1

To Twist the Meaning: Newton's *Regulae Philosophandi* Revisited

Maurizio Mamiani

The theme of this investigation is a principle developed in various publications by I. Bernard Cohen: that "a dynamic rather than a static point of view" should guide analyses of the development of scientific ideas.[1] One consequence of this principle is that many important innovations in science prove, on close examination, to consist, to some degree, of radical "transformations" of existing ideas, concepts, and methods. In many cases, however, finding a specific or causal link among scientific ideas involves considerable difficulty. For example, it is historically certain that Newton's "New Theory of Light and Colors" of 1672 is in part a transformation of Robert Boyle's ideas about colors of 1664. There is, however, no direct inductive or deductive link between these two sets of ideas. Clearly, Boyle himself did not see any such inductive or deductive transformation; this was Newton's great move forward.

There is a paradox here. If scientific innovation tends to be a transformation, what is the process (neither induction nor deduction) that leads from the old ideas to the new ones? There is no simple and straightforward path that leads from the old to the new ideas. The actual stages of the transformation and the cause are usually not obvious. In a sense, the history of the scientific ideas hides the actual transformation. But if such history depends on transformations, there seems to be a charge of circularity.

To escape the vicious circle, it is necessary to look for the actual cause or occasion of the growth of the scientific concepts. Where do we look? Often beyond science, namely, beyond the scientific tradition of the age we are studying. For instance, Boyle produced his ideas about colors in 1664 in a philosophical (i.e., physical) context. In the *Lectiones Opticae*, Newton modified the boundaries between physics and mathematics, which enabled him to twist the meaning of the same kind of the experiments on colors that he and Boyle had performed.

In what follows, my goal is to focus attention on a particular transformation that marked the migration of categories and methods from one discipline to another. I do not intend to discuss some kind of vague

influential metaphysics, something that is "in the air" like some kind of elusive ghost. Rather, I want to trace the transformation of a specific set of concepts and their integration into a wholly different kind of system of thought, thus disclosing a link between very different traditions of thought. The case study I wish to explore is the set of famous *regulae philosophandi* that appear at the head of Book III in the later editions of Newton's *Principia*.

There can be little doubt that these *regulae* are a transformed version of a set of "rules" that Newton composed somewhat earlier. These rules, sixteen in number, appear in Newton's *Treatise on the Apocalypse*.[2] Between the time of composition of the study of the Apocalypse and the writing of the *Principia*, Newton reduced the number of rules. Only two of the final set of rules from the *Treatise on the Apocalypse* appear in the first edition of the *Principia* (1687), where they are part of the introductory "Hypotheses." In the second edition (1713), they are joined by a third *regula*, and in the third and final edition there is an additional fourth *regula*.[3]

A simple comparison of the wording of the two sets of rules reveals the direct lineage between them; thus there is no difficulty in seeing how Newton transformed the rather diffuse rules of the *Treatise on the Apocalypse* into the more concise *regulae* of the *Principia*. This transformation is in many ways remarkable because the backgrounds of these two sets of rules involve different concepts deriving from logic, rhetoric, mathematics, theology, and the philosophy of nature. But no one, so far as I am aware, has sought to find the common source of the longer and earlier set. In what follows, I shall show how the sixteen rules for interpreting the Apocalypse were in turn a transformation of some rules and principles that Newton studied while an undergraduate at Cambridge.

As far as logic and rhetoric are concerned, Robert Sanderson's *Logicae Artis Compendium*[4] is the primary source of Newton's rules. In this work Sanderson followed the Ramists rather than the scholastics, stressing the theory of method.[5] Newton owned a copy of this work, in the flyleaf of which he inscribed his name and the date "1661." The "Trinity Note-Book" shows indisputably that in 1664 Newton carefully read Sanderson's *Logic* along with various works of Descartes. Although both Sanderson and Descartes deal with method, they do so in a very different manner. Newton's study of their works would have given rise to an intellectual difficulty in arriving at any conceptual harmony between them.

In the *Treatise on the Apocalypse*, Newton subdivided his rules into three sections: "Rules for Interpreting y^{e} Words and Language in Scripture," "Rules for Methodizing/Construing the Apocalypse," and "Rules

for Interpreting the Apocalypse." However, the numbering of the rules is continuous. The order of succession is from the most to the least general, according to Sanderson's suggestion. Yet their literary style is similar to the four precepts we find in Descartes's *Discours de la méthode*. Like Descartes, Newton introduces his rules as precepts: "To observe diligently," "To assign but one meaning," "To choose those constructions w^{ch} . . . reduce things to the greatest simplicity," and so on.

The twelfth rule is clearly borrowed from Descartes's *Discours*. "Every truth I found," Descartes stated, "is the rule that I need afterwards to find other truths." For Newton, this rule took the form: "The construction of y^{e} Apocalypse after it is once determined must be made the rule of interpretations."[6] Despite certain such links with Descartes's *Discours*, however, the sixteen rules of the *Treatise on the Apocalypse* are more closely tied to Sanderson's *Logic* than to Descartes's *Discours* and, on close examination, prove to be an expansion of the methodological laws Sanderson listed, a remarkable instance of conceptual transformation.

Sanderson and Descartes agree about the general meaning of method. Method is synonymous with order. Sanderson makes a clear distinction between the method of discovering knowledge and the method of presenting or teaching it. The first of these is called the method of invention and the second the method of doctrine, which is twofold: the method of composition [methodus compositiva] and the method of resolution [methodus resolutiva].[7] The two varieties of the method of doctrine, according to Sanderson, are applied differently, one (composition) to the theoretical sciences and the other (resolution) to the practical ones.

Sanderson lists five laws as common to both resolution and composition. On the contrary, the method of invention has no law, but four means or steps: sense, observation or history, experience, and induction [sensus, observatio sive historia, experientia, inductio]. The method of invention, according to Sanderson, has nothing in common with the method of resolution or analysis.

In the *Treatise on the Apocalypse*, Newton twists the meaning of Sanderson's distinctions. The method Newton follows is subdivided into three parts, which he calls "Rules," "Definitions," and "Propositions." This is apparently analogous to the geometrical method or *mos geometricus* that Newton described to Oldenburg in a letter of 21 September 1672:

> To comply wth your intimation . . . I drew up a series of such Expts on designe to reduce y^{e} Theory of colours to Propositions & prove each

> Proposition from one or more of those Expts by the assistance of common notions set down in the form of Definitions & Axioms in imitation of the Method by w^ch^ Mathematitians are wont to prove their doctrines.[8]

However, when writing of the order of the propositions in the *Treatise*, Newton uses the same terms by which Sanderson defined the method of resolution. According to Sanderson, the method of resolution begins with the notion of an end [finis] and searches for the substance [subiectum] and the means [media].[9] Newton interprets Sanderson in this manner: "I compare y^e^ pts of the Apocalyps one w^th^ another & digest them into order by those internal characters [the media] w^ch^ y^e^ Holy-ghost hath for this end [the finis] imprest upon them. And this I do by drawing up the substance [the subiectum] of y^e^ Prophecy into Propositions."[10]

The link among the rules of the *Treatise* and the laws of method of Sanderson's *Logic* is even closer. The first law of method, according to Sanderson, is the law of brevity [lex brevitatis]: "Nothing should be left out or be superfluous in a discipline" [Nihil in disciplina desit, aut redundet].[11] Newton transforms this law in the second and third rule of the *Treatise*: "To assigne but one meaning to one place of scripture" and "To keep as close as may be to y^e^ same sense of words."[12] The second law is the law of harmony [lex harmoniae]: "The individual parts of each doctrine should agree among themselves" [Doctrinae singulae partes inter se consentiant].[13] Newton expresses this law in many rules: the first, "To observe diligently the consent of Scriptures";[14] the eighth, "To choose those constructions w^ch^ ... reduce contemporary visions to y^e^ greatest harmony of their parts,"[15] from which the ninth and the fourteenth rules also depend.

Simplicity is a consequence of the law of harmony, as Newton makes clear in the ninth rule:

> To choose those constructions w^ch^ without straining reduce things to the greatest simplicity. The reason of this is manifest by the precedent Rule. Truth is ever to be found in simplicity, & not in y^e^ multiplicity & confusion of things. As y^e^ world, w^ch^ to y^e^ naked eye exhibits the greatest variety of objects, appears very simple in its internall constitution when surveyed by a philosophic understanding, & so much y^e^ simpler by how much the better it is understood, so it is in these visions.[16]

A number of rules in Newton's *Treatise* correspond to the third law of Sanderson's *Logic*, the law of unity or homogeneity [lex unitatis, sive

homogeniae]: "No doctrine should be taught that is not homogeneous with subject or end" [Nihil in doctrina praecipiatur, quod non sit subiecto aut fini homogeneum].[17] It will be sufficient to consider the fifteenth rule, which claims that the prophecies must be interpreted according to the end for which they are designed. Finally, consider the eleventh rule of the *Treatise*: "To acquiesce in that construction of y^{e} Apocalyps as y^{e} true one w^{ch} results most naturally & freely from y^{e} characters imprinted by the holy ghost on the severall parts thereof for insinuating their connexion."[18] There may be no doubt that this rule is a direct translation of the fifth law of Sanderson's *Logic*, the law of connection [Lex connexionis]: "The individual parts of a doctrine ought to be connected by opportune transitions" [Singulae partes doctrinae aptis transitionibus connectantur].[19]

What is new in Newton's rules? Neither the content nor the expression. It is true that Sanderson's laws are very concise whereas Newton's rules are verbose and redundant. We must wait for the rules of the *Principia* in order to find a conciseness equivalent to the laws of Sanderson's *Logic*. There is, however, a great difference among Newton's rules for interpreting the Apocalypse and Sanderson's laws. Sanderson is repeating the precepts of a dead tradition for presenting or teaching acquired knowledge. Newton is proposing rules to be used in discovering new knowledge. Here is a real transformation, in which Newton is transposing the old concepts beyond logical and rhetorical limits.

We may see a clear example of this transposition in Newton's use of the term "construction." In his *Treatise on the Apocalypse*, Newton titled the second section of rules premised to the definitions, "Rules for Methodizing the Apocalypse."[20] Afterwards he corrected the title by adding "construing" above "methodizing." In all the rules there are fourteen occurrences of the terms "construing" or "construction." What does this tell us? Newton himself declares the origin of his concept: grammatical analysis: "a man acquiesces in y^{e} meaning of an Author how intricate so ever when he sees y^{e} words construed or set in order according to y^{e} laws of Grammar, notwithstanding y^{t} there may be a possibility of forceing y^{e} words to some other harsher construction."[21] However, Newton does not limit himself to this notation. The order of the laws of grammar agrees with the mechanical order: "For ... of an Engin made by an excellent Artificer a man readily beleives y^{t} y^{e} parts are right set together when he sees them joyn truly with one another notwithstanding that they may be strained into another posture."[22] The conclusion is the same for both the comparisons: "a man ought wth equal reason to acquiesce in the construction of these Prophesies when he sees their parts set in order

according to their suitableness & the characters imprinted in them for that purpose."[23]

It is evident that Newton has put together different conceptual entities. And these are the means (the *media* of Sanderson's method of resolution) by which "the Language of y^{e} Prophets will become certain & y^{e} liberty of wresting it to private imaginations be cut of. The heads to w^{ch} I reduce these words I call Definitions."[24] In this phrase we see a consequence of the above mentioned transposition of concepts. For it is surely very inappropriate to affirm that a language will become certain, since certainty pertains to knowledge, not to speech.

The same ambiguity is in the term itself of "definition." The definitions listed by Newton in his *Treatise on the Apocalypse* appear to be linguistic definitions. But Newton also considers them mathematical definitions. Therefore these propositions, in which he draws up the substance of the prophecy according to Sanderson's method of resolution, are proved by subjoining the reason for their truth, as if they were mathematical propositions. This goes beyond grammar and logical order. Newton is mobilizing concepts from the logical and rhetorical tradition as if they belonged to the mathematical tradition.

However, if we take into consideration the propositions of the *Treatise on the Apocalypse*, we may notice that Newton does not prove them solely by means of the definitions and rules, but by adding lists of particulars. For example, he proves the eighth proposition ("The Dragon & Beast are y^{e} Kingdome whose symptomes are declared in y^{e} Seales & Trumpits, whereof y^{e} Dragon begins wth y^{e} Seales & y^{e} Beast wth y^{e} Trumpets")[25] by eight particulars, and the meaning of each particular refers to the definitions. Newton twists the meaning both of the traditional *mos geometricus* and the logical and rhetorical methods. In *De Gravitatione*, as well as in the above quoted letter to Oldenburg concerning optics, we find the same philosophical discussions as in the *Treatise on the Apocalypse*; the difference between them is one of detail and reference, since the letter and *De Gravitatione* refer to natural experiments and not to parts of the Scripture.

In the *Treatise on the Apocalypse*, Newton fuses and integrates many different methodological procedures: grammatical analysis, rules of construction and of interpretation, definitions, double demonstration of propositions by means both of particulars and common notions.

In actual fact, in his *Treatise on the Apocalypse*, Newton cancels out the traditional distinction, present in Sanderson's *Logic*, between the methods of invention and of doctrine. Indeed, according to Sanderson,

the particulars pertain to the method of invention and not to the method of doctrine, to which the analysis or method of resolution pertains. Consequently, Newton is no longer able to distinguish between analysis and method of invention.

In the seventeenth century the term "analysis" became more and more ambiguous. Sanderson lists many meanings of this term according to logical, rhetorical, and grammatical traditions. Analysis is the method (the *methodus resolutiva*) of practical sciences, but it is also a logical operation [operatio logica], analogous to the procedures with the same name in grammar and rhetoric. Logical analysis, which may be applied both to the theoretical and practical sciences, is twofold: *simplex* or *methodica*. Methodical analysis may be, in turn, *thematica*, *problemathica*, or *methodica stricte*.[26] Only problematical analysis is concerned with demonstration, the kind of demonstration Newton is concerned with in the *Treatise on the Apocalypse*. However, Sanderson does not mention the analysis of mathematics, which was also a demonstrative procedure. This analysis is very different from the method of resolution, because the former is a method of demonstration, the latter of explanation. As we will see, Newton made a fusion, or confusion, of nearly all the meanings of the term "analysis."

Newton was not the only one to have done so. We may find a sibylline account of analysis and synthesis in Descartes's reply to the second objections to the *Meditations*. The Latin text of this work, the one that Newton read,[27] is very different from Clerselier's French translation. According to Descartes the analysis is a method of invention: "The analysis shows the true way by means of which a thing is found methodically and as it was a priori."[28] The ancient authors made no public use of it: "Not because they did not simply know it, but, as I think, because they judged it so important to reserve it to themselves as a secret."[29] Descartes does not mention resolution. However, an echo of Descartes's statements may be found in a handwritten passage of Newton's, often quoted. Newton likely wrote it for the second edition of the *Principia*, but it also is very similar to the statement Newton made in the concluding portion of his (anonymous) review of the *Commercium Epistolicum*, published in the *Philosophical Transactions*:

> The Ancients had two Methods in Mathematicks w^{ch} they called Synthesis & Analysis, or Composition & Resolution. By the method of Analysis they found their inventions & by the method of Synthesis they [published them] composed them for the publick. The Mathematicians of the last age have very much improved [Analysis &] Analysis [& laid aside the Method of synthesis] but stop there [in so much as] & think

> they have solved a problem when they have only resolved it, & by this means the method of Synthesis is almost laid aside. The Propositions in the following book were invented by Analysis. But considering that [they were] the Ancients (so far as I can find) admitted nothing into Geometry [but wha] before it was demonstrated by Composition I composed what I invented by Analysis to make it [more] Geometrically authentic & fit for the publick.[30]

Like Descartes, Newton considers analysis and synthesis two mathematical methods. However, he adds their names (resolution and composition) according to the logical tradition. It is odd that Clerselier added the same names to the French translation of Descartes's replies to the second objections. Evidently there is a contamination of the linguistic sources that prefigure the conceptual transformations. In Newton's language, analysis and synthesis, or resolution and composition, become, respectively, the method of invention and the method of doctrine. Sanderson made this distinction too, with the difference that he included resolution in the method of doctrine.

Finally, we must consider briefly the conceptual sources of the *regulae philosophandi* of the second and third edition of the *Principia* and their place in Newton's method. Neither the *regulae philosophandi* nor the rules of the *Treatise on the Apocalypse* agree with the scheme we find in Newton's paragraph, quoted above, concerning the mathematical methods of the ancients. In the *Principia* the rules have the function of linking together the particular phenomena in the same manner that the rules of the *Treatise* assemble the meanings of scriptural language. Both are linked to the laws and to the method of invention as described by Sanderson, rather than to mathematical analysis or synthesis. For this reason it is possible to find a correspondence between the *regulae philosophandi* and the rules of the *Treatise*, notwithstanding the great temporal gap between them.

Table 1.1 describes the conceptual links and analogies among the laws of Sanderson's logic, the rules of the *Treatise on the Apocalypse*, and the *regulae philosophandi*.

In this table the interconnection and fusion of Sanderson's methods of invention and of resolution are clear. There is no doubt that the transformations Newton gradually introduced are very great and significant. In the eighteenth century, the *regulae philosophandi* were correctly considered the canon of experimental science, the result of a revolution that had given an established configuration to science. Nevertheless, their conceptual source is Sanderson's *Compendium*, a manual that combines the scholastic matter of the logical and rhetorical traditions with the liberal arts

Table 1.1

Sanderson's *Compendium*	Rules of the *Treatise on the Apocalypse* (ca. 1672)	*Regulae philosophandi*
Law of brevity (*lex brevitatis*): "Nothing should be left out or be superfluous in a discipline (Nihil in disciplina desit, aut redundet)."	"2. To assigne but one meaning to one place of scripture." "3. To keep as close as may be to the same sense of words."	Regula I (1687) "Causas rerum naturalium non plures admitti debere, quam quae et verae sint & earum phaenomenis explicandis sufficiant."
Law of harmony (*lex harmoniae*): "The individual parts of each doctrine should agree among themselves (Doctrinae singulae partes inter se consentiant)."	"1. To observe diligently the consent of Scripture." "8. To choose those constructions w^{ch} . . . reduce contemporary visions to y^{e} greatest harmony of their parts." "9. To choose those constructions w^{ch} . . . reduce things to the greatest *simplicity*."	Comment to Regula I "Natura enim *simplex* est & rerum causis superfluis non luxuriat."
Law of unity or homogeneity (*lex unitatis, sive homogeniae*): "No doctrine should be taught that is not homogeneous with subject or end (Nihil in doctrina praecipiatur, quod non sit subiecto aut fini homogeneum)."	Rules 4, 6, 7, 10, 12, 14, 15	Regula II (1687) "Ideoque effectuum naturalium eiusdem generis eaedem assignandae sunt causae, quatenus fieri potest."
Law of connection (*lex connexionis*): "The individual parts of a doctrine ought to be connected by opportune transitions (Singulae partes doctrinae aptis transitionibus connectantur)."	"5. To acquiesce in that sense of any portion of Scripture as the true one w^{ch} results most freely & naturally from y^{e} use & propriety of y^{e} Language & tenor of the context in that & all other places of Scripture to that sense." "11. To acquiesce in that construction of y^{e} Apocalyps as y^{e} true one w^{ch} results most naturally & freely from y^{e} characters imprinted . . . for insinuating their connexion."	Regula III (1713) "Qualitates corporum quae intendi & remitti nequeunt, quaeque corporibus omnibus competunt in quibus experimenta instituere licet, pro qualitatibus corporum universorum habendae sunt."

Table 1.1 (continued)

Sanderson's *Compendium*	Rules of the *Treatise on the Apocalypse* (ca. 1672)	*Regulae philosophandi*
"Induction, by which we make up a universal conclusion summoning many experiences (*Inductio*, qua collectas plures Experientias ad *universalem* conclusionem adhibemus)."	"[2]. If two meanings seem equally probable he is obliged to beleive no more then in general y^{e} one of them is genuine untill he meet wth some motive to prefer one side."	Regula IV (1726) "In philosophia experimentalis, propositiones ex phaenomenis per *inductionem* collectae, non obstantibus contrariis hypothesibus, pro veris aut accurate aut quamproxime haberi debent, donec alia occurrerint phaenomena, per quae aut accuratiores reddantur aut exceptionibus obnoxiae."

of the *trivium*. Thus, the transformation of concepts is the key to understanding the innovative procedures of the "new science." We may see in this example how, historically, the genesis of experimental method involves a complexity of interactions that, from a static point of view, are hidden and thus irremediably lost.

I wish to conclude with an observation of Koyré's, in his *Newtonian Studies*. After having studied the *De Gravitatione*, Koyré concluded that the ways followed by human thought in the search for truth are indeed very odd. However, it is not very odd that a new way is often a rectification of an old one.

NOTES

1. I. Bernard Cohen, *Introduction to Newton's Principia* (Cambridge: Harvard University Press, 1971), 21.

2. The work of Newton's that I have called his *Treatise on the Apocalypse* is an untitled work (part of the Yahuda MSS in the University of Jerusalem). A transcription of this work, together with an Italian translation and commentary, may be found in my edition, I. Newton: *Trattato sull'Apocalisse* (Torino, Italy: Bollati Boringhieri, 1994). Frank E. Manuel edited another partial version in Appendix A of his *The Religion of Isaac Newton: The Freemantle Lectures* (Oxford: Clarendon Press, 1974, 107–125); here the abbreviations have been spelled out and the details of Newton's alterations are not given. The parts of this "treatise" containing the rules have subtitles: "Rules for Inter-

preting the Words and Language in Scripture," "Rules for Methodizing/Construing the Apocalypse" and "Rules for Interpreting the Apocalypse."

3. On this topic see I. B. Cohen, "Hypotheses in Newton's Philosophy," *Physis* 8 (1966): 63–184.

4. R. Sanderson, *Logicae Artis Compendium* (Oxoniae, 1618); now in anastatic reprint, edited by E. J. Ashworth (Bologna, Italy: Clueb, 1985). Newton's library included a copy of the third edition of Sanderson's *Compendium* (Oxoniae, 1631) with Newton's signature and date ("Isaac Newton Trin Ccli Cant 1661") and a few signs of dog-earing. Cf. John Harrison, *The Library of Isaac Newton* (Cambridge: Cambridge University Press, 1978), 231.

5. W. S. Howell, *Logic and Rhetoric in England, 1500–1700* (New York: Russell & Russell, 1961), 302.

6. Newton, *Trattato sull'Apocalisse*, 30.

7. Sanderson, *Logicae artis compendium*, 226–7.

8. H. W. Turnbull, ed., *The Correspondence of Isaac Newton*, (Cambridge: Cambridge University Press, 1959), 1:237. Cf. M. Mamiani, *Isaac Newton filosofo della natura* (Firenze: La Nuova Italia, 1976), 184–212.

9. Sanderson, *Compendium*, 227, 231.

10. Newton, *Trattato sull'Apocalisse*, 18.

11. Sanderson, *Compendium*, 227.

12. Newton, *Trattato sull'Apocalisse*, 20–2.

13. Sanderson, *Compendium*, 227–8.

14. Newton, *Trattato sull'Apocalisse*, 20.

15. Ibid., pp. 26–8.

16. Ibid., p. 28.

17. Sanderson, *Compendium*, 228.

18. Newton, *Trattato sull'Apocalisse*, 28.

19. Sanderson, *Compendium*, 228.

20. Newton, *Trattato sull'Apocalisse*, 26.

21. Ibid., p. 30.

22. Ibid.

23. Ibid.

24. Ibid., p. 18.

25. Ibid., p. 128.

26. Sanderson, *Compendium*, "Appendix prima, De Analysi Logica," 75–84.

27. Cf. Harrison, *The Library of Isaac Newton*, 132, and *Certain Philosophical Questions*, ed. J. E. McGuire and M. Tamny (Cambridge: Cambridge University Press, 1983), 23.

28. "Analysis veram viam ostendit per quam res methodice, et tanquam a priori inventa est." R. Descartes, *Meditationes de Prima Philosophia* (Amstedolami, 1642), 172.

29. "Non quod . . . plane ignorarent, sed, quantum judico, quia ipsam tanti faciebant ut sibi solis tanquam arcanum quid reservarent." Descartes, *Meditationes*, 173.

30. Newton, Review of *Commercium Epistolicum* published in *Philosophical Transactions*, Cambridge University Library, MS Add. 3968, fol. 101.