

ΕΝ ΑΡΧΗ ΗΝ Ο ΛΟΓΟΣ: THE LONG JOURNEY OF GRAMMATICAL ANALOGY*

Grammar as a discipline devoted to the study of language was greatly advanced by the Alexandrian philologists,¹ and especially by Aristarchus, as demonstrated by Stephanos Matthaios.² In order to edit Homer and other literary authors, whose texts were often written in archaic Greek and presented many linguistic problems, the Alexandrians had to recognize linguistic grammatical categories and declensional patterns. In particular, to determine the correct orthography or accentuation of debated morphological forms they often employed analogy, which is generally defined as the doctrine that grammatical forms must follow strict rules of declension. Modern scholars have often opposed the Alexandrian doctrine of analogy to the Pergamene doctrine of ‘anomaly’, which favoured spoken usage to determine debated forms.³ Detlev Fehling and David

* This is a revised version of a paper I presented (in different versions and research stages) between 2006 and 2007 at the Radcliffe Institute, Harvard University, at New York University, at the Centre Louis Gernet (Paris), at Yale University and at *Greek from Alpha to Omega: A Birthday Symposium for Anna Morpurgo Davies*, Oxford University. I would like to thank the colleagues present in each of these occasions as well as the anonymous readers for *Classical Quarterly* for their helpful comments and criticism. Anna Morpurgo Davies enjoyed the talk when I presented it at the symposium in her honour. I do not know if she would still approve of it, but I dedicate this article to her memory: she was an inspirational figure and very enjoyable company when I was Junior Research Fellow at Somerville College from 2001 to 2004.

All translations are mine unless otherwise noted.

¹ For brief and clear surveys of grammar in antiquity, see D.J. Taylor, ‘Rethinking the history of language science in classical antiquity’, in D.J. Taylor (ed.), *The History of Linguistics in the Classical Period* (Amsterdam and Philadelphia, 1987), 1–16; A. Kemp, ‘The emergence of autonomous Greek grammar’ in P. Schmitter (ed.), *Geschichte der Sprachtheorie 2: Sprachtheorien der abendländischen Antike* (Tübingen, 2. verb. Aufl., 1996), 302–33; S. Matthaios, ‘Neue Perspektiven für die Historiographie der antiken Grammatik: Das Wortartensystem der Alexandriner’, in P. Swiggers and A. Wouters (edd.), *Grammatical Theory and Philosophy of Language in Antiquity* (Leuven, Paris and Sterlin, VA, 2002), 161–220; P. Swiggers and A. Wouters, ‘Description of the constituent elements of the (Greek) language’, in F. Montanari, S. Matthaios and A. Rengakos (edd.), *Brill’s Companion to Ancient Greek Scholarship* (Leiden and Boston, 2015), 759–97.

² S. Matthaios, *Untersuchungen zur Grammatik Aristarchs: Texte und Interpretation zur Wortartenlehre* (Göttingen, 1999).

³ E.g. H. Steinthal, *Geschichte der Sprachwissenschaft bei den Griechen und Römern mit besonderer Rücksicht auf die Logik*, 2 vols. (Berlin, 1890–1²), II 71–146, esp. 127–46; J. Collart, *grammairien latin* (Paris, 1954), 135–49; J. Collart, ‘Analogie et anomalie’, in C.O. Brink et al., *Varron: six exposés et discussions* (Vandoeuvres-Genève, 1963), 117–40; R. Pfeiffer, *History of Classical Scholarship. From the Beginnings to the End of Hellenistic Age* (Oxford, 1968), 203 (but see 245); E. Siebenborn, *Die Lehre von der Sprachrichtigkeit und ihren Kriterien. Studien zur antiken normativen Grammatik* (Amsterdam, 1976), 97–104; R.H. Robins, ‘Varro and the tactics of analogist grammarians’, in A. Morpurgo Davies and W. Meid (edd.), *Studies in Greek, Italic, and Indo-European Linguistics Offered to Leonard R. Palmer on the Occasion of his Seventieth Birthday, June 5, 1976* (Innsbruck, 1976), 333–6; M. Baratin and F. Desbordes,

Blank,⁴ however, have shown that this strong opposition never really existed and it is mostly due to Varro.⁵ More correctly, ancient grammarians identified inflectional rules as well as forms derived from spoken usage or otherwise aberrant forms—however, respect for spoken usage in the latter case was not labelled ‘anomaly’, which was never a technical term of ancient grammar.⁶ Rather, and especially in the Roman period, grammarians used the term ‘pathology’ to account for and explain irregular forms.⁷

Starting from these premises, in this paper I will analyse the concept of grammatical analogy in a broader context and look at it from a diachronic perspective, from the Hellenistic period to Herodian (second century C.E.). By showing that analogy greatly evolved from its Alexandrian beginnings to the Imperial period, I will argue that such a change is also connected to important developments within the aim and the status of the τέχνη γραμματική; to a certain extent, thus, the history of analogy is also, at least in part, the history of ancient grammar.

1. ARISTARCHUS’ ANALOGY

I will focus on Aristarchus’ use of analogy, as he is the Alexandrian grammarian for whom we have most fragments, preserved especially by the scholia to Homer.⁸ Aristarchus used various types of analogical procedures to find a particular grammatical form or to establish the correct accentuation or orthography of a word while working on his edition of Homer. The examples of analogical procedure employed by Aristarchus can be divided into three main groups: 1) two-term analogy; 2) four-term analogy; 3) six-term analogy. All three types are examples of ancient grammatical analogy, but there is a difference between the two-term analogy and multi-term (that is, four or more) analogy.

L’analyse linguistique dans l’antiquité classique, 1. Les théories (Paris, 1981), 43–6; W. Ax, ‘Sprache als Gegenstand der alexandrinischen und pergamenischen Philologie’, in P. Schmitter (ed.), *Geschichte der Sprachtheorie 2: Sprachtheorien der abendländischen Antike* (Tübingen, 2. verb. Aufl., 1996), 275–301, at 294.

⁴ D. Fehling, ‘Varro und die grammatische Lehre von der Analogie und der Flexion’, *Glotta* 35 (1956), 214–70; D.L. Blank, *Ancient Philosophy and Grammar: The Syntax of Apollonius Dyscolus* (Chico, CA, 1982), 1–5, 11–12, 24–8; D.L. Blank, ‘Analogy, anomaly and Apollonius Dyscolus’, in S. Everson (ed.), *Language* (Cambridge, 1994), 149–65, at 151–8; D.L. Blank, *Sextus Empiricus. Against the Grammarians (Adversus mathematicos I)* (Oxford, 1998), xxxiv–xl.

⁵ Yet, while D. Fehling (‘Varro und die grammatische Lehre von der Analogie und der Flexion. Schluß’, *Glotta* 36 [1957], 48–100, at 95–6 and 99), rather unconvincingly, concluded that the anomaly-analogy controversy was entirely Varro’s creation, Blank (n. 4 [1998], xxxvi–xl) suggests that the source for the anti-analogical arguments was an empiricist, either Epicurean or Sceptic.

⁶ See Fehling (n. 4), 267; Blank (n. 4 [1994]), 152–4; and Blank (n. 4 [1998]), 254. The term ‘anomaly’ occurs in a treatise by Chrysippus, Περὶ τῆς κατὰ τὰς λέξεις ἀνομοαλίας πρὸς Δίωνα (Diog. Laert. 7.192 = *SVF* II fr. 14), but indicates the ‘inconsistency’ that sometimes occurs between the signified and the signifier (Varro, *Ling.* 9.1 = *SVF* II fr. 151).

⁷ See Blank (n. 4 [1982]), 41–9 and J. Lallot, ‘Analogie et pathologie dans la grammaire Alexandrine’, *Lalies* 15 (1995), 109–23.

⁸ On Aristarchus’ methodology in his Homeric studies, see F. Schironi, *The Best of the Grammarians: Aristarchus of Samothrace on the Iliad* (Ann Arbor, 2018). Aristophanes of Byzantium, too, used analogy; see C.K. Callanan, *Die Sprachbeschreibung bei Aristophanes von Byzanz* (Göttingen, 1987), 107–22 and W. Ax, ‘Aristophanes von Byzanz als Analogist. Zu Fragment 374 Slater (= Varro, de lingua Latina 9, 12)’, *Glotta* 68 (1990), 4–18. On analogy in Aristophanes and Aristarchus, see also L. Pagani, ‘Language correctness (*Hellenismos*) and its criteria’, in F. Montanari, S. Matthaios and A. Rengakos (edd.), *Brill’s Companion to Ancient Greek Scholarship* (Leiden and Boston, 2015), 798–849, at 806–12.

The two-term analogy is the simplest, because it consists of a comparison between two similar forms in Homer. Faced with a linguistic or orthographic difficulty, Aristarchus supports a particular reading by recalling another form which is similar in terms of inflection, ending or accentuation, but is free from uncertainties. The scholia to Homer have plenty of examples for this kind of analogy, as in the following case (*Sch. Il.* 1.52 [Hrd.]):

θαμειαί: Πάμφιλος ‘θαμειά’ λέγει ὡς ‘ὄξεια’ (*Il.* 11.268; *Od.* 19.517), Ἀρίσταρχος δὲ ὡς ‘πυκιναί’ (*Il.* 4.281, 5.93 al.)· ὁμοίως δὲ καὶ τὸ ταρφειαί.

θαμειαί: Pamphilus says θαμειά like ὄξεια (*Il.* 11.268; *Od.* 19.517), Aristarchus instead [says θαμειαί] like πυκιναί (*Il.* 4.281, 5.93 al.). And in the same way [he says] also ταρφειαί.

In order to determine a debated accentuation (θαμειά or θαμειαί?), Aristarchus selects a comparable form (πυκιναί), and uses it as a model for the word at issue (θαμειαί). The principle underlying this procedure is that one can compare similar forms, using one to correct the other on the basis of common characteristics. I will call this type of analogy ‘weak’ or ‘broad’ analogy. This operation is based on a very common logical procedure, by which the human mind tries to understand phenomena by relating them to other similar but simpler or already known ones. This is the kind of procedure that Geoffrey Lloyd analyses in his book *Polarity and Analogy*:

I shall take ‘analogy’ in the broadest sense, to refer not merely to proportional analogy (A : B :: C : D) but to any mode of reasoning in which one object or complex of objects is likened or assimilated to another.⁹

Indeed, this ‘broad’ or ‘weak’ meaning is the one most commonly used today, as we generally understand analogy a sort of ‘similarity’ or ‘likeness’, not only in grammar but also in many other fields. For example, the phrase ‘There is an analogy between phenomenon A and phenomenon B’ means that phenomena A and B share some common features that make them somehow similar.

However, Aristarchus employed a further development of this procedure, the four-term analogy. This type of analogy is more complicated and compares two different forms of the same word (A1 and A2) with two different forms of another word (B1 and B2) in the following way: the words A and B are comparable and the relationship between A1 and A2 (in terms of inflection or of derivation) is the same as the relationship between B1 and B2. Thus, a correlation is built, A1 : A2 = B1 : B2, where A2 is a form whose relationship to A1 is the same as the relationship of B2 to B1. For example (*Sch. Il.* 19.97a [Ariston.]):

{ἦρη} θῆλυσ: ὅτι οὕτως σχηματίζει θῆλυσ ὡς πῆχυσ· ἄρ’ οὐ πίπτει ‘θήλεας’ (*Il.* 5.269) ὡς πήχεας.

θῆλυσ: because he [*sc.* Homer] forms θῆλυσ like πῆχυσ, from which θήλεας (*Il.* 5.269) is declined like πήχεας.¹⁰

⁹ G.E.R. Lloyd, *Polarity and Analogy: Two Types of Argumentation in Early Greek Thought* (Cambridge, 1966), 175.

¹⁰ Cf. Matthaios (n. 2), 288–9, 409.

1. Problem: accent of ΘΗΛΥΣ
2. Premises: θήλεας = πήχεας
3. Proportion: πήχεας : πήχυς = θήλεας : x
4. Solution: x = θήλυς

While there are several examples of four-term analogy in the scholia derived from Aristarchus, there are also some examples of an even more complex form of analogy, which can be called ‘six-term analogy’. In this type of analogy, there are three terms in the proportion, $A1 : A2 : A3 = B1 : B2 : B3$, as in the following example (*Sch. Il.* 1.86 [Ariston.]):

Κάλχαν: ὅτι Ζηνόδοτος χωρὶς τοῦ ν, ‘Κάλχα’. τὰ δὲ εἰς ας λήγοντα, διὰ τοῦ ντ κλινόμενα ἐπὶ τῆς γενικῆς, ἔχει τὴν κλητικὴν εἰς ν, ‘Θόαν’ (*Il.* 13.222, 228), ‘Αἶαν’ (*Il.* 7.234 al.).

Κάλχαν: because Zenodotus [writes] *Κάλχα* without ν. But the nouns ending with -ας and inflecting in -ντ- at the genitive have the vocative in -ν: Θόαν (*Il.* 13.222, 228), Αἶαν (*Il.* 7.234 al.).

1. Problem: vocative of *Κάλχας*: *Κάλχα* or *Κάλχαν*?
2. Premises: *Κάλχας* = Θόας = Αἶας
3. Proportion: Θόας : Θόαντος : Θόαν = Αἶας : Αἶαντος : Αἶαν = *Κάλχας* : *Κάλχαντος* : x
4. Solution: x = *Κάλχαν*

Needless to say, a six-term proportion could be also seen as two four-term proportions combined together (for example $A1 : A2 = B1 : B2$ and $A2 : A3 = B2 : B3$). However, I prefer to consider it as a separate group, not only because it shows a more complex approach to declensional patterns but also because, unlike the four-term analogy, Aristarchus uses it only for nouns (especially proper nouns) and never for verbs.¹¹ In fact, this characteristic of Aristarchus’ six-term proportions will also be useful for a comparison with Varro’s use of analogies (at § 5).

Four-term and six-term analogies imply a rather complex procedure. When facing a doubtful inflected form of a word, Aristarchus selects a comparable word (that is, same part of speech, same number of letters, same gender, same ending, etc.), whose paradigm is known; by comparing the two words and their corresponding inflected forms and by applying the inflected form(s) of the word used as model to the uncertain one, Aristarchus finds a solution for the form at issue. Unlike the two-term analogy, the four-term or six-term analogies require some criteria for comparison of two different words as well as some notions about inflexion. This method is based on the idea that

¹¹ See Schironi (n. 8), 394–7.

language is rational—meaning that, if a certain inflectional pattern is found for one form, the same pattern applies to all the other words similar to that form.

These examples in the Homeric scholia¹² clearly indicate that Aristarchus used not only simple comparisons of two terms but also more complex analogical proportions involving at least four terms.¹³ The ‘weak’ two-term analogy can be simply understood as a comparison with heuristic goals. This type of procedure is extensively used in Greek philosophy and early science, from the pre-Socratic philosophers to the early Hippocratic writers, who often used ‘analogies’ with known phenomena to explain unknown or hidden phenomena,¹⁴ such as the detailed comparison between the plant in the earth and the development of the foetus in its mother’s womb in *On the Nature of Child* xxii–xxvii. Otto Regenbogen called this method ‘Beweisanalogie’, that is, a comparison whose aim is not simply clarification but indeed also proving something by induction.¹⁵ This is certainly the starting point for the development of analogy in grammar. However, the more complex types of analogy (the four-term and the six-term analogy) used by Aristarchus and his colleagues require a further step, as these analogies insist on the logical relationships between at least four terms. The different standpoint is also shown by the shape that this more complex form of analogy takes, namely that of a proportion.

In fact, one could even read the two-term analogy as a case of a four- (or more) term analogy, where part of the proportion is simply omitted. For example, in the case of *Sch. Il. 1.52* quoted above, the two-term proportion $\pi\upsilon\kappa\iota\nu\alpha\acute{\iota} = \theta\alpha\mu\epsilon\iota\alpha\acute{\iota}$ could be imagined as $\pi\upsilon\kappa\iota\nu\alpha\acute{\iota} (: \pi\upsilon\kappa\iota\nu\acute{\alpha}\zeta) = \theta\alpha\mu\epsilon\iota\alpha\acute{\iota} (: \theta\alpha\mu\epsilon\iota\acute{\alpha}\zeta)$. In other words, even in the case of the two-term analogy, Aristarchus must have been aware of some common characteristics that made the two forms comparable, though he was not necessarily interested in explicitly pointing out an inflectional pattern based on a similarity of relation. On the contrary, in the four- (or more) term analogy the idea that different inflected forms were linked by certain relationships was clearly conveyed. For this reason, the four- (or more) term analogy was the more important of the two for the development of the τέχνη γραμματική, because it clearly and visually displayed the concept of morphological patterns and of inflection.

Even if the more complex proportions are comparable to what modern linguists now call ‘analogical proportion’, there are a few, important differences. Indeed, though the method is the same, the background or, better, the perspective of Aristarchus was profoundly different from that of modern linguists. The fundamental difference is that, unlike a modern grammarian, Aristarchus was not concerned with inflectional paradigms *per se*. His focus was philology, and his scope was to determine *which* form a word should have in his edition of Homer—and not *why* it had it. He was even less interested, in fact, in

¹² The last two scholia discussed derive from Aristonicus, who is generally considered to preserve Aristarchus’ notes from the commentary. Thus, even if Aristarchus is not expressly quoted in those scholia, the scholarly consensus is that they preserve Aristarchean views.

¹³ Pace Siebenborn (n. 3), 71, according to whom Aristarchus was generally concerned with simple comparisons (i.e. two-term analogies) and used them mostly to discuss questions of prosody and not to determine inflectional patterns. Cf. also Matthaios (n. 2), 28–30.

¹⁴ The seminal studies on this regard are O. Regenbogen, ‘Eine Forschungsmethode antiker Wissenschaft’, in F. Dirlmeier (ed.), *Kleine Schriften* (München, 1961), 141–94, originally published in *Quellen und Studien zur Geschichte der Mathematik 1.2* (Berlin, 1930), 131–82, and Lloyd (n. 9).

¹⁵ Cf. Regenbogen (n. 14), 150–6 and 168 (‘Beweisanalogie’).

using the results from his proportions to elaborate general rules of inflection. This point leads to the second main difference between Hellenistic analogy and modern analogy. In modern historical linguistics, analogy is generally defined as a linguistic process that models word forms perceived as irregular on the basis of more regular forms.¹⁶ In other words, modern linguists see analogy from the point of view of the speaker, as a way to explain how a form developed historically, since analogy is seen as a process by which speakers adapt difficult words to regular inflectional patterns. Aristarchus, on the other hand, approached analogical proportions strictly as a tool for figuring out a difficult form—not as an operation with which speakers of a language naturally engaged.

2. MATHEMATICAL ANALOGY

Since the word ‘analogy’ is still used in modern languages, and in particular in the field of grammar and linguistics, it seems obvious to assume that Hellenistic analogy is the direct predecessor of modern analogy. This is to some extent true, but I argue that Hellenistic analogy is something more—or rather something more specific—than a simple comparison. This becomes clear when looking at the original meaning of *ἀναλογία*. In the fifth and the fourth centuries B.C.E. this word was used to indicate a very precise operation—the mathematical proportion—and was not simply a synonym or quasi-synonym for ‘similarity’ or ‘likeness in shape’. The word is first attested in Archytas of Tarentum (c.435/10–360/50 B.C.E.),¹⁷ who defines the three types of mathematical proportions or means (fr. 2 Huffman, ex Porph. in *Ptol. Harm.* 1.5):¹⁸ the arithmetic mean ($A - B = B - C$), the geometric mean ($A : B = B : C$) and the harmonic mean: ($[A - B] : A = [B - C] : C$). Even though Archytas calls all these means *ἀναλογίαι*, the term *ἀναλογία* was generally intended as ‘sameness of ratios’ and thus particularly suitable for defining the geometric analogy of the type $A : B = B : C$, which Archytas defines as follows: ‘the first term has the same ratio to the second term as the second term has to the third’. Indeed, the geometric mean was later regarded by Pappus as the only ‘real’ *ἀναλογία* (*Syn.* 3.30, p. 70.27–8 Hultsch: γεωμετρική δὲ λέγεται μεσότης, τουτέστιν ἀναλογία κυρίως).

The theory of proportion—and, in particular, the geometric proportion or *ἀναλογία*—was very well known in Greece: Plato, Aristotle and, in general, the pre-Euclidean mathematicians all used it. From Aristotle, moreover, we know that around the fourth century all the theories about means and proportions were unified and a new theory of proportion was developed and proved generally valid (Arist. *An. post.* 74a23: νῦν δὲ καθόλου δείκνυται). Aristotle’s statement is further clarified by an anonymous scholium to Euclid (*Sch. Eucl. El.* 5.1.1–9):

σκοπὸς τῷ πέμπτῳ βιβλίῳ περὶ ἀναλογιῶν διαλαβεῖν· κοινὸν γὰρ τοῦτο τὸ βιβλίον γεωμετρίας τε καὶ ἀριθμητικῆς καὶ μουσικῆς καὶ πάσης ἀπλῶς τῆς μαθηματικῆς

¹⁶ Cf. *OED* s.v. ‘analogy’ (8). On analogy and analogical change, see H. Hock, *Principles of Historical Linguistics* (New York, 1991²), 166–209 and L. Campbell, *Historical Linguistics: An Introduction* (Edinburgh, 2013³), 91–105.

¹⁷ Cf. J. Ritter, *Historisches Wörterbuch der Philosophie* (Basel, 1971–2007), Band 1, s.v. *Analogie*, 214–29, at 214–15.

¹⁸ On this fragment, see C.A. Huffman, *Archytas of Tarentum: Pythagorean, Philosopher, and Mathematician King* (Cambridge and New York, 2005), 166–81.

ἐπιστήμης, τὰ γὰρ ἐν αὐτῷ ἀποδεικνύμενα οὐ μόνον γεωμετρικοῖς ἀρμόζει θεωρήμασιν, ἀλλὰ καὶ πᾶσι τοῖς ὑπὸ μαθηματικῆν τεταγμένοις, ὡς προεῖρηται, ἐπιστήμην. ὁ μὲν οὖν σκοπὸς οὗτος, τὸ δὲ βιβλίον Εὐδόξου τινὲς εὗρεσιν εἶναι λέγουσι τοῦ Πλάτωνος διδασκάλου.

The aim of the fifth book is to distinguish about proportions. This book is valid for geometry, arithmetic, music and simply for every mathematical science, because what is demonstrated here applies not only to geometric theorems but also to all those theorems depending, as said, on the mathematical science. This is the aim, and some say that this book is the discovery of Eudoxus, the teacher [*sic; leg.* ‘pupil’] of Plato.

According to the scholiast, the fifth book of Euclid, dedicated to the standard systematization of the theory of proportion, was based on the work of Plato’s pupil and great mathematician Eudoxus in the first half of the fourth century B.C.E. Eudoxus added other means (the fourth, the fifth and the sixth means) and, more importantly, developed a general theory of proportion, which was equally applicable to geometry, arithmetic, music and all the mathematical sciences.¹⁹

Despite our almost complete lack of knowledge about his life,²⁰ we can say with some certainty that Euclid lived in the first half of the third century B.C.E. In his *Elements* comprising thirteen books, he systematized Greek mathematics. In particular, in Book 5, where he expounds Eudoxus’ new theory of proportion,²¹ Euclid gives this definition of ratio (*El.* Book 5, def. 3):

λόγος ἐστὶ δύο μεγεθῶν ὁμογενῶν ἢ κατὰ πηλικότητά ποια σχέσις.

A ratio is a sort of relation in respect of size between two magnitudes of the same kind.²²

If two sets of magnitudes of the same kind have the same ratio, they are proportional (*El.* Book 5, def. 6).²³ Four-term proportions are defined twice by Euclid, once in Book 5, where he discusses the geometric proportion (Book 5, def. 5), and once in Book 7, where he deals specifically with the arithmetic proportion (Book 7, def. 20).²⁴ A discussion of the relationship between these two different Euclidean definitions of proportion and of their mathematical implications is beyond the scope of the present work.²⁵ For grammatical analogy the important points are:

1. Ἀναλογία in Greek meant ‘mathematical proportion’, which was a relation between magnitudes having the same ratio. The word was applied by Archytas to all the

¹⁹ Cf. Th.L. Heath, *A History of Greek Mathematics*, 2 vols. (Oxford, 1921), 1.322–34, esp. 1.325–7 (on Eudoxus’ theory of proportion).

²⁰ On Euclid’s biography, see Heath (n. 19), 1.354–7; Th.L. Heath, *The Thirteen Books of Euclid’s Elements, Translated from the Text of Heiberg, with Introduction and Commentary*, 3 vols. (Oxford, 1926²), 1.1–6; B. Vitrac, ‘Euclide’, in R. Goulet (ed.), *Dictionnaire des philosophes antiques*, vol. 3 (Paris, 2000), 252–5.

²¹ On Eudoxus and the fifth book of the *Elements*, see F. Acerbi, ‘Drowning by multiples. Remarks on the fifth book of Euclid’s *Elements* with special emphasis on Prop. 8’, *Archive for History of Exact Sciences* 57 (2003), 175–242, at 220–37 (esp. 227–37).

²² Transl. Heath (n. 20), 2.114. Cf. Heath (n. 20), 2.116–19.

²³ Cf. also Heron, *Def.* 136.31, p. 134.12–13 Heiberg: ἀναλογία ἐστὶν ἢ τῶν λόγων ὁμοιότης.

²⁴ On these definitions of analogy, cf. Heath (n. 20), 2.120–9, 2.292–3.

²⁵ This is one of the most debated problems in the *Elements*. On this question, see B. Vitrac, *Euclide d’Alexandrie, Les Éléments. Traduction et commentaires. Vol. 2. Livres V–VI: proportions et similitude, Livres VII–IX: arithmétique* (Paris, 1994), 507–38.

- three means (arithmetic, geometric and harmonic), but *ἀναλογία* was specifically used for geometric proportions of the type $A : B = C : D$.
2. In the fourth century B.C.E., Eudoxus probably formulated and extended the theory of proportion to any type of magnitudes (numbers, lines, solids, time). This allowed one to see in the theory of proportion a unifying and comprehensive theory that could be extended to any scientific field.
 3. The concept of proportion was reformulated and systematized during the Hellenistic period, especially by Euclid in the third century B.C.E.
 4. In Euclid's words, proportional ratios were possible only among 'homogeneous' magnitudes.

The fourth and the third centuries B.C.E. thus are those during which the theory of *ἀναλογία* was most thoroughly developed. This also means that to any native Greek speaker (or at least to any educated one), and especially to those living in the Hellenistic period, the word *ἀναλογία* was closely associated with mathematical reasoning. It is now worth asking ourselves why the Greek grammarians chose this mathematical tool and why they used it in their discipline.²⁶

3. ANALOGY IN OTHER FIELDS: PLATO AND ARISTOTLE

Geometric proportions were applied outside the realm of pure mathematics even before Aristarchus. In particular, both Plato and Aristotle used them as a sort of explicatory or even heuristic method in many different fields. Even though neither of them was a pure mathematician, their interest in mathematics might have encouraged them to apply this heuristic mathematical tool to other areas. Moreover, the theory of proportion was at the centre of mathematical speculation at the time. Many of the examples in Plato and Aristotle are simply based on the idea of similarity between two objects or two phenomena, and thus are closer to what I called 'weak' analogy, as in the several cases analysed by Otto Regenbogen and by Geoffrey Lloyd.²⁷ Nevertheless, in both Plato and Aristotle there are also a few more complex cases, which go well beyond a pure comparison and, in fact, are much closer to the 'real' geometric analogy.

Plato uses proportion in a famous passage of the *Gorgias* (464b2–465d6) to distinguish between a real science (*τέχνη*) and an empirical—hence uncertain—knowledge (*ἐμπειρία*). With reference to the body and the soul as well as to curative and prophylactic aims, Socrates builds a whole series of four-term proportions (Pl. *Grg.* 465b6–c3):

ἴν' οὖν μὴ μακρολογῶ, ἐθέλω σοι εἰπεῖν ὥσπερ οἱ γεωμέτραι—ἤδη γὰρ ἂν ἴσως ἀκολουθήσῃς—ὅτι ὁ κομμωτικὴ πρὸς γυμναστικὴν, τοῦτο σοφιστικὴ πρὸς νομοθετικὴν, καὶ ὅτι ὁ ὀσποικὴ πρὸς ἰατρικὴν, τοῦτο ῥητορικὴ πρὸς δικαιοσύνην.

[Socrates:] To avoid prolixity, I want to speak to you like the geometers—for now you should follow me: as embellishment is to gymnastic, so is sophistry to legislation; and as cookery is to medicine, so is rhetoric to justice.

²⁶ The link between mathematics and grammatical analogy was already hinted at by Siebenborn (n. 3), 56–62. I will now develop this idea further and examine it diachronically.

²⁷ On analogy in Plato and Aristotle, see Lloyd (n. 9), 360–80, 389–414. 'Weak' analogy occurs also in the Hellenistic period: the empirical school of medicine used the *μετάβασις κατ' ἀναλογίαν*, 'analogical transition', to understand and cure hitherto unknown diseases by equating them to similar (and known) conditions; cf. K. Deichgräber, *Die griechische Empirikerschule, Sammlung der Fragmente und Darstellung der Lehre* (Berlin, 1930), 48.9–10 (fr. 10b).

The proportion (γυμναστική : κομμωτική = νομοθετική : σοφιστική = ιατρική : ὄψοποιική = δικαιοσύνη : ῥητορική) is placed at the end of Socrates' explanation in order to clarify a set of relationships that is not immediately obvious. Furthermore, Socrates explicitly says here that he is borrowing this method from the 'geometers'. Plato uses mathematical proportions elsewhere—for example in the famous image of the divided line used by Socrates in the *Republic* (509d–511e) to explain the relationship between 'intuition' (νόησις) and 'reasoning' (διάνοια), which pertain to the intelligible world, and 'belief' (πίστις) and 'conjecture' (εἰκασία), which pertain to the visible world. This line is indeed divided according to a proportion (νόησις : διάνοια = πίστις : εἰκασία), as Socrates clearly explains at the end (511e2: καὶ τάξον αὐτὰ ἀνά λόγον).²⁸ Another example is in the *Timaeus*, when Plato uses a proportion to clarify the relationship between the elements (32b5–7: πῦρ : ἀήρ = ἀήρ : ὕδωρ and ἀήρ : ὕδωρ = ὕδωρ : γῆ).

Aristotle, too, often used analogy to clarify other aspects of human knowledge.²⁹ In the *Nicomachean Ethics*, when he analyses distributive and corrective justice (1131a10–1132b20), he explicitly acknowledges his use of mathematical proportions (1131b12–13: καλοῦσι δὲ τὴν τοιαύτην ἀναλογίαν γεωμετρικὴν οἱ μαθηματικοί). Defining analogy as an equality of ratios (1131a31: ἡ γὰρ ἀναλογία ἰσότης ἐστὶ λόγων),³⁰ Aristotle explains that there are two kinds of geometric proportion: the continuous proportion (ἡ συνεχῆς ἀναλογία), where the middle is repeated ($A : B = B : C$), and the discrete or divided proportion (ἡ διηρημένη ἀναλογία), where all four terms are different ($A : B = C : D$). In particular, distributive justice is a divided geometric proportion ($A : B = C : D$), since the distribution happens according to merit (1131b4–9). Given two persons, A and B, their respective shares will be A1 and B1, according to the following geometric proportions: $A : B = A1 : B1$ and $A : A1 = B : B1$.³¹

While analogical reasoning and 'weak' analogies are extremely common and widespread in Aristotle's biological works, in the *Historia Animalium* (486b17–21) a series of proportions illustrate similar anatomical parts in different animals ([man:] bone = [fish :] spine; [man :] nail = [horse :] hoof; [man :] hand = [crab :] claw; bird :

²⁸ The questions of how the line is divided and oriented, as well as what the ratio between the members of the proportion is, are still debated; see, for example, N.D. Smith, 'Plato's divided line', *AncPhil* 16 (1996), 25–46.

²⁹ See Arist. *Top.* 1.17 (108a7–17). On Aristotle and analogy, see B. Einarson, 'On certain mathematical terms in Aristotle's logic', *AJPh* 57 (1936), 33–54 and 151–72; M. Hesse, 'Aristotle's logic of analogy', *PhilosQ* 15 (1965), 328–40; T.M. Olshewsky, 'Aristotle's use of analogia', *Apeiron* 2 (1968), 1–10. In particular, Hesse (this note), 333 distinguished between 'substantive analogy' (= possession of common properties) and 'formal analogy' (= similarity of relation). On this distinction, see E. Nagel, *The Structure of Science: Problems in the Logic of Scientific Explanation* (New York, 1961), 110–11. On the value of mathematical models for Aristotle, see F. Acerbi, 'Osservazioni sulle origini aritmetiche della teoria aristotelica del sillogismo', in M. Alessandrelli and M. Nasti de Vincentis (edd.), *La logica nel pensiero antico. Atti del colloquio, Roma, 28–29 novembre 2000* (Naples, 2009), 77–104.

³⁰ On Aristotle's definition, see Huffman (n. 18), 180.

³¹ Corrective justice, on the other hand, is an arithmetic proportion (i.e. progression) of the type: $A - B = B - C$. On this passage, see F. Dirlmeier, *Aristoteles, Nikomachische Ethik* (Berlin, 1999), 100–5; D. Keyt, 'Aristotle's theory of distributive justice', in D. Keyt and F.D. Miller, Jr. (edd.), *A Companion to Aristotle's Politics* (Oxford and Cambridge, MA, 1991), 238–78, at 240–2; C.M. Young, 'Aristotle's justice', in R. Kraut (ed.), *The Blackwell Guide to Aristotle's Nicomachean Ethics* (Malden, MA and Oxford, 2006), 179–97, at 184–6. A similar 'proportional' concept of justice is to be found again in Aristotle (*Pol.* 1301b29–1302a8) as well as in Plato (*Leg.* 744b1–c4 and 757a5–758a2; *Grg.* 507e5–508b3).

feather = fish : scale).³² More interestingly for our purposes, the *Poetics* provides an example of an analogical procedure applied to the study of literary texts. This is the closest parallel to Aristarchus' application of analogy, though the goals are different, since Aristotle applies analogy to literary criticism and not to grammatical categories. According to Aristotle, in a 'metaphor by analogy' the poet sees the same sort of relationship between two pairs of objects and inverts the terms of the proportion (*Poet.* 1457b16–25):³³

τὸ δὲ ἀνάλογον λέγω, ὅταν ὁμοίως ἔχη τὸ δεύτερον πρὸς τὸ πρῶτον καὶ τὸ τέταρτον πρὸς τὸ τρίτον· ἐρεῖ γὰρ ἀντὶ τοῦ δευτέρου τὸ τέταρτον ἢ ἀντὶ τοῦ τετάρτου τὸ δεύτερον. ... λέγω δὲ οἷον ὁμοίως ἔχει φιάλη πρὸς Διόνυσον καὶ ἀσπίς πρὸς Ἄρη· ἐρεῖ τοίνυν τὴν φιάλην ἀσπίδα Διονύσου καὶ τὴν ἀσπίδα φιάλην Ἄρεως. ἢ ὁ γῆρας πρὸς βίον, καὶ ἐσπέρα πρὸς ἡμέραν· ἐρεῖ τοίνυν τὴν ἐσπέραν γῆρας ἡμέρας ἢ ὡσπερ Ἐμπεδοκλῆς, καὶ τὸ γῆρας ἐσπέραν βίου ἢ δυσμάς βίου.

By analogy I mean when the second is to the first and the fourth is to the third; for [the poet] will say the fourth instead of the second, or the second instead of the fourth. ... I mean, for example, that the wine-bowl is to Dionysus as the shield is to Ares; so [the poet] will call the wine-bowl 'shield of Dionysus' and the shield 'wine-bowl of Ares'. Or, as old age is to life, so the evening is to the day; so [the poet] will call the evening 'old age of the day', as Empedocles does, and old age 'the evening of life' or 'the sunset of life'.

The explicit mathematical framework is recalled only in the passage from the *Nicomachean Ethics*. Nevertheless, in the *Poetics*, too, though the context is somehow looser, Aristotle expresses the idea through a mathematical proportion, and its phrasing (ὅταν ὁμοίως ἔχη τὸ δεύτερον πρὸς τὸ πρῶτον καὶ τὸ τέταρτον πρὸς τὸ τρίτον) recalls Archytas' words (fr. 2: ἀ γεωμετρικὰ δέ, ὅκκα ἔωντι οἶος ὁ πρῶτος ποτὶ τὸν δεύτερον, καὶ ὁ δεύτερος ποτὶ τὸν τρίτον) as well as those of Euclid (*El.* Book 5, def. 5: ἐν τῷ αὐτῷ λόγῳ μεγέθη λέγεται εἶναι πρῶτον πρὸς δεύτερον καὶ τρίτον πρὸς τέταρτον, ὅταν ...).

4. ANALOGY IN ALEXANDRIA: ERATOSTHENES, ARISTOPHANES AND ARISTARCHUS

The development of a general theory of proportion in mathematics as well as the application of proportion to other fields by Plato and Aristotle suggest that in the early Hellenistic period analogy was a method that, though primarily mathematical, had already been successfully applied to other disciplines. Proclus gives us interesting

³² Arist. *Hist. an.* 486b17–21 ἔνια δὲ τῶν ζῴων οὔτε εἶδει τὰ μόρια ταῦτά ἔχει οὔτε καθ' ὑπεροχὴν καὶ ἔλλειψιν, ἀλλὰ κατ' ἀναλογίαν, οἷον πέπονθεν ὀστοῦν πρὸς ἄκανθαν καὶ ὄνυξ πρὸς ὄπλην καὶ χεὶρ πρὸς χηλὴν καὶ πτερὸν λεπίς. ὁ γὰρ ἐν ὄρνιθι πτερὸν, τοῦτο ἐν τῷ ἰχθύϊ ἐστὶ λεπίς ('some animals have parts which are not the same in form, nor by excess or by defect: but they [are identical] by analogy; for example, bone has the same [analogical] relationship to spine, nail to hoof, hand to claw, and scale to feather; for what the feather is in a bird, the scale is in a fish'). For a discussion on analogies in Aristotle's biological works, see M. Wilson, 'Analogy in Aristotle's biology', *AncPhil* 17 (1997), 335–58.

³³ As R. Janko, *Aristotle Poetics I, with The Tractatus Coislinianus, A Hypothetical Reconstruction of Poetics II, The Fragments of the On Poets* (Indianapolis and Cambridge, 1987), 130 says: 'It corresponds to "metaphor" in our sense, and depends on discerning likenesses between pairs of things.'

clues on how Eratosthenes of Cyrene (c.275–194 B.C.E.), the third librarian of Alexandria, considered analogy (Procl. in *Eucl. Prolog. I*, p. 43.22 Friedlein):

καὶ μὴν καὶ τὸν σύνδεσμον τῶν μαθημάτων οὐ τὴν ἀναλογίαν, ὡσπερ Ἐρατοσθένης οἶεται, θετέον. ἢ γὰρ ἀναλογία τῶν κοινῶν τοῖς μαθήμασιν ἐν τι καὶ λέγεται εἶναι καὶ ἔστιν. πολλὰ δ' αὐτὸ καὶ ἄλλα διήκει διὰ πάντων ὡς εἰπεῖν τὰ καθ' αὐτὰ ὑπάρχοντα τῇ κοινῇ φύσει τῶν μαθημάτων.

As what unifies sciences, we should not suppose it to be proportion as Eratosthenes believes. For proportion is said to be, and is, one of the features common to all sciences. But there are many other characteristics that are all-pervading, so to speak, and intrinsic to the common nature of sciences.

Even though Proclus disagrees, Eratosthenes maintained that ἀναλογία was the one bond of all the μαθήματα. Being a polymath (geographer, mathematician, grammarian), Eratosthenes might have found that the principle of proportion could be successfully applied to several and disparate fields with good results. This was consistent with Eudoxus' 'new' theory of proportion, which must have been popular at Alexandria. Since the word μάθημα normally indicates mathematical sciences, in this specific context Eratosthenes most likely referred to arithmetic, geometry, stereometry, astronomy and music only.³⁴ Yet, we can perhaps speculate that already Eratosthenes had applied analogy as a heuristic tool in his philological studies, which he must have regarded as part of his scientific interests rather than as a sort of humanistic *otium* to counterbalance his main activities as mathematician and geographer.³⁵ When dealing with grammatical questions (he wrote a treatise called Γραμματικά), Eratosthenes might have used proportions to find out inflections and the correct orthography of debated words. If so, he could have also included grammar and philology in the μαθήματα for which analogy was useful.³⁶

A much clearer link between grammar and analogy at Alexandria as well as a hint at the mathematical origin of analogy are present in the definition of the six parts of grammar (that is, philology) by Dionysius Thrax, a pupil of Aristarchus (Dion. Thrax 1.1–6):³⁷

γραμματική ἐστὶν ἐμπειρία τῶν παρὰ ποιηταῖς τε καὶ συγγραφεῦσιν ὡς ἐπὶ τὸ πολλὸν λεγομένων. μέρη δὲ αὐτῆς ἐστὶν ἕξ: πρῶτον ἀνάγνωσις ἐντριβὴς κατὰ προσῳδίαν, δεύτερον ἐξήγησις κατὰ τοὺς ἐνυπάρχοντας ποιητικοὺς τρόπους, τρίτον γλωσσῶν τε καὶ ἱστοριῶν πρόχειρος ἀπόδοσις, τέταρτον ἐτυμολογίας εὔρεσις, πέμπτον ἀναλογίας ἐκλογισμός, ἕκτον κρίσις ποιημάτων, ὃ δὴ κάλλιστόν ἐστι πάντων τῶν ἐν τῇ τέχνῃ.

Grammar is experience of what is for the most part said by poets and writers. Its parts are six. First, practised reading aloud according to prosody; second, interpretation according to the poetic tropes present [in the text]; third, straightforward explanation of rare words (γλωσσῶν) and matters of fact (ἱστορία); fourth, discovery of etymology; fifth, calculation of analogy;

³⁴ So K. Geus, *Eratosthenes von Kyrene: Studien zur hellenistischen Kultur- und Wissenschaftsgeschichte* (Munich, 2002), 149–51, 164–5.

³⁵ Indeed, Eratosthenes is the first to claim to be a φιλόλογος (Suet. *Gram. et rhet.* 10). See Pfeiffer (n. 3), 158–9.

³⁶ In fact, μάθημα is sometimes used with the more generic meaning of 'knowledge' (Ar. *Nub.* 1231, Av. 380, Thuc. 2.39.1) and of 'science' in the broadest sense (Pl. *La.* 182b6–7; Isoc. *Panath.* 27).

³⁷ It is debated whether the Τέχνη Γραμματική, attributed to Dionysius Thrax, is authentic; see Taylor (n. 1), 8–11; Kemp (n. 1), esp. 307–15; V. Law and I. Sluiter, *Dionysius Thrax and the Technē Grammatikē* (Münster, 1995). However, this first paragraph certainly is, as Sextus Empiricus quotes it almost verbatim and attributes it to him (*Math.* I § 57 and § 250).

sixth, judgement of poems, which is the finest part of all those [contained] in the art [of grammar].

Analogy is the fifth part of grammar, and Aristarchus' work, where analogy played an important role to establish correct grammatical forms, proves the importance of this task in his Homeric recension (διόρθωσις). Dionysius speaks of 'calculation (ἐκλογισμός) of analogy'. The word ἐκλογισμός is derived from ἐκλογίζομαι, whose primary (and usual) meaning is 'to compute', 'to reckon'. This phrase, thus, keeps a link between this particular part of grammar and mathematics.³⁸ It also underscores the heuristic function of analogy in grammar as defined by Dionysius—that is, philology.³⁹

Charisius (fourth century C.E.) provides further evidence for the status and function of analogy among the Alexandrian grammarians (149.26–150.2 Barwick):

huic [sc. analogiae] Aristophanes quinque rationes dedit uel, ut alii putant, sex; primo ut eiusdem sint generis de quibus quaeritur, dein casus, tum exitus, quarto numeri syllabarum, item soni. sextum Aristarchus, discipulus eius, illud addidit, ne umquam simplicia compositis aptemus.

Aristophanes gave analogy five criteria or, as some believe, six: first, that the objects of inquiry be of the same gender; then, of the same case; then, of the same ending; fourth, of the same number of syllables; finally, of the same accent. Aristarchus, his pupil, added this sixth [rule]: that we never link simple forms to compounds.

According to Charisius, the so-called canons of analogy (*rationes analogiae*) were first introduced by Aristophanes of Byzantium, and then further developed by Aristarchus.⁴⁰ These two scholars thus felt the need to provide some rules in order to apply analogy correctly to textual criticism, which was their main focus. Establishing some criteria in order for a method to be rigorous and work properly is the first step toward the foundation of a scientific discipline. This seems also to be the process shaping the beginning of grammar at Alexandria: Aristophanes and Aristarchus developed a method to deal with debated linguistic forms and gave it some rules in order to apply it correctly. Furthermore, the principle that *comparanda* should follow certain criteria in order for the forms in the analogy to be 'of the same kind' is consistent with Euclid's definition 3 in Book 5 quoted above. Thus, the Alexandrian philologists seem to have borrowed the analogical method, which was key in the development of grammar, from other, more advanced disciplines, that is, the mathematical μαθήματα, just like Plato and Aristotle had done before them.

³⁸ Pace Pfeiffer (n. 3), 203, n. 1, according to whom grammatical ἀναλογία 'is hardly derived from the mathematical and philosophical term ἀναλογία (= proportion) used by Eratosthenes, the Platonist, in his *Platonicus*'.

³⁹ For another connection between mathematics and Dionysius Thrax, see P. Berrettoni, 'On the geometrical background of Dionysius Thrax' definition of comparatives', in R. Petrilli and D. Gambarara (edd.), *Actualité des anciens sur la théorie du langage* (Münster, 2004), 17–36.

⁴⁰ On this definition and also on other criteria for analogy, especially among Latin grammarians, see A. Garcea, 'César et les paramètres de l'analogie', in L. Basset, F. Biville, B. Colombat, P. Swiggers and A. Wouters (edd.), *Bilinguisme et terminologie grammaticale gréco-latine* (Leuven, Paris and Dudley, MA, 2007), 339–57 and A. Garcea, *Caesar's De Analogia: Edition, Translation, and Commentary* (Oxford and New York, 2012), 167–79. See also Siebenborn (n. 3), 72–83, Pagani (n. 8), 834–8 and Schironi (n. 8), 383–6.

5. VARRO: GRAMMATICAL ANALOGY AND MATHEMATICS

The most compelling evidence for the link between mathematical and grammatical proportions can be found in Varro. Varro's mathematical models for analogy have been studied by Daniel J. Taylor and Alessandro Garcea.⁴¹ Without repeating the points already discussed by these two scholars, my aim here will be to show how Varro's analogy can be seen both as depending on Alexandrian analogy as well as going beyond it. Varro, in other words, is what links and explains the two main phases of Greek analogy: the one inaugurated by the Alexandrian philologists, and the one developed later by the 'technical grammarians' such as Apollonius Dyscolus and Herodian.⁴²

As is well known, Varro devotes Books 8–10 of *De lingua Latina* to analogy (and anomaly).⁴³ When introducing the concept of analogy for the first time Varro explicitly uses the Greek term ἀναλογία (*Ling.* 8.23: *Graeci Latinique libros fecerunt multos, partim cum alii putarent in loquendo ea uerba sequi oportere, quae ab similibus similiter essent declinata, quas appellarunt ἀναλογίας*).⁴⁴ This introduction presents Latin grammar as derived from, and closely linked to, the Greek τέχνη γραμματική. The Greek term is used once again in Book 10, dedicated to an analysis of the principles that rule languages (*Ling.* 10.37):

sequitur tertius locus, quae sit ratio pro portione. <e>a Gr<a>ece uoca[n]tur ἀνὰ λόγον; ab ἀναλόγω dicta ἀναλογία. ex eodem genere quae res inter se aliqua parte dissimiles rationem habent aliquam, si ad eas duas alterae duae res collatae sunt, quae rationem habeant eandem, quod ea [uerba] bina habent eundem λόγον, dicitur utrumque separatim ἀνάλογον, simul collata quattuor ἀναλογ<ι>α.

Next there is the third topic: what the relation by proportion is. In Greek this is called ἀνὰ λόγον; and from ἀνάλογον, ἀναλογία is derived. If two things of the same type, though dissimilar in some respects, have some relation to each other and two other things which have the same relation are compared to these two things, then, because the two sets have the same λόγος, each of the two is said separately to be ἀνάλογον; and the four taken together are called ἀναλογία.

Here Varro clearly presents analogy as a mathematical concept which allows the discovery of the rational principles governing languages. The link with mathematics is further strengthened by the fact that he uses the Greek words (ἀνὰ λόγον, λόγος, ἀνάλογον, ἀναλογία), so that the etymological link with the mathematical procedure

⁴¹ D.J. Taylor, 'Varro's mathematical models of inflection', *TAPhA* 107 (1977), 313–23; A. Garcea, 'Varron et la constitution des paradigmes flexionnels du latin', *Histoire, Épistémologie, Langage* 30 (2008), 71–89.

⁴² While Taylor sees Varro's mathematical model mostly as his original contribution, Garcea (n. 41), 78 more correctly states that Varro was actually not the first to use four-term analogies; rather, he developed this mathematical model already used by the Alexandrian grammarians into a more complex system (for example with the idea of *formula*, as discussed by Garcea [n. 41], 78–81). The goal of the present study is to ideally complement Garcea's study of Varro's analogy and to explore how this method started before Varro and developed after him, especially in the Greek world.

⁴³ Book 8 is dedicated to the arguments against analogy and in favour of anomaly, Book 9 to the arguments in favour of analogy and against anomaly, and Book 10 presents Varro's attempt to mediate between these two approaches to language.

⁴⁴ I would like to thank Wolfgang de Melo, who kindly allowed me to use his new text of Varro's *De lingua Latina* before its publication (W. de Melo, *Varro: De lingua Latina. Introduction, Text, Translation, and Commentary* [Oxford, 2019]).

becomes apparent. In addition, Varro confirms that the theory of proportion, devised in the field of mathematics, was indeed used in other fields too (*Ling.* 10.41–2):

haec fiunt in dissimilibus rebus, ut in numeris si contuleris cum uno duo, sic cum decem uiginti. nam <quam> rationem duo ad unum habent, eandem habent uiginti ad decem. in nummis, in similibus, sic est ad unum uictoriatum denarius, si ad alterum uictoriatum alter denarius. sic item in aliis rebus omnibus pro portione dicuntur ea, in quo est sic quadruplex natura, ut in progeie cum est filius ad patrem, sic [si] est filia ad matrem, et ut est in te <m>poribus merides ad diem, sic media nox ad noctem. hoc poetae genere in similitudinibus utuntur multum, hoc acutissime geometrae, hoc in oratione diligentius quam alii ab Aristarc<h>o grammatici, ut cum dicuntur pro portione similia esse amorem amori, dolorem dolori, cum ita dissimile[m] esse uideant amorem et amori, quod est alio casu, item dolorem dolori, sed dicunt, quod ab similibus.

This happens in things which are different from each other, as in numbers, if you compare two with one, so also twenty with ten; for twenty has to ten the same relation which two has to one. Similarly, with coins, one denarius is to one victoriate as a second denarius is to a second victoriate. So likewise in all other things those are said to be in relation where there is a fourfold nature, as among children when the son is to the father, then so the daughter is to the mother, and in time-reckoning midnight is to the night as midday is to the day. The poets often use this kind of relationship in their similes, and the geometricians use it very keenly; in reference to speech, the grammarians of the school of Aristarchus use it with more care than others do, as when *amorem* and *amori*, on the one hand, and *dolorem* and *dolori*, on the other, are said to be similar by proportion, even though they see that *amorem* is different from *amori*, because it is in another case, and likewise *dolorem* is different from *dolori*; but they say [that they are similar by proportion] because they derive from similar forms.

In addition to showing Varro's awareness of the mathematical origin of grammatical analogy, this passage also lists non-mathematical uses of analogy. Aside from geometry and arithmetic, Varro specifically speaks of (human) biology, time and money-reckoning, and poetry, fields that in part overlap with those to which Plato and Aristotle had also applied analogy. Furthermore, within this list Varro explicitly mentions Aristarchus' use of analogy in grammar as another application of this mathematical method. Thus, Varro confirms the reconstruction of the early history of grammatical analogy as outlined in the previous sections.

In *Ling.* 10.45–6 Varro also distinguishes between two kinds of analogy: *genus coniunctum* (1 : 2 = 2 : 4) and *genus deiunctum* (1 : 2 = 10 : 20). These distinctions correspond exactly to the *συνεχῆς ἀναλογία* and to the *διηρημένη ἀναλογία* of Aristotle.⁴⁵ Going a step further and applying analogy to grammatical questions, Varro (*Ling.* 10.47) distinguishes between the kind of analogical proportion used for nouns, which is *quadruplex* and *deiuncta* (*rex : regi = lex : legi*), and the analogical proportion used for verbs, which is *triplex* and *coniuncta* (*legebam : lego = lego : legam*, which can also be written as *legebam : lego : legam*). This distinction is new and does not seem to be operative in Aristarchus' examples. Aristarchus always uses disjoint proportions of the type $A_1 : A_2 = B_1 : B_2$ or $A_1 : A_2 : A_3 = B_1 : B_2 : B_3$, and never conjoined ones. Indeed, even though they seem similar, Varro's *triplex* analogy (*legebam : lego : legam*) is essentially different from Aristarchus' proportions of the

⁴⁵ Yet, I agree with Garcea (n. 41), 83, when he claims (*contra* Taylor) that Varro did not take this model from Aristotle but rather from mathematical treatises which were circulating in Rome at his time and which were probably similar to the preserved *Introduction to Arithmetic* by Nicomachus of Gerasa (c.100 C.E.).

type *Κάλχας* : *Κάλχαντος* : *Κάλχαν*,⁴⁶ all of which involve nouns but never verbs. The reason is that a proportion like *Κάλχας* : *Κάλχαντος* : *Κάλχαν* cannot be rewritten as a συνεχῆς ἀναλογία of the type $A1 : A2 = A2 : A3$, because *Κάλχας* : *Κάλχαντος* = *Κάλχαντος* : *Κάλχαν* does not make any sense in terms of ‘logical relationship’, as the link between a nominative and a genitive cannot be defined as ‘proportional’ to the link between a genitive and a vocative. On the contrary, a temporal logical relation underlines the proportion *legebam* : *lego* = *lego* : *legam*, since the past is to the present as the present is to the future. The *triplex* and *coniuncta* proportion as defined by Varro is thus typical of verbs because ‘*lego* has to *legam* the same relation which *legebam* has to *lego* (*Ling.* 10.47: *quam rationem habet legebam ad lego, hanc habet lego ad legam*). Though Aristarchus was aware of verbal tense (χρόνος) and of the difference between tenses,⁴⁷ he does not seem to have ever employed this sort of conjoined proportions with verbal tenses. The reason is that such proportions were not very useful to a philologist, especially one who was interested not in discovering how a language is logically structured but rather in solving a specific editing problem. On the other hand, the conjoined analogies would have been extremely interesting from a linguist’s point of view, because they called attention to the logical relationship among tenses. Varro’s distinction between the analogical proportion used for nouns (*quadruplex* and *deiuncta*) and the analogical proportion used for verbs (*triplex* and *coniuncta*) can thus be seen as a further development of the doctrine of analogy from Alexandria to Rome.⁴⁸

6. ANALOGY AND THE TEXNH ΓΡΑΜΜΑΤΙΚΗ

While the mathematical origin of analogy was not forgotten during the time separating the Alexandrian grammarians and Varro, analogy had already evolved with Varro and especially when it was adopted by the Greek grammarians of the Imperial period. For instance, there are many scholia in which Herodian (second century C.E.) discusses Aristarchus’ solution to linguistic problems in Homer. One example will be sufficient to highlight both similarities and differences between Aristarchus and Herodian in discussing the same linguistic problems (*Sch. Il.* 16.827 [Hrd.]):

{ὡς πολέας} πέφνοντα: ὡς τέμνοντα. οὕτως καὶ Ἀρίσταρχος, ὁ δὲ Τυραννίων (fr. 40 P.) παροξύνει ὡς λαβόντα, δεύτερον ἀόριστον ἐκδεχόμενος. οὕτως δὲ καὶ τὴν εὐθειαν ὀξύνει, ‘κῆρ ἄχεος μεθέικα, χερειονά περ καταπεφνών’ (*Il.* 17.539), τοῦ Ἀριστάρχου βαρύνοντος, καὶ μοι δοκεῖ ὁ Τυραννίων λόγῳ ὑγιεῖ χρῆσθαι· εἰ γὰρ πέφνω πέφνεις πέφνει οὐ λέγομεν, ὑποτακτικῶς δὲ πέφνω, ‘πέφνης’ (*Od.* 22.346), ‘πέφνη’ (*Il.* 20.172 al.) καὶ ‘πέφνε γὰρ Ὀθρυονῆα’ (*Il.* 13.363), καὶ ἔστι δεύτερος ἀόριστος ὡς ‘ἔλαβε’ (*Il.* 4.463 al.), λάβω λάβης, ‘λάβη’ (*Il.* 4.230, 24.480), δηλον ὅτι ὀφείλομεν καὶ τὴν μετοχὴν ὀξύνει. ὁ μὲντοι Ἀρίσταρχος καὶ τῷ χαρακτῆρι τῆς φωνῆς ἐπέισθη καὶ οὕτως ἐβάρυνεν· ἐπεὶ γὰρ αἱ εἰς νων λήγουσαι μετοχαί, ἔχουσαι πρὸ τοῦ ν σύμφωνον κατ’ ἐπιπλοκῆν, ἦτοι ἐβαρύνοντο ἢ περιεσπώντο, οὐδέποτε δὲ ὠξύνοντο, ὡσπερ ἔχει ἡ τέμνων κάμνον πίντων, ἐδοκίμαζε καὶ τὴν πέφνων βαρύνειν, οὐχὶ ὀξύνειν. εἰ δὲ τις λέγοι ‘διὰ τί γὰρ οὐ περιεσπῶ;’, διδαχθήσεται ἐκ τῆς κλίσεως: οὐ γὰρ πεφνούντα ἐροῦμεν ἢ πεφνόντα ὡς

⁴⁶ See *Sch. Il.* 1.86 (reported above, at p. 478).

⁴⁷ Cf. Matthaios (n. 2), 326–51.

⁴⁸ A further example of such a development is Caesar’s *De analogia*; see now Garcea (n. 40 [2012]), who correctly observes (at 15–18) that the aim of Caesar’s treatise is not purely grammatical or philological but rather rhetorical.

νοούντα. οὕτως δὲ καὶ ἡ ἴσας **μετοχή** ἐβαρύνετο τῷ χαρακτήρι καὶ τῇ ποιότητι τοῦ στοιχείου, οὐ τῇ **κλίσει** τῆ τοῦ **ἐνεστώτος**, ὡσπερ ἀπεδείξαμεν.

πέφνοντα: **πέφνοντα** like **τέμνοντα**. So also Aristarchus. Tyrannio (fr. 40 P.) instead pronounces it as paroxytone like **λαβόντα**, considering it a **second aorist**. Thus, he also pronounces the **nominative** as oxytone, [for example], **κῆρ ἄχθος μεθέηκα, χερειονά περ καταπέφνον** (*Il.* 17.539), while Aristarchus pronounces it as barytone. It seems to me that Tyrannio is using a sound argument: for if we do not say **πέφνω πέφνεις πέφνει**, but **πέφνω** is a **subjunctive** [like] **πέφνης** (*Od.* 22.346), **πέφνη** (*Il.* 20.172 al.) and [there is] **πέφνε γὰρ Ὀθρυνῆα** (*Il.* 13.363), and [the form] is a **second aorist** like **ἔλαβε** (*Il.* 4.463 al.), **λάβω λάβης, λάβη** (*Il.* 4.230. 24.480), it is clear that we must pronounce also the **participle** as oxytone. However, Aristarchus followed the typical form of the word, and, therefore, pronounced it as barytone. For the **participles** ending in -vov and with a consonant before the v in a cluster are either barytone or perispomena but never oxytone, as are **τέμνων, κάμνων** [and] **πίτων**, and therefore he decided to pronounce **πέφνων** too as barytone and not as an oxytone. And if someone were to ask: ‘and why doesn’t he pronounce it as perispomenon?’ **He will be taught by the declension**. For we will not say **πεφνούντα** or **πεφνώντα** like **νοούντα**. Thus, also the **participle** ἴσας was barytone according to its form and the quality of the letter and not according to the **declension** of the **present**, as we showed.

Without discussing in detail the specific content of this scholium, I would like to focus on Herodian’s way of dealing with the problem at issue compared to what he reports about Aristarchus. Aristarchus finds a form through a simple two-term analogy (**τέμνοντα = πέφνοντα**).⁴⁹ The same procedure (though with different forms and different results: **λαβόντα = πεφνώντα**) is performed by Tyrannio, a grammarian living at Rome in the first century B.C.E. Working in the second century C.E., however, Herodian follows a different path to solve the same problem (that is, the choice between different accentuations of a Homeric word). He explains his choices by recalling grammatical rules (**κανόνες**), which ensure that a certain form with certain characteristics must be accented in a certain way. Moreover, Herodian makes ample use of grammatical terminology, highlighted in underlined bold type in the quotation: **εὐθειᾶ** (nominative), **ὑποτακτικὸς** (subjunctive), **δεύτερος ἀόριστος** (second aorist), **ἐνεστώς** (present), **μετοχή** (participle). In addition, Herodian claims that **κλίσις** (declension) teaches us how to find the form for which we are looking (**διδαχθήσεται ἐκ τῆς κλίσεως**). Nothing like this can be found in Aristarchus’ analogical procedure.⁵⁰

These differences demonstrate that between Aristarchus and Herodian several important changes occurred. After Aristarchus, similarities and regularities in language were increasingly recognized and considered independently from the task of editing Homer. Language became *the object* of study in the search for these similarities and rules. Starting with the end of the first century B.C.E. and then with Apollonius Dyscolus and his son Herodian in the second century C.E., the **τέχνη γραμματική** became a fully autonomous discipline (the so-called ‘technical grammar’), focussed on studying language *qua* language—and not just a tool used to edit a literary text. Now language was considered an entity with its own rules and exceptions, independently from the text of Homer or any other writer. Literary authors were not neglected by Herodian and his colleagues, but literary quotations had become a means for better understanding the linguistic phenomenon, which was now the goal, not as before, when grammar was

⁴⁹ See also *Sch. Il.* 17.539b (Hrd.) <καταπέφνον:> Ἀρίσταρχος ὡς τέμνων (καταπέφνον: Aristarchus [reads it] like τέμνων).

⁵⁰ There are countless examples of the different approach of Herodian compared to Aristarchus in the Homeric scholia; see e.g. *Sch. Il.* 6.244; 11.495; 24.228a.

only a tool for Homeric criticism. Herodian's panoply of grammatical rules is thus very different from Aristarchus' use of analogical proportions as heuristic tools to establish the right reading in a text. This is also evident from a direct quotation of the latter by Herodian (*Sch. Il.* 24.8a [Hrd.]):

πείρων· Πάμφιλος περισπᾶ ... ὁ μέντοι Ἀρίσταρχος βαρύνων ἀναγινώσκει, ὡς 'κείρων' (cf. *Il.* 21.204, *Od.* 24.459). φησὶ γοῦν οὕτω γενόμενος ἐπὶ τοῦ 'παννυχὴ μὲν ῥ' ἢ γε καὶ ἠὼ πείρε κέλευθον' (*Od.* 2.434): "τὸ 'πείρε' διδάσκει ἡμᾶς καὶ τὴν πείρων μετοχὴν βαρύνειν· ὡς γὰρ ἔκειρε κείρων, οὕτως ἔπειρε πείρων· εἰ γὰρ περιεσπᾶτο, ἦν ἂν ὁ παρατατικὸς ἐπείρα". ...

'Making it through (πείρων) [wars of men and painful waves]': Pamphilus pronounces πείρων as perispomenon ... Aristarchus, however, reads it as barytone like κείρων (cf. *Il.* 21.204, *Od.* 24.459). Thus, coming to discuss 'thus all night long and through the dawn [the ship] made it through (πείρε) her journey' (*Od.* 2.434), he says: "πείρε teaches us that the participle πείρων is also barytone, for as ἔκειρε κείρων, so ἔπειρε πείρων. If it were perispomenon, the imperfect would be ἐπείρα" ...

Herodian's verbatim quotation of Aristarchus conclusively proves that four-term analogies were indeed used by Aristarchus and were not an addition by later grammarians such as Herodian himself. More importantly for us now, Aristarchus here introduces the four-term proportion (ἔκειρε : κείρων = ἔπειρε : x) with the verb 'to teach', claiming that the examples of ἔκειρε and κείρων together with πείρε in *Od.* 2.434 'teach' us that the right accent for the problematic participle ΠΕΙΡΩΝ is πείρων and not πειρῶν. Even if he too uses grammatical terms such as μετοχή (participle) and παρατατικὸς (imperfect), Aristarchus is not invoking any inflectional rule, as Herodian did in the previous scholium in which the 'teacher' was not an analogical proportion but rather 'a rule of declension' (κλίσις). Aristarchus, on the contrary, simply appeals to a set of 'logical' ratios which give a single precise result.⁵¹

With the development of technical grammar, analogy did not lose its importance; however, it did greatly change its scope and essence. Within this new discipline that studied linguistic phenomena and established rules, analogy evolved from a heuristic method into a tool for reconfirming the value of these rules. Analogy then became a feature that forms had to follow a certain paradigm or certain declensional rules. This does not mean, however, that Herodian never used 'heuristic' proportions; in fact, sometimes he adopted them for forms that were particularly problematic and did not seem to follow any of his 'rules'. In *Sch. Il.* 12.201d, for example, Herodian discusses the accentuation of the adjective ὙΨΙΠΙΕΤΗΣ, 'high-flying', whether it is ὕψιπέτης or ὕψιπετής, and agrees with Aristarchus that the reading ὕψιπετής, in analogy with τιμῆς, is impossible. The reason is that for τιμῆς there is an accusative τιμῆντα (*Il.* 18.475), which—Herodian explains—'ἐδίδασκε τὸ τῆς εὐθείας πάθος', that is, 'taught the modification undergone by the nominative'; in other words, the accusative τιμῆντα proves that the contracted declension (τιμῆς from τιμήεις) is possible. On the contrary, there is no sign of any other contracted form derived from ὕψιπετήεις. The procedure adopted by Herodian in this case is very similar to the Aristarchean one, as shown also by the use of the same verb διδάσκειν for attested forms in Homer which 'teach' that a certain declensional pattern exists. Unlike Aristarchus, however, Herodian seems to have used this deductive method only when he did not have the

⁵¹ On this scholium, see H. Erbse, 'Zur normativen Grammatik der Alexandriner', *Glotta* 58 (1980), 236–58, at 237–9 and Matthaios (n. 2), 330, 343, 344–5, 409–10, 411, 421.

right κανόν to apply and was dealing with particularly problematic or uncommon forms; otherwise the ‘teacher’ was the rule of declension (κλίσις).⁵²

7. ANALOGY: DEVELOPMENT OF A TERM

So far, my focus has been analogy as a method, namely the mathematical proportion applied to the study of language. Now I will focus on the word itself, and how it develops in grammar. Admittedly, the term ἀναλογία is not very much used in the scholia. In the scholia to the *Iliad* derived from Aristarchus, for instance, not only is the word ἀναλογία entirely absent, but derivatives such as ἀνάλογον and ἀναλόγως are also never specifically used to label the procedure of grammatical proportions so common in Aristarchus’ practice.⁵³ It is only later, when grammar became an independent discipline, that the words ἀναλογία, ἀνάλογον and derivatives were increasingly used. However, Herodian’s use of these words clearly indicates the great change which linguistic analogy underwent since its origins (*Sch. Il.* 12.158 [Hrd.]):

ταρφειάς: Ἀρίσταρχος ὀξύνει ὡς πυκνάς. ὁ δὲ Θρᾶξ Διονύσιος (fr. 16 Schm. = fr. 5 Linke) ὁμοίως προεφέρετο τῷ ταρφείας, παρὰ τὸ ταρφύς ἀρσενικόν, οὗ πολλοὶ ἦσαν χρήσεις παρὰ τοῖς παλαιοῖς καὶ παρ’ Ὀμήρῳ (cf. *Il.* 11.69, 387 al.). καὶ δῆλον ὅτι ἀναλόγως μὲν ἀναγινώσκει ὁ Θρᾶξ, ἐπεκράτησε δὲ ἡ Ἀριστάρχου.

ταρφειάς: Aristarchus pronounces ταρφειάς oxytone like πυκνάς. Dionysius Thrax, on the other hand, pronounced it like ταρφείας, from the masculine ταρφύς, which was very much used by the ancients and by Homer (cf. *Il.* 11.69, 387 al.). And it is clear that [Dionysius] Thrax reads it according to analogy, but the reading of Aristarchus prevailed.

In this case, both Aristarchus and Dionysius Thrax use an analogical proportion, though they choose different forms for their proportion, which lead in turn to different results: Aristarchus reads ταρφειάς on the basis of πυκνάς, whereas Dionysius reads ταρφείας on the basis of ταρφείας. This proves, on the one hand, that analogy was a tool that could be applied by anyone and gave different results according to the choice of the *comparandum*. On the other hand, however, the comment of Herodian complicates the situation, since he notes that only the reading of Dionysius is analogical, though the reading of Aristarchus prevailed (ἀναλόγως μὲν ἀναγινώσκει ὁ Θρᾶξ, ἐπεκράτησε δὲ ἡ Ἀριστάρχου). This seems contradictory, because both Aristarchus and Dionysius Thrax have used analogy in this instance. Why then does Herodian claim that Aristarchus has chosen a non-analogical reading? Herodian’s comment can be explained only if we assume that by analogy he means something different from the procedure that allows one to establish a relationship between two pairs of forms in order to determine the morphology or the accentuation of one of the two. As shown by *Sch. Il.* 16.827 analysed above, Herodian was working within a completely different framework: he relied on grammatical rules (κανόνες), so that a form was

⁵² On the different meaning of analogy in Herodian (i.e. a quality of certain words as well as a method and an activity of a technical grammarian), see I. Sluiter, ‘A champion of analogy: Herodian’s *On Lexical Singularity*’, in S. Matthaios, F. Montanari and A. Rengakos (edd.), *Ancient Scholarship and Grammar: Archetypes, Concepts and Contexts* (Berlin and New York, 2011), 291–310.

⁵³ Also in Euclid’s *Elements* the noun ἀναλογία is seldom used (14 times)—despite a pervasive use of the indeclinable adjective ἀνάλογον (395 occurrences).

analogical *only if* it followed a certain *canon*. Hence, analogy could lead only to one result, the result allowed by grammatical rules. On the contrary, the analogical procedure of Aristarchus and of his direct pupil Dionysius could lead to different results according to what they chose as *comparanda* to build their mathematical proportions. In other words, for both of them, the result depended on the way in which analogy was applied.

By understanding this difference, it is also possible to explain why Herodian can say, for example, that a certain reading (Αἶπυ instead of Αἶπύ for a toponym) is ‘more analogical’ than another one (*Sch. Il.* 2.592b: *χρῆ μέντοι γινώσκειν ὅτι ἀναλογωτέρω ἀνάγνωσις ἦν ἢ βωρεῖω*).⁵⁴ Such a statement would not have made sense at the time of Aristarchus, when analogy was a tool to discover a form: a form could be analogical, that is, proportional or not, but not more analogical, that is, proportional, than another. For Herodian, however, being analogical meant following a rule—and, indeed, it is possible to have a form that follows a rule more closely than another.⁵⁵

The analysis of different definitions of analogy in the Greek and Roman world confirms that this development took place in the Imperial period, so that the link with mathematics grew progressively weaker. In Sextus Empiricus (*Math.* I, § 199) or in the scholia to Dionysius Thrax (for example *Sch. Dion. Thrax* 15.11–12 and 309.9, cf. also *Sch. Dion. Thrax* 169.26–7), for instance, analogy is defined as ἡ τῶν ὁμοίων παράθεσις, the ‘juxtaposition of similar [forms]’. Although a specific link with mathematics is missing, it is still possible to perceive the idea of the ‘shape’ of a mathematical proportion in the way in which one has to ‘juxtapose’ similar elements in order to proceed with a comparison. However, the goal of this operation is now to find a grammatical rule, as becomes clear in other scholia to Dionysius (*Sch. Dion. Thrax* 454.17; 568.6–7), which define ἀναλογία as ἀπόδοσις κανόνων/κανόνος, ‘explanation of rule(s)’. In fact, *Sch. Dion. Thrax* 454.17 even specifies that the rules are those of the ‘technical grammarians’ (ἡ τῶν τεχνικῶν κανόνων ἀπόδοσις). Grammar was now a *technē* with its own rules, which were *explained* (but not *discovered*) by analogy.

The Roman world developed the concept of analogy along the same path, as well as introducing some novel notions.⁵⁶ I have surveyed the way in which Latin grammarians ‘translated’ ἀναλογία and defined this concept elsewhere.⁵⁷ Here I want simply to recall some key points for my present analysis. Among Latin grammarians, analogy is often defined as a comparison between similar forms or as the declension of similar forms.⁵⁸ Even though this is the ‘weak’ sense of analogy (just like the Greek definition

⁵⁴ The same happens in *Sch. Il.* 14.464a (ex.) Ἀρχέλοχος: Ἀρίσταρχος ἀναλογώτερον τοῦ Ἀρχύλοχος, ὡς φερένικος, ‘Μενέλαος’ (*Il.* 2.408 al.).

⁵⁵ Siebenborn (n. 3), 63–7 recognizes three kinds of analogy: 1) the ‘zweigliedrige Vergleichen’, which I call the ‘two-term proportions’; 2) the ‘viergliedrige Flexions- und Derivationsanalogien’, which I call ‘four- or more term proportions’ and 3) the κανόνες, which I consider the ‘descriptive’ analogy, as conceived by Herodian. As we saw in n. 13 above, according to Siebenborn ([n. 3], 71), Aristarchus mostly employed the first type of analogy, but I have tried to show that he also used the second type (but not the third).

⁵⁶ On analogy among Latin grammarians, see C. Wolde, *De analogiae disciplina apud grammaticos Latinos* (Regimonti, 1911). More modern studies are those by Garcea (n. 40 [2007]) and (n. 40 [2012]), which also provide additional bibliography.

⁵⁷ See F. Schironi, ‘Αναλογία, analogia, proportio, ratio: loanwords, calques and reinterpretations of a Greek technical word’, in L. Basset, F. Biville, B. Colombat, P. Swiggers and A. Wouters (edd.), *Bilinguisme et terminologie grammaticale gréco-latine* (Leuven, Paris and Dudley, MA, 2007), 321–38.

⁵⁸ E.g. Quint. *Inst.* 1.6.4 (*eius* [sc. *analogiae*] *haec uis est, ut id quod dubium est ad aliquid simile, de quo non quaeritur, referat et incerta certis probet*); Gell. *NA* 2.25 (*ἀναλογία est similitum similis*

ἢ τῶν ὁμοίων παράθεσις, ‘the juxtaposition of similar [forms]’), in these Latin examples the link with the Greek background and with the mathematical origin of the concept are still preserved in at least two aspects. First, these definitions often point to the Greek term, thus showing that the Romans were aware of the Greek origin of the concept. Second, together with the Latin *analogia*, which is borrowed from the Greek, these grammatical texts also display an attempt to translate the term into Latin with *proportio*, which again alludes to mathematics. In fact, *proportio* is the technical term for ‘mathematical proportion’ in Latin; this calque from the Greek was first introduced by Cicero in his translation of Plato’s *Timaeus*⁵⁹ and then used often by Vitruvius, who also connects it to Greek ἀναλογία (*De arch.* 3.1).⁶⁰ Yet, even if the etymological meaning of analogy is sometimes present in the Latin grammarians’ definitions, they tend to use the Greek loanword *analogia* rather than *proportio* when discussing linguistic analogy and examples of it.⁶¹ While being aware of the mathematical origin of the grammatical analogy, Latin grammarians thus seem to distance themselves from it. This is also the impression we get from Diomedes (late fourth century or early fifth century C.E.) (*GL* I 384.15–16):

analogia apud nos, id est proportio, praetermissis Graecorum ambagibus simplici modo tam in uerbis quam in nominibus obseruatur.

Among us [that is, Roman grammarians] analogy, namely *proportio*, is observed both in verbs and in nouns simply and without the circumlocutions of the Greeks.

Even though he explains that *analogia* corresponds to *proportio* (so he keeps the mathematical connection), Diomedes clearly states that Latin *analogia* is much simpler and more straightforward than Greek ἀναλογία. What Diomedes means by *ambages*, ‘circumlocutions’ or ‘obscurities’, is uncertain, but these *ambages* might perhaps be the ‘mathematical’ connections, which must have appeared odd to a Latin grammarian of this period.⁶² Now analogy is more simply (*simplici modo*) something that is observed in nouns and verbs. Indeed, for the Latin grammarians of the fourth or fifth century, analogy was above all what lay behind a grammatical rule, as proven by their defining analogy as *regula*⁶³ or a *ratio* connected with the *disciplina declinationis*⁶⁴—definitions which are not very far from how Herodian himself understands ἀναλογία.

The semantic shift from Greek ἀναλογία to Latin *analogia* becomes clear in the following quotation from the so-called *Donatiani fragmentum* (*GL* VI 275.16–17):⁶⁵

declinatio); Pompeius, *GL* V 197.22 (*quae est analogia? comparatio similitum*); Servius, *GL* IV 435.15–16 (*analogia dicitur ratio declinationis nominum inter se omni parte similitum*).

⁵⁹ In *Tim.* 4 § 13: *quae Graece ἀναλογία, Latine (audendum est enim, quoniam haec primum a nobis nouantur) comparatio proportiue dici potest* (‘what in Greek is ἀναλογία can be called “proportion” or “comparison” in Latin [for we must be bold, since we are the first to coin these terms]). Here the Greek context of ἀναλογία is purely mathematical (*Pl. Tim.* 31c3–32a7). On Cicero’s translation of the *Timaeus*, see D. Sedley, ‘Cicero and the *Timaeus*’, in M. Schofield (ed.), *Aristotle, Plato and Pythagoreanism in the First Century BC: New Directions for Philosophy* (Cambridge, 2013), 187–205.

⁶⁰ See Schironi (n. 57), 322–3.

⁶¹ See Schironi (n. 57), 326–8.

⁶² Just like his colleagues, aside from this passage, Diomedes never uses the word *proportio* but only *analogia* (e.g. *GL* I 307.22; 375.18; 377.22; 378.14–15; 384.21; 386.*passim*; 387.4).

⁶³ E.g. Donatus, *GL* IV 379.3–4; Ps.-Palaemon, *GL* V 539.21.

⁶⁴ Ps.-Probus, *GL* IV 47.23–4 (*ratio recta perseuerans per integram declinationis disciplinam*).

⁶⁵ On Donatianus and the *Donatiani fragmentum*, cf. R.A. Kaster, *Guardians of Language: The Grammarian and Society in Late Antiquity* (Berkeley, 1988), 274–5.

analogiam sic Graeci definirunt, ἀναλογία ἐστὶ συμπλοκὴ λόγων ἀκολουθῶν, id est conexus orationum consequentium.

The Greeks define analogy in this way: συμπλοκὴ λόγων ἀκολουθῶν, that is, a combination of expressions in regular succession.

Interestingly, Donatianus uses the Greek language when giving the definition of analogy, as though he wanted to go back to the origin of the concept. However, the Greek definition συμπλοκὴ λόγων ἀκολουθῶν is ambiguous, because it can mean both ‘combination of expressions in regular succession’ and ‘combination of ratios in regular succession’, where the latter interpretation is close to a geometric proportion of the type analysed above.⁶⁶ The Greek definition thus points to the original etymological meaning of the grammatical ἀναλογία, or, at least, is conceived ambiguously enough to keep both meanings available—the mathematical meaning (where λόγος is ‘ratio’) and the grammatical meaning (where λόγος is ‘phrase’, ‘expression’). Yet, when Donatianus translates the definition into Latin, he uses *orationum* for λόγων, showing that for a Latin grammarian of the fourth or the fifth century C.E. the mathematical origin of analogy was completely foreign. Of course, *oratio* is one of the possible translations of the Greek λόγος, and it is also the most obvious translation in a linguistic context such as this one. However, even though the Latin translation is consistent with the grammatical context, it still shows that a certain amount of ‘bleaching’ has occurred in the meaning of the word ἀναλογία.⁶⁷ In fact, with this choice, Donatianus eliminates the ambiguity of the definition and confines it within a purely grammatical world, where ‘phrases’ are at stake.

To conclude, by adopting the non-Latin term *analogia*, Latin grammarians virtually eliminated the mathematical idea underlying the operation of analogy, which would have been otherwise more obvious if they had used *proportio*. The loanword *analogia* only meant grammatical analogy in Latin and was understood in the ‘modern’ sense of application of canons or similarity of declension. On the Greek side, Herodian could not use another term borrowing it from elsewhere, since grammar was a Greek invention with Greek terminology; yet he almost ‘resemanticized’ the original term ἀναλογία by using it in the same sense as the Latin *analogia*. Both in Herodian and in the Latin grammarians, linguistic analogy thus became more and more detached from its original link with mathematical reasoning, because its function had also changed. No longer being a heuristic tool to find out problematic forms in absence of full-fledged grammatical canons, analogy became more a way to describe how each form would behave in respect with those (now well-established) canons from the second century C.E. onward.⁶⁸

⁶⁶ Charisius 149.22–6 Barwick offers a very similar definition, including the Greek phrasing (*analogia est, ut Graecis placet, συμπλοκὴ λόγων ἀκολουθῶν, ... ἀναλογία ἐστὶν συμπλοκὴ λόγων ἀκολουθῶν ἐν λέξει*).

⁶⁷ On this definition, see Blank (n. 4 [1982]), 26–7, who states: ‘now συμπλοκὴ is a word often used for syntactic construction, while ἀκόλουθος describes the sentence whose construction is consequent or whose words are in proper agreement with one another. Hence the words συμπλοκὴ λόγων ἀκολουθῶν themselves would seem to indicate that analogy is consequent syntactic construction.’ (27) This is true if we read this definition from a purely linguistic point of view. I have tried, however, to show that the same phrase can also have a mathematical meaning, and that it was used in this sense by the first Greek grammarians. At the time when Donatianus or Charisius used the term, it indeed meant what Blank argues that it did. Blank himself, though, readily acknowledges the ‘scientific background’ of grammatical ἀκολουθία (n. 4 [1982], 16–17).

⁶⁸ My point is limited to the study of grammar. Mathematical proportions as heuristic tools were in fact used in the Latin world until late. For example, Calcidius (second half of the fourth century C.E.)

8. CONCLUSIONS

In the Hellenistic period, Alexandrian grammarians used various kinds of analogical procedures. They employed two-term proportions, that is, comparisons between similar forms, which represent a rather common epistemological procedure and are the same kind of analogy analysed and discussed by Regenbogen and Lloyd. However, Aristarchus also used another, more refined kind of analogy, which did not involve only a simple comparison between two similar words, but required a much higher degree of abstraction. This was a four- (or more) term proportion and derived from mathematics, as demonstrated both by the word's etymology and by the explicit application of mathematical proportions by Plato and Aristotle in other fields, such as philosophy, biology and literary analysis. In the capable hands of the Hellenistic grammarians, the multi-term *ἀναλογία* became a heuristic method that allowed them to determine an unknown form through comparison of similar parts of speech with similar characteristics, when a complete set of declensional rules was not available.

The use of a tool from a different discipline can be explained by the status of the different sciences in the Hellenistic period. Unlike mathematics or medicine, grammar in the third and the second centuries B.C.E. was still in its initial stages of becoming a *technē*. Grammarians did not have a full-fledged analysis of the parts of speech and even less a complete set of declension rules. Therefore, they borrowed analytical tools from other, more advanced disciplines.⁶⁹ Mathematics already had a long and illustrious past: it was highly developed, with an array of powerful and tested tools, among which the general theory of proportion devised by Eudoxus and systematized by Euclid. From there, analogy could be adopted by grammarians such as Aristarchus to study and discuss linguistic problems.⁷⁰ With the help of 'mathematical' proportions, the Alexandrians determined declensional patterns, orthography and especially accentuation of debated forms.⁷¹ The linguistic patterns (that is, declensional paradigms) discovered through analogy, however, were ancillary to textual criticism and most certainly not part of a large set of grammatical rules. As Wolfram Ax very aptly put it,⁷² Aristarchus had a 'Grammatik im Kopf', which helped him to correct the

in his commentary to Plato's *Timaeus* applies proportions to the analysis of daemons (*Comm. in Tim.* 131); see A. Somfai, 'The nature of daemons: a theological application of the concept of geometrical proportion in Calcidius' *Commentary to Plato's Timaeus* (40d–41a)', in R.W. Sharples and A.D.R. Sheppard (edd.), *Ancient Approaches to the 'Timaeus'* (London, 2003), 129–42.

⁶⁹ The borrowing of methodologies from different disciplines as well as the crossing of disciplinary boundaries in ancient Greece (and China) has been recently highlighted by G.E.R. Lloyd, *Disciplines in the Making. Cross-Cultural Perspectives on Elites, Learning, and Innovation* (Oxford, 2009), esp. 179–82. However, he does not discuss grammar—in this paper I have tried to add this field to the interdisciplinary group of *technai* of Greek antiquity.

⁷⁰ The Alexandrians' application of a mathematical model to language is not isolated; even before them, Plato used a (meta)mathematical model to define *logos* in the sense of 'statement', 'proposition': see P. Berrettoni, 'A metamathematical model in Plato's definition of *logos*', *Histoire, Épistémologie, Langage* 30 (2008), 7–19.

⁷¹ Indeed, accentuation and prosody more generally were particularly problematic, because there was no written record; see P. Probert, *Ancient Greek Accentuation: Synchronic Patterns, Frequency Effects, and Prehistory* (Oxford, 2006), 14–45. As she notes (at 45), sometimes grammarians might have accessed a tradition which preserved some archaic accentuation; yet, even in such cases, grammarians 'proved' the chosen accent by using an analogy with a similarly accented form. One such case (*Sch. II.* 12.158, mentioned above) is discussed in Schironi (n. 8), 405–7.

⁷² W. Ax, 'Aristarch und die "Grammatik"', *Glotta* 60 (1982), 96–109, esp. 108–9; Ax (n. 3), esp. 276 and 288.

Homeric text and figure out the most correct forms, without however venturing into a complete description of Greek language.

In the following centuries—and, especially, by the time of Herodian, in the second century C.E.—grammar became a full-fledged *technē*, a discipline unto itself. Κανόνες, ‘grammatical rules’, were discovered, and the aim of the ‘technical’ grammarians was to provide a precise description of the Greek language, which was now studied as the primary object of interest rather than as a tool for making a good edition of difficult poets like Homer, as it was for Aristarchus. In this new environment, analogy evolved into a descriptive principle, which allowed grammarians to check whether or not a form was in accordance (that is, *in analogy*) with a grammatical canon. Only rarely, and for particularly difficult cases, did Herodian use analogical proportions with a ‘heuristic’ aim in the way in which Aristarchus did centuries earlier. Most often, however, since the rules, the κανόνες, were already available, analogy was now simply the principle that words had to follow a specific declensional rule, as described in the grammatical handbooks. The ‘teachers’ were now inflectional rules, not forms found out through proportions.

In conclusion, analogy in grammar underwent a strange evolution. The term originally pertained to mathematics and meant a rather specific operation, the mathematical proportion. It was in this sense that the concept was adopted by the first grammarian-philologists at Alexandria. In the course of the centuries, however, analogy as a term was not preserved in mathematics, which eventually adopted the Latin term *proportio* (hence, the modern terms: Engl. proportion, Fr. *proportion*, Ger. *Proportion*, Ital. *proporzione*). Instead, ἀναλογία was kept in grammar, and remained a linguistic term in other languages (starting with Latin). Therefore, whereas in modern languages ‘proportion’ (derived from Latin) is still something strictly related to mathematics, the Greek ‘analogy’ no longer is. When we use the words ‘analogy’ in English, *analogie* in French, *Analogie* in German, and *analogia* in Italian, we refer to more-or-less generic similarities.⁷³ The link between grammar and mathematics has been lost, because now (and, in fact, since the first centuries C.E.) grammar is indeed a science *per se*, which does not need to borrow any method from other disciplines. This is surely an achievement, but to understand analogy as ‘similarity in declension’, or as ‘grammatical rule’, or even as ‘similarity’ would have sounded odd to Euclid and Aristarchus, who were instead both concerned with the λόγος, the rational principle, of reality.

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⁷³ Modern linguistics, perhaps ironically, employs the concept of ‘proportional analogy’ opposed to ‘non-proportional analogy’: the very need to specify that an analogy is ‘proportional’ (a tautology, from an etymological point of view!) is evidence that the original meaning of Greek ἀναλογία is lost in modern linguistics; see Hock (n. 16), 171; Campbell (n. 16), 92–3; P. Kiparsky, ‘Analogy’, in W. Bright (ed.), *International Encyclopedia of Linguistics* (New York and Oxford, 1992), 1.56–61, at 56.