

University of Groningen

Modelling the history of early modern natural philosophy

Sangiaco, Andrea

Published in:
British Journal for the History of Philosophy

DOI:
[10.1080/09608788.2018.1506313](https://doi.org/10.1080/09608788.2018.1506313)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2019

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):
Sangiaco, A. (2019). Modelling the history of early modern natural philosophy: the fate of the art-nature distinction in the Dutch universities. *British Journal for the History of Philosophy*, 27(1), 46–74.
<https://doi.org/10.1080/09608788.2018.1506313>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.



Modelling the history of early modern natural philosophy: the fate of the art-nature distinction in the Dutch universities

Andrea Sangiacomo

To cite this article: Andrea Sangiacomo (2019) Modelling the history of early modern natural philosophy: the fate of the art-nature distinction in the Dutch universities, *British Journal for the History of Philosophy*, 27:1, 46-74, DOI: [10.1080/09608788.2018.1506313](https://doi.org/10.1080/09608788.2018.1506313)

To link to this article: <https://doi.org/10.1080/09608788.2018.1506313>



© 2018 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



[View supplementary material](#)



Published online: 11 Oct 2018.



[Submit your article to this journal](#)



Article views: 864



[View related articles](#)



[View Crossmark data](#)

ARTICLE

 OPEN ACCESS

 Check for updates

Modelling the history of early modern natural philosophy: the fate of the art-nature distinction in the Dutch universities

Andrea Sangiacomo

Faculty of Philosophy, University of Groningen, Groningen, the Netherlands

ABSTRACT

The ‘model approach’ facilitates a quantitative-oriented study of conceptual changes in large corpora. This paper implements the ‘model approach’ to investigate the erosion of the traditional art-nature distinction in early modern natural philosophy. I argue that a condition for this transformation has to be located in the late scholastic conception of final causation. I design a conceptual model to capture the art-nature distinction and formulate a working hypothesis about its early modern fate. I test my hypothesis on a selected corpus of 25 works published in the Dutch academic milieu between 1607 and 1748. I analyse the corpus through a procedure based on concordancing of keywords associated with the model. I argue that the results obtained constitute a successful pilot study for the implementation of the model approach on larger scale research.

ARTICLE HISTORY Received 29 June 2017; Revised 28 October 2017, 27 February and 24 June 2018; Accepted 13 July 2018

KEYWORDS Model approach; art-nature distinction; natural philosophy; Aristotelian philosophy; Mechanical philosophy


What is the reading of a text, in fact, except the recording of certain thematic recurrences, certain insistences of forms and meanings?

Italo Calvino, *If on a Winter's Night a Traveller*

1. The model approach

In a series of recent papers, Arianna Betti and Hein van den Berg (‘Modelling the History of Ideas’ and ‘Towards a Computational History of Ideas’) advocated what they call the ‘model approach’ to the history of ideas. By ‘models’ they mean ‘fully explicit and revisable interpretive frameworks or networks of

CONTACT Andrea Sangiacomo  a.sangiacomo@rug.nl

 Supplemental data for this article can be accessed at <https://doi.org/10.1080/09608788.2018.1506313>.

© 2018 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

concepts developed by the historians of ideas themselves' (Betti and van den Berg, 'Towards a Computational History of Ideas'). Models are heuristic and interpretative devices that can be used to study the transformation of philosophical concepts and ideas across time. The model approach has a number of methodological advantages, among which are (1) the fact that it makes explicit the background assumptions that guide the historian in assessing her material, thereby facilitating the possibility of uncovering biases or falsifying historical hypothesis; and (2) makes it possible to process large corpora and analyse conceptual change over time in ways that would be difficult (if not impossible) to pursue with traditional close reading or individual case studies.¹

In this paper, I apply the model approach to the domain of the history of early modern natural philosophy. In particular, I focus on the fate of the Aristotelian art-nature distinction across the seventeenth and the mid-eighteenth centuries.² This period has often been associated with the effort of several *novatores* to conceptualize the natural world as a sort of clockwork, in which natural phenomena could be accounted for in terms of matter in motion only, as in the case of artificial mechanical engines. This early modern mechanistic picture of nature was at odds with the traditional scholastic framework. Building on this contraposition, the master narrative of the seventeenth-century 'Scientific Revolution' (Butterfield, *The Origins of Modern Science*; Koyré, *From the Closed World to the Infinite Universe*; Rupert Hall, *The Scientific Revolution, 1500–1800*; Westfall, 'The Scientific Revolution of the Seventeenth Century') portrayed a radical break between the early modern period and the previous scholastic tradition.

The issue of mechanization is an important example of the broader historiographical shift which has occurred in the last four decades of scholarship about early modern philosophy and science. By problematizing the narrative about the Scientific Revolution, most of today's historians tend to stress the continuities between the early modern and the late medieval period (e.g. Laird and Roux (eds.), *Mechanics and Natural Philosophy before the Scientific Revolution*; Ariew, *Descartes and the First Cartesians*). Moreover, they emphasize the complexity and multiplicity of different (and often irreducible) views that characterize both the *novatores* (Garber, 'Remarks on the Pre-History of the Mechanical Philosophy') and the scholastics themselves (Leijenhorst, Lüthy and Thijssen, 'The Erosion of Aristotelianism'). Part of this historiographical shift has been motivated by the broadening of the historical canon (Zinsser, *Men, Women, and the Birthing of Modern Science*) and by a

¹The use of the model approach contributes to the integration of more quantitative methods in philosophy and history of philosophy. See, e.g. Bluhm, 'Corpus Analysis in Philosophy' about the use of corpus linguistics methods for the study of natural language in contemporary philosophy of language. For the role of quantitative approaches in detecting and correcting biases in contemporary philosophical research, see Polonioli, 'A Plea for Minimally Biased Empirical Philosophy'.

²The model approach has been implemented so far for the study of axiomatic systems, see De Jong and Betti, 'The Classical Model of Science'.

more serious consideration of the role played by a number of scholastic authors operating in the university context (Schmitt, *Aristotle and the Renaissance*). Today's scholarship suggests that seemingly traditionalist figures such as university professors paved the way for the acceptance and dissemination of the apparently new positions introduced by several early modern natural philosophers (Sgarbi, *The Aristotelian Tradition and the Rise of British Empiricism*; Craig, *Subverting Aristotle*). With regard to the specific issue of mechanization of the natural world, this new historiographical attitude supports two connected claims: (1) mechanization was in fact far less dominant than early accounts of the Scientific Revolution suggested (Duchesneau, *Les modèles du vivant de Descartes à Leibniz*; Graukroger, *The Collapse of Mechanism and the Rise of Sensibility*); (2) the early modern endorsement of a new mechanist account of the natural world should be understood alongside the conceptual frameworks developed by late scholastic authors (Hattab, *Descartes on Forms and Mechanisms*).

In this paper, I implement the model approach in order to provide further evidence for the current view that early modern transformations in natural philosophy (such as the dismissal of the art-nature distinction and the mechanization of nature) are better understood if assessed in connection with the problems left open in the scholastic framework. At the same time, I argue that implementing the model approach has three distinct benefits.

First, the model approach offers a promising way of testing current scholarly assumptions and insights by exploring new (and potentially broader) historical corpora. One of the major problems of the master narrative about the Scientific Revolution is that it relies on undue generalizations based on the consideration of a few canonical figures. The model approach appears to be a suitable methodological antidote to this problem. It allows for the verification and expansion of the domain of validity of historical hypotheses to more comprehensive and representative (but still vastly unstudied) corpora. For instance, the erasing of the art-nature distinction is often considered to be a mark of the 'new' natural philosophy (Dijksterhuis, *De mechanisering van het wereldbeeld*; Westfall, 'The Scientific Revolution of the Seventeenth Century'; Shapin, *The Scientific Revolution*, 30–46). By implementing the model approach to study a still unexplored early modern corpus, I investigate whether, and to what extent, the authors included in this corpus actually dismissed this distinction. Moreover, I use the model approach to determine if and how this dismissal relates to relevant conceptual changes in the established scholastic framework.

Second, the model approach has distinctive heuristic advantages insofar as it draws attention to a number of apparently non-standard positions and authors that would be worthy of further close investigation, but who are not easily detected by more traditional historiographical approaches.

Third, since the model approach tends to produce quantitative results about the frequency at which certain claims are instantiated, it generates a

new array of research questions. These questions would not only be worth exploring but would also require (in order to be successfully answered) a more significant integration of quantitative methods and tools in the still mostly qualitative approach of most historians of philosophy and science. In this sense, the implementation of the model approach can work as a methodological catalyst for a more thorough development and integration of quantitative methods in the history of philosophy and science (Laubichler, Maienschein and Renn, 'Computational Perspectives in the History of Science').

I proceed as follows. Section two introduces my model for studying the dismissal of the traditional art-nature distinction. Section three presents the implementation of the model in the case study of a selected corpus of works published in the Dutch Republic between 1607 and 1748. Section four outlines an agenda for further research.

2. Modelling the late scholastic conception of physical reality

The second book of Aristotle's *Physics* begins with the following distinction:

Of things that exist, some exist by nature, some from other causes. By nature the animals and their parts exist, and the plants and the simple bodies (earth, fire, air, water)—for we say that these and the like exist by nature. All the things mentioned plainly differ from things which are not constituted by nature. For each of them has within itself a principle of motion and of stationariness (in respect of place, or of growth and decrease, or by way of alteration). On the other hand, a bed and a coat and anything else of that sort, qua receiving these designations—i.e. in so far as they are products of art—have no innate impulse to change.

(*Physics*, II.1 192b)

In this passage, Aristotle suggests that natural beings have an internal principle of change, while other beings (such as 'a bed and a coat and anything else of that sort') do not. In this respect, natural beings are different from artificial beings (or products of art), whose changes are always brought about by principles external to them.

In the late sixteenth century, the famous Jesuit Conimbricenses' commentary on Aristotle's *Physics* echoes that one of the main reasons why nature differs from art is that:

[B]ecause natural forms are causally active and 'alive' (so to say), while forms produced by art are as if they were inert and dead, and do not have any efficacious force [...]. And from this it follows that natural things can have in themselves a principle of motion and rest, while things produced by art (as such) cannot.³

³[De Gois] *Commentarii Collegii Conimbricensis Societatis Iesu In octo Libros Physicorum Aristotelis Stagiritae*, 280 (my translation): "quia formae naturales sunt actuosae, et quasi vivae: formae vero arte factorum

The Conimbricenses, however, also introduce a number of further discussions that do not have clear parallels in Aristotle's original text but rather engage with the long history of receptions, interpretations and debates that surrounded it. For instance, discussing how *final causes* operate and which conditions they require in order to cause their effects, the Conimbricenses state that 'objective being is the condition *sine qua non* for the end to move.'⁴ In this context, 'objective being' refers to the object's way of being in the subject's mental apprehension of it. Thus, the fact that the agent cognizes or mentally apprehends the end is a necessary condition for final causality to take place. The idea that acting for an end requires some form of cognition (call this the 'cognition condition') is a genuine scholastic innovation (Pasnau, 'Intentionality and Final Causes', Schmid, 'Teleology and the Dispositional Theory of Causation in Thomas Aquinas', Sangiacomo, 'Aristotle, Heereboord and the Polemical Target of Spinoza's Critique of Final Causes').

Reconstructing the history of the cognition condition (and the reasons that led to its acceptance) goes far beyond the limits of this paper. For present purposes, I would like to stress that late scholastic authors were committed to the following three claims: (i) the original Aristotelian art-nature distinction, based on the presence of an internal principle of change in natural beings; (ii) the fact that natural beings operate for an end; and (iii) the cognition condition, according to which only agents that cognize their ends can operate for the sake of these ends in virtue of their own nature or internal principle of change. While Aristotle himself would subscribe to the first two commitments, he would reject the third (Sangiacomo, 'Aristotle, Heereboord and the Polemical Target of Spinoza's Critique of Final Causes'). I shall call the account that results from the conjunction of these three main commitments the 'late scholastic conception of physical reality'.

I propose to capture the way in which these three main commitments (i-iii) are connected in the late scholastic conception of physical reality by using the following model M, which consists of the conjunction of two members (M1 and M2). Following Kuukkanen ('Making Sense of Conceptual Change') I distinguish between the 'core' and the 'margins' of a concept. The core defines the fundamental features of a concept that all historical instances of that concept ought to instantiate. The margins define additional notions that can be determined or ways in which certain notions can be qualified in various ways in different historical instances without introducing a substantial change to the core of the concept. In my model, core notions are marked in bold, while marginal notions are marked in italics.⁵ My model reads as follows:

tanquam stolidae et emortuae, nullam effectricem vim habentes [...]. Atque hinc est, quod res naturales possunt habere in se motionis et quietis principium; arte factae vero, qua tales, non item."

⁴[De Gois] *Commentarii Collegii Conimbricensis Societatis Iesu In octo Libros Physicorum Aristotelis Stagiritae*, 410 (my translation): "esse objectivum est conditio, sine qua finis non movet."

⁵I use this convention introduced by Betti and van den Berg, 'Towards a Computational History of Ideas'.

Late scholastic conception of physical reality (M):

M1. All physical beings are subject to *change* (either by producing *changes* in other beings or by undergoing *changes* in themselves).

- a. If a physical being has an **internal principle of change**, then the physical being is a product of **nature**.
- b. If a physical being has only an **external principle of change**, then the physical being is a product of **art**.

M2. All *changes* of physical beings aim to an **end**.

- a. If the physical being is able to **cognize the end** for the sake of which the *change* is brought about, then the *change* is caused by the physical being's **internal principle**.
- b. If the physical being is not able to **cognize the end** for the sake of which the *change* is brought about, then the *change* is caused by a *principle* that is **external** to the physical being.

The first member (M1a-b) models the first commitment of the late scholastic account, namely, the traditional Aristotelian art-nature distinction. This distinction is sharp insofar as no physical being can simultaneously satisfy both conditions of M1 (because something that has *only* an external principle of change cannot have also an internal principle and vice versa). The second member (M2) introduces the second commitment, namely, the idea that all physical beings operate for an end. The 'cognition condition' (M2a) captures the third commitment, which requires that the agent must cognize its ends in order to consider that agent as internally determined to operate for the sake of those ends. If the agent does not satisfy the cognition condition, then it should be considered as directed by some external agent (M2b).

Model M seems to work smoothly in the case of some kinds of physical being. For instance, human beings are physical beings that count as products of nature (M1a) because they have an internal principle of change, and they are also able to cognize their ends (M2a), since they are capable of knowledge and cognitive self-direction. M also successfully captures the case of artefacts and products of human crafts, which are physical beings that do not have an internal principle of change (M1b) and that are not able to cognize their ends (M2b).

However, there is also a class of physical beings that constitute a potential counterexample to M. This class includes inanimate natural beings, plants and (depending on the authors' commitments) non-human animals. This class of physical beings is of central importance to natural philosophy, which is the early modern discipline that studies both inanimate and animate natural beings (usually excluding human beings as such). These physical beings seemingly have an internal principle of change (which explains their 'natural' operations, such as natural movements and growth), although they are also

seemingly deprived of cognition. Being deprived of cognition, these physical beings should be considered as directed by an external principle of change (M2b). However, this conclusion has repercussions for the qualification of these beings as 'natural' (M1a). Since all the changes endured by these physical beings aim towards an end (M2), and these changes have an external principle (because of their lack of cognition, M2b), it follows that all the changes of these physical beings are brought about by an external principle. Hence, they should be counted as 'artificial' (M1b) rather than 'natural' beings (M1a).

My working hypothesis aims to tackle the way in which historical authors respond to this counterexample. I assume that authors have two main alternatives: (a) they do not alter the core notions or conditions of model M but make only adjustments in the marginal notions in order to accommodate the counterexample with the model; (b) they alter some core notions or commitments of model M in order to accommodate the counterexample. Since changes in the marginal notions do not entail a radical conceptual change in the late scholastic conception of physical reality, I shall refer to this first option as 'traditional', while I refer to the second option (which involves some core conceptual changes in M) as 'non traditional'. Let me articulate both options.

(a) A defender of the traditional option can solve the problem posed by the counterexample by distinguishing between different kinds of *change* and their relative principles on the basis of the different kinds of causality involved. When referring to the kind of change relevant to whether a physical being is natural or artificial (M1), one may assume that this has to be a change related to *formal* and *efficient* causality. Natural beings have an *internal* principle of change *in the sense that* the changes they produce as formal or efficient causes depend on their own internal principle. For instance, the fact that a plant structures its material components in a certain way or grows in a certain direction depends on the plant's substantial form, which is usually considered to be an internal principle of change (since it is the principle that inheres in the plant itself and defines its nature). However, when it comes to the change related to the physical being's acting for an end (M2), this kind of change concerns *final* causality.

A supporter of the traditional account can deny that the *same* agent that counts (M1a) as a natural being and operates as a formal and efficient cause in virtue of an internal principle of (formal and efficient) change must also satisfy the cognition condition (M2a). In order to satisfy the commitment according to which *all* natural beings act for an end, it is sufficient that some other agent directs these natural beings that lack cognition towards their end (M2b). The most widespread solution is to maintain that God providentially guides and concurs with those agents that lack cognition (Des Chene, *Physiologia*, 194–200). In this case, an agent lacking cognition is still operating towards an end (M2) although not in virtue of its own internal principle

(M2a), but somehow by proxy and in virtue of the direct intervention of an external agent (M2b).

This traditional solution does not entail a change in any of the core notions or commitments of the late scholastic conception of physical reality (M). Rather, it accommodates the counterexample by distinguishing between different kinds of change and adding a further qualification to the marginal notion of *change* that features in the model (by making possible the combination of M1a and M2b, which was challenged by the counterexample). The kind of change involved in the cognition condition (M2a) concerns *final* causation, while the kind of change involved in the art-nature distinction (M1) concerns *formal* and *efficient* causation. Hence the *same* agent can have an internal principle of (formal and efficient) change (M1a) while having also an external principle of (final) change (M2b). For instance, a plant has an internal principle of change (i.e. its substantial form) with respect to its physical structure, growth and biological processes, while it has an external principle (i.e. God) insofar as the plant cannot actually cognize its ends and thus has to be directed towards them by an agent who cognizes them.⁶ Having *both* internal and external principles of change (when these principles relate to different kinds of change) is compatible with being a natural physical being (M1a).

While this traditional solution does not require a change in the core notions of the late scholastic conception of physical reality, it does come with some costs and ultimately shifts the problem from the model itself to the overall scholastic account of the way in which different kinds of causation are related together. Let me briefly elaborate on this point.

It is worth recalling that (in the scholastic framework) an agent counts as a genuine cause of some effect if (given all the necessary conditions required) the effect obtains because of the agent's own nature.⁷ For instance, fire is the proper (or *per se*) cause of heat in other bodies because it belongs to the nature of fire to be hot and thus to produce heat in other bodies. Now, assume that the defender of the traditional account maintains that final causality is necessary for efficient causality to work, insofar as it is in virtue of the final cause that the efficient cause is determined to produce a certain effect in a certain way.⁸ Final causation plays a crucial role in this account because it determines the end that a certain causal process is directed towards in the first place. It is final causation (M2) that guides and rules the causal process. In this scenario, if the agent by itself cannot account for the *final* cause of a

⁶Suárez, for instance, maintains that natural agents lacking cognition are only *improperly* called final causes, since they can act for the sake of a certain end only insofar as they are guided by God. See DM 23.10.6.

⁷See, for instance, Suárez DM, 17.2.2, in Suárez, *On Efficient Causality. Metaphysical Disputations 17, 18 and 19*, 11.

⁸Concerning this point, see Penner, 'Final Causality'.

certain action (in the sense that its internal principle of change cannot direct the action towards its end), then the same agent cannot be its *efficient* cause either. Whichever internal principle belongs to that agent, the effect produced does not obtain *because* of the agent's own nature, which by itself is incapable of accounting for the end towards which that effect tends. Rather, it must be some external principle that inclines the agent to produce that effect in a certain way and towards a certain end. Hence, if an agent cannot account for the *final* cause of some effect (because the agent is directed by an external agent to aim at a certain end), then it seems problematic to maintain that such an agent can account for the same effect as its *efficient* cause. In this scenario, the agent cannot determine itself (in virtue of the agent's own nature, or *per se*) to produce a certain effect towards a certain end (because it is assumed that the agent on its own cannot cognize that end), and thus the agent cannot initiate the whole causal process towards that end.

A way out from this impasse consists in dismissing the interdependency between efficient and final causation. However, this would mark a significant departure from the standard scholastic account of causation, in which efficient causation depends on final causation. Ultimately, if efficient causation does not depend on final causation, and if one assumes that efficient causation is what is at stake in the art-nature distinction (M1), then it becomes problematic to maintain that all changes in physical beings tend to an end (M2), because the changes associated with the agent as a natural being (M1) do not depend on final causation (M2). By divorcing efficient and final causation, the late scholastic conception of physical reality is at risk of falling apart.

(b) Let me now consider the case of an author who, instead of striving to maintain the late scholastic conception of physical reality, attempts to change this model in order to accommodate the counterexample. This non-traditional solution can be articulated in two main ways. The author may change either the art-nature distinction (M1a-b) or the commitment to final causality in nature (M2).⁹ My hypothesis is that, in this scenario, it is *more likely* that early modern authors are willing to change the art-nature distinction (M1a-b) rather than the idea that physical beings (including natural beings) operate for an end (M2) or the cognition condition (M2a). This means that, when faced with the counterexample of natural beings that do not cognize their ends (e.g. plants), a non-traditional account would *deny* that having an internal principle of change is necessary to qualify as a natural being (vs. M1a).

Before moving further, let me add two methodological disclaimers. First, the conceptual change introduced by non-traditional accounts of the art-nature distinction (M1) may be articulated in different ways and there is no

⁹Of course, an author may also simply reject the whole late scholastic conception of physical reality altogether. However, in this case the author would *not* accommodate the model M with the counterexample but would simply reject the model.

need to assume a 'one fits all' solution. For instance, some authors may use a definition of 'natural' that does not rely on whether a physical being has an internal principle of change, but rather on whether a being is produced by human craft. Other authors might reduce the difference between natural and artificial beings to a difference in the complexity of their form and structure, or even drop the art-nature distinction from the conception of physical reality entirely. There seems to be no need to assume that all the authors supporting non traditional views should endorse the *same* strategy (there is in fact evidence that they did not, see Garber, 'Remarks on the Pre-History of the Mechanical Philosophy'). However, what they will all share is that they are trying to change the late scholastic conception of physical reality by dismissing or significantly altering one of its two main pillars (namely M1 or M2).

In this sense, my model is a helpful heuristic guide to grouping together otherwise different non traditional accounts and focusing on the common strategy they adopt to change the core features of the late scholastic conception of physical reality. I do not propose to use my model to predict a priori how these changes will be carried out or which specific new core notions will be introduced. The function of my model, rather, is to direct research focus towards those core features of the traditional model M that are expected to change in non traditional accounts. How exactly this change occurs and in what particular fashion are details that ought to be clarified by direct historical and textual examination.

Second, my hypothesis concerns the relative frequency with which this reaction is instantiated compared to the whole array of authors who discuss and engage with this topic. In this respect, my hypothesis does not mainly concern the position of any individual author, but rather the pattern or historical trend that can be uncovered within a group of authors. My hypothesis can be falsified if (a) the majority of historical authors are willing to maintain both M1 and M2 (as if there were no conceptual tension between them), or (b) they dismiss the idea that natural beings operate for an end (by altering M2), or (c) if they dismiss the cognition condition (M2a) in order to dissipate the tension.

3. Corpus, procedure and results

3.1. Establishing the corpus

The hypothesis I presented in the previous section concerns a conceptual change in the late scholastic conception of physical reality. The domain of texts to look at in order to test this hypothesis should thus be such as to represent late scholastic views and study how they were transformed during the early modern period. Late scholastic natural philosophy was mostly taught at universities. Recent scholarship also acknowledges that early modern universities were laboratories for the constant adjustment and reshaping of

traditional views (Sgarbi, *The Aristotelian Tradition and the Rise of British Empiricism*) and for the dissemination of new approaches (Ariew, *Descartes and the First Cartesians*; Ducheyne and van Besow, 'Newton and the Dutch 'Newtonians': 1713–1750'). I have thus focused on university textbooks and systematic presentations of natural philosophy as the main domain for compiling my corpus. Given the limitations of this study, I also restricted my geographical focus to the Dutch universities only. Let me explain why this focus seemed appropriate for my research.

Existing scholarship stresses that Dutch universities were incredibly receptive towards new ideas while also determined to carry over more traditionally inspired scholastic curricula (Ruestow, *Physics at Seventeenth- and Eighteenth-Century Leiden*; van Bunge, 'Philosophy'). It has been discussed how religious debates put pressure on leading Dutch universities to develop new scholastic 'protestant' curricula (van Ruler, 'Franco Petri Burgersdijk and the case of Calvinism within the Neo-Scholastic Tradition', 'The Shipwreck of Belief and Eternal Bliss'; Leijenhorst and Lüthy, 'The Erosion of Aristotelianism'). While deeply influenced by leading (Catholic) scholastic authors, this educational project was at the same time open to inputs coming from the 'new' philosophy of Descartes and interested in developing a Protestant agenda (e.g. Krop, 'Medicine and Philosophy in Leiden around 1700'). These circumstances determined Dutch professors to develop rather eclectic and hybrid positions, which integrated both traditional late scholastic materials and new approaches developed by early modern *novatores*. Hence, the Dutch universities offer an ideal domain for my study since it includes both innovative and more traditional elements. Moreover, a corpus based on texts connected with universities (textbooks, disputations, introductions, etc.) offers a relatively high degree of homogeneity from both a linguistic and structural point of view that facilitates the comparison and analysis of different works.

To distil my corpus, I based my selection on the authors and works included in the *Dictionary of Seventeenth and Eighteenth-Century Dutch Philosophers* (van Bunge et al., hereafter referred to as *Dictionary*). To filter the entries of the *Dictionary* and compile the final list of authors and works included in my corpus, I applied the following four criteria:

- (1) *Language: Latin*. For reasons of linguistic homogeneity, I restricted the corpus of my research to texts written in Latin only.
- (2) *Genre: textbooks and systematic works*. I included only those works that were more general in scope, such as textbooks, introductions or systematic discussions of natural philosophy, and collections of disputations on natural philosophy. I left out most of the texts focused on other scientific disciplines (such as medicine) or on particular problems (such as the mind-body relationship). The advantage of focusing on more systematic

texts is that they do not primarily aim at engaging in controversies, but rather attempt to offer an up-to-date state of the discipline. This feature of my corpus helps to more directly identify the position defended by each author. I based my selection both on the keywords included in the titles (e.g. 'natural philosophy', 'physic', and 'philosophy') and on the bio-bibliographical information offered in the *Dictionary*, which often presents summaries of the content and character of the author's main works.

- (3) *Author-publications ratio: one publication per author.* I included only one title per author in order to reduce distortions in the results that might depend on the over-representation of the position of a single author due to the relatively greater availability of his publications. When more than one work per author was available, I selected the title that fit better the other selection criteria listed here.
- (4) *Availability: Google Books.* To have access to digitalized versions of these texts, I relied on the rather large collection of these works that was available on Google Books (February 2017).

Based on these criteria, the final list of texts that compose my corpus is the following (see complete bibliographical details in the *Dictionary*):

Case	Publication Date	Title (shortened)	Author's surname	Affiliation
A	1607	<i>Partitiones physicae</i>	SNELLIUS	Leiden
B	1613	<i>Physicae, hoc est, naturalis philosophiae</i>	GUTBERLETH	Deventer
C	1615	<i>Institutiones physicae</i>	JACCHAEUS	Leiden
D	1620	<i>Exercitationes philosophicae</i>	GORLAEUS	Leiden
E	1631	<i>Idea philosophiae tum naturalis, tum moralis</i>	BURGERSDIJK	Leiden
F	1644	<i>Introductio ad physicam</i>	SENGUERD, A.	Amsterdam
G	1645	<i>Institutiones physicae</i>	KYPER	Leiden
H	1646	<i>Fundamenta physices</i>	REGIUS	Utrecht
I	1650	<i>Medulla physicae</i>	ISENDOORN	Harderwijk
J	1651	<i>Philosophia naturalis</i>	HOLWARDA	Franeker
K	1651	<i>Commentaria physica</i>	De MEY	Middelburg
L	1653	<i>Disputatio physica</i>	De BRUYN	Utrecht
M	1654	<i>Philosophia naturalis, moralis, rationalis</i>	HEEREBOORD	Leiden
N	1654	<i>Clavis philosophiae naturalis</i>	De RAEY	Leiden
O	1660	<i>Physica generalis</i>	SCHOOCK	Groningen
P	1664	<i>Physica</i>	CLAUBERG	Groningen
Q	1671	<i>Institutiones physicae</i>	GREYDANUS	Franeker
R	1680	<i>Philosophia naturalis</i>	SENGUERD, W.	Leiden
S	1681	<i>Disputationes philosophicae</i>	De VOLDER	Leiden
T	1688	<i>Compendium physicae</i> (ed. C. LANGENHERT)	GEULINX	Leiden
U	1695	<i>Physica sive de rebus corporeis</i>	Le CLERC	Amsterdam
V	1710	<i>Syntagma theologico-physico-metaphysicum</i>	ANDALA	Franeker
W	1727	<i>Principia philosophiae naturalis</i>	ODÉ	Utrecht
X	1736	<i>Introductio ad philosophiam, metaphysicam et logicam continens</i>	's GRAVESANDE	Leiden
Y	1748	<i>Institutiones physicae</i>	Van MUSSCHENBROEK	Utrecht

Let me add three remarks to this list.

First, although these titles represent only a relatively small selection of the long list of broadly relevant authors and titles that might be considered in a more ambitious and large-scale investigation,¹⁰ they offer an almost complete list with respect to authors of Latin textbooks or systematic treatises in natural philosophy during this period.¹¹

Second, chronologically speaking, the corpus spans from 1607 to 1748, with a certain concentration of titles in the central decades of the seventeenth century. This concentration does not necessarily introduce a bias since the period coincides with the first spreading of the Cartesian philosophy in the Dutch Republic. Independently of whether the higher number of publications produced in these decades is positively correlated with the debates surrounding Cartesian philosophy, it is relevant for the purposes of this current study to examine the texts from that period.

Third, this corpus does not create any obvious expectations about the validity of my working hypothesis. Since the corpus includes many authors who were close to scholastic positions (cases A, B, C, E, F, G, I-M), it does not suggest that 'new' mechanist positions will be dominant at all. The corpus also includes a number of Cartesian-friendly authors (cases H, N, P, S, T). It would be expected that these authors reject the cognition condition (M2a) or are silent on it (in line with Descartes' own rather dismissive attitude towards discussions of teleology in physics). Should this be the case, they would falsify my hypothesis (which assumes that authors tend to *accept* the cognition condition while rejecting the traditional art-nature distinction). Finally, insofar as the corpus includes a number of eighteenth-century texts (cases U-Y), it might be expected that they will show a decline of discussion of the art-nature distinction (which is very much entrenched within the late scholastic framework that should no longer be expected to be of much relevance in the eighteenth century). Given these considerations, the corpus does not suggest that the verification of my hypothesis is an obvious outcome.

¹⁰Based on the information contained in the *Dictionary*, approximately 89 authors and 235 titles would be relevant for broader research on the evolution of natural philosophy in general (and on the concept of 'nature' in particular) in the seventeenth and eighteenth-century Dutch context. The great majority of these texts are in Latin, although a few of them are in Dutch and French. At the time when I conducted this survey (February 2017), 69 authors and 136 titles out of this long-list were available online on Google Books.

¹¹Only six authors writing this genre of works are not included in my corpus because their works were not digitally available on Google Books when I conducted the inventory. These six authors are Gerard (1604–50) and Arnold (1606–53) Bootius (co-authors), Nicolaus Engelhard (1696–1765), Johannes Schulerus (1619–74), Rutger van Loenen (1623/4–72), Arnoldus Verhel (1583–1664), and Daniel Voet (1629–60). See bio-bibliographical details in the *Dictionary*.

3.2. Procedure for testing the hypothesis

In order to analyse the corpus, I combined an algorithmically-planned procedure with close reading. On the one hand, I used the model described in section two to design three queries that guided the analysis of each text of the corpus. On the other hand, I assessed the results of these queries by close reading of selected excerpts from each text.

Based on model M, I designed the following three queries:

Q1: does the text deny the cognition condition (M2a)?

Q2: does the text deny that natural beings have an internal principle of change (M1a)?

Q3: does the text deny the art-nature distinction (M1a-b)?

Let me briefly explain why these three queries are suitable to check my working hypothesis. The three queries are formulated in a negative way because my goal is to investigate a conceptual change occurring in the late scholastic conception of physical reality (as modelled by M). In all these queries, by 'denial', I mean that the relevant core notions in the model are dismissed or changed, or that the author argues that some of the conditions included in model M should be discarded. My working hypothesis supposes a relatively stronger tendency among early modern authors towards accepting the cognition condition (thus answering 'no' to Q1) while rejecting the idea that natural beings have an internal principle of change (thus answering 'yes' to Q2) and the traditional art-nature distinction (thus answering 'yes' to Q3 as well).

For each query, I attribute the following values:

+1= 'Yes'

+0,5 = Not explicit, but probably 'Yes'

0 = Missing evidence

-0,5 = Not explicit, but probably 'No'

-1= 'No'

This table of values is intended to allow a certain degree of flexibility in assessing results. I do not expect that all the relevant passages will be detected. An obvious reason for this is that a specific text might simply not deal with the relevant concept(s). Another more technical reason might be that, given the often low quality of the OCR used for this study, the search for keywords associated with each model could not capture all the relevant instances. However, this problem is somewhat compensated for by the fact that I do not focus on the frequency of words or concepts *within* a single

text. Rather, I take one instance in the whole text to be sufficient to answer the query for that text considered as a unit. My assumption is that, if a relevant notion is discussed more than once, the procedure should be able to capture at least one of its occurrences. Also, a close reading might reveal only indirect or implicit support to answer affirmatively or negatively to a specific query. This 'indirect' support is assessed on the basis of interpretation and contextual reconstruction that goes obviously beyond a bare keywords search. For instance, I discarded occurrences of keywords that were framed in the context of quotes from other texts or refutations of other authors, and thus were not representative of the ideas of the author of the text under analysis. Although sometimes an explicit answer to a query is missing, different related passages can be taken to be indicative of the author's position.

The procedure I implemented to analyse each case of the corpus was articulated as four steps. For each query, the whole procedure was iterated in the same way. Cases were analysed in chronological order. The procedure is the following:

Step 0. Defining the working dictionary used for the search: keywords are assigned to core and marginal notions involved in the query. The dictionary is adjusted at each new iteration based on previous cases examined.¹²

Step 1. Retrieval of the text (conducted online on Google books).

Step 2. Concordancing of the core terms (taken as keywords) with their marginal terms (taken as context words).

Step 3. Locating the textual excerpts that most explicitly appear to verify or falsify each query. Double-check occurrences of the key terms to verify whether the text contains any further passage that conveys a different meaning or position (these different meanings are taken into account in step 4).

Step 4. Assessing, by means of close reading, whether the excerpts answer the query positively or negatively.

Before implementing this procedure on my corpus, I tested it in two paradigmatic cases. This allowed me to compare the results obtained by my method and those which ought to be expected in light of existing scholarship. Using these two test cases I also designed a spectrum of possible scenarios in which the cases included in my corpus could be classified.

¹²The dictionary I generated for this study is presented in the Appendix. However, larger-scale studies that incorporate more advanced techniques would benefit from balancing this top-down approach with bottom-up methods and so enhancing the appropriateness of the working dictionary and the possibility for serendipitous discovery. See, on this point, Betti and van den Berg, 'Modelling the History of Ideas'. New digital tools are currently under development for the reconstruction and study of conceptual vocabulary: see van Wierst et al., 'Phil@Scale'; De Bolla et al., 'Distributional Concept Analysis'.

3.3. Test cases and spectrum definition

Betti and van den Berg ('Towards a Computational History of Ideas') argue that models need to be preliminarily tested against the results obtained by traditional scholarship in order to secure the meaningfulness of the results that they produce. I agree with this methodological recommendation. To test my model, I implemented it in the case of two specific authors: Suárez and Descartes. They are not part of my corpus, but there is significant scholarly consensus about their relevance for shaping the debate among Dutch university professors (which constitute the main population of my study).

Suárez is recognized as one of the most influential late scholastic authorities, especially for early modern authors (Carraud, *Causa sive ratio*, Hattab, *Descartes on Forms and Mechanisms*). Moreover, there is evidence that his works shaped Dutch early modern scholasticism too (van Ruler, 'Franco Petri Burgersdijk and the case of Calvinism within the Neo-Scholastic Tradition'). On the contrary, Descartes is one of the iconic figures usually associated with the Scientific Revolution and the mechanization of nature. Moreover, it is also widely acknowledged that Descartes' thought was widely debated in the Dutch Republic (Schmaltz, *Early Modern Cartesianisms*). I used these two authors as representative of 'traditional' views (Suárez) and 'non traditional' views (Descartes). It goes without saying that labels such as 'traditional' and 'non traditional' are here employed only as conventional shorthand and bear no normative value.

I analysed Suárez's *Metaphysical Disputations* and Descartes' *Principles of Philosophy*. The results I obtained can be summarized as follows:

Suárez:¹³ Q1 = -1; Q2 = -1; Q3 = -1

Descartes:¹⁴ Q1 = 0; Q2 = +1; Q3 = +1

Results obtained in Suárez's case confirm that he defends the traditional late scholastic conception of physical reality introduced at the beginning of section two. The fact that Q1 receives a negative answer means that Suárez is committed to the cognition condition (M2a). The fact that Q2 and Q3 receive negative answers entails that Suárez *does not* dismiss the traditional notion of nature as having an internal principle of change (M1a) and that he does not blur the art-nature distinction (M1a-b). Results obtained in the case of Descartes regarding Q2 and Q3 confirm that he rejects the traditional idea of nature (vs. M1a) and explicitly reduces natural beings to a kind of artificial being (vs. M1a-b). In the text considered, Descartes does not *explicitly*

¹³References for results (DM= *Metaphysical Disputations*, in *Opera*, voll. 25–26): Q1, see DM23.7.2 (value -1); Q2 see DM23.10.3 (value -1); Q3 see DM15.2.8 (value -1).

¹⁴References for results (PP= *Principles of Philosophy*, in *Oeuvres*, vol. 8): Q1, see PP I.28 (value 0); Q2 see PP II.37 (value +1); Q3 see PP IV.203 (value +1).

dismiss the cognition condition, nor does he accept it (so the text is not conclusive concerning M2a).¹⁵

Given the setting of the investigation, results can be presented in two ways. First, it is possible to simply represent the results for each query obtained in each case. Second, it is possible to calculate an 'absolute' result for each case, which is the arithmetic sum of the results obtained by the three queries. This absolute result can be used to represent how the case under scrutiny is located in a spectrum. The absolute results for my two test cases are the following:

$$\text{Suárez: } (Q1 = -1) + (Q2 = -1) + (Q3 = -1) = -3$$

$$\text{Descartes: } (Q1 = 0) + (Q2 = +1) + (Q3 = +1) = +2$$

Taking Suárez and Descartes as test cases, it is possible to suppose that a full-blown mechanist would also explicitly deny M2a ($Q1=+1$), and thus would assume an absolute value close to +3. This value would locate full-blown mechanist at the opposite of Suárez's position on the spectrum of possible conceptual options. However, more positions can be envisaged between Suárez and Descartes assuming that only one query is positive, or that two queries are positive and one negative. Cases in which only one query is positive bear greater resemblance with the traditional late scholastic conception of physical reality, although they also entail some alteration of it. For this reason, I label them 'Eccentric Late Scholasticism' (in the sense of non-standard). Cases in which two queries are positive suggest that only a few aspects of the traditional scenario remain in place, although they do not fully depart from it. I label these cases 'Moderate Mechanism'.

The table here below summarizes how the different combinations of answers to each query delineate different scenarios. I present here only clear-cut values, but I shall treat non-integer values ($\pm 0,5$) depending on their positive or negative connotation.

Q1	Q2	Q3	Absolute Value	Scenario	Relation to WH
-1	-1	-1	-3	Traditional Late Scholasticism (Suárez's case)	No relevant change
+1	-1	-1	-1	Eccentric Late Scholasticism A	No relevant change
-1	+1	-1	-1	Eccentric Late Scholasticism B	Confirms WH
-1	-1	+1	-1	Eccentric Late Scholasticism C	Confirms WH
-1	+1	+1	+1	Moderate Mechanism A	Confirms WH
+1	-1	+1	+1	Moderate Mechanism B	Contrasts WH
+1	+1	-1	+1	Moderate Mechanism C	Contrasts WH
0	+1	+1	+2	Cartesian Mechanism (Descartes's case)	Contrasts WH
+1	+1	+1	+3	Full-blown Mechanism	Contrasts WH

¹⁵Schmaltz, 'Descartes' Critique of Scholastic Teleology' argues that Descartes' considered view in the *Meditations* remains closer to Aristotle and ultimately dismisses the cognition condition. Concerning Descartes' account see also Simmons, 'Sensible Ends: Latent Teleology in Descartes'.

My working hypothesis assumes that, over time, if Q1 is negative (i.e. the author under examination does *not* deny the cognition condition), Q2 or (inclusive) Q3 tend to assume positive values (i.e. the author denies that natural beings have an internal principle of change, or he denies the art-nature distinction as a whole). This means that authors that confirm my hypothesis fall into the Eccentric Late Scholasticism B and C (−1) and Moderate Mechanism A (+1) scenarios. Authors that fall into the Moderate Mechanism B or C scenarios or into Cartesian or Full-blown Mechanism scenarios contrast my hypothesis because they deny that natural beings have internal principles of change (M1a) or the art-nature distinction (M1a-b) *without* accepting the cognition condition (M2a). My hypothesis would be verified if the analysis of the corpus detects a relatively greater frequency of cases that confirm it, and it would be falsified in the case of a relatively greater frequency of cases that contrast it.

3.4. Results obtained

My results are summarized in the following table (see the Appendix for textual excerpts for each case):

Case	Date	Q1	Q2	Q3	Absolute result	Scenario
A	1607	−0,5	−1	−1	−2,5	Traditional Late Scholasticism
B	1613	+0,5	−1	−1	−1,5	Eccentric Late Scholasticism A
C	1615	−1	−1	−1	−3	Traditional Late Scholasticism
D	1620	+0,5	−1	0	−0,5	Eccentric Late Scholasticism A
E	1631	−1	−1	−1	−3	Traditional Late Scholasticism
F	1644	−1	−1	−1	−3	Traditional Late Scholasticism
G	1645	−1	−1	−1	−3	Traditional Late Scholasticism
H	1646	−1	−1	+1	−1	Eccentric Late Scholasticism C
I	1650	+1	−1	−1	−1	Eccentric Late Scholasticism A
J	1651	−1	−1	+0,5	−1,5	Eccentric Late Scholasticism C
K	1651	−0,5	−1	−0,5	−2	Traditional Late Scholasticism
L	1653	−0,5	+1	+0,5	+1	Moderate Mechanism A
M	1654	−1	−1	−1	−3	Traditional Late Scholasticism
N	1654	−1	+1	+0,5	+0,5	Moderate Mechanism A
O	1660	−1	−1	−1	−3	Traditional Late Scholasticism
P	1664	−1	−0,5	+1	−0,5	Eccentric Late Scholasticism C
Q	1671	−0,5	+1	+0,5	+1	Moderate Mechanism A
R	1680	0	+1	+0,5	+1,5	Cartesian Mechanism
S	1681	−1	+1	+0,5	+0,5	Moderate Mechanism A
T	1688	−1	+1	+1	+1	Moderate Mechanism A
U	1695	−1	0	−1	−2	Traditional Late Scholasticism
V	1710	−1	+1	+0,5	+0,5	Moderate Mechanism A
W	1727	−0,5	−1	−0,5	−2	Traditional Late Scholasticism
X	1736	+0,5	+0,5	−0,5	+0,5	Moderate Mechanism C
Y	1748	+0,5	−0,5	−0,5	−0,5	Eccentric Late Scholasticism A

I shall analyse these results in three steps. I first discuss the aggregate of the absolute results, which only gives an impression of the absolute amount of traditional versus non traditional positions in the whole corpus. Then, I present the same absolute results in chronological order. These two ways

of representing the results do not take into account the specific answers to the different queries. For this reason, these ways of representing the results do not directly contribute to either verifying or falsifying my working hypothesis. Nonetheless, they are interesting insofar as they provide an overview of the degree of conceptual change that my approach detected in the corpus and its distribution over time. Finally, I present the split results for each query in order to check whether they verify or falsify my working hypothesis.

The aggregate of the absolute results is presented in the following diagram (Figure 1).

When Eccentric Late Scholasticism scenarios were included among non traditional scenarios, my model detected a high rate (60%) of non traditional texts (i.e. cases in which absolute results are equal or above $-1,5$). This suggests not only that the corpus includes both traditional and non traditional cases, but also that the model and the procedure implemented are able to detect and distinguish among them.

Figure 1 shows that the majority of authors who constitute the corpus introduce at least some conceptual changes to the late scholastic conception of physical reality. However, absolute results read without reference to chronology cannot be used to analyse a conceptual drift, which occurs in time. If distributed chronologically, the absolute results appear as in the following diagram (Figure 2).

The diagram shows that the distribution between the traditional (lower than $-1,5$) and non traditional (equal or higher than $-1,5$) approaches

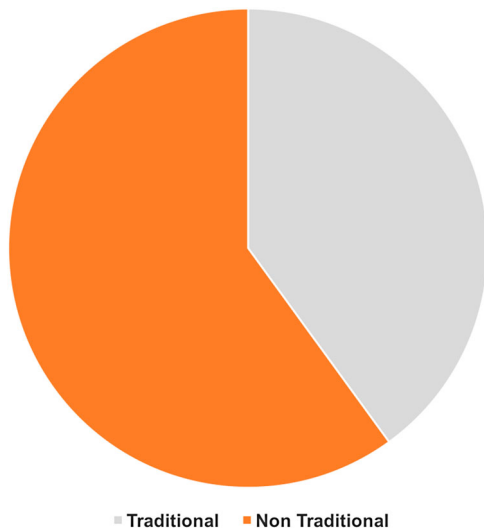


Figure 1. Aggregate absolute results.

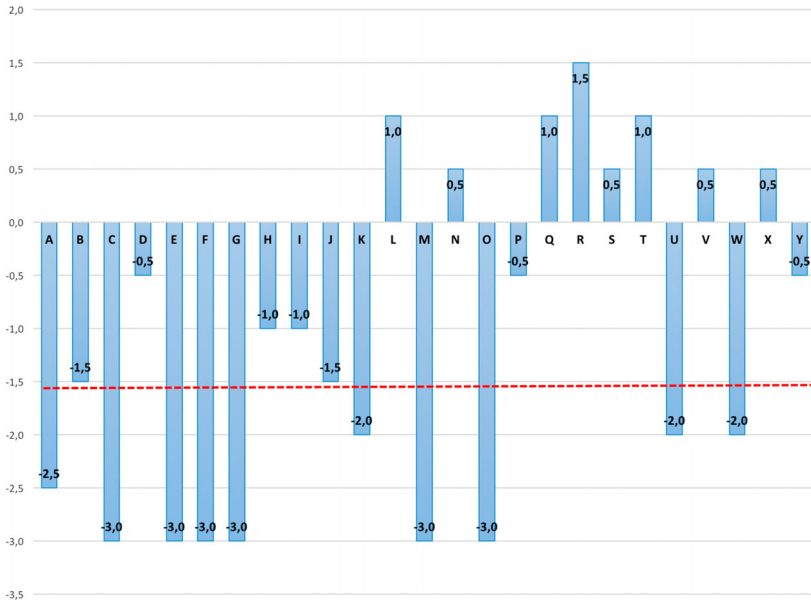


Figure 2. Absolute results over time.

varies significantly over time. Traditional approaches were dominant in the first half of the seventeenth century (cases A-G), then they became a minority in the second half of the century (cases H-U), and finally an exception in the first half of the eighteenth century (cases V-Y). This result shows that, despite the ‘continuity’ with the previous period defended by some current scholarship, early modern natural philosophy demonstrates a progressive decline of traditional positions, at least as far as the late scholastic conception of physical reality is concerned.

The analysis of the split results obtained for each query suggests further insights. Consider the next diagram (Figure 3).

There are only five cases (B, D, I, X and Y) in which Q1 has a positive value, namely, in which the cognition condition (M2a) is denied. The diagram shows that the great majority of cases (76%) uphold the cognition condition. This means that, independently of how traditional or non traditional each case might be, the acceptance of the cognition condition remains relatively constant across the whole corpus.

The acceptance of the cognition condition does not necessarily entail a dismissal of the art-nature distinction. However, when such a dismissal emerges (cases H, J, L, N, P, Q, R, S, T, V, and X, namely 44% of the whole corpus) it is significantly more frequently associated (82% of the cases in which the art-nature distinction is dismissed) with cases in which the cognition condition is in place (cases H, J, L, N, P, Q, S, T and V). Only rarely (cases R and X), a

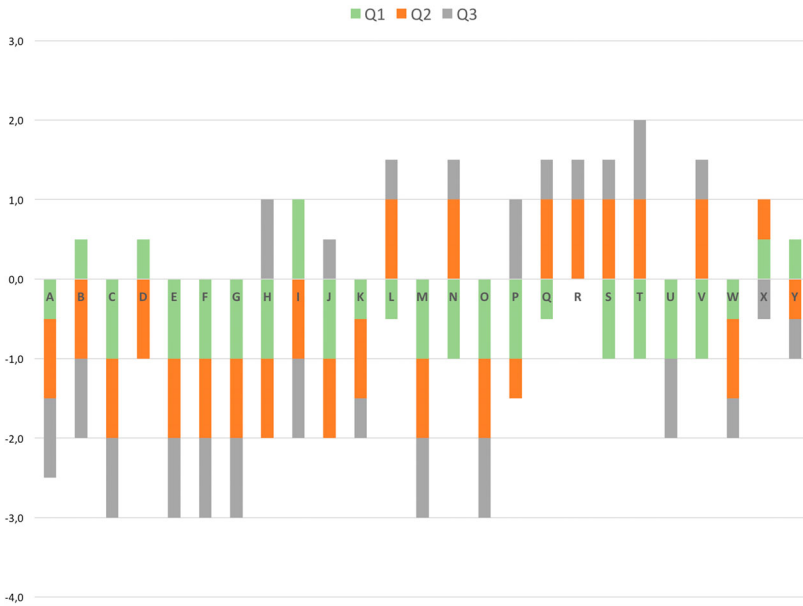


Figure 3. Split queries results.

rejection of the art-nature distinction occurs together with a denial (or simply a bracketing) of the cognition condition. This outcome is in line with what my hypothesis predicted.

The following diagram (Figure 4) provides further support to my hypothesis by showing the relative number of cases per scenario based on absolute results.

As mentioned in the previous section, my hypothesis is verified if the greatest number of non traditional cases falls within the Eccentric Late Scholasticism B and C or Moderate Mechanism A scenarios. As the diagram shows, this is in fact the case.

The implementation of the model approach offers a new way of quantifying and studying elements of continuity and discontinuity between late scholastic and early modern natural philosophy. My results support the idea that there is some significant discontinuity between early modern natural philosophy and the traditional understanding of the art-nature distinction, since they indicate that this traditional position gets progressively marginalized during the period. Nonetheless, they also show that this transformation is supported 'from within' the traditional framework. Insofar as authors were committed to preserving the cognition condition (M2a), the acceptance of a new 'mechanical' understanding of nature (which rejects at least part of M1) became a viable solution to the problem nestled in the late scholastic conception of physical reality (M).

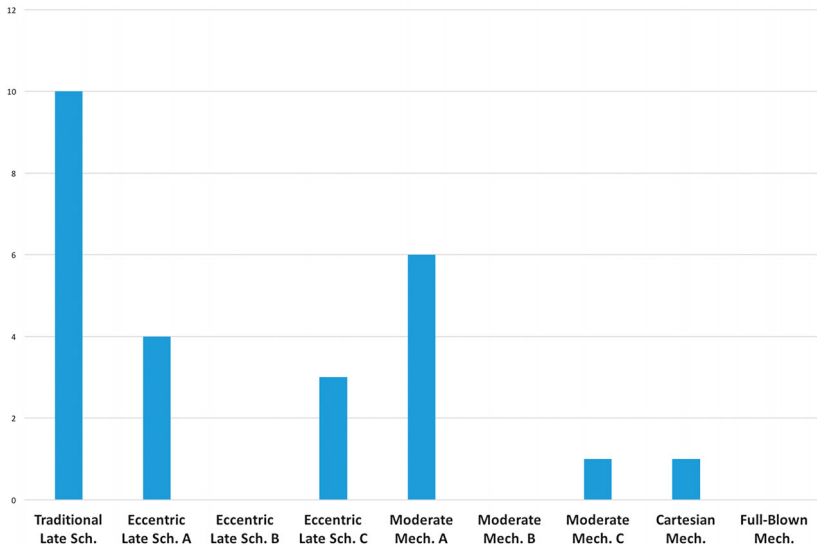


Figure 4. Absolute results per scenario.

Before moving any further, let me defuse a major (plausible) objection to my interpretation of the results that I collected. The fact that the cognition condition (M2a) remains quite constantly upheld across the corpus might be interpreted as a sign that it is some sort of left over from the late scholastic tradition. While other elements (the idea that natural beings have an internal principle of change and the art-nature distinction) change, that particular aspect of the traditional framework (M2a) simply remains in place. After all, conceptual change does not have to be radical or abrupt and there might be conceptual elements that are more resistant to alteration. On this basis, one might contend that the results I obtained concerning Q1 do not necessarily mean that the change in the art-nature distinction *conceptually depends* on the cognition condition for the reasons suggested by my working hypothesis. The cognition condition might be a background claim that is not affected (for whatever other reasons) by such a change. In other words, one might object that the dismissal of the traditional art-nature distinction (M1a-b) is conceptually independent from the acceptance of the cognition condition (M2a).

In this study, however, I did not randomly pick two elements and then claim that they are conceptually dependent on the basis of my results. Both the cognition condition (M2) and the art-nature distinction (M1a-b) are an integral component of the late scholastic conception of physical reality as I presented it in section two. My hypothesis can be proved to be *wrong* by showing that the trend it supposes (i.e. that authors are more likely to dismiss the art-nature distinction than the cognition condition) does not

capture an actual historical pattern in the corpus. For instance, the examination of the texts might have shown that historical authors rather tended to dismiss the cognition condition (as foreseen in the Moderate Mechanism B and C scenarios). Some existing scholarship maintains, in fact, that the dismissal of the art-nature distinction goes hand in hand with the dismissal of the use of teleological arguments and final causes in the natural domain (Shapin, *The Scientific Revolution*, 135–161; Gaukroger, *The Emergence of a Scientific Culture*, 457–471). However, my analysis reveals that this is not the most *prevalent* attitude in the corpus I examined (although it is not completely absent either, see cases R and X).

The topic of the definition of nature and that of final causes were not remote and mutually independent provinces in the system of natural philosophy. Aristotle himself introduced both in the very first chapters of the second book of his *Physics*. The whole commentary tradition that followed was very well aware of the conceptual connection between these two topics. It is thus historically and philosophically plausible to expect that the discussion of what allows agents to act for an end also affects the discussion of what a natural being is and how it operates. I do acknowledge that historical authors might not have phrased the conceptual tension that I discussed in this study as explicitly as I presented it in my model. However, making explicit conceptual implications that are arguably nestled (and otherwise overlooked) in historical materials is one of the chief tasks of the historian and, in this respect, the model approach is a resourceful methodological tool to achieve it.

4. Agenda for future research

This study aimed to show both the fruitfulness and the feasibility of the implementation of the model approach in the domain of the history of early modern philosophy and science. In conclusion, let me point out three main ways in which my initial results corroborate this contention.

First, my study shows that the model approach does indeed have the potential to extend the validity of historical hypotheses to corpora that have not been fully investigated yet by existing scholarship (such as the authors I considered for this study). This point is particularly important. Today there is a growing debate about the issues raised by the canon of Western philosophy and its inclusiveness and representativeness (Shapiro, 'Revisiting the Early Modern Philosophical Canon'; Beaney, 'Twenty-Five Years of the British Journal for the History of Philosophy'). The methodology used by philosophers and historians has an impact on their ability to overcome the narrowness of the established Western canon. Traditional research in the history of philosophy and science is mostly based on close reading. Despite its strengths (such as philosophical and philological accuracy, fine-grained analysis and historical sensibility),

close reading alone makes it difficult to study and investigate large and still unstudied corpora. Moreover, close reading requires framing the relevance of individual cases within broader narratives (Henry, 'Essay Review. The Scientific Revolution', 817). Yet these narratives are most commonly based on generalizations drawn from small-scale inquiries. These small-scale inquiries are often based on the interpretation of canonical or already well-researched figures. What's more, such inquiries often do not make clear how and to what extent they are representative of broader historical trends. For this reason, close reading by itself raises the risk of unduly subsuming not-yet studied figures within already established narratives inspired by more canonical texts and authors.

The model approach is a good antidote to the risks and limitations of relying on close reading alone. The hypothesis I aimed to confirm (i.e. that acceptance of the cognition condition is positively correlated with a greater likelihood of dismissing the art-nature distinction) was at odds with the established narrative about the seventeenth-century mechanization of nature (according to which early modern *novatores* would dismiss both the art-nature distinction and the cognition condition). Initial expectations about the composition of my corpus suggested that results would in fact have *contradicted* my hypothesis. And yet, the use of the model approach lent support to my hypothesis. In this respect, the model approach challenges the way in which historians project their expectations on not-yet-studied corpora on the basis of the case studies with which they are already familiar.

Second, the model approach confirms *some* of the results obtained by traditional scholarship concerning the early modern 'mechanization' of nature, especially the fact that early modern constructions are better understood against the background of late scholastic thought (Hattab, *Descartes on Forms and Mechanisms*; Sgarbi, *The Aristotelian Tradition and the Rise of British Empiricism*). However, my results also call for a more balanced rethinking of the discontinuities between this late scholastic background and the early modern developments of natural philosophy. While my study confirms that it is difficult to sharply oppose traditional and innovative authors, it also shows that around the mid-seventeenth century certain important tenets of the traditional scholastic framework got progressively rejected or transformed. Today's scholarship (Garber, 'Remarks on the Pre-History of the Mechanical Philosophy', 'Why the Scientific Revolution Wasn't a Scientific Revolution, and Why It Matters') offers a wealth of evidence of the fact that traditional scholastic views were under attack on many different fronts and in many different ways. Nonetheless, my results suggest that preferences were not equally distributed across all the possible philosophical positions and scenarios but that *some* alternatives had significantly more followers than others. The model approach brings an interesting historical and

philosophical layer to this investigation by raising the following urgent research questions: *why* did historical authors accept *certain* transformations in the traditional framework instead of others? Why did they prefer to preserve *certain* tenets (e.g. the cognition condition) instead of others (e.g. the art-nature distinction)?

Consider again, for instance, the distribution of cases per scenario captured in Figure 4. This result is somewhat puzzling insofar as it shows that 7 out of 17 cases that could be broadly described as late scholastic are not aligned with the most traditional version of the late scholastic position. Eccentric Late Scholasticism A (4 instances) denies the cognition condition, thus showing the survival of positions that are in fact closer to that of Aristotle himself in the early modern period. Eccentric Late Scholasticism C (3 cases) instantiates a somewhat bizarre hybrid view, in which the art-nature distinction is weakened while the general understanding of nature is not. From a merely conceptual point of view, this position is puzzling because it is seemingly inconsistent. Yet it should provoke historians to further investigate *why* this form of Eccentric Late Scholasticism was favoured over its parallel alternative (Eccentric Late Scholasticism B), which has not been detected at all in the corpus considered here. Looking at authors who defended versions of a mechanical natural philosophy, it would be worth investigating *why*, from a historical point of view, Moderate Mechanism A (rather than its rival scenarios) aggregated most of the consensus. In this respect, the model approach is a powerful heuristic tool which can be used to further investigate the genuine complexities of historical debates.

Third, since the model approach draws attention to the *frequency* with which certain views are instantiated in a given corpus, it calls for the use of more refined quantitative tools capable of analysing this frequency and identifying patterns in the spreading and transformation of ideas across time and space. There is no question that historians and philosophers should continue to practice and cultivate close reading. However, I have argued that the model approach can significantly enhance and complement close reading and more traditional methodological approaches. How to best develop this suggestion remains an open topic for future investigations and trials. It would be necessary to develop strategies to study how certain positions become progressively accepted and regarded as standard or 'normal' positions within certain communities. It would also be crucial to find ways to assess the socio-political factors that shaped these patterns and study the co-evolution of social and conceptual elements. While the model approach, by itself, does not solve these problems, it forcefully draws attention to their importance for a better and more nuanced understanding of the complex historical dynamics that shaped the emergence of early modern natural philosophy. In turn, developing tools for dealing with these problems would lead to a better integration of quantitative approaches in the toolkit of the historians of early modern philosophy and science.

Acknowledgments

This paper is part of my NWO Veni research grant *Occasionalism and the secularization of early modern science: Understanding the dismissal of divine action during the scientific revolution*, which I run at the Faculty of Philosophy at the University of Groningen. I would like to thank Han Thomas Adriaenssen, Bianca Bosman, Elisabetta Cattanei, Torin Doppelt, Laura Georgescu, Martin Lenz, Jeff McDonough, Tamer Nawar and Doina-Cristina Rusu, for helpful discussions and insightful comments on various versions of this paper.

Supplementary material

The online Appendix can be accessed at <https://doi.org/10.1080/09608788.2018.1506313>.

Funding

This work was supported by Nederlandse Organisatie voor Wetenschappelijk Onderzoek [grant number Veni grant 275-20-051].

Bibliography

- Ariew, Roger. *Descartes and the First Cartesians*. New York: Oxford University Press, 2014.
- Aristotle. *The Complete Works of Aristotle*, edited by Jonathan Barnes. Vol 1. Princeton: Princeton University Press, 1984.
- Beaney, Michael. 'Twenty-Five Years of the British Journal for the History of Philosophy'. *British Journal for the History of Philosophy* 26, no. 1 (2018): 1–10.
- Betti, Arianna, and Hein van den Berg. 'Modelling the History of Ideas'. *British Journal for the History of Philosophy* 22, no. 4 (2014): 812–835.
- Betti, Arianna, and Hein van den Berg. 'Towards a Computational History of Ideas'. In *Proceedings of the Third Conference on Digital Humanities in Luxembourg with a Special Focus on Reading Historical Sources in the Digital Age. CEUR Workshop Proceedings, CEUR-WS.org.*, edited by L. Wieneke, C. Jones, M. Düring, F. Armaselu, and R. Leboutte, vol. 1681, 2016.
- Bluhm, Roland. 'Corpus Analysis in Philosophy'. In *Evidence, Experiment and Argument in Linguistics and the Philosophy of Language*, edited by M. Hinton, 91–109. Bern: Peter Lang, 2016.
- Butterfield, Herbert. *The Origins of Modern Science*. London: Bell, 1957.
- Carlin, Laurence. 'Boyle's Teleological Mechanism and the Myth of Immanent Teleology'. *Studies in History and Philosophy of Science Part A* 43, (2012): 54–63.
- Carraud, Vincent. *Causa sive ratio: la raison de la cause, de Suarez à Leibniz*. Paris: Puf, 2002.
- Craig, Martin. *Subverting Aristotle. Religion, History, and Philosophy in Early Modern Science*. Baltimore: John Hopkins University Press, 2014.
- De Bolla, Peter, Ewan Jones, Paul Nulty, Gabriel Recchia, and John Regan. 'Distributional Concept Analysis: A Computational Model for Parsing Conceptual Forms'. *Contributions to the History of Concepts* forthcoming 2019.

- [de Gois, Manuel]. *Commentarii Collegii Conimbricensis Societatis Iesu In octo Libros Physicorum Aristotelis Stagiritae*. Reprint, Hildesheim: Georg Olms Verlag, 1984 [1593].
- De Jong, Willem, and Arianna Betti. 'The Classical Model of Science: A Millennia-Old Model of Scientific Rationality'. *Synthese* 174, no. 2 (2010): 185–203.
- Des Chene, Dennis. *Physiologia. Natural Philosophy in Late Aristotelian and Cartesian Thought*. Ithaca and London: Cornell University Press, 1996.
- Descartes, René. *Oeuvres*, edited by C. Adam and P. Tannery, co-eds. J. Beaudé, P. Costabel, A. Gabbey and B. Rochot, 11 Vol. Paris: Vrin, 1964–1974.
- Dijksterhuis, Eduard. *De mechanisering van het wereldbeeld*. Amsterdam: Meulenhoff, 1950.
- Duchesneau, François. *Les modèles du vivant de Descartes à Leibniz*. Paris: Vrin, 1998.
- Ducheyne, Steffen, and Jip van Besouw. 'Newton and the Dutch "Newtonians": 1713–1750.' In *The Oxford Handbook of Newton*, edited by E. Schliesser and C. Smeenk. Oxford: Oxford University Press, 2017. doi:10.1093/oxfordhb/9780199930418.013.20.
- Garber, Daniel. 'Remarks on the Pre-History of the Mechanical Philosophy'. In *The Mechanization of Natural Philosophy*, edited by D. Garber and S. Roux, 3–26. Dordrecht-Heidelberg-New York-London: Springer, 2013.
- Garber, Daniel. 'Why the Scientific Revolution Wasn't a Scientific Revolution, and Why It Matters.' In *Kuhn's Structure of Scientific Revolutions at Fifty: Reflections on a Science Classic*, edited by R. J. Richards and L. Daston. Oxford: Oxford University Press, 2016. doi:10.7208/chicago/9780226317175.001.0001.
- Gaukroger, Stephen. *The Emergence of a Scientific Culture. Science and the Shaping of Modernity. 1210–1685*. Oxford: Oxford University Press, 2006.
- Gaukroger, Stephen. *The Collapse of Mechanism and the Rise of Sensibility. Science and the Shaping of Modernity. 1680–1760*. Oxford: Oxford University Press, 2010.
- Hattab, Helen. *Descartes on Forms and Mechanisms*. Cambridge: Cambridge University Press, 2009.
- Henry, John. 'Essay Review. The Scientific Revolution: Five Books About It'. *Isis* 107, no. 4 (2016): 809–817.
- Koyré, Alexandre. *From the Closed World to the Infinite Universe*. Baltimore: The Johns Hopkins Press, 1957.
- Krop, Henri. 'Medicine and Philosophy in Leiden Around 1700: Continuity or Rupture?' In *The Early Enlightenment in The Dutch Republic 1650-1750*, edited by Wiep van Bunge, 173–96. Leiden-Boston: Brill, 2003.
- Kuukkanen, Jouni-Matti. 'Making Sense of Conceptual Change.' *History and Theory* 47, no. 3 (2008): 351–72.
- Laird, Walter Roy and Sophie Roux, eds. *Mechanics and Natural Philosophy Before the Scientific Revolution*. Dordrecht: Springer, 2008.
- Laubichler, Manfred D., Jane Maienschein, and Jürgen Renn. 'Computational Perspectives in the History of Science: To the Memory of Peter Damerow'. *Isis* 104, no. 1 (2013): 119–130.
- Leijenhorst, Cees, and Christoph Lüthy. 'The Erosion of Aristotelianism. Confessional Physics in Early Modern Germany and The Dutch Republic'. In *The Dynamics of Aristotelian Natural Philosophy From Antiquity to the Seventeenth Century*, edited by Cees Leijenhorst, Christoph Lüthy, and J. M. M. H. Thijssen, 375–411. Leiden-Boston: Brill, 2002.
- Leijenhorst, Cees, Christoph Lüthy, and J. M. M. H. Thijssen. 'The Tradition of Aristotelian Natural Philosophy. The Theses and Seventeen Answers.' In *The Dynamics of*

- Aristotelian Natural Philosophy From Antiquity to the Seventeenth Century*, edited by Cees Leijenhorst, Christoph Lüthy, and J. M. M. H. Thijssen, 1–30. Leiden-Boston: Brill, 2002.
- Pasnau, Robert. 'Intentionality and Final Causes.' In *Ancient and Medieval Theories of Intentionality*, edited by Dominik Perler, 301–323. Leiden: Brill, 2001.
- Penner, Sydney. 'Final Causality: Suárez on the Priority of Final Causation.' In *Suárez on Aristotelian Causality*, edited by J. L. Fink, 121–48. Leiden: Brill, 2015.
- Polonioli, Andrea. 'A Plea for Minimally Biased Empirical Philosophy.' [Preprint] <http://philsci-archive.pitt.edu/12890/>.
- Ruestow, Edward G. *Physics at Seventeenth- and Eighteenth-Century Leiden: Philosophy and the New Science in the University*. The Hague: Martinus Nijhoff, 1973.
- Rupert Hall, Alfred. *The Scientific Revolution, 1500–1800: The Formation of the Modern Scientific Attitude*. Boston: Beacon Press, 1966.
- Sangiaco, Andrea. 'Aristotle, Heereboord and the Polemical Target of Spinoza's Critique of Final Causes', *Journal of the History of Philosophy* 54, no. 3 (2016): 395–420.
- Schmaltz, Tad. *Early Modern Cartesianisms: Dutch and French Constructions*. New York: Oxford University Press, 2016.
- Schmaltz, Tad. 'Descartes' Critique of Scholastic Teleology.' In *The Modern Turn*, edited by Michael Rohlf, 54–73. Washington, DC: The Catholic University of America Press, 2017.
- Schmid, Stephan. 'Teleology and the Dispositional Theory of Causation in Thomas Aquinas.' *Logical Analysis and History of Philosophy* 14 (2011): 21–39.
- Schmitt, Charles B. *Aristotle and the Renaissance*. Cambridge, MA: Harvard University Press, 1983.
- Sgarbi, Marco. *The Aristotelian Tradition and the Rise of British Empiricism. Logic and Epistemology in the British Isle (1570–1689)*. Dordrecht: Springer, 2013.
- Shapin, Steven. *The Scientific Revolution*. Chicago and London: The University of Chicago Press, 1996.
- Shapiro, Lisa. 'Revisiting the Early Modern Philosophical Canon'. *Journal of the American Philosophical Association* 2, no. 3 (2016): 365–383.
- Shenghui, Wang, Stefan Schlobach, and Michel Klein. 'Concept Drift and How to Identify it'. *Web Semantics: Science, Services and Agents on the World Wide Web* 9, (2011): 247–265.
- Simmons, Alison. 'Sensible Ends: Latent Teleology in Descartes' Account of Sensation'. *Journal of the History of Philosophy* 39, no. 1 (2001): 49–75.
- Suárez, Francisco. *On Efficient Causality. Metaphysical Disputations 17, 18 and 19*. Translated by A. J. Freddoso. New Haven: Yale University Press, 1994.
- Suárez, Francisco. *Opera Omnia*. Paris: apud Ludovicum Vivès, 1856–1861.
- Van Bunge, Wiep. 'Philosophy.' In *W. Frijhoff and M. Spies with the Collaboration of W. Van Bunge and N. Veldhorst, Dutch Culture in a European Perspective. Vol. 1: 1650 Hard-Won Unity*, 281–348. Van Gorcum: Palgrave Macmillan, 2004.
- Van Bunge, Wiep, Henri Krop, Bart Leeuwenburgh, Han van Ruler, Paul Schuurman, Michiel Wielema. *The Dictionary of Seventeenth and Eighteenth-Century Dutch Philosophers*. Bristol: Thoemmes Press, 2003, vol. 2.
- Van Ruler, Han. 'Franco Petri Burgersdijk and the Case of Calvinism Within the Neo-Scholastic Tradition.' In *Franco Burgersdijk (1590–1635). Neo-Aristotelianism in Leiden*, edited by E. P. Bos and H. Krop, 37–65. Amsterdam-Atlanta: Rodopi, 1993.
- Van Ruler, Han. 'The Shipwreck of Belief and Eternal Bliss: Philosophy and Religion in Later Dutch Cartesianism'. In *The Early Enlightenment in The Dutch Republic 1650–1750*, edited by Wiep van Bunge, 109–136. Leiden-Boston: Brill, 2003.

- Van Wierst, Pauline, Sanne Vrijenhoek, Stefan Schlobach, and Arianna Betti. 'Phil@Scale: Computational Methods Within Philosophy'. *CEUR Workshop Proceedings*, 1681, 2016.
- Westfall, Richard. 'The Scientific Revolution of the Seventeenth Century: The Construction of a New World View.' In *The Concept of Nature*, edited by J. Torrance, 63–93. New York: Oxford University Press, 1992.
- Zinsser, Judith, ed. *Men, Women, and the Birthing of Modern Science*. DeKalb: Northern Illinois University Press, 2005.