothetical method: it typically (1) starts from posited theses (such as candidate definitions of the virtues) from which (2) consequences are elicited, with (3) a range of argumentative agendas and results, but (4) often so as to elicit a contradiction, (5) sometimes with a regress to the positing of some more explanatorily basic thesis, and (6) always with defeasible, provisional results – as Socrates habitually reaffirms by emphasising the need for re-examination and further discussion. [47] The Platonic hypothesis is quite similar in its function to the contemporary scientific hypothesis. However, there is a difference between the two kinds of hypothesis. Plato's hypothetical method bears clear marks of Socratic dialectical skills, which could be seen in the rhetorical style of the Platonic dialogues.[48] In other words, Plato's hypothetical method is a rhetorical approach used to develop persuasive speeches with vivid demonstrations.

According to Glass and Hall, the modern usage of hypotheses began with Galileo, whose understanding of the hypothetical method was in line with Aristotle and Archimedes.[49] While Archimedes was praised by George Sinclair in his work of 1683 for 'his divine knowledge, both in Speculative and Practical part' – the former comprising his mathematical methods and demonstrations, the latter his inventions,

[43] Rescher (1991) 32.

[44] Barney (2022) 28.

[45] Barney (2022) 32.

[46] In the *Meno*, the thesis of the hypothesis is the teachability of virtue. Socrates first agrees to investigate Meno's question concerning virtue and knowledge 'by means of a hypothesis' (86e). Barney comments that 'hypothesis as introduced here seems to be related to the geometrical procedure known later as analysis; the use of hypothesis is thus part of a broader Platonic aspiration to bring mathematical-style rigour to bear on questions of ethics, also visible in his enduring fascination with the idea of measurement (*Euthyphro* 7b–d, *Protagoras* 356a–357d, *Statesman* 283c–285c)'. In the *Phaedo*, the topic of the hypothesis concerns the immortality of the soul. Here, the hypothesis 'may become the object of explanation and argument', instead of being a proposition itself. According to Barney, 'one should hold fast to the hypothesis as a "safe" answer: "but you, afraid, as they say, of your own shadow and your inexperience, would cling [*echomenos*] to the safety of your own hypothesis [*hupothesis*] and give that answer. And if someone were to take hold of [*echoito*] your hypothesis itself, you would ignore him and would not answer until you had examined the consequences that follow [*ta hormēthenta*] from it, to see if they agree [*sumphōnei*] with one another or disagree [*diaphōnei*]. And when you must give an account of your hypothesis itself you would give it in the same way, setting down [*hupothemenos*] another hypothesis again, whichever one seems to you best of the higher ones until you come to something sufficient [*ti hikanon*]; but you will not jumble the two as the debaters [*antilogikoi*] do by discussing the principle [*archē*] and its consequences [*hōrmēmena*] at the same time, if you wish to discover any truth"' (101c9–e3; Grube's translation, in Cooper (2007), as cited in Barney (2022) 35). Here, the 'hypothesis' becomes an object of argument and persuasion, which could be explained, defended, or revised by examining the consequences that follow from this hypothesis. For the discussion above, see Barney (2022) 33–35.

[47] Barney (2022) 39–40. For a discussion of the role of the hypothetical method in the *Phaedo*, see also Bedu-Addo (1979).

[48] See Barney (2022) 40.

[49] Glass and Hall (2008) 378.

such as 'Engines for peace and war'[50] – Galileo used the data from his astronomical observations to confirm his hypotheses, which exemplifies the basic practice of the hypothetical method.[51] According to Anstey, hypotheses gain their affinity to natural philosophy in the deductive reasoning (syllogism) of Aristotelian tradition.[52] The discussion of the use of the hypothesis, as well as its definition, appear in Aristotle's *Posterior Analytics*:

> 'I apply the term thesis to an immediate indemonstrable first principle of syllogism the grasp of which is not necessary for the acquisition of certain kinds of knowledge; but that which must be grasped if any knowledge is to be acquired, I call an axiom; for there are certain things of this nature and we are accustomed to apply this name especially to them. A *thesis* which assumes one or the other part of a proposition, i.e., that something does, or does not exist, is a *hypothesis*; a thesis which does not do this is a definition. A *definition* is a kind of thesis <or laying-down>, because the arithmetician lays it down that to be a unit is to be quantitatively indivisible; but it is not a hypothesis, because to define the nature of a unit is not the same as to assert its existence'.[53]

Here, a hypothesis is a method of acquiring knowledge. According to Aristotle, a hypothesis – as part of a proposition – assumes the status of something; such as, whether this thing exists or not. Nevertheless, testing the reliability of hypotheses can be difficult. There is no way to check whether the knowledge gained through hypotheses is true to nature or merely logically valid.

Bacon was the first early modern philosopher to discuss the problem of the hypothetical method. In his *Novum Organum* (1620), Bacon realised that there are problems with the use of a hypothesis; for example, if the premise is set in advance of the experiment by a hypothesis, then the reasoning would be twisted to meet that premise.[54] Thus, Bacon replaced deductive reasoning with inductive reasoning, which avoids the problem of the 'unexamined premise' in the hypothetical method.[55] Accordingly, in his influential *De dignitate et augmentis scientiarum* ('Of the

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[50] Sinclair (1683) 234, as cited in Wilson (2019) 162. The title of Sinclair's work reads *Natural Philosophy Improven by New Experiments Touching the Mercurial Weather-Glass, the Hygroscope, Eclipsis, Conjunctions of Saturn and Jupiter, by New Experiments, Touching the Pressure of Fluids, the Diving-Bell, and all the Curiosities Thereof,* which was published in Edinburgh.

[51] See Glass and Hall (2008) 378.

[52] Anstey (2022) 637–39. Anstey classifies hypotheses into one type of 'principles' being used by early modern philosophers. According to Anstey, 'Aristotle distinguished between axioms, hypotheses, and definitions. His axioms are common principles, whereas hypotheses and definitions are proper principles (*Posterior Analytics* I 2.72a14–24; I 10.76a31–77a4). Hypotheses are principles that presuppose the existence of the subject of a science', see Anstey (2022) 1683. Anstey argues that the early moderns following Aristotle 'posited three different sorts of principle: axioms, definitions, and hypothesis', see Anstey (2022) 637. However, Anstey also acknowledges that '[t]his typology of principles underwent significant transformations and critique in the early modern period, though most early modern philosophers simply spoke of principles and did not indulge in fine-grained distinctions between axioms, hypotheses, and definitions'. There is no clear evidence to prove that early moderns commonly recognised the use of the three types of principles, including hypotheses, as a methodology. For Anstey's tripartite classification of early modern 'principles' and supplementary arguments to his classification, see Anstey (2022) 1680–83.

[53] I 2.72a15–25. Translation by Tredennick and Forster (1960) 33–35.

[54] Glass and Hall (2008) 378.

[55] See Glass and Hall (2008).

proficiency and the advancement of learning') of 1623, Bacon distinguished the quest of natural philosophy – in 'scholastic terms' – between 'operative' and 'speculative' undertakings. He argues,[56]

> '[T]hat these be the two parts of natural philosophy – the inquisition of causes, and the production of effects; speculative and operative; natural science, and natural prudence. For as in civil matters there is a wisdom of discourse, and a wisdom of direction; so is it in natural. And here I will make a request, that for the latter (or at least for a part thereof) I may revive and reintegrate the misapplied and abused name of natural magic, which in the true sense is but natural wisdom, or natural prudence; taken according to the ancient acception, purged from vanity and superstition. Now although it be true, and I know it well, that there is an intercourse between causes and effects, so as both these knowledges, speculative and operative, have a great connection between themselves; yet because all true and fruitful natural philosophy hath a double scale or ladder, ascendent and descendent, ascending from experiments to the invention of causes, and descending from causes to the invention of new experiments; therefore I judge it most requisite that these two parts be severally considered and handled'.[57]

Bacon presents the differences between the two undertakings. The 'speculative' undertaking refers to the inquisition of causes, which is the task of natural science. Being ascendent, the 'speculative' undertaking ascends from experiments to 'the invention of causes', while for the 'operative' undertaking, it seeks the production of effects, which is the task of natural prudence. Here, natural prudence refers to natural wisdom (human reason). The 'operative' undertaking conducts experiments on natural objects under the guidance of causes to gain empirical knowledge of nature. Bacon believes that both undertakings are necessary for the investigation of nature: 'first ascending to axioms, then descending to works'.[58]

Bacon biases towards the 'operative' undertaking rather than the 'speculative' undertaking. According to Jalobeanu, Bacon's project 'for the advancement of learning took natural and experimental history to be the basis of a reformed natural history'; [59] Bacon did not take into account the 'speculative' undertaking. Accordingly, the hypothetical method that belongs to the 'speculative' undertaking is also excluded from Bacon's system of knowledge.

The impact of Bacon's distinction between 'operative' and 'speculative' undertakings is significant. According to Jalobeanu, 'fellows of the early Royal Society were rather liberal in producing and discharging hypotheses. But they were also willing to distinguish between "histories" and "speculations" in a thorough Baconian manner'.[60] The relationship can be better illustrated through the case of Sir

[56] Wilson (2019) 162.
[57] See Vickers (1996) 193.
[58] Bacon, *New Organon* I, 103, as cited in Wilson (2019) 162.
[59] Jalobeanu (2022) 156.
[60] Jalobeanu (2022) 156.

Robert Moray's ban on speculation, in the Royal Society, on the 'Originall causes'.[61] Sir Robert Moray asserted:

> 'This society *will not own any Hypothesis, systeme, or doctrine of the principles* of Naturall philosophy, proposed, or maintained by any Philosopher Auncient or Moderne, *nor the explication of any phaenomenon, where recourse must be had to Originall causes*'.[62]

Here, Moray explicitly rejected all hypotheses and any 'explications' based on 'Originall causes'. Moray's rejection is understandable because the 'Originall causes' usually refer to God as the ultimate cause or the first cause. In this way, the work of natural philosophy would not obtain any new knowledge; rather, it would fall into the theological context. This is what natural philosophers wanted to avoid.

Natural and experimental histories, in Bacon's term, abound in the second part of the seventeenth century.[63] The distinction between experimental and speculative approaches to natural philosophy substituted the 'operative' and 'speculative' undertakings respectively: while the experiment was associated with experimental philosophy, hypotheses were recognised as crucial components of speculative philosophy.[64] According to Anstey, experimental philosophy proposes that 'it is not possible to discover the true principles of the science of nature in the absence of experiment and observation', although 'a priori reasoning and the faculty of the imagination might be involved'. Speculative philosophy, by contrast, presupposes that 'the principles of a science can be discovered in the absence of experiment and observation or with only limited or at best post hoc reference to them'.[65] Anstey finds that such a distinction was popular among natural philosophers.[66] Therefore, the use of hypotheses in the late seventeenth century must be viewed through the lens of the distinction between experimental philosophy and speculative philosophy, and the significant implications thereof in natural philosophy.[67]

Through writing experimental reports, natural philosophers in favour of the experimental approach to natural philosophy gradually formed an 'experimentalist rhetoric'.[68] Anstey offers the examples of Glanvill and Parker, who represent the classical position of experimentalist rhetoric. Both scholars believed that natural knowledge should be advanced through experiments instead of hypotheses.[69] Glanvill

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[61] Wilson (2019) 166.

[62] Wilson (2019) 167, as quoted by Anstey (2005) 225, from Hunter (1995) 173; the italics are my own.

[63] See Jalobeanu (2022) 156.

[64] Anstey (2022) 639.

[65] Anstey (2022) 638.

[66] See Anstey (2005) 215–20, Anstey (2022) 636–37.

[67] See Anstey (2005) 216, see also Wilson (2019) 159.

[68] Anstey (2005) 227.

[69] **Glanvill** argued in his 'An Adress [*sic.*] to the Royal Society', and in his *Scepsis scientifica*, that '[nor] are these all the *advantages* upon the Account of which we owe *acknowledgments* to *Providence* for your *erection*; since from your *promising* and *generous endeavours*, we may hopefully expect a considerable inlargement of the *History of Nature*, without which our *Hypotheseis*are but *Dreams* and *Romances*, and our *Science* meer *conjecture* and *opinion*. For while we frame *Scheames* of things without consulting the *Phænomena*, we do but *build* in the Air, and describe an Imaginary World of our own making; that is but little a kin to the *real one* that *God made*. And tis possible that all the *Hypotheseis* that yet have been contrived, were built upon too narrow an *inspection* of *things*, and the

argues that an experimental method could replace hypotheses, which are nothing 'but *Dreams* and *Romance*'.[70] Glanvill believes that the hypothetical method limits our 'inspections of things', while 'advancing [...] the experimental knowledge' could 'disclose' the appearances of nature.[71] Meanwhile, Parker joins Glanvill in suggesting that 'the Mechanical and Experimental Philosophie' proposes a more inquisitive method of attaining certainty than the Aristotelian sciences: experiments are 'exact and certain', while hypotheses are 'doubtful and uncertain'.

Stimulated by the Cartesian use of hypotheses in his vortex theory, the opposition to speculative philosophy reached a summit. According to Anstey, 'as the century progressed Descartes's natural philosophy, and in particular his vortex theory,[72] came to be regarded as the archetypal form of speculative natural philosophy'.[73] In fact, Descartes explicitly proposes, in his *Principia Philosophiae*, that 'the observed motions of planets may be explained by various hypotheses'.[74] Descartes founds his hypotheses upon his critique of those of Tycho and Copernicus. Nevertheless, Descartes wishes his denial of Copernican hypothesis 'to be considered simply as a hypothesis <or supposition that may be false> and not as the real truth'.[75] Descartes

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phasies of the *Universe*. For the advancing *day* of *experimental knowledge* discloseth such *appearances*, as will not lye *even*, in any *model* extant' (Glanvill [1665], as cited in Anstey [2005] 227; the underlining is my own). Like Glanvill, **Parker** argues that 'the chief reason therefore, why I prefer the Mechanical and Experimental Philosophie before the *Aristotelean*, is not so much because of its so much greater certainty, but because it puts inquisitive men into a method to attain it, whereas the other serves only to obstruct their industry by amusing them with empty and insignificant Notions. And therefore we may rationally expect a greater Improvement of Natural Philosophie from the *Royal Society*, (if they pursue their design) then it has had in all former ages; for they having discarded all particular Hypotheses, and wholly addicted themselves to exact *Experiments* and Observations, they may not only furnish the World with a compleat *History of Nature*, (which is the most useful part of *Physiologie*) but also laye firm and solid foundations to erect *Hypotheses* upon, (though perhaps that must be the work of future Ages:) at least we shall see whether it be possible to frame any certain *Hypotheses* or no, which is the thing I most doubt of, because, though the Experiments be exact and certain, yet their Appliction to any *Hypotheses* is doubtful and uncertain; so that though the Hypothesis may have a firm Basis to bottome upon, yet it can be fastned and cemented to it no other way, but by conjecture and uncertaine (though probable) applications, and therefore I doubt not but we must at last rest satisfied with true and exact Histories of Nature for use and practice; and with the handsomest and most probable *Hypotheses* for delight and Ornament' (Parker [1666] 45–46, as cited in Anstey [2005] 226–27); underlining is my own.

[70] Glanvill (1665), as cited in Anstey (2005) 227; the italics are original.

[71] Glanvill (1665), as cited in Anstey (2005) 227.

[72] The Cartesian theory of vortex, constructed using the hypothetical method, is a theory of vortical celestial mechanics. According to Schuster, the vortex theory is the 'engine room' of Descartes' system of natural philosophy. 'Descartes starts his vortex theory with an "indefinitely" large chunk of divinely created matter or extension in which there are no void spaces whatsoever. When God injects motion into this extension, it is shattered into microparticles, and myriads of "circular" displacements ensue, forming gigantic whirlpools or vortices. This process eventually produces three species of corpuscle, or elements, along with the birth of stars and planets. The third element forms all solid and liquid bodies on all planets throughout the cosmos, including the earth. Interspersed in the pores of such planetary bodies are the spherical particles of the second element. The second element also makes up the bulk of every vortex, while the spaces between these spherical particles are filled by the first element, which also constitutes the stars, including our sun', see Schuster (2016) 757. For a more experimental approach to the vortex theory, see Dear (2005). For the role of the vortex theory in Descartes' natural philosophy, see Schuster's (2005) detailed reconstruction.

[73] Anstey (2005) 230. See also Heilbron (1979) 92.

[74] Part 3, principle 15. Translation by Cottingham, Stoothoff, and Murdoch (1985) 250, shortened as 'CSM (1985)' henceforth.

[75] Part 3, principle 19. Translation by CSM (1985) 251.

explicitly mentions that he wants the causes of the astronomical phenomena 'that [he] shall set out here to be regarded simply as hypotheses'. He explains his reason for claiming his theory of vortex as hypotheses:

> 'When philosophizing about such important matters, however, it would seem to be excessively arrogant for us to assert that we have discovered the exact truth <where others have failed>; and so I should prefer to leave this claim on one side, and put forward everything that I am about to write simply as a hypothesis <which is perhaps far from the truth, so as to leave everyone free to make up his own mind>. And if it is thought that the hypothesis is false, I shall think I have achieved something sufficiently worthwhile if everything deduced from it agrees with our observations; for if this is so, we shall see that our hypothesis yields just as much practical benefit for our lives as we would have derived from knowledge of the actual truth <because we shall be able to use it just as effectively to manipulate natural causes so as to produce the effects we desire>'.[76]

Descartes is aware that we might not discover the truth through 'philosophizing' (composing hypotheses). He also notes that even if a hypothesis might be false, it could still exercise 'much practical benefit' as long as 'everything deduced from it agrees with' the observations. Descartes believes that such a practical benefit exists so long as it could effectively produce the effects we want. Therefore, for Descartes, a hypothesis is useful because it could produce effects we desire, thus being similar to Bacon's 'operative' undertaking that focuses on the production of effects.

However, Descartes goes further in his argument by arguing that even if a supposition is false, we can still deduce true and certain result from the supposition:

> '[N]o proportion or order is simpler or easier to know than that characterized by complete equality in every respect. This is why I am supposing at this point that all the particles of matter were initially equal in respect both of their size and their motion; and I am allowing no inequality in the universe beyond that which exists in the position of the fixed stars, which is so clearly apparent to anyone looking at the night sky that it is quite impossible to deny it. In fact it makes very little difference what initial suppositions are made, since all subsequent change must occur in accordance with the laws of nature. And there is scarcely any supposition that does not allow the same effects (albeit more laboriously) to be deduced in accordance with the same laws of nature. For by the operation of these laws matter must successively assume all the forms of which it is capable; and, if we consider these forms in order, we will eventually be able to arrive at the form which characterizes the universe in its present state. Hence in this connection we need not fear that any error can arise from a false supposition'.[77]

Here, Descartes uses the term 'false supposition', which he has previously used to refer to 'hypothesis'. He believes that the truth of a hypothesis is irrelevant to our understanding of nature, as any changes to a hypothesis must conform to the laws of

[76] Part 3, principle 44. Translation by CSM (1985) 255.
[77] Part 3, principle 47. Translation by CSM (1985) 257–58.

nature, which is 'a precise organization now to be found in things'.[78] The laws of nature are universal and equal everywhere, because 'no proportion or order is easier to know than that characterized by complete equality in every respect'.[79] Therefore, natural laws are equal and universal, producing the same effects regardless of the truth of the original hypotheses.[80] Descartes believes that the laws of nature are reliable, and therefore the truth or falsity of hypotheses will not affect the results deduced from them. In this way, Descartes justifies his use of hypotheses in pursuing the knowledge of nature.

The tide against Descartes and Cartesian philosophy began in the early 1680s. Locke, for example, was unsure whether the Cartesian method would really obtain any natural knowledge because of the occult qualities of speculative philosophy.[81] Locke later came up with a more comprehensive criticism of hypotheses. He argues, in his letter to William Molyneux on 15 June 1697, that 'I have always thought, that laying down, and building upon hypotheses, has been one of the great hindrances of natural knowledge'.[82] Blackmore echoes Locke: '[T]he raising of an Hypotheses in Philosophy obtains little more Credit with me, than erecting a Scheme[83] in Astrology; and the Judgments and Decisions that are given upon them seem to me alike Precarious and uncertain'.[84]

These criticisms of hypotheses in scientific practices are consistent with a trend that was popular in seventeenth-century natural philosophy. '[B]y the early decades of the seventeenth century there is a discernible, broad-based shift towards the

[78] CSM (1985) 257.

[79] CSM (1985) 257. Descartes compares the laws of nature with God's supreme perfection, where he argues that the laws of nature could be better understood 'in accordance with the supreme perfection of God the creator of all things than proportions or order'. Although not explicitly argued, Descartes seems to justify the universality of laws of nature through God's supreme perfection.

[80] Later in this section, we will see that Hume criticised the reliance on the laws of nature, though his criticism was not explicitly targeted at Descartes.

[81] Locke (1976), II, 176, as cited in Anstey (2005) 230. In the 1680s, Locke also advocated his own hypothesis – the corpuscular hypothesis – in which he argued that matter is composed of tiny, invisible, and indivisible bits, called corpuscles, to better understand the knowledge of the qualities of the bodies. In his *An Essay Concerning Human Understanding*, which was first published in 1689, Locke claims that 'I have here instanced in the corpuscularian hypothesis, as that which is thought to go furthest in an intelligible explication of those qualities of bodies; and I fear the weakness of human understanding is scarce able to substitute another, which will afford us a fuller and clearer discovery of the necessary connexion and coexistence of the powers which are to be observed united in several sorts of them' (Locke [1975, 1689[1]] 547–48). It was not until the late 1690s that Locke realised that the use of hypotheses is 'one of the great hindrances of natural knowledge' (see his letter to Molyneux in the main text).

[82] Locke (1976), VI, 144, as cited in Anstey (2005) 229. See also Locke to Thomas Molyneux, 1st November 1692: 'I hope the age has many who will follow his [Sydenham's] example, and by the way of accurate practical observation, as he has so happily begun, enlarge the history of diseases, and improve the art of physick, and not by speculative hypotheses fill the world with useless, tho' pleasing visions' (Locke [1976], IV, 563, as cited in Anstey [2005] 229).

[83] The 'Scheme in Astrology' was created to 'condense and arrange' all the data observed by the early modern astrologists/astronomers and to present the data visually. The term refers to 'the graphical depiction of the positions of the Sun, Moon, and planets', see Boxer (2020) 20. The function of 'scheme' is similar to the 'hypothesis' in early modern contexts. Both terms were being used by the early modern natural philosophers to explain the empirical data gathered through observations and experiments. However, there is a difference between the two terms. Hypotheses contain (sometimes speculative) arguments based on empirical data, while 'schemes' focus on visualising the data in a graphical format.

[84] Blackmore (1697) ix, as cited in Anstey (2005) 229.

prioritizing of experience over theory, or experiential knowledge over theoretical knowledge'.[85] For example, Petrus de Witte wrote that 'For that begetteth but a speculative and theoretical knowledge in the understanding; but there must be an experimental knowledge by searching'.[86] Theoretical knowledge was deemed to be speculative and built upon hypotheses, and as a result, hypotheses faced rejection from experimental philosophers. This wave of rejection was usually interpreted as 'anti-hypotheticalism'.[87]

Newton's attitude towards the use of hypotheses might best represent the increasing influence of anti-hypotheticalism by the end of the seventeenth century. According to Anstey,

> 'Newton appears to have accepted Cartesian vortices until the early 1680s.[88] However, his *De gravitatione et aequipondio fluidorum*, which B. J. T. Dobbs has recently argued was composed in the mid-1680s,[89] is a strongly anti-Cartesian essay in metaphysics in which Newton attempts to do away with Descartes's fictions (figmenta). Newton's attack on Descartes was to culminate in his demolition of the vortex theory in the *Principia*'.[90]

It was in the *Principia* that he made the famous claim: *hypotheses non fingo* ('I do not forge hypotheses'). Newton summarised his definition of 'hypothesis' in a draft of a letter to Roger Cotes from March 1713:

> 'Hypothetical Philosophy consists in imaginary explications of things & imaginary arguments for or against such explications, or against the arguments of Experimentall Philosophers founded upon Induction. The first sort of Philosophy [Experimental philosophy] is followed by me, the latter too much by Cartes, Leibniz & some others'.[91]

Newton's criticism of Descartes was first responded to by Huygens and Voltaire. Huygens regards the Cartesian hypotheses as merely 'conjectures and fictions'[92] and claims that the Cartesian hypotheses of 'vortices [were] destroyed by Newton'.[93] In his famous *Lettres anglaises*, Voltaire contrasts the Cartesian approach with the Newtonian approach:

> 'A Frenchman who arrives in London finds a great change in philosophy, as in everything else. He left the world full, he finds it empty. In Paris one sees the Universe composed of vortices of subtle matter. In London one sees nothing of this. In Paris it is the pressure of the moon that causes the flux of the sea; in England it is the sea that gravitates toward the moon. With your Cartesians,

[85] Harrison (2011), as cited in Anstey (2022) 638.
[86] De Witte (1664) 27, as cited in Harrison (2011) 420.
[87] See Anstey (2022) 645.
[88] See Dobbs (1991) 122–29 and Wilson (2002) 206, both as cited in Anstey (2005) 230.
[89] See Dobbs (1991) 143–46, as cited in Anstey (2005) 231.
[90] Anstey (2005) 230–31.
[91] Newton (1959–1977), V, 398–399, as cited in Anstey (2005) 232.
[92] See Huygens' notes on *Baillet's Life of Descartes* (1691), as cited in Anstey (2005) 231.
[93] See Huygens' *Varia Astronomica* (1688), as cited in Koyré (1965) 117.

> everything is done by an impulsion that nobody understands; with Mr.Newton, it is by an attraction, the cause of which is not better known'.[94]

Here Voltaire criticised the Cartesian approach to natural philosophy for being vague and difficult to understand, while praising Newton's account of gravity for its clarity. Voltaire enhanced his pro-Newtonian position in the famous preface he wrote for Du Châtelet's French translation of Descartes's *Principia Philosophiae* which, according to Koyré, 'announced to the world the definitive victory of Newtonian science':

> 'Everything that is given here as principle is indeed worthy of that name; they are the first springs [*ressorts*] of nature, unknown before him; and it is no longer possible to call oneself a physicist without knowing them. If there were still somebody absurd enough to defend subtle and twisted (screwformed) matter, to assert that the Earth is an encrusted Sun, that the Moon has been drawn into the vortex of the Earth, that subtle matter produces gravity, and all those other romantic opinions that replaced the ignorance of the Ancients, one would say: this man is a Cartesian; if he should believe in monads, one would say he is a Leibnizian. But there are no Newtonians, as there are no Euclideans.[95] It is the privilege of error to give its name to a sect'.[96]

This passage describes the Cartesian hypotheses of vortices, which were constructed via hypotheses, as 'romantic opinions'; another way of saying that it is being speculative. Voltaire explicitly calls the Cartesian theory of vortices and the Leibnizian theory of monad, 'error[s]'. He contrasts these with the natural philosophy of the Newtonians and Euclideans, who use mathematics and geometry to understand nature. In Voltaire's view, Newtonian natural philosophy, with its mathematical forms, won the battle against Descartes and his use of hypotheses; this passage of 1759 represents the victory of anti-hypotheticalism over the Cartesian hypothetical method.

However, Voltaire's claim may not fully present the prevailing attitude towards the use of hypotheses in the eighteenth century. In fact, the attitude towards the use of hypotheses gradually changed among natural philosophers. As Anstey asserted, 'the hunger for evidence outstripped the capacities of the virtuosi to deliver'.[97] The chaos brought by the lack of theories forced scientists to pick up the hypothetical method they despised. Apart from the return to the hypothetical method, Anstey also noticed that the criticism of 'hypothesis' often fell into a 'straw man' situation.[98] The term 'hypothesis' was used as a substitute for more concrete speculative theories that were being criticised. Both of these new developments influenced Newton's attitude toward

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[94] *Lettresphilosophiques*, edition critique par Gustave Lanson (Paris: Edouard Cornely, 1909, and later editions, letter 14, vol. 2, p. 1), as cited in Koyré (1965) 55.

[95] As the term 'Newtonians' refers to people who followed the Newtonian methodology at that time, 'Euclideans' refers to people who were influenced by Euclid's *Elements*, either through the work itself or its many early modern translations and interpretations. One of the representative characteristics of Euclidean geometry is its axiomatic system. For an analysis of the early modern reception of Euclidean geometry, see De Risi (2016).

[96] *Principes mathimatiques de la philosophie naturelle par feue Madame la Marquise du Chastelet* (Paris, 1759, p. vii), as cited in Koyré (1965) 62.

[97] Anstey (2007) 144.

[98] Anstey (2022) 643.

hypotheses. Although Newton did not clearly express himself in favour of the use of hypotheses, he appeared to have slightly changed his opinion in his *Opticks*. According to Wilson, 'Newton added even more speculative elements, in the form of active powers, to the spare Cartesian system of matter and motion in the Queries to his *Opticks*':[99]

> 'Have not the small Particles of Bodies certain Powers, Virtues, or Forces, by which they act at a distance … upon one another for producing a great part of the Phaenomena of Nature? For it's well known, that Bodies act one upon another by the Attractions of Gravity, Magnetism, and Electricity … and … there may be more attractive Powers than these. For Nature is very consonant and conformable to her self'.[100]

Wilson comments that 'speculations of this type were permissible because theology and non-material powers were carefully and explicitly built into them'.[101] Thus, there is a controversy about how to interpret Newton's position on hypotheses. While Walsh claims that the use of hypotheses in *Opticks* was only instrumental,[102] Anstey argues the opposite: Newton is not a rigorous opponent of hypotheses; rather, Newton's famous *Hypotheses non fingo* was a tactical response to the antagonism of experimental philosophers towards speculative philosophy. [103] Anstey's view resonates with the deep influence of the criticisms of hypotheses by the end of the seventeenth century and reveals a possibility that hypotheses could be used as a scientific method. This becomes clearer in the context of the English experimentalists of the Royal Society, who published articles about the hypothetical method in the *Philosophical Transactions*.

To better observe the attitude towards hypotheses among natural philosophers, I exemplify the general acceptance of hypotheses through an overview of a continuous publication in the field of natural philosophy – the *Philosophical Transactions* – which was first published in 1665 and has been published ever since. According to the articles published in the *Philosophical Transactions*, until 1800, the term 'hypothesis' was mentioned in ninety-five articles. The first use of the term in this journal is in its second issue of the first volume in 1665: 'Hypothesis' appeared in an excerpt of a letter from Rome, in which the author wrote:

> '[T]he Hypothesis of Georg. Domenico Cassini, touching the motion of the Comet about the *Great Dog* in a Circle, whose Centre is in a streight line drawn from the Earth through the laid Star. I believe it will shortly be published in print, as a thought I lighted upon in discoursing with one of my Friends, who did maintain, that if turned about a Centre, because that its Perigee had been over against the *Great Dog*, as I had noted in my *Ephemerides*'.[104]

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[99] Wilson (2019) 170.
[100] Newton, *Opticks* (1952[4], pp. 375–76), as cited in Wilson (2019) 170.
[101] Wilson (2019) 170.
[102] Walsh (2019) 125.
[103] See Anstey (2005) 236; Anstey (2022) 645.
[104] Anonymous(1665) 18.

This mention of the term 'hypothesis' in an astronomical context was subsequently adopted in the reply to this letter, which was published in the same issue of the *Philosophical Transactions*. Later, the term 'hypothesis' was used in various contexts between 1666 and 1707, such as animal generation (the hypothesis of the animalcules in semen[105] in 1698), the structure of the internal parts of the earth (in 1692), alkali and acid (in 1676), and an anonymous review of recently published works, including Robert Boyle's work on mechanical hypothesis (in 1674).[106] Boyle was a fellow of the Royal Society. The reviewer claims that Boyle distinguished between two kinds of hypotheses: 'philosophical hypotheses' and 'mechanical hypotheses'. Boyle argues for 'mechanical hypotheses', which are based on experiments and could lead scientists to the 'truth search of the Nature', while 'philosophical hypotheses' are either 'foiled by [mechanical hypotheses], or found reconcileable to it'.[107] Such a distinction lays the ground for the subsequent discussion and use of the term 'hypothesis'. Unlike mechanical hypotheses, which are based on experiments, philosophical hypotheses can either be proven false or be reconcilable to mechanical hypotheses.[108] Such a distinction reappears in the works on electricity to be discussed in section 4.

According to my study of the *Philosophical Transactions*,[109] the earliest affirmative evaluation of the hypothesis from a methodological perspective probably comes from an article by Francis Hauksbee, published in 1707. He comments, with a positive tone, on the merit of hypotheses: '…the greatest Satisfaction and Demonstration that can be given for the Credit of any Hypothesis, is, That the Experiments made to prove the same, agree with it in all Respects, without force'.[110] This praise of the hypothetical method shows that scientific experiments had become more task oriented. Natural philosophers designed experiments to verify or falsify certain hypotheses, rather than to document random and scattered data. According to Bazerman, this marked the affirmation of the usefulness of hypotheses in experiments.[111]

The mention of the term 'hypothesis' went quiet for almost twenty years after 1707 before displaying a steady growth in use from the 1730s. In the 1750s, scientists

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[105] See Lister (1698) 337.

[106] The full title of this anonymous review reads: 'An accompt of some books. I. *About the excellency and grounds of the mechanical hypothesis, some consideration occasionally propos'd to a friend* by R. B. E. Fellow of the R. Society. London,1674. in 4°. II. Mr. John Smith's *Englands Improvement revived, in a treatise of husbandry and trade, by Land and Sea, &c*. III. Davidis van Der Becke *Experimenta & Meditationes circa Naturalium Rerum Principia*'. It was published on 25 May 1674, in volume 9, issue 103. The work *The excellency and grounds of the mechanical hypothesis* is one of the two excellencies written by Robert Boyle. The other one is called *The excellency of theology*, written in 1665. The two excellencies were published together in 1674, see the introduction of MacIntosh's edition of Boyle's two excellencies in 2008.

[107] Anonymous (1674) 54, see also Boyle (2008) 229.

[108] A hypothesis based on experimentation may be referred to as 'mechanical'. However, experimentation is not always necessary for a hypothesis to be considered 'mechanical'. For example, Descartes developed his vortex hypotheses within the framework of his mechanical philosophy, but they were still considered 'speculative' due to the lack of experimental support.

[109] To illustrate the evolution of the use of hypotheses intuitively, I will limit my focus to those articles that explicitly use the term 'hypothesis' to refer to their own or others' research findings.

[110] Hauksbee (1707) 2415–17.

[111] Bazerman (1988) 67.

started to use hypotheses to explain the phenomena and experiments of electricity, such as thunder (1752), and elastic fluids (1771, 1787) in electricity experiments, among other biological and astrological articles. There was a peak of the mention of 'hypothesis' in the 1780s and 1790s. During this period, forty-five articles using 'hypothesis' were published in the *Philosophical Transactions*, which amounted to almost half of the number of articles using the term 'hypothesis' until 1800. William Herschel, a late eighteenth-century astronomer and physicist, was the author who used hypotheses most frequently in his articles. Indeed, ten out of ninety-five articles mentioning the term 'hypothesis' were written by Herschel and published between 1789 and 1800. This rising tendency proves that the term 'hypothesis' gradually gained its independence from speculative philosophy and became a term accepted by experimental philosophers.

The widespread use of hypotheses in other countries in the mid- and late-eighteenth century (including Germany, France, and colonial British America) mirrors the inclination documented in the *Philosophical Transactions*. Laudan identifies several scientific theories that he believes have applied the hypothetical method to their scientific investigation; for example, Franklin's fluid theory of electricity in the mid-eighteenth century, as well as George LeSage's chemical and gravitational theories, David Hartley's neurophysiological theories, and Roger Boscovich's general theory of matter in the late eighteenth and early nineteenth century.[112] According to Laudan, the last three theories that utilised and theorised the hypothetical method were the 'most controversial', and probably the most radical.[113] Hartley and LeSage recognised the limitations of the inductive method – a common practice in experimental philosophy – and advocated for the hypothetical method to serve a supplementary function.[114]

Hartley and LeSage's awareness echoes the attempt of Hume in his *An Enquiry concerning Human Understanding*, who cautiously suggests introducing the use of hypotheses in explaining experimental observations. Hume begins his arguments by criticising one of the philosophical endeavours of the eighteenth century:

> 'Being determined by custom to transfer the past to the future, in all our inferences; where the past has been entirely regular and uniform, we expect the event with the greatest assurance, and leave no room for any contrary supposition. But where different effects have been found to follow from causes, which are to appearance exactly similar, all these various effects must occur to the mind in transferring the past to the future, and enter into our consideration, when we determine the probability of the event. Though we give the preference to that which has been found most usual, and believe that this effect will exist, we must not overlook the other effects, but must assign to each of them a particular weight and authority, in proportion as we have found it to be more or less frequent'.[115]

[112] See Laudan (1981) 12.
[113] See Laudan (1981) 12.
[114] See Laudan (1981) 13.
[115] Hume (2007, 1748[1]) 42.

In this passage, Hume first presents a common habit among human beings: We '[are] determined by custom to transfer the past to the future, in all our inferences'.[116] This is the thinking habit that had been developed by the favouring of inductive reasoning. The things that happened most often are the ones that are most likely to happen in the future. Hume reminds us of the importance of going beyond such inductive reasoning. He argues that we should not be limited by our past experience but should give appropriate weight to things that were less likely to happen. The same applies to scientific theories. Although inductive reasoning could lead to certain conclusions based on current experimental results, we should not overlook that there may be possible counter-cases to such inductive conclusions. If such a possibility exists, inductive reasoning alone could not satisfy the needs of scientific inquiry. Therefore, Hume moves on to the second step of his attempt, which is to use the hypothetical method to supplement inductive reasoning:

> 'We shall make trial of this, with regard to the hypothesis, by which, we have, in the foregoing discourse, endeavoured to account for all experimental reasonings; and it is hoped, that this new point of view will serve to confirm all our former observations'.[117]

Hume proposes to exploit the facilitation of hypotheses to account for experimental reasonings to confirm the previous observations. In this way, Hume combines the use of hypotheses with experimental reasoning, setting the stage for the further use of hypotheses in experiments. Nevertheless, Hume is also aware of the speculative nature of the hypotheses, since he also reproached the assumptions of nature without empirical basis as 'mere possibility and hypothesis', and 'mere conjecture and hypothesis'.[118] Thus, he further insists that 'a mere hypothesis', can 'not to be insisted on, without more experiments'.[119]

To conclude, a transformation from anti-hypotheticalism to a more positive attitude toward hypotheses was required, both from a practical aspect by the practising scientists, and from a theoretical aspect by philosophers. To better reveal this transformation, I move to a textual analysis of the eighteenth-century works on electricity.

4. The shifts in the rhetoric of 'hypothesis': Late eighteenth-century electricity literature

This section explores how eighteenth-century natural philosophers working on electricity mentioned the term 'hypothesis' in their works. By examining the context of their mentions of this term, this section explicates their methodological reflections and innovations in the use of hypotheses.[120] First, it explains why electricity, rather

[116] Hume (2007, 1748[1]) 42.
[117] Hume (2007, 1748[1]) 76.
[118] See Hume (2007, 1748[1]) 103, 106.
[119] Hume (2007, 1748[1]) 124.
[120] According to Laudan, there exists a purist model in the historiography of science, which asserts that scientific methodology advancements are only valuable when they arise from 'philosophical' considerations, such as those articulated by prominent philosophers like Descartes, Newton, and Hume. However, this model undermines the importance of fieldwork in methodological progress. In

than other scientific subjects, provides the place for the rebirth of the hypothetical method. It then examines how the rhetoric of hypothesis in electricity works in two aspects: (1) the definition and methodology of 'hypothesis', and (2) references to specific hypotheses. Finally, it addresses the research question by providing a thorough explanation of the transition towards the use of the hypothetical method.

Newly emerged as an interest in the experimental context, the study of electricity attracts the use of hypotheses in explaining the results of electricity experiments.[121] Adams, a natural philosopher on electricity of the late eighteenth century, writes that

> 'As electricity is in its infancy, when considered as a science, its definitions and axioms cannot be stated with geometric accuracy. I shall, endeavour to avoid, as much as possible, the use of positive expression; in order to invite the reader to examine the experiments himself, to compare them one with another, and then draw his own conclusions; beginning with those Experiments which were the foundation of the present state of electricity, and which gave rise to the principal technical terms made use of in this science'.[122]

This exhibits a clear experimentalist rhetoric. The newly emerged study of electricity does not have an accurate theoretical structure. Therefore, Adams tries to explain the mechanism of electricity through experiments.

But why is Adams so cautious about his experimentalist approach, to the extent that he avoids the use of positive expressions as much as possible? The following passage gives the answer:

> '[F]ew philosophical sciences afford so much entertainment as electricity: in it the useful and agreable are intimately blended; and the philosopher, while he is investigating the abstruse parts, is entertained by the variety and beauty of the experiments, which confirm or disprove the hypothesis he wishes to establish'.[123]

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opposition to this purist model, Laudan argues that the methodological contributions of scientists working in the field require more attention from the historiography of science. See Laudan (1981) 7.

[121] However, this by no means implies that the study of electricity is the most unique field to study the rhetoric of 'hypothesis' exclusively. It also does not mean that such shifts only took place in the field of electricity study. Instead, the study of electricity only constitutes a particular case of the overall shift in the rhetoric of 'hypothesis'. As a case study, this paper explores how the meaning of 'hypothesis' changed in the study of electricity. It hopes to provide a specific approach from the study of electricity to reflect upon how the idea of 'hypothesis' shifted in the overall picture of late-eighteenth-century natural philosophy. Apart from the study of electricity, the popularisation of the use of hypotheses also emerged in other fields of early modern natural philosophy. For example, the popular experiments involving air-pumps across Europe gave rise to many hypotheses on the relationship between air and vacuum, see Shapin and Shaffer (2011). The early modern period also witnessed a growing interest in the theory of animal generation. Different hypotheses have been created regarding the formation of animals; for example, Malebranche's theory of preexistence, Blumenbach's formative power, and Kant's hypothesis of epigenesis in his early philosophy, see Smith (2006). The study of magnetism also contributed many hypotheses in early modern period. For example, the 'garlic effect': garlic's deprivation from a magnet of its power of attraction, which was caused by a misreading of a corrupt or ambiguous passages in Pliny's *Natural History*, see Sander (2020). For information on the occult qualities of magnets and their Galenic origin, refer to Reeves (2002), and Sander (2023). For a general description of early modern magnetism, see Sander (2018) and (2023).

[122] Adams (1787) 3.

[123] Adams (1787) 63.

Adams contrasts the experimentalist rhetoric he has previously mentioned with the philosophical approach that he presents here. He articulates the case for the study of electricity where, because of the lack of theoretical structure, electricity experiments attracted not only the experimentalists for their usefulness, but also the philosopher who used electricity experiments to 'confirm or disprove the hypothesis he wishes to establish'.[124] According to Adams,

> '[I]t must appear surprising to every searcher after truth, that electricity, which is now allowed to be one of the principal agents employed in producing the phænomena of nature, should have remained so long in obscurity; for, comparatively speaking, its existence was not known to the ancients'.[125] [126]

Adams presents two characteristics of electricity: (1) The study of electricity is newly emerged. It thus lacks a readily available structure, which leads to (2) the study of electricity is closely linked to hypotheses, even in an experimental context.

Both characteristics make describing electricity experiments a challenging task. Facing the experimental data, philosophers want to uncover the unified causes behind the various phenomena. Such attempts lead these philosophers to the hypothetical method, which is an effective way to present their understanding or assumptions to

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[124] Adams (1787) 63.

[125] However, this does not mean electricity phenomena were not studied in antiquity. Instead, there are continuous discussions on the electric properties of lodestones (the magnetite) and amber among ancient natural philosophers. According to Meyer, Thales of Miletus was the first to observe the electrical properties of amber, see Meyer (1971) 4. Aristotle, in his *On the soul*, also documents Thales' theory of the motion of magnets: 'Thales, too, to judge from what is recorded of his views, seems to suppose that the soul is in a sense the cause of movement, since he says that a stone a has a soul because it causes movement to iron' (*On the soul* I 2.405a20–22, translated by W. S. Hett). Here, Aristotle attributes the reason for the motion of magnets to the 'soul' presented in the rocks. However, the official use of the term 'magnet' came from Theophrastus. Theophrastus calls such kind of stone 'Magnesian stone', which is usually interpreted as the stone being discovered from localities bearing the name Magnesia and were named after them, see Caley and Richards (1956) 53, 144. Pliny later describes a magnet's property of attracting iron in his *Natural History*. He depicts the attraction of the magnet as an 'embrace': 'For iron is attracted by the magnet, and the substance that vanquishes all other things rushes into a kind of vacuum and, as it approaches the magnet, it leaps towards it and is held by it and clasped in its embrace. And so the magnet is called by the Greeks by another name, the "iron stone", and by some of them the "stone of Heracles"' (*Natural History* XXXVI.25.127, translated by D. E. Eichholz). Pliny also documents the repelling phenomena of another kind of stone ('haematite magnet') discovered in Ethiopia and a nearby place: '[I]n Ethiopia and at no great distance is another mountain, (the ore from) which on the contrary repels and rejects all iron' (*Ibid.*, XXXVI.25.130, translated by D. E. Eichholz). Plutarch also describes the attraction of the magnets (lodestones) in comparison to amber in his *Moralia*: 'Amber does not attract any of the objects placed near it as the loadstone does not either, nor does any of the things in their neighbourhood spring to them of itself; but the loadstone emits certain effluvia which are heavy and like wind, and the contiguous air, forced back by these, pushes the air that is before itself, and that air, moving around in a circle and settling again upon the vacated space, forces the iron back and drags it along with itself' (*Moralia* XII.1005b, translated by H. Cherniss).

[126] Adams (1787) 2. Adams then continues: 'They were not, indeed, altogether ignorant of the peculiar properties of those bodies that we now term electrics nevertheless PER SE; their knowledge was circumscribed as being confined to the observation only, of those phœnomena which nature presented to their senses, in the ordinary course of her operations; hence near two thousand years elapsed, before any addition was made to the little which was known to Theophrastus, and this branch of natural history remained uncultivated, till the happy period arrived, when the philosopher was emancipated from the chains of hypothetical reasoning, and the uncertainties of vague conjecture'. See Adams (1787) 2–3.

others. Furthermore, the appearance of hypotheses also met the need for theoretical structure in the study of electricity. Therefore, in the absence of a clear explanatory framework, the formulation of a hypothesis could be both rhetorically effective and necessary. Accordingly, electricity studies witnessed the birth of many hypotheses during the early modern period.

While composing such hypotheses, natural philosophers working on electricity might criticise other theories for their occult qualities. For example, when talking about Franklin's hypotheses on electricity, Lyon claims that Franklin's electricity hypothesis 'is neither less nor more than a mixture of the Newtonian philosophy of attraction and repulsion, and of the Peripatetic; viz. of occult qualities'.[127] Here, the passage conveys the idea that a part of the electricity hypothesis is Peripatetic or Aristotelian, which involves occult qualities that are beyond experimental knowledge.

The term 'occult' is used by early modern Aristotelians. According to Heilbron,[128] while corpuscular or Newtonian philosophers can find only a few, if any, causes of a phenomenon, early modern Aristotelian philosophers can always categorise the phenomenon into four categories; that is, the formal, efficient, material, and final causes, as well as several subspecies under these categories. One of the subspecies is termed 'occult', which later became a symbol for the early modern Aristotelian methodology in the seventeenth and eighteenth centuries. The term 'occult' is also used for a polemical reason in the debates between Newtonian and Cartesian philosophers. Philosophers often use 'occult' to refer to explanations that account for theories that cannot be proved by experiment. For example, 'philosophers admitted an occult gravitational quality to account for the apparent directed self-movement of heavy bodies'.[129] As mentioned previously, the lack of clarity regarding the causes of electrical phenomena led to many hypotheses in this field. Thus, electricity became representative of possessing 'occult' qualities. According to Adams, the reference to being 'occult' is mainly caused by the fact that the power of electricity remains 'subtle, and in most cases invisible'.[130] This 'occult' property, and its relationship with early modern Aristotelianism, partly explains why experimental natural philosophers took a very cautious attitude towards the use of the term 'hypothesis' in their rhetoric. It also makes the study of electricity an excellent subject to observe the gradual acceptance and transformation of hypotheses. Therefore, to better analyse the evolution of hypotheses, the study of electricity should be the most appropriate subject.

To better study the development of the hypothetical method, I propose to study the works that were influential and widespread during the late eighteenth century. 'Influential and widespread' here refers to the most widely accepted; in other words, these works are like the typical or 'average textbooks' of the time, representing the consensus reached on the subjects studied.[131] According to the 'network of the works of early modern natural philosophy' created by Sangiacomo and others, there are two

[127] Lyon (1781) 14–15.
[128] See Heilbron (1979) 19.
[129] Heilbron (1979) 23.
[130] Adams (1787) 2.
[131] Sangiacomo and others refer to this type of work as the 'average textbook' of early modern natural philosophy, see Sangiacomo et al. (2022) 37.

lists of works on electricity that represent the 'average textbooks' on electricity.[132] The two lists are based on two different statistical models[133]: topic modelling,[134] and multilingual word embeddings.[135] Using the works in the two lists to study the evolution of hypothesis represents the most widely accepted practice of using hypotheses in the study of electricity, which is arguably the best subject to observe the development of hypotheses. The two lists contain eighteen works in total. While several works do not refer to the term 'hypothesis' or '(causal) explanation', most of the writings use at least one of the two terms.

LIST 1 The most prominent works according to topic modelling, ranked in descending order of importance:

Adams, G. (1787). *An Essay On Electricity Explaining Theory And Practice.*
Peart, E. (1789). *On The Elementary Principles of Nature.*
Brook, A. (1789). *Miscellaneous Experiments And Remarks On Electricity.*
Bennet. (1789). *New Experiments On Electricity.*
Milner, T. (1783). *Experiments And Observations In Electricity.*
Wilson, B. (1756). *Observations On Æries Of Electrical Experiments.*
Henly, W. (1774). *An Account Of Some New Experiments In Electricity.*
Lyon, J. (1781). *Farther Proofs That Glass Is Permeable By Electric Effluvia.*
Wilson, B. (1752). *A Treatise On Electricity.*

[132] The ERC Starting Grant project 'The Normalisation of Natural Philosophy: How Teaching Practices Shaped the Evolution of Early Modern Science' provided the statistical data.

[133] These two models are the two methods used to create the 'textual correlation multiplex network', which 'studies similarity from the more general perspective of the textual features of the entire books and the entire corpus', see Sangiacomo et al. (2022) 39. To create such a network of early modern books on natural philosophy, they 'take into account three centrality measures, interpreted as follows: (a) degree centrality: the number of connections a work established in the network (Newman 2010, 169); (b) eigenvector centrality: a measurement which establishes the most prominent nodes in the network, heavily dependent on the degree of the respective node (work), as well as on the degree of the works connected to that node (ibid.); (c) betweenness centrality: a measure of the centrality of a work based on the number of shortest paths between other works going through the respective work (ibid., 186). Thus, most of the works with the highest number of links will appear to have the highest eigenvector while, typically for the corpus in question, the node with the lowest degree will rank highest in terms of betweenness centrality if it is placed on the path between other nodes', see Sangiacomo et al. (2022) 40. The selection of treatises and articles in the two lists follow these three measures of centrality, which refer to the works on electricity that were most influential in the sense of being most engaged with other contemporary works. These treatises and articles, therefore, represent the models of the 'average textbook' on electricity in early modern natural philosophy, see Sangiacomo et al. (2022) 37.

[134] Topic modelling 'uses a probabilistic model (the Latent Dirichlet Allocation, LDA) that estimates probability distributions for topics in documents and words in topics related to natural philosophy (Blei and Jordan 2002)', see Sangiacomo et al. (2022) 42.

[135] Multilingual word embedding is 'a technique to represent words in a text as vectors based on each word's context and "embed" these vectors in a vector space (Bjerva and Praet 2015; Joulin et al. 2016; Alaux et al. 2019)', see Sangiacomo et al. (2022) 42. However, such a method is not perfect. When comparing the importance of a text in works written in different languages (in this case, English, French, and Latin), the 'text will establish the strongest connections with another text written either in the same language or between two well represented languages, because performance across languages in fastText is unequal (i.e., the alignment of vectors between English and French will be more accurate than that between Latin and French)', see Sangiacomo et al. (2022) 54.

LIST 2 The most prominent works according to multilingual word embeddings, ranked in descending order of importance:

Symmer, R., and Mitchell, J. (1759). 'XXXVI. New experiments and observations concerning electricity'.
Wilson, B. (1780). *A Short View Of Electricity.*
Eliot, J. (1788). *Elements Of The Branches Of Natural Philosophy.*
Read, J., Henry, R., and Bennet, A. (1794). 'Experiments and Observations Made with the Doubler of Electricity, with a View to Determine Its Real Utility, in the Investigation of the Electricity of Atmospheric Air, in Different Degrees of Purity. By Mr. John Read. Communicated by Richard Henry Alexander Bennet, Esq. F. R. S.'.
Henly, W., and Priestley, J. (1772). 'An Account of a New Electrometer, Contrived by Mr. William Henly, and of Several Electrical Experiments Made by Him, in a Letter from Dr. Priestley, F. R. S. to Dr. Franklin, F. R. S.'.
Arden, J. (1774). *An Analysis of Mr. Arden's Course of Lectures on Natural and Experimental Philosophy.*
Fowler, R. (1793). *Experiments And Observations Relative To The Influence Lately Discovered By Mr. Galvani.*
Delaval, E. (1761). 'LV. An account of several experiments in electricity: In a letter to Mr. Benjamin Wilson, F. R. S. By Edward Delaval, Esq; F. R. S.'.

The works on electricity mentioned here were usually divided into four parts: (1) Introduction and literature review; (2) Propositions of electricity (to explain the aim or method of the experiments); (3) Documentation of electricity experiments, and (4) Comments or Concluding Remarks. Of the four parts of a work, research methodology is usually found in the 'Introduction' or the 'Concluding Remarks', where most of the discussions of hypotheses and causal explanations take place. Accordingly, my study of these works focuses on the parts that contain methodological reflections on the use of hypotheses, which constitute my discussions in section 4.1. Since the 1770s, however, there has been a new usage of 'hypothesis'; namely, using the term 'hypothesis' to refer to specific scientific theories. I will discuss this usage in section 4.2.

4.1 Hypothesis as a term: methodology and practice

This subsection demonstrates the changing use of the term 'hypothesis'. First, the benefits of hypotheses in scientific practice were highlighted, including their effectiveness in accounting for the newly discovered natural phenomena and their suitability for pursuing the uniformity of natural principles held by natural philosophers. Second, natural philosophers endeavoured to systematise the utilisation of hypotheses: (1) hypotheses were reinterpreted by an experimentalist rhetoric and were dissociated from their speculative philosophic context; (2) the alterations in the interpretations of Newtonian methodology presented these electricity theorists with a theoretical foundation to employ hypotheses in their research, and (3) a set of primary criteria for the hypothetical method was established. Electricity theorists advocated

for methodological refinements of hypotheses and a reflection upon their misuse in the context of experimental philosophy.

In the 1750s, the use of hypotheses was not very popular. However, several theorists of electricity endeavoured to use this term; for example, Wilson justified the hypothesis of the propagation of light by referring to Newton's philosophy. Wilson wrote:

> 'Light is proved by Sir Is. Newton to consist of particles of various sizes: but the particles of æther, he says, are exceedingly smaller than those of light.
> Proposition XVII æther is more subtile than light
> [.....]
> The velocity of light is exceeding[ly] great, and though the particles constituting the different rays are of various sizes, yet they all describe equal spaces in the same time. To account for the propagation of light from the sun to us, in so short a time as seven or eight minutes, various have been **the hypotheses framed**. All these Isaac Newton has endeavoured to show, in question xxviii, to be very erroneous, and from the force of reason joined to the observation and experiments, substituted the æther we have so often mentioned, and this at a time when electricity was but little known'.[136]

Something interesting can be observed in this passage. Wilson explains that the hypothesis is composed 'to account for the propagation of light from the sun to us'.[137] The term 'to account for' proves that the function of a hypothesis is to explain the causes of the observed phenomena during an experiment. Instead, according to Wilson's account, Newton advocated for the merging of reason with observation and experimentation. Newton dismissed the various hypotheses formulated for the particular experiment, including the supposed 'æther', which is 'very erroneous'. Nevertheless, Wilson also reminds the readers that such a substitution of 'æther' only happened when 'electricity was but little known'.[138]

Such an attitude shifts when Wilson discusses the reflective and refractive power of a body facing light, which 'is proved by Newton to consist of particles of various sizes'.[139] Wilson refers to Newton when he says that 'the particles of *æther,* [...], are exceedingly smaller than those of light'.[140] Wilson argues that 'the law established between the æther and bodies, for making the æther the cause of most of the phænomena of, respects both the quantity of matter and the quantity of light contained in bodies'.[141] He adds that there are spheres of æther surrounding bodies, whose sizes depend on the sizes of the bodies.[142] Wilson further justifies this use by referring to Newton's *Opticks*, where Newton claims that there are small particles emitted from the activity of polishing a tube, because these particles have already existed at the surface of the tube.[143] Thus, the æther was reintroduced by Wilson as the cause of

[136] Wilson (1752) 111, the bold and underlining are my own.
[137] Wilson (1752) 111.
[138] Wilson (1752) 111.
[139] See Wilson (1752) 110, 113.
[140] Wilson (1752) 110.
[141] Wilson (1752) 113.
[142] Wilson (1752) 115.
[143] Wilson (1752) 119.

tribostatic phenomena, which was the medium that produced electricity between two objects.

Wilson concludes this section by arguing that on the one hand, he follows Newton by rejecting the use of the hypothesis of the æther to explain the properties of light. Wilson renames the small particles of light that surround all bodies – which is 'supposed by Sir Isaac Newton to be the cause of the reflection, refraction, and inflection of light' – as 'the different names of the reflective, refractive, inflective, and medium, or, in one word, by atmosphærulas'.[144] On the other hand, he keeps the hypothesis of 'æther' in his theory to explain electrical phenomena. The existence of 'æther' accounts for tribostatic phenomena.

Such a preservation of 'hypothesis' continues in the later part of Wilson's work, where he explains the uniformity of natural philosophical principles regarding electricity that are derived from experiments.[145] He claims:

> 'I have endeavoured to explain the nature of the force, by which light bodies are moved in electrical experiments, and attempted to show, that it is the same force with that which causes gravitation; which force can be no other, than a fluid exceedingly more subtile and elastic, than air, at the surface of the earth [...] I should not be surprised, if the nature of muscular motion, vegetation, and even magnetism itself, should be hereafter explained upon the same principles'.[146]

Therefore, there is a uniformity between different forces that cause various natural phenomena, such as electricity and gravitation.

On the uniformity of natural principles, Wilson reluctantly acknowledges the advantage of several hypotheses:

> 'However, this may be, what I have advanced seems to have the advantage of the several hypotheses hitherto framed for explaining the nature of electricity, as it is the most universal and consistent with itself; at the same time, that in the most plain and simple manner it account for the other phænomena in nature, as well as those in electricity'.[147]

When it comes to the uniformity of nature, hypotheses have the advantage of proposing a consistent account of the nature of electricity. Wilson believes that the hypothetical account, which refers to æther according to his previous context, could also effectively explain other phenomena in nature: 'If the existence of an æther be admitted, we may reason by analogy concerning other parts of the planetary system'.[148] Here, Wilson's quest for an effective explanation and a consistent account of the nature of electricity seems to overwhelm his reluctance to use hypotheses.

Such a reflection is echoed by Adams, who argues for the merit of the hypothetical method in describing universal phenomena. Adams argues that

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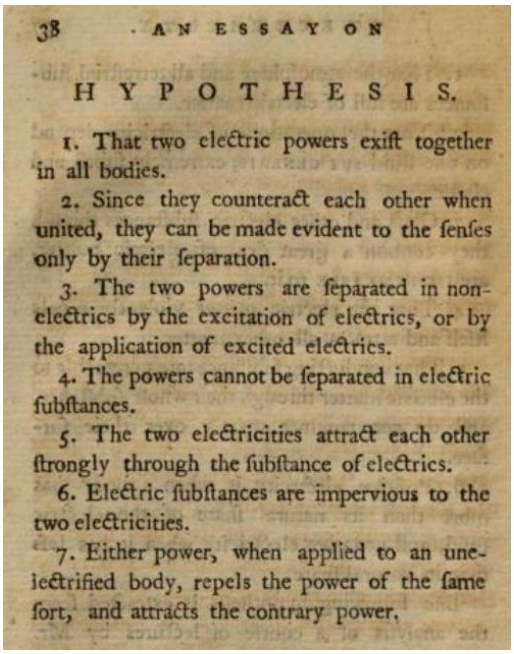
[144] Wilson (1752) 119.
[145] See also Heilbron (1979) 61.
[146] Wilson (1752) 199–200.
[147] Wilson (1752) 200.
[148] Wilson (1752) 200.

> '[T]he powers of genius which have been hitherto employed in prosecuting this subject,[149] have not been able to frame an hypothesis, that will account, in an easy and satisfactory manner, for all the various properties of the magnet, or point out the links of the chain which connect it with the other phænomena of the universe'.[150]

Framing a hypothesis would be able to connect the field of electricity to other fields in nature and extract the uniform law beneath all the phenomena. The use of hypotheses could justify the uniformity of nature. In the same work, Adams lists seven hypotheses about electricity in clear and propositional form. He presents this list at the end of a series of experiments on electricity to show the universality of these hypotheses:[151]



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HYPOTHESIS.

1. That two electric powers exiſt together in all bodies.

2. Since they counteract each other when united, they can be made evident to the ſenſes only by their ſeparation.

3. The two powers are ſeparated in non-electrics by the excitation of electrics, or by the application of excited electrics.

4. The powers cannot be ſeparated in electric ſubſtances.

5. The two electricities attract each other ſtrongly through the ſubſtance of electrics.

6. Electric ſubſtances are impervious to the two electricities.

7. Either power, when applied to an unelectrified body, repels the power of the ſame ſort, and attracts the contrary power.

This further enhances the idea that hypotheses can be used by scientists to pursue a more unified description of the laws of nature based on experiments. According to Adams, the establishment of a hypothesis is simple: it could be extracted from a single experiment.[152] However, such a hypothesis, though verified by this experiment, could not reconcile other facts.[153] Therefore, it could not contribute to the discovery of the uniformity of nature.

While theorists of electricity acknowledged the merits of hypotheses, they were also trying to normalise the use of hypotheses in their accounts of electricity experiments. Wilson mentions that Franklin's method of conducting electricity experiments does not please him. Instead, he wishes to methodise the papers based on the explication of the Leyden experiment.[154] Here, Wilson mentions that he might not

[149] The subject here refers to magnetism according to the context of Adams's work.
[150] Adams (1787) 393–94, the underlining is my own.
[151] Adams (1787) 38.
[152] Adams (1787) 156.
[153] Adams (1787) 156.
[154] Wilson (1756) 82–83.

be able to answer the rejections of his hypothesis by 'a good philosopher'; nonetheless, he believes that such rejections 'may contribute to improve my hypothesis, [...] which I should not have thought on had there been no objection made'.[155] Wilson's words show a detachment of 'hypothesis' from its philosophical context. Hypotheses could be used by theorists of electricity in the context of doing experiments. Wilson keeps the hypothetical method in his argument, while at the same time he dissociates it from speculative philosophy. Although philosophers may reject such a hypothesis, it is not necessary for researchers to reply to these rejections, as long as they do not come from experimental data.

Therefore, Wilson founds his hypotheses on experiments instead of pure philosophical speculation. For example, in an earlier case, he argues that 'perhaps the soldering of metals and the cementation of iron by fire may be considered as strong proofs of the truth of their hypothesis'.[156] To supplement this example, Wilson cites several hypotheses that were famous at the time: the hypothesis of Phlogiston, and the hypothesis of animal and vegetable life.[157] Wilson's citation of these hypotheses enhances his pro-hypothesis stance.

In 1781, Lyon further justified the use of hypotheses by referring to Newton's methodology. Lyon claims that

> 'though this was, and still is, my private opinion, I did not **build hypothesis upon it**, till I had first Consulted Sir Isaac Newton's *Principia*, and found myself authorized in reasoning from my experiment and observations; and from the analogy discovered between them and the different operations of nature; and that propositions collected from general induction from phænomena, were to be considered as nearly true, notwithstanding any contrary hypothesis that may be imagined, till such time as other phænomena occur, by which they may either be made more accurate, or liable to exception'.[158]

In this passage, Lyon claims that hypothesising is a process of reasoning from experiment and observation.[159] Thus, natural philosophers could compose hypotheses through reasoning so long as the hypotheses are based on experiments. Lyon then argues for a criterion of 'hypothesis' that is similar to falsifiability:

> 'that propositions collected from general induction from phænomena, were to be considered as nearly true, notwithstanding any contrary hypothesis that may be imagined, till such time as other phænomena occur, by which they may either be made more accurate, or liable to exception'.[160]

In other words, there would be phenomena that could falsify the current hypothesis. Indeed, being falsifiable by empirical evidence is the cornerstone of the contemporary definition of a hypothesis. Lyon's argument marks the contribution of an

[155] Wilson (1756) 83.
[156] Wilson (1756) 61.
[157] Wilson (1756) 63.
[158] Lyon (1781) 5, the bold and underlining are my own.
[159] Lyon (1781) 5.
[160] Lyon (1781) 5.

experimentalist to the formation of the contemporary hypothetical method. He indicates a standard for producing a hypothesis:

> (1) it can result from propositions 'collected from general induction';[161]
> (2) it remains true until counter empirical evidence appears, and
> (3) it can be revised to be 'more accurate, or liable to exception' by replying to the counter evidence.

In this way, hypotheses become different from 'philosophical speculation' or the untestable theories before and during the 1750s. Such a standard of hypothesis finds its counterpart in Fowler, who argues that the hypothesis in his treatise is composed (1) from the contradiction discovered in the current hypothesis, which caused 'the breach of equilibrium'; (2) from observing, and (3) from finding these phenomena in various situations to satisfy the need of universality.[162] The contradiction in step 1 represents the need for a new hypothesis to replace the problematic one. Step 2 refers to the empirical data needed to establish a new hypothesis, while step 3 refers to the findings proved by a wide range of experiments by various philosophers. In contrast to the new hypothesis, the old hypothesis loses its effect when it cannot explain certain phenomena: 'In the experiment now under consideration, it is absolutely impossible to give a rational account of the appearance of the electric fluid, in motion in the spiral tube, by Dr. Franklin's hypothesis'.[163] In this way, Lyon proves that Franklin's hypothesis of electric effluvia is false because it cannot provide a rational account for the observed facts.

Lyon further criticises Franklin's use of a hypothesis in a passage that we have previously discussed. Lyon argues that the Franklinian hypothesis

> 'is neither less nor more than a mixture of the Newtonian philosophy of attraction and repulsion, and of the Peripatetic; viz. Of occult qualities; of bodies acting upon other bodies, by some unknown property, through an impenetrable barrier'.[164]

Because Newtonian philosophy – which advocates deducing from experiments and observations – justifies Lyon's hypothetical method, Lyon's criticism of the Franklinian hypothesis about the interactions between different electrified bodies falls on the similarities between Franklin's hypothesis and Peripatetic philosophy, both of

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[161] Lyon (1781) 5.

[162] Fowler (1793) 31–32: '(1) The interval which commonly takes place between the contradictions; which interval, according to him [note: Dr. Valli], is necessary for the restoration of the breach of equilibrium. (2) From observing, that fishermen, in order to preserve their fish from putridity, crush their brains; and thus, by interrupting the medium between the external and internal surfaces of muscles, prevent these repeated discharges of the electrical fluid, which, according to Dr Valli, hastens their putridity. (3) From finding that in general, when the sciatic nerve on one side of a living frog was divided, the other being lest entire, communicating with the brain, both armed and equally excited, the limb, in which the nerve had been divided, preserved its power of contracting longer than the other. From this well devised experiment, he concludes, likewise, that animal electricity is the principle of life. That, on the side where the nerve remained entire, it was withdrawn from the muscles, and deposited in the brain. That, from the impossibility of this taking place on the other side, where the nerve was divided, it had continued in the limb, and enabled it to contract' (The note is my own.).

[163] Lyon (1781) 40–41.

[164] Lyon (1781) 14–15.

which believe that 'bodies [act] upon other bodies, by some unknown property'.[165] Referring to such an unknown property reflects the occult characteristic of Franklin's hypothesis. Lyon argues that such a theory has nothing to do with the Newtonian scientific method: '[T]he two systems of these matters will no more incorporate with each other than water and oil'.[166] Therefore, Lyon justifies the hypothetical method through a rational and pro-experimental approach, in contrast to the occult properties within Franklin's hypothesis.

In addition to the methodological refinement of hypotheses, there appears to be an increasing disassociation in the use of 'philosophy', or 'philosophical', and 'hypothesis'. The fundamental purpose of hypotheses in natural philosophy has remained constant: to explain the observed natural phenomena in nature or experiments. Nevertheless, the use of hypotheses is more frequently justified by experimental results – such as in the case of Lyon – rather than by pure philosophical speculation.

However, not every scientist agrees with such a disassociation. Brook reminds us that even though the experimental result could verify a hypothesis,[167] the essence of a hypothesis is still philosophical:

> 'It appears that many Gentlemen of the Royal Society were present with Mr. Nairne, when he shewed Mr. Smeaton the great difference between the two gages, &c. in April 1776, [see page 134] one of whom was the Hon. Mr. Cavendish, **whose great philosophical knowledge is well established.** He then recollecting some former observations, **readily suggested an hypothesis**, whereby to account for the difference between the two gages which he had just before seen. The substance of this hypothesis is given by Mr. Nairne in the Philosophical Transactions, but something different from the manner in which Mr. Smeaton gave it in his answer to my first letter to Dr. Watson, as will appear by and by'.[168]

According to Brook, the establishment of a hypothesis relies on philosophical knowledge, which would enable the natural philosopher to '[recollect] some former observations, [and] readily [suggest a] hypothesis' to explain the new phenomena that have occurred.[169]

Along with the popularity of the hypothetical method, scientists also reflected on the improper use of this method in writing experimental reports. A criticism of such misuses was found in Lyon's work in 1781. Lyon criticises natural philosophers for selecting evidence in favour of their pre-established hypotheses. Lyon claims:

> 'I will venture to say, that this single experiment[170] effectually overthrows the Franklinian doctrine of electric atmospheres, as well as the supposed laws of the directions of the star and the brush. If this experiment had been as much in

[165] Lyon (1781) 15.
[166] Lyon (1781) 15.
[167] Brook (1789) 174.
[168] Brook (1789) 157–58, the bold and underlining are my own; the note is original.
[169] Brook (1789) 157.
[170] Lyon's eighth experiment in this treatise.

> favour of their darling hypothesis, as it apparently makes against it, it would, without doubt, have been selected for the inspection of the public with an officious hand'.[171]

Lyon's message could be interpreted as follows:

> (1) the result of his eighth experiment overthrows or falsifies the Franklinian doctrine. This shows his process of hypothesis testing;
> (2) however, other philosophers do not recognise this result; they select evidence of experiments to compose experimental reports that favour the Franklinian doctrine;
> (3) Lyon criticises these philosophers for losing their impartiality and for providing selective evidence for public inspection.

The criticism here reflects the potential danger of scientific rhetoric. The truth of a hypothesis could be misinterpreted by reorganising evidence while writing experimental reports on electricity, even though the hypothesis might have been tested by experiment; it is a danger that the hypothetical method might face in the context of the rhetoric of science.

Lyon firmly objects to the provision of selective evidence when testing a hypothesis. He asks, '[are] we to trust to the evidence of our senses, or to a theory which contradicts it?'.[172] Lyon's answer advocates the importance of empirical facts in hypothesis testing:

> 'I am to give up the privilege of reasoning, and judging from what I see, hear, and feel, because it clashes with an hypothesis proposed in the infancy of this science, and since embraced and supported by almost every electrician,[173] because it is earlier treading in the steps of others, than tracing out a new path for ourselves'.[174]

In other words, Lyon gives priority to empirical facts perceived by our senses, instead of pure 'reasoning', which is equal to speculation. Lyon's answer enhanced the importance of empirical or experimental facts in testing a hypothesis.

4.2 The mention of 'hypothesis' for particular theories

This subsection presents another shift in the rhetoric of 'hypothesis': the increasing usage of the term 'hypothesis' to refer to specific scientific theories. It provides a brief overview of this trend.

The use of 'hypothesis' became popular in the 1770s. Henly used 'principle' to refer to Franklin's theory.[175] However, three years later, in *Experiments and Observations in Electricity* (which is not included in List 1 or 2), Henly started to use the term 'Franklin's hypothesis' to address Franklin's theory.[176] This reference to

[171] Lyon (1781) 25, the underlining is my own.
[172] Lyon (1781) 35.
[173] The 'electrician' here refers to the natural philosophers who worked on electricity at that time.
[174] Lyon (1781) 35.
[175] See Henly (1774) 14.
[176] See Henly (1777) 21, 24, 26–27, 61.

Franklin was inherited by Lyon, who stated that 'in the experiment now under consideration, it is absolutely impossible to give a rational account of the appearance of the electric fluid, in motion in the spiral tube, by Dr. Franklin's hypothesis'.[177]

Scientists later used the term 'hypothesis' to refer to a wide range of scientific theories. For example, Eliot used the term 'hypothesis' to refer to Newton's hypothesis in his 'Appendix of Light'.[178] Brook used 'hypothesis' to refer to Cavendish's theory of elastic vapour,[179] which Brook inherited from his citations of Nairne and Smeaton (who explained Cavendish's hypothesis and published it in the *Philosophical Transactions* on 19 December 1776). Fowler ascribed Valli's theory, which accounts for the presence of electricity in the movement of muscles, to 'Dr. Valli's hypothesis'.[180] During this period, people seemed not to take Newton's rejection of 'hypothesis' very seriously. Compared to thirty years ago – for example, in Wilson's work of 1752 – there were no reflective comments on the terminological use of 'hypothesis'. Instead, scientists paid more attention to examining the content of the hypotheses.

4.3 The re-emergence of hypotheses in scientific writing

To conclude this section, I will answer the research question of this paper: Why did the notion of 'hypothesis' shift from being severely condemned in the natural philosophical writings of the late seventeenth and early eighteenth centuries – and almost falling into a 'virtual eclipse' – to become a standard term for philosophers of science from the nineteenth century onwards? I propose the following reasons to explain the re-emergence of 'hypothesis' in late eighteenth-century works on electricity:

The first reason is the critical reflection on anti-hypotheticalism. As discussed in section 3, observations and experiments yielded data that exceeded the explanatory power of conventional theories used to account for these phenomena. Such a development leads to the need for new theories to explain the meaning of experimental or observational phenomena. The demand for theoretical systems weakened the anti-hypotheticalism that emphasised the attainment of organic knowledge from experiments rather than hypotheses. Furthermore, Hume's critique of the unreliability of inductive reasoning accelerated the acceptance of the hypothetical method among natural scientists during the mid-eighteenth century.

The natural philosophers working on electricity contributed another reason for the re-emergence of hypothetical methods, which is the need to explain experimental data. This reason is composed of three aspects:

(1) Following the decline of anti-hypotheticalism, hypothetical reasoning was introduced into scientific inquiries. Scientists distinguished two kinds of hypothesis: philosophical and mechanical. The natural philosophers working on electricity constructed their (mechanical) hypotheses by reasoning from the experimental results. This practice distinguishes their use of hypotheses from the conventional use of hypotheses based on philosophical knowledge and pure speculation. In other words,

[177] Lyon (1781) 40–41.
[178] Eliot (1788) 303, 306, 318.
[179] Brook (1789) 163, 166, 168, 171.
[180] Fowler (1793) 32, 41–42.

hypotheses that cannot be verified or falsified by experiments will be excluded from valid hypotheses or deemed 'non-scientific', which avoids the charge of being speculative. The interaction between hypotheses and experiment thus becomes more akin to each other.[181]

(2) A resurgence of deductive reasoning strengthened the prevalent belief among scientists in the field that the uniformity of nature exists. The uniformity of nature propelled natural philosophers working on electricity to create a comprehensive theory of electricity by synthesising and abstracting experimental data.

(3) Beyond documenting experimental data, scientists needed to convince the public with their discoveries through either a written form or public presentation.[182] Regardless of the chosen form, the challenge was to effectively present the research findings in a clear and convincing manner. Therefore, it was crucial for scientists to develop an effective communication strategy to engage readers or audiences who were not present during experiments. Put simply, hypotheses were employed as a means of persuasion in scientific communication, with persuasion being a fundamental component of scientific rhetoric.

5. Conclusion

This paper answers the question of why and how 'hypothesis' evolved from illusion and speculation into an important concept in contemporary philosophy of science. It accomplishes this task in three steps. First, it presents contemporary definitions of 'hypothesis' and explains two key characteristics of such a hypothesis: falsifiability and testability. A scientific hypothesis is an assumption that is made *a priori* to the experiments and could be falsified by the experimental results, while the hypothetical method is the method that uses hypotheses to explain the observed phenomena. Second, it articulates the history of 'hypothesis' before the late eighteenth century, with a particular focus on the development of anti-hypotheticalism in the late seventeenth century. Third, it explains, through an analysis of late eighteenth-century works on electricity, the shifts that took place when compared to the earlier use of 'hypothesis', and the reasons for such shifts.

The study shows that between the late seventeenth and the nineteenth centuries, the recognition of the hypothesis underwent significant changes, allowing it to not only be freed from the charge of being speculative, but also to adopt the experimentalist

[181] Von Wright articulates 'experiment' and 'hypothesis' as two distinctive scientific activities, termed 'descriptive' and 'theoretical' science respectively (1). The contrast between the two 'is usually characterized as causal versus teleological explanation' (2). However, Von Wright argues that 'there is nevertheless dialogue between the positions, and a kind of progress. The temporary dominance of one of the two trends is usually the result of a breakthrough following a period of criticism of the other trend. What emerges after the break-through is never merely a restoration of something which was there before, but also bears the impress of the ideas through whose criticism it has emerged. [...] The position which is in process of becoming superseded usually wastes its polemical energies on fighting already outmoded features in the opposed view, and tends to see what is retained in the emerging position as only a deformed shadow of its own self' (32–33). Although Von Wright's arguments target the controversy between the two activities in the early twentieth century, they are also applicable to explain the controversy between hypotheses and experiments encountered in this paper. Despite occasional hostility, the two activities engage in a continuous dialogue. This is also evident in the eighteenth-century works on electricity. See Von Wright (1971) 1, 2, 32–33.

[182] For the communication in written form, see Bazerman (1988) 69, 72–74, 78; for the one in public presentation, see Lyon (1781) 25.

rhetoric: hypotheses should only be framed by experimental data. Apart from the peculiarities of the study of electricity, such a change took place because of the resonance between the need to explain the experimental data collected, the problems of inductive reasoning, and the search for the uniformity of natural laws among natural philosophers working on electricity. All this contributed to a gradual shift in the use of hypotheses and brought the term 'hypothesis' into contemporary philosophy of science. The late eighteenth-century critique of the misuse of hypotheses in scientific experimentation also sheds light on contemporary reflections on the hypothetical method. Moreover, such an analysis contributes to the methodology of the historical study of science. The study of these practising natural philosophers working on electricity demonstrates that the methodological refinements made by practising scientists deserve more attention than they have received.

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Utrecht University
Simon Fraser University