

Robert Hooke's Baconianism

A Corpus-Based Study



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'For my name and memory, I leave it to men's charitable speeches, and to foreign nations, and the
next ages.'

Francis Bacon

'Now that I may not be mistaken in my Expressions, and that the Words I make use of, which are commonly used, but by various Men are understood to signify various and very differing Notions, I would willingly explain in what sense I understand them, and what Notions I would willingly have them to communicate, when made use of by me.'

Robert Hooke

1. Introduction

Robert Hooke was a philosopher who feared being misunderstood. For example, in a 1687 lecture, he confessed that it 'has been no small discouragement to my progress in explicating some Phaenomena of Nature by some new Hypotheses, to find that they have been misrepresented, or at least misunderstood or misconstru'd.'¹ Given the conflicting accounts of his written legacy that historians of science and philosophy have produced during the past centuries, it appears that Hooke's fears were not completely without ground. Even today, historians of science and philosophy are still trying to understand him. In this thesis, I contribute to our understanding of this remarkable actor in the history of early modern science by elucidating hitherto underexposed features of his methodology using computational tools to gather evidence from a wide range of his texts.

By contributing to our understanding of Robert Hooke, I do not mean adding to the wealth of literature that discusses Hooke's private and social life. There has been a plethora of studies about Hooke's involvement in London's coffeehouse culture, about the difficulties he faced being a Royal Society Fellow of 'lower' social standing, or even about the sexual escapades with his younger niece. One review article states that even if all such studies revealed indubitable truths about Hooke, they 'would tell us everything we needed to know about Hooke other than that which makes him interesting and important.'² Surely, such a statement is too blunt. It fails to appreciate the relevance of Hooke's social embedding in understanding him. Further, it fails to distinguish between the relevance of understanding Hooke's role within the Royal Society and knowing intimate details about his private life. Still, there is a serious imbalance between conceptual analyses of Hooke's writings and socio-cultural investigations into his persona or into the practical aspects of his work, and this imbalance becomes uncomfortable when one realizes that there are still gaps in our understanding of his views on scientific method. Hooke was an experimental philosopher with his own views on

¹ Hooke 1687d, 'Navigation and Astronomy Lecture (II)', 545.

² Lewis 2006, *Hooke at 371*, 570.

philosophical methodology, and these views cannot all be captured by studying his day-to-day life.

It has become commonplace to say that Hooke was an innovative scientist in the Baconian tradition.³ In this thesis I will address an issue with this commonplace, which is that even though quite some scholars have written about Hooke's Baconianism, we still do not have a complete view of what exactly his version of the Baconian method was. I have identified a cluster of difficulties that are to blame for giving rise to this issue. There is the aforementioned disproportionate fixation on Hooke as a juncture in early modern London's social and intellectual life. With this fixation, there has been a decrease in attention to the conceptual content of his writings. Restoring the balance is only a matter of focus. The other two difficulties are, I think, more serious, and need methodological considerations to be overcome.

As for the first difficulty: in analyzing scholarly writings on Hooke's methodology I have come to conclude that there are differing and sometimes incompatible criteria for what can be called 'Baconianism' implicit in these texts. For example, sometimes Hooke is compared with an anti-hypothetical Bacon⁴, while in a different text he is matched with a more theory friendly Bacon that allowed for hypothetical reasoning.⁵ In other places, Hooke is said to be a Baconian because he makes references to Bacon⁶, or because he copied Bacon completely.⁷ In one place he is called Baconian because he developed Bacon's method⁸, in another he deviates from Baconianism because he allegedly ignored induction.⁹ In none of these texts, it is sufficiently made clear how 'Baconianism' is to be understood, and the highlighting of certain aspects of the concept at the expense of equally

³ For example, Chapman (2005) writes that 'it goes without saying that Hooke was an experimentalist in the Baconian tradition' (Chapman 2005, *England's Leonardo*, 53). Shapin (1989) correctly states that Hooke did not refer to himself that often as a natural philosopher, let alone as a scientist, an anachronism that Shapin calls 'unfortunate but not necessarily vicious' (Shapin 1989, 'Who was Robert Hooke', 253). Be that as it may, Hooke uses other terms to refer to his work that indicate that he did think of himself as more than 'one of the surveyors of the City', or as 'Curator of Experiments to the Royal Society' (*Ibid.*). For example, he claimed to work on an overarching natural philosophical methodology called 'Philosophical Algebra', sometimes called his own type of natural history 'Philosophicall History', and the fact alone that he constantly engaged with and opposed great natural philosophers (e.g. Newton, Huygens, Kepler, and Brahe) indicates that he thought of himself as engaging in philosophy or science, whatever he and his contemporaries wished to call him. It is this Hooke that was studied in writing this thesis.

⁴ E.g. Drake 1996, *Restless Genius*, 69 & 81; Inwood 2002, *The Man Who Knew*, 15.

⁵ E.g. Sacco 2019, *Real, Mechanical, Experimental*, 36-37; Oldroyd 1972, 'Robert Hooke's Methodology', 120.

⁶ Espinasse 1956, *Robert Hooke*, 30-31.

⁷ Whewell 1847, *Inductive Sciences*, 267.

⁸ Hunter 2003, 'Natural Philosopher', 122; Centore 1970, *Contributions to Mechanics*, 93.

⁹ Malherbe 2006, 'Bacon's Method of Science', 75.

important other aspects conveys an air of arbitrariness.¹⁰ In projecting a complex concept such as ‘Baconianism’ onto philosophical texts, and in order to trace its development or constancy through these texts, I contend that the first step in doing so should be making one’s conceptual presuppositions as explicit as possible.

The second difficulty has to do with the fact that Hooke’s thoughts on methodology are dispersed throughout his texts. Except for his 1666 *General Scheme*, his main methodological work, no passages spanning more than a few paragraphs are fully dedicated to scientific method and these are scattered all over his works in various papers, lectures, and experimental reports.¹¹ This trait of Hooke presents a challenge to the historian of philosophy who wants to reconstruct Hooke’s methodology, especially since there is to date no complete collection of Hooke’s writings, let alone one that is easily accessible and searchable.

In providing remedies for these difficulties, I aim to contribute to the completion of our knowledge of Hooke’s Baconianism. Given the versatility of Bacon’s methodology, I cannot completely fill all gaps in that knowledge in this thesis. Fortunately, scholars that have paid attention to Hooke’s methodology have already highlighted some features that can be regarded as central to Baconianism, such as his views on the role of the senses (both naked and assisted) in obtaining natural knowledge¹², as well as the role of hypotheses in ascending the Baconian ladder.¹³ However, two aspects of Hooke’s Baconianism have been understudied and have naturally led to two subquestions that I address in this thesis. First, precisely what division between natural philosophy and natural history did Hooke envisage, and if there is such a distinction for Hooke, did it translate into distinct tasks for natural historians and philosophers? Second, to what extent did Hooke adopt or develop Bacon’s doctrine of the idols?

I answer these two questions by first tackling the aforementioned problems—the problem of non-conceptual focus, the problem of implicit, incompatible, and incomplete conceptions of ‘Baconianism’, and the problem presented by Hooke’s ‘dispersed meditations’ on method—by proposing conceptual, digital, and computational tools. First, I approach the question as a historian of ideas and use a novel methodology that facilitates fine-grained analysis of historical concepts on a large scale. Second, I construct a so-called ‘interpretive model’, along the lines of Betti & van den Berg’s ‘model approach’, in which what I take to be an uncontroversial perspective on Baconianism is made explicit.¹⁴ In such a model, a concept is represented as a network of subconcepts belonging to the

¹⁰ A welcome exception is Hunter (2003), who quite clearly states what he takes Baconianism to consist of before he starts comparing Hooke with Bacon (see section 2).

¹¹ Hunter 2003, ‘Natural Philosopher’, 109.

¹² Bennett 2003, ‘Hooke’s Instruments’, 63-67.

¹³ Oldroyd 1972, ‘Robert Hooke’s Methodology’, 145-163, Sacco 2019, *Real, Mechanical, Experimental*, 35-40.

¹⁴ Betti & van den Berg 2014, ‘Modelling the History of Ideas’, 818-821.

modeled concept; in my case, subconcepts such as ‘natural history’, ‘particulars’, ‘theory’, and ‘false appearances’. And third, I build a comprehensive, high quality, digital corpus of Hooke’s texts, that can be searched using computational tools. Joining the three, by searching for Hooke’s expressions of concepts in a large corpus by querying clusters of search terms that relate to subconcepts in the model, I systematically collect a body of evidence that can be used to answer the two questions.

Answering these questions using the method presented here only partially answers the larger question of Hooke’s Baconianism. However, I think of the value and significance of my research more broadly. First, I contribute a comprehensive corpus of Hooke texts to the scholarly community and provide some suggestions on how to come up to the standards that make a corpus applicable in humanities research. Corpora that approach these standards are very rare and therefore quite valuable. As will become clear, the creation of such corpora is also an almost Augean labor that should not be underestimated. However, a corpus only has to be made once, while its benefits can be reaped as long as we choose to. Next to the corpus, another concrete deliverable of this thesis is the model of Baconian Natural Philosophical Methodology (BNPM), that can guide future research into what ‘Baconianism’ meant for other historical actors.

Further, I provide an operationalization of a promising methodology for studying the history of ideas. These operationalizations are scarce, and I hope successful applications promote its use and development.¹⁵ The history of ideas in general has been in some disrepute since some objections have been leveled at its method. First, it is noted that by treating ideas as monolithic units, historians of ideas have no means of contextualizing ideas. In other words, by taking ideas to be unchanging over time historians fail to see different expressions of ideas in different periods or in texts by different authors.¹⁶ The second worry, which has been expressed in this introduction by myself, is that historians of ideas employ their personal perspectives on concepts, which makes for perspectival and arbitrary historiography.¹⁷ The answers are rather simple. First, by modeling concepts as having both stable parts (that remain fixed through time) and variable parts (that can differ in different contexts), concepts are made context sensitive.¹⁸ As for the second worry, given that there is no obvious way around perspectival historiography, the best way to ameliorate its effects is by making your analytical categories explicit.¹⁹

¹⁵ Published research in the history of ideas using a mixed method that combines qualitative and quantitative elements such as in this thesis includes: Betti et al. (2019), Sangiacomo (2019), and Betti et al. (2020).

¹⁶ Skinner 2002, *Regarding Method*, 62.

¹⁷ Skinner 2002, *Regarding Method*, 57-59.

¹⁸ Betti & van den Berg 2014, ‘Modelling the History of Ideas’, 816-817.

¹⁹ Ibid., 830.

The historiographical lacunae that I fill by shedding light on the underexposed features of Hooke's methodology should be seen as a small but welcome contribution to restoring the equilibrium between concept-focused scholarship and socio-cultural histories of knowledge. While this thesis is by no means intended to downgrade all work that has been done in the latter field, I think that Hooke's ideas as a philosopher, as a scientist, or as a thinker in general deserve at least equal attention.

But more importantly, with an incomplete picture of the impact of Bacon's methodology on Hooke's, we have an incomplete picture of the development of modern science at large. If we do not know to what extent the influence of Bacon reached key actors in the history of modern science, such as Hooke, we cannot accurately assess the centrality and importance of Bacon himself in that history. And, if we lack knowledge about the content of Hooke's methodology, we cannot in turn accurately assess the influence of his methodology on his successors. For example, rivaling claims about Hooke being or not being a mere precursor to Newton in terms of method are therefore to some extent shots in the dark.²⁰ In patching some of the holes in our knowledge of Hooke's method, I aim to add a little to a more coherent larger history of scientific methodology.

This thesis is structured as follows. The next section contains a brief overview of Hooke scholarship since his death in 1703, with a specific focus on how he has been compared with Bacon. In the third section I will explain my methodology in detail. The model approach will be introduced and I will explain their dual function as the basis for lists of search terms, and as tools to interpret collected evidence. Further, I will clarify how the collected evidence is processed by using annotation schemes. In the fourth section I will present the Hooke corpus and show in detail how it was made. In addition, it contains a short explanation of the workings of the computational tool I have used in mining the corpus for evidence. The fifth section is dedicated to my model of Baconian Natural Philosophical Methodology (BNPM). This section contains some preliminary applications of the model that should elucidate how it can (and cannot) be applied. Then, having explained the complex pipeline that led to the answering of my two questions, the question of the 'Hookean idols' will be discussed first in the sixth section. Briefly, contrary to what has been suggested, all of Bacon's four idols are expressed by Hooke throughout his writings, where he referred to them using terms such as 'prejudices', 'byasses', and 'prepossessions'. Apart from some minor refinements, Hooke stayed remarkably close to Bacon's original doctrine. The question of Hooke's division between natural history and natural philosophy will be tackled in the seventh section. In short, it will become clear that while Hooke

²⁰ For rivaling claims about priority, about whom influenced whom, and even which of Newton and Hooke 'was the greater mind', see e.g.: Centore 1970, *Contributions to Mechanics*, vii, 112-113; Gal 2002, *Meanest Foundations*, 11-15.

indicated some such division early in his career, the division was one without substance: all natural philosophical work could be achieved by the tasks he had in mind for the natural historian. In the final section I take stock of the results, and look forward.

2. State of the Art

2.1. 1705-1930: Fall and Rise

The posthumous publishing of the bulk of Hooke's papers, experimental reports, lectures, and correspondence started in 1705, shortly after his death in 1703, with Waller's *The Posthumous Works of Robert Hooke*, followed by Derham's 1726 *Philosophical Experiments*. In the century following the release of Derham's collection, Hooke had almost fallen into oblivion. Although Hooke did play a significant role in Birch's 1756 *History of the Royal Society*, no books fully dedicated to Hooke were written in this period. While occasional references to him are made by continental philosophers (e.g. Oetinger²¹ and Horrebow²²), Hooke's compatriots appear to have ignored him almost completely. There are competing explanations of Hooke's decline into obscurity, and perhaps the most plausible one is that he has been written out of history by post-Newtonian writers.²³

From the mid-19th century onward, references to Hooke reappear in the literature, but still there are no full studies and there is nobody inquiring in-depth into his methodological development and philosophy of science. Most writings from this era, including journal articles and history books, strictly portray Hooke as an avid inventor or experimenter, not as a philosopher.²⁴

There are 19th century commentators of Bacon that do place Hooke in the Baconian tradition but do so without elucidating which aspects of Hooke's philosophy corresponded to Bacon's, without indicating whether and to what extent Hooke developed Baconianism, and without really explicating what 'Baconianism' even consists in and instead relying on their reader's intuitive grasp of the concept. For example, in Fowler (1889) Hooke is said to be 'deeply imbued with the spirit of Bacon's teaching'²⁵ What exactly this spirit consists in is left to the

²¹ Oetinger 1771, *Die Metaphysic*, 491.

²² Horrebow 1741, *De Zegepralende Copernicus*, 3.

²³ Chapman 2005, *England's Leonardo*, 42-43.

²⁴ For example, Thompson (1851), Haaxman (1875), Snellen (1891), and Proctor (1892) highlight specific inventions and experiments, but only in passing, and ignore Hooke's philosophical contributions. Bryson (1856) and Boucher James (1896) include some biographical information, but do not venture beyond what could already be found in Waller (1705) and Derham (1726).

²⁵ Bacon & Fowler (ed.), 1889, *Bacon's Novum Organum*, 118. This same spirit is also invoked in Hoppus (1827) commentary on the *Novum Organum*: if we compare the

attentive reader. Whewell (1847) states that Hooke simply ‘repeated the truths which Bacon had proclaimed.’²⁶ Whewell puts forward Hooke’s 1666 *General Scheme* as evidence for this rough claim. The same imprecision can be found in Spedding et al. (1858). Like Whewell, they characterize Hooke as essentially copying the *Novum Organum* in his 1666 *General Scheme* and supplementing it with his ‘philosophical algebra’.²⁷ As will be shown in sections 6 and 7, this picture is both incomplete and inaccurate: Bacon’s doctrine of the idols is not well represented in the *General Scheme* at all, and since Hooke probably never wrote his treatise on the philosophical algebra, it can hardly be seen as a supplement to Bacon.²⁸

2.2. 1930 Onwards: Hooke as a Subject in his own Right

Gunther (1930a & 1930b) were the first books since Derham (1726) that were fully dedicated to Hooke, and were written with the aim to ‘do justice to one of the most inventive geniuses that the world has ever seen’.²⁹ However, Gunther does not engage with Hooke’s philosophy of science, and Bacon’s influence is nowhere mentioned in the two books. Around the same time the first edition of Hooke’s diary was published, which together with Gunther (1930a & 1930b) would fuel a century of Hooke studies.

The first full-length biography of Robert Hooke is ‘Espinasse (1956). While ‘Espinasse stresses the influence of the Baconian heritage on the Royal Society Fellows, she does so by quoting these Fellows’ explicit references to Bacon and by pointing at frontispieces with portraits of Bacon; not by tracing the extent to which Baconian concepts are present in Hooke’s methodological writings.³⁰ From ‘Espinasse onward, we witness a growing interest in the more practical aspects of Hooke’s working life as a scientist and instrument fanatic that was embedded in the daily life of the early Royal Society, as for example in Bennett (1980), Hunter (1994), and Hunter & Schaffer (1989).

Finally, in this era we also see historians looking more seriously at the philosophical import of Hooke’s writings and at his interpretation of Bacon, notably in Kargon (1971) and in Oldroyd (1972 & 1987). These latter scholars have moved away from the older notion that Hooke merely copied Bacon, but some

‘whole spirit and manner of’ Hooke’s texts with pre-Baconian texts, it is ‘impossible not to perceive the commanding influence of Bacon’s labours’ (Hoppus 1827, *An Account of Novum Organum*, 35).

²⁶ Whewell 1847, *Inductive Sciences* vol. 2, 267.

²⁷ Spedding et al. (eds.), *Works of Bacon* (4), 25.

²⁸ E.g. Hesse 1966, ‘Philosophical Algebra’, 67–83; Yeo 2007, ‘Between Memory and Paperbooks’, 26; Sacco 2019, *Real, Mechanical, Experimental*, 62.

²⁹ Gunther 1930, *Early Science in Oxford* (6), ix.

³⁰ Espinasse 1956, *Robert Hooke*, 17–18.

elements of their discussion leave something to wish for. In particular, while Oldroyd presents an impressive first analysis of the role of the hypothesis in Hooke's work, he portrays Hooke as being quite permissive with respect to the formulation of hypotheses, while 'the Lord Chancellor [viz. Bacon] took this step most unwillingly'.³¹ Oldroyd states that 'Hooke's methodology was essentially Baconian, except that he openly urged that hypotheses should be proposed'.³² In section 7, it will become clear that, like Bacon, Hooke had always maintained that hypotheses should be formulated on the basis of natural histories. The two issues that are discussed in this thesis—the nature of the division between history and philosophy and the question of Hooke's idols—are not touched upon by these authors.

2.3. Hooke's Tercentennial: Recent Work

The practical turn in the history and philosophy of science has resulted in a large number of texts discussing the socio-cultural embedding of Hooke as a practicing experimentalist. The philosophical aspects of Hooke are often absent in these texts, let alone comparisons with Bacon. For example, the only similarity between Bacon and Hooke that is discussed in Jardine (2003) is the fact that they were both drug-users. The question of Baconianism is altogether ignored in all contributions to Hunter & Schaffer (1989). Instead, we are presented with details about specific inventions, instruments, and detailed expositions of Hooke's private and social life. In the *Tercentennial Studies* edited by Hunter & Cooper (2006) Bacon enters stage as a confirmed pederast, but not a word about his influence on Hooke's thought.³³

Among the more philosophically inclined historians it is now, and always has been, commonplace to label the early Royal Society Fellows as 'Baconians'. There is nothing wrong with that label *an sich*, and the early Fellows, including Hooke, would not have minded being called 'Baconian'. What is wrong with the label is the way many scholars have interpreted and applied it. For example, according to Drake (1996) the Baconianism of the early Fellows consisted in their dedication to 'collection and repeated observation'. Hooke allegedly moved away from Baconianism by allowing the use of hypotheses and by believing that 'a collection of facts should not be an end in itself' but rather the foundation of a lasting philosophical structure.³⁴ Clearly, there is something wrong with Drake's reading of Bacon: Bacon did allow the use of hypotheses in scientific reasoning, and surely Bacon had higher aims than the mere collection of facts. If Baconianism is to be understood as a (1) fact-finding, (2) anti-hypothetical, and even (3)

³¹ Oldroyd 1972, 'Robert Hooke's Methodology', 121.

³² Ibid.

³³ Cooper & Hunter 2006, *Tercentennial Studies*, 13.

³⁴ Drake 1996, *Restless Genius*, 69 & 81.

anti-theoretical enterprise, none of the philosophers typically called Baconian does qualify as Baconian—Bacon included. (1)-(3) thus cannot all be necessary conditions of Baconianism, which means that Drake's concept is inaccurate

Inwood (2002) also invokes the concept of Baconianism and contrasts it with Cartesianism, where the former is 'inductive, empirical, arguing from fact to theory' and the latter is 'deductive, hypothetical, arguing from theory to fact'.³⁵ Hooke, Inwood says, was not a 'simple Baconian observer'³⁶ but finds middle ground between 'Baconian fact and Cartesian theory'³⁷ in his admittance of hypotheses. Inwood's characterization of Hooke's views is fine, his views on Bacon are not: again, Bacon did not eschew hypotheses, and Baconianism is not a label that should apply to mere fact-collectors, or 'ants'.

A more precise enumeration of methodological tenets shared by Bacon and Hooke can be found in Hunter (2003). For Hunter, Hooke, like Bacon, stressed the importance of natural histories and of organizing them systematically. Further, he recognizes the two-way relationship between axioms and experiments, and the importance of ameliorating the idols. But even though Hunter acknowledges that Hooke had a concept of Baconian idols, he does not look beyond the *General Scheme* in analyzing the Hookean variant. Further, Hunter states that Hooke developed Bacon's concept of natural history by adding a wider range of topics, or 'heads', suitable for inquiry, and leaves the analysis there. Also, the complex relationship between natural history and theory is not discussed. We will see in section 7 that Hooke had a lot more in mind for the natural historian than just some extra topics.

The latest comprehensive study of Hooke as a philosopher is Sacco's *Real, Mechanical, Experimental* (2019). The book is an impressive analysis of many aspects of Hooke's experimental and philosophical work. Due attention is paid to Baconian influences on Hooke, and even though Sacco nowhere makes explicit what he thinks Baconianism precisely entails, he shows a more nuanced and sophisticated conception of Bacon's philosophy than some of the aforementioned scholars. However, Sacco's treatment of the Hookean idols is based on a too small portion of Hooke's writings and is as a result incomplete and partially mistaken, as we will see in section 6.³⁸ In addition, Sacco claims that Hooke's initial division of labor between natural historical and natural philosophical tasks gradually disappears in his later work, but we are not given textual evidence that supports this claim, and neither are we told when this merging sets in. In sections 6 and 7, I complete and nuance the picture sketched by Sacco.³⁹

³⁵ Inwood 2002, *The Man Who Knew*, 15.

³⁶ Ibid., 68.

³⁷ Ibid., 65.

³⁸ Sacco 2019, *Real, Mechanical, Experimental*, 14-15.

³⁹ Ibid., 62; See also: Mulligan 1992, 'Certain Knowledge', 158.

To sum up: given the ever-growing attention paid to Hooke, one would expect that Hooke's Baconianism has been researched fully by now. The above survey shows that it is not. The scholars that do pay attention to Baconian elements in Hooke use differing, sometimes inaccurate, and even mutually incompatible conceptions of Baconianism. To be sure, certain aspects, such as the role of the senses, the gradual ascent to natural knowledge and the role of hypotheses in that ascent have been researched quite extensively. However, other aspects have been seriously underexposed, notably the 'Hookean Idols', or Hooke's ideas about the prevention and detection of false appearances, as well as his perspective on the exact relationship between natural history and natural philosophy and the division of labor between them. In this thesis, these aspects of Hooke's methodology will be treated in-depth. In the following section I will present a way of structuring, or modeling, a concept like 'Baconianism' with the aim of having explicit, shared, and revisable interpretive tools to study the history of such concepts. The age-old 'spirit of Bacon's teaching' just won't do that trick.

3. Methodology

By analogy, the challenge that the historian of ideas faces in doing large-scale research is similar to the challenge that confronted Baconian philosophers in interpreting nature: how does one move from an 'undigested heap of particulars'⁴⁰ to a sound interpretation within a certain domain of inquiry? For the Baconian, what is to be interpreted is some aspect of the natural world, and the 'heap of particulars' consists of matters of fact concerning this aspect, piled up by means of experiment and observation. Historians of ideas, on the other hand, inquire into concepts or conglomerates of concepts, which they will have to identify in typically large amounts of written text. In doing so, they will have to overcome two methodological obstacles: (1) they will need a reliable way to unearth the textual excerpts in which their concepts of interest are expressed, and then (2), they require a sound and transparent method for interpreting the way in which these concepts are used in the retrieved excerpts. Let us call (1) the *retrieval challenge*, and (2) the *interpretation challenge*. The main methodological claim that I will defend in this thesis, is that both these challenges and their corollaries can be met by applying the so-called 'model approach' to the history of ideas, first formulated by Betti and van den Berg (2014 & 2016). Let me first specify what the challenges exactly are.

3.1. The Retrieval Challenge

⁴⁰ Bacon 1670, *Sylva Sylvarum*, i.

Say, a historian of ideas, X, is interested in the relation between natural history and natural philosophical theory in Hooke's work. Where should X start?

Writers convey their ideas by means of written language, and they do this by using terms or relations between terms to refer to concepts they want to express. Therefore, any piece of evidence about a historical writer's use of a certain concept is likely to be textual; a sentence, paragraph, or perhaps some larger fragment of text in which this concept can be identified.⁴¹ Hooke was an avid but at times abstruse writer, who used difficult sentence constructions. As a consequence, X is confronted with an overwhelming amount of rather dense material to consult.⁴² Now let us assume the best-case scenario, in which X has actually obtained copies of all of Hooke's writings and thus all evidence is in principle accessible. Let us also assume that not every passage in this body of texts will concern the relation between natural history and theory, but that the lion's share of Hooke's writings will be about different things. By what method should X retrieve the relevant excerpts?

One possible strategy for X is to go the distance and start close reading all of Hooke's writings, written between 1661 and 1702. When a piece of evidence is encountered it is marked or copied, and in this way the evidence can be collected. Even though X is a trained professional, proper close-reading is a time-consuming activity for everyone—especially when one reads Hooke—and it should be clear that this will be an extremely tedious task, possibly spanning a couple of months or even years. And if, after finally having analyzed how Hooke thought of the relationship between natural history and theory, X wants to examine some other concept—say, 'force'—then X must make their way through the entire Hooke corpus again. X should not want to spend their entire academic career studying the meaning of a very limited number of concepts for a limited number of authors, and therefore the page-by-page approach is not recommended. I will call the problem that this type of research faces the *scale-problem*, for it is the scale of this type of research that will inevitably be limited by its time-consuming nature.

One way of solving the scale-problem could be settling for a selection of texts, for example by using only canonical works. One drawback of this approach is that it raises the probability of ending up with an incomplete history. Further, making a (non-random) selection of texts is prone to bias. Moreover, when the

⁴¹ One might reply that there are exceptions to this by pointing at works like Hunter (2016), in which an extremely detailed exposition of all aspects of the frontispiece to Sprat's *History of the Royal Society* (1667) is presented. A book like Hunter's is very helpful in understanding the extent to which the early Royal Society Fellows wore Bacon on their sleeves, and how they used him symbolically. However, the book does not tell us anything about the early Society's Baconianism that is not better explained by analyzing the Fellow's textual output.

⁴² To compare, the Hooke corpus is in size approximately as large as the complete works of Shakespeare, and about 33 times as large as this thesis.

selection consists of only canonical texts there will be little prospect of doing truly new, unexpected findings. One could also avoid the problem by spending large amounts of time and resources, which arguably is academically indefensible. I will show in what follows that neither approach is necessary, and that the scale-problem can be ameliorated by relying on complete corpora and accurate text retrieval methods.

Instead of close reading all of Hooke, the better strategy would be to rely on finding devices such as indices or concordances. X then only needs to consult a finding device, look up ‘natural history’ and all passages about natural history can be collected in this manner. There is little hope for this strategy to work. First, specifically in the case of Hooke, there are no such devices. Hooke’s writings are scattered throughout different sources, such as editions of the *Philosophical Transactions*, lectures, posthumous collections, and manuscripts in the Royal Society archives. There is as of yet, unfortunately, no volume in which all of Hooke’s writings are collected, and therefore there is even less hope of an accurately referring index or concordance.⁴³

But more importantly, even if such finding devices were available for Hooke’s texts, in order to obtain a complete body of evidence regarding, say, the concept of natural history, it would still be ill-advised to fully rely on them. First, there are more terms or expressions than just ‘natural history’ that can be mapped one-to-one to the concept of natural history; more obscure phrases such as ‘well collected Heap’⁴⁴, ‘great Stock of accurate Observations’⁴⁵, and ‘Store-house of Art and Nature’⁴⁶ are used interchangeably with ‘natural history’ by Hooke. An item in an index does not necessarily refer to passages in which co-extensive terms occur, and if it does, its maker generally does not provide the in- or exclusion criteria for these terms. To this extent, an index is not theory-free, and we cannot be sure whether it is complete.

In addition, there are expressions that are not fully equivalent with ‘natural history’ but which are semantically close to it, to the effect that passages in which they occur might very well concern the relation between natural history and natural philosophy. Look at the following fragment:

‘First, it would be almost as much Labour to demolish this Fabrick, as it was to raise it, and a third fruitless Labour to erect another. Nor can it be expected to be

⁴³ Among the deliverables of this thesis will be a rich collection of Hooke’s works in machine-readable form, and indices of terms referring to the subconcepts in the Baconian model (see: section 5). For the appendix, see:
<https://github.com/thijsossenkoppele/Hooke>.

⁴⁴ Hooke 1665, *Micrographia*, vii.

⁴⁵ Hooke 1682a, ‘Discourse of Comets’, 159.

⁴⁶ Hooke 1674, *Motion of the Earth*, iii.

otherwise, till such a Structure be founded upon a *natural, firm, and solid Ground*, and not upon feigned and imaginary Suppositions.'⁴⁷

The ‘solid Ground’ mentioned here may not be fully co-extensive with ‘natural history’, but the term is at least semantically very close to it.⁴⁸ And it is clear that this passage expresses a relation between a natural history and a natural philosophical ‘Structure’, as well as a rejection of ‘feigned Suppositions’, or ill-founded hypotheses, as a foundation for that structure. This fragment should be considered a piece of evidence by X, but since it contains neither ‘natural history’, ‘natural philosophy’, or ‘theory’, nor terms that are co-extensive with these terms, it is highly uncertain that X would have found it by using traditional finding devices. In fact, the above fragment is from a relatively obscure discussion of Philippe de la Hire’s work on frost from 1694, and has never been cited in the literature as far as I know. Since this text is not primarily about natural history, it is not obvious at all why scholars would consult it for evidence about Hooke’s views on natural history. Basic digital finding devices would also not have been of any help; even if X had a complete machine-readable corpus of Hooke’s texts, a simple query for ‘natural history’ would not have excavated this fragment. If X wants a body of evidence that is as complete as possible, they will need a reliable system for mapping terms to concepts. Let’s call this the *mapping problem*.

To sum up this section: the retrieval challenge is the challenge of finding a reliable method of retrieving passages in an author’s complete *oeuvre* that are relevant to some concept of interest. First, one must face the scale-problem. If the scale-problem is left unsolved, the results will either be incomplete because they are based on some selection of texts, or the results will be complete but highly resource intensive. The most promising solution to the scale problem is reliance on finding devices. However, given the limited availability or reliability of these devices, one is faced with the mapping problem. Solving this problem means finding a way to construct clusters of terms, as complete as possible, that refer to the concepts under scrutiny. These clusters of terms can then be used to retrieve evidential passages by using computational tools.⁴⁹

In the next section, I present a method for interpreting retrieved passages. It will become clear that the proposed solution to the interpretation challenge, the use of *interpretive models*, also points towards a solution to the mapping problem.

⁴⁷ Hooke 1694b, ‘Discourse of Frost’, 292 (emphasis mine).

⁴⁸ As used in this fragment, ‘solid Ground’ is *functionally synonymous* with ‘natural history’. The terms are not interchangeable in all possible contexts, but in the quoted fragment they play the same role.

⁴⁹ Details about the tool, HitPaRank, that has been used to collect evidence in writing this thesis in section 4.4.

3.2. The Interpretation Challenge

How should one trace the nature or development of Hooke's use of methodological concepts, or indeed the history of any concept, in a methodologically sound way? This question, in short, poses the interpretation challenge. In order to answer it I will first introduce the solution to the challenge, interpretive models, and then I will explain how and why they form the backbone of a sound method for writing histories of ideas.

The concepts that are studied in the history of ideas—e.g. ‘field’⁵⁰, ‘the art-nature distinction’⁵¹, ‘epistemology’⁵², or ‘romanticism’⁵³—are typically complex. They admit of parts; of subconcepts. In an interpretive model, a conceptual presupposition is made explicit, and the modeled concept is represented as a relational network between the subconcepts that belong to this concept.⁵⁴ The great benefit of modeling concepts in this way, is that we can stipulate what the stable parts of a concept are (their *core*), and which parts of a concept may vary between authors or contexts (their *margin*). Distinguishing between the core and margin of a concept allows us to track conceptual change or stability and helps us to identify varying instantiations of a concept in different contexts. In other words, the margins of a modeled concept allow the historian to analyze a single concept in different contexts. That does not mean that historical context cannot affect the core of a concept; it means that when it does, we are speaking of the replacement of the modeled concept with something else.

By means of illustration, we can stipulate that the core of a conception of ‘element’ is a) it cannot be decomposed into simpler substances, and b) it is material. Then as margins we can have for example c) that there is some number x of different types of them, and d) that they explain observable qualities of bodies.⁵⁵ Now if we look at ancient Greek philosophers who used the concept ‘element’, we find them adhering to a) and b), and thus the core of this particular conception of ‘element’ remains stable in this period. Not all of them accepted d), and while most accepted c), there is variation in how x is filled in, and thus we can say that x is a *determinable*. For example, for Empedocles $x = 4$, while for Aristotle $x = 5$; the latter accepted aether as a fifth element. From Lavoisier onwards, d) is generally dropped, and we see x increasing rapidly. Thus, during a certain period, while there is no complete *conceptual stability* in the concept of element, which would be the case if both core and margin remained stable, we can detect *conceptual change* because

⁵⁰ Nercessian (1984).

⁵¹ Sangiacomo (2019).

⁵² Betti et al. (2020).

⁵³ Lovejoy 2001, *Great Chain of Being*, 288–314.

⁵⁴ Betti & van den Berg 2016, ‘Computational History’, 1685–1686.

⁵⁵ The example of the concept of element is originally from Kuukkanen (2008). I have added some details here to illustrate the example.

the margins change. There is no *conceptual replacement*, which would be the case if we saw deviation from the core.⁵⁶

Note that the above conceptualization of ‘element’ is not the only historiographically viable one; there may be other candidates. Thus, when a concept is modeled, a certain perspective is modeled. One might suspect that the perspectival nature of models makes for arbitrary narratives, but this should not be the case. Historians using models should not stipulate the core of some concept only according to their own interests; they should ‘affirm that what they identify as the core of the concept is also significant for the authors they study’⁵⁷ That means that in constructing a model, one should include only features that the studied historical actors themselves would have ascribed to the modeled concept, im- or explicitly so, and thus using models requires the same kind of contextual understanding and top-down domain expertise that characterizes other types of historiography.⁵⁸

After the initial setting up of the conceptual framework, historians should continually fine-tune their models by using their findings as feedback. Since models are perspectives made explicit they are easier to test, to falsify, and to revise, compared to more implicit conceptual frameworks used elsewhere in historiography.

3.3. Solving the Mapping Problem

In section 3.1 I have introduced the mapping problem, the issue of finding an as complete as possible set of terms which can be used to retrieve passages in which some concept of interest is expressed. Having explained models, it is now easier to see how they can help solve the mapping problem. Look at the following fragment of the Baconian model (for the full model, see section 5):

- (1) *Sensory input* provides access to *particulars*.

I have explained in this section that interpretive models are constructed as relational networks between (sub)concepts. Here we see that (1) expresses a dyadic relation between two subconcepts, namely ‘x’s provide access to y’s’. We can identify both ‘sensory input’ and ‘particulars’ as margin terms. For example, what is to be counted as sensory input in providing access to facts about nature can differ among Baconian philosophers while still fulfilling the same function in a larger Baconian framework. For example, Bacon was not too optimistic about the use of instruments to enhance the senses, such as microscopes and telescopes, while

⁵⁶ Betti & van den Berg 2014, ‘Modelling the History of Ideas’, 817.

⁵⁷ Ibid., 819.

⁵⁸ Ibid.

Hooke saw great benefit in their use. Similarly, there is a wide variety of terms fulfilling a function that is similar to ‘particulars’. In this specific case thus, the mapping problem is the problem of mapping functionally synonymous or semantically similar terms onto concepts like ‘particular’. It is solved as follows. We start two lists of terms, and add terms that can be considered basic to both subconcepts in (1), such as ‘senses’, ‘particular’, ‘sensory’, ‘data’, etc. These lists are supplemented by other terms deriving from one’s knowledge of Hooke’s use of language. Then, the corpus is searched for paragraphs in which terms from both lists co-occur. In doing so, the following paragraph will be returned:

‘There are yet many Impediments to be removed, and many Helps to be supplied before any very great Increase in Knowledge is to be expected. It may be questioned whether piecing or mending will serve the turn, or whether there must not be a new Foundation laid on the **Informations** of our **Senses**, and more strictly examined and Purveyed by accurate and judicious Experiments and Observations. [...] For ‘tis not to be expected from the Accomplishments the Creator has endowed Man withal, that he should be able to leap, from a few particular **Informations** of his **Senses** [...] to the general Knowledge of Universals or abstracted Natures, and thence be able, as out of an inexhaustible Fountain, to draw out a perfect Knowledge of all **Particulars**. [...] Man’s Memory seems very shallow and infirm, and so is very prone to forget many **Circumstances**.⁵⁹

Besides confirming (1) for Hooke, two new terms—‘Informations’ and ‘Circumstances’—that seem to play a role similar to ‘particular’ can be found in this passage, as is confirmed by other passages in which these two terms occur. These newly found terms are collected in a list that corresponds to the subconcept ‘particular’, and can be used to collect more paragraphs, which in turn can yield new search terms. Functionally synonymous or semantically close terms that are used by Hooke are mapped onto each subconcept in the model in this way. For example, ‘prejudice’, ‘prepossession’, and ‘chymera’ are mapped onto the concept of ‘false appearance’, ‘conjecture’, ‘hypothesis’, and ‘axiom’ onto ‘bit of theory’, and ‘supellex’, ‘store-house’, and ‘artificial memory’ onto ‘natural history’. By looking for co-occurrences of these terms, paragraphs that might contain evidence for Hooke’s determination of (1) can be found that cannot be found by just searching for co-occurrences of ‘senses’ and ‘particulars’.

To sum up: the mapping problem is solved by creating lists of terms deriving from two sources. The first source is the researcher’s top-down knowledge. They must be familiar with terms Hooke frequently uses when discussing natural philosophical theory: ‘Philosophical Structure’, ‘Superstructure’, ‘Speculative Philosophy’, ‘Fabrick’, ‘Conjectures’, etc. In writing about natural history, Hooke

⁵⁹ Hooke 1666, ‘General Scheme’, 61 (emphasis mine).

uses e.g. ‘Repository’, ‘Particulars’, ‘Store-house’, ‘Granary’, ‘Treasury’, ‘Foundation Stones’, ‘Ground’, etc. Searching for passages in which these terms co-occur will yield a ‘first vintage’ of potentially evidential passages.

The second source of terms comes from these collected passages and is thus found by a bottom-up approach. More unusual terms can be encountered in the collected passages—‘Ground-plat of the whole Labyrinth’, ‘Supellex’—and these must be added to the lists. Then new passages can be searched for and the whole process should be iterated until no new terms pop up, to ensure the lists will be as complete as possible. The researcher can then do a final round of collecting and settle for a definitive collection of passages. These passages are then processed according to a premeditated annotation procedure (see section 3.4).

The methods explained in sections 3.1-3.3 are, I think, promising solutions to both the scale-problem and the mapping problem. It should be noted that the method still cannot guarantee that the final body of evidence is absolutely complete; there may be relevant terms that are missed somehow, or it may be that some relevant passages are phrased in a very obfuscated way, perhaps in a highly poetic or metaphorical manner, to the effect that it does not contain any of the listed terms.⁶⁰ Nevertheless, the results will still be far more complete compared to what can be gathered by traditional methods in a reasonable amount of time, and they are collected and interpreted in an explicit and systematic manner. Because of the transparency and systematicity of the process, the criteria for falsification are on the table and the research is arguably more open to replication.

In the following section, the procedure of annotating the collected evidence will be explained.

3.4. Moving from Particulars to Histories

I have shown how the interpretation of passages can be guided by interpretive models (section 3.2). I have also shown how the retrieval challenge can be overcome by systematically mapping terms to subconcepts that occur in such models (section 3.3). What has not been discussed up till here is the ultimate aim of retrieving passages and interpreting them, which is answering research questions. In this section I describe the procedure of moving from a collection of passages, to a body of evidence, to history.

Of course, any construction of models will be preceded by prior research from which certain research questions or hypotheses have emerged.⁶¹ In this thesis, the prior research indicated a historiographical and conceptual gap with respect to

⁶⁰ As we will see in section 7, it proved very beneficial to add metaphorical natural historians, ‘Architects’ and ‘Gardeners’ to the list corresponding to natural history, as these two are recurring figures in Hooke’s work.

⁶¹ Oortwijn, Ossenkoppele, & Betti 2021, ‘Interrater Disagreement Resolution’, 134.

Hooke's determination of the complex concept of 'Baconian methodology'. My question is, in other words, to exactly what extent is Hooke's philosophy to be called 'Baconian'? The model of Baconian science that was constructed for this thesis is based on (traditional) close reading of relevant methodological work by Francis Bacon, in particular his *Novum Organum*, as well as his *Parasceve*, *De Augmentis Scientiarum*, *Descriptio Globi Intellectualis*, and *Phaenomena Universi*.⁶² From these works, the elements that according to my perspective are most central to the Baconian conception of scientific method were put together in a model. For example, such elements include a particular relation between natural history and theory, the avoidance or detection of 'False Appearances', and some method for 'ascending' and 'descending' to and from axioms and particulars. If Hooke's views on scientific method include these elements, which among others I take to constitute the core of Baconianism, he is according to this perspective a Baconian philosopher. The way in which he specifies the margins—*his* method for building theory from particulars, or *his* view on the role of natural history in natural philosophy—will determine his specific 'flavor' of Baconianism.

Now, how do we move from a large collection of paragraphs to formulating answers to the research questions? For example, one of my research questions is: to what extent does Hooke deviate from Bacon's doctrine of the idols? This is a question at the corpus level; its complete answer will be a wide-scope claim, ranging over everything relevant Hooke ever wrote about idol-like concepts. As a first step in answering this question, it should be decided which of the collected passages actually contain evidence, since it is highly improbable that all of them do. In order to do so, an annotation task is formulated that contains subquestions that can be answered at the paragraph level. For this particular research question, the subquestions are:

SQ1: Is at least one of Bacon's four idols represented in this paragraph?

SQ2: Does Hooke introduce a source of false appearances that cannot be subsumed under one of Bacon's idols?

SQ3: Does Hooke encourage the use of some method for detecting or avoiding the false appearances found in answering **SQ1** and/or **SQ2**?

As a means of answering these subquestions, a scoring system is set up to assign different degrees of evidentiality to the collected paragraphs. One could choose to simply distinguish between sufficient and insufficient evidence, but this may lead to forced or arbitrary decisions in cases where it is genuinely unclear which

⁶² For the *Novum Organum*, *Parasceve*, and *De Augmentis Scientiarum*, I consulted Spedding et al. (1858). For the *Descriptio Globi Intellectualis* and *Phaenomena Universi*, I consulted the English translations in Rees (1996). For the model of Baconianism, see section 5.

thought a passage really purports to convey. Unclarity is a real feature of natural language that should be reflected in annotations.⁶³ Therefore, a three-valued scoring system was used, 1, 0, and -1, roughly corresponding to ‘yes’, ‘maybe’, and ‘no’.⁶⁴ In order to prevent the option of scoring a ‘0’ from becoming a convenient way for an annotator to mask their incompetence with respect to some domain of interpretation, they should attach to each annotation a short note explaining their reasons for annotating the way they did.⁶⁵ In this specific case, the notes are also used to indicate which of the idols is expressed in a passage, or what means of detecting or avoiding it is suggested by Hooke. Making the annotations explicit in this way also provides clear grounds for other historians to formulate their agreements or disagreements with particular annotations afterwards, and it keeps the overall interpretation procedure transparent.

Using a scoring system to indicate degrees of evidence on top of including notes that actually answer the subquestions may seem superfluous but has a great benefit outside of the field of history, namely in the field of computational linguistics. In this field so-called distributional semantics models are being developed, which can for example take a paragraph as input, and return a list of paragraphs in descending order of similarity with the input paragraph. However, the results of these models need to be evaluated against results obtained by humans to check if they perform as desired within the domain they are applied (e.g. some models may perform better than others on philosophical or historical texts).⁶⁶ The scored paragraphs obtained in this thesis can be used for these ends.

After this stage of annotating, when all that remains are passages that are relevant to the research question, these passages are still somewhat of an ‘indigested heap of particulars’. In order to draw historical conclusions from these particulars further steps must be taken. The way in which the dots are to be connected varies between different types of research questions. For example, if a researcher wants to show that a historical actor uses a concept inconsistently within some timespan, they just need to show that there are different instantiations of that concept within that timespan. Or, if a researcher wants to show that different historical actors use a concept in a similar way, they should present these different expressions and show that there is no conceptual replacement by showing that the core remains stable with these actors. If one wants to show that there is some conceptual development over time in a single actor, they should order the evidence chronologically and show how the margins are specified at different times. This ordering can be done by assigning metadata that indicates the year of writing to each passage. The model approach does not

⁶³ Oortwijn, Ossenkoppele, & Betti 2021, ‘Interrater Disagreement Resolution’, 134.

⁶⁴ The precise meanings assigned to 1, 0, and -1 are different for the annotation tasks presented in sections 6 and 7.

⁶⁵ Oortwijn, Ossenkoppele, & Betti 2021, ‘Interrater Disagreement Resolution’, 134.

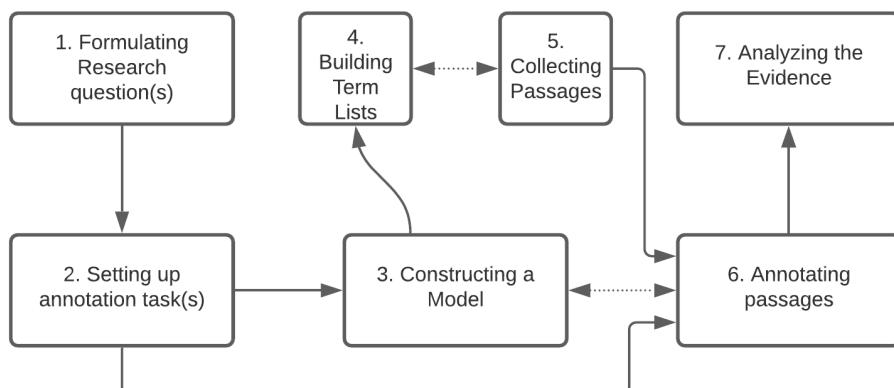
⁶⁶ Betti et al. 2020, ‘Ground Truth Construction’, 6699.

include a general procedure for writing history from the collected evidence; this is research specific.

3.5. Summary

I hope to have shown that interpretive models are a promising analytical tool that assists historians in both retrieving and interpreting passages of relevance to their research questions. I also hope that the reader understands that the model approach is *not* designed to replace qualified historians in any way. Models are a tool that supplements the historian's toolbox. If it were the only tool, then no good history would be written. Model-driven research still requires contextual understanding, close-reading skills, and conceptual analysis expertise; i.e., everything that makes a good historian of ideas.

To conclude this section, look at the following flowchart for a concise stepwise summary of the full procedure:



- Step1:** The historian does prior research, indicates some historiographical gap or unclarity, and formulates one or more research questions.
- Step2:** Annotation tasks are specified that are needed to annotate the passages in order to obtain evidence to answer the research question(s). These annotation tasks contain questions that are to be answered for each paragraph.
- Step3:** The historian constructs a conceptual framework, an interpretive model, in which the core and margin of the concept under scrutiny are represented as a relational network.
- Step4:** An initial term list is built. The historian relies on prior knowledge in mapping terms to the subconcepts from the model built at 3.

- Step5:** The terms obtained at 4. are used as search terms to collect passages from a digital corpus. New terms can be gathered from these passages and these are used to enrich the term lists at 4, and these can in turn be used to collect more passages. This step is repeated until no new terms are encountered.
- Step6:** The final collection of passages obtained at 5. is annotated according to the task specified at 2. The identification and classification of concepts in these passages is aided by the model constructed at 3. The model is revisable, and hence new findings at this stage can be fed back into the model. In case of a relatively drastic revision, it may be necessary to rerun the procedure from step 3.
- Step7:** After all passages have been annotated, the evidence can be collected, ordered, and processed in order to draw historiographical conclusions from them. The aim of this step is to answer the question(s) formulated at 1., by analyzing the full body of evidence obtained in answering the paragraph level questions at 6. The way in which this part of the research is carried out is not informed by the model approach and can vary between different types of research questions.

The model approach, as I aim to show in the following sections, is a very helpful tool for writing histories of ideas but is not on its own sufficient to elucidate the full social, institutional, or political contexts in which a concept like Baconianism finds expression. That means, the results obtained in the history of ideas proper may indicate *that* there is conceptual change, it can show exactly *what* it is that changes, but it cannot always explain *why* such change occurs. Answering such why-questions might require additional contextual knowledge that transcends mere conceptual knowledge, for example knowledge about the political, scientific, religious, or even personal contexts in which concepts are expressed. In other words, where conceptual analysis can *indicate* change, contextual knowledge can help *explain* this change. Such contextual knowledge is quite different from knowing the content of concepts themselves. A great deal of prior conceptual knowledge is requisite, however. In accurately interpreting the concepts that Hooke employs, for example, one must start with a detailed understanding of his broader philosophical outlook.

It might be that Hooke expresses himself at some point in a certain way because of pressure from outside—from the Royal Society, or from the Church of England—but this information cannot always be gathered from the text alone; the content of a text cannot always tell *why* that content is as it is. For example, in the introduction to the *Micrographia*, Hooke takes great pains to separate his own conjectures from the views of the Royal Society at large. From this introduction, we can gather *that* Hooke thought such a separation was in order, but he does not tell

us *why* he thought so. To fully understand Hooke's choice, additional knowledge of the Royal Society's attitude towards hypotheses is necessary. My aim in this thesis is not primarily to illuminate London's 17th century socio-scientific environment. My primary aim is conceptual.⁶⁷ That is not to say that historians of ideas should be indifferent to the broader field of the history of science. To the contrary: I see the results from this thesis as the necessary groundwork for a more encompassing history of scientific concepts. The why-question is often at least as interesting as the what-question, but the former can be answered in a much more satisfying way if the latter has been answered in detail.

4. The Hooke Corpus

The evidence base for the results presented in this thesis, the Robert Hooke corpus, is the first attempt at a complete collection of Hooke's published and unpublished writings. These include his books, lectures, published papers, unpublished papers, correspondence, experimental reports, various archival material, and his contributions to works by other authors such as prefaces written by him. Since a corpus is textual, pictorial archival material such as diagrams and drawings have not been included.

The Robert Hooke corpus is a work in progress. That means that to date, it has not been completed.⁶⁸ Still, it is by far the most extensive, complete, diverse, and accessible collection of Hooke material currently available. The corpus contains 210 separate texts out of the 356 listed in the bibliography that is appended to this thesis.⁶⁹ However, it is very well possible that many of the remaining 146 texts are in fact already included in the corpus: many of Hooke's papers and correspondence listed as 'archival material' have been included in posthumous collections such as Richard Waller's *Posthumous Collections* (1705), William Derham's *Philosophical Experiments* (1726), and Robert Gunther's *Early Science in Oxford* (1930). While I have identified quite a few of such instances, I was

⁶⁷ That being said, I hope that I will be forgiven if I, in this thesis, at times venture a guess at explaining certain expressions of Hooke. Or, as Hooke said: 'I may seem to condemn my own Course in this Treatise; in which there may perhaps be some Expressions, which may seem more positive then your Prescriptions will permit. [...] I desire to have them understood only as Conjectures and Quaeries.' (Hooke 1665, *Micrographia*, i.)

⁶⁸ The main reason for it not being completed is that this thesis was written largely during the COVID-19 pandemic, and therefore a visit to places where the remaining material is stored was impossible. These places include the Royal Society archives, the Bodleian Library, the British Museum, and Trinity College. If anyone reading this owns a copy of one of the entries marked as not included in the Hooke bibliography (see: [appendix](#)) and would like to contribute to the completion of the Hooke corpus, please contact the author of this thesis.

⁶⁹ See: [appendix](#).

not able to check every item, and hence there may be duplicates among the 356 entries. The corpus was intended to contain as little errors as possible, to be paragraph segmented, and to be published in both text format and FoLiA (Format for Linguistic Annotation), the latter being a high standard XML-format.⁷⁰ Texts in FoLiA can be used in sophisticated search engines such as AutoSearch, provided by ‘Instituut voor de Nederlandse Taal’ (INT).⁷¹

In this section, I will describe the construction of the Hooke corpus in three consecutive steps. First, the original Hooke texts were collected in digital form. Second, these texts were post-OCR corrected, meaning that the errors that occurred in them as a result of the conversion from digital image to text were corrected. And third, the corrected documents were converted into FoLiA. In the fourth subsection I will introduce HitPaRank, the tool that was used to retrieve paragraphs from the corpus using the lists of search terms as explained in section 3.⁷²

4.1. Collecting the Texts

The first step in creating the corpus was building a bibliography. As a starting point, I collected all the entries in Geoffrey Keynes’ *A Bibliography of Robert Hooke* (1960) into a Google Sheet. These entries have been supplemented with texts by Hooke that have surfaced in the years after 1960, and which are referred to or have even been transcribed in full by other historians. Examples of such texts are the papers transcribed in Oldroyd (1972, 1980 & 1987), Hooke’s transcribed ‘Musick Scripts’ in Gouk (1980), and Hooke’s lectures on algebra in Sacco (2019). There is no telling whether my Hooke bibliography is actually complete, for there may be material by Hooke stored somewhere that I am not aware of. In any case, the bibliography is surely large enough to form the basis of a very comprehensive digital collection of Hooke’s work.

Each entry in the bibliography is accompanied by metadata, such as the entry’s source, full and short titles, publishing information, number of pages, dates, and for archival material, references to places where the entry can be accessed physically. This metadata can be assigned to digital texts corresponding to the entries and can be used in text retrieval platforms such as Sketch Engine.⁷³

4.2. Cleaning the Texts

⁷⁰ <https://proycon.github.io/folia/>

⁷¹ <https://taalmaterialen.ivdnt.org/download/pp-autosearch-j/>

⁷² <https://github.com/martinreynaert/HitPaRank>

⁷³ <https://www.sketchengine.eu/>

All Hooke texts that were included in the corpus were digitally available through collections such as Google Books⁷⁴, Early English Books Online (EEBO)⁷⁵, The Royal Society Corpus 6.0⁷⁶, and the Internet Archive⁷⁷. Works that have been transcribed by historians are digitally available through repositories such as JSTOR.⁷⁸ Fortunately, only a few digitizations were of such low quality that they had to be retyped.

Unfortunately, the fact that most texts were digitally available does not mean that they were machine readable to a degree that is required to conduct historical research. For example, while the Hooke works available through Google Books are OCR'ed⁷⁹, the resulting text is highly unreliable and heavily distorted for multiple reasons. For example, some scans from the original texts are done sloppily, ink blots are recognized as letters, and oftentimes spaces are not recognized, leading to conjoining of words that should be separated. Moreover, 17th and 18th century printers used symbols that are currently out of fashion, such as the 'long s' (ſ), the 'double v' instead of a 'w' (e.g. in 'vvorks' instead of 'works'), or the 'æ' instead of 'ae'. Even the texts digitized by EEBO, which are of very high quality compared to texts from Google Books, contain such 'errors'. Moreover, many texts contain commentary by editors, margin notes, headers, page numbers, etc., which contribute nothing but noise to the corpus.⁸⁰ In order to promote the Hooke corpus to the desired standard and to be able to convert it into FoLiA format, a post-OCR correction, or 'cleaning' procedure was put into operation.

First, the OCR'ed text was inserted into a Google Doc. Then, the most frequently occurring undesired items were replaced automatically. These include the 'double v', the 'long s', and the 'æ'. In EEBO text, the frequently occurring symbols '•', '|', and '*' were removed automatically. The '•' symbol in EEBO texts indicate an OCR-error. In these cases, the original document was consulted and the errors were successfully corrected. Page numbers from EEBO texts were also automatically removed.⁸¹ The rest of the cleaning procedure, described below, had to be done manually. This is a highly time-consuming job, spanning several months. Pending reliable OCR techniques that can turn early modern prints into

⁷⁴ <https://books.google.com/>

⁷⁵ <https://quod.lib.umich.edu/e/eebogroup/>

⁷⁶ https://fedora.clarin-d.uni-saarland.de/rsc_v6/

⁷⁷ <https://archive.org/>

⁷⁸ <https://www.jstor.org/>

⁷⁹ Ocr means 'Optical Character Recognition', which is a collection of techniques that transform images of text into machine readable text.

⁸⁰ In cases where editorial commentary did not consist of personal interpretations of the content, but contained information about the nature of the texts, this information was copied and stored in the bibliography sheet in the column 'notes' (see: [appendix](#)).

⁸¹ This could be done by using the option Google provides of searching texts for so-called 'regular expressions'. In the case of page numbers the query 'Page \[.*?\]' finds all page numbers.

machine readable text, I see no substitute for this manual labor for the average researcher.⁸² Nonetheless, the result is a machine readable, paragraph segmented corpus of very high quality. Corpora of early modern authors are quite rare, and those that are of a reliability comparable to the Hooke corpus are non-existent, and as I hope to convince the reader of this thesis, extremely valuable.⁸³ Moreover, a corpus only has to be built once and can then be presented to the scholarly community where it can be used to conduct corpus-based research.

The manual cleaning proceeded as follows:

- Large texts, such as books and collections were split into chapters, and large chapters were split into sections.
- Front matter has been removed. Prefaces and introductions, if written by Hooke himself, have been retained.
- Margin notes by commentators have been removed, as well as page numbers and headers.
- Footnotes have been inserted in the running texts, by deleting its marker (usually an asterisk) and appending '[NOTE: (content of the footnote)]' to the sentence in which the footnote marker occurs. Hooke uses footnotes sparsely.
- All texts have been paragraph segmented, in order for FoLiA converters to recognize and index separate paragraphs. As a result, search engines can return coherent paragraphs instead of artificial fragments of text of fixed length as most search engines do. Paragraphs need to be separated by double newlines in order for FoLiA converters to recognize them. In practice, this means inserting white lines into the Google Docs using the original texts. While for the most part I have preserved Hooke's original paragraph structure, I have made a few exceptions to this which should be seen as edits. For example, in some cases I have conjoined one-sentence paragraphs that clearly belong to larger ones that follow them, in order to end up with a corpus consisting of coherent paragraphs.⁸⁴

⁸² Research projects working with sufficient financial resources could outsource the building of corpora to commercial parties such as the Deutsches Textarchiv (<https://www.deutsches-textarchiv.de/>).

⁸³ One possible exception is the Newton Project (<https://www.newtonproject.ox.ac.uk/>). While the Newton Project is an impressive feat, it is in many ways incomparable to the Hooke corpus. First, the texts from the Newton Project are full of errors, and they are not neatly paragraph segmented. Moreover, the corpus has not been published, and thus searching it has to be done using the website's internal search engine, which is rather limited. To compare, the Hooke corpus can be implemented in many different text retrieval platforms because it is available in both text- and FoLiA-format, and thus more complex queries can be used. Moreover, much attention has been paid to cleaning the Hooke corpus of OCR errors, which makes it more reliable.

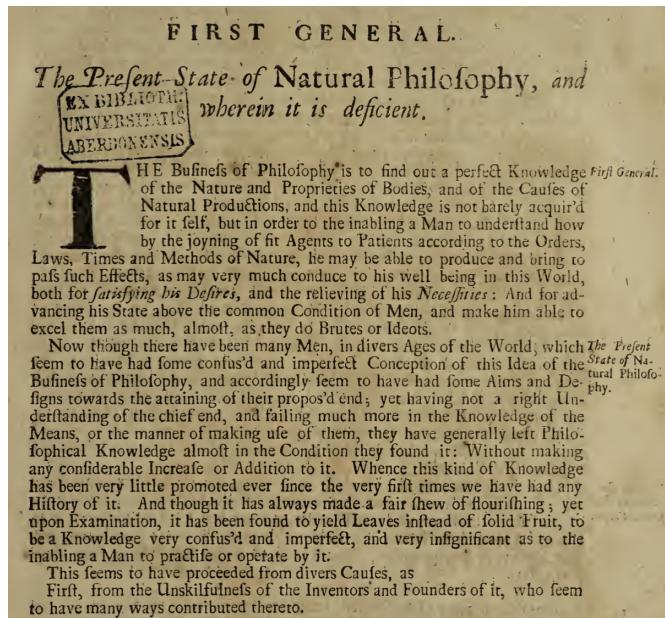
⁸⁴ Hooke has a habit of using short sentences before paragraphs. For example, in the *Micrographia*, he places a one-sentence paragraph stating: 'Upon the Anatomy or Dissection of the Head, I observ'd these particulars', which is then followed by a

- Drawings, diagrams, tables, and other non-textual elements have been replaced by the tag '[TABLE]'. Of course there are cases where a researcher would want to inspect such non-textual elements. In these cases, one can consult the Hooke bibliography in which links to the original texts are provided.
- Frequently, words are separated (as in 'var iety' instead of 'variety') due to OCR errors or as a result of end-of-line hyphenation. These instances have been corrected. Conversely, conjoined words that should be separate have been separated.
- Mathematical formulas have been replaced with [MATH]. Symbols such as ♀, as used in both Hooke's chymical and his astronomical writings, have been replaced with [CHYM].
- In many cases, the 'long s' is OCR'd as an 'f', leading to errors such as 'affisted' instead of 'assist'. In order to correct these cases, all 'f's were highlighted in the Google Docs and checked manually. The same holds for 'ct', which is often incorrectly rendered as '&'.
- Unreadable fragments have been replaced with the tag '[?]'.
- While latin terms have been corrected, longer fragments in latin have not been paid much attention to, and are not cleaned sufficiently. Anything expressed in Greek symbols has been replaced with [GREEK].
- Not much attention has been paid to the correct rendering of strings of numbers. Especially fractures (e.g. '3 ¾') are often very difficult to read in older prints, and I judged the cost/benefit ratio of spending lots of time in cleaning them to be unfavorable. Again, those who are interested in specific numbers in the Hooke corpus can consult the Hooke bibliography to find the original texts.
- After the above steps had been completed, the texts were skimmed to capture the remaining errors. This was by far the most time-consuming part of the cleaning procedure, despite the fact that I have lots of experience in reading and cleaning texts in this way and have developed an eye for spotting OCR errors. One cannot rely on the red markings with which Google Doc indicates spelling errors, since many such cases are not errors but early modern spelling variants that modern spelling checkers do not recognize.
- The results were exported as txt-files. The files were named according to the following form: 'year_author_short_title_section/chapter'. Especially in Waller (1705), a lot of texts are undated. Many of these dates were found and published by Hooke scholars, notably by Rappaport (1986), and this information has been used to add the correct year to almost all texts. In

paragraph containing the particulars he refers to. To make more sensible units, such short runner up to larger paragraphs have been merged with the larger paragraphs.

cases where we only know that it was written before some time without knowing the exact date, I used the form ‘year_before’ (as in: ‘1680_before_Hooke_Cause of Gravity_sec2’). If no indication could be given at all, a ‘?’ is used instead of a year.

As an example of the results of this procedure, first look at this original, unprocessed fragment from Hooke’s *General Scheme* (1666):



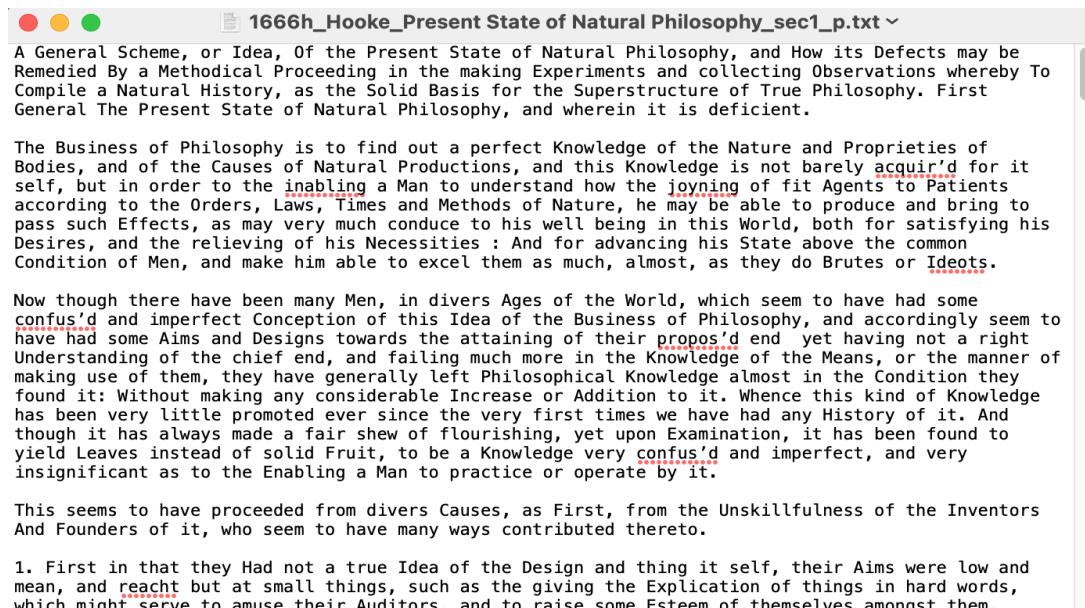
Copying this text into an editor shows how much Google’s OCR leaves to wish for, as the results are barely usable⁸⁵:

Untitled — Edited

FIRST GENERAL.
The Present State of Natural Philosophy, and
EX BIBLIOTHECA UNIVERSITATIS ABERDONENSIS wherein it is deficient. XULV35HSmTLS| auxttsiss.
HEBufinesofPhilofophy#1stofindoutaperfectKnowledgeFirstGeneral. of the Nature and Proprieties of Bodies, and of the Cauſes of Natural Producions, and this Knowledge is not barely acquir'd for it ſelf, but in order to the inabling a Man to understand how by the joyning of fit Agents to Patients according to the Orders, Laws, Times and Methods of Nature, fie may be able to produce and bring to pafs ſuch Effects, as may very much conduce to his well being in this World, both for fortifying hit Defirs, and the relieving of his Necessities : And for advancing his State above the common Condition of Men, and make him able to excel them as much, almolt, as .they do Brutes or Ideots.
*
Now though there have been many Men, in divers Ages of the World, which feem to have had ſome confus'd and imperfect Conception of this Idea of the Bufines, . Bufines of Philofophy, and accordingly feem to have had ſome Aims and De- ^ 1100 figns towards the attaining of their propoſ'd end ^ yet having not a right Underſtanding of the chief end, and failing much more in the Knowledge of the Means, or the manner of making uſe of them, they have generally left Philofophilical Knowledge almoſt in the Condition they found it: *Without making any confiderable Increase or Addition to it. Whence this kind of Knowledge has been very little promoted ever ſince the very firſt times we have had any History of it. And though it has always made a fair ſhew of flouriſhing *, yet upon Examination, it has been found to yield Leaves inſtead of ſolid Fruit, to be a Knowledge very confus'd and imperfet, and very iñificant as to the Enabling a Man to praefice or opefate by it.
This feems to have proceeded from divers Cauſes, as
First, from the Unſkilfulness of the Inventors and Founders of it, who feem to have many ways contributed thereto.|

⁸⁵ Fortunately, not all texts are as distorted as the one presented in this example. However, almost all of Waller (1705) is OCR’ed as badly as the example. As we shall see in sections 6 and 7, many fragments that were used as evidence in this thesis are from Waller (1705), and could not have been found by computers without cleaning the texts as prescribed.

After this fragment has been cleaned using the procedure described above, it looks as follows:



Text files such as the above are considered properly cleaned and are ready to be converted into FoLiA.

4.3. Text to FoLiA

The final step of the corpus-building procedure could be done automatically and is therefore much less labor-intensive than the preceding steps. First, all texts were tokenized using UCTO⁸⁶, a web-based tool developed at Radboud University. UCTO takes text files as input, separates words from punctuation, and splits sentences and paragraphs. UCTO then outputs an xml-file with separated word, sentence, and paragraph tokens, each given its unique ID.

Then, all the output xml files from UCTO were converted into FoLiA using a very simple Python script.⁸⁷ A text in FoLiA is part-of-speech (POS) tagged. POS tagging adds a tag to each word, corresponding to that word's part of speech (e.g. 'the' is a determiner, and is tagged 'DT', 'Robert' is a proper noun, and is tagged 'NNP', etc.). Further, all words are lemmatized, meaning that variant forms of words are grouped together, such as 'philosophy', 'philosophical', 'philosophize', etc. Finally, FoLiA uses entity recognition, and segments n-grams into entities. For example, 'Henry Power' is recognized as a person in the Hooke corpus, and 'eight

⁸⁶ <https://webservices.cls.ru.nl/ucto>

⁸⁷ See: [appendix](#), the script uses modules from the 'foliapy' library (<https://github.com/proycon/foliapy/>)

inches' as a quantity. The conversion to FoLiA was for this corpus primarily intended to enable its integration into advanced search engines like AutoSearch, and to be able to use HitPaRank to retrieve paragraphs using lists of search terms (see next section). Since FoliA does not support Hooke's early modern English, I deem the reliability of the POS-tags, lemmas, and collected entities insufficient to use in scientific research, and have not used them for this thesis.⁸⁸

The final result looks as follows:

```

</p>
<p xml:id="I1666h_Hooke_PresentStateofNaturalPhilosophy_sec1_p.p.2">
<s xml:id="I1666h_Hooke_PresentStateofNaturalPhilosophy_sec1_p.p.2.s.1">
<w xml:id="I1666h_Hooke_PresentStateofNaturalPhilosophy_sec1_p.p.2.s.1.w.1" class="WORD">
<t>The</t>
<pos set="https://raw.githubusercontent.com/proycon/folia/master/setdefinitions/spacy/spacy-pos" class="DT"/>
<pos set="https://raw.githubusercontent.com/proycon/folia/master/setdefinitions/universal-pos.foliaset.ttl" class="DET"/>
<lemma class="the"/>
</w>
<w xml:id="I1666h_Hooke_PresentStateofNaturalPhilosophy_sec1_p.p.2.s.1.w.2" class="WORD">
<t>Business</t>
<pos set="https://raw.githubusercontent.com/proycon/folia/master/setdefinitions/spacy/spacy-pos" class="NNP"/>
<pos set="https://raw.githubusercontent.com/proycon/folia/master/setdefinitions/universal-pos.foliaset.ttl" class="PROPN"/>
<lemma class="Business"/>
</w>
<w xml:id="I1666h_Hooke_PresentStateofNaturalPhilosophy_sec1_p.p.2.s.1.w.3" class="WORD">
<t>of</t>
<pos set="https://raw.githubusercontent.com/proycon/folia/master/setdefinitions/spacy/spacy-pos" class="IN"/>
<pos set="https://raw.githubusercontent.com/proycon/folia/master/setdefinitions/universal-pos.foliaset.ttl" class="ADP"/>
<lemma class="of"/>
</w>
<w xml:id="I1666h_Hooke_PresentStateofNaturalPhilosophy_sec1_p.p.2.s.1.w.4" class="WORD">
<t>Philosophy</t>
<pos set="https://raw.githubusercontent.com/proycon/folia/master/setdefinitions/spacy/spacy-pos" class="NNP"/>

```

In total, 210 Hooke texts were found, cleaned, and converted to FoLiA, resulting in a high quality, highly structured corpus consisting of 229 documents (due to splitting in sections), 4079 paragraphs, and 885,332 tokens. The documents can be accessed in the appendix to this thesis and are available in both (paragraph segmented) text format and in FoLiA.⁸⁹

4.4. Paragraph Retrieval: HitPaRank

For the retrieval of the paragraphs I used HitPaRank, a script written in Perl that was developed by the 'Concepts in Motion' group at the University of Amsterdam.⁹⁰ HitPaRank was designed to retrieve clusters of paragraphs, using (wildcarded) term lists as input. It has three modes of working. Mode 1 extracts all n-grams up to

⁸⁸ For example, since Hooke starts many nouns with capitals, FoLiA categorizes 'Philosophy' as a proper noun.

⁸⁹ See: [appendix](#).

⁹⁰ The script was written in close collaboration between a programmer and three philosophers working at the Concept in Motion group, of which the author of this thesis was one.

4-grams from the corpus, and outputs these in four tsv-files. Mode 2 takes text files with lists of search terms as input. These search terms can contain wildcards, marked by ‘*’. HitPaRank outputs a txt file with a list of expanded wildcarded terms as they occur in the tsv-files obtained in Mode 1. Before Mode 3 is put into operation, one can choose to manually curate the lists of expanded terms that were obtained in Mode 2. Doing so was necessary in writing this thesis. As an example, as expansions of the wildcarded term ‘maxim*’ I wanted to retain ‘maxim’ and ‘maxime’ as search terms, but not ‘maximum’ and ‘maximilian’. Finally, the (curated) lists and the full corpus in FoLiA are used as input for Mode 3, which outputs a tsv file with a cluster of paragraphs in which terms from the lists occur. Each row in the tsv file contains a retrieved paragraph plus additional information, including its corresponding ID, (for each list) the search terms that occur in the paragraph, and a binary code that indicates for each list whether or not a term from it is present in the paragraph.⁹¹ The tsv file can then be imported into a spreadsheet, and the paragraphs proper to a certain annotation task can be filtered out using the binary code. For example, from the set of paragraphs that was the basis for sections 6 and 7, only paragraphs containing terms from both the ‘natural history’ list and the ‘bits of theory’ list were retained and annotated.

5. What is this Thing Called ‘Baconianism’? Modeling the Baconian Method

To recap: as explained in the third section, a model in Betti & van der Berg’s sense is a representation of a complex concept by means of its subconcepts and their interrelations. A model consists of a *core*, its stable part, and a *margin*, the parts of the concept that may vary between contexts without deviating from the core. Further, a concept is modeled according to a certain perspective. Since models make these perspectives explicit, they are interpretive tools that allow for great transparency, especially in comparison with the more implicit use of complex concepts by historians.

A highly complex concept such as ‘Baconianism’ can be modeled in numerous ways. There are many aspects of Bacon’s work that we might want to trace in the writings of later authors. Among these, one might model Bacon’s elaborate classifications of knowledge. Or, one might ignore all classification and all of Bacon’s methodological prescriptions and precisely model his envisioned final product of scientific inquiry, that is, one could model the concept of a complete operative Baconian science. And again, for each of these there is more than one

⁹¹ For all types of information per column, see:
<https://github.com/martinreynaert/HitPaRank#contents-of-output-list-a--extracted-paragraphs>.

possible model. In this thesis, however, I use ‘Baconianism’ as a term referring to the Baconian idea of natural philosophical methodology. The model I present in this section, the ‘Model of Baconian Natural Philosophical Methodology’ (BNPM), consists of core statements that I take to be necessary and sufficient conditions for a methodology to be called Baconian. BNPM is not as narrow as to only include Bacon himself, for the model contains margins that can be specified in different ways by different thinkers. And, the model is not as permissive as to apply to non-Baconian philosophers such as Descartes. Let’s first look at the full model, and then at the separate elements.

Model of Baconian Natural Philosophical Methodology (BNPM)

For any natural philosophical methodology (NPM), NPM is Baconian if it satisfies the following conditions:

- Condition 1:** NPM includes the assumption that *sensory input* (**a**) provides access to *particulars, instances, or data* (**b**).
- Condition 2:** Within NPM, *natural histories* (**c**) are composed out of (sets of) *particulars, instances or data* (**b**)
- Condition 3:** NPM includes (*a set of*) *organizing principle(s)* (**d**) that add structure to *natural histories* (**c**) or *particulars, instances or data* (**b**).
- Condition 4:** Any *bit of theory* (**e**) that is formulated using NPM is grounded in *natural histories* (**c**).
- Condition 5:** Using NPM, new *particulars* (**b**) are derived from *bits of theory* (**e**).
- Condition 6:** NPM prescribes *ways to avoid or to detect false appearances* (**f**).⁹²

I propose conditions (1)-(6), the core of the model, to be both necessary and sufficient conditions for an NPM to be accurately labeled ‘Baconian’, that is, there are no other conditions that are as relevant as (1)-(6) to constituting a Baconian methodology, and a Baconian methodology should fulfill all of (1)-(6). Now, when I say that a model is a representation of a perspective that is revisable, I mean that it is claims like the one in the previous sentence that are up for discussion. A historian that has a different perspective might downgrade one of my conditions or

⁹² The letters (a-f) correspond to the term lists that were constructed for each determinable. See [appendix](#). The terms in italics correspond to the margins of the concept of Baconianism.

might want to add one that is missing from my model.⁹³ That said, I do not think that BNPM shows a very controversial perspective on Baconian methodology, but is rather quite conservative and does not deviate from what writers of early modern history of science tend to attribute to Baconianism. In what follows, I explain why I take these conditions to be central to Baconianism.

Condition (1) is pretty straightforward: it states the accessibility relation between sensory input (**a**) and the elementary building blocks of science (**b**). Both sensory input and these building blocks are considered to be determinables in the model. What exactly is to be counted as legitimate sensory input differs quite drastically between philosophers. For example, it is well known that Hooke was a true optimist about amplifying the naked eye with instruments, and often spoke about the ‘great benefit the use of a Microscope may be for the discovery of Nature’s course.’⁹⁴ By contrast, a contemporary philosopher such as Margareth Cavendish who was, like Hooke, aware that the naked senses can deceive also stated that especially ‘exterior inspection through an optic glass, is so deceiving, that it cannot be relied upon.’⁹⁵ But what counts as reliable sensory input can also differ between two philosophers that can both be called Baconian. In fact, some passages from Bacon himself appear to agree more with Cavendish than with Hooke, as he states that ‘sense by itself is a thing infirm and erring; neither can instruments for enlarging or sharpening the senses do much.’⁹⁶ Still, for Bacon but not for Cavendish, ultimately the senses extract information from the world, of which ‘sight has the chief office.’⁹⁷ As long as sensory input plays this role in accessing nature, it functions in a Baconian sense.

⁹³ One could think of the cooperative aspect of Baconian science as being a necessary component of Baconian methodology. Bacon repeatedly speaks of science as a cooperative endeavor, and the Royal Society can be seen as an embodiment of Bacon’s ideals. Still, cooperation should not be seen as a fundamental constituent of Bacon’s method as a concept, but rather as more of a practical consequence of the large amount of work the method prescribes; it would be very hard, if not impossible, for a single person to compile very extensive natural histories. Thus, in principle, according to the modeled perspective on Baconianism, one could be Baconian without explicitly acknowledging the cooperative element, but not without acknowledging statements (1)-(6). In practice however, we will see the cooperative part being expressed as a determination of the margin term ‘organizing principle’ (**d**) in condition (3). In addition, it has been argued that the cooperative element was a way of fending off the idols (e.g. Shapin & Schaffer 2011, *Leviathan*, 78). Shapin and Schaffer only cite Thomas Sprat in this context, but if this idea can be traced in other Baconians, the cooperative element will also surface as a determination of determinable (**f**) in condition (6); as a way of avoiding false appearances. That being said, I acknowledge that the in- or exclusion of cooperation as a core element of Baconianism is debatable.

⁹⁴ Hooke 1665 *Micrographia*, 186.

⁹⁵ Cavendish 2001, *Experimental Philosophy*, 9.

⁹⁶ Bacon 1889, *Works of Bacon*, 58 (Novum Organum, Book I: L).

⁹⁷ Ibid., 129 (Novum Organum, Book II: XXXIX).

Determinable (**b**) in condition (1) refers to that which has been extracted from nature by the senses. In early modern philosophy there are many different terms that refer to these building blocks of science that are functionally similar but not necessarily conceptually identical. Among these are ‘particulars’, ‘observations’, ‘informations’, ‘instances’, ‘facts’, ‘data’, ‘materials’, etc.

Conditions (2) and (3) are about the composition of natural histories. There are some strictures on what can take the place of determinable (**c**). Not any old history will do, and therefore organizational principles (**d**) are employed. Bacon restricts (**c**) to what he calls ‘Inductive’ natural histories: histories that are of use in inductive science, as opposed to ‘Narrative’ histories that are not meant to be of help in progressing towards knowledge that transcends the histories themselves.⁹⁸ Bacon does not mention concrete examples of ‘Narrative’ histories, but describes them as containing ‘fables, antiquities, quotations, idle controversies, philology and ornaments’.⁹⁹ This description is reminiscent of what Ashworth Jr. (1990) has called ‘emblematic’ natural histories, and we may conjecture that Bacon had something like the type of histories that Ashworth Jr. describes in mind.¹⁰⁰ In any case, the restriction to include data specifically with a view of its use in induction can be called an organizational principle (**d**) for Bacon, as well as his grouping together of types of data under ‘heads’, also found in Hooke.¹⁰¹ Other organizational principles that should make for a useful history are Bacon’s use of ‘Tables of Discovery’¹⁰², Hooke’s emphasis on brevity in writing and his highly detailed prescriptions for the material form of a written natural history, up until the type of glue that should be used,¹⁰³ and both Hooke’s and Boyle’s prescriptions to include summarized hypotheses and theories from other philosophers.¹⁰⁴

⁹⁸ Bacon 1889, *Works of Bacon*, 298 (De Augmentis, Book II: Chapter III).

⁹⁹ Ibid., 299 (De Augmentis, Book II: Chapter III).

¹⁰⁰ Bacon and Hooke might appear to see Pliny the Elder as an exception to the emblematic tradition. Hooke states that we are ‘extreamly obliged’ to Pliny (Hooke 1687a, ‘Earthquakes (II)’, 377). Bacon saw him as a historian who ‘undertook a Natural History according to the dignity of it’ (Bacon 1889, *Works of Bacon*, 295 (De Augmentis, Book II: Chapter III)). Further, Hooke frequently cites Pliny in his lectures about earthquakes. However, both Bacon’s and Hooke’s stance towards the use of Pliny’s work as a foundation for philosophy is somewhat ambiguous, as elsewhere they state that Pliny’s histories are not very significant in this respect (Hooke 1666, ‘General Scheme’, 3; Bacon 1889, *Works of Bacon*, 254 (Parasceve)).

¹⁰¹ See e.g.: Hooke 1666, ‘General Scheme’, 22-26. Hunter notes that Hooke improves significantly upon Bacon concerning the number of ‘heads’ suitable for natural history (Hunter 2003, ‘Natural Philosopher’, 120). Perhaps Hunter’s observation can partially be explained by realizing that Hooke’s concept of natural history was something much more inclusive than Bacon’s.

¹⁰² Bacon 1889, *Works of Bacon*, 96 (Novum Organum, Book I: CII).

¹⁰³ Hooke 1666, ‘General Scheme’, 64. Hooke can highly recommend ‘Mouth Glew’.

¹⁰⁴ Hunter & Anstey 2008, ‘Robert Boyle’s Designe’, 102-107; Hooke 1666, ‘General Scheme’, 65.

Condition (4) states that all bits of theory (**e**)—every axiom, hypothesis, or conjecture, all ‘Consectaries and Corrolaries’¹⁰⁵—are to be grounded upon natural histories. It is safe to say that (4), together with (3), is one of the most distinguishing features of Baconian science, and Bacon himself frequently contrasts his way of grounding theories in natural history with the methods of the philosophical tradition that preceded him; with those who did not interpret but who anticipated nature.¹⁰⁶ The relation that is expressed (4) is unidirectional, and describes a move, or ‘ascension’, from natural histories to propositions that go beyond what is available in these histories. For Bacon this move is established by his method of induction, which is a much more complex method than what he calls induction by ‘simple enumeration’ for it incorporates deductive steps such as exclusion.¹⁰⁷ Although Hooke may not exactly copy Bacon’s method of induction, he does talk about a type of induction that also transcends simple enumeration and involves comparisons between ‘Philosophical Tables’ in order to ascend to explanations of phenomena, his so-called ‘Synthetick’ method.¹⁰⁸

Condition (5) describes the reverse direction of reasoning, which Hooke calls ‘Analytick’. Hooke’s ‘Analytick’ method proceeds by deducing consequences from hypotheses and testing them with new experiments.¹⁰⁹ Bacon, when discussing the ‘descending’ part of his methodology, mostly speaks of deduction in the context of deriving new works in the operative part of his philosophy once the speculative part has been brought to completion; that is, when the most fundamental axioms have been discovered. This has led some to suspect that Bacon, unlike Hooke, did not deduce experiments from intermediary axioms or hypotheses in order to test these axioms.¹¹⁰ However, Bacon describes something quite similar to Hooke’s ‘Analytick’ method. First, he states that axioms should lead to more empirical consequences than just the data from which the axioms were induced; the axioms should be ‘larger and wider’.¹¹¹ And then, he says that ‘we must observe whether by indicating to us new particulars it confirms that wideness and largeness as by a collateral security.’¹¹² Thus, scientific reasoning in the direction as stated in (5) can start from both ‘middle axioms’ and the most general axioms, and

¹⁰⁵ Hooke 1694a, ‘Earthquakes (VI)’, 450.

¹⁰⁶ Bacon 1889, *Works of Bacon*, 51 (Novum Organum, Book I: XXVI). Calling (3), and (4) the most distinguishing features of Baconianism does not mean that they alone could be constitutive of Baconianism, as (1), (2), (5) and (6) are equally important. Rather, I mean that one would be hard-pressed to find a non-Baconian thinker arguing for (3) and (4).

¹⁰⁷ Ibid., 70 (Novum Organum, Book I: LXIX); Vickers 1992, ‘Progress of Knowledge’, 515.

¹⁰⁸ Hooke 1687b, ‘Earthquakes (III)’, 330. Hooke reverses the meanings of ‘analytic’ and ‘synthetic’ investigation with respect to most of his contemporaries, see section 7 for details).

¹⁰⁹ Ibid.

¹¹⁰ See e.g.: Urbach 1982, ‘Precursor to Popper’, 117-118.

¹¹¹ Bacon 1889, *Works of Bacon*, 98 (Novum Organum, Book I: CVI).

¹¹² Ibid.

is essential both to checking whether hypotheses hold and in practicing ‘Operative’ natural philosophy.

The final condition, (6), concerns an essential aspect of Baconian natural philosophical inquiry. At the core of Baconian methodology is the prescription that philosophers should try to purge themselves, or at least become aware, of sources that lead to what Bacon calls ‘False Appearances’.¹¹³ In Bacon’s philosophy, condition (6) is fulfilled by his famous doctrine of the idols. Hooke, contrary to what has been suggested in the literature, had a concept of idols that is remarkably similar to Bacon’s as will be shown in section 6. There are no studies that compare the exact implementation of Bacon’s idols in the methodologies of the Royal Society fellows, but the suggestion in Daston (1994)—that their collective and incessant stress on impartiality with regard to theory, as well as shared tendencies of ‘avoiding abstract terms’ and the weighing of ‘falsifying instances as heavily as confirming ones’ were all ‘techniques’ to bypass Baconian idols—is at least plausible.¹¹⁴

One might argue that (6) is not a proper methodological condition, but more of a guideline to put Baconian science in practice, on par with Bacon’s recommendations for doing science cooperatively. Or, as has been argued recently: even if we think of the doctrine of the idols as a methodological tool, it is only used to prepare the human mind for Baconian science, not to actively contribute to its progress.¹¹⁵ In detecting, preventing, and dispensing with fallacies deriving from tradition, prejudice, or human limitations, the idols only play a role in the *pars destruens* of Bacon’s methodology, not in its *pars construens*. But, as Montuschi (2012) has argued, the doctrine of the idols is not just used to prepare minds for the new science and are then to be dispensed with; they are of essential use at every stage of the Baconian method.¹¹⁶ In fact, Bacon has made it quite clear that of all the idols only the idols of the theatre can be eradicated; the other three are innate and ‘cannot be wholly removed’.¹¹⁷ Thus, the doctrine cannot be understood as purely preparative or destructive. And the fact that the doctrine can be employed in e.g. detecting that one hypothesis appears more favorable than another for personal reasons, or in motivating additional measurements out of distrust of the senses, makes the idols of direct use in the constructive part of science, the *pars*

¹¹³ Bacon 1889, *Works of Bacon*, 431 (De Augmentis, Book V: Chapter IV).

¹¹⁴ Daston 1994, ‘Baconian Facts’, 47. Daston sees the purging of idols as a way of realizing the early modern ideal of ‘mechanical objectivity’, which is somewhat of an anachronism. I agree with Zagorin (2001) that in doing so, she unwarrantedly depicts Bacon as a relentless empiricist who left no room for theory in his quest for hard matters of fact (Zagorin 2001, ‘Objectivity and the Idols’, 383).

¹¹⁵ Smith 2021, ‘On the Possibility of Knowledge’, 58-61.

¹¹⁶ Montuschi 2012, ‘Ordering Knowledge’, 11-12.

¹¹⁷ Bacon 1889, *Works of Bacon*, 431 (De Augmentis, Book V: Chapter IV).

construens. Therefore, I incorporate a method to detect ‘False Appearances’ as an integral part of Baconianism in my model.¹¹⁸

Having explained the conditions of the model, let us look at its scope. I have stated before that a Baconian should conform to all of (1)-(6). Most non-Baconian philosophers, if not all, conform to one or more of the conditions, but none conform to all conditions. For example, while Hobbes is sometimes taken to be the antithesis of Bacon¹¹⁹, there are some definite similarities between the two:

‘The first beginnings, therefore, of knowledge, are the phantasms of sense and imagination [(1)]; and that there be such phantasms we know well enough by nature; but to know why they be, or from what causes they proceed, is the work of ratiocination; which consists [...] in *composition*, and *division* or *resolution*. [...] And the resolute [method] is commonly called *analytical* method, as the composite is called *synthetical* [(5)].’¹²⁰

In addition, (6) Hobbes had concepts that resemble Bacon’s idols very closely.¹²¹ However, while we know that Hobbes showed some interest in Baconian natural history, it is nowhere as fundamental an enterprise to his philosophy as it was for Bacon.¹²² Thus, since Hobbes’ ‘analytical’ method is not based on extensive, well ordered natural histories, his methodology does not fulfill (2)-(4).

While Descartes satisfies the same conditions as Hobbes, the former can be said to be farther removed from Baconianism than the latter. Descartes’ adherence to (5) is uncontestable. But, while he conforms to (6), his method for avoiding false appearances is very radical and not as fine-grained as Hobbes’, or Bacon’s for that matter; Descartes assumed that virtually everything he believed is a false appearance. And while he leaves room for empirical investigation in natural philosophy, he is highly skeptical of (1). In addition, he shows even less interest in large-scale accumulation of natural historical data than Hobbes did, with some few exceptions.¹²³

The model specifies that there is a natural historical basis from which theory is to be built, but it does not say when reasoning in the other direction, the deducing of empirical consequences, can commence. This is intended to leave

¹¹⁸ To be sure, for Bacon this method consisted in his doctrine of the idols, but other Baconian philosophers can deviate from this doctrine as long as they incorporate something functionally similar in their methodology.

¹¹⁹ E.g. Shapin & Schaffer (2011) call him ‘the beast of deductivism’, which shows a rather one-sided interpretation of Hobbes’ philosophy (Shapin & Schaffer 2011, *Leviathan*, 176).

¹²⁰ Hobbes 1839, *Concerning Body*, 66.

¹²¹ Funari 2011, *Intellectual Discourse*, 96-97.

¹²² See e.g.: Raylor 2018, *Rhetoric and Hobbes*, 94-126.

¹²³ See e.g.: Jalobeanu 2014, ‘The French Reception of Bacon’, 6-9.

room for a variety of Baconianisms. One variant is Hooke's, Bacon's, and Boyle's that allowed for the deduction of empirical consequences from hypotheses based on a not-yet-complete natural history. Another version of Baconianism is exemplified by Joseph Glanvill, who stated that all the early Royal Society could aspire to was a 'History of Things', while the making of hypotheses is 'the happy privilege of Succeeding Ages'.¹²⁴ For both versions, condition (5) is fulfilled, only for Glanvill's version it would be put into practice in a distant future.

The model can also be used to shed light on the question to what extent Newton could be called a Baconian scientist. Now the long-standing myth of Bacon as completely distrustful of mathematics has been replaced with a picture of Bacon who accorded mathematics its proper place in natural philosophical investigation, which is after the process of fact collection¹²⁵, we can assess the compatibility of mathematical approaches to science with Baconian approaches.¹²⁶ While Newton's Baconianism deserves a treatment that cannot be done in full here, some interesting suggestions have been proposed by Jalobeanu (2014) and Domski (2013). I am not too convinced by Domski's argument that we could regard Newton as fitting in the Baconian tradition because his contemporaries such as Locke welcomed his scientific work.¹²⁷ However, I do think that both Domski's and Jalobeanu's suggestion that Newton's Baconianism hinges on the significance he attributed to natural histories, and not on the importance of mathematics in his work, is very much on point.¹²⁸ Both suggest an interesting departure from Baconianism in Newton's work between his reports on experiments in optics to the Royal Society in 1672, and his *Principia* (1687), which surely was based on 'experience' but not clearly on a Baconian natural history.¹²⁹ However, pending an in-depth study of 'Newtonian Idols', I think we still miss an essential piece of the puzzle of Newton's Baconianism.

I hope to have convinced the reader of the accuracy of both the conditions and the scope of BNPM. To summarize: the core of the model, consisting of statements (1)-(6), applies to philosophers that, for good reasons, have traditionally been called 'Baconian' such as Hooke and Boyle. The core includes a variety of

¹²⁴ Shapiro 2003, *Culture of Fact*, 147.

¹²⁵ Bacon 1889, *Works of Bacon*, 126 (Novum Organum, Book II: VII).

¹²⁶ The myth of Bacon as distrustful of mathematics, combined with the picture of mathematical approaches to science as 'triumphant' over Baconian approaches, was used by e.g. Alexander Koyré in 1939 to state that 'Bacon understood nothing of science' (Koyré 1978, *Galileo Studies*, 39). Later, Thomas Kuhn in his *Essential Tension* (1977) would propagate the myth by completely separating an incompatible 'classical mathematical tradition' and a Baconian experimental tradition (Kuhn 1977, *Essential Tension*, 60-95).

¹²⁷ Domski 2013, 'Observation and Mathematics', 166.

¹²⁸ Jalobeanu 2014, 'Constructing Natural Facts', 41; Domski 2013, 'Observation and Mathematics', 165.

¹²⁹ Domski 2013, 'Observation and mathematics', 165.

Baconians that are often typified as mere ‘fact collectors’, but only if such fact collection is done with a view to constructing a (future) natural philosophy, a view that is exemplified by Glanvill. Actual theory-avoiding fact collectors, Bacon’s ‘Ants’, are rightly excluded from Baconianism. The core of the model gives clear criteria to assess doubtful cases, of which Newton is perhaps the most interesting, and it excludes those who fall outside of the Baconian tradition such as Hobbes and Descartes. The margin of the model, its determinables, allow us to identify and trace a wide variety of Baconianisms that includes different ideas on the desired structuring of natural histories, differences in what should be counted as legitimate sensory input, different ideas on what constitutes a ‘False Appearance’, different ways of referring to theoretical propositions, and so on.

As a final remark, one should be aware that BNPM is designed to trace the presence of Baconianism (as expressed in the model’s conditions) in the writings of philosophers. This is something else from tracing the direct *influence* of Bacon on other philosophers. In this thesis, I am concerned with questions concerning the version of Robert Hooke’s Baconianism, whose indebtedness to Bacon is relatively uncontroversial. For Newton, the story would be different, as there are no clear references to Bacon in his work, and the direct influence of Bacon on his work is all but clear.¹³⁰ If one would want to investigate the direct influence of Bacon on Newton, other means than the model approach would be necessary.

6. The Hookean Idol

Having explained BNPM, it is now time to apply it to Hooke’s texts. In this section, the question to what extent Hooke adhered to Bacon’s doctrine of the idols will be answered in detail.

6.1. Bacon’s Idols

Bacon reserves in his prescriptions for the correct interpretation of nature a distinct role for the detection or alleviation of misguided apprehensions of phenomena:

¹³⁰ See e.g. Pérez-Ramos 1996, ‘Bacon’s Legacy’, 319. One could for example hold that Newton’s use of ‘experimentum crucis’ in a letter that was published in the Philosophical Transactions of the Royal Society from 1672 is a direct reference to Bacon, but this is anything but obvious. In the first place, Bacon used ‘instancia crucis’ instead of ‘experimentum crucis’. Hooke, to whom Newton refers in the 1672 letter did use the term ‘experimentum crucis’ on multiple occasions, for example, in Hooke 1697, ‘Concerning Amber’, 337). The direct influence of Bacon on Newton is thus not established by Newton’s reference to the crucial experiment.

'The formation of ideas and axioms by true induction is no doubt the proper remedy to be applied for the keeping off and clearing away of idols. To point them out, however, is of great use; for the doctrine of the Idols is to the Interpretation of Nature what the doctrine of the refutation of Sophisms is to common Logic.'¹³¹

In other words, the detection and prevention of what Bacon calls 'False Appearances'¹³², or idols, is an integral part of his methodological outlook. Idols are 'the deepest fallacies of the human mind'¹³³, and to prevent unreliable sciences from being grounded upon them, 'men being forewarned of the danger' ought to 'fortify themselves as far as may be against their assaults.'¹³⁴

Bacon divides his idols into four categories:

1. **Idols of the tribe:** fallacies that are due to our human constitution, or, misinterpretations due to our limited sensory capabilities.
2. **Idols of the cave:** fallacies that are the result of our individual constitution. This includes misinterpretations due to individual bodily and mental limits (e.g. having bad eyesight, missing hands, being slow in understanding, etc.), as well as misinterpretations due to preconceptions, biases, or dispositions individuals might have as a result of their upbringing or education.
3. **Idols of the marketplace:** fallacies resulting from careless and imprecise use of language. This includes both naming those objects or properties that do not exist, as well as using inaccurate definitions for those that do exist.
4. **Idols of the theater:** fallacies due to the adherence to dogmatic systems of philosophy or religion.

While much has been written about Bacon's idols¹³⁵, in this section I only want to emphasize two elements that are important to keep in mind when trying to identify the concept of an idol (and its detection and prevention) in a text that is not Bacon's own.

First, it should be clear that Bacon categorized his idols by the sources from which they spring: the idols of the tribe from our human nature, the idols of the cave from our individual natures, the idols of the marketplace from communication with other persons, and the idols of the theater from philosophical and religious currents and traditions. Thus, a passage in which a false appearance is mentioned (e.g. a report of a faulty observation, or some conclusion based on a sloppy

¹³¹ Bacon 1889, *Works of Bacon*, 54 (Novum Organum, Book I: XL).

¹³² Ibid., 431 (De Augmentis, Book V: Chapter IV).

¹³³ Ibid.

¹³⁴ Ibid., 53 (Novum Organum, Book I: XXXVIII)

¹³⁵ For a wide range of different and original takes on Bacon's doctrines of the idols, see: van Leeuwen 1970, *Certainty in English Thought*, 1-12; Gaukroger 2001, *Transformation of Early-Modern Philosophy*, 101-131; Zagorin (2001); Montuschi (2012); Weeks (2019); Smith (2021).

experiment) is not automatically a passage in which an idol is expressed; in addition, the source of the false appearance must be addressed.

Second, it should be clear that these sources of false appearances are all *internal to* or *internalized by* humans. Ultimately, all idols are due to our internal human constitution, both individually (by nature and nurture) and as a species. Idols of the cave that are due to individual natures and all idols of the tribe are innate, while the idols of the marketplace and idols of the cave that are due to upbringing, education, or habit are not innate but rather ‘steal into the understanding secretly’¹³⁶ and are thus internalized. The idols of the theater are not innate, nor do they secretly enter the understanding. But even these idols, although ‘superinduced by corrupt theories or systems of philosophy’¹³⁷ are only false appearances because they have been ‘impressed and received into the mind from the play-books of philosophical systems.’¹³⁸ In other words, the ultimate source of an idol of the theater is an internalized philosophy, and thus ultimately depends on the internal constitution of a person; the dogmatic philosophy *qua* system of thought that exists out in the world is innocent.

I emphasize this second characteristic of idols—of being ultimately internally caused—because it clearly separates genuine idols from a class of fallacies that have *external* sources, a class that I will not discuss in this thesis. In case of some inaccurate observation due to bad weather, for example, the source of the inaccurate observation is external to the observer and is thus not an idol. In effect, when Hooke writes of a misapprehension caused by something external to him as a human being—by, say, a broken microscope—we should not read this as expressing something analogous to the Baconian concept of a false appearance.

Finally, I am not using present day scientific knowledge to uncover false appearances that Hooke himself had. I am purely interested in Hooke’s conception of false appearances, not in his misinterpretations of nature.

6.2. Uncovering the ‘False Appearance’ in Hooke’s Work

We can quite easily discern that Robert Hooke was influenced by Bacon’s doctrine of the idols. Already in the preface to his *Micrographia* (1665), which arguably is Hooke’s main work, he speaks of the ‘mischiefs, and imperfection, mankind has drawn upon it self [...] whereby every man, both from a deriv’d corruption, innate and born with him, and from his breeding and converse with men, is very subject to slip into all sorts of errors.’¹³⁹ In another case, Hooke even refers directly to Bacon, also known as ‘Lord Verulam’, and his idols:

¹³⁶ Bacon 1889, *Works of Bacon*, 62 (Novum Organum, Book I: LXI).

¹³⁷ Ibid., 431 (De Augmentis, Book V; Chapter IV).

¹³⁸ Bacon 1889, *Works of Bacon*, 62 (Novum Organum, Book I: LXI).

¹³⁹ Hooke 1665, *Micrographia*, i.

'That thereby the *Idols* (as my Lord *Verulam* says) which pre-possess the Minds of some Men, and molest them in the discovery and imbracing of the Sciences may be detected, and, as much as may be removed and dissolved, thereby to leave the Mind more free to Discourse and Reason aright, without the prejudices of any unsound, unaccountable, and unwarrantable Doctrines formerly imbrac'd.'¹⁴⁰

These fragments cannot suffice to give a full account of Hooke's conception of 'False Appearances'. In order to gain a deeper understanding of Hooke's integration of Bacon's idols in his own methodological framework, a larger body of textual evidence is needed. Not much historiographical work has been done on Hooke's integration of the idols, and hence there are quite some open questions to be answered. First of all, are all of Bacon's idols represented in Hooke's texts, and if so does Hooke stick to Bacon's quadripartite division? Did Hooke put significant emphasis on any of the idols, does he relax any of them? And, can we discern internal sources of error in Hooke's work that cannot be subsumed under one of Bacon's idols? These are the questions that will be settled in this section.

The influence of Hooke's idols on Bacon has not gone unnoticed, but an in-depth study of the exact place of them in Hooke's methodology is still wanting. H.F. Cohen (2010) devotes a small section to Hooke's idols, but only briefly discusses his ideas on the idols of the cave.¹⁴¹ Mulligan (1992) states that Hooke thinks of preventing the idols as belonging to the tasks of the natural historian, but does not do more than refer to a passage in which Hooke speaks of 'Preparing the Mind'.¹⁴² Both Hunter (2003) and Sacco (2019) state that Hooke's idols look much like Bacon's, except for the fact that Hooke had three categories of idols, grouping the idols of the marketplace and the theatre together.¹⁴³ Both base their findings on one passage in Hooke's *General Scheme*, in which Hooke indeed appears to use the tripartite division Sacco and Hunter suggest. This section is intended to improve upon these suggestions. It should become clear that Hooke maintained Bacon's quadripartite division, and thus thought of the idols of the marketplace and theatre as separate sources of error, with specific remedies for each of them.

I will answer the questions surrounding Hooke's idols using the methods explained in the previous sections, keeping to the annotation task described below and the characterization of the idols given in section 6.1. My aim here is getting clear on how condition (6) in the Baconian model applies to Hooke. Recall that condition (6) was:

¹⁴⁰ Hooke 1689, 'Earthquakes (V)', 433.

¹⁴¹ Cohen 2010, *Modern Science*, 486-487.

¹⁴² Mulligan 1992, 'Certain Knowledge', 153.

¹⁴³ Hunter 2003, 'Natural Philosopher', 119-120; Sacco 2019, *Real, Mechanical, Experimental, 14.*

Condition 6: NPM prescribes ways to avoid or to detect false appearances (f).

(6) only expresses that a Baconian methodology should have some prescriptions with respect to false appearances and says nothing about Bacon's idols specifically. In creating the list to search for passages relevant to the current annotation task, I have included terms that are Hooke uses to designate the concept of 'false appearances' (e.g. 'phant'cy/fancy', 'prepossession', 'prejudice', 'errour', etc.). In the passages thus retrieved, I have identified the idols using the four categories delineated above.

As noted in section 6.1, Bacon himself fills determinable (f) in with his idols. Apart from the idols of the theatre, none of the idols can be completely got rid of; they can only be detected and ameliorated to some extent. The following annotation task is designed to fill in (f) for Hooke, and to find out what his means of detection and prevention were. By first answering three subquestions (SQ's) for each paragraph, a body of evidence is established with which the following overarching research question (RQ) can be answered:

RQ. To what extent does Hooke's conception of the (internal) sources of false appearances deviate from Bacon's doctrine of the idols?

The SQ's are:

SQ1: Is at least one of Bacon's four idols represented in this paragraph?

SQ2: Does Hooke introduce a source of false appearances that cannot be subsumed under one of Bacon's idols?

SQ3: Does Hooke encourage the use of some method for detecting or avoiding the false appearances found in answering **SQ1** and/or **SQ2**?

The distinction between RQ's and SQ's is made because it cannot be expected that single paragraphs provide conclusive answers to the larger RQ on their own. Rather, the annotated paragraphs will be accumulated into a larger body of evidence that will be analyzed after all annotations have been carried out. In other words, the SQ's are directed to be answered at the paragraph level, the RQ is directed to be answered at the corpus level, using the answers to the SQ's.

The actual annotation proceeds as follows. For each passage and for each SQ, the annotator scores 1, 0, or -1:

Score :	Explanation:
1	This paragraph contains sufficient evidence to provide an answer to the SQ.

o	This paragraph might contain some evidence to provide some answer to the SQ, but the paragraph must be read in context of surrounding paragraphs, or the annotator is otherwise not confident that it deserves a score 1 or -1.
-1	This paragraph does not contain sufficient evidence to provide any answer to the SQ.

In addition, scores are accompanied by a justification from the annotator that should clarify the way they scored. For scores of o or 1 on SQ1 or SQ2, the justification should contain information about the Baconian or Hookean idol that was identified in the paragraph. The justification can be omitted when the paragraph is scored a -1 because it is completely and obviously irrelevant to the annotation task.

After annotating, the annotated paragraphs and their comments were collected and reconsidered. What follows are the answers to the RQ.

6.3. The ‘Wandering of our Senses’ the ‘Slipperiness or Delusion of our Memory’, and ‘the Confinement or Rashness of our Understanding’: Hooke’s Idols of the Tribe

According to Sacco (2019), Hooke has a conception of idols of the tribe but only speaks of the inadequacy of our senses as a source of them. I do agree with Sacco’s claim that the idol of the tribe can be identified in Hooke. However, in what follows I will disprove his claim that this idol was connected only to our faulty sensory apparatus and show that Hooke believed that false appearances are also caused by our faculties of memory and the understanding, which are infirm by nature too. We will see that even though Hooke did place a lot of emphasis on false appearances caused by limited visual capacities, human memory and reason are definitely mentioned as sources as well. Further, it will become clear that he also had specific methods of avoiding and detecting the idols of the tribe in mind. Let us first look at Hooke’s idea of false appearances due to our limited sensory capacities.

According to Hooke, the way productions of nature are perceived is relative to a species: ‘if there were another Species of Intelligent Creatures in the World, they might have quite another kind of Apprehension of the same thing.’¹⁴⁴ We perceive darkness in the absence of sunlight because of our peculiar human constitution; ‘it is not so to Cats and Owls.’¹⁴⁵ Not only looking at other creatures,

¹⁴⁴ Hooke 1666, ‘General Scheme’, 8.

¹⁴⁵ Ibid.

but also instruments can make evident that certain qualities such as heat and cold ‘are only Relative to our Constitution’, as for example is shown by Hooke’s ‘Weather Glass’ which ‘feels many Degrees of Heat before it be sensible to us.’¹⁴⁶ It is important to note that Hooke does not only think our human constitution leads to limited apprehensions of things, but can also cause us to ‘slip into all sorts of errors.’¹⁴⁷ In other words, being human leads to false appearances, to idols of the tribe.

As said earlier, the lion’s share of instances of Hooke’s idols of the tribe point to the senses as unreliable, and in these cases Hooke speaks almost exclusively about our limited visual capacities. Many of these instances can be found in his *Micrographia*. This should be no surprise, as the work can be regarded as Hooke celebrating the microscope, or negatively as him lamenting the naked eye. What to the naked eye appears as a perfectly round point of a needle reveals itself under the microscope as hiding ‘a multitude of holes and scratches and ruggednesses’.¹⁴⁸ What is perceived by the naked eye as ‘a very fine Purple’ turned out to be a ‘Phantasm’ when Hooke placed it under the microscope and ‘could easily distinguish both the Red and the Blue particles’.¹⁴⁹ It is striking that Hooke thought of the microscope as a tool for both the detection and for the avoidance of the false appearances of the unassisted eye.¹⁵⁰ It is also here where Hooke clearly deviates from Bacon. Bacon did not see specific instruments as self-sufficient ways of detecting and overcoming our shortcomings as human observers but placed much more emphasis on the beneficial effects of his methodological prescriptions at large: the building of natural histories, the use of tables, and his method of induction.¹⁵¹ For Hooke on the other hand, reparations to the deficiency of the senses could be made by ‘the addition of such artificial Instruments’ as microscopes and telescopes.¹⁵²

Our unreliable faculty of memory, *pace Sacco*, is also mentioned by Hooke as a specific cause of idols of the tribe. Hooke had a materialistic conception of memory. Even though the soul itself is an ‘Incorporeal Being’, it ‘makes use of Corporeal Organs, and without them cannot effect what it wills.’¹⁵³ Thus, Hooke

¹⁴⁶ Ibid.

¹⁴⁷ Hooke 1665, *Micrographia*, i.

¹⁴⁸ Ibid., 2.

¹⁴⁹ Ibid., 78.

¹⁵⁰ Hooke made much of the shortcomings of the naked eye. He even measured the accuracy of the naked eye by testing the Royal Society Fellows vision on at least two occasions and was intent on convincing everyone present of its limits. Present day research has shown that Hooke’s tests were quite accurate. However, he appears to have dismissed the capabilities of the naked eye too quickly, as astronomers like Hevelius had ways of registering minute distances without using what Hooke would have called advanced instruments (Buchwald & Feingold, *Origin of Civilization*, 44-52).

¹⁵¹ Weeks 2019, ‘Universal Madness’, 34.

¹⁵² Hooke 1665, *Micrographia*, i.

¹⁵³ Hooke 1682b, ‘Lectures of Light (VII)’, 140.

states, ‘Memory I suppose to be as much an Organ, as the Eye, Ear, or Nose’, an organ that is nothing but a ‘Repository of Ideas’.¹⁵⁴ Hooke is known to have had a particularly bad memory himself, something he was well aware of.¹⁵⁵ But next to his recognition of differences in individual retentive capacities, he also recognized natural limits to memory that applied to everybody. Furthermore, these limits lead to false appearances, and hence memory is a true source of idols of the tribe.

For example, Hooke states that ‘Man’s Memory seems very shallow and infirm, and so is prone to forget many circumstances.’¹⁵⁶ Moreover, not only do we ‘often let many things slip away from us, which deserve to be retain’d’, of the things which we do retain, ‘a great part is either frivolous or false’.¹⁵⁷ To make matters worse, the useful things that we do remember are ‘in tract of time obliterated, or at best so overwhelmed and buried under more frothy notions, that when there is need of them, they are in vain sought for’.¹⁵⁸ Imperfect unassisted memory leads to false appearances because it is, together with the senses, a faculty that provides the factual foundation for natural philosophy. We can assist the senses with instruments to make more accurate observations, but if these observations are not properly stored and ‘ranged in the best and most Natural Order’, anything deduced from them is at best uncertain, and likely to be false.¹⁵⁹ This storing and ranging is done by constructing a ‘Philosophicall History’, which Hooke conceived to be the ‘Armour, Engine, and Assistance’ of human memory.¹⁶⁰

The final source of idols of the tribe is our faculty of reason, or understanding. Hooke is not entirely clear and univocal about what he thinks is wrong with human reason and how it leads to false appearances.¹⁶¹ In the introduction to his *Micrographia* from 1665 he speaks about the inherent ‘confinement and rashness of our Understanding’ as a source of error.¹⁶² Although the passage is formulated in a somewhat obfuscated manner it appears that the ‘confinement’ of our understanding limits the extent of our knowledge, while the ‘rashness’ of our understanding is detrimental to the quality of our knowledge, as we are by nature not ‘scrupulous and exact’ enough.¹⁶³ Hooke does not come with a clear-cut and well-formulated solution to the false appearances caused by our

¹⁵⁴ Ibid., 139.

¹⁵⁵ Mulligan 1996, ‘Self-scrutiny’, 333.

¹⁵⁶ Hooke 1666, ‘General Scheme’, 6.

¹⁵⁷ Hooke 1665, *Micrographia*, i.

¹⁵⁸ Ibid.

¹⁵⁹ Hooke 1666, ‘General Scheme’, 34.

¹⁶⁰ Ibid.

¹⁶¹ Perhaps this point was completely obvious to Hooke, whose avid experimentation shows in itself that he believed reason cannot be relied upon alone in interpreting nature, to the effect that it did not cross his mind to further elaborate on this point.

¹⁶² Hooke 1665, *Micrographia*, iii.

¹⁶³ Ibid., vi. The idea of human understanding being ‘rash’ is frequently found in Bacon as well, for example when he characterizes those who anticipate instead of interpret nature. (Bacon 1889, *Works of Bacon*, 51 (Novum Organum, Book I: XXVI)).

understanding. Although he first suggests a compromise, or taking ‘the middle wayes’ between quality and quantity, he continues that ‘nothing is to be omitted, and yet every thing to pass a mature deliberation’, which implies the maximization of both quality and quantity, and not a ‘middle way’.¹⁶⁴ Human understanding should function as a ‘lawful Master’ of the two lower faculties of sense and memory, and not ‘in croach upon their Offices’; it should control the senses without anticipating them, and it should inspect the particulars stored in memory while distinguishing between that which is well collected and the ‘extravagant Ideas, and mistaken Images’.¹⁶⁵

How exactly we are to assist our faculty of understanding as such is left unclear, and it may very well be the case that Hooke never gave a final solution to the problems of the understanding. Bacon thought of his inductive method as a ministration to reason, but no such thing can be found in Hooke.¹⁶⁶ The mysterious ‘Philosophical Algebra’ he incidentally alludes to in his work as a tool for improving our reasoning remains equally vague, and appears to be merely an unfulfilled promise; there is no historical evidence that Hooke ever completed his Algebra, nor are there indications of his use of it in his experimental work, and the different historiographical accounts of its nature are at best conjectural.¹⁶⁷ That being said, the one thing that is evident is that Hooke did believe that the understanding itself was an imperfect faculty capable of generating false appearances, and that, like the senses and memory, it is in need of assistance. And in this Hooke is closer to Bacon than Sacco would have it, for Bacon does not only speak of ‘the incompetency of the senses’ as sources of false appearances, but points to our understanding as being of its own nature prone to assuming order and regularity, to superstition, and to receiving ‘an infusion from the will and affections’.¹⁶⁸ Although Bacon did believe that the faculty of memory was in need of ‘ministrations’¹⁶⁹, it is not mentioned as a source of false appearances in his discussion of the idols of the tribe, nor in his discussion of idols of the cave, and thus Hooke departs somewhat from Bacon in explicitly mentioning it as a source of idols.

6.4. ‘Every Man’s own Peculiar Structure’ as a Source of ‘Errour’: Hooke’s Idols of the Cave

¹⁶⁴ 1665, *Micrographia*, iii.

¹⁶⁵ *Ibid.*, vii.

¹⁶⁶ Weeks 2019, ‘Universal Madness’, 34.

¹⁶⁷ For discussions about Hooke’s ‘Philosophical Algebra’, see e.g. Hesse (1966), Hunter (2003), Sacco (2019), Yeo (2007). Both Hunter (2003) and Sacco (2019) conclude that the historical evidence is insufficient to say anything substantial about Hooke’s algebra.

¹⁶⁸ Bacon 1889, *Works of Bacon*, 55–59 (Novum Organum, Book I: XLIV-LII).

¹⁶⁹ *Ibid.*, 127 (Novum Organum, Book II: X).

Bacon divides his idols of the cave into different categories: those caused by someone's education and habit, those caused by accident, and those proceeding from our 'peculiar constitution', which is further divided into a bodily and a mental part. Sacco briefly mentions only an instance of an idol of the cave relating to education and habit, which gives the impression that Hooke disregards innate causes of idols of the cave.¹⁷⁰ But Hooke clearly states that 'Every Man has born with him, or contracted by some way or other, a Constitution of Body and Mind, that does more or less dispose him to this or that kind of Imagination or Phant'sy of things.'¹⁷¹ Elsewhere, Hooke says that an argument may appear more or less plausible depending on whether a person is '*by nature* or education prejudiced to this or that way'.¹⁷² In what follows I will show that instances from all Bacon's subdivisions can be found in Hooke, and hence conclude that Hooke followed Bacon closely in his ideas on the idols of the cave. Let us first look at an instance of an idol of the cave that derives from an individual bodily constitution.

In a lecture on the causes of gravity read before the Royal Society in 1682, Hooke calls sight the 'chiefest sense' that can inform about the nature of comets.¹⁷³ Looking at the 'Accounts of several Historians' of their observations of comets he finds them all to be different from one another, and he cannot decide which of them to rely on. As one of the causes of the differing observational accounts Hooke mentions 'the difference of the goodness of [the historian's] Sight.' Since he is not talking about the human eye in general as a source of false appearances but rather about specific individual differences between observers, this passage expresses an idol of the cave caused by particular bodily constitutions.

Individual innate mental constitutions influence our dispositions, and therewith our perceptions and beliefs as well, as some constitutions 'more incline a Man to Contemplation, and Speculation, another to Operation, Examination, and making Experiments'.¹⁷⁴ Some types of mental dispositions lead to false appearances, such as that of a 'melancholy Person, that thinks he meets with nothing but frightful Apparitions'.¹⁷⁵ The mental constitution of such a person acts as a filter that turns 'all things he either sees or hears into dreadful Representations, and makes use of them to strengthen his Phant'sy, and fill it fuller of such uneasy Apprehensions, so is it in Constitutions of Mind as to Philosophy'.¹⁷⁶

¹⁷⁰ Sacco 2019, *Real, Mechanical, Experimental*, 14.

¹⁷¹ Hooke 1666, 'General Scheme', 9 (emphasis mine).

¹⁷² Hooke 1674, *Motion of the Earth*, 2 (emphasis mine).

¹⁷³ Hooke 1682a, 'Discourse of Comets', 151.

¹⁷⁴ Hooke 1666, 'General Scheme', 9.

¹⁷⁵ Ibid.

¹⁷⁶ Ibid. Hooke's attribution of 'dreadful Representations' to melancholy instead of direct intervention of demons or witches fits into a broader degradation of supernatural explanations for e.g. ghost sightings and witchcraft accusations in favor of more naturalistic explanations. For example, Hooke's contemporary and Royal Society Fellow Hans Sloane, who was a physician, thought that such delusions were the result of

Individual prepossessions and ‘byasses’ that are due to an individual’s education, acquired taste, profession, or habit are the idols of the cave that are the most common in Hooke’s writings. Hooke himself claims not to be led by ‘any preconceiv’d Notion’ in devising experiments, but conversely makes his experiments the ‘standards [...] or Touchstones by which I try all my former Notions.’¹⁷⁷ He similarly praises sea captain Robert Knox, for whom Hooke wrote the introduction to *An Historical Relation of the Island Ceylon* from 1681. Knox, says Hooke, is in no way ‘prejudiced or byassed by Interest, affection, or hatred, fear or hopes, or the vain-glory of telling Strange Things, so as to make him swarve from the truth of Matter of Fact.’¹⁷⁸ It is important for Hooke to emphasize this element of impartiality because he frequently accuses other authors of falsely interpreting nature while being led by their preconceptions. For example, in a passage from a lecture about comets read in 1695 Hooke addresses the French astronomer Claude Comiers, who defended a theory on tail formation in comets.¹⁷⁹ Hooke accuses Comiers of rejecting and ‘bespattering’ observations that do not fit his theory while ‘at the same time relying on Observations of the Antients to prove what he would have to be so.’¹⁸⁰ A philosopher’s specific interest can color all of their observations and theories, and thus Aristotle’s ‘Physick’ is colored by his ‘Logick’, Descartes’ philosophy by his ‘Opticks’, while Pythagoras’, Bruno’s, and Kepler’s works are given substance by their preoccupation with ‘Arithmetick and the Harmony of Numbers.’¹⁸¹ In other words, most philosophers tend to make everything ‘agreeable or subservient’ to the things they have ‘accidentally studied’ or are well-versed in, and hence impose fallacies upon others, but most of all upon themselves.¹⁸²

Hooke also gives some examples of false appearances due to the lack of skill or education, for example, of coastal maps made by mariners that do not give ‘true Representations’ of coastlines, since mariners are ‘generally, very little skill’d in the Art of Delineation.’¹⁸³ Or, one who is not ‘well accustomed to the phænomena of fluids of differing figures and refractions’ will not be able to correctly observe and represent substances such as fat and ‘inspissated juyces’.¹⁸⁴

‘hypochondriack Melancholy’ and should be cured by purgative methods such as bloodletting and vomiting (Hunter, *Decline of Magic*, 128–129).

¹⁷⁷ Hooke 1661, *Attempt for the Explication*, 42.

¹⁷⁸ Knox 1681, ‘Introduction’, iv.

¹⁷⁹ Wright 2000, ‘Pepys’ Diary’, 23–27.

¹⁸⁰ Hooke 1695, ‘Navigation and Astronomy Lecture (IV)’, 540.

¹⁸¹ Hooke 1666, ‘General Scheme’, 9–10. There is a striking similarity between this paragraph by Hooke and Bacon’s aphorism LIV in the *Novum Organum*: ‘Men [...] distort and colour [contemplations] in obedience to their former fancies; a thing especially to be noticed in Aristotle, who made his natural philosophy a mere bond-servant to his logic.’

¹⁸² Ibid.

¹⁸³ Hooke 1694c, ‘Instrument to Take the Draught’, 294.

¹⁸⁴ Hooke 1678, *Lectures and Collections*, 92.

Hooke points to some concrete paths out of the cave. First, one should become aware of one's constitution in order to discover 'what one is either naturally or accidentally inclin'd to believe.'¹⁸⁵ Then, one should for a certain period try to work contrary to their constitution. For example, one who 'fancies Novelty' should be wary of admitting anything that is new, one that is 'addicted to Chymical or Mechanical Operations' should refrain from accepting chymical or mechanical answers to questions, at least until all relevant alternatives have been honestly considered. In this way, one might 'perceive many things to have proceeded from Prejudice.'¹⁸⁶ Bacon stated something very similar, as he advised every philosopher to hold in suspicion 'whatever his mind seizes and dwells upon with peculiar satisfaction.'¹⁸⁷

There is somewhat of a tension between Hooke's advocacy of 'Hypothetical Skepticism' and his adherence to mechanical philosophy, especially as they are both presented as separate means of detecting and avoiding idols of the cave. On the one hand, Hooke argues for a skepticism whereby we 'impose upon ourselves a Disbelief of everything whatsoever, that we have already imbraced or taken in as Truth, [...] even all those things of which we are most confident.'¹⁸⁸ One would expect that the mechanical hypothesis would be among these 'Truths', but in the same work Hooke writes that we can 'regulate the Conceptions of the Mind' and get rid of our 'Puerile and Childish fancies', not by tentatively rejecting all propositions, but by inquiring specifically into the 'mechanical ways' such as pressing, pounding, grinding, etc.¹⁸⁹ One might expect that Hooke prefers mechanical experiments because they keep us down to earth, or because mechanics was an excellent fit for experimental philosophy. Thus, even though Hooke was attracted to mechanism as a type of explanation, he did not give any special credence to it in explaining more fundamental operations of nature. However, in the same passage, Hooke states that our knowledge of mechanical operations in visible things could provide insight into more hidden and invisible things in nature, such as magnetism. For example, he says that 'the Observations that by the cutting off a part of any Stone from one side of it, does alter the Center of Gravity of it; And that a Musical String, wherever it be stopp'd, if it be struck does make the longest Vibrations in the middle, may prompt us perhaps somewhat

¹⁸⁵ Hooke 1666, 'General Scheme', 10.

¹⁸⁶ Ibid.

¹⁸⁷ Bacon 1689, *Works of Bacon*, 60 (Novum Organum, Book I: LVIII).

¹⁸⁸ Hooke 1666, 'General Scheme', 11. On another occasion, Hooke claimed to have practiced what he preached, and provides an instance of his maxim. After considering different accounts of comets, and after stating that he based his own 'Conjecture' on many observations, 'the Repetitions of them some hundreds of times', he decides to 'throw aside all manner of Hypotheses concerning [comets], and to observe them as if there never had been any such Appearance before, and to attend wholly to what the Appearances themselves would teach me.' (Hooke 1682a, 'Discourse of Comets', 152)

¹⁸⁹ Hooke 1666, 'General Scheme', 60.

of the Reason of the Poles of the Magnet upon the paring off one side.”¹⁹⁰ Thus, Hooke did think that inquiry into mechanics could provide useful analogies in explaining the more hidden parts of nature. Resolving this tension between Hooke’s prescribed rejection of preconceived theories and his far-reaching adherence to the mechanical hypothesis is thus not easily resolved. Perhaps there is an interesting suggestion for future research here.

6.5. Words as ‘Improper Marks’ and ‘Jurare in Verba Magistri’: Hooke’s Idols of the Marketplace and of the Theatre

The reason I discuss Hooke’s idols of the marketplace and theater in tandem is because they are in need of some disentanglement. As stated above, both Sacco (2019) and Hunter (2003) believed that Hooke used a tripartite division of idols. Sacco states that ‘Bacon distinguished between the idols of the marketplace and the idols of the theatre, whereas Hooke joined obstacles of education and of language in a single kind of prejudice.’¹⁹¹ As evidence, Sacco presents one fragment from the preface to Hooke’s *General Scheme* (1666) in which Hooke indeed expresses his concerns about ‘Traditional learning’ and the process of instilling ‘Philosophical words’ based on ‘confused and complicated Notions’.¹⁹² This is the same fragment that Hunter uses as evidence for his similar claim. Consonant with the one of the main methodological arguments I want to defend in this thesis I will show in this section that when we rely on the full Hooke corpus instead of a small selection there is definitely a distinction to be discerned between Hooke’s idols of the marketplace and of the theater.

In the preface to the *Micrographia*, written around the same time as the *General Scheme*, Hooke says that imperfections and errors arise from our ‘breeding and converse with men’.¹⁹³ Further, in one of his *Lectures of Light* (1680), he discusses the Aristotelian notion of light: Aristotelians have supposed that the source of light is fire, which when not dense only produces the effects of light, and when ‘dense enough’ produces the effects of fire in addition.¹⁹⁴ Hooke believes that this is a fallacy that is due to bad definition: ‘tis but giving of it another Name, and calling Light by the Name of Fire or Flame.¹⁹⁵ The fact that Hooke happens to be discussing an Aristotelian notion of fire here does not make this passage an instance of an idol of the theater. The passage is clearly about misconceptions due

¹⁹⁰ Ibid.

¹⁹¹ Sacco 2019, *Real, Mechanical, Experimental*, 14.

¹⁹² Hooke 1666, ‘General Scheme’, 10.

¹⁹³ Hooke 1665, *Micrographia*, i.

¹⁹⁴ Hooke 1680, ‘Lectures of Light (I)’, 72.

¹⁹⁵ Ibid.

to an ill-defined natural phenomenon, and thus about language, not about the dogmatic acceptance of Aristotelian philosophy.

Hooke also indicates a way of detecting the idols of the marketplace. Listeners must be ‘extreamly attent’ and ‘very perspicacious’ in mapping the right notions onto words, for ‘the Notions signified by some words being very many and very perplex.’¹⁹⁶ Thus, listeners must make sure that the words they hear indeed signify what they think they signify. Hooke also proposes a more ambitious project of revising scientific language; we should come up with ‘new Words’ that are ‘set upon more distinct Conceptions and Notions’.¹⁹⁷ In doing so, ‘other words ought to be wholly blotted out and rejected’ in case some word refers to a thing, but imperfectly so, or when a word expresses a ‘Phantasm, for which there is no ground in Nature’.¹⁹⁸ This division of the idols of the marketplace corresponds perfectly with Bacon’s, who divided them into ‘names of things which exist, but yet confused and ill-defined’ and ‘names of things which do not exist.’¹⁹⁹

Expressions of idols of the marketplace occur much less frequently in Hooke’s work than idols of the tribe, cave, or theater. A possible reason why Hooke did not write much in relation to these idols is that he might have recognized that his suggestions to alleviate them were not very impressive, and he may have shared Bacon’s pessimism regarding their eradication. Bacon called these idols ‘the most troublesome of them all’, and thought they were practically impossible to dispense with.²⁰⁰ Hooke’s pieces of advice are also not very helpful; they boil down to ‘pay attention’ and ‘make a better language’. He does not share further details about how exactly we are to reform language. In preventing and detecting the other idols, Hooke could turn to microscopes, telescopes, and inductive natural histories, which might explain the more frequent recurrence of the other three idols.

Hooke’s idols of the theater are mostly presented as disconnected from fallacies due to language, which should suffice to show that Hooke thought of the theatre as a locus of error distinct from the marketplace. The references to schools of thought that Hooke perceives to be dogmatic ‘stage plays’ and their actors are ubiquitous. Examples are the ‘Ptolomaick’ or ‘Tychonic’ non-Copernican systems, the peripatetics, the stoics, the ‘Solid Orb men’, the ‘Sympathy and Antipathy men’, and mechanical philosophies that Hooke disapproved of, such as Cartesian systems of vortices.²⁰¹ Many of these dogmatists were already disapproved of by Bacon, and Hooke supplements the list with more recent systems of which Bacon could not have known, such as the Cambridge platonists. Hooke warns us that if we ‘remain

¹⁹⁶ Hooke 1666, ‘General Scheme’, II.

¹⁹⁷ Ibid., 10.

¹⁹⁸ Ibid.

¹⁹⁹ Bacon 1889, *Works of Bacon*, 61 (Novum Organum, Book I: LX).

²⁰⁰ Ibid., 60–61 (Novum Organum, Book I: LIX).

²⁰¹ Hooke 1674, *Motion of the Earth*, 3; Hooke 1681, ‘Lectures of Light (III)’, 104; Hooke 1692, *Telescopes and Microscopes*, 264.

tied up to the Opinions we have received' from such systems and disbelieve everything not conforming to them 'tho' never so rational, [...] this will be truly Jurare in verba Magistri [i.e. 'swearing by the words of our masters'].'²⁰²

A concrete example of a false appearance due to adherence to a dogmatic stage play can be found in Hooke's discussion of the existence of the 'hylarchic spirit', as defended by Cambridge platonist Henry More. The hylarchic spirit is a hypothetical principle of nature that governs (otherwise inert) matter. It is based on traditional concepts of an active principle handed down by platonic and stoic philosophers, and is according to Hooke encouraging 'Ignorance and Superstition', while discouraging deeper inquiry into the true causes of things.²⁰³ By accepting the hylarchic principle, More is committed to the for Hooke obviously false appearance that the running faster or slower of water is regulated by the hylarchic spirit. Instead, one should leave open the possibility that the 'quantity of matter and motion' regulates the movement of water. At least these are 'within the power and reach of man's Industry and Invention'.²⁰⁴ There is no mention of language in this passage, and hence no connection to the idols of the marketplace; the false appearance presents itself to those that uncritically accept dogmatic platonism, not to those who use 'improper Marks'.

Another false appearance due to philosophical stage-plays, or due to 'a prepossession of Tradition or common Fame', is the commonly held Aristotelian notion that comets are 'exhalations of the earth' and that they are sublunary meteors, as discussed by Hooke on at least two different occasions.²⁰⁵ Hooke speculates that such ideas have found their origin in reasoning on the basis of superficial sense appearances.²⁰⁶ Of course, Hooke does not mean here that we should not care about sense appearances. Rather, the emphasis is on the fallaciousness of syllogizing with 'the most obvious' empirical data as premises, as opposed to 'true Ratiocination' from particulars obtained by strict experimentation and observation.²⁰⁷ And again here, Aristotle is treated as a deceptive stage-player, not as a source of lexical confusion.

Hooke, in treating idols of the theater as a category separate from idols of the marketplace, also has methods of detection and avoidance of unwarranted adherence to dogmatic schools. In his *Discourse concerning Telescopes and Microscopes* from 1691/92, Hooke introduces the concept of *autopsia*:

'Autopsia is not only necessary for directing the Mind and Intellect, in its Progress to be made, for what is gone thro' with; but 'tis necessary also, for the reducing to

²⁰² Hooke 1694a, 'Discourse of Earthquakes (VI)', 450.

²⁰³ Hooke 1677, *Lampas*, 34.

²⁰⁴ *Ibid.*

²⁰⁵ Hooke 1678, *Lectures and Collections*, 18-19; Hooke 1681, 'Lectures of Light (III)', 105.

²⁰⁶ Hooke 1681, 'Lectures of Light (III)', 105.

²⁰⁷ *Ibid.*, 104.

its right Way from which it may have been misguided, by the false and erroneous Suggestions it hath formerly met with, either in some famous Authors that have positively asserted, or defended a Falsity.’²⁰⁸

Autopsia is a term that can also be found in the works of physician William Harvey, who used it to denote repeated direct observations in inquiries into human anatomy, as opposed to accepting claims by hearsay.²⁰⁹ Using *autopsia*, we detect and avoid dogmatizing by carrying out the investigation of nature ourselves. There is an interesting difference between Harvey’s and Hooke’s use of the term. Harvey thought that *autopsia* was not applicable to astronomical investigations, since he believed that direct apprehension of celestial phenomena was practically impossible. He states that in ‘searching for the cause of the Eclipse, one should be placed above the Moon.’²¹⁰ The only time Hooke mentions ‘autopsia’ he precisely applies the term to his own astronomical observations with a ‘good telescope’, to contrast himself with Vossius’ ‘very small, and very imperfect telescope.’²¹¹ This strongly suggests that Hooke had a conception of ‘direct apprehension’ that was different from Harvey’s, to the effect that observation through a telescope would qualify as direct, or at least as direct enough.²¹²

More general advices for escaping traditional systems of thought can be found in one of Hooke’s *Discourses on Earthquakes* from 1694: we ought to be ‘making use of the Senses’, we should base our reasoning on reliable natural histories instead of non-Baconian traditional histories such as Pliny’s, and we should rely on ‘Evidence and Reason’ instead of ‘Prejudice’.²¹³ Elsewhere, Hooke suggests something that conforms with *autopsia* without using the term: we should refrain from imposing wild notions that transcend direct experience and the ‘plain Deductions of Reasons therefrom’.²¹⁴

To conclude this section: I hope to have made evident that Hooke did separate the idols of the marketplace and the idols of the theater. There are

²⁰⁸ Hooke 1692, *Telescopes and Microscopes*, 263.

²⁰⁹ The use of ‘autopsia’ in anatomical contexts can be traced back to Vesalius, who in his 1543 ‘Fabrica’ urged ‘students who have not attended my dissections in the last two years to examine all this with their own eyes (or as the Greeks say, by *autopsy*)’ (Vesalius 2009, *Fabric*, 218).

²¹⁰ Harvey quoted in: Goldberg 2016, ‘Harvey on Anatomy and Experience’, 315.

²¹¹ Hooke 1692, *Telescopes and Microscopes*, 263.

²¹² If this suggestion is correct, then Harvey and Hooke would determine the margin term ‘sensory input’ in condition (1) of BNPM in a different way. To what extent Harvey could be called a Baconian is a topic of debate. While there are certain elements of Baconianism present in Harvey’s methodology, he did not think that Bacon’s system produced something to be called natural philosophy, and Aubrey quotes Harvey as even calling the Baconians ‘shitt-breeches’ (French 1994, *Harvey’s Natural Philosophy*, 325–328).

²¹³ Hooke 1694a, ‘Discourse of Earthquakes (VI)’, 450.

²¹⁴ Hooke 1677, *Lampas*, 34.

passages in his work where he points at false appearances due to the use of confusing terms without connecting these to dogmatic philosophies, and there are passages in which idols of the theater are identified without reference to anything that pertains to language. Both are properly seen as counterexamples against Sacco's and Hunter's claim that Hooke merged the marketplace and the theater.

6.6. Conclusion

In 72 of the 598 annotated paragraphs that contained terms relating to false appearances, one or more of the Baconian idols were identified. The rest of the paragraphs were either irrelevant to the task, were not informative enough, or contained instances of false appearances with external sources. The idols of the tribe, cave, and theater are expressed with similar frequencies, the idols of the marketplace were only identified in five paragraphs.

From what has been presented in this section, it should be clear that Hooke stays very close to Bacon's original design when it comes to ideas about internal sources of false appearances, or idols. He sticks to Bacon's division into four idols and gives examples of each of them. The term 'false appearance' itself can only be found in Bacon, not in Hooke. But even though the term 'idol' with its Baconian meaning is found only once in the Hooke corpus, this is enough to show that he was familiar with Bacon's concept. I have shown that Hooke uses different terms to denote the same concepts; terms such as 'Prejudice', 'Prepossession', 'Chimera', and 'Phant'cy' play a role that is quite the same as Bacon's idiosyncratic terms as should be clear from the passages presented in this section.

Hooke adds the frailty of memory as a cause of idols of the tribe, while Bacon only mentions the senses and the understanding. That is not to say that Bacon did not think of the memory as an imperfect retentive faculty; he thought of memory as in need of a ministrant in the form of tabularizing natural historical facts, and both his *Novum Organum* and *De Augmentis* contain passages mentioning various mnemonic devices.²¹⁵ But more importantly, where Hooke sees memory as a material organ that is separate from the understanding, Bacon includes memory in the understanding along with reason and imagination. Moreover, these three faculties of the understanding are not completely separate, but interfere in undesirable ways.²¹⁶ Thus, while Bacon does not mention memory explicitly in his discussion of the idols, we can be quite sure that his talk of the understanding in this context includes memory as well. Thus, although memory is not specifically mentioned in the context of the idols, Hooke's concern with

²¹⁵ Bacon 1889, *Works of Bacon*, 161-164 (Novum Organum, Book II: XXVI); Bacon 1889, *Works of Bacon*, 435-437 (De Augmentis, Book V: Chapter V).

²¹⁶ Weeks 2019, 'Universal Madness', 19-20.

memory still fits well within the overall Baconian framework. Hooke's more explicit mention.²¹⁷

There were no internal sources of false appearances identified that could not be reduced to one of the original Baconian idols, with the possible exception of one case. At one point in the *Micrographia*, Hooke contrasts the active intervention of observers of living creatures under the microscope—by ‘dissecting and mangling’—with them passively watching and not disturbing these creatures in their natural course of action.²¹⁸ Hooke states that by intervention, we can interfere with nature's regularities and hence cause a false appearance. We can avoid such disturbance if we do not ‘endeavour to pry into [nature's] secrets by breaking open the doors upon her’, but instead ‘quietly peep in at the windows, without frightening her out of her usual byas.’²¹⁹

I have called this a ‘possible exception’ because it is debatable whether this type of false appearances is caused internally (from the action or disposition of the observer) or externally (by creatures in the external world reacting to intervention); the false appearance is generated as a result of an observer's interaction with the world, and thus intervention operates on the border of the internal and the external. In addition, Hooke is not generally reluctant to interfere with nature's normal course of action, as he also approves of experiments ‘wherein Nature is as ‘twere put to Shifts and forc'd to confess’.²²⁰ This agrees with the Baconian theme of uncovering the secrets of nature ‘more readily under the vexations of art than when they go their own way’.²²¹

7. Hooke's History-Philosophy Divide

In this section, I formulate an answer to the second question of this thesis: what is the exact nature of the distinction between natural history and natural philosophy for Hooke? Which parts of the scientific process can be done by the natural historian, and what is left for the philosopher?

²¹⁷ Blair (2010) claims that Hooke, but also his contemporaries such as Malebranche, explicitly downgraded memory and so contributed to a broader shift in attitude toward erudition. While Bacon (Blair 2010, *Too Much to Know*, 75).

²¹⁸ Hooke 1665, *Micrographia*, 186.

²¹⁹ Ibid. Besides the voyeuristic aspect in this fragment, the old theme of nature as a female that must be ‘unveiled’ or even ‘penetrated’ in order to make her confess her secrets can also be felt here. Bacon, whose frontispiece to his *New Atlantis* depicts a young woman being dragged out a cave, can be seen as a key promotor of this theme (see also: Hadot (2006)).

²²⁰ Hooke 1666, ‘General Scheme’, 34.

²²¹ Bacon 1889, *Works of Bacon*, 94–95 (Novum Organum, Book I: XCVIII).

7.1. A Gradual Merging?

One of the most central characteristics of Bacon's scientific methodology is the role of natural history as the foundation for natural philosophy. Bacon likened the natural knowledge to a pyramid, with three successive levels: at the bottom there is natural history as the foundation of 'Physic', which is Bacon's peculiar way of referring to the part of speculative natural philosophy that deals with material and efficient causation.²²² 'Physic', in turn, is the foundation of 'Metaphysic', which is knowledge of forms, viz. knowledge of what produces 'simple natures' such as heat, density, color, and weight.²²³ Natural history is the domain of the most particular, 'the variety of things', whereas 'Physic' and 'Metaphysic' are concerned with, respectively, variable and constant causes.²²⁴ Traditional philosophy has led humankind astray in neglecting natural history and founding conclusions on a limited number of particulars.²²⁵ Bacon believed natural philosophy required careful preparation, both by cleansing the mind of idols (see section 6) and by collecting the 'basic stuff and raw material of the true and legitimate induction.'²²⁶

The foundational role of natural history for speculative natural philosophy does not mean that the relation between the two is a one-way street: Bacon makes it abundantly clear that his method prescribes a process that moves from data to axioms and back; new experiments are deduced from 'axioms' established by induction.²²⁷ But, since Bacon classifies natural history as a part of knowledge that branches out from history, not philosophy, it does not belong to the domain of natural philosophy but rather serves as its foundation.

With respect to Hooke, it has been suggested by several scholars that as his career developed, we can see a gradual merging of the initially distinct roles of the natural historian and the natural philosopher in his methodology. Mulligan (1992) states that Hooke 'had begun by distinguishing "two main Branches" in his method', that later merged into a 'steady progression from empirical data-collection to the formulation of high-level axioms and the necessity of continual return to the empirical base. The task of the natural historian, at first described as discrete from that of the philosopher, came to merge with the latter's role.'²²⁸ Sacco (2019) claims that in Hooke's methodological maturation 'the already porous border between historical and philosophical domain [sic] gradually disappeared'.²²⁹

²²² Bacon 1889, *Works of Bacon*, 352 (De Augmentis, Book III: Chapter IV); Anstey 2012, 'Classification of Natural History', 20.

²²³ Bacon 1889, *Works of Bacon*, 122 (Novum Organum, Book II: V).

²²⁴ Ibid., 346–347 (De Augmentis, Book III: Chapter IV).

²²⁵ Bacon 1996, *Philosophical Studies*, 3 (Phaenomena Universi, Preface).

²²⁶ Ibid., 104 (Descriptio Globi Intellectualis, Chapter III).

²²⁷ Bacon 1889, *Works of Bacon*, 104 (Novum Organum, Book I: CXVII).

²²⁸ Mulligan 1992, 'Certain Knowledge', 158.

²²⁹ Sacco 2019, *Real, Mechanical, Experimental*, 48.

I think Mulligan's and Sacco's claim about the development of Hooke's thought is significant, for it would mean a development in his Baconianism. However, I don't think it is evident at all that he ever made a meaningful division of labor between the philosopher and the natural historian. My aim in this section is to show that he never did. I will show that on the rare occasion in which he appeared to divide experimental philosophy into a natural historical and a natural philosophical part, the philosophical part remains vague. Moreover, the whole process of scientific discovery as conceived by Hooke could be completed by the tasks he had in mind for the natural historian.

The second subsection will consist of passages from the Hooke corpus to prove my point and should suffice to establish that Hooke never conceptualized a substantial division of labor between natural history and philosophy. While Hooke's distinction between the two is hinted at in the early stages of his career, the natural historian is the only one who ever gets a detailed job description; the philosopher is promised a 'Penus Analytica' which Hooke never completed.²³⁰ In view of the evidence presented, we may wonder what the merging as suggested by Mulligan and Sacco really entails. I argue that the only shift we can uncover in Hooke's work is one of terminology: Hooke quite suddenly stops referring to purely philosophical aspects of his method, starts using the terms 'Analytick' and 'Synthetic' to refer to the Baconian concepts of ascent and descent to and from axioms that were already present in his early writings. This terminological development is illustrated by an analysis of recurring, but differently expressed versions of Hooke's metaphors of the 'Architect' and the 'Gardener'. In the third subsection I will compare the findings of the second section with Bacon's classification and philosophy of science, and briefly summarize my findings in the final subsection.

Although the question of the relation between natural history and natural philosophy touches upon all of (2-6), the relation is expressed in statement (4). Therefore, passages that were used as evidence were collected by querying for co-occurrences of terms from a list of 'e-terms' (e.g. 'hypothesis', 'philosophy', 'conjecture', 'axiom', etc.) and 'c-terms' (e.g. 'foundation', 'natural history', 'supellex', 'repository', etc.), resulting in a collection of 353 paragraphs to be annotated.²³¹ The RQ's (corpus level) that were answered are the following:

RQ1: Is there, *cf.* Mulligan (1992) and Sacco (2019), indeed a 'gradual merging' of the natural historical and philosophical parts in Hooke's methodological programme?

RQ2: If so, can we tell 1) when this merging sets in, and 2) whether the merging is apparent in all types of text?

²³⁰ Hooke 1666, 'General Scheme', 61.

²³¹ For the full lists and collection of paragraphs see: [appendix](#).

RQ3: If not, does Hooke maintain a clear *methodological* distinction between the historical and the philosophical parts (as opposed to a mere *conceptual* distinction without a methodological division of labor between the historian and philosopher)?

The SQ's (paragraph level) are:

SQ1: Does this paragraph contain a suggestion of a distinction between the historical and the philosophical components of investigation into nature?

SQ2: If 1 or 0 to **SQ1a:** Are there in this paragraph also clear *methodological* directions for the respective natural historical and natural philosophical parts, and/or directions for connecting the two?

SQ3: Does this paragraph contain expressions that explicitly suggest the merging of natural historical and philosophical methods?

In answering the SQ's, the following scoring system was used:

Score:	Meaning:
1	Yes
0	Maybe/Context needed (surrounding paragraphs must be consulted)
-1	No

As in the annotation task used in section 6, the annotator scores a 1, a 0, or a -1 for each paragraph, and adds justification/comments where necessary.

7.2. Hooke's Early Methodological Writings

The most rhetorically flourished expressions of the foundational role of natural history with respect to philosophy can be found in Hooke's earliest texts. In his 1661 *An Attempt for the Explication*, we find Hooke's first clear expression of the relation between natural history and philosophy. Hooke envisages an 'everlasting structure and Temple to Nature' not built upon 'unstable Fancies and unsound Opinions' but on a 'sure Foundation of Experiments [...] well mixt, concocted and digested'.²³² 'Structure', or 'Superstructure' is a term that is commonly used by Hooke to denote a philosophical system, and the well-organized foundation here refers to a natural history.

²³² Hooke 1661, *Attempt for the Explication*, 43.

A similar expression can be found in a private letter to Robert Boyle from 1664. Here, Hooke makes the distinction between constant and systematic observations on the ‘baroscopical index’ and the ‘theoretical pillar, or pyramid’ of meteorological knowledge which, when raised, provides us with the means to accurately predict the weather.²³³ This metaphor might be a reference to the Baconian pyramid of knowledge as discussed above: elsewhere, around the same time, Hooke uses the metaphor again and refers to it as ‘the pyramid of natural knowledge’.²³⁴ To climb it, we must be ‘well furnish’t with that which the noble *Verulam* calls *Scala Intellectus*’, or scaling ladders.²³⁵ This is an unambiguous reference to the Baconian idea that we should not leap to generalities, but that we should approach the causes of things nature hides from us by small (inductive) steps from a solid natural historical foundation.²³⁶

Hooke’s main work, the *Micrographia* (1665) contains similar expressions. For example, the passage from the *Attempt at the Explication* (1661) quoted above is copied in full. Further, in an unmistakably Baconian fashion, Hooke contrasts his methodology with that of the ‘philosophy of discourse and disputation’, which is a reference to traditional, speculative philosophy. Traditional philosophy focuses only on the ‘subtilty of its Deductions and Conclusions’, while Hooke promotes ‘the real, the mechanical, the experimental Philosophy’.²³⁷ To this ‘real’ philosophy, Hooke humbly explains in one passage, he has contributed only the ‘meanest Foundations

²³³ Hooke 1930, ‘Hooke to Boyle (Oct. 6, 1664)’, 203. According to Hunter, this passage is about a ‘wheel barometer’, and is the earliest piece of evidence of a working instrument put to use at the Royal Society (Hunter 2016, *Image of Restoration Science*, 110).

²³⁴ Hooke 1665, *Micrographia*, 93.

²³⁵ *Ibid.*

²³⁶ It is interesting that expressions like the pyramid metaphor should occur in a private letter from Hooke to Boyle, since it has been hypothesized that the early Fellows of the Royal Society used such rhetorical flourishing only as an apologetic device for the outside world, or to impress potential patrons (Wood 1980, ‘Methodology and Apologetics’, 21).

²³⁷ Hooke 1665, *Micrographia*, iii. Hooke here merges references to methodology (experimental philosophy) and a specific natural philosophy (mechanical philosophy) into a single term. Shapiro (2004) has claimed that both Boyle and Hooke, in contrast with Newton, identified experimental philosophy with mechanical philosophy and stated that the terms were synonymous for them, citing this phrase as evidence (Shapiro 2004, ‘Newton’s “Experimental Philosophy”’, 205–206). There are some problems with Shapiro’s reading. First, it is not at all obvious from this conjunction of mechanical and experimental philosophy in a single phrase (it occurs only once in the corpus) that the two terms were synonymous for Hooke. But moreover, we have seen in section 6.4 that ‘Hypothetical Skepticism’ was a tool in Hooke’s experimental toolkit, as a means of avoiding idols of the cave. This skepticism led him to (temporarily) question the mechanical hypothesis, which shows that experimental philosophy was not only distinct from mechanical philosophy for Hooke, but could even be a means of departing from it. Thus, while Shapiro is right in stating that Hooke was more strongly committed to mechanical philosophy than Newton was, he misses the difference between experimental and mechanical philosophy for Hooke.

whereon others may raise nobler Superstructures.²³⁸ Hooke will be ‘abundantly satisfied’ if his ‘small Labours shall be thought fit to take up some place in the large stock of natural Observations’, hoping to ‘serve to the great Philosophers of this Age, as the makers and the grinders of my Glasses did to me.’²³⁹ Even though Hooke does place himself above instrument makers here, its message is in stark contrast with the commonly presented picture of Hooke as someone who often claimed much more for himself than he had actually achieved.²⁴⁰

Although Hooke appears to make a distinction between philosophers and mere observers in this last fragment, the distinction can hardly be called meaningful as the passage ends with: ‘that I may prepare and furnish [the great Philosophers] with some Materials, which they may afterwards order and manage with better skill, and to far greater advantage.’ First, it is unclear what the ‘ordering and managing’ of observations consists in; this is ambiguous between inserting data into something like Baconian ‘Tables of First Presentation’ and the ordering of propositions in axiomatic structures. The task of the philosopher thus remains unspecified. Moreover, the sentence suggests that Hooke did some degree of philosophizing already, albeit with lesser skill and to lesser advantage. The fact that Hooke, in the preface, excuses himself for ‘some *Expressions*, which may seem more *positive* than [the Royal Society’s] Prescriptions will permit’ attests to some degree of theory interlaced with Hooke’s ‘natural Observations’ in the *Micrographia*.

Hooke’s *General Scheme* (1666) is similarly full of references to the distinction between natural history and natural philosophy. Again, Hooke contrasts himself with those that had a less perfect ‘Conception of this Idea of the Business of Philosophy’.²⁴¹ Although the likes of Aristotle and Pliny had ‘some esteem’ of natural history, what has been handed down by them under that name is ‘so uncertain and superficial, taking notice only of some slight and obvious things, and those so inaccurately, as makes them signify but little.’²⁴² The division of labor is explicitly stated in this text: the natural historian collects ‘Materials for a Philosophical Supellex, to fill up the Repository of memory’²⁴³, while the philosopher is concerned with ‘proceeding or operating with this so collected and qualify’d Supellex’.²⁴⁴ Hooke extensively discusses what type of data is welcome in the ‘Supellex’ and how the natural historian should go about and collect and digest it. To aid the philosopher, Hooke mentions a ‘Penus Analytica’ (tr. ‘treasury of analysis’), an analytical tool he claimed to have designed to facilitate ‘raising

²³⁸ Ibid., v.

²³⁹ Ibid., v-vi.

²⁴⁰ Hunter 2003, ‘Natural Philosopher’, 153–155.

²⁴¹ Hooke 1666, ‘General Scheme’, 3.

²⁴² Ibid.

²⁴³ ‘Supellex’ is literally translated from latin as ‘furniture’.

²⁴⁴ Hooke 1666, ‘General Scheme’, 18.

Axiomes, and more general Deductions from a sufficient Stock of Materials' but reserves the explication of it to 'some other Opportunity'.²⁴⁵ Unfortunately, this proved to be an empty promise, and no evidence has ever been found that Hooke's 'Penus Analytica' was actually written.²⁴⁶

Where the philosophical side of Hooke's method remains vague, what does become clear from the *General Scheme* is that natural historians are supposed to do quite a lot more than just observing and experimenting. For example, they are saddled with the uncovering of 'material Efficient and Instrumental Causes of divers Effects, not too far removed beyond the reach of our Senses.' The historian does so with the help of the senses (either 'Naked' or 'assisted with Instruments, and arm'd with Engines') and by 'Induction', to be understood as 'comparing the collected Observations [...] and ratiocinating from them'.²⁴⁷ This may be why Sacco calls the border between natural history and natural philosophy in early Hooke 'porous'; if theoretical elements such as (proximate) causal explanations are allowed into natural histories, then apparently for Hooke bits of theory could cross over into the realm of the cold matter of fact.²⁴⁸ In view of this fact—that the natural historical could reel in theoretical elements—one might then wonder at what point the work of the philosopher begins. Hooke answers:

'As for the discovery of the more internal Texture and Constitution, as also of the Motion, Energy, and operating Principle of Concret Bodies, together with the Method and Course of Nature's proceeding in them: These will require much deeper Researches and Ratiocinations, and very many Vicissitudes of Proceedings from Axiomes to Experiments, and from Experiments to Axiomes, *and are indeed the Business of the Philosopher, and not of the Historian.*'²⁴⁹

It is undeniable that Hooke had at least some concept of a distinction between the tasks of the natural historian and the philosopher. However, inconclusive passages like the above suggest that the domains of the natural philosopher and the natural historian are only separated by the vague border between inquiry into proximate

²⁴⁵ Ibid., 61.

²⁴⁶ Hesse 1966, 'Philosophical Algebra', 67–83; Yeo 2007, 'Between Memory and Paperbooks', 26; Sacco 2019, *Real, Mechanical, Experimental*, 62.

²⁴⁷ Hooke 1666, 'General Scheme', 35.

²⁴⁸ We know that this transition of status from theory to matter of fact can be found in Boyle as well. Boyle first referred to the 'spring' of air as a hypothesis, but later became a matter of fact that was itself in need of a higher-level causal explanation (Shapin & Schaffer, *Leviathan*, 50; Sargent 1995, *The Diffident Naturalist*, 132–133). Sargent (1995) observes, rightly I think, that Shapin & Schaffer (2011) recognize the epistemic difference between matters of fact and causal explanations, but from then speak of two separate linguistic categories, viz. 'speech of matters of fact' and 'speech of the physical causes of these facts'. In doing so, they obscure that physical causes can also cross over into the factual domain, as was the case for Boyle's spring of the air.

²⁴⁹ Hooke 1666, 'General Scheme', 61 (emphasis mine).

causes and inquiry into ‘deeper’ causes that are farther removed from the senses, and Hooke nowhere further specifies what these ‘deeper Researches and Ratiocinations’ exactly entail. In any case, it is not at all clear from this passage how Hooke defines natural history and natural philosophy as distinct activities; ‘much deeper’ and ‘very many Vicissitudes’ between effects and causes suggest at most a difference in degree, not in kind. Now, given that Hooke, just like Bacon, characterizes the method of induction as a means of gradually venturing ‘further into the recesses of Nature’²⁵⁰, and given that induction is the province of the natural historian for Hooke, we may again wonder when exactly Hooke’s philosopher comes into play. Hooke never gives a satisfying answer to this question. To the extent that the border between Hookean natural history and natural philosophy was ‘porous’, it was so from the very beginning. Whatever difference Hooke had in mind, it can only be read as a difference in degree, not as a hard dichotomy between the ‘two main Branches’ of history and philosophy.²⁵¹

7.3. Architects, Gardeners, and the Writing of a ‘Philosophicall History’

At one point in 1668, relatively early in his career, Hooke explicitly questioned the utility of the heaping up of observational and experimental data as a separate task from doing natural philosophy. ‘When this mighty Collection is made,’ Hooke asks, after imagining an immense collective endeavor of unguided fact gathering, ‘what will be the use of so great a Pile? Where will be found the Architect that shall contrive and raise the Superstructure that is to be made of them, that shall fit every one for its proper use?’²⁵² Hooke argues—*contra* the prescriptions of the Royal Society²⁵³—that the ‘Architect’ should not arrive at the scene at the end of the process of fact collection but should be closely involved in it. Hooke explains the function of the ‘Architect’:

²⁵⁰ 1668a, ‘Penetration of Liquors’, 285. Compare Bacon’s Novum Organum XVIII-XIX: ‘In order to penetrate into the inner and further recesses of nature, it is necessary that both notions and axioms be derived from things by a more sure and guarded way, and that a method of intellectual operation be introduced altogether better and more certain. There are and can be only two ways of searching into and discovering truth. The one flies from the senses and particulars to the most general axioms, and from these principles, the truth of which it takes for settled and immovable, proceeds to judgment and to the discovery of middle axioms. And this way is now in fashion. The other derives axioms from the senses and particulars, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all. This is the true way, but as yet untried.’

²⁵¹ Hooke 1666, ‘General Scheme’, 7.

²⁵² Hooke 1668b, ‘Discourse of Earthquakes (I)’, 280.

²⁵³ *Ibid.*

'There may be use of Method in the collecting of Materials, as well as in the use of them, and to shew that there may be made a Provision too great, as well as too little, that there ought to be some End and Aim, some pre-design'd Module and Theory, some Purpose in our Experiments, and more particular observing of such Circumstances that are proper for that Design.'²⁵⁴

In other words, Hooke believes that the compiling of a natural history should be a guided procedure instead of haphazard accumulation of facts, and this guidance is done by the 'Architect'.²⁵⁵ Of course, the 'Architect' cannot know in advance everything that is requisite, 'for as in any great building, none can be so perspicacious as to foresee every particular thing he shall need'.²⁵⁶ One might think that architects in Hooke are metaphorical natural philosophers, but nothing in their description states that they should be concerned with 'deeper Researches', and moreover, in the *General Scheme* their tasks have already been assigned to the natural historian.²⁵⁷

What then, is this 'pre-design'd Module and Theory' in the above passage? It is not a straightforward reading of the above passage to interpret 'pre-design'd Module and Theory' as 'hypothesis'. If we look at another passage from the Hooke corpus in which the architect metaphor occurs, we might think that Hooke is mostly assigning organizational tasks to the 'Architect', in this fragment from two years earlier in the *General Scheme*:²⁵⁸

'In providing a proper History for the perfecting of a new Body of Philosophy, the Intellect should first like a skillful Architect understand what it designs to do, and then consider as near as can be, what things are requisite to be provided in order to this Design, then those Materials are to be carefully sought for and collected, and safely laid up in so convenient an Order, that they may not be far to seek when they are wanting, nor hard to be come by when they are found.'

However, a later and more elaborate occurrence of the metaphor, to be found in a 1686/1687 lecture on what can somewhat anachronistically be called 'geology', shows that indeed it is the 'Architect' that should provide hypotheses. Here, Hooke discusses the 'Analytick' and the 'Synthetick' ways of reasoning:

²⁵⁴ Ibid.

²⁵⁵ Ibid.

²⁵⁶ Ibid.

²⁵⁷ Hooke 1666, 'General Scheme', 18.

²⁵⁸ There are three occurrences of the metaphorical use of 'Architect' in the Hooke corpus. Since Hooke was a renowned actual architect himself, most occurrences of 'Architect' are in the context of the design of real buildings, not the metaphorical raising of philosophical 'Structures'.

²⁵⁹ Hooke 1666, 'General Scheme', 18.

'The [Analytic Method] is the proceeding from the Causes to the Effects. The [Synthetick Method] from the Effects to the Causes: The former is the more difficult, and supposes the thing to be already done and known, which is the thing sought and to be found out. [...] An Inquisition by the [Analytick Method] is resembled fitly enough by that Example of an Architect. [...] I have divers Instances [...] wherein from an *Hypothesis* being supposed or a *premeditated Design*, all the Phenomena of the Subject will be a Priori foretold. [...] And in truth the Synthetick way by Experiments and Observations &c. will be very slow if it be not often assisted by the Analytick.'²⁶⁰

Hooke further makes it clear that the 'Synthetick' method is foundational and 'the more proper for experimental inquiry', and that the 'Analytick' way—suggesting hypotheses and deducing consequences from them—is meant to 'facilitate and hasten the progress to Perfection'.²⁶¹ Interestingly, Hooke's use of analysis and synthesis reverses the meanings these terms had for both ancient Greek mathematicians²⁶² and his contemporaries such as Hobbes²⁶³, Leibniz²⁶⁴, and Newton²⁶⁵. Hesse (1966) has suggested that he might have wanted to make a case for the demonstrative character of induction from effects to causes, which proceeds from the seen to the unseen, instead of identifying demonstration with starting from the unknown and unseen.²⁶⁶ While Hooke does not explicitly confirm her reading, searching the Hooke corpus for 'demonstration' lends Hesse's explanation some credence, as Hooke sometimes indeed used 'demonstration' to denote induction: 'This Principle [of perseverance of uninterrupted motion] will not admit of any other Demonstration than that of Induction from particular Observations in Natural Motions'.²⁶⁷

²⁶⁰ Hooke 1687b, 'Discourse of Earthquakes (III), 330 (emphasis mine).

²⁶¹ Ibid.

²⁶² Hesse 1966, 'Philosophical Algebra', 80. The method of discovering solutions to mathematical problems was called 'analysis', while 'synthesis' was used for the method of demonstration from axioms, such as Euclid's.

²⁶³ 'The method of philosophy [...] is partly analytical, and partly synthetical; namely, that which proceeds from sense to the invention of principles, analytical; and the rest synthetical' (Hobbes 1839, *Concerning Body*, 75).

²⁶⁴ 'Synthesis is achieved when we begin from principles and run through truths in good order [...] Analysis goes back to the principles in order to solve the given problems only, just as if neither we or others had discovered anything before' (Leibniz 1989, *Philosophical Papers*, 232).

²⁶⁵ In query 31 in his Opticks, Newton states that 'the Method of Analysis [...] consists in making Experiments and Observations, and in drawing general conclusions from them by Induction' while 'Synthesis consists in assuming the Causes discover'd [...] and by them explaining the Phaenomena proceeding from them, and proving the Explanations' (Newton 1721, *Opticks*, 380-381).

²⁶⁶ Hesse 1966, 'Philosophical Algebra', 81-82.

²⁶⁷ Hooke 1687c, 'Discourse of Earthquakes (IV), 355.

For Hooke, hypotheses to be investigated analytically are not to be conjured up out of thin air; they should always be grounded upon carefully collected and organized evidence; in other words, condition (4) of BNPM is thus satisfied by Hooke. This requires some restraint, for it is a ‘long and tedious way of coming to a certainty of knowledge by Experiments’, while ‘Men are usually very impatient [...] and affect rather to leap into a Theory at once, and make to themselves an Hypothesis upon some few Observations [...] or some few Experiments [...] or some pretty Conception or Hypothesis they have accidentally pitch’d upon that pleases them.’²⁶⁸ Instead of using such ‘feigned and imaginary Suppositions’, we perform and compare ‘many Inductions from a multitude of Particulars’ as to limit the number of ‘Hypotheses fit to be enquired into by the [Analytick] method.’²⁶⁹ Elsewhere, Hooke prescribes that one should not commit oneself strongly even to their own experimentally obtained hypotheses, but should remain open to inform their ‘Judgement by other Appearances’ in ‘future Trials’.²⁷⁰

In the 1686/1687 lecture on geology, we’ve seen that the direction of reasoning from causes to effects was to be orchestrated by the ‘Architect’. The other direction, the ‘Synthetick’ way from observable effects to causes, is the work of the ‘Gardener’ who ‘prepares his Ground and sows his Seed, and diligently cherishes the growing Vegetable, supplying it continually with fitting Moisture, Food, Shelter, &c. observing and cherishing its continual Progression.’²⁷¹ A few years later, and nearing the final stages of Hooke’s career, the ‘Gardener’ reappears in a discussion on method in a lecture on navigational instruments. The ‘Architect’ does not occur in this fragment, rather, all his tasks appear to have been usurped by the ‘Gardener’. Hooke likens the constructing of a natural philosophy to the growing of a plant or tree from a seed. This seed is initially nourished by ‘proper and adapted’ soil (the foundational history), allowing it to form a body and ‘shoot forth Branches, and from them Leaves’ (conjectures and hypotheses) that draw out of the air a ‘more refin’d, spirituous and inlivening Juice’ (deduced empirical consequences). This ‘inlivening Juice’ allows the plant or tree to ‘send forth more Fibrills and greater Roots’ (new data, obtained by testing the deduced consequences) which enables the plant to grow even more leaves (new hypotheses for higher level explanations). This process is repeated by ‘continu’d and constant Circulations’, until ‘it attain to a State of Perfection of Flowering and Blooming; a complete natural philosophy.²⁷²

There is no discernible division of labor between the natural historian and the philosopher in Hooke’s methodology as pictured in this fragment from his later work. Moreover, it is only a more elaborate version of the well-known passage from the *Micrographia*, in which the young Hooke pictures the building of a natural

²⁶⁸ Hooke 1686, ‘Navigation and Astronomy Lecture (I)’, 484.

²⁶⁹ Hooke 1687b, ‘Discourse of Earthquakes (III)’, 331.

²⁷⁰ Hooke 1682a, ‘Discourse of Comets’, 152. See also section 6.4.

²⁷¹ Hooke 1687b, ‘Discourse of Earthquakes’, 330.

²⁷² Hooke 1690, ‘Navigation and Astronomy Lecture (III)’, 553.

philosophy as a continual process starting with ‘the Hands and the Eyes’, proceeding ‘through the Memory’, continued ‘by the Reason’, and returning to the ‘Hands and Eyes again.’²⁷³ Hooke did not separate natural history and philosophy in a way that marks two distinct fields of inquiry as Bacon did. Even though Hooke started out by dividing science into the two branches early in his career, the above analysis shows that there is no identifiable point where natural history stops and natural philosophy starts. Instead of speaking of two branches, it would have been more apt for Hooke to speak of a spectrum ranging from inquiry into directly observable nature to finding out its most hidden features. Given what has been suggested in this section—that moving from one side of the spectrum to the other is done by the methods reserved for Hooke’s natural historian, even in the beginning of his career—Mulligan’s and Sacco’s talk of a ‘gradual merging’ loses significance. More than a significant change in methodology, Hooke shows a shift in terminology. He stops referring to distinct historical and philosophical elements of method quite suddenly after writing the *General Scheme* in 1666 and adds the terms ‘Analytick’ and ‘Synthetick’ to his vocabulary to refer to directions of reasoning that were always present in his philosophy of science.

To sum up: for Hooke, all parts of the scientific procedure rested on the shoulders of the Architect and the Gardener, who are consistently categorized as natural or ‘Philosophicall’ historians in Hooke, the purely philosophical side of the scientific medal consisting only in a never fulfilled promise of a ‘Penus Analytica’. From this observation it follows that, for Hooke, a complete natural philosophy might as well have been called a complete natural history, built from immediate sensory evidence, through the proximate causes, to more and more remote causes, up till the first principles, well-ordered and ‘cleans’d and freed from all those things which are superfluous and insignificant to the great Design.’²⁷⁴

7.4. Back to Bacon

Given the findings presented in the previous section it is an empty question to ask whether Hooke moved closer to or away from Bacon’s original design with respect to the division of labor between natural history and natural philosophy. I have defended that Hooke’s views on the relation between the two did not undergo a significant change, so likewise his compliance with Bacon in these respects should remain more or less constant. Projecting Hooke’s classification of knowledge onto Bacon’s, however, is not at all a straightforward thing to do: Bacon’s complex branching of knowledge into ‘Speculative’, ‘Operative’, ‘Physic’, ‘Metaphysic’, ‘Poesy’, ‘History’, etc. and their subsequent branchings are not easily mapped onto Hooke,

²⁷³ Hooke 1665, *Micrographia*, vii.

²⁷⁴ Hooke 1666, ‘General Scheme’, 18.

not in the least place because Hooke never explicitly compares his categories with Bacon's and was on the whole much less concerned with elaborate classification of knowledge. In addition, Bacon's classifications of knowledge were themselves subject to some change, as has been expounded in detail in Anstey (2012). Still, it is worth comparing the two, and see whether Hooke departs radically from Bacon in some respects.

Bacon classified natural history as a branch of knowledge that is separate from natural philosophy. He first divides all of knowledge into 'History', 'Poesy', and 'Philosophy', where history branches out into a 'Civil' and a 'Natural' part, treating the 'deeds and works' of, respectively, nature and human beings.²⁷⁵ Natural history is divided into a 'Narrative' part, that is useful 'for the sake of the knowledge of the things themselves', and an 'Inductive' part that provides the 'stuff and material of a solid and lawful Induction, and may be called the nursing-mother of philosophy'.²⁷⁶ It is this latter part of natural history we are concerned with here. Bacon, like Hooke, calls it the 'Foundation of Philosophy'.²⁷⁷

As for natural philosophy, Bacon divides it into two parts: a 'Speculative' and an 'Operative' part, 'the mine and the furnace'.²⁷⁸ The 'Speculative' part, burdened with 'searching into the bowels of nature' for causes of phenomena, branches out into 'Physic' and 'Metaphysic'.²⁷⁹ The 'Operative' part is concerned with 'shaping nature as on an anvil'; with producing effects by applying the knowledge obtained in speculative inquiry.²⁸⁰ The 'Operative' part is split into 'Mechanic' and 'Magic', respectively corresponding to 'Physic' and 'Metaphysic'.²⁸¹ Bacon is somewhat ambiguous in his expressions on the division of labor between 'Speculative' and 'Operative' philosophy. He conceives of 'two professions or occupations of natural philosophers', speculative 'miners' and operative 'smiths', but is also aware of the 'close intercourse between causes and effects, so that the explanations of [Speculative and Operative philosophical inquiry] must in a certain way be united and conjoined'.²⁸² What is currently of interest, however, is the division of labor between natural history and natural philosophy for Bacon.

²⁷⁵ Hobbes 1839, *Concerning Body*, 75. AUGMENTIS 293. Note that the division into Civil and Natural is not a distinction between natural and artificial: Bacon subsumes experimental and mechanical history under natural history.

²⁷⁶ Bacon 1889, *Works of Bacon*, 298 (De Augmentis, Book II: Chapter V).

²⁷⁷ Ibid., 299 (De Augmentis, Book II: Chapter V).

²⁷⁸ Ibid., 343 (De Augmentis, Book III: Chapter III).

²⁷⁹ Ibid., 343-344 (De Augmentis, Book III: Chapter III).

²⁸⁰ Ibid., 343; Ibid., 366-367 (De Augmentis, Book III: Chapter V).

²⁸¹ Ibid., 365-368. Bacon makes sure to contrast his conception of 'Magic' with the state he thinks contemporary alchemy and astrology are in. There is nothing inherently wrong with the alchemical ideal of transmutation of metals, Bacon thinks, but its foundation should be a mastery of Forms, not haphazard experimentation.

²⁸² Ibid., 343 (De Augmentis, Book III: Chapter III).

Let us first look at the subject matter of both natural history and natural philosophy. ‘Physic’, for Bacon, is divided into ‘Concrete’ and ‘Abstract’.²⁸³ The ‘Concrete’ part inquires into ‘substances, with every variety of their accidents’, such as lions and oak trees. The ‘Abstract’ part covers the ‘accidents’, or natures, such as heat or gravity.²⁸⁴ Bacon appears to distinguish between the subject matter of natural history and the ‘Abstract’ part of ‘Physic’ in *De Augmentis*, as he says that ‘all Physic lies in a middle term between Natural History and Metaphysic, the [Concrete] part [...] comes nearer to Natural History, the [Abstract] to Metaphysic.’²⁸⁵ However, Bacon elsewhere explains that he does think of what he calls ‘Cardinal’ or ‘Catholic Virtues’ such as heat and gravity as the subject matter of natural history.²⁸⁶ The subject matter, at least, of the whole of ‘Physic’ and natural history coincide. It also follows that, given the fact that ‘Physic’ and ‘Metaphysic’ share the same subject matter (but look for different types of causes of it, viz. efficient/material and formal/final²⁸⁷), the subject matter of ‘Metaphysic’ also overlaps with that of natural history. In sum, thus, for both Hooke and Bacon, natural history and natural philosophy range over the same things. However, we can see that where Bacon assigns inquiry into material and efficient cause to ‘Physic’, Hooke believes that searching for ‘material Efficient and Instrumental Causes of divers Effects, not too far removed beyond the reach of our Senses’ is natural historical work.²⁸⁸

So much for subject matter. I have indicated that there is a complete overlap between the procedures of natural history and natural philosophy for Hooke, or at least, that barring his mysterious ‘Penus Analytica’ he is committed to identifying the former with the latter. For Bacon, however, the story is different.

Inductive natural history, Bacon says, ‘relates the fact’, whereas natural philosophy ‘examines the causes’.²⁸⁹ We have seen that Bacon calls natural history the ‘nursing-mother’ of natural philosophy. In the preface to the *Great Instauratio*, in which Bacon expounds his (never completed) overarching plans, he makes a similar analogy. ‘Natural history’, he says, is meant to give ‘light to the discovery of causes and supply a suckling philosophy with its first food’.²⁹⁰ Bacon wants to ‘wait for harvest-time’ of natural historical facts, wait until it is time to inductively establish axioms and then proceed in his ‘pursuit of works and the active department of the sciences,’ that is, in the ‘Operative’ part of philosophy.²⁹¹ So far,

²⁸³ Ibid., 347 (*De Augmentis*, Book III: Chapter IV).

²⁸⁴ Ibid.

²⁸⁵ Ibid.

²⁸⁶ Ibid., 29 (*Instauratio Magna*, Plan of the Work). See also Anstey 2012, ‘Classification of Knowledge’, 24–25.

²⁸⁷ Ibid., 357 (*De Augmentis*, Book III: Chapter IV).

²⁸⁸ Hooke 1666, ‘General Scheme’, 18.

²⁸⁹ Bacon 1889, *Works of Bacon*, 347 (*De Augmentis*, Book III: Chapter IV).

²⁹⁰ Ibid., 28–29 (*Instauratio Magna*, Plan of the Work).

²⁹¹ Ibid., 29.

this looks much like what Hooke has to say about the foundational role of natural history in causal inquiry, with one big difference. For Hooke, we have seen, induction is a method belonging to natural history. For Bacon, however, induction is the business of the philosopher. Bacon's inductive historian inquires into compound substances and abstract natures, and digests the collected information into tables, the 'Presentation of Instances to the Understanding'. It seems that for Bacon, the natural historical part of interpreting nature stops here, and 'Induction itself must be set at work.'²⁹²

This hard distinction between historical and philosophical work in Bacon should not be seen as a very controversial reading. First and foremost, he explicitly states that induction as a method belongs to natural philosophy, not natural history.²⁹³ Second, induction is constantly mentioned throughout Bacon's writings as a method of discovering causes by establishing axioms. Given what has been said above about Bacon's categorization of history as fact-finding and 'Speculative' philosophy as axiom-establishing enterprises, we can safely conclude that induction is a method in the toolkit of Bacon's 'Speculative' philosopher.²⁹⁴ In addition, Sargent (2006) has shown that there are some passages in Bacon where he literally divides the work of the natural historian and the natural philosopher, despite his inclusive talk of 'leveling of wits' elsewhere.²⁹⁵ The roles of artisans and mechanics were limited to the contributions they could make to natural history, while the philosophical work is relegated to 'workers with more speculative and rational abilities'.²⁹⁶

This difference between Bacon and Hooke is only a difference in categories. Chiefly, the category of Hookean natural history includes both Baconian natural history and philosophy. This fact alone does not make Hooke's methodology deviate from the Baconian model as presented in section 5. However, some have claimed that Hooke did deviate significantly in other respects. We have seen that the role of hypotheses was an essential part of Hooke's method in climbing the *Scala Intellectus*. Centore (1970) believes that Hooke's method did significantly differ from Bacon's, and even improved upon it, in the sense that Hooke 'did not spurn the use of hypotheses' while allegedly Bacon did.²⁹⁷ This myth—of an anti-hypothetical Bacon—has been repeated in many different contexts²⁹⁸, and is dispelled quite easily. First, it is true that Bacon deplored 'Anticipations of Nature',

²⁹² Ibid., 145 (Novum Organum, Book II: XV).

²⁹³ See e.g. Ibid., 411 (De Augmentis, Book V: Chapter II): 'in Physics [...], syllogism failing, the aid of induction (I mean the true and reformed induction) is wanted everywhere.'

²⁹⁴ Ibid., 254 (Parasceve, II).

²⁹⁵ Sargent 1996, 'Cooperative Scientific Research', 149–150.

²⁹⁶ Ibid., 150.

²⁹⁷ Centore 1970, *Contributions to Mechanics*, 93.

²⁹⁸ One notable propounder of the myth was Karl Popper. See Vickers (1992) for an overview of examples.

hasty generalization over a few instances.²⁹⁹ However, ‘Anticipations’ are not hypotheses. As Zagorin (2001) explains, Bacon made it clear that he identified hypotheses as (tentative) axioms, which had to be ‘wider and larger’ and should ‘cover more’ than the particulars from which they were derived.³⁰⁰ Moreover, one must be able to confirm hypotheses by testing new experiments deduced from them, ‘for our road does not lie on a level, but ascends and descends; first descending to axioms, then descending to works’.³⁰¹ This is exactly the role of the ‘First Vintage’ as described in the *Novum Organum*. Moreover, as has been described in section 7.2, it is also exactly the role for hypotheses that Hooke had in mind: hypotheses are established by the slow ‘Synthetick’ upward way, while works and experiments are deduced from them in the ‘Analytick’ phase.

Hooke may have deviated from some of the more radical empiricist prescriptions of the Royal Society by using hypotheses in his methodology. But in deviating from these prescripts, I hope to have convinced the reader that he ended up using a methodology that mirrors Bacon’s in many aspects.

7.5. Conclusion

What has been defended in this section is that 1) there is no gradual merging between the roles of the natural philosopher and the natural historian in Hooke, and 2) the main elements of Baconian science as expounded in the BNPM model in section 5, are shared between Bacon and Hooke, albeit that Bacon’s philosopher has a well demarcated field of expertise that is subsumed by the Hookean historian. The latter is a difference of categorization, not a structurally different view of scientific method, and hence no deviation from the BNPM model.³⁰²

As indicated in section 3.5, analyzing concepts does not always illuminate the reason why concepts are the way they are. Hooke does not explain why he uses such a broad category of natural history. However, an interesting suggestion can be gathered from the way we have seen Hooke assuming a position between, on one side, the mariners who drew the maps he used and the workers who ground his glasses, and on the other side, the great intellects of his own and future times. Hooke might have felt that he crossed a social boundary by identifying himself overtly as a philosopher, and thus on a par with someone like Boyle, who was born

²⁹⁹ Bacon 1889, *Works of Bacon*, 51-52 (Novum Organum, Book I: XXVI-XXVIII).

³⁰⁰ Zagorin 2001, ‘Objectivity and the Idols’, 391.

³⁰¹ Ibid.; Bacon 1889, *Works of Bacon*, 96 (Novum Organum, Book I: CIII).

³⁰² We can only guess at the reason why Hooke felt the need for distinguishing between ‘two Branches’ at the very beginning of his career, even though he had no clear distinction in mind. Mulligan (1992) and Sacco (2019) offer no solution. As Shapin & Schaffer (2011) have suggested, some members might have felt the urge to defend that what they were doing was really philosophy, as this claim was denied by non-experimental philosophers like Hobbes (Shapin & Schaffer 2011, *Leviathan*, 79).

of nobility. Hooke was not of independent means and had to be paid a regular salary as a curator of experiments. Therefore, he came to be regarded as more of an artisan than a gentleman.³⁰³ But it might very well be that Hooke, by broadening the scope of natural history to the extent that it absorbed the domain of the natural philosopher and by leaving philosophy itself indeterminate, could legitimize his engagement with natural philosophy without being recognized as a gentleman. In other words, Hooke was somewhat of a philosopher in disguise, a blue-collar philosopher.

To be sure, there are ways in which scholars have talked about Hooke's development of Bacon's method that I can agree with to some extent. For example, Centore (1970) states that 'we find Hooke developing Bacon's basic inductive method by adding some precision to the experimental procedure.'³⁰⁴ This 'precision' consists, for Centore, in Hooke's stress on exact measurement. Surely Hooke did a lot more than Bacon in providing sophisticated 'ministrations' to enlarge the senses. But 'developing' here should not be made too much of, in the sense that Hooke did not radically alter the core of Bacon's methodology in any way by using microscopes and telescopes. Perhaps it would be more apt to say that Hooke *refined* some elements of Baconianism, which on the whole remained stable.

In view of other findings in this section, we can also wonder whether recurring claims like 'members of the Royal Society claimed kinship with the author of the *Novum organum*, but ignored Baconian induction as a scientific method' really apply to Hooke.³⁰⁵ It may be that Hooke did not exactly copy Bacon's tables of First Presentation. But in speaking of the construction of a 'Natural and Artificial History, [...] ranging and registering its Particulars into Philosophical Tables' to 'make them most useful for the raising of Axioms and Theories', and of the procedure of 'comparing of varieties of such Inductions' in order to 'arrive to so great an assurance and limitation of Propositions as will be at least be sufficient to ground Conjectures upon'³⁰⁶, Hooke is not pointing at induction by 'simple enumeration'.³⁰⁷ Rather, such passages show that Hooke did not ignore Baconian induction; rather, they describe a form of induction that is at the very least inspired by, and apparently functionally similar to Bacon's idea of induction.

Hooke did not ignore Baconian induction as a scientific method. He did not, just like Bacon did not, spurn the use of hypotheses. Compared with Bacon, he had a much broader, even all-encompassing, concept of natural history. This has only classificatory consequences, no methodological ones. When it comes to method, Hooke was very much a Baconian natural philosopher (or natural historian).

³⁰³ Shapin 1989, 'Who was Robert Hooke', 260-261.

³⁰⁴ Centore 1970, *Contributions to Mechanics*, 93.

³⁰⁵ Malherbe 2006, 'Bacon's Method of Science', 75.

³⁰⁶ Hooke 1687b, 'Discourse of Earthquakes (III)', 331.

³⁰⁷ Bacon 1889, *Works of Bacon*, 70 (Novum Organum, Book I: LXIX).

8. Conclusion

My main aim in this thesis was to fill gaps in our knowledge of Robert Hooke's methodology. More specifically, I have addressed two aspects of his variant of Baconianism: the methodological distinction between natural philosophy and natural history, and Hooke's version of Bacon's doctrine of the idols. Concerning the latter: in 72 out of the 598 paragraphs that were annotated in finding out to what extent Hooke's concept of idols deviated from Bacon's, one or more of the Baconian idols were identified. It was found that Hooke, contrary to what has been suggested in recent literature, stays remarkably close to Bacon: all four idols are represented in Hooke, the idols of the marketplace to some lesser extent than the other three idols. Hooke slightly deviates from Bacon by recognizing our limited human memory as a specific source of error and by identifying different remedies to the idols, such as visual aids, introspection, temporary rejection of one's usual explanatory frameworks (such as rejecting mechanical explanations for the time being), *autopsia*, and his 'Penus Analytica', his never delivered ministrations to the understanding.

Hooke's distinction between the enterprises of natural history and natural philosophy, while perhaps of use to him on a rhetorical level, proved to be one without substance. In none of the 353 paragraphs in which terms relating to, respectively, natural history and theory co-occurred could a clear division of labor between the natural historian and the natural philosopher be identified. While Hooke frequently states that natural histories ought to be the foundation of natural philosophies, he is also committed to the idea that all there is to the establishment of these philosophies is the gradual ascent from the 'seen' to the 'unseen', a ladder that can be climbed fully by the natural historian. Even Hooke's recurring metaphorical 'Architect', the one who proposes hypotheses and who should prevent the process of experimentation and observation from being blind, haphazard fact collection, is a natural historian for Hooke. Given the finding that essentially nothing changes in Hooke's division of labor throughout his career, there is no 'gradual merging' of distinct natural historical and natural philosophical tasks as suggested by Mulligan (1992) and Sacco (2019).

In Bacon's classification of knowledge, 'Inductive' natural history and 'Speculative' natural philosophy are distinct fields. There is also a corresponding division of labor in Bacon, as the work of the natural historian stops where the philosopher can start with induction. For Hooke, induction is part of the historian's job description. This difference, however, being only classificatory, does not mean that Hooke deviates from BNPM. BNPM is a model of Baconian methodology, and its conditions do not concern classifications of knowledge. Therefore, from a methodological perspective, Hooke's broad conception of natural history does not impact his Baconianism.

Adding the results of the two inquiries, we may thus conclude that Hooke was very much a Baconian scientist. He did not ‘copy’ Bacon’s design, but also did not leave it completely untouched. In any case, the differences between his and Bacon’s ‘method talk’—his specific suggestions to detect and minimize the effects of idols, his more frequent defense of hypothetical reasoning, and his use of terms such as ‘Analytick’ and ‘Synthetick’—should be seen as refinements of Bacon’s methodology, not as very significant developments or radical deviations from it.

While I have focused specifically on conditions (4) and (6) in BNPM, which Hooke both satisfies, some light has been shed on the remaining four conditions as well. His adherence to (1) should go without saying, albeit that he determines what is to be called ‘sensory input’ in a different way from Bacon by being more optimistic about the use of microscopes and telescopes. As discussed in section 6, he even thought of such instruments as means to fend off the idols of the tribe related to our limited sight. With respect to (2), (3), and (5), I have discussed his appointment of an Architect who manages the influx of particulars into natural histories, and who professes the ‘Analytick’ method, the deduction of particulars from theoretical propositions (see section 7).

Presumably, much more can be said about each of (1), (2), (3), and (5) than what has been touched upon here in passing, which I will leave for future research. The Hooke corpus that is appended to this thesis is intended as a valuable tool in assisting such research, or research into anything else for which evidence lies in Hooke’s written work. I hope to have made clear that mining such corpora is a very helpful way of collecting a body of evidence geared at answering specific research questions. For example, we have seen that those who previously addressed the issue of Hooke’s idols limited the discussion to a review of Hooke’s most concentrated methodological exposition, his 1666 *General Scheme*. As a result, the picture we had of Hooke’s idols was limited as well. By searching the whole Hooke corpus for expressions of ‘false appearances’, evidential passages were found in a variety of less canonical texts, such as the introduction to Robert Knox’s history of Ceylon (1681), a 1694 paper in which Hooke presents a portable Camera Obscura, his discussion of a new oil lamp from 1677, as well as a wide variety of lectures. Similarly, the question of Hooke’s alleged merging of natural history with natural philosophy could be assessed in detail using works that one might not intuitively access by non-computational means, such as his lectures, a 1668 experimental report on the ‘Penetration of Liquors’, and a letter to Boyle. Some of these texts were not intended for publication and appeared in posthumous collections such as Waller (1705) and Derham (1726). By supplementing evidence from canonical texts such as the *Micrographia* and the *General Scheme* with evidence gathered from Hooke’s less frequently consulted writings, a more nuanced and complete picture of his Baconianism could be presented.

The fact that relevant passages were found in a wide variety of texts, both published and unpublished in Hooke's time, suggests at least two things that should be of interest for historians of science. The first is not new, but its importance is emphasized by the results of this thesis: it is that historians are well advised to leave the beaten paths and consult non-canonical texts in order to leave no stone unturned. The second is more significant, and sheds light on present day discussions about 'method talk'. It is quite frequently claimed that there is a large discrepancy between the Royal Society Fellow's public presentation and rhetoric, and their actual scientific practice.³⁰⁸ Purportedly, methodology should be seen as rhetoric, as a means of justifying practice instead of guiding or even influencing practice. I think that Hooke is an interesting case that shows that Baconian method talk was *not* always intended to convey the air of Baconianism to the outside world. For example, his talk of ascending a theoretical pyramid in a private letter to Boyle, which further contains mundane practicalities such as experimental results and Hooke's negotiations with his patron John Cutler, is not easily explained away as being merely rhetorical.³⁰⁹ The same holds, for example, of Hooke stating he ventures deep into the recesses of nature in a 1694 experimental report, or his contrasting of a solid foundation with feigned suppositions in another.³¹⁰ It seems from examples like these that Hooke's Baconianism was rather intertwined with his experimental practice, and that a rigid separation between 'method talk' and experimental practice cannot easily be drawn for him. Hooke's case then raises the question to what extent the distinction between methodological rhetoric and scientific practice makes sense for the other fellows. Of course, there are clear cases such as Thomas Sprat, whose *History of the Royal Society of London* is shown to be an almost caricaturistic and probably intentional misrepresentation of the actual business of experimental philosophers to safeguard the Society from clerical attacks.³¹¹ However, Sprat himself was not a practicing experimentalist, and therefore not the most interesting case. It would be interesting for future scholars to focus on the presence of Baconian terminology in the works of practicing early Fellows, and especially in works that are not primarily methodological. Perhaps the blurring of the distinction between purely rhetorical method talk and experimental practice extends beyond Hooke.

Finally, creating a corpus is a lot of work, but it need not be done by a single person; it could be a collaborative effort. I think the scholarly community would be greatly served, for example, if historians would make a habit of transcribing more of the archival material they consult for future use according to some standard,

³⁰⁸ See e.g. Schuster & Yeo (1986); Dear 1985, 'Totius in Verba', 159; Shapin & Schaffer 2011, *Leviathan*, 14.

³⁰⁹ Hooke 1930, 'Hooke to Boyle (Oct. 6, 1664)', 203.

³¹⁰ Hooke 1668a, 'Penetration of Liquors', 285; Hooke 1694b, 'Discourse of Frost', 292.

³¹¹ See: Wood 1980, 'Methodology and Apologetics', 1-21.

instead of using only what they need for their own research.³¹² The aim of this thesis then, was not only to contribute to our story of Hooke's Baconianism, but also to convince the reader of the long-term benefits of properly digitizing the yellowing papers that contain the story of our science.

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³¹² Many historians that do publish transcriptions of archival material publish only so-called 'diplomatic editions', in order to preserve as much as possible of the character of the transcribed manuscripts, including deletions, abbreviations and punctuation. While there is certainly value in preserving such elements, such diplomatic editions are typically not very accessible by digital tools. My suggestion would be to publish both diplomatic and 'normalized versions', as the builders of the Newton corpus have done (<https://www.newtonproject.ox.ac.uk/>). Normalized texts have been subject to some amount of editing that makes them more suitable for exploration by digital means.

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