Experiments for Knowledge and Health:
Robert Boyle (1627-1691) and the Uses of Medical Experiment

PhD Thesis
Susanna Lahtinen
Filosofian, historian, taiteiden ja
kulttuurien tutkimuksen laitos
Helsingin yliopisto

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INTRODUCTION

Robert Boyle was a diligent proponent of experimental natural philosophy. He believed that experiment was the best means for improving and enlarging our knowledge about nature. Furthermore, according to him, experimentally gained knowledge would not remain on the level of speculation bringing intellectual delight for scholars, but would produce practical applications for the benefit of mankind as well. Boyle made a distinction between speculative and practical natural philosophy. Speculative philosophy was concerned with theoretical knowledge about the causes of natural phenomena. Reason was the principal tool of speculative philosophy, whereas practical philosophy explored phenomena by experiment. One of the central goals of Boyle’s experimentalism was to create an interactive relationship between practical experimental action and speculative reason.¹

Boyle is known for his cautious attitude towards theory formation and system building. In his natural philosophical works, he preferred to present himself as an ‘underbuilder’ whose efforts in acquiring basic information about natural processes would form a firm basis for future natural philosophers to build their theories on. Hence, rather than a great theorist and methodologist, Boyle was first and foremost an industrious experimentalist who, together with his assistants and amanuenses, performed a vast amount of experiments of various kinds in different fields of natural investigation. Experiment has a central role in his natural philosophical and medical works. One way or another, these treatises describe and discuss a variety of experiments. The manner in which Boyle’s writings emphasize experiment and describe his experimental work gives an impression that making experiments was almost a purpose in itself for him.

This is a study about the interaction between Boyle’s experimentalism and medicine. In it, I explore Boyle’s medical works to find out what kind of activities were called ‘experiment’ on the one hand, and to explicate the functions of experimental texts in his

medical writings, on the other. The method of this study is to approach Boyle’s medical works from several viewpoints. First of all, I examine Boyle’s role as a medical author and place his medical writings in the immediate context formed by contemporary medical literature. Secondly, I explore the different kinds of texts Boyle wrote on the basis of medical experiments and the functions these texts have in his published works. Finally, I examine what these texts tell us about the nature of his experimental activities.

In this study, Boyle’s medical writings of various kinds, such as recipe books, natural historical works and treatises discussing medical practice, theory and medical reform are explored. When writing about medical issues, Boyle emphasized that he participated in medical discussion as a natural philosopher. None of his medical works is purely medical in the sense of clearly belonging to a particular genre of medical literature or of being of interest only to the professional readers. At the time, however, the disciplinary boundaries were vague and, in addition to university educated physicians, all kinds of authors participated in medical discourse. Therefore, the category of ‘medical’ is left somewhat broad and flexible also in this study. ‘Medical text’ and ‘medical experiment’ are likewise used as flexible terms referring to various kinds of writings and activities which might not have had medicine as their starting point but which, in one way or another, had significance for medicine as well.

Boyle’s published works approach medicine and medical issues from various perspectives. His medical writings place emphasis on practical medicine and therapeutics, in particular. His first published essay, ‘An Invitation to a Free and Generous Communication of Secrets and Receipts in Physick’ (1655), discusses a practical medical topic from the standpoint of moral philosophy. In Some Considerations of the Usefulness of Experimental Natural Philosophy. The Second Part. The First Section. Of It’s Usefulness to Physick (1663) Boyle used medicine as an example of a field where the experimental approach could produce useful knowledge. In the treatise, he addressed several medical questions as well. In addition, out of his

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2 In what follows, Some Considerations of the Usefulness of Experimental Natural Philosophy. The Second Part. The First Section. Of It's Usefulness to Physick (1663) is referred to as the medical Usefulness in the main text.
large collection of medical recipes, three recipe books were published. Moreover, he often included medical recipes and practical information in his medical and natural historical works.

In addition to Boyle’s medical works, several natural historical and philosophical works of his have a medical connection. Since contemporary academic medicine was based on natural philosophy, the areas of natural philosophy and medicine overlapped. Medicine was generally conceived to start where natural philosophy ended. Natural philosophy was concerned with the animal body and its function as part of nature, whereas medicine focused on the human body and the things affecting its health and illness. Hence two natural historical works of Boyle’s – *Memoirs for the Natural History of Humane Blood* (1684) and *Short Memoirs for the Natural Experimental History of Mineral Waters* (1685) – were of significance for medicine as well. Likewise, several of Boyle’s natural philosophical treatises contain sections discussing their subject matter from the standpoint of medicine. Of these works, *New Experiments Physico-Mechanick, Touching the Spring of the Air, and its Effects* (1660) is examined in this study. In addition to publishing the air-pump experiments relevant to Boyle’s notion of the air pressure, *Spring of the Air* contains a section contributing to contemporary investigation into respiration physiology.

This study is concerned with Boyle as a medical author. In order to investigate how Boyle’s works relate to contemporary medical discourse I explore several seventeenth-century medical works on similar subjects or participating in the same discussion as Boyle did. Boyle’s relationship to medicine consisted both of his personal and natural

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philosophical interests. To start with the more personal, his own experience of ill health and of the available methods of treatment convinced him that medicine, and especially therapeutics, was in need of reform. He collected medicinal recipes and practical medical information. His knowledge of medical literature was also notable. Such an interest of a lay person in medical matters was by no means exceptional at the time. The degree of specialization in medicine was low and, as a consequence, the field was open to an educated lay person as well. In Boyle’s case, however, his interest led him to engage in medical experimentation and to write several medical works.

Boyle’s status as a natural philosopher provided him with a justification to write about medical issues. Due to the strong connection between natural philosophy and academic medicine, the natural philosophical and medical communities merged to a high degree. A considerable number of seventeenth-century English physicians was interested in new natural philosophical ideas and many of these physicians found experimental natural philosophy particularly interesting. As a consequence, physicians formed an important occupational group in the English community of experimentalists and were important contributors to natural historical and philosophical inquiries.⁵ Through his experimental work and his membership in the Royal Society Boyle was associated with several medical men. He also emphasized the connection between natural philosophy and medicine and suggested that his kind of experimental natural philosophy was the best candidate to replace the Aristotelian natural philosophy of the schools as the basis of medicine.

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At the same time, medicine offered Boyle a model of a discipline which, unlike other learned disciplines, embodied several notions of experiment and ways of writing about experiment. Hence, Boyle’s involvement in medicine was a complicated exchange of ideas and practices. It is evident that medical literature and the medical notions of experiment had an impact on his experimental philosophy. However, he did not follow the conventions of contemporary medical literature as such but rather refashioned the medical models to suit his own purposes. Moreover, he applied his own ideas about experiment and its functions to his medical work as well. Consequently, Boyle’s medical writings offer an excellent source material for an investigation into his ideas about experiment, its functions and the various ways of writing about experiment.

Boyle wrote various kinds of texts from the basis of medical experiments. Generally, the principal difference between different kinds of experimental texts is the proportion of narrative, on the one hand, and the amount of detail included in the text, on the other. These things depended largely on how Boyle saw the function of a particular text. The simplest form of an experimental text is a recipe. A recipe embodies the traditional medical notion of experimenta, in other words, a trial-and-error experiment of a medical practitioner and condenses it into a list of ingredients and instructions. Although a recipe may be understood as presenting an argument of a form ‘if you take these and do this, as a result you end up with this’, its principal purpose is practical rather than argumentative. Boyle included recipes and practical medical instructions also in his treatises. In addition to providing readers with useful information, recipes and instructions functioned as practical proof for his argument.

A connection between a simple recipe and the more descriptive experimental report can be observed in Boyle’s medical works. An experimental report, which gives an account of the performance of a particular experiment in the past, differs from a recipe first and foremost with the proportion of narrative included. It has been suggested that the principal function of the experimental report was to create belief in the truth of the

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experimentally discovered matters of fact. Although establishing the truth of the matters of fact was an important issue, I approach Boyle’s experimental texts rather from the standpoint of the use of facts than their truth. According to Boyle, an extensive collection of matters of fact formed a solid foundation for theory formation. For this purpose, he collected an extensive amount of experimental matters of fact into his natural histories wishing these would serve theory formation in the future. His natural historical works also aimed at creating order into their subject matter by dividing it into titles and arranging the information available according to this division. However, although Boyle regarded natural history as the basis of sound theory formation, he was cautious about premature theorizing. He wished that ‘men in the first place would forbear to establish any Theory, till they have consulted with ... a considerable number of Experiments in proportion to the comprehensiveness of the Theory to be erected on them.’ No straightforward process from the factual basis to theory formation can be observed in Boyle’s medical works. Instead, Boyle used the experimental matters of fact in various and more complicated ways.

Both recipe book and natural history were established literary genres when Boyle wrote his works. Although otherwise different in many respects, the emphasis on experience


and practice rather than theory and argumentation is common to both genres. Recipe books were traditionally based on medical *experimenta* and natural history with its flexible and descriptive nature was open for the description of experiment as well. These genres present experimental texts principally in a non-argumentative context in which no interpretation is offered. By contrast, no literary genre conventionally used for the interpretation of experiment and using it in an argument was available. Medical literature offered some models of writing about experiment and using it as part of a theoretical explanation but these were not suitable for Boyle’s purposes. Instead, he chose the reflective and open-ended essay format for his experimental discourses. The format allowed him the liberty to describe, interpret and discuss experiment but required neither a systematic presentation of the subject matter nor definite conclusions.

During the recent decades, several studies have been written about the linguistic practices and rhetoric of seventeenth-century English natural philosophers. Particularly Boyle’s ‘literary technology’ has recently received much attention. Steven Shapin has presented Boyle as a skilled strategist who carefully wrote his experimental texts to recruit his readers as ‘virtual witnesses’ for his experiments. Subsequently, several


historians have shown that writing about experiments posed more complex issues for Boyle than what Shapin’s interpretation suggests.\textsuperscript{15} I find it also likely that Boyle’s manner of writing about experiment and its interpretation involved a complicated set of factors to be taken into consideration. Boyle took into account the subject matter, the intended audience and his own aims when writing and publishing a particular text. In practice, these factors naturally intermingled. In the absence of literary conventions guiding his work, Boyle had to carefully consider these factors when writing his works. The essay form was not commonly used for natural philosophical or medical writing, at least in discussion involving questions of causal knowledge. Boyle was aware that he was presenting his readers philosophical and medical discussions in a form that they were not familiar with. His mixed audience consisting of both gentlemanly and scholarly readers required additional considerations of literary presentation and style.

Boyle was not overtly confident about the reception of his experimental writings. On the contrary, at the early stage of his natural philosophical career, he wrote an essay where he explained his stylistic choices and his method of literary composition.\textsuperscript{16} We have also reasons to believe that Boyle’s new style of experimental writing was not a straightforward success. It seems that the method and the style of his writings occasionally failed to satisfy both his own requirements and the tastes of his readers. In a letter to William Wotton, John Evelyn made a remark about Boyle’s literary style which ‘those who are Judges, thinke he was not altogether so happy in, as in his Experiments’. Evelyn did not wish to call the style ‘Affected’ but pointed out that it was ‘doubtlesse not answerable to the rest of his greate parts’.\textsuperscript{17} Evelyn probably judged first and foremost Boyle’s style, whereas Thomas Hobbes criticized experiment as a method of scientific proof. Hobbes, who advocated the method of logical demonstration in science, claimed that Boyle attempted to ‘demonstrate without the principle of


\textsuperscript{16} Boyle, ‘A Proemial Essay’, 10-17, 33-34.

demonstration.”\textsuperscript{18}

This study is concerned both with Boyle’s experimentalism as a means of discovering and proving new knowledge about natural and medical phenomena and with his literary methods. The general meaning of ‘method’ is ‘a way of doing anything, especially according to a defined and regular plan’ (\textit{OED}). Boyle and his contemporaries understood the term in a similar manner. When Boyle discussed ‘method’, he usually referred to the principles of literary presentation. From the perspective of Boyle’s contemporaries, his literary method was rather that of rhetorical persuasion than a method of ‘scientific’ demonstration. In this study, Boyle’s rhetoric is discussed from the standpoint of seventeenth-century conception of rhetoric as a discipline which was part of the humanist educational \textit{curriculum}. Hence, this study discusses rhetoric rather as an established method of literary presentation and proof than as a particular ‘literary strategy’ of Boyle’s.\textsuperscript{19}

When it comes to experiment, even though Boyle conceived it as a means of discovery and proof he did not associate experiment with ‘method’. His experimental writings, however, often conflate his literary method and his ideas about experiment as a means of discovery and proof by showing the manner his experiments and other proofs had led him to a particular conclusion. By doing this, these writings also reveal to us that instead of employing a single method of discovery and proof, Boyle varied his experimental approach according to the state of knowledge and technology available in each field of his investigations. Moreover, although not taken as transparent windows to the past reality, Boyle’s experimental texts tell us that his category of ‘experiment’ was somewhat broad including activities of various kinds some of which would not be recognized as experiments today.


Boyle’s medical works have hitherto received only slight attention from the modern historians of science and medicine. The older studies in the history of science have presented Boyle as one of the leading figures of the ‘scientific revolution’. Consequently, these studies have concentrated first and foremost on such fields of inquiry – such as chemistry or pneumatics – where Boyle’s work produced results which seem to have led the field towards modern science. Likewise, the older medical history, which takes modern knowledge of the bio-medical sciences as its starting point, has attempted to uncover the route and development of the early modern ‘physic’ into the modern medical science. Since Boyle’s medical works and ideas have very little in common with modern science, they have been of slight interest for the older history of science and medicine. The older studies have likewise examined past experimental activities from the standpoint of the modern notion of the scientific experiment and method. Consequently, a vast number of activities which the past experimenters conceived as important experiments have been either ignored or their significance has been underrated. A significant part of Boyle’s medical experiments, in particular, falls into this category of ‘pre-scientific’ experiment.

During the recent decades, the older positivist approach to the history of science and medicine has given way to contextualist studies taking into account also the wider context in which past science and medicine have been practised. The contextualist historical studies aim at uncovering the meanings that past scientific activities had for practitioners. As for studies written on Boyle, Steven Shapin and Simon Schaffer’s study *Leviathan and the Air-pump* (1985) used Boyle’s dispute with Thomas Hobbes in its provocative attack against the positivist and internalist interpretations of past science. Shapin and Schaffer attempted to show that the success of the practises used in the production of scientific knowledge is not merely a matter of science but is connected to the larger social context in which science is practised. Subsequently, Shapin and Shaffer’s sociological approach to the history of science has both found support and aroused criticism. Despite the criticism presented towards the sociological approach, however, these studies have for their part succeeded in broadening the scope of both the studies on the history of science and on Boyle.
The recent contextualist studies on the history of science make an attempt of understanding the rationale and the meanings scientific activity had for past scientists. Consequently, the viewpoints from which past science is approached have changed. In addition, new studies have been written about several previously neglected subjects, such as the alchemical interests of the leading seventeenth-century natural philosophers, for instance. Boyle’s extensive literary output has likewise received increased attention and several new studies have been written on a variety of his writings and interests. These studies are important part of the new studies on seventeenth-century experimentalism and natural philosophy.20 Particularly Michael Hunter’s work in cataloguing Boyle’s extant manuscripts, editing Boyle’s complete works and correspondence has opened new perspectives and possibilities for studies on Boyle.21 In his own studies, Hunter has published a significant number of Boyle’s manuscripts and succeeded also to uncover previously unknown features about Boyle’s life and work, such as the ‘dysfunctional’ side of Boyle’s personality and his disordered manner of working, for instance.22

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Despite the increased interest in various aspects of Boyle’s work, his medical works still remain largely neglected. In general, the studies into the history of science tend to regard medicine as a field separate from science. Thus medical issues are seldom examined in the context of seventeenth-century developments in natural philosophy and experimentalism. Moreover, it is true that when Boyle’s work is considered as a whole, medicine indeed appears as a minor interest of his. Hence, besides Barbara Kaplan’s ‘Divulging of Useful Truths in Physick’: The Medical Agenda of Robert Boyle (1993), no extensive study on Boyle’s medical works exists. Kaplan’s study aims at presenting an overall view on the different aspects of Boyle’s medical work and does not examine the complicated relationship between experimentalism and medicine in detail. The historians of medicine, however, often discuss the influence of natural philosophical developments on medicine. Consequently, they have shown some interest also in Boyle’s medical works and ideas. My study makes an attempt to understand the relationship between the medical traditions of experiment and Boyle’s experimentalism. A thorough examination of Boyle’s medical works presents us a natural philosopher with an agenda of promoting an experimental approach to practical and theoretical knowledge. These works also show how Boyle built his approach to medical knowledge by adopting elements from both the medical tradition and from novel medical and philosophical trends.

My dissertation advances an argument about Boyle’s experimentalism and method. A majority of the studies written about Boyle’s natural philosophy and medicine tend to start from the presumption that Boyle applied a particular experimental method in his investigations. Barbara Kaplan, for instance, conceives Boyle’s method as a ‘carefully

constructed program of hypothesis formulation and verification.’ 24 Rose-Mary Sargent’s Diffident Naturalist: Robert Boyle and the Philosophy of Experiment (1995), which is the most important modern study on Boyle’s experimentalism, likewise presents a systematic although more nuanced and accurate interpretation of Boyle’s experimental philosophy. According to Sargent, Boyle ‘sought to give experimental practices a rational foundation – to construct a "comprehensive method" that would lead to knowledge in all areas of human concern.’ 25 Sargent has also paid attention to the impact of the medical tradition on Boyle’s experimentalism. 26 She emphasizes in particular the influence of William Harvey’s method of medical research on Boyle’s experimental philosophy and points out that ‘Harvey’s case typified the experimental program and became the paradigm that Boyle would follow in all his investigations.’ 27

Although medicine was a minor interest of Boyle’s, I argue that an examination of his medical works opens a new perspective to his ideas about the uses of experiment. First and foremost, such an approach to Boyle’s work avoids an interpretation of his experimentalism as a single and consistent scientific method. On the contrary, this study presents his medical experimentalism as a somewhat disorderly effort and suggests that Boyle employed no such method in his investigations. Instead, his experimentalism embodied various kinds of experimental methods. Some of these methods, such as the trial-and-error method of practical medicine, are not recognized as scientific methods today. Nevertheless, the trial-and-error experiment had a major role in Boyle’s medical experimentation and writings.

Boyle’s writings do not define experimentalism as a method or an art but rather as a particular kind of approach to natural knowledge. Moreover, the manner in which Boyle’s medical works describe his experimental activities shows that there hardly was much method in his manner of working. The degree of design and orderliness of his experimental activities varied greatly from carefully planned experiments to medicinal

25 Sargent, Diffident Naturalist, 1.
26 Sargent, Diffident Naturalist, 75-84.
27 Sargent, Diffident Naturalist, 83.
trial-and-error experiments. Furthermore, Boyle occasionally regarded contingent and accidental events as experiments. Hence also the meanings of ‘experiment’ in his works are various. This study attempts to clarify some of these meanings by examining how Boyle wrote about experiments and used these texts in his medical works. While doing this, it shows that experiment had no clearly defined function but Boyle rather experimented with different ways of making experiments and using these in his writings. Moreover, I suggest that it is possible that Boyle was quite satisfied with his somewhat disorderly manner of working. Since he recognized the role of ‘uncertain sagacity’ in experimental inquiries, he might have preferred creativity over the strict rules of method.\footnote{BP, vol. 9, fol. 52.} Furthermore, it is likely that his sensitivity to criticism prevented him from publicly committing himself to a definite set of methodological rules or to an ‘art of experimenting’.

Hence my argument is in line with Nancy Siraisi’s interpretation of Renaissance medicine. In her study on a sixteenth-century physician, Girolamo Cardano, Siraisi notes that Renaissance medicine allowed various methodological and philosophical options which were seldom seen as mutually exclusive. According to her, ‘the notion of a single correct scientific – or, for that matter philosophical – method that rigorously excluded other approaches was not part of the sixteenth-century mental universe. Cardano freely selected from and combined a variety of approaches to nature and the art of medicine.’\footnote{Nancy G. Siraisi, \textit{The Clock and the Mirror: Girolamo Cardano and Renaissance Medicine}, (Princeton University Press, Princeton, New Jersey, 1997), 69.} This, I seek to argue, applies to Boyle’s medical work as well.

My study is concerned with the interaction between Boyle’s experimentalism and medicine and, therefore, makes no attempt to provide novel insights into seventeenth-century English medicine. Furthermore, the scope of the study does not allow a detailed examination of all the medical questions addressed; these are examined only insofar they were relevant to Boyle’s medical ideas and work. Consequently, several complicated medical issues are only briefly outlined. I should also say something about the terminology used. The ‘medical community’ refers to a vaguely outlined group of

Plan of the study

This study makes an attempt to present systematically and methodically a subject matter which does not have much inherent order in it. The division of the dissertation into four chapters is made according to the kinds of writings in which Boyle published medical experiments. The first chapter examines Boyle’s medical experimentalism from two standpoints. The first part of the chapter explores practical medical texts, such as recipes and how-to instructions, and presents Boyle as a medical ‘traditionalist’. There was nothing new in making medicinal experiments in order to find effective novel medicines and publishing the results of these \textit{experimenta} in various kinds of self-help books. Boyle’s personal experience of ill health and disease, together with his interest in practical medicine and medical recipes, were not exceptional in a time when medicine had only a few effective means to cope with disease and accidents which killed or disabled a significant number of people. In Boyle’s case, his personal experience of contemporary medicine intertwined with his view of the charitable duty of a Christian forming an agenda of publishing useful medical information for the public good.
The second part of the first chapter moves to discuss the reciprocal relationship between experiment and theory as the major novelty Boyle’s experimental philosophy offered to medical investigation. The relationship between experiment and theory is also one of the leading themes of this study. Although the medical tradition embodied several notions of experiment, it did not regard experiment as relevant to theoretical knowledge except in the specialist field of anatomical investigation. Thus medicine offered no general model of a reciprocal relationship between experiment and theory for Boyle. Also his own efforts in finding ways of using medical experiment for theoretical discovery remained scattered and vague and failed to produce any significant results.

The second chapter explores the historical approach to medical and natural knowledge. Historical writing was a popular way of examining a variety of subjects. The natural historical works of the period form a literary genre with great flexibility and variety. The chapter asks whether the historical approach in its flexibility was open for the use of experiment in the discovery of medical knowledge. In England, Francis Bacon’s writings presented, if not a straightforward model, at least a justification for natural historical studies. In medicine, the historical approach was associated with the anatomical studies on the one hand, and with the Hippocratic clinical medicine, on the other. The chapter seeks to show that instead of models of method, Bacon and Hippocrates functioned as authorities offering natural and medical historians first and foremost a justification for different kinds of empiricist approaches to knowledge. In addition, Bacon’s works and the Hippocratic corpus were used as sources of various kinds of ideas which could be employed in natural historical and medical investigations.

The third and fourth chapters examine how experiment functions in different kinds of arguments. The common theme of these chapters is rhetoric. Chapter three explores Boyle’s medical Usefulness and some contemporary polemical medical works which participated in the dispute about chemical medicine in the 1660s. The chapter focuses on the use of testimony and on the distinction between authority and matter of fact, in particular. I compare Boyle’s use of testimony in the medical Usefulness to that of the physicians participating in the dispute about chemical medicine. Medical men used
testimony mostly in a traditional manner and provided proof for their arguments by appealing to the approved authorities. Boyle, by contrast, generally disapproved of the traditional rhetorical manner of appealing to authority in natural philosophical discourse and preferred to prove by matter of fact. However, the persuasive force of naked facts was not strong, at least when it came to popular medical discourse. As a consequence, Boyle’s discourse in the medical *Usefulness* combines matters of fact with medical authority in a complex manner which makes no total separation between authority and fact.

The final chapter studies those air-pump experiments of Boyle’s which addressed the theories about the use of respiration and air for animal life. In it, the use of experiment as evidence for theoretical ideas is examined. The chapter seeks to argue that although it is tempting to regard seventeenth-century English investigation into respiration physiology as an early form of scientific research, where experiment was used as evidence by a community of medical scientists, no consensus about the use and the interpretation of experimental evidence existed. Neither did the participants associate experiment with the concept of evidence. Boyle regarded experiment as a category of proof and his manner of using experiment to evaluate the theories about respiration did not differ from the way he used experiment in a persuasive discourse. His manner of proving by experiment and other proofs aimed at creating concurrence of probabilities. However, rhetorical modes of argument were not acceptable in learned medical discourse. Hence, by contrast to Boyle’s experimental proof and concurrence of probabilities, the English anatomists rather linked experiment to demonstration which produced knowledge with a high degree of certainty. Furthermore, they extended their notion of experimental demonstration outside anatomical experimentation as well. Thus the anatomists’ idea about the role and the probatory force of experiment was somewhat different from Boyle’s. Consequently, no commonly shared idea of an experimental method or experimental evidence was employed in the inquiry into respiration physiology.
Medicine offered Boyle several opportunities for making experiments and models for using experiment for the discovery of new knowledge. He advocated experiment as a means for medical discovery. At the same time, he adopted medical experimental practices but modified these to fit his overall philosophical outlook. From medical literature, discussion and his work with several medical men Boyle eclectically built his own view of medicine and medical reform. Rather than attempting to dictate to physicians how they should manage their professional field, on the one hand, or adopting a particular kind of medical outlook from the medical men he knew, on the other, he interwove medical ideas from various sources with his natural philosophy to create a coherent view of nature. Neither did he adopt the conventions of medical literature as such but refashioned these to serve his own purposes. He distributed medical information in a traditional recipe form in his works but was uncomfortable about publishing recipe books. He collected narratives about interesting cases of disease and cure but, unlike physicians, he did not use these as a basis for generalizations. Neither did he publish case histories as collections but used these as examples in medical discourse. His manner of using experiments for evaluating physiological theories was likewise different from the physicians’ way of experimental demonstration.

Boyle’s medical work produced no significant innovations in the fields of practical or theoretical medicine. Even though medicine offered him several models of experiment and ways of using these both for theoretical discovery and practical innovation, it provided no ready solution for the issue of closing the gap between experiment and theory. The major revision in epistemology that was required for building an interactive relationship between theory and practice could not be achieved overnight.
PROLOGUE

Feavers burn us, Agues shatter us, Dropsies drown us, Phrensies unman us, the Gout tortures us, Convulsions wrack us, Epilepsies fell us, Collicks tear us; and in short, there is no considerable Disease that is not very troublesome in itself.31

Robert Boyle suffered from disease and health problems all his life. He was susceptible to disease since ‘being the thirteenth or fourteenth Child of a Mother, that was not above 42 or 43 Years old when she dyed of a Consumption’ he had ‘not inherited a robust, or healthy Constitution’.32 Boyle seldom revealed details of his private life in his writings. His state of health and the diseases he suffered from, however, make an exception; besides brief references to his health problems in several treatises, he accounted the development of his poor health in detail in the preface to the second volume of Medicinal Experiments (1693).

Boyle regarded the riding accident he had in the 1650s as the principal cause and origin of his subsequent ill health. While travelling in Ireland, he fell ‘from an unruly horse into a deep place’ being thereby badly bruised. The consequences of the accident, together with the ‘long Journey’ in the ‘bad Weather’, the ‘bad Accommodation in the Irish Inns’ and ‘the mistake of an unskilful or drunken Guide’, were disastrous and he fell ill in a ‘Fever’ and a ‘Dropzie’. In a hope of a recovery, he travelled to England, ‘but in so unlucky a time, that an illcondition’d Fever rag’d there’. While recovering from the ‘Fever’, the convalescent philosopher caught a ‘violent Quotidian or double Tertian Ague’. During the illness, his vision begun to deteriorate and, for the rest of his life, he was forced to resort to the assistance of amanuenses and servants while working. This ‘train of Mischiefs’ was ‘succeeded by a Scorbuitck Cholick’. Moreover, as a

consequence of ‘the long sitting’ when he had the ‘Palsie’, he suffered from the pain caused by the ‘Stone’. Nevertheless, in spite of the bouts of serious disease, severe pain and weak eyesight, Boyle continued his work until his death at the age of 64 publishing over 40 philosophical and religious treatises during his career.

1. ADVANCING ‘PHYSICK’

And though I ignore not, that ‘tis much more fashionable and celebrated practice in young Gentlemen, to kill men, than to cure them, And that mistaken Mortals think it the noblest Exercise of vertue to destroy the noblest Workmanship of Nature, (and indeed in some few cases the requisiteness and danger of destructive valour may make its Actions become a vertuous Patriot) yet when I consider the Character, given of our great Master and Exemplar, in that Scripture, which says, That he went about doing good, and Healing all manner of Sickness; and all maner of Disease among the people, I cannot but think such an Implyoment worthy of the noblest of his Disciples.  

This chapter examines Boyle’s lifetime interest in practical medicine and therapeutics, in particular. In it, I focus on a clinical trial-and-error experiment and Boyle’s manner of communicating the results of such experiments in his medical writings. Boyle collected medical recipes, experimented with various medicinal substances and, together with medical practitioners, tested novel medicines on patients. He published the results of these experiments as medical recipes and instructions in his medical works. In addition, four printed recipe books published part of his large recipe collection.

33 Boyle, Medicinal Experiments, II, 211.
34 Boyle, Usefulness II, sect. 1, 479.
The chapter begins by examining Boyle’s position as an author of practical medical texts. The first section also introduces some of the principal issues of medical controversy in seventeenth-century England which provide part of the medical context for the current and the following chapters. The second section of the chapter discusses the practical medical experiment and examines how Boyle’s practical medical texts relate to the genres of contemporary medical literature. The examination suggests that when it comes to practical medical innovation, Boyle was rather a medical traditionalist than a radical reformist.

Section 1.3. digresses from medicine to discuss experiment and method. It presents a summary of Boyle’s general methodological ideas, such as his classification of experiments and his ideas about the relationship between experiment and theory. Boyle conceived experimentalism rather as a philosophy with a somewhat vaguely defined epistemological attitude than as a systematic methodology. He did not explicate any experimental method in his published works. Instead, his ideas about the uses of experiment are found principally in brief manuscript fragments. I argue that his reluctance to discuss methodology in public was a deliberate choice by which he aimed at maintaining the flexibility of his experimentalism.

The final section turns back to medicine and explores the relationship between the experiment of practical medicine and medical theory. In the traditional learned medicine, a trial-and-error experiment of medical practice had no connection to theory. It was used first and foremost as a means of discovering novel remedies. Boyle’s view about the significance of a clinical trial-and-error experiment for pathological and pharmacological theory departed from the medical tradition. He recommended creating a reciprocal relationship between practical medical experiment and theory. However, his suggestions about how clinical experiment could be used for theoretical discovery were somewhat scattered and vague. Neither did his practical experimental work in the fields of pathology and therapeutics produce any significant theoretical discovery.
1.1. Experiments for Health and Wealth

This section examines Boyle as a medical author and his position in the English medical community. Like many of his countrymen, Boyle was interested in practical medicine. The sad state of medicine is a much discussed issue in seventeenth-century medical literature. The radical reformers of the Interregnum era had strongly criticized the traditional learned medicine and its practitioners of maintaining elitist medicine and medical care. At the same time, a large number of healers of other kinds – surgeons, apothecaries, midwives and various kinds of empirical practitioners – practised medicine much to the annoyance of the learned medical community. Furthermore, well meaning lay people provided medical care for the poor out of charity. The confused situation in the medical field aroused numerous initiatives for the development of medicine. No consensus existed about medicine but, instead, the field was full of controversy dividing the medical community into different camps according to the views held about theory, practice and medical reform.\(^{35}\)

The boundary between lay people and the medical profession was vague. In case of illness, people acquired medical care from a variety of sources; the means used for curing disease varied from self-medication to the therapies offered by medical practitioners of various kinds. In addition to physicians, a variety of practitioners with their arsenal of different kinds of therapies was available.\(^{36}\) Generally, seventeenth-century Englishman’s interest in medicine extended far beyond those diseases and therapies he had experience of himself. In this sense, Boyle’s interest in practical medicine was by no means exceptional. Lay people interfered in medical matters besides by their choice of practitioners and remedies, also by providing medical care and advice to others and by participating in medical discussion. People had a habit of collecting and exchanging medical recipes, preparing medicines and discussing medical topics. It was common to read medical literature and some lay people, such as Boyle,

\(^{35}\) Cook, *Trials of an Ordinary Doctor*, 118.

even became medical authors.

I

Boyle started his career in the late 1640s as a moralist, a natural philosopher and an author in London where he was associated with the German intelligenzer Samuel Hartlib. After emigrating to England, Hartlib had gathered around him a group of people interested in practical innovation and educational reform.\(^{37}\) Boyle’s correspondence with Hartlib reveals that both men were interested in agricultural innovation, chemistry and practical medicine. Their interest in practical medicine originated partly from personal experience of painful disease and the inefficacy of the therapies commonly available. They discussed health problems and their habit of trading medical secrets in their correspondence. In addition, Boyle and Hartlib shared medical preparations and recipes of promising novel medicines with each other. During the 1650s, for instance, Hartlib suffered from painful ‘fits of stone’ which were a recurring theme in his letters to Boyle at the time. Hartlib described his efforts seeking and experimenting with new medicines for his disease. Boyle, too, had problems with his health at the time. Finally, Hartlib told Boyle that he had found a medicine which had relieved his pains. After gaining a recipe for this ‘water against the stone’, he wished that Boyle would ask the Chemist Peter Stahl to ‘make a good quantity for yourself and the poor’ and to let Hartlib ‘also be partaker of it.’\(^{38}\)

Medical reform was one of the central themes of the Hartlibians, who often approached practical reform from the basis of their religious ideas.\(^{39}\) In addition to the emphasis on Christian charity, they stressed the importance of placing public good above private


\(^{39}\) Webster, *Great Instauration*, 261, 293-295, 302-308.
interests. Hartlib’s attempt to establish an Office of Address for organizing and publishing new practical knowledge shows the importance the Hartlibian agenda placed on distributing useful information.\textsuperscript{40} Boyle shared the Hartlibian philanthropical ethos and ideas about public good.\textsuperscript{41} He also published his first essay, ‘An Invitation to a Free and Generous Communication of Receits in Medicine’ (1655), in a work edited by Hartlib. The essay was originally intended as part of a larger work Boyle referred to as a ‘Discourse of Publicke-Spiritednesse’.\textsuperscript{42} The published essay emphasized the importance of publishing medical knowledge in the vernacular while criticizing the secrecy prevailing in the medical community.

Despite its medical subject matter, Boyle’s early essay belongs to his moral philosophical writings as for its style and rhetoric.\textsuperscript{43} Boyle emphasized the religious imperative for disclosing secret medical recipes by using biblical authority and the example of Christ to prove that helping the sick and the poor is the duty of every Christian. He described the open communication of medical secrets in religious terms as a ‘strong obligation, that not charity onely, but bare humanity layeth upon us to relieve the distresses of those, that derive their pedegree from the same father we are descended from’.\textsuperscript{44} Boyle’s manner of appealing to the religious imperative when discussing a practical medical issue was not exceptional at the time. On the contrary, in medical disputes, Christian ethics and charity were often set against what were regarded as the more individualistic values of university educated physicians.\textsuperscript{45}

\textsuperscript{40} Webster, \textit{Great Instauration}, 67-77.
\textsuperscript{42} Boyle to Lady Ranelagh, 2.8.1649, \textit{Correspondence}, vol. 1, (79-81), 80. See also Hunter, \textit{Boyle}, 61.
\textsuperscript{43} Principe, ‘Virtuous Romance and Romantic Virtuoso’, 385.
Boyle’s early career in the Hartlib circle took place in the civil war and the Interregnum era which was exceptionally rich in various kinds of plans for religious and social reform. Strong criticism also was expressed towards monopolies in practical fields, such as medicine and law, for instance.46 The London College of Physicians, which attempted to regulate medical practice in London by prosecuting unlicensed practitioners, was the principal target of the criticism towards medical monopoly. Moreover, due to its position as the institution of learned medicine in the capital, all criticism towards the traditional academic medicine tended to become aimed particularly against the College and its learned members. The membership of the somewhat exclusive College was difficult to obtain and, therefore, in addition to empirical healers, numerous university educated physicians practised in London without its licence.47

The medical scene of the capital was disorderly and full of controversy between different kinds of healers. The diversity of the medical practitioners, together with the patients, whose means of obtaining medical care varied greatly, formed a complex whole which the historians of medicine usually refer to as the ‘medical marketplace’.48 Generally, people tended to treat their diseases using the means available in the household and often consulted a physician or other healer only when all self-help methods had failed.49 In the countryside, in particular, the divines and the wives of the local gentry frequently provided medical care for people, especially to those of the poorer sort, out of charity.50 The medical choices of people depended largely on their socio-economic position on the one hand, and on the reputations of available practitioners, on the other. However, even those who could afford the services of a learned physician often chose a healer or several healers of other kinds. Hence an academic education was not necessarily among the most important criteria people used when choosing a medical practitioner. Instead, the opinions and recommendations of family members, friends and neighbours, together with the considerations of the price of

46 Webster, Great Instauration, 256-264.
47 Cook, Decline of the Old Medical Regime, 94-132, Webster, Great Instauration, 250-256.
48 Wear, Knowledge & Practice, 28-29.
49 McCray Beier, Sufferers & Healers, 4, 166-169.
50 Cook, Decline of the Old Medical Regime, 32.
the treatments available, weighed more than the university learning of a practitioner.\textsuperscript{51}

University educated physicians formed a minority in the medical marketplace. Despite their medical education, the learned practitioners had to compete for patients with other practitioners, such as apothecaries, surgeons, midwives and various kinds of empirical healers. Moreover, the learned medical community hardly led a harmonious existence among itself. Among the members of the College of Physicians, for instance, controversies about the politics of the College, the development of medical theory and practice arose from time to time.\textsuperscript{52} However, the attempt to control the medical scene of the capital was the common cause of the collegiate physicians. The College reproached all healers practising without its licence and warned the people of the dangers of the remedies of empirical healers.

At the same time, the opponents of the traditional medicine often accused the members of the College of avarice. Moreover, the critics claimed that the traditional therapies of learned medicine were besides painful, also mostly ineffective.\textsuperscript{53} Learned physicians were few and being expensive, their services and treatments were beyond the means of a large part of the population. Boyle, among others, pointed out that the high prices of medicines could ruin the household of a working man; ‘tis certain that the Bills of Apothecaries, especially in Chronical Diseases, do often prove so chargeable, that even when the Remedies succeed, by that time a poor Patient is recovered, he is undone, and pays for the prolongation of his Life, that which should have been his lively-hood’. Although the principal goal of medical care was the patient’s health, reducing the costs of treatment and medicines ‘ought in Charity, if not also in Equity, to be the endeavor of the Physitian, especially when he dealeth with Patients that are not rich.’\textsuperscript{54}

\textsuperscript{51} McCray Beier, Sufferers & Healers, 8-50, Cook, Decline of the Old Medical Regime, 28-69, Porter, Quacks, 41-92, Wear, Knowledge & Practice, 21-28.
\textsuperscript{52} Cook, Decline of the Old Medical Regime, 162-165, 170-180, 193-195, 207-209, 215-221, 225-228.
\textsuperscript{53} McCray Beier, Sufferers & Healers, 12, 176-180, Cook, Decline of the Old Medical Regime, 71-74, 78-79, 113-115, 120-127.
\textsuperscript{54} Boyle, Usefulness, II, sect. 1, 377.
The Interregnum criticism towards the academic medicine was connected with the various larger plans for medical and educational reform. Although all medical or educational reformists did not demand a total abandonment of the traditional medicine and university education, most of their schemes, if realized, would have caused significant changes in these areas. After the restoration of the monarchy in 1660, medical disputes lost their most radical religious and social overtones. Nevertheless, the College of Physicians, which was often regarded as the fortress of the conservative ‘glenical’ medicine, remained a target for criticism against the traditional learned medicine.\textsuperscript{55} The dislike of passionate expressions of religious beliefs, which became characteristic during the Restoration period, had an impact also on the style of Boyle’s medical works. Boyle continued to argue for innovation and reform of practical medicine. However, instead of the religious imperative he had employed in his first essay, he frequently appealed to the practical benefits and the public good following from an experimental approach to medicine.\textsuperscript{56}

Boyle’s published medical works do not present as radical ideas about medical practice and theory as those of the Interregnum medical reformers or the later critics of the College of Physicians. Due to the moderate style and mostly conciliatory tone of his published medical works, Barbara Kaplan has suggested that Boyle’s aim in medicine was ‘to augment and improve the existing methodus medendi.’\textsuperscript{57} In his published works, Boyle indeed often disapproved of medical extremists, such as the unlearned empirics, the radical chemists and the conservative Galenists. Instead, he argued for a moderate medical reform which included elements from various approaches to medical practice. He also stressed his reluctance to align himself with any of the medical sects of the day.\textsuperscript{58}

\textsuperscript{55} Cook, Decline of the Old Medical Regime, 141-162.
\textsuperscript{56} Hunter, ‘Reluctant Philanthropist’, 212.
\textsuperscript{57} Kaplan, ‘Divulging of Usefull Truths in Physick’, 142.
\textsuperscript{58} Boyle, Usefulness, II, sect. I, 317, 532-533.
Nevertheless, Boyle's unpublished texts show that he disapproved of the way medical practice was conducted and regulated at the time. Michael Hunter has shown that in the 1660s, Boyle planned a critical treatise about the state of contemporary medicine. According to Hunter, the manuscript fragments indicate that the treatise would have been an ‘outright assault on the fundamentals of contemporary medical practice’. In addition to Boyle’s suppressed medical treatise, a manuscript draft for a preface to a recipe collection shows that Boyle disapproved of the attempts to restrict the licence to practice medicine. According to him, curing disease ‘is such an important philanthropic activity that it ought in no way be restricted to professional physicians by any law so strict as to prevent other people from being able to rush to help’ in the case of a serious disease. Philanthropic medical activities of lay people and self-medication were justified because ‘most lack the opportunity and many the means to consult doctors’. Moreover, ‘it very often happens that the medicines of doctors do not produce cures.’

Boyle suppressed his most polemical medical texts and chose a more moderate style for his published works. Hunter has suggested that the major reason for Boyle’s choice of style was his anxiety over the feelings of the learned medical community. During his career, Boyle became acquainted with a large number of physicians who held various and often conflicting views on natural philosophy and the development of medical practice and theory. Natural philosophy formed both the basis of the academic medical education and the foundation of a learned practitioner’s art. As a consequence, physicians were particularly interested in new natural philosophical trends and eager to participate in natural philosophical inquiries. During his early career in the Hartlib circle, Boyle was associated with medical reformists, such as the emigrant iatrochemists Fredrick Clodius and George Starkey. These chemical physicians, who advocated

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Helmontian chemical philosophy and medicine, were openly hostile towards the traditional academic medicine.\textsuperscript{63} By contrast, when Boyle settled in Oxford in 1655, he moved from the practically orientated Hartlib circle to the Oxford academic medical community. Instead of practical medicine, the investigations of the Oxford community focused on anatomy and the post-Harveian physiology, in particular.

II

Although maintaining his connections and good relations with the academic medical community throughout his career, Boyle also remained open-minded for more heterodox approaches to practical medicine. His published medical works present an attempt to find a middle ground between his own medical views and the attitudes prevailing in the medical community. His view about the importance of an open communication of medical information, however, did not change much over the years. He did not publish his most polemical medical texts but his medical writings emphasize the importance of publishing practical medical information. He was aware, however, that from the standpoint of the medical community an open communication of medical knowledge involved complex issues.

In his first published essay, Boyle argued for a free communication of medical secrets and showed no particular understanding for the occupational interests of medical men. In his later medical writings, however, he took into account the attitudes and interests of the medical community. Boyle often traded with medical secrets. For instance, in the medical \textit{Usefulness}, he accounted how he, while staying in Ireland, went looking for an ‘empiric’ famous for his cure of the ‘stone’. Having found the ‘empiric’ Boyle purchased his secret remedy for the common and painful disease of the ‘stone’.\textsuperscript{64} He recognized the economic value these secrets had for practitioners. When publishing medical recipes he had gained from a medical practitioner, he considered the possible

\textsuperscript{64} Boyle, \textit{Usefulness II, sect. I}, 339.
consequences that publishing these recipes might have. If a recipe of a good medicine were published in a manner that also identified the practitioner using it, ‘not only ... other Physicians would quickly make as much advantage of it as he, but many Patients would think themselves by that discovery dispens’d with ... from going to any Physitian at all’. Moreover, Boyle had acquired many medical recipes on condition of keeping the secret at least as long as the inventor was alive and his income dependent on his secret. The narrative about how Boyle came to publish the recipe of the *Helmontian Laudanum* presents a case in point. He had first acquired the recipe from ‘an expert Chymist’. However, not having the ‘Chymist’s’ permission, he could not publish the recipe since his source ‘made a great and deserved Benefit of the *Laudanum*. ‘Fourteen or fifteen years’ later he came across with an improved recipe of the same medicine and this time, with the permission of his source, he published the recipe in the *Philosophical Transactions*.

Practical manuals of all kinds offering easy medical recipes and instructions for solving common domestic problems were highly popular in seventeenth-century England. Although recipe book was an established genre having its origins in medieval manuscript collections, publishing such works involved some delicate questions. Medical authors and their works tended to be read and classified through contemporary disputes between different medical camps and competition in the medical marketplace. The learned physicians often associated the vernacular medical books with medical empiricism since empirical healers encouraged self-medication by selling remedies which could be used without the supervision of a physician. The vernacular self-help books likewise downplayed the traditional role of a physician by giving lay people

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65 Boyle, *Usefulness II*, sect. 1, 486.
66 Robert Boyle, ‘An Account of the two Sorts of the *Helmontian Laudanum*, communicated to the Publisher by the Honourable Robert Boyle, together with the Way of the Noble Baron F.M. van Helmont (Son to the famous *Johannes Babista*) of preparing his *Laudanum*, *Philosophical Transactions*, 9, (no. 107, 26 October 1674, 147-9), *Works*, vol. 8, (527-529).
access to medical knowledge.\textsuperscript{69}

The physicians regarded their theoretical knowledge about the causes of disease as an indispensable element in effective and safe treatment of disease. For instance, in his \textit{Short Discoverie of the Unobserved Dangers of severall sorts of ignorant and unconsiderate Practisers of Physicke in England} (1612), John Cotta M.D. warned the public ‘that wholesome medicines by the hands of judicious dispenser, are as Angels of God sent for the good of men; but in the hands of the unlearned, are messengers of death unto their farther evill.’\textsuperscript{70} James Primrose M.D. was likewise worried about the great number of unlearned practitioners, such as apothecaries, ministers and women, who dabbled in medicine. According to him, ‘there is necessary unto a cure, the knowledge of the disease, the method of healing, and the use of indications, without which no remedy can be applyed. For remedies are the finger of God, but as a sword in the hand of a mad man, they are good indeed to him that uses them aright, but dangerous, being administred by him that neither knowes well the disease, nor the method of curing.’\textsuperscript{71}

Michael Hunter has shown that Boyle was often concerned over his reputation and the reception of his works.\textsuperscript{72} In this respect, medical authorship, in particular, involved complicated issues. In his medical works, Boyle repeatedly stressed that his intention was not to meddle in the professional matters of the physicians. Instead, he emphasized his role as a natural philosopher whose work produced knowledge which could be useful in the field of medicine as well. In the learned medical tradition, medicine was


associated with natural philosophy. Hence, a learned physician was also a natural philosopher by his education. In his medical practice, he used his natural philosophical knowledge to provide his patients with advice about maintaining their health by living in harmony with nature. Medicine, with its task of curing disease, was only part of a learned physician’s field, ‘physic’.  

Boyle also regarded medicine as ‘a Part, or an Application of Natural Philosophy’. He made a distinction between the viewpoint of a physician and a natural philosopher. Although a natural philosopher and a physician shared a common object of knowledge, their perspectives were different; ‘there are divers hurtful or advantageous accidents and changes of the humane Body, whereof the Naturalist takes notice, but as they are Phaenomena or changes produc’d by Natural causes in the Body of an Animal, whilst the Physician considers them as Symptoms of Diseases, or Effects of Medicines, the former directing his Speculations to the discovery of truth, and the other his Theory to the recovery of health.’

Boyle conceived curing disease as the principal task of a physician. According to him, therapeutics was the most important section of medicine ‘without which, three at least of the four others may prove indeed delightful and beneficial to the Physitian, but will be of very little use to the Patient, whose relief is yet the principal end of Physick’. By publishing practical medical information and medical recipes Boyle took a major step away from the area of natural philosophy. His own distinction placed practical medical information in the medical rather than in the natural philosophical field. Moreover, by publishing practical medical information, he became exposed to the threat of being

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74 Robert Boyle, Experimenta & Observationes Physica Wherein are Briefly Treated of Several Subjects Relating to Natural Philosophy in an Experimental Way, (1691), Works, vol. 11, (367- 437), 398.
75 Robert Boyle, Of the Reconcileableness of Specifick Medicines to the Corpuscular Philosophy, (1685), Works, vol. 10, (351-435), 353.
76 Boyle, Usefulness, II, sect. 1, 364. Boyle divided ‘physick’ in a conventional manner into five sections; ‘the Physiological ... Pathological, Semeiotical, Hygieinal and Therapeutical’ (Usefulness II, sect. 1, 298-99). Medicine was also often divided into theory, consisting of physiology, aetiology and semiology, and practice, which included hygiene and therapy, (Per-Gunnar Ottoson, Scholastic Medicine and Philosophy, (Bibliopolis, Napoli, 1984, 70). See also Maclean, Logic, Signs and Nature, 69-70.

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understood as advocating the mere medicine of the empirical healers instead of the holistic physic of the learned physicians.

However, it was by no means exceptional that a lay person and a gentleman collected and published medical recipes for the public good or ‘for the benefit of poor’. To justify publishing, Boyle presented similar reasons as other contemporary authors of the vernacular medical works.77 His preface in *Medicinal Experiments II* justifies publication by example and authority. According to Boyle, by contrast to the English medical men, the French medical community favoured an open communication; the public spirited Parisian ‘Assembly of Physicians, Chirurgeons, and others ... impart to the Publick such as they shall think worthy and seasonable; which Communications consist not of only new Discoveries, odd Cases, Speculations, and Observations, but of Receipts and Processes of Remedies, Printed for the most part in French’.78 Furthermore, ‘the Dictates of Philosophy and Christianity’, as well as the ‘great Examples’ of philosophers, such as Democritus and Pythagoras, together with the King of France, who encouraged medical research and an open communication of practical medical information in his kingdom, induced Boyle to publish some of his ‘Simple’ and ‘Easily Prepared’ medicines.79

Particularly the manner Boyle’s recipe collections were printed, distributed and published shows that publishing medical information involved delicate issues for him. None of his recipe collections was published in an ordinary manner during his lifetime. He had his first collection *Receipts of Medicines* printed in 1688 and, instead of publishing the book, he distributed it privately to a select group of recipients. To avoid being seen as an advocate of medical empiricism, Boyle often emphasized that his remedies were not intended to replace the services of a physician.80 In the preface of *Receipts of Medicines*, he likewise pointed out that he did not ‘pretend that these

80 E.g. Boyle, *Usefulness II*, sect. 1, 534.
[recipes] should play the part both of Medicines and Physicians too; but only that they may be Usefully employ’d, by One that, like You, knows how to Administer them Discreetly.\footnote{Robert Boyle, \textit{Some Receipts of Medicines, For the most part Parable and Simple. Sent to a Friend in America}, (1688), \textit{Works}, vol. 11, (173-186), 175-176.}

The authors of recipe books did not usually give reasons for why a medicine was effective in a particular disease; the rationale of taking the medicine rested solely on the authority of the author.\footnote{Andrew Wear, 'Epistemology and Learned Medicine in Early Modern England', in Bates, (ed.), \textit{Knowledge and the Scholarly Medical Traditions}, (151-173), 159-160.} By contrast, in \textit{Receipts of Medicines}, Boyle pointed out that experiment provided the grounds for trusting the medicines of the collection. He classified the recipes into three classes according to the number of trials made on the medicines. The classification was based either on trials he had ‘caus’d to be made’ or on ‘the Affirmation of the Physitian, or other Credible Persons’ that had imparted him the recipe.\footnote{Boyle, \textit{Receipts of Medicines}, 176.} Although Boyle’s classification did not eliminate the significance of his authority as grounds for trust, it pointed out that authority was based on experiment and experience.

Boyle’s three-volume recipe collection \textit{Medicinal Experiments} (1692-1694) was published posthumously. We have, however, evidence that during his lifetime Boyle planned to publish a significant part of his private recipe collection. Several manuscript drafts for prefaces to recipe books are extant. In addition, several lists of Boyle’s unfinished works, which he was preparing for publication, include recipe collections. In the list of 1684, for instance, both ‘A Short Collection of Parable Medicines’ and ‘A Short Collection of Medicines for the Eyes’ are mentioned, together with ‘An Introductory Preface to Receipts Chymical, and medicinal communicated to the Author’.\footnote{‘Catalogue of Boyle’s unpublished writings, 7 July 1684’, (BP 36, fols. 59-60), \textit{Works}, vol. 14, (341-342), 341.} These works, together with other recipe books, appear also in the later lists of Boyle’s unpublished writings.\footnote{‘Birch’s and Miles’ list of Boyle’s unpublished writings’, \textit{Works}, vol. 14, (356-358).} The first part of the posthumous \textit{Medicinal Experiments}
is based on the earlier Receipts of Medicines.\textsuperscript{86} The publisher’s preface explains that the collection originated from a collection of recipes Boyle had sent to a ‘learned Physician beyond Sea’ of which he later ‘did permit a few Copies of them to be Printed’ and distributed them to ‘the Hands of some of his Friends’. Afterwards, when the medicines had been found effective ‘upon many Experiments carefully made’, Boyle’s friends ‘addressed themselves with much Importunity to the Noble Author, to suffer Things which were of such general Benefit … to be made more publick.’\textsuperscript{87}

Boyle wrote several drafts for prefaces from which he seems to have chosen one of the most moderate for Receipts of Medicines.\textsuperscript{88} The first part of the posthumous Medicinal Experiments is based on the earlier Receipts of Medicines and its preface contains a similar remark about the role of a physician in curing diseases.\textsuperscript{89} By contrast, the editors of the second volume of Medicinal Experiments had no scruples about the sentiments of the learned medical community when selecting a preface from Boyle’s drafts. The second volume of Medicinal Experiments has Boyle’s own preface which, however, places no emphasis on a physician’s role. Instead, the collection was intended as a self-help book ‘for the use of those that live in the Country, in Places where Physicians are scarce if at all to be had, especially by Poor People.’\textsuperscript{90} The third volume was, according to the editor’s preface, likewise published for the ‘Ordinary and Inferiour Sort of Men, [who] either have not Ability … to reward Physicians; or by reason of the Remoteness of their Habitations, have not Opportunity to Consult them.’ \textsuperscript{91}

\textsuperscript{86}Robert Boyle, Medicinal Experiments; Or, a Collection Of Choice and Safe Remedies, For the Most Part Simple, and Easily Prepared, I, (1692), Works, vol. 12, (177-206), 180.

\textsuperscript{87}Publisher’s preface to Medicinal Experiments I, 179.

\textsuperscript{88}Hunter, ‘Reluctant Philanthropist’, 209.

\textsuperscript{89}Boyle, Medicinal Experiments I, 180.

\textsuperscript{90}Boyle, Medicinal Experiments II, 212.

\textsuperscript{91}Robert Boyle, Medicinal Experiments; Or, a Collection Of Choice and Safe Remedies, For the Most Part Simple, and Easily Prepared III, (1994), Works, vol. 12, (269-298), 271. See also Works, vol. 12, xxix.
1.2. Medicinal Experiments

Boyle regarded therapeutics as the most important part of medicine and, therefore, most of his medical works discuss practical medical issues. He claimed that experimental natural philosophy could provide the solution for the sad state of contemporary medicine. Experimentalism solved medical problems on two levels; firstly, it provided natural philosophical knowledge which formed the theoretical basis of medicine.\(^{92}\) Secondly, the experimental approach could be applied to medical investigations and used as a means of discovery of new medical knowledge. Experiment, however, was no novelty in medicine. It was already part of the medical tradition and the learned physicians and other practitioners were familiar with the concept and its meanings in medicine.

This section focuses on a trial-and-error experiment which was typical in practical medicine at the time. In an experiment of this kind, the effects of treatment were observed – not systematically as a planned series of observing numerous similar cases – but as individual events which were used to find practical helps for medical practice.\(^{93}\) Boyle regarded a successful trial-and-error experiment as proof for the efficacy of a medicine. In this respect, he agreed with a view commonly held by many medical men.

I

In the traditional learned philosophy and medicine, experiment and reason were conceived as two different, and separate, ways to truth. The superior way of reason produced scientia; universal, demonstrable and necessary knowledge about causes. By contrast, experiment and experience provided factual data about empirical phenomena as witnessed by someone.\(^{94}\) Although medicine was an academic discipline and thus


belonged to the sphere of the ‘schools’, it was an exceptional field since it was divided into a theoretical scientia and a practical art. Theoretical medicine got much of its status as a learned discipline from its close relationship to natural philosophy.\textsuperscript{95} Thus theoretical medicine focused on scientia, in other words, on demonstrating how a known fact necessarily followed from causes rather than on discovering empirical novelties.\textsuperscript{96} Even though applying the Aristotelian notion of knowledge to the field of theoretical medicine presented some problems, it nevertheless created an ideal which for its part defined the status of the discipline and its practitioners.\textsuperscript{97}

At the same time, however, medicine was also a practical art where knowledge of causes though considered important, was not the only road to successful practice. Experiment or medical trial had an important role in practical medicine and it was a commonplace already in medieval Scholastic medicine.\textsuperscript{98} In their medical practice, physicians and other healers dealt with individual patients and cases of disease of which there could be no universal and necessary knowledge. Instead, practical medicine operated with conjectural and probable knowledge.

In medicine, the notions of experientia and experimentum referred to a variety of experiential material. Medical experimentum was a practical matter; it was often performed with a trial-and-error method in order to find solutions to the problems physicians faced in their medical practice. It did not provide knowledge about causes but ‘knowledge of one thing without rational justification’.\textsuperscript{99} ‘Experience’ was about things as they usually are and it was constructed out of similar observations of a large


\textsuperscript{96} Eamon, \textit{Science and the Secrets of Nature}, 55.

\textsuperscript{97} Maclean, \textit{Logic, Signs and Nature}, 101-147.


group of people.\textsuperscript{100} No strict distinction between \textit{experimentum} and \textit{experientia} were made but these were somewhat loose categories including empirical trials, such as the testing of medical prescriptions, for instance, and the observation of contingent events.\textsuperscript{101}

Boyle was modest about his contribution to the improvement of therapeutics. He complained that he seldom had an opportunity to make experiments on patients and referred to such experiments only briefly in his published works.\textsuperscript{102} A manuscript text, however, gives a more systematic and detailed account about his medical experimentation and information sources. In the text, Boyle relates that he received medical information from those ‘doctors or empirics’ who supplied him with the recipes of novel medicines. He also considered the accounts of people who had successfully engaged themselves in self-medication. In addition, he occasionally prescribed medicines and made observations of their effects when no physician was available. He also ‘arranged’ medicines ‘to be administered by other practitioners of medicine.’ Moreover, he ‘sometimes passed some time in hospitals where, by the permission of the most learned doctors who had charge of them,’ he made ‘many experiments’.\textsuperscript{103}

Boyle’s medical works show that he adopted the traditional experimental activities of practical medicine in his own work in improving therapeutics. His medicinal experiments, particularly those where medicines were tested on patients, were similar to the trial-and-error \textit{experimenta} of medical tradition. In general, Boyle preferred ‘artificial and design’d experiments and firsthand observation.\textsuperscript{104} Medical trial-and-error experiments, however, hardly involved much design or artificiality. Instead of being guided by a theory or a hypothesis, the rationale of a ‘pre-modern’ trial-and-error experiment was to see what happens when something is done.\textsuperscript{105}

\textsuperscript{100} Dear, ‘\textit{Totius in verba’, 148-50.  
\textsuperscript{101} Eamon, \textit{Science and the Secrets of Nature}, 55-56.  
\textsuperscript{103} Boyle, ‘Medical Prescriptions’, 295-296.  
\textsuperscript{104} BP, vol. 9, fol. 25.  
\textsuperscript{105} Peter B. Medawar, \textit{The Art of the Soluble}, (Menthuen, London, 1971), 134-135, quoted in Antonio Pérez-Ramos, \textit{Francis Bacon’s Idea of Science and the Maker’s Knowledge Tradition}, (Oxford University
A major part of Boyle’s medicinal experimentation was performed with no clear theoretical presumptions. He experimented on different substances in order to discover whether they had medicinal qualities. In his medical works, he often related how he had met an interesting remedy in literature and experimented on its preparation. He examined the efficacy of novel remedies by testing them on patients. Moreover, he often relied on second-hand information and collected narratives about disease and cure from various sources. He received reports about the effects of the medicines he had delivered to practitioners to be tested in medical practice. He was particularly interested in extraordinary and difficult cases of disease where common therapies failed and novel remedies were required.

The meaning of the traditional medical notion of experiment included contingent events where significant observations were made. Boyle’s medical works also contain narratives of such contingent events although these are more rare. These more or less random experimenta of his are not necessarily associated with medicine but may, for instance, be chemical experiments, such as those he described in his Memoirs for the Natural History of Humane Blood (1684). In that work, Boyle gave an account of an experiment where a vial containing a chemical specimen was ‘mislaid’ and ‘not look’d upon again till many days after.’ Despite the mistake, however, the experiment produced some interesting observations. In another similar experiment, Boyle found among his vials a forgotten bolthead containing spirit of blood. The label on the bolthead indicated that the vessel had been closed ‘much above a whole twelve Month’. When he opened the container, he found its contents uncorrupted and concluded that spirit of blood had ‘a great embalming Vertue’.

II

On the basis of his medicinal experiments, Boyle wrote several kinds of texts which he published in his medical works. In addition to the recipe books, works such as his

106 Boyle, Human Blood, 32.
107 Boyle, Human Blood, 54.
medical *Usefulness, Human Blood, Of the Reconcileableness of Specifick Medicines to the Corpuscular Philosophy* (1685) and *Experimenta & Observationes Physicae* (1691) contain recipes, practical instructions for medical preparations and narratives about interesting cases of disease and cure.

In medical literature, the experiential aspects of medicine were already in the sixteenth century embodied in established forms. The *experimenta* literature recorded the trial-and-error experiments of practitioners as recipes and practical instructions. In addition to recipes, the *experimenta* texts often contained descriptions about the cases of disease where the medicine had been successfully used. In the seventeenth century, the share of descriptive material in practical medical texts increased. In addition to the *experimenta* literature, practical medical texts traditionally took forms such as *exempla* (medical anecdotes), *consilia* (advice to individual patients often published as collections), *curationes* (accounts of successful cures) and *observationes* (narratives about individual cases of disease). Published works often combined several of these forms. For instance, when presented together, *observationes* and *curationes* accounted the course of an individual case of disease and its cure. *Curationes*, in particular, often also contained medical recipes.

Except for the recipe books, none of Boyle’s medical works belong to the established genres of medical literature. His works, however, share several features with the traditional forms of practical medical literature. The titles of the recipe collection *Medicinal Experiments* and Boyle’s late work, *Experimenta & Observationes Physicae* which contains miscellaneous natural philosophical and medical material, reflect the traditional notion of *experimenta* as medical recipes and practical instructions. Boyle’s medical works also contain numerous narratives of extraordinary cases of disease and cure. Moreover, his works combine his own experiments and personal experience with testimonies received from other people and literature in a manner which was typical for

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109 Pomata, ‘*Praxis Historialis*’, 125-127.
110 Pomata, ‘*Praxis Historialis*’, 122-137. See also Siraisi, *Clock and the Mirror*, 45, 59-61, 195-213.
practical medical literature.\footnote{Siraisi, \textit{Clock and the Mirror}, 45.} Boyle’s medical \textit{Usefulness}, in particular, presents a great variety of information sources; the work published narratives of Boyle’s own experiments and numerous testimonies of other people. Furthermore, it contains information gained from both ancient and contemporary medical literature and travel books. In addition, several recipes for medical preparations are published in the work.

Medical practitioners had several reasons for publishing practical medical works. For the learned physicians, publishing narratives of cases of disease and treatment (\textit{curationes} and \textit{consilia}) offered an opportunity to present examples of the rational method they employed in their medical practice. In the seventeenth century, the severe competition in the medical marketplace intensified the need medical practitioners felt for promoting their medical practice. Medical works furnished both physicians and empirical healers with a channel for self-advertisement. Furthermore, the published narratives of cases of disease and cure could be used to legitimize empirical medical practice. Likewise, the narratives of successful cures could be used to justify novel remedies not based on the learned medical doctrine.\footnote{Pomata, ‘\textit{Praxis Historialis}’, 124-127.} In addition, these medical \textit{historiae} – various kinds of collections of case histories – were the medium of information exchange in the medical community providing a channel to communicate and register medical novelties and extraordinary phenomena.\footnote{Pomata, ‘\textit{Praxis Historialis}’, 134-136.}

Boyle also published narratives about cases of disease and cure to legitimize the use of novel remedies. According to him, the physicians should not reject effective medicines even though no causal explanation for their effects existed at the time. For Boyle, a successful medicinal experiment was the best justification for using a novel remedy.\footnote{Boyle, \textit{Usefulness II, sect. I}, 437-438 and Boyle, \textit{Specific Medicines}, 354.} When a medicine was found effective and safe in practice, finding a theoretical explanation for its effects was a secondary task which could be performed afterwards. Moreover, Boyle regarded empirically discovered therapies as safer for the patient than those based merely on medical theory. Theory-based practices were dubious and might
be even dangerous for the patients:

There are two Relations or Respects wherein we may consider ye Influence of ye Theory of Physic upon ye Practise, for in some cases the Remedys of Diseases having been emperically found out; men have accommodated Causes to them; but in other cases men have taken ye Hypotheses of Galen and others for granted, & from them suppos’d knowledge of ye Causes of ye Distemper men have deriv’d Remedys. In the former of these two cases it may be allowed yt it is not so very material whether the Hypothesis of Physitians be good or not, nor consequently whether we imploy the theories of this or that sect only; because the Dispute for the main is but speculative ... But in the later case it is much otherwise, for if I ground my practise upon my Hypothesis & chuse to imploy such a Remedy, not because experience has recommended it, but because I think I know ye Cause of ye Disease & thence Inferr that such a remedy must be proper to cure it, if I proceed upon a false supposition & mistaken cause I may not only miss of curing my Patient, but may probably do him harm.115

Although Boyle also used medical innovation to promote his experimental philosophy, his reasons for publishing medical information were mostly practical; the recipes and instructions enabled his audience to prepare and experiment on the remedies he recommended. He encouraged his readers to prepare novel medicines and experiment on different medicinal substances.116 His instructions were principally aimed at lay readers although they also might have been of some use for medical men. Since ‘kitchen

116 See Boyle, Human Blood, 86.
medicine’ was a common activity in many households at the time, Boyle had all the reasons to expect that at least part of his lay audience would really use his recipes and instructions for preparing medicines. In the medical Usefulness, he pointed out that skilled chemists and physicians might find his instructions trivial. The recipes published in the work were intended first and foremost to the ‘many Persons of Quality of either Sex, who scarce read any other then English Books’ and ‘have out of Charity or Curiosity or both, begun to addict themselves to Chymistry, and venture to be tampering with Spagirical Remedies’. 

Boyle’s practical medical texts vary from a mere recipe listing ingredients to a circumstantial report about his own experience about the preparation process. The reasons for the variation in the textual forms were practical. The recipes published in Receipts of Medicines and Medicinal Experiments were intended principally for the use of lay people providing medical care for others. The collections consisted of recipes for easy and familiar medicines. In such cases, a recipe was sufficient to enable Boyle’s readers to prepare the remedies. In general, Boyle favoured simple medicines and recommended their use to the professional practitioners as well. Simple medicines consisted only of one or of a maximum of three commonly used substances. Due to the small number and the availability of materials used, these medicines were cheaper than either the complicated compounds of the ‘official’ pharmacopeia or the ‘pompous Processes’ of some chemists. Moreover, it was easier to predict the effects of simple remedies than those of the traditional medicines and, therefore, simple medicines also were safer for the patients.

Generally, Boyle preferred a detailed description to a mere recipe. Particularly when it came to novel medicines and complicated processes, he wrote narratives about his own experiments. Especially in the case of chemical medicines, he provided his readers with

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117 On domestic remedies Wear, Knowledge & Practice, 47-55.
118 Boyle, Usefulness II, sect. 1, 484.
120 Boyle, Usefulness II, sect. 1, 376-381, Boyle, ‘Simple Medicines’, 420-421.
detailed instructions. Moreover, he warned his audience ‘not to be forward to believe Chymical Experiments when they are set down only by way of Prescriptions, and not of Relations; that is, unless he that delivers them mentions his doing it upon his own particular knowledge’. In his medical works, he published instructions for several chemical preparations he had invented, obtained from another chemist or found in chemical literature. For instance, in the medical *Usefulness*, he published instructions for the preparation of *Ens Veneris* which was one of his favourite remedies. The medicine originated from chemical literature. Since it required ‘more care, not to say skill, to Prepare it well’, in addition to instructions for the preparation of the medicine, Boyle provided his readers with a narrative of his own experience about the process.

Boyle regarded *Ens Veneris* as an important medical novelty. Therefore, the narrative and instructions for the preparation of the medicine cover ten pages in the medical *Usefulness*. This is an exceptionally large space given to a description of a single experiment in Boyle’s medical works. The following passage from *Human Blood* is a more typical example of Boyle’s manner of describing a medicinal experiment:

I made the following Experiment, for Tryals sake. We took some dry’d Volatile Salt of Humane Blood, (being then better able to spare than that than Spirit), and put to it as much Spirit of Nitre, as would just serve to satiate it; and then by Evaporation we obtain’d thence an Anomalous kind of compounded Salt, which afterwards, because we desired a Medicine in a dry form, we sublim’d from a Convenient quantity of a well chosen fixed Alcaly, (if I mistake not, we took an equall weight of *Salt of Tartar*) fit to retain, not the only the Phlegmatick parts, but the Oleaginous too, which oftentimes lye conceal’d in Volatile Salts and Liquors,

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123 Boyle, *Usefulness II*, sect. 1, 500-505.
wherein they do not at all at first appear, and unto which
the greatest part of their foetid or offensive smell may
probably be imputed By this means we obtain’d a dry
white Salt of a very piercing smell. But I had no
opportunity to try this sublim’d Salt upon diseased
Persons.\textsuperscript{125}

Boyle’s habit of publishing medical recipes and instructions indicates that he did not
place much emphasis on a physician’s role in curing disease. Moreover, his preference
of an experiential instead of a theoretical basis of therapy could be understood as
favouring outright medical empiricism. However, he did not recommend a pure
empiricist or practical approach to medical knowledge. On the contrary, he thought that
natural philosophical learning was the basis for medicine. ‘For general speaking’, he
regarded ‘a learned Doctor though unasisted with Chymical Arcana’ as having ‘in most
cases great advantages to help ye sick in comparison of a mere Emperick’.\textsuperscript{126}

1.3. Experiment and Method

So far I have focused on those aspects of Boyle’s work which connect him with the
tradition of practical medicine. This section moves away from medicine to study
Boyle’s methodological ideas. In it, I discuss the relationship between experiment and
theory. The section serves as a framework for the examination of the relationship
between medicinal experiment and theory in the following section. Experiment is a
means of producing facts. In modern scientific methods, its use is firmly tied with
theory. In general, the rules determining the nature of the inference from facts to theory
form the core of the scientific method. Theory guides experimentation on the one hand,
and experiment tests, confirms or falsifies theory, on the other. A modern scientist would
hardly follow Boyle’s example and perform experiments ‘for Tryals sake’ and, even if

\textsuperscript{125} Boyle, \textit{Human Blood}, 68.
\textsuperscript{126} BP, MS 199, fol. 44.
he did, the scientific community would not acknowledge his acts as experiments. Contingent events and trial-and-error tests are no longer recognized as experiments. Instead, rationality, orderliness and design characterize accounts about modern experiments; the rationale of making an experiment is based on previous experiments and relevant theories which suggest new experiments and create expectations about their results.

Boyle’s experimentalism was no consistent scientific method in the modern sense of the term. The reservations Boyle held towards philosophical systems apply to his methodological ideas as well. Nonetheless, although Boyle did not explicate any experimental method, the extant manuscripts show that he felt the need to bring some order to his work. He classified experiments to various kinds of categories and considered the ways in which experiment and theory could be combined to produce new knowledge about nature. In his published works, instead of explicating an experimental method, Boyle defined his experimentalism by distinguishing it from other philosophical currents and the experimental practices of the theoretically ignorant ‘empirics’. He conceived several ways by which experiment and theory could interact. In practice, however, the uses of experiment in relation to theory depended on the state of knowledge and technology in each field of inquiry.

I

Generally speaking, seventeenth-century concept of method referred either to ‘the artistic’ method, which was concerned with teaching and communication, or to the ‘the scientific’ method of demonstration. In medicine, ‘method’ had likewise the traditional meanings as a means of systematizing, demonstrating and presenting the existing medical knowledge. In addition, medical ‘method’ referred to practice; the methodus medendi of learned medicine combined medical theory and practice to a

rational treatment of disease. In this last sense, ‘method’ also frequently appears in Boyle’s texts; for instance, he refers to the ‘vulgar Method of Physick’ when discussing medical practices based on the traditional academic medical theory. In addition, in his treatises, ‘method’ often refers to technological procedures, such as the ‘Method of Weighing Bodies in the Water’ published in Medicina Hydrostatica (1690).

In seventeenth-century philosophy, ‘method’ was associated to literary presentation, philosophical demonstration and teaching rather than to the discovery of new knowledge. Various attempts to distinguish the means of the discovery of new knowledge from these literary methods were made. Of these, Francis Bacon’s distinction between his new method of discovery and literary inventio was crucial for Boyle and other English experimentalists. According to Bacon, ‘invention is of two kinds much differing: the one of arts and sciences, and the other of speech and arguments.’ By the ‘invention of speech and arguments’ Bacon referred to the dialectical/rhetorical methods of literary presentation and demonstration. Arts and sciences required their own distinct method of discovery and proof. Bacon’s distinction was important for Boyle who, however, did not conceive his experimental philosophy as a methodological doctrine in the sense of the ‘Physical Logick’ Bacon had begun to outline in his Novum Organum. When Boyle discussed ‘method’, he usually referred to the rules of literary presentation, that is, the arrangement of the subject matter and the discourse in a proper order or ‘methodically’.

129 BP, MS 199, fol. 120.
132 Boyle, ‘The Mutual Assistance that the Practicall and Theorickall Parts of Naturall Philosophy may afford one another’, 351-352.
133 See e.g. Boyle, Human Blood, 9-16.
Rather than a methodological doctrine, Boyle’s experimentalism was a philosophical enterprise which used experiment in various ways for the discovery of theoretical and practical knowledge. Instead of employing a particular scientific method, an experimental philosopher applied various approaches and research techniques depending on the subject matter of inquiry and the state of knowledge at the time. We have good grounds to believe that the somewhat unmethodical nature of experimentalism was a deliberate choice. Thomas Sprat wrote in History of the Royal-Society (1667) that the experimental philosophers of the Society had decided ‘not to prescribe to themselves, any certain Art of Experimenting, within which to circumscribe their thoughts’. Instead, ‘the true Experimenting has this one thing inseparable from it, never to be a fix’d and settled Art, and never to be limited by constant Rules’. It is likely that also Boyle deliberately refrained from constructing a systematic methodology in the sense of a set of rules defining the nature of the inference ‘from Experiments to Axioms’ and ‘from Axioms to Experiments’. On the contrary, in a manuscript text, he noted that he attempted rather ‘in a popular, though not altogether in common way of writing, to shew some of the uses of the Theorick & experimental parts of Physicks to one another, & consequently to a Science, that is very useful to Mankind, than expressly, or in any curious Method, to deliver the precepts of a Physical Logick’.

Boyle was rather a practical experimentalist than a great methodological theorist. The manuscript texts on methodology reflect his practical experimental work to a high degree. These writings show that he considered methodological issues from various viewpoints. The extant manuscripts contain fragments and lists on topics such as the classification of experiments, the relationship between experiment and theory, the various uses of experiment, and on the roles of reason, authority and experience in natural philosophy. Boyle’s socio-economic status as a wealthy aristocrat provided

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135 Boyle, ‘The Mutual Assistance that the Practicall and Theorickal Parts of Naturall Philosophy may afford one another’, 351-352.
136 See e.g. BP, vol. 9, fols. 25, 31, 52, 62, 118, 120, 122.
him with leisure and ample resources to conduct a large scale experimental work on several subjects simultaneously. It is likely that also the wide scope of his experimental work taught Boyle to prefer flexibility over the strict rules of method. Experimental activity was creative work full of surprises. As a consequence, it was ‘not only very Difficult for him that makes a true Experiment to know fully what it may be good for, but perhaps it is not easy to say what it may not be good for’.137

In practice, Boyle’s experimental work had a variety of starting points. We have already seen that Boyle sometimes performed experiments ‘for Tryals sake’ and that he occasionally regarded contingent events as experiments. In some cases, a theory or a widely held ‘vulgar notion’ of the subject matter guided his experimental work and created expectations about the results of experiments. Experimental literature functioned in a similar role; Boyle performed numerous experiments in order to repeat those he had met in literature. In addition, a hypothesis, even when formulated merely for heuristic purposes, might serve as a starting point for experimentation since ‘truth does more easily emerge out of Error than Confusion’.138 Experimentalism provided no ready formula for discovery but allowed a role for ‘Uncertain Sagacity’ and other fortuitous aspects involved in the work as well.139

Boyle modified his experimental approach according to the technology available and the state of knowledge in each field of inquiry. His classification of experiments shows how the state of knowledge influenced his experimental work. ‘Exploratory’ experiments aimed at finding out basic facts about the subject matter of inquiry; ‘in Exploratory Experiments our aim is to discover what quality or other Attribute may be found in the Subject, of which we have, but a suspicion, not Knowledge, that it ought to or may belong to it: & perhaps wherein we endeavor to discover, whether or no it has such an Attribute, or not rather one that is very remote from it; or per chance, even contrary to it.’ Exploratory experiments, in particular, were ‘Experiments for

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137 BP, vol. 9, fol. 104.
139 BP, vol. 9., fol. 52.
Boyle also categorized experiments according to the nature of their results. ‘Luciferous’ experiments provided theoretical knowledge about causes, whereas ‘fructiferous’ experiments produced significant effects and suggested new experiments. These categories were not mutually exclusive; ‘there are few Fructiferous Experiments, which may not readily become Luciferous to the attentive Considerer of them.” Hence a single experiment ‘may serve both to give Light to the Speculative Philosopher and Direction to the Practical Naturalist. For many an Experiment as it indicates Causes may be refer’d to the Theoretical part of Philosophy, and as it directs or otherwise helps men to produce effects, may be referable to the operative part of Physicks.”

II

Boyle’s methodological ideas are for the most part found in manuscript fragments. In his published works, he settled for defining his experimental philosophy by distinguishing it from other philosophies and traditions of experiment. The most important of these were the ‘school’ philosophy on the one hand, and the chemical tradition, on the other. First and foremost, Boyle emphasized the difference between his experimental philosophy and the traditional natural philosophy of the ‘schools’. He claimed that his experimental philosophy explored ‘the Mysteries of Nature’, whereas the ‘school’ philosophy with its interest in the philosophical system of Aristotle and his

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140 BP, vol. 9., fol. 118.
141 BP, vol. 9., fol. 118.
142 BP, vol. 9., fol. 52. See also Sargent, Diffident Naturalist, 170-176.
143 BP, vol. 9, fol. 62.
144 Robert Boyle, Some Considerations Touching the Usefulness of Experimental Natural Philosophy, The Second Tome, Containing the later Section of the Second Part, (1671), Works, vol. 6, (389-540), 433-434.
145 BP, vol. 9, fol. 62.
commentators was a misguided pursuit. Over the years, the school philosophers had built on an Aristotelian basis a complicated and obscure philosophical system which, whenever criticized, they attempted to save with ‘frivolous Distinctions’ and ‘Metaphysical or Logical Subtleties’. The complexity of the system thereby created had led to confusion among the ‘modern schoolmen’ who no longer had a clear idea neither about nature nor their own philosophy.\textsuperscript{146}

Boyle regarded the ‘school philosophy’ as too speculative and more interested in words than nature. By contrast, he appreciated the practical experimentalism of the chemical tradition. However, he regarded contemporary chemical theory as ‘Dark and Narrow’.\textsuperscript{147} Moreover, he disapproved of the ‘obscure, ambiguous, and almost Enigmatical Way’ many chemical authors used for ‘expressing what they pretend to Teach’.\textsuperscript{148} When it comes to iatrochemistry, Boyle valued particularly the practical medicinal knowledge of Jean Baptista van Helmont although he regarded van Helmont’s theoretical ideas as ‘scarce intelligible’ and ‘frequently extravagant’.\textsuperscript{149} Boyle’s experimentalism was a philosophical enterprise. Hence the use of experiment for the discovery of theoretical knowledge was crucial. Therefore, Boyle reproached such chemists that were skilled in practical operations but ignorant or indifferent to the chemical theory. He regarded chemists whose interest in practical chemistry was purely commercial as ‘either Cheats, or but Laborants’.\textsuperscript{150}

The crucial issue of Boyle’s experimentalism was how to create an interconnected relationship between theory and practice; ‘the happy Marriage, or combination of these two may as wel contribute to the production of usefull Experiments as of those that are but luciferous or curious’.\textsuperscript{151} Considering the traditional view of reason and experiment

\textsuperscript{146} Robert Boyle, \textit{The Origine of Formes and Qualities, (According to the Corpuscular Philosophy)}, (1666-7), \textit{Works}, vol. 5, (281-443), 289-297.
\textsuperscript{147} Boyle, \textit{Origin of Formes and Qualities}, 301, Boyle, \textit{Sceptical Chymist}, 208.
\textsuperscript{148} Boyle, \textit{Sceptical Chymist}, 209.
\textsuperscript{149} Boyle, \textit{Usefulness II, sect. I}, 374.
\textsuperscript{150} Boyle, \textit{Sceptical Chymist}, 213.
\textsuperscript{151} Boyle, ‘The Mutual Assistance that the Practicall and Theoricall Parts of Naturall Philosophy may afford one another’, 351.
as two separate ways to truth, the attempt to combine experiment and theory was a significant novelty. Like most of his contemporaries, Boyle understood ‘theory’ principally as causal explanation. According to him, in addition to stating the causes, an adequate explanation explicated the process from the causes to the effect; ‘for to explicate a Phænomenon, ‘tis not enough to ascribe it to one general Efficient, but we must intelligibly shew the particular manner, how that general Cause produces the propos’d Effect.’\(^\text{152}\)

When Boyle discussed theoretical knowledge his terminology varied. In addition to ‘theory’, he used terms such as ‘hypothesis’ and ‘speculation’ when referring to causal explanation.

Boyle’s corpuscular hypothesis explained phenomena on the most fundamental level. The insensible particles of various shapes and sizes, together with their local motion, were the causes of natural bodies and their qualities. Furthermore, the causal powers of bodies were relative to the qualities of other bodies they interacted with.\(^\text{153}\) However, the gap between the corpuscular level and phenomena was great and, therefore, intermediate theories often provided sufficient explanations. In practical medicine, for instance, no corpuscular explanation was required. For the purposes of medical practice, theoretical knowledge about the causal powers of different qualities was sufficient; ‘if a Physitian be ask’d why Rhubarb does commonly cure Loosenesses, he will probably tell you as a Reason, that Rhubarb is available in such Diseases, because it hath both a Laxative vertue ... and an astringent Quality.’ In the context of his medical practice, ‘a skilful Physitian would justly think himself wrong’d, if the Reasons he renders of things in his own Profession were deny’d the Name of Reasons, because made without recourse to Atomical Principles.’\(^\text{154}\)

In his published works, Boyle was not explicit about the manner in which experiment and theory interacted. Mary Poovey has noted that, despite their emphasis on the role of


\(^{153}\) Boyle, *Origin of Forms and Qualities*, 305-322.

experiment in natural philosophy, Bacon and his followers left the process from the matters of fact to theory unexplored.\textsuperscript{155} Boyle was familiar with the precepts of Bacon’s ‘physical logic’ outlined in \textit{Novum Organum}. Bacon had called his new method ‘induction’. Inductive inference was understood in various ways at the time. On a general level, ‘induction’ was defined as a ‘passage from the particular to universal’ and was often associated with sense perception and experience. In rhetoric and dialectic, it belonged under similitude and involved analogical reasoning. Before Bacon’s novel application of ‘induction’ as a method of discovery, induction was usually regarded as belonging to the logic of proof and having nothing to do with the discovery of empirical knowledge.\textsuperscript{156} Therefore, Bacon had made a strict distinction between his new logic and the ordinary ‘puerile’ induction of the ‘logicians’ which ‘proceeds by simple enumeration’.\textsuperscript{157} Boyle’s views about natural history followed Bacon’s ideas.\textsuperscript{158} However, he seems to have had only slight interest in Bacon’s natural philosophy. Although Boyle often referred to Bacon in his writings, he did not discuss Bacon’s idea of natural philosophy or his induction. It has been suggested that Bacon’s successors conceived his method as two methods; one functioning as an aid for memory (natural history) and another as an inductive method of understanding.\textsuperscript{159} Hence Boyle would have adopted only the Baconian natural history but not his inductive method.

Rose-Mary Sargent has examined Boyle’s methodology and drawn a parallel between Boyle’s experimentalism and his ideas about biblical hermeneutics. According to Sargent, experiment was for Boyle a similar tool of interpretation as hermeneutics. Hermeneutics was a means of interpreting the Scripture, whereas Boyle used experiment to interpret the Book of Nature. According to this view, Boyle’s experimental method involved a process from experiment to theory and from theory back to new experiments. During the process, knowledge about phenomena increased

\textsuperscript{155} Poovey, \textit{History of Modern Fact}, 189.
\textsuperscript{156} Pérez-Ramos, \textit{Bacon’s Idea of Science}, 199-238.
and theoretical knowledge about causes became more accurate.\textsuperscript{160} Boyle’s manuscript texts provide strong support for Sargent’s interpretation. For instance, the manuscript listing seven ‘uses of experiments to theory’ and seven ‘uses of theory to experimentation’ create a picture of a versatile interplay between theory and experiment:

The uses of Expts to Speculative Philosophy

1. The 1st our senses \textit{helps} \& \textit{rectifys}
2. The next affair Hypotheses brings supplys
3. The 3rd by Illustrations gives light
4. The 4th determines doubtful questions right
5. The 5th dos Truths Confirm as Disclose
6. The 6th that Errors are indeed such shows
7. The 7th gives hints of new Expts And helps to make ym
   prosperously presents

Seven uses of speculative to practical philosophy

1. The 1st dos such experiments devise As may from
   Principles \& Reasonings rise
2. The next doth Tools \& Instrumnts invent such as for
   Tryals are convenient
3. The 3rd Improve our Known Experimts And skilful
   ways of varying ym presents
4. The 4th foreshows the events of untry’d things
5. The 5th the use of apply’d Rations brings
6. The 6th of things various uses gives we from their
   shape, bulks motions may derive
7. The 7th their useful circumstances shows As measure
   order weight \& such as those.\textsuperscript{161}

\textsuperscript{160} Sargent, \textit{Diffident Naturalist}, 112, 162-165.
\textsuperscript{161} BP, MS 186, fol. 152.
In *Human Blood*, Boyle likewise referred to a similar relationship between matter of fact and theory; the particulars collected in the natural history may ‘be found serviceable to hint new Hypotheses or Theories, or to illustrate them, to examine those of others, and if they be true, to confirm them, and if erroneous, to confute them.’

Moreover, the accounts Boyle gave about his experimental work in his published treatises give an impression that his experimental activities often proceeded more or less in this manner.

However, creating interplay between theory and experiment required some kind of theoretical framework suitable for the purpose. When no such framework existed, achieving interplay between theory and natural history was problematic; ‘a solid and complete theory of nature is not to be had without such a history of nature, as is not to be made without the theory it should minister to.’ Therefore, Boyle often adopted the role of a natural historian in his experimental work. Instead of emphasizing the interaction between experiment and theory, he proceeded to ‘devise Experiments, and to enrich the History of Nature with Observations faithfully made and deliver’d; that by these, and the like Contributions made by others, men may in time be furnish’d with a sufficient stock of Experiments to ground Hypotheses and Theorys on’.164

1.4. Medicinal Experiments and Theory

And indeed the Causes of Diseases, the Constitutions of Patients, and the Complications of Distempers are so very various, intricate, and obscure, that it is extreamly difficult even for the most knowing and experienc’dPhysitian to make an accurate, and constant Experiment in the

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163 Royal Society MS 189, fol. 48r., quoted in Sargent, *Diffident Naturalist*, 163.
Therapeutical part of Physick.  \^165

This section examines the relationship between medicinal experiment and theoretical knowledge about disease and medicines. For Boyle, practical medicine presented an example of a field which had a strong tradition of experiment. The experiment of practical medicine, however, had no impact on pathological or pharmacological theory. In learned medicine, theory had a foundational role of providing the basis for the ‘rational’ practice of a learned physician. By contrast, seventeenth-century empiricist medical trends tended to deny the significance of theory of any kind for medical practice. However, all kinds of practitioners used medical theory as a means of explaining diseases and cures.

Boyle adopted many of the practices and methods of earlier experimental traditions, such as those of chemistry and practical medicine. His medical works show that he also pondered the question of how the trial-and-error experiment of medical practice could be used to serve the discovery of theoretical knowledge. In this respect, his views differed from those commonly held in the medical community. However, Boyle’s efforts to bring medicinal experiment to bear on theoretical knowledge remained tentative at best. His medical works provide us with only a few scattered ideas about the ways of using experiment for theoretical discovery and about the problems involved in using experiment for this purpose. In his inquiries into practical medical matters, Boyle employed no systematic method of medical investigation. Moreover, no clear idea about such a method resulted from his work. Instead, his medicinal experiments produced principally novel remedies in a traditional medical manner.

I

Since learned medicine consisted of both a theoretical *scientia* and a practical art, the significance of practical experience, on the one hand, and medical theory, on the other,

\^165 Boyle, *Usefulness II, sect. 1*, 531.
has been repeatedly discussed in the history of European medicine. In learned medicine, theory functioned as the basis for the ‘rational’ methods of maintaining health and curing disease. As a consequence, a seventeenth-century ‘rational’ doctor claimed to derive his therapies from medical theory. By contrast, empirical healers often denied the significance of theory for medical practice. Instead, they commonly justified their prescriptions by their past success.\textsuperscript{166} The fact that the majority of seventeenth-century healers practised medicine without thorough knowledge of ancient medical theory or academic qualifications indicated that theoretical knowledge was not a prerequisite for a successful medical practice.\textsuperscript{167} We saw above that, in this respect, Boyle took rather the side of experience than theory. Even though not denying the significance of theory for medical practice, he preferred medicines proven effective by experiment over those based only on medical theory.

Nonetheless, all practitioners, whether basing their practices on theory, experience or both, needed medical theory when an explanation of illness and its cure was required. No alternative medicine existed at the time and, as a consequence, all practitioners used somewhat similar theoretical language in their explanation of disease and cure.\textsuperscript{168} The explanation of disease and its cure was a narrative about the hidden events taking place inside the body. The expectations of the patients rather than the theoretical views of a practitioner dictated the nature of the explanation; in order to create belief in his skills a doctor had to explain bodily events using language which his patients understood and found convincing.\textsuperscript{169} Likewise, most medical authors, whether physicians, chemists, empirics or lay people, tended to speak common medical language combining humoral

\textsuperscript{166} Wear, \textit{Knowledge & Practice}, 130-133.
Boyle also combined the terminology of contemporary and traditional medical theories when discussing disease and remedies. In particular, when presenting a novel remedy, he used this ‘common medical language’ to convince his readers of the efficacy of the medicine. For instance, in *Human Blood*, Boyle discussed the ‘Spirit of Human Blood’ which was a new chemical medicine he had invented. The invention of the novel remedy was loosely based on contemporary acid-alkali theory; ‘when I consider, that, as far as I have observ’d, we do not meet regularly with any *Acid* Substance ... in a sound Humane Body ... whereas the several parts of it, whether *Solid*, as Bones, or *Liquid*, as Blood, afford in Distillation a store of Liquor impregnated with Volatile Salt; I am induc’d to think it probable, that the Spirit of Humane Blood, wherein such a Salt abounds, and whereof it is the main and predominant Ingredient, is like to have notable operations upon the Humane Body, and afford Medicines of great Efficacy in many of its Diseases.’

Boyle’s explanation of the effects of the ‘Spirit of Human Blood’ combines a larger variety of theoretical ideas than his account about the invention of the medicine. First of all, the ‘Spirit of Human Blood’ ‘mortifies Acid Salts’ which many chemically inclined physicians regarded as causes for several diseases. Because of its ‘resolvent’ quality, it is also good for ‘opening Obstructions’ and for purging ‘divers Noxious Salts’ and expelling ‘divers Contagious or Malignant Corpuscles’ from the body. Furthermore, it counteracts the ‘Putrefaction and Coagulation of the Blood’ and ‘promotes the free Circulation of the Blood’. The medicine could be used as an antidote for poisons as well. Moreover, its effects were gentler than those of the traditional purgative medicines since it was ‘very friendly to the *Genus Nervosum*’ and it did ‘not weaken or cause great

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170 Wear, *Knowledge & Practice*, 441, 469.
Evacuations."^173

Boyle’s explanation was intended for a wide range of readers. In general, Boyle preferred contemporary natural philosophical and medical theories to the common humoral pathology when explaining medical phenomena. Hence he referred only briefly to some commonly held lay beliefs about the causes of disease such as ‘obstructions’ and ‘putrefaction’.^174 For the most part, his explanation employs medical and philosophical terms. Boyle referred to the corpuscular hypothesis (‘Contagious or Malignant Corpuscles’) and used medical terminology such as ‘Genus Nervosum’. In addition, his explanation employs William Harvey’s theory about the circulation of the blood and the chemical acid-alkali theory.

II

Andrew Wear has noted that the new philosophical ideas had no significant effect on medicine beyond the linguistic level of medical explanation.^175 As for experiment, the persistence of traditional medical theory and epistemology discouraged its use as a means of theoretical discovery. Roughly speaking, the traditional learned medicine combined the Aristotelian theory of knowledge and natural philosophy with the ideas of medical authorities, such as Galen for instance, and their later commentators. Learned medicine or ‘physic’ was concerned with both maintaining health and curing disease. Health and disease were conceived as bodily states. In a healthy body, the ‘naturals’, which included ‘all those things that the human body is composed of and which enable it to exist as a living being (elements, qualities, complexion, humours, spirits, virtues or powers, morphological constituents, etc.)’, were in balance. The management of the six non-naturals (air and environment, food and drink, sleep and wakefulness, motion and rest, evacuation and repletion, and the passions of the mind) was crucial for the maintenance of health. The failure of maintaining the bodily balance was the principal

^173 Boyle, Human Blood, 72.
^174 Wear, Knowledge & Practice, 136-141.
cause of disease. Bodily balance was not similar in all people but an individual had a ‘constitution’ or ‘temperament’ particular to him.\textsuperscript{176} One of the most important skills of a learned physician was to determine the constitution of his patient and give him advice about the maintenance of his individual bodily balance.\textsuperscript{177}

Illness followed when one failed to maintain the bodily balance. The individualized body formed the setting for illness which was regarded as an event in that particular body. In addition to its causes, disease tended to get identified by what modern medicine regards as the patient’s subjective symptoms, together with other outward signs. Consequently, therapy was prescribed both to answer the patient’s symptoms in different stages of his illness and to destroy the causes of disease.\textsuperscript{178} The purpose of therapy was often to evacuate the body of the ‘morbifick matter’ causing the disease. This was achieved by phlebotomy and various kinds of ‘purging’ remedies, such as emetics, laxatives and diuretics, for instance. The physician varied his therapeutic methods according to the indications observed in different stages of the disease. Therefore, instead of prescribing a specific medicine to destroy the cause of the disease, a physician used several remedies in the different phases of the illness.\textsuperscript{179} Ideally, in addition to prescribing remedies and evacuative procedures, a learned physician also gave advice about the management of the six non-naturals during the illness. As a consequence, curing disease by the ‘vulgar method of physick’ was often a complicated and time-consuming affair. In practice, however, physicians often gave in to their patients’ demands and prescribed specific medicines.\textsuperscript{180}


\textsuperscript{179} Wear, Knowledge & Practice, 139-140, 144, 378-384.

\textsuperscript{180} Cook, ‘The New Philosophy and Medicine’, 411-413.
It is impossible to say whether or to what degree theoretical ideas on the one hand, and practical experience, on the other, guided the medical practices of past physicians. Although their theoretical education did not encourage a generalizing approach to disease, physicians often learned their clinical skills as apprentices to more experienced healers and thereby probably came to pay attention to the similarities they observed in different cases of disease.\textsuperscript{181} Moreover, the professional success of a physician had an impact on his standpoint in the matter. Andrew Wear has pointed out that ‘the more time one could devote to a patient the more one could be a rational physician’.\textsuperscript{182} A successful physician treated only a few patients, perhaps only members of a single household. As a consequence, he had the time to concentrate on the individuality of his patients, whereas a less fortunate practitioner hardly had a similar chance when treating a large number of patients with a lower social and economic status.

Since an individual case of disease was conceived as an essentially unique event, it is obvious that a medicinal trial-and-error experiment could have no influence on the theory about causes. Like the traditional theory of knowledge pointed out, there was no science of particular, that is, of a unique event, such as a single case of disease. However, factors shifting the focus from the individuality of the patient to disease and its common causes existed as well. The observation of contagious disease and epidemics strongly indicated a common cause behind individual cases. Modern historians have paid attention particularly to epidemic disease, such as the plague and the rapidly generalized new disease, ‘the pox’, as factors that undermined the idea of the uniqueness of each case of disease.\textsuperscript{183} In addition, the increasing supply and demand for the specific remedies of empirics, who claimed that their medicines cured diseases of all kinds of people disregarding their individual constitution, tended to shift the medical focus to disease and away from the patient.\textsuperscript{184} Besides such practical matters, new theoretical ideas changed the ways of conceiving disease. The increasing popularity of

\textsuperscript{183} French, Medicine before Science, 150-153, 158-159 and Wear, Knowledge & Practice, 275-313.
\textsuperscript{184} Wear, Knowledge & Practice, 437.
the iatrochemical theories among the medical community in the second half of the seventeenth century also spread the iatrochemical view that disease had its specific causes. Whereas the traditional medical theory regarded disease as a unique event in a particular body, iatrochemical theory approached disease by focusing on its causes which were regarded as existing independently of individual bodies.\(^\text{185}\)

Boyle regarded both the individuality of the patient and the common cause of disease as significant factors for the course of disease. On the one hand, he believed that factors such as age, sex and the individual complexion of a patient had at least some medical significance.\(^\text{186}\) In the medical *Usefulness*, he pointed out ‘that ’tis one thing to dispute, *Whether all Diseases be curable;* and another, *Whether all Persons be recoverable.*’\(^\text{187}\) On the other hand, however, the information he had about non-European healers, who were ‘unskill’d in Physick’ but still succeeded in curing their patients ‘without making Distinction of temperament, Sex, age, or other important circumstances in the Patient’, indicated that effective specific medicines played a more important role in therapeutics than the individual characteristics of a patient.\(^\text{188}\) Nonetheless, assessing the impact of the different factors involved in an individual case of disease was difficult. As a consequence, Boyle was ‘as sensible as another of the almost insuperable Difficulty, of making any certain Experiments in Physick’.\(^\text{189}\) ‘Not only the constitutions of Patients may as much alter the effects of Remedies, as the causes of diseases, but even in the same Patient and the same disease, the single circumstance of Time may have almost as great an operation upon the success of Medicine as either of the two particulars’\(^\text{190}\)


\(^{188}\) BP, vol. 18, fol. 9.

\(^{189}\) Boyle, ‘Simple Medicines’, 417.


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Despite the complex circumstances involved in medicinal experiments, Boyle conceived such experiments capable of producing theoretical knowledge ‘touching the Nature of Remedies, if not also of Diseases’. In the medical Usefulness, he remarked that collecting careful observations of numerous cases of disease and cure in the ‘histories of disease’ could produce counterexamples to refute false pathological theories. He did not explicate his ideas about the ways a medicinal experiment could be used to produce theoretical knowledge. However, his medical works, where he presented some tentative conclusions about his medical experiments, give some hints about how he conceived the use of experiment in this context. In Human Blood, he cautiously criticized Thomas Willis’s fermentation theory about fevers from an experimental basis. Willis’s theory postulated the fermentation of blood as a specific cause for fevers. Boyle pointed out that he had not been able to perform a requisite number of experiments to prove Willis’s theory false but, on the basis of experiments he had made, he could not be ‘sure that there is any Fermentation truly & properly so call’d in Humane Blood’. From a similar experimental basis Boyle likewise criticized the chemical acid-alkali theory although he admitted that the theory might be of some use to physicians.

Boyle also believed that clinical experiments made on patients could produce knowledge about the causes of disease. He thought that an observation that a medicine cured various symptoms or diseases indicated a common cause of disease. It was possible that ‘the same hurtful Humour, or other Agent, may produce sicknesses that pass for differing ones, (and accordingly have distinct Denominations) only as the same Morbific Agents bad effects are diversify’d’. As a consequence, ‘the same searching medicine being endowed with qualities destructive to the texture of that Morbifique matter, where it ever finds it, may be able to cure either all, or the greatest part, of the

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191 Boyle, Usefulness II, sect. 1, 476.
192 Boyle, Usefulness II, sect. 1, 322.
193 Boyle, Human Blood, 42.
194 Robert Boyle, Experiments, notes, &c. about the Mechanical Origine or Production of divers particular Qualities (1675), Works, vol. 8, (315-523), 409-419.
196 Boyle, Human Blood, 71.
Diseases which the various translation of such Matter hath been observed to beget."¹⁹⁷ For instance, when tested on patients, Boyle's *Ens Veneris* was found to be ‘a potent Specifick for Rickets’; the medicine had cured ‘perhaps a hundred, or more Children, of that disease.’ In addition, Boyle prescribed it ‘also in Favors, and other Distempers, to procure sleep’. Moreover, he had found it effective in ‘the Head ache likewise’ as well as ‘in suppressione Mensium obstinata.’¹⁹⁸ A similar inference could be employed to prove the opposite. Boyle pointed out that diseases were not always identified and named according to their causes. He had observed that ‘the same disease’ sometimes ‘will be increased in one by the same remedy by which it has been cur’d in another’. Therefore, he suspected that ‘the same disease’ might proceed ‘in several persons from quite differing causes’.¹⁹⁹

In practice, however, the hidden causes of disease were impossible to observe and identify. Barbara Kaplan has pointed out that ‘given the limited state of experimental science in his age, analogy was probably one of the few available techniques open to one who eschewed a priori reasoning about causes.’²⁰⁰ In the medical *Usefulness*, Boyle used analogy as a means of producing insights into the causes of the disease of ‘stone’. He had observed the process of petrification in nature. In addition, he had himself ‘diverse times produc’d a body of almost stony hardnesse in lesse then halfe an hour’. These experiments could be used to theorize about the causes and the manner of the formation of the ‘stone’ in human body. However, Boyle could not state a single cause for the ‘stone’ on the basis of these experiments. On the contrary, ‘the observation of many such effects, manifesting, that nature doth actually produce them so and so, suggests to us severall wayes of explicating the same Phenomenon’²⁰¹

In *Specific Medicines*, Boyle employed his corpuscular hypothesis to speculate on the causes of disease and the mechanisms through which medicines functioned. However,

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¹⁹⁷ Boyle, *Usefulness II*, sect. 1, 473.
¹⁹⁸ Boyle, *Usefulness II*, sect. 1, 392-393.
he emphasized that, for the time being, the explanations referring to the shape, size and motion of the unobservable particles of matter were mere speculations.\textsuperscript{202} Corpuscular speculations of this kind could be of interest for a natural philosopher but they were of no practical use for medical men. By contrast, the intermediate explanations which explicated causes such as ‘Heat, Cold, Weight, Fluidity, Hardness, Fermentation, &c.’ were sufficient for practical medicine.\textsuperscript{203}

According to Boyle, chemical experiments, in particular, ‘may much assist the Physitian to discover the Qualities of Medicines, whether \textit{simple or compound} and, furthermore, ‘the Experiments of the Spagyrists [chemists] may much contribute to the examining of those many things themselves prepare’\textsuperscript{204}. In addition to chemical experiments, Boyle recommended other methods of examining the qualities of medicinal substances. The variation in the quality of the substances used for medicinal preparations posed serious problems for seventeenth-century practitioners. Boyle’s \textit{Medicina Hydrostatica} addressed the problem by presenting a method of examining medicinal and other substances by weighing these in water. The treatise was published for both ‘Knowledge and Health’.\textsuperscript{205} The hydrostactical method could be used to examine the genuineness of medicinal substances thereby making medicines safer for patients. In addition, hydrostatical measurement revealed the specific gravity of a substance and thus gave theoretical knowledge about one of its qualities.

Boyle believed that also a trial-and-error experiment of medical practice could produce knowledge about medicinal qualities. He had only a few opportunities to make such experiments himself. Therefore, he encouraged medical practitioners to experiment with medicines in their medical practice. For this purpose, he recommended especially simple medicines which consisted of one or only a few ingredients. Simple medicines were useful in medical practice and, furthermore, by experimenting with simple

\textsuperscript{202} Boyle, \textit{Specific Medicines}, 369.
\textsuperscript{204} Boyle, \textit{Usefulness II, sect. I}, 368.
\textsuperscript{205} Boyle, \textit{Medicina Hydrostatica}, 201.
remedies, ‘Men will be able to discover the true qualities ... of the particular Bodies, that are compris’d under the name of the Materia Medica’. Because of the limited number of ingredients, it was easier to discover which ingredient was medicinally effective and proceed to examine its qualities. However, although Boyle hoped that in time the ‘occult’ or imperceptible qualities of medicines would be discovered, he feared that ‘men will not be successful, in tracing out the true and immediate causes of those good effects of some remedies, that depend upon such fine and uncommon Textures, and such latent and odly guided Motions, as fall not under our Senses, thô perhaps assisted by Instruments.’

Boyle experimented on medicines somewhat diligently. In his medical works, he discussed his medicinal experiments, published medical recipes and practical medical information. Although he believed that the experiments of practical medicine could produce theoretical knowledge as well, he discussed the topic relatively rarely in his works. He wished that medicinal experiments of various kinds would somehow hint to the ‘hidden’ causes of medical phenomena. However, although he developed novel medicines and discussed their qualities in his works, he made no significant contribution to the medical method or theory. Experiment gave no access to the interaction between the causes of disease, the qualities of remedies and the individual characteristics of a human body.

SUMMARY

In the seventeenth century, medicine was an established academic discipline. It was, however, an exceptional discipline since it involved both philosophical learning and a practical art. The degree of specialization in medicine was somewhat low and, therefore, also lay people were able to gain considerable medical knowledge and practical skills. Hence a gentlemanly philosopher, such as Robert Boyle, could conduct medical

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207 Boyle, Specific Medicines, 361.
investigations and participate in medical discussion by publishing medical treatises. Like many of his contemporaries, Boyle was interested in practical medicine. He read medical literature and collected recipes of remedies. When ill, he was likely to be an active participant in finding the best treatment for his illness. Moreover, Boyle combined his personal interest in medical matters with his career as a natural philosopher. Natural philosophical inquiries often converged with medical issues and offered Boyle opportunities to make his results bear on medical questions as well.

Boyle was particularly interested in the development of the therapeutic part of medicine. He believed that with his experimental work he could make a significant contribution to therapeutics. He was especially concerned with practical medical innovation, such as the novel remedies which he published in his medical works. For Boyle, publishing practical medical information, however, involved complicated considerations about his authorial ethos and the reception of his works. His meddling in practical medical matters tended to obscure his status as a gentlemanly natural philosopher. Furthermore, by publishing practical medical works in the vernacular he risked becoming involved in contemporary controversy between the learned physic and empirical medicine.

Boyle’s experimental philosophy embodied no general method of investigation applicable in different fields of study. On the contrary, experimental inquiry was highly dependent on the state of knowledge and technology in each field of study. Experience and experimentation were common means of gaining practical medical knowledge and skills. For the most part, Boyle conducted his medicinal experiments using the practical methods familiar from the medical tradition. However, he wished that in addition to useful practical information, medicinal experiments could produce theoretical knowledge as well. The academic medicine acknowledged no idea about interplay between clinical experiment and medical theory as an epistemological tool. In medicine, experiment was first and foremost a means of discovering an effective treatment in a particular case of disease.
Nevertheless, Boyle experimented diligently on medicines and, when having an opportunity, tested his novel remedies on patients. Likewise, he experimented with different ways of using his medicinal experiments for theoretical discovery. In his medical works, he presented several conjectures of his about the causes of various medical phenomena. None of these, however, led to any theoretical discovery. On the contrary, the results of his medicinal experiments were similar to those of other medical men; Boyle’s medical works provided his readers first and foremost with the recipes of novel empirically discovered medicines.
2. EXPERIMENTAL NATURAL HISTORY AND MEDICINE

Either one may in a full and methodical History prosecute the Phaenomena; or one may make a Collection of various Experiments and Observations whence may be gathered divers Phaenomena to illustrate several, but not all of the Heads or Parts of such an ample or methodical History; or (in the third place) one may deliver miscellaneous experiments and observations on the subject matter.\textsuperscript{208}

This chapter examines ideas about natural and medical history by exploring Boyle’s and some of his contemporary physicians’ historical writings. It focuses particularly on different ideas about applying the historical approach to medical investigations. Historia, in the sense of description of particular empirical events, phenomena and objects was a highly popular topic of interest in the seventeenth century. However, the ideas of historia and its function were various. In medicine, historical approach was employed in several areas; different fields, such as botany and anatomy, had their specific uses for historia. Seventeenth-century neo-Hippocratic trend in medicine likewise emphasized the significance of recording clinical particulars. At the same time, Bacon’s ideas about natural history and its role in inquiry offered a model somewhat different than those of medicine. This chapter aims at showing that no historical method existed but that different writers understood and employed historical approach in various differing ways. In particular, when it comes to medical inquiries, Bacon’s model of natural history and the ‘Hippocratic’ idea about the ‘history of disease’ were two distinct projects.

I start by discussing the different models of historia and proceed by examining Boyle’s general design for natural history. In Section 2.2., I move to study natural history and focus on Martin Lister’s and Boyle’s natural histories of mineral waters. Lister separated his role as a natural historian from his medical profession and chose a natural

\textsuperscript{208} Boyle, Mechanical Qualities, 321.
philosophical viewpoint in his inquiry into mineral waters. Boyle, by contrast, combined his interest in practical medicine with his natural historical work. In addition to his work on mineral waters, also his natural history of blood displays his attempt to connect natural philosophy with practical medicine.

The two following sections explore the medical ideas of the history of disease. In 2.3., I examine the writings of Boyle, William Petty and Thomas Sydenham about the history of disease. Petty and Sydenham belong to the group of medical men with whom Boyle discussed about medical matters and medical reform, in particular. The section argues that experiment played only a minor role in inquiries into the history of disease. Furthermore, the type of experiment employed in the historical approach to disease was first and foremost the trial-and-error experiment of medical practice.

The final section turns to examine ideas about the relationship between the history of disease and theory. It contrasts Boyle’s attitude towards theory formation to that of Thomas Sydenham. Sydenham was the most diligent historian of disease of the day. He disregarded the significance of natural philosophical theory to practical medicine. Moreover, he saw no connection between the history of disease and medical theory. Boyle, by contrast, regarded the experiment and observation of practical medicine as relevant also for the theoretical discovery of the causes of disease. Hence, the history of disease project of Thomas Sydenham was a somewhat different enterprise from Boyle’s natural historical work. I end the section by discussing the significance of the two most important authorities of the historical approach – Bacon and Hippocrates – for the natural and medical historical work of Boyle and Sydenham.

2.1. Ideas of historia

This section discusses the historical approach to natural and medical phenomena and the ideas about the uses of historia. The first part of the section provides an introductory discussion about the ideas about natural and medical historia. In the second part, I proceed to examine Boyle’s general design for a natural history. In general, historical
approach to natural and medical phenomena was employed in various ways in the seventeenth century. As for medicine, in anatomical studies historia functioned as a foundation for causal explanation. By contrast, in practical medicine historia had no foundational function but its use was a more practically orientated one.

Natural history had a major role in Boyle’s work. Boyle used natural history for diverse purposes. Like Bacon, he regarded natural history as a foundation for theoretical explanation. His view of natural history was comprehensive; he often used a natural historical work as a means of mapping, arranging and creating a preliminary plan for a future inquiry into a particular subject matter. In addition, natural history provided him with a channel of communicating miscellaneous experimental facts to the community of experimentalists.

I

Various kinds of historiae consisting of descriptions of particular events, phenomena and objects, were highly popular among seventeenth-century readers. Historia described besides human deeds, also natural and medical phenomena. ‘Natural history’ had various meanings and covered a large range of topics.\(^{209}\) Accordingly, published natural histories form a literary genre with a great diversity when it comes to subject matter and literary style. Works such as Martin Lister’s De fontibus medicatis Angliae Excercitatio, Nova & Prior (1684), Robert Plot’s Natural History of Oxfordshire (1677), John Gerard’s Herball, or General History of Plantes (1597), Robert Boyle’s Memoirs for the Natural History of Humane Blood (1684) and Thomas Sydenham’s Methodus curandi febres (1668) although different in many respects, all share what we might call the historical approach.

Seventeenth-century natural historical works share the emphasis on empirical and descriptive; historia was used for ‘recording, communicating and validating observation’.\(^{210}\) Natural history was concerned with the description of natural phenomena and objects, such as climate, plants or animals, for instance. In addition, the

\(^{209}\) Pomata and Siraisi, Historia, 2-8.

historical approach was applied to subjects with a degree of artificiality in them, such as gardens or experiments, for instance, or to a whole region including the accounts of its nature, population and man-made objects, such as houses and antiquities. Natural history was thus a flexible field encompassing a variety of subjects of study. Moreover, no strict rules for the literary presentation of natural history existed but the genre allowed natural historians a liberty of arranging their material in the miscellaneous or essay style.\textsuperscript{211}

Medicine had a special relationship to \textit{historia}. In general, the different kinds of medical \textit{historiae} emphasized experience and observation. The works of ancient medical authorities, Galen and Hippocrates, advocated the idea of sense perception as the source of historical knowledge hence offering a justification for an empirical approach to medical questions.\textsuperscript{212} Galen’s authority and his praise of the medical knowledge of Hippocrates, in particular, provided academic physicians with a warrant for turning to the more empirical Hippocrates with no damage done to their status as learned men and philosophers.\textsuperscript{213}

Natural history as a learned discipline had entered the university curriculum through medical botany in the Italian universities in the sixteenth century.\textsuperscript{214} Accurate botanical description was important for physicians who needed to recognize plants and know their medical qualities; thus the first book printed with illustrations drawn from life is a book of medicinal plants and animals, \textit{Gart der Gesundheit} (1485).\textsuperscript{215} In anatomy, \textit{historia anatomica} – the description of a body part as it was observed in a dissection – formed the basis of the explanation of causes.\textsuperscript{216} In practical medicine, the Hippocratic \textit{casus} – a

\textsuperscript{211} Katie Whitaker, ‘The Culture of Curiosity’, in Jardine, Secord and Spary, (eds), \textit{Cultures of Natural History}, (75-90), 84.
\textsuperscript{212} Pomata, ‘Praxis Historialis’, 111-112.
\textsuperscript{216} Pomata, ‘Praxis Historialis’, 116-117.
narrative about the course of a single case of disease – functioned as a model for *historia medica* which focused on clinical observation.\(^{217}\)

*Historia anatomica* and *historia medica* belonged to different sections of medicine and served different purposes. The anatomical *historia* was part of an Aristotelian explanation of causes, whereas the Hippocratic *casus* had no similar connection to causal knowledge. As a consequence, as Robert Martensen has noted, the physicians and natural philosophers who focused on anatomical studies seldom referred to the Hippocratic *corpus* and, vice versa, the ‘Hippocratic’ physicians tended to depreciate anatomical inquiries. Anatomical inquiry was part of the academic theoretical medicine and, therefore, of interest only to a relatively small group of physicians and natural philosophers. By contrast, the ‘Hippocratic’ physicians focused on medical practice and often published popular medical works in the vernacular.\(^{218}\)

Sixteenth-century recovery of new Hippocratic treatises, especially *Epidemics I and III*, which displayed Greek observational medicine by describing individual cases of disease, drew attention to *historia* in a practical medical context.\(^{219}\) In seventeenth-century England, ‘Hippocratism’ referred first and foremost to empiricist methodological trends.\(^{220}\) The Hippocratic medicine was also often contrasted to what was regarded as the excessively rationalist Galenic medicine.\(^{221}\) Due to its size and the wide range of its texts, the Hippocratic *corpus* offered a variety of models for different kinds of approaches to medicine.\(^{222}\) Hence the texts of the Hippocratic *corpus* could also be read as presenting a medical method. The ‘Hippocratic method’, however, could be identified with almost any method in which observation or experiment had a central

\(^{219}\) Pomata, *Praxis Historialis*, 112.
\(^{221}\) Cantor, *Reinventing Hippocrates*, 6-7.
role.\textsuperscript{223} According to Harold Cook, in England Hippocrates was regarded first and foremost as ‘the collector of case-studies, the compiler of medical details, the inductivist’ and ‘the early founder of true methods of natural history whose achievement had been devaluated by the rationalist practitioners following him.’\textsuperscript{224} Since Hippocrates was regarded as the founder of natural history, the ‘Hippocratic method’ was often associated with Bacon’s ideas about natural history. Physicians, in particular, seized on Bacon’s praise of the ‘serious diligence of Hippocrates, which used to set down a narrative of the special cases of his patients and how they proceeded, and how they were judged by recovery or death.’\textsuperscript{225}

In the late seventeenth century, the Hippocratic ‘method’ surfaced as histories of disease in the works of authors such as Thomas Sydenham. Sydenham’s medical method consisted of clinical trial-and-error experiments and careful observations. His record of case histories functioned as a basis for his classification of disease and the discovery of new methods of cure. With his inquiries into the history of disease, Sydenham aimed at reforming medical practises. By contrast, he regarded theoretical knowledge of the ‘occult’ causes of disease as both impossible to obtain and irrelevant to medical practice. Sydenham himself associated his method with both the Baconian natural history and the ancient Hippocratic method.\textsuperscript{226}

However, despite the fact that many seventeenth-century authors of natural historical and medical works referred to both Bacon and Hippocrates as if these two authorities were proponents and progenitors of a similar method of discovery, in practice they represented somewhat different approaches to knowledge. In spite of his appreciative remark about Hippocrates in \textit{The Advancement of Learning}, Bacon elsewhere disapproved of what he regarded as the excessive empiricism and superficial

\textsuperscript{223} Cantor, \textit{Reinventing Hippocrates}, 6-7.
\textsuperscript{224} Cook, \textit{Decline of the Old Medical Regime}, 185.
observation of Hippocrates.227 Bacon’s method of discovery placed historia as the basis for causal knowledge thereby extending the scope and importance of the historical approach in natural inquiries. A Baconian natural history was collected in order to give human reason material to work upon in the discovery of the causes of phenomena.228 In addition, Bacon had regarded natural history as connected with memory. In the faculties of mind, memory corresponded to history in its role to know descriptive accounts of events and particulars. In order to serve the understanding, the natural historical data was to be systematically arranged into a written natural history.229 Moreover, a natural history was not to consist of random heaps of data but, instead, it was to contain significant information, that is, ‘information rich in inductive power’.230 The data was not used to formulate generalizations but the natural historical facts functioned rather as ‘indicators leading us to visualize what is going on in the innermost recesses of matter’.231

A Baconian natural history was a storehouse of selected pieces of information and hence it was related to the traditional commonplace book. A commonplace book contained useful sayings of approved authors, whereas a natural history was to be collected from experiments and observations of natural phenomena. Instead of the invention of arguments, the new commonplace book would guide the discovery of new knowledge about nature.232 At the time, various answers to the question of how particulars were connected with causal knowledge existed. Bacon had recommended an inductive procedure different from that of traditional philosophy which concludes ‘upon an enumeration of particulars, without instance contradictory’.233 According to him, ‘the induction of which the logicians speak ... concludes at hazard; is always liable to be upset by a contradictory instance; takes into account only what is known and ordinary;

228 Sargent, Diffident Naturalist, 50-54.
230 Malherbe, ‘Bacon’s Method of Science’, 84.
231 Pérez-Ramos, Francis Bacon’s Idea of Science, 260.
233 Bacon, Advancement of Learning, 120.
and leads to no result." In Bacon’s kind of ‘eliminative’ induction, different categories of instances were compiled to tables and then eliminated by making comparisons until only the true cause remained.

Bacon’s model of natural history was important for seventeenth-century English natural historians and philosophers. Many natural philosophers and physicians became to regard natural history as an indispensable element in natural philosophical and medical investigation. However, it seems that their ideas about the uses of natural history differed from those of Bacon. Instead of following the pre-existing models, the function and the epistemological value of historia rather depended on the disciplinary context. Botanical history aimed at knowledge by description and classification. In medicine, it had first and foremost the practical function of helping physicians to recognize medicinal plants. Neither did historia medica, which described the course of a single case of disease and cure, have any theoretical function. Historia anatomica was part of the anatomical explanation and an interest of a group of specialists. Despite the popularity of the Baconian and the Hippocratic notions of historia, they created no single and clearly defined idea about natural and medical historia.

II

The grand rule in drawing up a History must be that all the Particulars that compose it be so rang’d & pen’d as may make them most assistant to the attainment of Truth, & may most facilitate the advancement & perfecting the Invention already known, & the finding out of new Ones.237

234 Bacon, Great Instauration, 23.
Peter Anstey and Michael Hunter have shown that sometime during the 1660s Boyle adopted the Baconian method of natural history.\(^{238}\) Like Bacon, Boyle regarded natural history as a factual foundation for theory formation. In addition to publishing narratives about his own experiments, Boyle’s comprehensive ‘memoirs’ for natural histories aimed at mapping their subject matter by arranging it under suitable topics thereby outlining a research plan for the field. A published natural history, although still inchoate, functioned as a commonplace book of a kind storing data which the community of naturalists could use for various practical or theoretical purposes. Due to its comprehensiveness, this kind of natural history was a collective enterprise to be conducted by a community of natural historians during a long period of time.

Boyle published first and foremost experimental natural histories. In 1666, he wrote a letter to Henry Oldenburg presenting his ‘Designe about Natural History’. Bacon’s method of natural history was the starting point for Boyle’s design. The ‘Designe for a Natural History’ briefly discussed Bacon’s three-part division of natural history into ‘that of Generations, Preter-generations and Arts’ and elaborated it further into a seven-part scheme.\(^{239}\) The design extended arts, which was one of the three parts of Bacon’s history, into every part of the seven part division thereby ignoring the traditional division of phenomena into natural and artificial.\(^{240}\) In his design, Boyle made clear his preference of designed experiment over mere observation. He illustrated his view by comparing experiment to the deconstruction of ‘automata’. Passive observation produced superficial knowledge, whereas experiment revealed the internal structure of things:

**Someone who wishes to acquire a sound understanding of automata, and obtain skill in mending them and in making similar mechanisms or others for the same use, will never arrive there by gazing at mere pictures … Rather he must inspect them open and uncovered, their cases set aside,**

\(^{238}\) Anstey and Hunter, ‘Robert Boyle’s ‘Designe about Natural History’”, 91.


\(^{240}\) Anstey and Hunter, ‘Robert Boyle’s ‘Designe about Natural History”, 83-87, 110-111.
and consider their internal structure, and observe the number, symmetry and movement of the wheels in their correspondence to each other, their manufacture, weight and balance, and the other components of the mechanism. The relevance of this presents itself more clearly than to need mentioning.\textsuperscript{241}

Boyle’s design for a natural history was comprehensive. It aimed at including everything and, therefore, the division of the work was to be flexible; ‘the best Division seems to be that which is the most comprehensive and easy’. However, it was not to be ‘stable & fix’t’ but ‘Probationary and so to be alter’d &c. according as further Discoverys or more mature Considerations shall enable’.\textsuperscript{242} A natural history was to consist of ‘Preliminarys, ... the Body of the History it self; Additaments and various Indices.’\textsuperscript{243} ‘The Body’ of the history included ‘the History of Bodys’, ‘particular Qualities’, ‘the States of matter’, ‘Natural Processes and Actions’, ‘Casualtys’, ‘loose Experiments ...which are not reduc’d to any particular art’ and, lastly, of ‘miscellaneous Particulars’.\textsuperscript{244} A natural history was also to have an appendix consisting of an adequate number of parts – Boyle’s plan lists six – where the possible mistakes in the history would be corrected and the experiments and observations omitted from the original text would be published. In addition, new experiments and ‘casual or Anomalous experiments’ required their own sections. Reports of strange phenomena and ‘fictitious experiments’ were to be included, together with a section discussing such ‘practical reflections, inferences, hints, Applications’ which would increase man’s ‘dominion over the works of nature.’\textsuperscript{245}

\textsuperscript{242} Boyle’s letter to Oldenburg, 13 June 1666, in ‘The text of Boyle’s ‘Designe about Natural History”, 4.
\textsuperscript{243} Boyle’s letter to Oldenburg, 13 June 1666, in ‘The text of Boyle’s ‘Designe about Natural History”, 1.
\textsuperscript{244} Boyle’s letter to Oldenburg, 13 June 1666, in ‘The text of Boyle’s ‘Designe about Natural History”, 3.
\textsuperscript{245} Boyle’s letter to Oldenburg, 13 June 1666, in ‘The text of Boyle’s ‘Designe about Natural History”, 5.
The first part of the history – the Preliminary – discussed the relationship between natural history and philosophy. In it, the hypotheses relevant to the subject matter were to be summarized. By ‘hypotheses’ Boyle meant the natural philosophical theories, such as the Peripatetic, Epicurean and Cartesian ‘hypotheses’. A discussion about hypotheses was required since it ‘will conduce to make the History both more exact and compleat in it self, and more ready for use, and more acceptable to those that love to discourse upon Hypotheses’. No particular hypothesis, however, was to be allowed to guide the compilation of a history.246

The distinction between historical and theoretical was important for Boyle. Roughly speaking, ‘theoretical’ was about causes and causal processes, whereas ‘historical’ referred to the description of the matters of fact. It was important that the facts of a natural history were not collected with a particular theoretical purpose in mind. The independence of facts from any theory made them both more reliable and available for various uses; ‘for, to be short, the knowledge of matters of fact cannot but be some way or other, and probably more ways than one, serviceable to a Naturalist, that has Sagacity and Judgement to make a right use of them.’247

Boyle’s design outlined a framework of a somewhat complicated work containing everything a natural historian considered relevant to the subject matter. Boyle’s published natural historical works, however, do not follow his theoretical design as such. Nonetheless, when facing the choice between brevity and copia, Boyle chose copia and often apologised for his ‘prolixity’. According to him, ‘we ought to view the Subject in as many differing lights as we can expose it to, and take in as many helps to discovery as we can; since a great many particulars, that singly, or at the first view, seem not very pertinent, if they be survey’d in conjunction, and be skilfully apply’d, may much conduce to the desir’d end.’248

246 Boyle’s letter to Oldenburg, 13 June 1666, in “The text of Boyle’s ‘Designe about Natural History’”, 2.
Boyle’s *New Experiments and Observations Touching Cold Or an Experimental History of Cold, Begun* (1665) with its almost 900 pages is a good example of how a carefully collected natural history, even when only begun, easily swelled up to massive proportions. The comprehensive nature of natural history made the compilation of such works difficult. In *Cold*, for instance, Boyle used no ‘exact Method’, but the work was rather a ‘Scheme of heads of Inquiry’ he had outlined to give himself ‘a general Prospect of the subject’. Instead of finished treatises, Boyle regarded his published natural histories as starting points for the inquiry in their subject matter; ‘even after all that has already been done ... the History will hereafter appear to have been rather begun then compleated the nature of things, & the Industry of skilful men being so very fertile, that the knowledg of the Subject of the History will from time to time be encreas’d, and so the History it self may be enlarged and corrected, but will not .. in many Ages, if ever it be at all, be made absolutely perfect.’ Natural history required continuous correcting and supplementing. In practice, it was a collaborative enterprise of numerous natural historians and their informants. Boyle illustrated the collective and open-ended nature of natural history by a biblical comparison:

A Natural Subject being proposed to be Historically treated of, there may occurr something like what happen’d to the *Israelites*, in reference to the Land of *Canaan*. For at their first entrance into it, *Joshua*, and the other Spyes took a transient view of the Country, and could bring back but an unaccurate account of it, together with a little of the most remarkable Fruit. But upon a second Expedition, the Spyes were furnished with fuller Instructions, and order’d to direct their Researches to the answering of a great many particular Articles of Enquiry; their Industry to answer which produced in Methodical Tables or Schemes, a far more copious and distinct Chorography, and Survey of the

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fruitfull land of Canaan.²⁵¹

In addition to the co-operation of natural historians, natural historical work also required numerous reports from all kinds of informants describing experiments and phenomena they had performed or witnessed. Furthermore, despite its empiricist flavour and emphasis on personal experience, natural historical experience was ‘informed by a thick web of references to scholarly learning.’²⁵² Although Boyle emphasized experiment and eye witnessing, he also included numerous testimonies of other people in his natural histories. His Cold, for instance, contains, in addition to his own experiments, also the testimonies of various witnesses and those originating from literature. Boyle ‘could not omit’ these testimonies ‘without leaving out some of the eminentest Phaenomena of Cold.’²⁵³

Natural history also furnished Boyle with a channel to publish a large number of experimental reports. Numerous experiments for which no immediate use could be found were preserved in published natural histories for the use of future experimentalists and natural philosophers. As a natural historian, Boyle acted as an ‘underbuilder’ who contributed rather to the factual foundation than to the theoretical part of natural philosophy. Furthermore, his natural histories also aimed at directing ‘those that want better Guides, what enquiries to make, and to what Heads to refer, what they have found by Observation or Tryal’.²⁵⁴ In this respect, Boyle’s natural histories function as storehouses which collect experiments and observations under suitable titles and point out topics requiring further research. The posthumous General History of the Air (1692), in particular, displays the resemblance between Boyle’s natural history and a commonplace book; ‘some of the Titles’ of the work function as ‘a kind of Common Places’.²⁵⁵

²⁵¹ Boyle, Human Blood, 11.
²⁵³ Boyle, Cold, 219.
²⁵⁴ Boyle, Human Blood, 6.
It is evident that Boyle also saw intrinsic value in particulars. He had a habit of working on several works simultaneously and, as a consequence, he had a vast amount of material intended for treatises he never published. Therefore, he planned to publish a large number of miscellaneous particulars in a work called *Paralipomena*.256 ‘Finding the Number of such particulars of this sort’, he noted, ‘that had been supplyed me, partly by my own subsequent Tryals, and partly by some Passages I had taken notice of in the writings of Travellers, and in some other Books; amounted to a not inconsiderable Number: I was not uneasily perswaded, it was not fit that all those Particulars should be lost; especially since some of them were *Experiments & Observations*, that might (perhaps) be fit to be receiv’d among the *Materialis*, that are gathering in this Industrious Age, towards the *History of Nature*.257 The massive *Paralipomena*, which would have consisted of particulars arranged under over 20 headings printed in several 500-page volumes, was never realized. Boyle’s final work was *Experimenta & Observationes Physicae* (1691) which published a minor part of his miscellaneous material arranged loosely under various topics.258

Boyle considered the historical approach suitable also for medical investigation. His natural history of human blood has a medical subject matter and his natural history of mineral waters likewise addressed the medical issues involved in the inquiry into minerals. In addition, he collected material for the posthumously published *General History of the Air* which examines air and weather from various points of view of which human health is one.259 Moreover, the extant manuscripts contain various plans for medical natural histories. Barbara Kaplan has published a manuscript listing Boyle’s topics for medical histories. The list emphasizes chemical experiments; titles such as ‘the History of the Liquors of Body’, ‘the Chymico-Mechanical History of ye Firm or Stable (or consistent) parts of the Body’, ‘the History of the Invisible Fluids of the Body’ and ‘the chymico-mechanical Examen, or History of several aliments’ are included. Boyle also suggested that animal experimentation could be applied in the

258 Hunter, Knight and Littleton, ‘Robert Boyle’s *Paralipomena*’, 177-180, 186-188.
259 Boyle, *General History of Air*, 146-156.
inquiries into the causes of disease by ‘the Artificial production of Diseases in the Bodys of Animals.’

2.2. Physicians and Natural History

Many seventeenth-century English physicians were interested in natural history and wrote natural historical works. In their role as natural historians, the physicians seldom had the advancement of the therapeutic part of medicine as their primary goal. On the contrary, since all kinds of unlearned healers based their therapies on empirical experience, a learned physician might have felt somewhat uncomfortable with conducting an empirical inquiry into the causes of disease or therapeutics. As a consequence, a physician acting as a natural historian often presented himself rather as a natural philosopher than a medical man. Martin Lister, whose De Fontibus medicatis Angliae Exercitatio, Nova & Prior (1684) is discussed in this section, aimed at solving a natural philosophical issue in his natural historical work on mineral waters. Although mineral waters were a disputed topic also in practical medicine at the time, Lister did not discuss the implications of his work for therapeutics.

Boyle, by contrast, aimed at combining practical medicine with his natural historical and philosophical work. His natural history of Mineral Waters (1685) outlines a scheme for a larger research programme. Boyle’s own experiments published in the work contributed principally to the development of the techniques used in the investigation of mineral waters. However, Boyle included in the work a section which suggested topics for the inquiry into mineral waters particularly from the viewpoint of medical practice. Boyle’s natural history of blood likewise contains a section discussing its subject matter from the standpoint of medical practice.

I
The theory of learned medicine was founded on natural philosophical knowledge. According to the established medical theory, health and longevity were achieved by living in harmony with nature. Hence, in his medical practice, a physician applied his natural philosophical education in the holistic task of caring for human health and prolonging life. Due to the importance of natural philosophical knowledge for ‘physic’, physicians were often involved in natural historical and philosophical work on a larger scale than what their strictly medical interests required. Many English physicians found the Baconian outlook and natural history tempting. As a consequence, several medical men participated in the work of the Royal Society although rather in the capacity of natural historians and philosophers than medical men.262

Harold Cook has pointed out that many physicians found the empirical emphasis of natural history somewhat embarrassing. When combined to practical medicine, empiricism was associated particularly with the medical activities of non-academic healers. Instead of giving advice on how to live according to nature, empirical healers concentrated principally on curing disease. By doing so, they tended to identify medicine with therapeutics, whereas the learned physicians regarded therapeutics only as part of their larger professional field.263 Consequently, a learned physician might not have conceived the improvement of the ‘curative part of physick’ as the primary goal of his natural historical enquiry. On the contrary, many physicians tended to keep their roles as natural historians and physicians separate and did not refer to medical issues in their natural historical works. Furthermore, in their historical works physicians occasionally felt the need to legitimate their activities by authoritative examples. Hence Bacon’s example, in particular, is commonly appealed to in the English natural historical and philosophical works. In addition, and especially for a learned physician, the Hippocratic corpus offered an authoritative example which justified an interest in the empirical and particular.264

262 Cook, ‘Physicians and Natural History’, 98-100, 102-105.
264 Cook, ‘Physicians and Natural History’, 102.
Martin Lister’s and Boyle’s natural historical works on mineral waters display the flexibility of natural history as a literary genre. Moreover, these works show that their authors held different ideas about historical approach and its function. Mineral waters were a topic which had aroused the interest of European physicians already in the Middle Ages. In England, there was a long tradition originating from the Roman period of travelling to the natural springs to ‘take waters’, that is, to prevent and cure disease either by bathing in springs or drinking mineral waters, or both. Although the interest in English baths and mineral waters had intensified already at the end of the sixteenth century, the popularity of drinking these waters for therapeutic purposes increased with the popularity of iatrochemistry in the seventeenth century. The explanations for the medical effects of waters were various and the topic was diligently examined and discussed. As a result of the increased interest in mineral waters, several studies on the subject matter, such as Boyle’s Mineral Waters, Martin Lister’s De Fontibus medicatis Angliae and an English translation, Observations on the Mineral Waters of France, of the French work of Samuel Du Clos, were published in the 1680s.

The discussion and investigation into mineral waters show how natural historical and philosophical inquiries intertwined with medical issues and the occupational concerns of physicians. The principal natural philosophical question concerned the formation of metals and minerals. Several theories about how minerals were formed existed. As for practical medicine, the dispute about mineral waters revolved around the question of which salt was medicinally the most effective. Hence theoretical knowledge about the formation of minerals and their salts was relevant to the medicinal uses of waters as

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269 Coley, ‘Cures without Care’, 196.
270 See Roos, Salt of the Earth, 67-68.
271 Roos, Salt of the Earth, 114.
well. The theoretical explanation of minerallogenesis, when combined with knowledge about minerals and their salts, helped to identify the particular medical qualities of different healing springs found in Europe. For the physicians practising in the spa regions, mineral waters and the chemical products using waters as raw material were of great economic significance. The occupational interests of local physicians are displayed in their writings which advertise the effective medicinal qualities of the waters of their region and their own expertise in administering the water treatments. Mineral waters were likewise a topic of controversy. For instance, between 1667 and 1680, the English physicians Robert Wittie and William Simpson conducted a bitter dispute about the medicinal qualities of Scarborough Spa waters.

Martin Lister, of whose De Fontibus medicatis Angliae a second and enlarged edition was published in 1684, focused on the issue of minerallogenesis and ignored the practical medical aspect involved in the inquiry into mineral waters. Nevertheless, Lister referred to Wittie’s and Simpson’s dispute about the matter and noted that ‘the very subject matter’ [mineral waters] had so far been treated in a manner that seemed inevitably to engage the authors in ‘disputes and quarrels’ of which Lister had ‘a great dislike’. Lister belonged to the group of English physicians who took interest in the new experimental philosophy and became members of the Royal Society. As a natural historian, he focused on a variety of biological studies on botany, spiders, fossil classification, conchology and mineral waters. Lister’s general outlook as a natural historian and a philosopher hardly had anything especially medical in it. This applies as well to his De Fontibus medicatis Angliae. Although Lister did take Wittie’s side when it came to the theoretical explanation of minerallogenesis and the ingredients of English mineral waters, he did not discuss the practical medical aspect involved in the issue at all.

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273 Coley, ‘Cures without Care’, 200-205. On the dispute between Wittie and Simpson see Roos, Salt of the Earth, 109, 114-121.
274 Lister, De Fontibus medicatis Angliae, 208.
275 Roos, Salt of the Earth, 65.
276 Lister, De Fontibus medicatis Angliae, 258. See also Roos, Salt of the Earth, 114-115.
Although Lister did not examine the medical qualities of mineral waters in De Fontibus medicatis Angliae, his medical education did shape his natural historical work. The Latin De Fontibus medicatis Angliae is an exercitatio, a form of academic essay.\textsuperscript{277} Lister’s text proceeds in an orderly manner by examining ‘the salts of the individual medicinal springs’, ‘their native earth’ and ‘the origin of all these’ or ‘the means by which they are created.’\textsuperscript{278} Lister’s principal argument was that the English mineral waters contained only two kinds of salts.\textsuperscript{279} De Fontibus medicatis Angliae stresses the role of chemical experiment in the investigation; the reader is provided with detailed descriptions about experiments on minerals and mineral waters.

The historical part of the work served Lister’s explanation of the formation of minerals.\textsuperscript{280} Although he used his experiments to prove his theoretical explanation of minerallogenesis, no demonstration of causes was included in the work. Instead, Lister emphasized the historical character of his work and the certainty of the matters of fact delivered by pointing out that he had ‘nothing further to affirm, and no intentions which go beyond giving an account of a phenomenon’. As for his theoretical explanation, he noted that his ‘other currently-held fixed opinions … may in short time cease to have’ his ‘support (even if they have it now!).’\textsuperscript{281}

II

Boyle had probably started experimenting on mineral waters already in the 1660s. The publication of his Mineral Waters in 1685 is associated with other works – particularly those of Martin Lister and Samuel Du Clos – published about the same topic in the 1680s.\textsuperscript{282} The publisher’s preface to Mineral Waters recommends Lister’s work, together with Du Clos’s ‘curious little Tract of the French Mineral Waters’.\textsuperscript{283} Boyle also refers


\textsuperscript{278} Lister, De Fontibus medicatis Angliae, 239-240.

\textsuperscript{279} Lister, De Fontibus medicatis Angliae, 231.

\textsuperscript{280} Lister, De Fontibus medicatis Angliae, 239-240.

\textsuperscript{281} Lister, De Fontibus medicatis Angliae, 209.

\textsuperscript{282} Works, vol. 10, xxix.

\textsuperscript{283} Boyle, Mineral Waters, 207.
to Lister’s *De Fontibus medicatis Angliae* as one of ‘those more elaborate Pieces, that have within no long time been publish’d by skilful Men’.\(^{284}\) Boyle seldom referred to other authors in this manner. However, in addition to his appreciative remark on Lister’s work, he claimed that ‘mens curiosity about’ the topic had so far ‘been conﬁn’d to very narrow Limits’. This was, according to him, one of the reasons for his decision to publish his own memoirs on the subject matter. He also pointed out that although the work was ‘only a bundle of *Short Memoirs*’, it ‘contributed towards the compiling ... a full and methodical History of Mineral Waters’.\(^{285}\)

Boyle’s *Mineral Waters* approaches natural historical work from a different standpoint than Lister’s *De Fontibus medicatis Angliae*. In general, Boyle was dissatisfied with contemporary state of natural history; ‘how incomplet the History of Nature we yet have ... and how difﬁcult it is to build an Accurate Hypothesis upon an Incompleat History of the *Phaenomena*’.\(^{286}\) Both his *Mineral Waters* and *Human Blood*, which was published the previous year, present an extensive plan of inquiry into their subject matter. Instead of complete treatises, Boyle’s natural histories are ‘memoirs’ which display his view that natural history required an enormous amount of work. These works aim at giving a direction for natural historical work by suggesting topics for future inquiries.

Also Boyle’s *Mineral Waters* emphasizes the incomplete state of the inquiry into its subject matter. A critical discussion about the research techniques commonly used in the inquiries into waters forms the principal substance of the work. The rest of the work consists mostly of titles and ‘marginal notes’ about Boyle’s own experiments.\(^{287}\) Minerallogenesis was one of the titles Boyle mentioned in the work but he neither discussed the issue nor suggested a solution for the debate about mineralogical theory. Instead, in the fourth section of *Mineral Waters*, he criticized the techniques so far used


\(^{286}\) Robert Boyle, *The Excellency of Theology, Compar’d with Natural Philosophy ... to which are annex’d Some Occasional Thoughts about the Excellency and Grounds of the Mechanical Hypothesis*, (1674), *Works*, vol. 8, (3-98), 89.

in the investigation. According to him, particularly the ‘gall tests’, which were the principal contemporary method of examining mineral waters, had serious defects.

For Boyle, a natural historical work was a means of publishing experimental matters of fact. Both *Mineral Waters* and *Human Blood* contain a large number of experimental facts disregarding their relevance to any current discussion. Particularly *Human Blood* shows the importance that publishing matters of fact had for Boyle. *Human Blood* is in many respects a similar work to *Mineral Waters*. The work outlines a preliminary disposition for a more comprehensive natural history about its subject matter. It is divided into four parts of which the first briefly discusses the method of compiling a natural history. The first part also contains a list of titles indicating the topics for further study on the subject matter. The second and third parts consist of descriptions of miscellaneous experiments. The fourth part presents an example of a title which is treated methodically by dividing it into secondary titles under which Boyle had arranged his experimental reports.

Similarly as in the case of mineral waters, Boyle had started his experimental work on blood long before the publication of *Human Blood*. While living in Oxford during the 1650s and 1660s, he had suggested blood as a topic of inquiry to the community of physicians who were conducting anatomical studies there at the time. For the purpose, he had constructed ‘a set of Enquiries’. Several members of the community took up Boyle’s suggestion and started to investigate the qualities of blood. Boyle also participated in these inquiries and conducted experiments on blood. His *Human Blood* published mostly these old experiments which were relevant to the topics discussed in the 1650s and 1660s. By the publication of *Human Blood* in 1684 the focus of the

investigation into blood had shifted to other topics. 292 Boyle, however, did not refer to the more recent studies on blood but, instead, noted that the subject matter had been so far neglected. 293 We do not know why he decided to publish his old experiments. Michael Hunter has suggested that these experiments might have been intended as part of Boyle’s suppressed work criticizing contemporary medical practice. 294

Boyle considered it important to publish miscellaneous and even old experiments. In this respect, his natural historical works differ significantly from the style of Martin Lister’s De Fontibus medicatis Angliae, for instance. Boyle regarded the experimental matters of fact as valuable in themselves disregarding whether they contributed to a specific contemporary discussion or not. Lister’s manner of employing the historical approach was different. His experiments were conducted according to his research problem. Only experiments relevant to Lister’s argument were published; De Fontibus medicatis Angliae contains no descriptions of superfluous experiments. Experimental reports do not form the substance of the work but are presented to serve the theoretical conclusion of the work.

Boyle was not ‘a profess’d Physician’ but ‘a Diligent Natural Historian’. 295 Nonetheless, his medical natural histories show that he attempted to combine natural history, philosophy and medicine. According to him, the best person to conduct experimental work on disease and its causes was ‘a Naturalist well vers’d both in Chymicall Experiments, and in Anatomy, and the history of Diseases, without being too much addicted either to the Chymist’s notions, or the receiv’d opinions of Physitians’. 296 In Human Blood, he pointed out that he had refrained from medical studies; ‘having resided for many years last past, in a place so well furnished with learned Physicians as London is’ he had been ‘careful to decline the occasions of entrenching upon their

292 Frank, Harvey and the Oxford Physiologists, 284.
295 Boyle, Human Blood, 76.
296 Boyle, Usefulness II, sect. 1, 322.
profession." Nonetheless, he was interested in practical medicine and suggested topics for medical inquiries in his natural historical works.

The experiments published in *Human Blood* were conducted only on healthy blood but Boyle pointed out that similar experiments should also be conducted on diseased blood in order to discover the causes of diseases. His ‘Scheme of Titles drawn up for the *History of Healthy Blood*’ provided an example ‘to any that would write the *History of Morbid or Depraved Blood* in any particular Disease, as a Pleurisie, a Quartan Ague, the Dropsy, the Scurvy, &c.’. He also included in *Human Blood* two sections where he discussed the ‘medicinal vertues of Spirit of Human Blood outwardly’ and ‘inwardly applyʼd’. The sections contain a discussion about chemical blood preparations and their medicinal uses. When discussing these medicines, Boyle did refer to his position as a natural historian by pointing out that his ‘designʼ was to ‘consider the Effects of Humane Blood upon Patients, less as they are Sanative, than as they are Signs of Qualities, whose knowledge tends to the discovery of the Nature of Spirit of Humane Blood’. Nevertheless, he also gave detailed instructions for preparing the medicines and described cases where they had been found effective.

Boyle stated that his *Mineral Waters* was ‘aimʼd much more to assist practical Physicians to find the vertues and effects of Mineral Waters, than to inform Speculative Naturalists of their causes and manner of being generated’. The sixth section of the work presents ‘a Set of Articles, referable to the Medicinal use of Mineral Waters’. The section suggests to physicians, who were ‘strangers to platforms of Natural History’ but whose ‘proper Officesʼ this part belongs to, titles ‘which may point out to them what particulars may be fit for their Inquiry, and furnish them with heads whereeto they may refer, and Receptacles wherein they may lodge what, upon Tryals or otherwise, they

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shall meet with worthy observation.” The titles comprise a combination of the traditional medical approach and the novel experimental way of examining medical questions. For the most part, Boyle recommended conducting experiments and observations of the effects that mineral waters have on patients. Most of the titles are concerned with observation of how the individual characteristics of patients on the one hand, and the variation in the circumstances of ‘taking the waters’ on the other, influence the effects the water treatments have on patients. The last title, however, introduces an experiment more familiar from anatomical studies. Boyle suggested that the new injection technique was to be applied to the inquiry into the medicinal qualities of mineral waters. These ‘Mechanico-Medical Trials, that may be made on Animals’ were ‘Analogous Experiments’ that could not be ‘well ... try’d in living Humane Bodies.”

2.3. The History of Disease

This section examines some ideas that were presented about applying historical approach in inquiries into disease and the methods of cure. In it, I discuss Boyle’s, William Petty’s and Thomas Sydenham’s ideas about the history of disease. Boyle and Petty regarded the history of disease as one of the means of advancing medical knowledge and wrote plans for such histories. Petty published his plan, whereas in Boyle’s case we have only manuscript evidence that he had considered the matter. Petty’s and Boyle’s ideas remained mere sketches with no actual work done on the subject. By contrast, Thomas Sydenham, whose medical practice offered him the opportunity of observing a large number of cases of disease, took up the task of collecting the history of epidemic disease.

303 Boyle, Mineral Waters, 247.
The section discusses the little we know about Boyle’s and William Petty’s ideas about the history of disease and examines Thomas Sydenham’s more substantive work on the subject. The examination shows that experiment had only a minor role in the historical inquiry into disease. In these inquiries, the historical approach first and foremost involved observation and recording instead of experiment. Moreover, the experiment employed in this context was rather a trial-and-error type of activity than a designed act with a high degree of artificiality.

I

Modern studies on the history of medicine often emphasize the ‘bookish’ and philosophical nature of the early modern learned medicine. However, it is likely that many university educated physicians were also successful clinicians. Even though they might have disagreed on other aspects of medicine and natural philosophy, many medical men valued experience and observation when it came to practical medical matters. To take an example of such a practical approach to medicine and medical reform we may briefly consider William Petty’s ‘baconian-spirited’ plan for the advancement of medicine published in 1647. Petty had studied medicine in the Netherlands and, like Boyle, was a member of the Hartlib circle in the Interregnum period. In 1647, he published a plan for the advancement of learning and ‘publick good’ which also included a scheme for the advancement of medicine. In Petty’s scheme, the observation of cases of disease and the systematic recording the results in case histories had a central role.

Petty’s vision about the advancement of medicine placed a medical institution, Nosocomium Academicum, in the centre of medical reform. The ‘baconian-spirited’ plan for Nosocomium Academicum envisioned a medical Solomon’s house built according to the model presented in Bacon’s New Atlantis. The institution dictated the duties of each member of the staff thereby guaranteeing the performance of its combined task of medical care, teaching and investigation. Petty’s Nosocomium was to be led by a

305 Cook, Decline of the Old Medical Regime, 110-111.
physician with the help of a ‘vice-physician’, a ‘chirurgeon’, and an apothecary. The members of the staff were to keep a systematic record of the patients, their diseases and the effects of the medicines prescribed. One of the tasks of the hospital was to collect histories of disease to serve as the basis of medical investigation.  

Petty regarded the histories of disease both as a source of practical medical knowledge and as a basis for theoretical discovery. The theoretical discovery was ‘the vice-physicians proper charge’; he was ‘to see the history of patients most exactly and consultantly kept’ and ‘for the compleating of the history, he shall apply himselfe to the making of luciferous experiments’. Moreover, ‘out of them’ [the written records], the physician in charge ‘by the end of the terme of his service, shall collect a Systeme of Physick and the most approved Medicinall Aphorismes; taking notice by the way where those of Hippocrates are deficient or true’. Like Bacon’s Solomon’s House, also Petty’s medical institution remained on the level of utopia. No Nosocomium Academicum was realized but medical inquiries and collecting the history of disease remained the work of individual physicians and natural historians.

Boyle also recommended collecting medical particulars in histories of disease but never published his ideas about the history of disease. We have, however, two extant manuscripts which clarify his views about what kind of things were to be observed and recorded when collecting a history of disease. Michael Hunter has recently published one of these manuscripts containing Boyle’s ‘Praeliminary Topicks or Articles of Inquiry, in order to The History of Diseases’. The manuscript outlines an agenda with twelve articles of inquiry. The agenda approaches disease in a multifaceted manner incorporating several factors, such as the place, the climate, the season of the year with the individual features and habits of people, in other words, the naturals and non-

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naturals of the traditional medical theory. Firstly, it was to be observed which diseases were typical for a particular place and climate, on the one hand, and which diseases occurred on the region only rarely or not at all, on the other. Secondly, the influence of the place and the climate on disease and cure was to be discovered by observing whether some diseases were cured when a patient chanced location; for instance, ‘as Scotland is wont easily to cure men of Agues’. Moreover, the individual characteristics of the people, such as age, sex, the bodily constitution and the ‘course of life’, were to be taken into account. In addition, the occurrence of particular diseases in different seasons was to be observed to find out ‘what influence the season of the Year may have upon the Disease, either to breed, encrease, change, or cure it.’ 309 The last article combines all these factors in order to investigate a particular disease from the standpoint created by the agenda:

What other Circumstances differing from those, mention’d already to the same purpose, may be observ’d about the Disease under Consideration. As, what Age, Sex, Climate, Soile, Complexion, Diet, course of Life &c. The Disease is more or less fatall, mischievous, or benigne. As ‘tis observ’d that the small pox is extreamly mortall in China, even slight wounds in the head, are far more dangerous in Italy, then in England, or France, and so small hurts of the Leggs about Geneva, and Lusty labouring men such as Diggers & Hedgers rarely recover of Pleurisy. What Constitutions either single or successive of the seasons of the year. What great alteration of the Air, by great & lasting Raines, Winds, Droughts, Earthquakes, fiery Eruptions, great spots in the sun, vanishing, or reappearing Starres, Comets &c. did precede or accompany the Disease; also whether it be a new Disease, or have been from the begining of the World, and even in this part of it,

whether in case it be new ‘twas introd’c’d & propagated by, or without manifest Contagion, whether it’s malignity encreases or lessens, by progress of Time, as many Physitians observe the symptoms of the Lues Venerea, to have been for some considerable time far milder then when the Disease began first to appear in Europe.\textsuperscript{310}

A general history of disease the manuscript describes was as comprehensive as Boyle’s general design for a natural history. It shows that Boyle conceived the work on the history of disease in a similar manner as a co-operative and an open-ended task.

The Royal Society Boyle Papers also contain a manuscript fragment which approaches the subject from the viewpoint of a particular disease. The manuscript is titled ‘In the History of a particular disease’ and it was to list ‘the 12. generall preliminaries or most of them are to be apply’d to ye particular Disease’. Of these, however, only six are found on the folio:

The usuall & also to [...] uncommon forerunners are to be recited.
The first invasion of ye disease is to be carefully & fully delivered.
The principle Circumstances & even the more minute ones of ye latent process or progress of the Disease are to be heedfully taken notice of & delivered and this considering the disease both absolutely & [...] or gradually.
The events of ye Disease whether naturall or medicinally procured & be they ordinary or extraordinary are to be faithfully & impartially sett downe.
The consequents of ye disease; (as when a quartan leaves a Schirrus [...] and ye measles other diseases &c are also to

\textsuperscript{310} Boyle, ‘Preliminary Topicks for the History of Diseases’, 34.
be noted.
Contignets & Anomalies (especially if very considerable) are not to be omitted.\textsuperscript{311}

Both manuscripts indicate that Boyle’s view about historical work on disease involved rather observation than experiment. Although the plan for the history of a particular disease mentions ‘the medicinally procured events’, otherwise its emphasis is on observation.

Conducting the work on the history of disease required opportunities for diligent and systematic observation of numerous cases of disease. In practice, a medical practitioner was best placed to collect and write such a work. We know that Boyle discussed the matter with his London neighbour Thomas Sydenham who subsequently took up the work on the history of epidemic disease in London.\textsuperscript{312} However, we know almost nothing about the contents of the discussions between Sydenham and Boyle. Only one letter from Sydenham to Boyle is extant. In this letter, Sydenham promised to give a detailed account of his medical observations in their next meeting. In addition, he told that he had dedicated to Boyle the second edition of his \textit{Methodus curandi febres Propriis Observationibus Superstructura} (1668).\textsuperscript{313} In that work, Sydenham notes that he ‘undertook the subject’ on Boyle’s ‘persuasion and recommendation’.\textsuperscript{314}

\textsuperscript{311} BP, MS 199, fol. 151.
\textsuperscript{312} Cunningham, ‘Thomas Sydenham’, 179-181.
\textsuperscript{313} Thomas Sydenham to Robert Boyle, 2. 4. 1668, \textit{Correspondence}, vol. 4, (55-57).
II

I cure not the rich till my being in the grave makes me an Authority’. 315

Thomas Sydenham started his medical practice around 1656 in London where he treated for the most part middle class and poor patients. 316 According to the standards of the time, his medical career was no success; he found no rich patron but had to treat a number of less well-to-do patients. His professional failure, however, put him in an ideal position to make systematic observations about the diseases of his numerous patients and the effects of his remedies.

Sydenham’s medical investigation was concerned with epidemic disease, fevers in particular. According to Sydenham, medicine ‘may be best improved, first, by a History, or Description of all Diseases, as graphically and naturally as possibly may be, and, secondly, by a perfect and stable Practice or Method respecting them’. 317 This was what he regarded as the ancient Hippocratic method. 318 During his career as a medical practitioner, he observed numerous cases of disease. He proceeded in his investigation by gathering case histories of different instances of the same disease. The case histories accounted the ‘course of the disease (without intervention) ... the symptoms it shows in the body ... the day and nature of its crisis’ and ‘its natural mortality (or recovery rate)’. 319 Sydenham’s task was twofold. Firstly, he used the recorded case histories for classifying disease by reducing all diseases ‘to certain and definite Species, with the same diligence we see it is done by Botanick Writers in their Herbals.’ 320 Secondly, he experimented on remedies in order to find general cures for epidemic fevers.

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317 Sydenham, Observationes Medicæ, a2.
318 Sydenham, Observationes Medicæ, a4.
320 Sydenham, Observationes Medicae, a2.
Sydenham published his results in *Methodus Curandi Febres* (1666) of which a modified second edition was printed in 1668.\(^{321}\) The work was based on the experiments and observations he had made during the past ten years in his medical practice. *Methodus Curandi Febres* published generalized descriptions of different kinds of fevers and methods of treatment founded upon Sydenham’s own observations and experiments.\(^{322}\) After publishing *Methodus Curandi Febres*, Sydenham continued his research. In 1676 he published an enlarged version of his earlier work under the title *Observationes Medicæ circa Morborum Acutorum Historiam et Curationem*. The work describes the ‘epidemic constitutions’ of particular periods of time in London. By ‘epidemic constitution’ Sydenham meant a combination of diseases that affected a significant number of people in a particular place during a particular period of time. After describing the epidemic constitution of a particular period, Sydenham proceeded to describe the typical and irregular features of these diseases. Finally, he gave instructions for the proper method of treatment.

Sydenham’s description of a particular disease was specific to a place and a period of time, that is, to an epidemic constitution. He was convinced that the epidemic constitution affected the nature of the diseases belonging to that constitution and, therefore, ‘the regular Small-Pox in the Years 1667, 68. and part of 69’ in London, for example, might have features different from epidemic smallpox under some other constitution.\(^{323}\) However, even though the symptoms and the course of the disease might have varied according to the prevailing epidemic constitution, Sydenham seems to have regarded disease as an ontological entity rather than as an individual event in a patient’s body. The disease preserved its essential features despite the constitutional variation. Hence Sydenham’s use of the historical approach for the classification of disease made perfect sense. Diseases were like plants; behind the individual features of different instances lied an essential similarity.

\(^{321}\) Cunningham, ‘Thomas Sydenham’, 165-166.
Sydenham believed that the same epidemic constitution might occur repeatedly but in such long intervals that would make the observation of epidemic cycles impossible for one person. In this respect, his view about historical work into disease resembled that of Boyle’s; it was an open-ended and collective project to be conducted by several generations of medical men. Sydenham had initiated the investigation into epidemic disease and published his own results in his treatises. In Observationes Medicae, he pointed out that the work was not intended as the final word on epidemic disease. Instead, it was published to encourage ‘those of better Parts to undertake hereafter’. 324

All our writers mention or at least refer to experiment when discussing the history of disease. However, their texts do not emphasize experiment and its role in medical investigation. On the contrary, the role of experiment in the historical investigation into disease was vague and somewhat insignificant. The history of disease was for the most part based on experience and observation rather than on designed experiment. Petty referred to ‘luciferous’ experiments but did not clarify what kind of experiments these would be when conducted in an institution focusing on medical practice and teaching. Likewise, in Observationes Medicae, Sydenham noted that his ‘method of healing’ was ‘sufficiently strengthened by a great number of Experiments’ but did not describe these experiments in detail. 325 In Human Blood and Mineral Waters, Boyle did make an attempt to introduce designed experiment to the investigations into therapeutics and the causes of disease. However, his manuscript schemes for a history of disease place no emphasis on experiment but only briefly refer to the ‘medicinally procured events of the disease’. 326

The older studies written on Sydenham have emphasized his relationship with Boyle and discussed the impact of Boyle’s experimentalism on Sydenham’s medical work. The interpretations of Andrew Cunningham and Sydenham’s biographer Kenneth Dewhurst have pictured Boyle as an experimental scientist who initiated and influenced the medical research of a physician. Dewhurst has emphasized the influence of Boyle’s

324 Sydenham, Observationes Medicae, a7.
325 Sydenham, Observationes Medicae, a4.
326 BP, MS 199, fol. 151.
investigation into air in Sydenham’s medical work: according to Dewhurst, the ‘new philosophy’ surfaces in Sydenham’s ideas about the aerial *effluvia* which were regarded as spreading contagious disease.\(^{327}\) Furthermore, he associated Sydenham’s ‘Baconian’ method of the history of disease with the work of the early Royal Society.\(^{328}\) In his more recent interpretation, Andrew Cunningham has likewise emphasized the influence that the ‘intellectually senior’ Boyle had in Sydenham. Cunningham also noted that Sydenham used experimental concepts and language in his treatises. In addition, according to him, Sydenham saw the cause of epidemic disease in the air rather than human bodies and, like Boyle, stressed the significance of *experimenta* and observation in medical investigation.\(^{329}\)

Andrew Cunningham claimed that ‘to Sydenham an experiment at the bedside consisted of nothing more sophisticated than *trial and error* in the administration of drugs and of medical techniques such as bleeding or purging. ... *Experimentum* thus meant making up, or working out, a sequence of cure as one went along!’\(^{330}\) The type of experiment Sydenham employed was commonly used to find a cure for an individual case of disease. When successful, the therapeutic method thereby discovered was to be tried in future cases of the same disease. In *Methodus Curandi Febres*, Sydenham published a case history which shows how he used experiment. The patient was a 21-year old ‘noble lady’ who suffered from fever. Sydenham soon noticed that, in this case, his ordinary method of curing fevers was not successful. Hence he inferred that ‘the fever was not of the common sort’ and, therefore, ‘it required a fresh method of treatment’. He proceeded to experiment with different remedies. The patient, however, died. Afterwards, Sydenham considered the case and, in particular, the signs of disease and the seasonal factors involved. He came to the conclusion that the strange fever might be treated ‘by precisely the same method’ that he had ‘often applied with singular success in pleurisy.’ Soon afterwards, he was called to see a patient with similar symptoms whom, and subsequently several others, he succeeded to cure with his new experimentally

\(^{327}\) Dewhurst, *Dr. Thomas Sydenham*, 60-61, 65-66.
\(^{328}\) Dewhurst, *Dr. Thomas Sydenham*, 62.
\(^{330}\) Cunningham, ‘Thomas Sydenham’, 186.
discovered method.\footnote{Sydenham, \textit{Methodus Curandi Febres}, 201-203.}

It is true that Boyle’s and Sydenham’s medical ideas have similarities. Nevertheless, Boyle and Sydenham also disagreed in important points. Hence, the relationship between the two men involved rather an exchange of medical and philosophical ideas than Boyle’s straightforward influence in Sydenham’s work. In the previous chapter, we saw that Boyle’s notion of experiment included also a similar trial-and-error experiment as that Sydenham used in his medical practice. Hence Boyle’s ‘intellectual superiority’ to Sydenham does not lie in the sophistication of his experimental method. Boyle regarded a clinical trial as useful for medical practice; such a trial could lead to the discovery of novel medicines even if it provided no theoretical explanation for the effects of these medicines. In his natural philosophical work as well, Boyle sometimes conducted experiments ‘for curiosity’s sake’ to see what the result would be like. Unlike Sydenham, however, Boyle conceived various uses for a trial-and-error experiment. He wished that a clinical experiment would produce besides novel remedies, also theoretical knowledge about disease and the medicinal qualities of different substances. By contrast, Sydenham conceived experiment merely as a means of finding effective therapies.

Boyle thought that a single experiment might have several uses.\footnote{BP, vol. 9, fol. 104.} Therefore, experiment had a value in itself for him. Consequently, Boyle published abundant reports about chemical experiments and interesting cases of disease where extraordinary methods of cure had been employed. In practical medical literature, some descriptions of particular cases were expected. However, publishing narratives about individual cases was an ambiguous matter. It could be understood as an attempt to bolster up the reputation of the physician. Furthermore, and particularly in the case of an empirical healer – or a doctor suspected as one – it was regarded as deceitful advertising.\footnote{See Lane Furdell, \textit{Publishing and Medicine}, 135-154, Porter, \textit{Quacks}, 133-181. On cure testimonials see Pomata, ‘\textit{Praxis Historialis}’, 126.} Sydenham presented almost no particulars in his \textit{Methodus Curandi Febres} and in
Observationes Medicæ he published only a few. Moreover, he explained his disregard for publishing particulars. Like many of his contemporary medical men, he considered particulars principally as a means of advertising:

I do not intend to enlarge the following Treatise with a great number of particular Observations, whereby I may give a Reputation to the Method there delivered: For it would be to no purpose, and nauseous to repeat those things singly, which have been treated of together ... And I declare, that no general Method has been published by me, which has not been established by repeated Experience.\textsuperscript{334}

Instead of making an attempt to prove the efficacy of his therapeutic methods by producing a large amount of examples, Sydenham presented practical proof by describing his methods and publishing the recipes of his medicines. Narratives of individual cases had no intrinsic value for him; ‘the publishing of particular Observations is not, in my Opinion, so beneficial: For if the Observator designs only to acquaint us, that this Disease was once or oftener cured by this Remedy, what advantage, I pray, will it be that one unknown Medicine is added to the almost infinite heap of celebrated Medicines.’\textsuperscript{335}

2.4. The History and the Causes of Disease

This section explores the relation of natural and medical historical knowledge to theory. The section seeks to show that no generally shared view about the uses and goals of the historical inquiry into medical phenomena existed. Boyle and Petty conceived a connection between historical and theoretical knowledge, whereas Sydenham’s inquiry into disease had strictly practical goals. All the three writers associated the historical

\textsuperscript{334} Sydenham, Observationes Medicæ, a7-a8.
\textsuperscript{335} Sydenham, Observationes Medicæ, a4.
approach either with Bacon’s ideas or with the Hippocratic medicine or both. Boyle’s view of natural history was related to the Baconian model although the extant manuscripts indicate that his view about the history of disease differed in some respects from his ideas about natural history. Petty’s ‘baconian-spirited’ plan for medical reform involved collecting the history of disease. Sydenham referred to both Bacon and Hippocrates when explaining his own method of medical inquiry. However, in practice, Boyle’s natural history, Petty’s *Nosocomium academicum* and Sydenham’s investigation into epidemic disease represent distinct enterprises which hardly had much in common except for the idea of the general usefulness of the historical approach in medical investigation.

In this section, I also discuss some of the meanings the Baconian and the Hippocratic models had for medical authors, in particular. The approved authorities, such as Aristotle, Bacon, Galen or Hippocrates, functioned both as sources of ideas and as labels aligning an author with a particular philosophical or medical current. The ideas of the authorities, however, were seldom adopted as such. Instead, the medical authors interpreted and modified these ideas to fit their own views. Boyle seldom referred to any authority in his natural historical works. Thomas Sydenham’s position as a medical author was different from that of a disinterested gentlemanly philosopher, such as Boyle. Sydenham’s published works promoted novel therapeutic methods which he had developed on the basis of his experience and experiments as a practitioner. Authorities, such as Bacon and Hippocrates, furnished him with a means of distinguishing his method and practises from those of the notorious medical empirics. The Hippocratic *corpus*, in particular, offered him an example of empirical inquiry that originated from the medical tradition. However, despite Sydenham’s appeal to the authority of Hippocrates and Bacon, his medical work was criticized in a similar manner as any other contemporary empirical approach to medical knowledge.
Boyle, Sydenham and Petty all regarded the historical approach as having a role in the advancement of medicine. For them, historical work involved experiment and observation, in particular. Knowledge thus gained was to be recorded as case histories and descriptions of experiments. However, their views about the relationship between historical and theoretical knowledge differed. Petty seems to have regarded theory as an integral part of history. In Petty’s ‘baconian-spirited’ plan for the advancement of medicine, the history of disease functioned both as a material for formulating practical ‘medicinal aphorisms’ and as a foundation for performing ‘luciferous experiments’ for ‘the compleating of the history’.336

We do not know what kind of theoretical explanations Petty’s ‘luciferous experiments’ were designed to discover. By contrast, we have a clear idea about Sydenham’s attitudes towards theory. In general, Sydenham focused on medical practice and had only slight interest towards theory. Moreover, his interests were strictly medical. He regarded natural philosophy as irrelevant to medical practice and conceived its philosophical ‘knowledge of fine points and all the pomp of subtle speculations ... matters which are as useful to physicians in driving away diseases as music is to masons in laying bricks’.337 He regarded the gap between medical practice and the natural philosophical ‘speculations’ about ‘remote causes’ as far too wide for the latter to have any significance for his own project. Furthermore, according to Sydenham, the ‘remote causes’ were ‘occult’ in the sense that they were both insensible and unintelligible. For him, the ‘remote causes’ of natural philosophy were ‘matters, like many others, upon which vain and arrogant philosophy speculates to no purpose’.338

336 W.P., Advice of WP. To Mr. Samuel Hartlib, 13.
337 Sydenham, Methodus Curandi Febres, 215.
Barbara Kaplan has claimed that Sydenham’s method of medical investigation posed a ‘challenge to Boyle’s methodology’.

She has pointed out that although Sydenham’s and Boyle’s medical ideas were in many respects similar, the narrow scope of Sydenham’s investigation was directly opposite to Boyle’s project of discovering the unobservable causes of phenomena and explaining these on a corpuscular level. I suggest that the contrast Kaplan has drawn between Sydenham and Boyle is all too sharp. She conceives Boyle’s ‘methodology’ as a single method of hypothesis formulation and verification by experiment.

In general, Boyle thought that historical knowledge had a connection to theory. According to him, the relevant theories were to be discussed in a natural historical work. He also included in his historical works theoretical digressions where he evaluated theoretical ideas in the light of his experiments. However, we have only fragmentary manuscript evidence about Boyle’s views about the history of disease which does not reveal how he conceived the relation of the history of disease to theory. Nonetheless, with its emphasis on observation and environmental factors, Boyle’s view of the history of disease is more ‘Hippocratic’ than his ‘Baconian’ design for an experimental natural history.

Boyle’s manner of approaching medical issues was all but straightforward. We know that Boyle regarded medical phenomena as a subcategory of natural phenomena. His own perspective into medical knowledge was that of a natural philosopher who was concerned with ‘the changes produc’d by Natural causes in the Body of an Animal’. However, he acknowledged that from the viewpoint of a medical man these changes were ‘Symptoms of Disease, or Effects of Medicines’. Barbara Kaplan conceives Boyle’s corpuscular hypothesis as a theory which governed theoretical explanation in every field of investigation. Boyle, however, believed that natural phenomena could be explained on various levels. The causal structure of nature was multilevel there being ‘oftentimes so many subordinate Causes between particular Effects and and the most

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339 Kaplan, *Divulging of Useful Truths in Physick*, 146.
340 Kaplan, *Divulging of Useful Truths in Physick*, 146-149.
341 Boyle’s letter to Oldenburg, 13 June 1666, in ‘The text of Boyle’s ‘Designe about Natural History”, 2.
342 See above pp. 94-97.
343 Boyle, *Specific Medicines*, 353.
General Causes of things, that there is left a large field wherein to exercise Mens Industry and Reason’.\footnote{Boyle, ‘A Proemial Essay’, 23.} Although the fundamental explanations of all natural and medical phenomena were to be found on the corpuscular level, in practice knowledge of intermediate causes was sufficient in the field of practical medicine.\footnote{Boyle, ‘A Proemial Essay’, 21-23.} In Specific Medicines, Boyle presented various possibilities of how the corpuscular hypothesis could be employed to explain the causes of disease and the effects of medicines.\footnote{Boyle, Specific Medicines, 353-354, 369.} However, Boyle wrote ‘less like a Physician than a Naturalist’ and admitted that at the time corpuscular explanations of medical phenomena were mere speculations.\footnote{Boyle, Specific Medicines, 353.}

Boyle’s and Sydenham’s ideas about the influence of environment and air, in particular, in human health illustrate their different attitudes towards theoretical knowledge. In the course of the seventeenth century, the ideas about the connection between environment and health gained new impetus when the Hippocratic Airs, Waters and Places, Aphorisms and Epidemics I and II had become more familiar to physicians.\footnote{Kaplan, ‘Divulging of Useful Truths in Physick’, 98.} These Hippocratic works explicate the idea that the climate and the weather of a region have a constitution with causal powers over the constitution and temperament of the people and the diseases typical for them. Therefore, they recommend that the environmental factors should be taken into consideration in the therapeutic section of medicine.\footnote{Frederick Sargent, Hippocratic Heritage: A History of Ideas about Weather and Human Health, (Pergamon, New York, 1982), 50-59 and Andrew Wear, ‘Making Sense of Health and the Environment in Early Modern England’, in Andrew Wear, (ed.), Health and Healing in Early Modern England’, (Ashgate, Aldershot, 1998, 119-147), 127.} Boyle’s interest in air and its influence in human health has sometimes been associated with the neo-Hippocratic medical ideas. However, the significance of air to health is only one aspect of his larger investigation into air and its properties. Nevertheless, according to Boyle, the ‘continual Use of the Air is so absolutely necessary to our Life; the good or bad Temperature of it is so important to our Health’ that ‘among mere Bodies there are perhaps few Subjects that more deserve our Curiosity.’\footnote{Boyle, General History of Air, 9.}

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Boyle conceived air as a heterogeneous substance with a corpuscular structure. In addition, air functions as a vehicle which carries other corpuscles, such as ‘salubrious and insalubrious effluvia’ originating from the earth, for instance.\(^\text{351}\) In his ‘Salubrity of the Air’ (1685), Boyle discussed his ideas about how the ‘impregnation’ of air ‘from Subterraneal Effluvia’ affected human health. According to him, it was probable that ‘the noxious Mineral Exhalations’ were the cause of various endemic and epidemic diseases. These ‘noxious particles’ could enter the body by respiration, through the pores of the body and with aliment.\(^\text{352}\) Boyle employed his chemical experiments, together with other proofs, to show that air carried these ‘subterraneal effluvia’. He also believed that the ‘Effluvia that pass into the Air, may be distinguish’d into several sorts, according to their respective Natures’.\(^\text{353}\) Sydenham likewise regarded epidemic effluvia, together with the sensible qualities of air, as probable causes for epidemic disease. He, however, conceived effluvia as ‘occult’ causes which were by definition impossible to know. In Observationes Medicae, he pointed out that air could have a ‘malignant’ constitution which caused epidemic disease. In case no sensible cause for the unwholesome nature of air was to be found, ‘we must confess our ignorance, and admit only a blind, inexplicable, and malignant constitution of the atmosphere.’\(^\text{354}\)

Although Boyle and Sydenham disagreed about the relationship between natural philosophy and medicine, their views met in the field of practical medicine. Boyle agreed with Sydenham that the principal goal of all medical investigation was the improvement of the therapeutic part of medicine.\(^\text{355}\) In addition, they shared the view about the explanatory level required in practical medicine. Sydenham thought that medical knowledge about the causes of disease was limited to ‘mediate causes’. His writings show that he conceived the ‘mediate causes’ principally as humoral factors of which he emphasized the changes in the qualities of blood as a cause of disease. The


\(^{352}\) Boyle, ‘Salubrity of the Air’, 312-313, 318, 322.

\(^{353}\) Boyle, ‘Salubrity of the Air’, 307, 324-325.

\(^{354}\) Sydenham, Methodus Curandi Febres, 59.

\(^{355}\) Boyle, Usefulness II, sect. I, 364.
'Conjunct of mediate causes’ could be known with certainty since they ‘offer themselves plainly to the Understanding, or may be discovered by the Testimony of the Senses, or by others Anatomical Observations made long ago.’ Boyle, too, regarded intermediary theories, such as knowledge about the medicinal qualities of different substances, as sufficient for successful medical practice. Moreover, according to him, ‘the most useful Notions we have both in Physicks, Mechanicks, Chymistry, and the Medicinal Art, are not deriv’d immediately from the First Principles; but from Intermediate Theories, Notions and Rules: it being often sufficient for very useful Purposes to terminate our researches into some settled Rule or aequivalent Axiome of Nature, and thence derive Practical Conclusions by way of Inference or Application.’

Despite his new method of medical investigation, Sydenham’s medical and natural philosophical outlook was somewhat traditional. He made a strict division between medical practice and theory. In a manner common to learned medical men, he saw no reason to apply his perspective of practical medical experience to the discovery of theoretical medical knowledge. When it comes to his ideas about natural philosophy, his view of its bookish nature, together with his ideas about ‘inscrutable occult’ causes, indicate that for him natural philosophy meant first and foremost the traditional ‘school’ philosophy. Nonetheless, his disregard for chemistry and preference for ‘others Anatomical Observations made long ago’ suggest that he regarded new philosophical ideas as no better. However, his reference to the Baconian method of natural history indicates that he made an attempt – even though a half hearted one – to associate his medical investigation with one of the natural philosophical currents of the day.

II

Seventeenth-century medical authors often referred to the ancient and modern authorities, such as Hippocrates or William Harvey, in their works. Particularly for those medical men who were concerned with practical medicine, a return to what was

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356 Sydenham, Observationes Medicae, a5-a6.
358 Sydenham, Observationes Medicae, a5-a6.
regarded as Hippocratic medicine and method was one of the solutions available in contemporary crisis of natural philosophical and medical theory.\textsuperscript{359} In natural philosophy, famous philosophers, such as Aristotle, Bacon or Descartes, functioned as similar indicators of the philosophical current the author wished to align his ideas with. Since learned physicians also were natural philosophers by education, they often combined natural philosophical and methodological currents with specifically medical trends, such as Hippocratism or Galenism. It is clear that some medical ideas assimilated more comfortably with a particular philosophical outlook. Hence a particular medical trend, such as Hippocratism for instance, was often combined with philosophical currents which placed emphasis on the empirical origins of knowledge.

However, although the Hippocratic \textit{corpus} and Francis Bacon’s ideas about natural history presented important models of experimental and observational approaches to knowledge, no Baconian-Hippocratic method of medical inquiry existed. Instead of offering a clear model of method, Bacon’s works and the Hippocratic \textit{corpus} functioned as sources of various methodological, philosophical and medical ideas. These ideas, however, were hardly adopted as such but modified and employed for different purposes. Moreover, Bacon and Hippocrates functioned as authorities who justified various novel approaches to medical epistemology. Petty and Boyle aligned themselves with the Baconian tradition but felt no need to justify their medical ideas by medical authority. By contrast, for a controversial medical practitioner and writer like Sydenham, Hippocrates offered an important authority and example. Sydenham justified his own experimental and observational method of medical inquiry by appealing to the example of Hippocrates. His ‘Baconian-Hippocratic’ method, however, was hardly a mere rhetorical move he made to protect himself from critics. On the contrary, in \textit{Observationes Medicae}, he explicated his Hippocratic method of medical discovery thereby exposing his medical method to criticism.\textsuperscript{360}

\textsuperscript{359} French, \textit{Medicine before Science}, 190-191.
\textsuperscript{360} Sydenham, \textit{Observationes Medicae}, a4.
Sydenham’s medical method resembled the practises of empirical healers. The term ‘empiric’ referred to a practitioner who had no academic learning but had gained his medical skills by practice. Moreover, an empiric focused on curing disease instead of practising the holistic learned ‘physick’. Accusations of medical empiricism and quackery were generally presented in seventeenth-century medical disputes disregarding the medical education of the target; also university educated physicians were often accused of medical empiricism.361 Sydenham is known for the controversy his work aroused in contemporary medical community. Despite his academic education and licence to practice medicine in London, he was criticized by his colleagues. Andrew Cunningham has suggested that Sydenham’s religious and political ideas were important causes for his occupational difficulties. Kenneth Dewhurst, however, has pointed out that Sydenham’s medical ideas certainly affected his unpopularity among learned physicians as well.362

We have good reasons to believe that Sydenham himself regarded his medical views and practises as the cause of the criticism his work faced. His remark in a letter to Boyle indicates that his critics had associated his work with that of medical empirics. Sydenham believed that the criticism harmed his practice and complained to Boyle that, due to his advanced methods of treatment, his learned colleagues rather attacked him than the real quacks:

I have the happiness of curing my patients, at least of having it said concerning me, that few miscarry under me; but cannot brag of my correspondency with some other of my faculty, who, notwithstanding my profoundness in palmistry and chemistry, impeach me of great insufficiency ... Though yet in taking fire at my attempts to

362 Cunningham, ‘Thomas Sydenham’, 175-176, 189, Dewhurst, Dr. Thomas Sydenham, 34-36, 42-44.
reduce practice to a greater easiness and plainness, and in
the mean time letting the mountebank at Charing-Cross
pass unrailed at, they contradict themselves. 363

The contemporary translator of Sydenham’s works, John Pechey, pointed out that
because Sydenham was ‘much conversant in Practice ... he was so much calumniated by
ill Men.’ Pechey himself fell likewise into a conflict with the London medical
establishment. Like Sydenham, he was a ‘practical doctor’. In addition to translating
Sydenham’s works, Pechey participated in the work of a joint repository with some of
his colleagues. Although never directly accused of medical empiricism, Pechey and his
associates anticipated such accusations and answered these in advance with a published
pamphlet. 365

Boyle’s interest in medicine has led some historians to ponder on how his medical
views relate to the neo-Hippocratic ideas of the day. Robert Martensen has noted that
the emphasis Boyle placed on therapeutics and his relative indifference towards causal
explanation in medicine give Hippocratic flavour to his medical work. 366 We have good
grounds to regard Boyle rather as a protagonist for a medical reform than as an adherent
of the traditional school ‘physic’. We have, however, no evidence that Boyle would
have regarded the Hippocratic corpus as a source of medical wisdom and a solution to
the sad state of medicine. It is true that his view about the significance of air to human
health, together with the manuscript evidence about his ideas about the history of
disease, were somewhat ‘Hippocratic’ in their emphasis on observation and
environmental factors. However, Boyle seldom referred to the Hippocratic corpus.
Generally, his use of authority was sparse. The medical Usefulness makes an exception.
Judging by that work, however, Boyle seems to have favoured Celsus instead of
Hippocrates. Furthermore, like Petty, he regarded the Hippocratic aphorisms as items of

363 Thomas Sydenham to Robert Boyle, 2. 4. 1668, Correspondence, vol. 4, (55-57), 56.
364 John Pechey, (ed. and trans.), The Whole Works Of that Excellent Practical Physician Dr. Thomas
366 Martensen, ‘Hippocrates and the Politics of Medical Knowledge’, 117, 123.
knowledge requiring critical examination and interpretation.  

Boyle was a natural philosopher who had a strong interest in medicine. He considered ways of approaching medical questions experimentally and published these ideas in his works. In addition, he used medicine as an example of a field where the experimental approach could and already had provided important progress. However, Boyle’s social status prevented him from practising medicine. As a consequence, he had no similar opportunity to conduct medical inquiries as a physician. He endeavoured to apply his experimental approach to medicine, for example by suggesting that designed experiments on animals were to be used to investigate the causes of disease and the effects of medicines. Nevertheless, it seems that when it came to practical medicine, he was somewhat satisfied with the means the reform-minded members of the medical community employed for improving their art. Furthermore, Boyle was reluctant to take sides in contemporary medical disputes and avoided making sharp statements about the different medical trends of the day. Consequently, it is difficult to associate his medical ideas with any particular current of medical thought, such as neo-Hippocratism, for instance.

SUMMARY

Seventeenth-century ideas and uses of historia were various. Boyle and other English natural historians often referred to Bacon’s idea of natural history as a model for their own work. Boyle followed the Baconian model of natural history elaborating it into his own kind of experimental natural history. Narratives about experiments and descriptions of their results dominate his published natural histories. For Boyle, however, natural history was a flexible genre. In addition to reports about experiments, his natural historical works contain information gained by witness testimonies and from literature, descriptions of experimental techniques he had developed, theoretical discourses and

367 W.P., Advice of WP. To Mr. Samuel Hartlib, 13, Boyle, Usefulness II, sect. 1, 296-297.
titles suggesting topics for further study on the subject matter. Boyle regarded natural history and philosophy as interconnected fields; the matters of fact and theory had a reciprocal relationship. Although he emphasized his role as a natural historian and philosopher, Boyle aimed at including also practical medicine in his natural historical inquiries.

The medical ideas of *historia* differed from the Baconian model of natural history. In medicine, *historia* referred botanical classification, to the description of anatomical experiment and to clinical case histories of several kinds. Of these, only *historia anatomica* had a role in a causal explanation. Many physicians also conducted natural historical inquiries according to the Baconian model. The Baconian natural history was associated with natural philosophy and the medical models of *historia* were not considered relevant in that context. Moreover, some physicians regarded natural history and philosophy as irrelevant to medicine. Thomas Sydenham’s work presents an extreme example of the distinction made between medical and natural history. His work on the history of epidemic disease aimed at the description and classification of disease. In addition, he performed clinical trial-and-error experiments in order to discover new remedies for epidemic fevers. Sydenham’s investigation was practically orientated and he dismissed natural philosophical knowledge as irrelevant for his project. Neither did he regard his work as capable of producing knowledge about the insensible causes of disease.

Sydenham claimed that his method of medical investigation was the ancient Hippocratic method. He also referred to the Baconian model of natural history. Sydenham later became known as the English Hippocrates and the Hippocratic corpus most likely influenced his medical ideas. This chapter has made an attempt to show that no ‘Baconian-Hippocratic’ method of inquiry existed but that the Baconian and the Hippocratic trends of historical inquiry were in many respects incompatible. Instead, the Hippocratic corpus and the works of Bacon functioned as sources of ideas which different authors refashioned according to their own needs. In addition, the names of
Bacon and Hippocrates were used as labels for various kinds of empiricist epistemological attitudes. Particularly in medical literature, the example of these authorities could be used to legitimate unorthodox medical views and practises.

Boyle was a gentlemanly natural historian and philosopher and hence an outsider in the medical community. However, since medicine was based on natural philosophy Boyle -- in his capacity as a natural philosopher -- was qualified to advice physicians when it came to medical knowledge. He advocated experiment as a means of practical innovation and theoretical discovery in the field of medicine. The manuscript writings of his indicate that his views about the history of disease might have differed from his general natural philosophical outlook. However, his medical ideas and methods are hardly associated with any particular medical current of the day. He regarded medicine as a subcategory of natural philosophy and, therefore, aimed at combining the viewpoints of practical medicine and natural philosophy also in his published natural historical works.
3. EXPERIMENT AND MEDICAL RHETORIC

Diseases are not cured with Eloquence, but by Remedies.368

This chapter studies the rhetorical uses of experience, experiment and authority in medical discourse. It focuses on the function of testimony as proof and examines the uses of authority and fact in persuasive medical discussion. The chapter studies Boyle’s use of testimony particularly in the medical *Usefulness*. In that work, medicine presents an example of an important field where experimentalism could and already had produced significant innovations. Testimony forms a major category of proof in the work. I also compare Boyle’s use of testimony to that of some of his contemporary physicians. My examination suggests that the rhetorical use of authority was an indispensable element of persuasive medical discourse. Furthermore, although Boyle, unlike most physicians, did not favour appeals to the approved authorities, he made no absolute separation between fact and authority in his medical *Usefulness*.

I begin the chapter by examining the attitudes Boyle and the English experimentalists held towards rhetoric. The first section discusses briefly the experimentalists’ general views on rhetoric and proceeds by examining Boyle’s views about the use of rhetorical means in different kinds of experimental texts. In addition, I discuss the significance of the considerations of the intended audience had for Boyle’s literary presentation and style. The section seeks to show that, instead of rejecting rhetoric, Boyle employed carefully chosen rhetorical means in his works. The second section of the chapter discusses the rhetorical category of testimony and the issue of evaluating witnesses and their testimony. Traditionally, the probatory force of testimony resided in the authority of the witness. It has been suggested that in the seventeenth century, a gradual shift of

emphasis from authority to the factual contents of testimony occurred.\textsuperscript{369} Boyle employed numerous witness reports in his treatises. The section examines his views about the use of testimony and his criteria for assessing the credibility of witnesses and their testimonies.

In the third section, I move to study the use of testimony in seventeenth-century polemical medical works. I begin with an examination of how testimony was used in the works participating in the controversy between the chemical physicians and the London College of Physicians. Although Boyle did not participate in the controversy, both sides of the dispute appealed to his authority and referred to his works. The section argues that medical matters of fact played only a minor role in the physicians’ rhetoric. In medical disputes, testimony was applied in a traditional manner by appealing to the approved authorities. Section 3.4. examines Boyle’s use of testimony in the medical Usefulness. In the first part of the section, I study the manner Boyle used authority in medical discussion and show that his use of testimony differed from that of physicians. The second part of the section explores the way the narratives about various kinds of medical experiments provided proof for Boyle’s argument. In addition, it examines Boyle’s manner of combining proof with the distribution of medical information. The section concludes that Boyle’s use of testimony combined fact and authority in a complex way which made no sharp separation between fact and authority.

3.1. Experimental Rhetoric

This section examines Boyle’s views on rhetoric. Thomas Sprat’s remarks against rhetoric in History of the Royal-Society of London (1667) indicate that the new experimental philosophy involved a total rejection of the rhetorical mode of literary presentation. Nevertheless, it seems that instead of rejecting rhetoric, the experimental

philosophers disapproved of the excessive use of rhetorical embellishment and employed a plain style rhetoric in their writings. Boyle’s views on rhetoric were not as negative as Sprat’s. On the contrary, Boyle accommodated the style of his literary presentation to the subject matter and the intended audience of his works in a manner recommended by the rhetorical theory.

I

The founding of the Royal Society at the beginning of the 1660s established the new experimental philosophy in England. The new experimental society also presented a target for the critics of experimental philosophy. Boyle’s contemporaries regarded several aspects of the new philosophy as suspicious. The mechanistic world-view held by many experimental philosophers seemed to implicate atheism. It was likewise feared that the experimental search for new knowledge would encourage ideas leading to religious and social disorder. At the same time, it was argued that the result of experimental inquiry was not knowledge but mere opinion. Moreover, some members of the learned medical community regarded experimental philosophy as a factor which undermined their authority in the battle against medical empiricism. The fact that the London wits and satirists chose experimental philosophers as their targets indicates that these issues were widely known and discussed in the capital.

Several works were published to defend the experimental philosophy. These works – Boyle’s Some Considerations of the Usefulness of Experimental Natural Philosophy (1663, 1671), Thomas Sprat’s History of the Royal-Society of London, For the Improving of Natural Knowledge (1667) and Joseph Glanvill’s Plus Ultra: or, The Progress and Advancement of Knowledge since the Days of Aristotle (1668) – aimed at

persuading the English audience about the usefulness of the experimental approach to natural knowledge. Boyle’s *Some Considerations of the Usefulness of Experimental Naturall Philosophy* emphasized particularly the practical benefits that the experimental natural philosophy would produce. The first part of the work addressed the religious issues raised by the critics of experimentalism. The first section of the second part presented medicine as an example of an important field where an experimental inquiry could produce useful practical innovations.

Thomas Sprat’s *History of the Royal-Society*, which published the agenda of the early Royal Society, was ordered by the Society and supervised by some of its members.\footnote{Hunter, *Establishing the New Science*, 45-71, Lynch, *Solomon’s Child*, 20, 165-166.} Sprat emphasized, among other things, the new ideas that the experimentalists held about language and literary presentation; he claimed that in their use of language the experimentalists had returned ‘back to primitive purity’ and hence used a ‘naked, natural way of speaking’.\footnote{Sprat, *History of the Royal-Society*, 113.} He was particularly hostile towards rhetorical modes of literary presentation and pointed out that ‘the ill effects of this superfluity of talking, have already overwhelm’d most other Arts and Professions; insomuch, that when I consider the means of happy living, and the causes of their corruption, I can hardly forbear recanting what I said before; and concluding, that *eloquence* ought to be banish’d out of all civil Societies, as a thing fatal to Peace and good Manners.’\footnote{Sprat, *History of the Royal-Society*, 111.}

Brian Vickers has noted that in spite of his attack on rhetoric, Sprat could not manage without it in his own treatise.\footnote{Vickers, *In Defence of Rhetoric*, 199. See also Brian Vickers, ‘The Royal Society and English Prose Style: A Reassessment’, in Nancy Struver and Brian Vickers, *Rhetoric and the Pursuit of Truth: Language Change in the Seventeenth and Eighteenth Centuries*, (Castle Press, Pasadena, 1985, 1-76). On Sprat’s work see Lynch, *Solomon’s Child*, 155-196.} Thus Sprat’s negative statements on rhetoric should neither be taken at face value nor as a statement concerning his own style. In his *Plus Ultra*, Joseph Glanvill admired the style of Sprat’s *History of the Royal-Society* and noted that the work ‘wants none of the proper ornaments of Language.’ Glanvill also pointed out that style should be chosen according to the purpose of the discourse; ‘styles
are *Cloathes* that must be fitted to the Subjects they are upon, and altered according to the *different kinds* of things they describe and express.\(^{376}\)

It is not clear whether the spokesmen of new experimental philosophy, such as Thomas Sprat for instance, conceived rhetoric as a theory of both argument and style or only as the excesses of style.\(^{377}\) Wilbur Howell has pointed out that, instead of a total rejection of rhetoric, seventeenth-century English philosophers created a new plain style rhetoric to serve their needs. The new rhetoric was not explicated in works on rhetorical theory but it surfaced in treatises on various other topics. According to Howell, the works of Sprat, Bacon, Hobbes and Glanvill, among others, represent the new plain style rhetoric. Some of its distinctive features were the preference of inartificial over artificial proof and the use of the ordinary patterns of speech instead of stylistic tropes and figures.\(^{378}\)

Boyle’s views on rhetoric were more positive than Thomas Sprat’s. Although Boyle’s formal education was restricted to two years in Eton, it is evident that he knew rhetoric as well as any of his contemporaries and used rhetorical means in his writings. In an early autobiographical text, Boyle accounted that he had studied elementary logic and rhetoric and ‘afterwards he esteem’d bothe those Arts (as they are vulgarly handled) not only unseasonably taught, but obnoxious to those (other) Inconveniences & guilty of those Defects, he dos fully particularize in his Essays.’\(^{379}\) John Harwood has pointed out, however, that Boyle either downplayed his knowledge of rhetoric in his early text or continued to study it in his mature years. According to Harwood, Boyle’s knowledge of rhetoric was later much more extensive than his early ‘Account’ suggests.\(^{380}\)

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\(^{377}\) Shapiro, *A Culture of Fact*, 160.


\(^{380}\) Harwood, ‘Science Writing and Writing Science’, 44.
Boyle explicated his views on rhetoric in several published works. In *Some Considerations Touching the Style of the Holy Scriptures* (1661), he divided rhetoric into two parts ‘the One which consists in the Embellishments of our Conceptions, and the Other that consists in the Congruity of them to our Designe and Method, and the suitable Accommodation of them to the various Circumstances considerable in the Matter, the Speaker, and the Hearers’.\(^{381}\) Hence, it seems that Boyle thought that rhetoric had to do first and foremost with selecting a style and the embellishments according to the nature and the audience of each discourse. However, the rules of rhetoric should not be obeyed ‘slavishly’ since ‘Wise-men ... will not easily lose Good Thoughts, or Good Expressions, because they are not Reducible to Them.\(^{382}\)

In ‘A Proemial Essay’, Boyle pointed out that rhetorical embellishments should be used according to the nature of each discourse.\(^{383}\) In *Excellency of Theology*, he noted that a plain style was often the most persuasive; ‘when the things we treat of are highly important, I think Truths clearly made out to be the most persuasive pieces of Oratory.\(^{384}\) Experimental reports should be written with no rhetorical decoration rather ‘in a Philosophical than a Rhetorical strain’. Moreover, the ‘expressions’ used ‘should be rather clear and significant, than curiously adorn’d’.\(^{385}\) However, as Harwood has pointed out, ‘the movement between the literal and figurative is an important aspect of Boyle’s sense of style.\(^{386}\) For instance, Boyle used a comparison to illustrate how the use of rhetorical embellishment in experimental reports might obscure the matters of fact delivered:

> And certainly in these Discourses, where our design is only to inform Readers, not to delight or perswade them, Perspicuity ought to be esteem’d at least one of the best Qualifications of a style, and to affect needless Rhetorical


\(^{382}\) Boyle, *Style of the Scriptures*, 455.


\(^{384}\) Boyle, *Excellency of Theology*, 98.


\(^{386}\) Harwood, ‘Science Writing and Writing Science’, 51.
Ornaments in setting down an Experiment, or explicating something abstruse in Nature, were little less improper than it were ... to paint the Eye-glasses of a Telescope, whose clearness is their Commendation, and in which even the most delightful Colours cannot so much please the eye as they would hinder the sight.\footnote{387}

By contrast to experimental reports, experimental discourses allowed the use of some rhetorical embellishments. Boyle disapproved both of the ‘Thorns of the Schoolmen’ and of ‘that dull and insipid way of writing which is practis’d by many Chymists’.\footnote{388} In addition to informing, the experimental discourses should also entertain their readers. Therefore, ‘though it were foolish to colour or enamel upon the glasses of Telescopes, yet to gild or otherwise embellish the Tubes of them, may render them more acceptable to the Users, without at all lessening the Clearness of the Object to be look’d at through them.’\footnote{389}

In addition to the considerations of the subject matter, Boyle’s manner of presenting himself as an author had an impact on his literary style. He often pointed out that he was a gentlemanly natural philosopher stressing thereby the difference between his literary style and that of the traditional learned discourse. Boyle aimed at maintaining a polite and moderate style which he contrasted to the disputative style of schoolmen. According to him, it was ‘fit that in a book written by a Gentleman ... the Language should be more smooth, and the Expressions more civil than is usual in the more Scholastick way of writing.’ Moreover, he disapproved of the way some chemical authors railed at their adversaries. In his published works, Boyle aimed at ‘giving an example of how to manage even Disputes with Civility’.\footnote{390}

\footnote{390} Boyle, Sceptical Chymist, 211-12.
II

The expectations and the tastes of the intended readers were important factors which influenced Boyle’s choice of style and argument. John Harwood has noted that in order to persuade, Boyle ‘adjusted his presentation for different kinds of audiences, both popular and learned.’ Generally, rhetorical presentation was regarded as a suitable method for the popular literary works. The treatises promoting experimental philosophy – Boyle’s Usefulness, Sprat’s History of the Royal-Society and Glanvill’s Plus Ultra – aimed at reaching a wide audience. These works were written in the vernacular indicating that they were intended for gentlemanly readers, not merely for scholars. The seventeenth-century English natural philosophical community itself was a heterogeneous group consisting of both the members of the academic community and gentlemen.

Boyle told Gilbert Burnet that his Usefulness of Experimental Natural Philosophy was written principally for a gentlemanly audience. Hence the tastes of gentlemanly readers had an impact on the style of the work. Boyle wanted to ‘addict’ gentlemen to the experimental study of nature. His ‘first designe in Philosophy was to recommend the Usefulness of Experimentall Philosophy to the Gentry who being disgusted with the dry Notions of that taught in schools and knowing no other were prejudiced against all Philosophy’. He ‘pursued it in that chiefly in Relation to Phisick’. To persuade his gentlemanly readers, Boyle discussed medicine in the first section of the second part of his Usefulness. He presented narratives about various kinds of medical experiments as examples to convince his readers about the diverse uses of experiment in medicine. Thomas Sprat used example in a similar manner in his History of the Royal-Society. He illustrated the work of the Society by reproducing instances of ‘their way of Inquiring, and giving Rules for Direction ... from whose exactness it may be gess’d, how all the rest are perform’d.’

391 Harwood, ‘Science Writing and Writing Science’, 41.
392 Howell, Logic and Rhetoric, 3-4.
393 The ‘Burnet Memorandum’: notes by Gilbert Burnet on his biographical interview(s) with Boyle’, in Hunter, (ed.), Robert Boyle by Himself and His Friends, (26-34), 28-29.
The rhetorical authorities recommended the use of example particularly in popular discourses. The classical authors, however, generally tended to recommend stronger means of persuasion than the historical example which, instead of certainty, produced only probability. Aristotle’s *Rhetoric*, for instance, recommends the use of example or induction only when the rhetorical syllogism, enthymeme, was unavailable. Aristotle’s *Topica*, however, suggests example for popular discourses since induction from examples is ‘more easily [than reasoning] grasped by sense-perception’ and is, therefore, familiar to the majority of people. Likewise, Quintilian recommends the use of historical example especially in deliberative speeches as the quickest way of securing assent; ‘practically all authorities are with good reason, agreed that there is no subject to which they are better suited, since as a rule history seems to repeat itself and the experience of the past is a valuable support to reason.’

In the seventeenth century, the general interest in history had an impact on the popularity of the historical example as well. Ann Blair has pointed out that the ‘pragmatic interest in learning from history’ was applied to ‘a broader set of worldly concerns.’ Boyle’s medical *Usefulness* was written for a lay audience to persuade them about the practical benefits experimental philosophy could produce. Testimonies of various kinds form the principal category of proof in the work. Boyle’s use of testimony was extravagant; the medical *Usefulness* contains descriptions of his own experiments, abundance of brief narratives and anecdotes about particular cases of disease and cure, together with a considerable number of quotations from medical literature and travel books. Boyle’s choice of proof seems to have succeeded well; when published, the work turned out to be a success and two editions of it were printed within a year.

Narratives about extraordinary cases of disease and cure were popular among lay readers. However, the learned disciplines, such as medicine, remained ambivalent in their attitudes towards historical example, particulars and induction. For instance, Ian Maclean has observed the general change in the attitudes towards induction in the works of the Paduan professor of medicine Sanctorius (1561-1636). According to Maclean, Sanctorius seems to have been of two minds about particulars and induction. On the one hand, he claimed that nothing follows out of particulars but, on the other, he occasionally admitted that induction indeed produced sufficient proof.\textsuperscript{400}

Also Boyle chose a different style when addressing an audience consisting of medical men and natural philosophers. In his later medical work, \textit{Of the Reconcileableness of Specifick Medicines to the Corpuscular Philosophy} (1685), his use of testimony was more sparse. \textit{Specific Medicines} is not a popular work but a theoretical treatise which speculates on the corpuscular explanations for the effects of medicines. The work is written in a form of a letter to a Dr. F. and it aims at convincing physician-natural philosophers that the corpuscular hypothesis can be employed to explain the effects of specific medicines. Boyle used similar categories of proof as in the medical \textit{Usefulness}; even some particulars presented in the \textit{Usefulness} are re-used in \textit{Specific Medicines}.\textsuperscript{401} However, instead of presenting a large number of interesting case histories, Boyle referred to medicinal experiments only briefly. Furthermore, he produced only a few quotations from the works of the approved authorities and mentioned no travel books.

3.2. Testimony

This section examines the rhetorical category of testimony and the issue of evaluating the credibility of witnesses. The first part discusses testimony and its use in natural philosophy. Testimony was traditionally employed by appealing to the approved authorities. The experimental philosophers, however, turned towards nature as the source of discovery and proof instead of the traditional authorities. Natural phenomena as witnessed by someone were the source of the experimental matters of fact. Hence, the

\textsuperscript{400} Maclean, \textit{Logic, Signs and Nature}, 168-169.
\textsuperscript{401} E.g. Boyle, \textit{Specific Medicines}, 356.
experimentalists’ use of testimony also appealed rather to the facts than to the authority of the witness.

The second part of the section examines the issues connected with the credibility of witnesses. Peter Dear has pointed out that in the work of the early Royal Society, authority was built on the accounts the trustworthy reporters presented about their past experience.402 However, the belief in the truth of matter of fact depended on the trustworthiness of the reporter. Especially in case of extraordinary phenomena, this raised the question about the credibility of the witness. Boyle employed the common criteria of moral qualifications and expertise when evaluating the credibility of a witness. Moreover, experimental repetition provided him with an additional means of assessing both his information sources and their testimonies.

I
Modern historians have emphasized the experimentalists’ distrust for the weight of authority as proof. Quentin Skinner has pointed out that the Royal Society motto – *nullius in verba* – is an explicit rejection of the rhetorical use of authority in science.403 The experimental philosophers of the Society criticized the natural philosophy of the schools for its bookish nature and reliance to the opinions of the authorities, Aristotle in particular. They claimed that experimental philosophy aimed at discovering new knowledge from the ‘Book of Nature’ instead of the writings of authorities. Hence, they rather appealed to the experimental matters of fact than to any intellectual authority.

Richard Serjeantson has examined the development of testimony in seventeenth-century England and shown that a change of emphasis from authority to fact in the use of testimony occurred during the period. In sixteenth-century rhetoric, testimony was employed as the sayings quoted from the works of the approved authorities. The authority of the source guaranteed the truth of his statement. By contrast, in seventeenth-century English natural philosophy, the probatory force of testimony became to reside more in the factual contents of the testimony and less in the authority

of the source. Consequently, the literary form of testimony changed from quotations taken out of the works of the best authors to descriptions of particular matters of fact.

In the traditional dialectical and rhetorical theories, the probatory force of testimony was weak. By the seventeenth century, however, the developments in the arts of discourse had changed these disciplines considerably. In short, dialectic had become more and more regarded as a general art of discourse, whereas rhetoric tended to be conceived as mere embellishment and ornament. The ‘new rhetorical theory’, which was influenced by Francis Bacon’s ideas of communication, tended to favour the inartificial proof provided by testimony instead of the artificial proof traditionally considered more persuasive. Bacon had emphasized the significance of experience and experiment as a method of discovery in sciences and arts. Hence, although the dialectical theory rejected the use of the inartificial topos of testimony in science and arts, Bacon found ‘places or directions of invention and inquiry in every particular knowledge, as things of great use’ since they were ‘mixtures of logic with the matter of sciences’.

The rhetorical and dialectical theories divided the places of inventio into artificial and inartificial. ‘Arguments derived from the whole, from its parts, from its meaning, and from the things that are in some way closely connected with the subject which is being investigated’ were considered originating from the subject matter itself and were brought into an argument artificially by the art of discourse. By contrast, the inartificial topic, which consisted of divine and human testimony, was external to the subject matter. Traditionally, the probatory force of testimony was considered weak. The classical authorities, such as Cicero, Aristotle or Quintilian, did not recommend the extensive use of testimony in discourse. Testimony remained weak proof until the seventeenth century; artificial proof was preferred, whereas most manuals recommend a

405 Lane Patey, Probability and Literary Form, 17 and Shapiro, A Culture of Fact, 160-165.
406 Howell, Logic and Rhetoric, 375-6.
407 Bacon, Advancement of Learning, 124.
sparse use of the inartificial testimony.\textsuperscript{409}

Richard Serjeantson has noted that Boyle used testimony by employing the matters of fact rather than by appealing to the authority of the source.\textsuperscript{410} In natural philosophical discussion, Boyle unambiguously rejected the traditional rhetorical use of testimony as authority. Although his explanation for why he did not present ‘Embellishment borrow’d from eminent Writers’ in ‘A Proemial Essay’ is moderate and almost apologetic, it nevertheless shows his negative attitude towards the rhetorical use of authority in natural philosophy.\textsuperscript{411} In natural philosophical discourse, Boyle did not appeal to other Writers as to Judges, but as to Witnesses, nor employing what I have found already publish’d by them basely as Ornaments to embellish my Writings, and much less as Oracles by their Authority to demonstrate my Opinions, but as Certificates to attest Matters of fact, I may hope that their Testimonies will as well be illustrated by mine, as mine by their’s, and that all of them may contribute to your better Information.\textsuperscript{412}

Nevertheless, Boyle used testimony differently in different works; the subject matter, the nature of the discourse and the intended audience of each work had an impact on his style and argument. In a persuasive discourse, in particular, he employed a more rhetorical style than in his natural philosophical works. Hence, although he preferred to prove by the matters of fact, he occasionally resorted to rhetorical use of authority as well.

\textsuperscript{411} Boyle, ‘A Proemial Essay’, 33-34.
II

Despite the general development of the function of testimony – from authority to fact – it is evident that no absolute separation between people and their testimony can be made. Steven Shapin has pointed out that ‘knowledge of people was constitutively used to make and unmake knowledge of things.’ Jan Golinski has likewise noted that the relationship between the authority of a witness and the plausibility of his report works both ways; the plausibility of a witnesses report affects his personal ‘credit’ as well.

Steven Shapin has studied the manner seventeenth-century English experimental community evaluated testimony and witnesses. He noted that this was a complicated procedure which involved both the examination of the characteristics of the witness and the consistency of his testimony. Shapin concluded that the gentility of a witness was a major factor contributing to his authority and the credibility of his testimony. Shapin’s view has subsequently been widely criticized. Barbara Shapiro, for instance, has argued that instead of assessing witnesses according to the gentlemanly codes of behaviour, the English experimentalists used procedures resembling those used in the common law for examination of witness statements. She has pointed out that the central concept of the English empirical tradition, ‘matter of fact’, is an adaptation from jurisprudence. Hence many of the common law procedures of discovering facts were accordingly carried over to seventeenth-century English experimentalism. In a jury court, the credibility of the witnesses was assessed according to their competence, reputation, demeanour, impartiality in the case, social and economic status on the one hand, and the plausibility and consistency of their testimony, on the other.

417 Shapiro, ‘The Concept ‘Fact, 227. For a more recent discussion of the subject see Shapiro, A Culture of Fact, 105-167.
418 Shapiro, A Culture of Fact, 9-33.
As for Boyle, Rose-Mary Sargent has suggested that he employed no general and fixed criteria when evaluating the credibility of a witness. Instead, he assessed each person according to his experience and competence. Moreover, as also Shapiro has pointed out, the credibility of a witness depended on the circumstances of each case.\(^{419}\) In *Christian Virtuoso*, Boyle noted that “tis as Justly as Generally granted, that the better qualify’d a Witness is, in the capacity of a Witness, the Stronger Assent his Testimony deserves’. ‘For the two grand Requisites of a Witness, being the *knowledge* he has of the things he delivers, and his *faithfulness* in truly delivering what he knows’.\(^{420}\) A Royal Society manuscript text likewise indicates that Boyle regarded the moral qualifications and the expertise of a witness as the principal factors contributing to his credibility. On the one hand, the credibility of testimony depended on the moral qualifications of the witness. According to Boyle, ‘many Testimonies are insufficient for want of moral qualifications in him that gives them’.\(^{421}\) It is obvious that the moral qualifications of the witness were crucial in each case. On the other hand, however, the honesty of the witness was not a sufficient guarantee of the truth of his testimony; ‘even of honest and sincere Witnesses, the Testimony may be insufficient if the matters of fact require Skill in the Relator.’\(^{422}\) Hence a physician was more reliable witness in medical matters than a gentleman or a carpenter, for example. In this respect, Boyle’s views on the matter resemble those presented in the classical rhetorical theory, in Cicero’s works for example.

Moreover, the circumstances under which witnesses and their testimonies were assessed were various. Boyle probably found no difficulty in assessing the qualifications of those witnesses he was personally acquainted with. In the case of an unknown witness, his social network of peers, patrons and acquaintances formed an important certificate of his moral qualifications and expertise. In the case of a literary witness, the plausibility of the matters of fact his testimony delivered had to be assessed in order to estimate the credibility of the author. In addition, as Richard Serjeantson has noted, experiment also functioned as a means of evaluating a witness and his testimony.\(^{423}\) A detailed


\(^{421}\) BP, vol. 9, fol. 25.

\(^{422}\) BP, vol. 9, fol. 25.

experimental report – or a recipe for that matter – provided a means for replication which, when successful, proved both the truth of the matter of fact and the honesty of the source.

3.3. Testimony in Medical Rhetoric

This section examines the use of testimony in the polemical medical works participating in the dispute about the founding of the College of Chymical Physicians. I begin with a brief introduction of the dispute and four works participating in it; Marchamont Nedham’s Medela Medicinae. A Plea For the Free Profession, and a Renovation of the Art of Physick, Out of the Noblest and most Authentick Writers (1665), George Thomson’s Galeno-pale, or, A chymical trial of the Galenists (1665), Robert Sprackling’s Medela Ignorantiae: Or, A Just and plain Vindication of Hippocrates and Galen (1665) and George Castle’s The chymical Galenist a treatise, wherein the practise of the ancients is reconcild to the new discoveries in the theory of physick, shewing that many of their rules, methods, and medicins, are usefull (1667).

The first part of the section examines the use of authority in polemical medical treatises. In the works participating in the dispute about the College of Chymical Physicians, the development from authority to fact in the use of testimony is hardly visible. The medical polemists followed the traditional use of testimony as authority rather than matter of fact. Also Boyle became involved in the dispute. Since his Sceptical Chymist presented him as a chemist and the medical Usefulness advocated medical chemistry, chemical physicians, in particular, employed his authority in their arguments. The second part of the chapter moves to explore the use of case history and medical experiment in the dispute. The section shows that the physicians’ attitudes towards the use of experiment and matter of fact were ambivalent. On the one hand, everyone agreed that the safest therapeutic methods were those that experience had proved effective and safe. On the other hand, however, no physician was willing to admit that he acted like an empiric who experimented on his patients.

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I

The dispute between the radical iatrochemists and the London College of Physicians in the 1660s offers an excellent case for examining how testimony was used in medical disputes. The controversy evolved around the chemical physicians’ attempt to establish their own society in order to legitimate their kind of medical practice. Hence, the chemical physicians involved in the enterprise attacked the right of the London College of Physicians to regulate medical practice in the capital. In addition, the iatrochemists, who were a heterogeneous group consisting of university educated physicians, chemical ‘operators’ and empirical healers, criticized the traditional learned medicine and its practises. The treatises participating in the controversy were highly polemical. Even though the dispute really was about the right to practice medicine in London, also questions about the validity of chemical and galenic theories and their therapeutic applications were raised.\textsuperscript{425}

The iatrochemists presented their petition for establishing a Society of Chemical Physicians in 1665. The controversy between the chemists and the defenders of the traditional learned medicine reached its peak the same year just before the outbreak of the plague in London. A \textit{Medicus Londinensis}, who turned out to be the controversialist Marchamont Nedham, attacked the College of Physicians with his \textit{Medela Medicinae} advocating ‘the Free Profession and a Renovation of the Art of Physick’. Nedham was a well-known figure and writer in the Interregnum political discourse. As a consequence, when he participated in medical controversy, some suspicions about his medical qualifications were voiced.\textsuperscript{426} Nevertheless, the chemical physicians presented a real threat for the London medical establishment since some influential members of the Court supported their enterprise; the Duke of Buckingham and the Archbishop of


Canterbury, together with several gentlemen, had signed the chemical physicians’ petition.\textsuperscript{427} Nedham’s \textit{Medela Medicinae}, in particular, succeeded in disturbing the peace of mind of the collegiate physicians. Subsequently, several members of the College of Physicians published polemical works refuting Nedham’s medical ideas.\textsuperscript{428}

Several of Nedham’s fellow chemists, such as George Thomson, also wrote works defending iatrochemistry against the ‘old-fashioned’ galenic medicine and its practitioners. Thomson, who had his medical degree from Leiden, was one of the leading iatrochemists. He was a prolific writer and published several works participating in the controversy.\textsuperscript{429} Both Nedham and Thomson claimed that the therapeutic methods of the ‘Galenists’ were ineffective and sometimes even dangerous for patients. Nedham justified his view about the need for medical reform by claiming that diseases had changed since the times of the ancient authorities. Therefore, also the traditional methods of learned medicine were out-dated.\textsuperscript{430}

When criticizing the members of the London College of Physicians, the iatrochemists constructed a stereotype of a conservative Galenist unswerving in his faith in Galen, Aristotle and other ancient medical authorities. It is unlikely that any of the members of the College came even close to the stereotype. By contrast, in the 1660s the members of the College held a variety of views about natural philosophy, medical theory and the reform of practical medicine.\textsuperscript{431} The physicians George Castle and Robert Sprackling, among others, defended the traditional learned medicine in the controversy. Although their views on the development of medicine differed, Sprackling and Castle were

\textsuperscript{427} Cook, ‘The Society of Chemical Physicians’, 71-73.
\textsuperscript{429} George Thomson, \textit{Galeno-pale, or, A chymical trial of the Galenists}, (London, 1665) and \textit{IAPANO-PHARMACOPOEIA, Or, A Gag to Johnson that Published Animadversions upon Galeno-pale and a Scourge For that pitiful Fellow Mr. Galen}, (London, 1665). In addition to these, Thomson wrote two treatises on plague, \textit{Loimologia} (1665) and \textit{Loimotomia} (1666). In the 1670s, he continued to defend iatrochemistry in a dispute with Henry Stubbe. For biographical information on Thomson see Charles Webster, ‘The Helmontian George Thomson and William Harvey: The Revival and Application of Splenectomy in Physiological Research’, \textit{Medical History}, 15, (1971, 154-67), 155-156.
\textsuperscript{430} M.N., \textit{Medela Medicinae}, 1-2, 29-55.
\textsuperscript{431} Cook, \textit{Decline of the Old Medical Regime}, 162-165.
university educated physicians and shared a similar educational background.

Robert Sprackling, who published his Medela Ignorantiae in 1665, answered Nedham from the standpoint of a medical humanist. Sprackling’s Medela Ignorantiae defended the ancient medicine of Galen and Hippocrates, in particular. Sprackling’s criticism of Nedham’s Medela Medicinae was built on the presumption that Nedham did not know Greek and, as a consequence, had misunderstood the Hippocratic Aphorisms.\(^{432}\) Sprackling regarded the traditional means of medical studies as sufficient. The anatomical research conducted by Harveian methods and philological studies on ancient medical texts were the means for the improvement of medicine. Philological studies, in particular, were important for correct understanding of the ideas of ancient medical authorities and for medical knowledge in general. Furthermore, according to Sprackling, no improvement of learned medicine was required since ‘the supposed new opinions are only Paraphrases and Enlargements on the old Text’.\(^{433}\)

George Castle’s views about the development of medicine combined the novel chemical and anatomical discoveries with the traditional therapeutic practices of learned medicine. In his Chymical Galenist (1667), he argued for a moderate medical reform which consisted of a combination of the traditional medicine, practical chemistry and the use of experiment.\(^ {434}\) Castle advocated a somewhat similar medical reform as Boyle did in his published works although Castle’s literary style was more polemical than Boyle’s. Castle’s general idea was to preserve those methods of cure which experience had proved successful even if ancient medical theory provided no explanation for their efficacy. Like Sprackling, he defended learned medicine by claiming that Nedham had either misunderstood or deliberately drawn false conclusions from the medical theories he had quoted in Medela Medicinae. Moreover, according to Castle, Nedham’s own

\(^{432}\) See e.g. Sprackling, Medela Ignorantiae, 4-23.

\(^{433}\) Sprackling, Medela Ignorantiae, 149.

\(^{434}\) George Castle, The Chymical Galenist: A Treatise, wherein The Practise of the Ancients is reconcil’d to the new Discoveries in the Theory of Physick; Shewing, That many of their Rules, Methods, and Medicins, are useful for the Curing of Diseases in this Age, and in the Northern parts of the World, (London, 1667), 10. See also Cook, Decline of the Old Medical Regime, 164-165.
medical theories were false; his theory of ‘the Pox and Scurvy’ was ‘a meer whim of his own, and so far from being a solid truth, that it is point blank contrary to the daily experience of the world and the authority and observations of the most learned and faithful Writers.’

Each one of the medical controversialists used testimony in their discourse. In medical literature, arguments were built on authority, reason, and experience. Reason and authority provided strong proof, whereas a particular example and inductive inference were regarded as proof of the weakest kind. For instance, Henry Ainsworth’s *Art of Logick* (1653) states that the ‘Testimonies Theoretical of some great and received Author, alledged after reasons of a Theoretical conclusion, have great force.’ Hence, all the participants in the dispute, except for George Thomson, appealed for the most part to the theories of ancient and contemporary medical authorities by quoting long passages from their works. By contrast, their use of narratives about particular cases was sparse; although the physicians generally acknowledged the value of the matters of fact, they published only a few narratives of individual cases in their works. Furthermore, when presenting narratives about difficult cases of disease and cure they seldom associated these with experiment.

Nedham was explicit about his literary method in *Medela Medicinae*. He noted that it was his ‘design, all along this Treatise, to say little but what is in the language of the best Writers of this latter Age, or agreeable to their Sense.’ He claimed that the traditional learned medicine was inadequate because diseases had changed since antiquity. He built his argument on those medical theories that seemed to agree with his view of disease and its change. Hence, he quoted lengthy passages from the works of modern medical authorities. While doing so, Nedham, whose status as a medical man was dubious, also displayed his medical competence and his knowledge of the recent developments in medical theory. In its excessive use of medical authorities, *Medela Medicinae*...
Medicinae almost becomes a parody of a polemical medical work. Sprackling, for instance, was not convinced about Nedham’s medical qualifications and pointed out that Nedham’s literary method was ‘fitter for a Romance or Poetical Rhapsody, than a serious Medical Discourse.’

The controversialists used the testimonies of the approved medical authorities to prove their claims. Robert Sprackling favoured Hippocrates, whereas George Castle preferred modern authorities, such as ‘the renowned Harvey; the learned Doctors, Glisson, Ent, Higmore, Wharton, and the present Ornament both of his University and Nation, Dr. Willis.’ Despite his preference for Hippocrates, Sprackling also appealed to modern medical authorities. Marchamont Nedham quoted passages first and foremost from the works of such contemporary physicians who had refuted or at least made significant revisions to ancient medical theory. Hence, he employed the theories of his famous contemporaries, such as Thomas Willis or William Harvey, ‘to give some countenance’ to his argument. George Thomson, whose rhetoric differed from that of the other controversialists, settled for occasionally quoting the Hippocratic Aphorisms in Greek in his Galeno-pale: Or, A Chymical Trial of the Galenists (1665). Nedham, Sprackling and Castle used the medical authorities to ‘give some countenance’ to their argument, whereas Thomson used his knowledge of the Hippocratic Aphorisms principally to establish his ethos as a learned physician and a medical author.

The ideas that George Thomson and the other iatrochemists held about medical reform and innovative therapies involved strong empiricist views. Instead of using medical authorities as proof for his argument, Thomson aimed at persuading his readers first and foremost by reminding them about their experience about the painful treatments of the traditional medicine. Moreover, Thomson accused the traditional ‘galenic’ physicians of ‘verbosity’ and claimed that eloquence was their predominant method of cure. Furthermore, according to Thomson, the ‘galenists’ concealed their errors in medical

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439 Sprackling, Medela Ignoratiae, 1.
440 Castle, Chymical Galenist, 3-4.
441 M.N., Medela Medicinae, 374, 487.
442 Thomson, Galeno-pale, 56, 60-61.
practice ‘by the best of Rhetorick or Logick’. In his hostility towards rhetoric and the rhetorical use of testimony Thomson resembles Thomas Sprat. Thomson also disapproved of the use of authority in arts and sciences and, in particular, the *ipse dixit*-type of argument:

Such reverence doth some mens Authority carry with it, that they need not take pains to invent *Arguments*, where an ἀντίδρασις puts the matter out of doubt. Indeed we much approve this in Religious Matters, but can by no means allow it in *Humane Arts* and *Sciences*, which ought to have something of *Demonstration* to confirm the *Truth* of them.444

Thomson’s discourse echoed some of the central ideas of the experimental natural philosophy. Some contemporaries, such as Henry Stubbe, associated the arguments of the iatrochemists with those employed by the experimental philosophers. According to Stubbe, Boyle’s medical *Usefulness* ‘hath been the occasion of all the insolencies’ the members of the College of Physicians ‘have received from Dowde to Glanvill and Thompson’.445

Boyle was one of the modern authors whose works both sides of the medical dispute appealed to. Boyle was reluctant to take sides in medical disputes.446 However, since his medical *Usefulness* emphasized the various uses of chemistry in medicine, the work was favoured among the iatrochemists. Nedham, in particular, appealed to the medical *Usefulness* and Boyle’s authority in *Medela Medicinae*.447 The advocates of the traditional learned medicine likewise readily appealed to Boyle’s authority; Boyle’s attempt in the medical *Usefulness* to compromise between the traditional medicine and

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446 See e.g. Boyle, *Usefulness II, sect.1*, 317, 415.
the new chemical therapies offered numerous opportunities for both sides of the controversy. Hence, both the chemical controversialist Nedham and the traditionalist Sprackling could select from the medical *Usefulness* passages to back up their arguments. Moreover, Sprackling contrasted Boyle’s moderate style to the ‘immodesty and rashness’ of Nedham’s ‘Pen’.\textsuperscript{448} In *Chymical Galenist*, George Castle likewise appealed to the authority of ‘that great inquirer into Nature, Mr. Boyle’ and quoted those passages from Boyle’s *Sceptical Chymist* which criticized contemporary chemists and chemistry.\textsuperscript{449}

II
Both parties of the controversy between the iatrochemists and the College of Physicians used testimony mostly in a traditional manner by appealing to the approved authorities. Medical authority provided stronger proof than experience and empirical particulars. In general, physicians tended to refer to the medical authorities and their theories to display their own status as learned practitioners.\textsuperscript{450} Medical theory was essential for the status of the discipline and its practitioners. When experience entered the physicians’ argument, it usually took the form of the ‘common experience of physicians’. Although the physicians occasionally referred to individual cases of disease and cure, they tended to be cautious about the use of case history as proof. In the previous chapter, we saw how Thomas Sydenham preferred not to include too many particular instances in his works. He conceived published case histories principally as a means of giving his therapeutic methods ‘a Reputation’. In addition, he regarded publishing case histories as disadvantageous for medicine; it added ‘one unknown Medicine ... to the almost infinite heap of celebrated Medicines.’\textsuperscript{451}

\textsuperscript{448} Sprackling, preface to *Medela Ignorantiae*.
\textsuperscript{449} Castle, *Chymical Galenist*, 11-13, 16-17, 21-22.
\textsuperscript{451} Sydenham, *Observationes Medicae*, a4, a7-a8.
Narratives about particular cases of disease and cure had their own genres and
established roles in medical literature. The medical genres of consilia, observationes
and curatio were discussed above in 1.2.. In learned medical discourse, particulars
provided only weak proof. Generally, publishing medical particulars was seen as an
activity of the inferior practitioners, such as surgeons, for instance. Therefore,
presenting narratives about individual cases was regarded as an unsuitable or a futile
practice for a learned physician.\footnote{Siraisi, Clock and the Mirror, 201-202.}
The inferior practitioners used narratives about
individual cases of disease and cure to legitimize their medical practices in several
ways. Common to these all was the idea that a narrative about a case of disease and its
successful cure testified for the skills of the practitioner and the validity of his practices.
For instance, when applying for a licence to practise from a town council or the church,
practitioners often proved their medical competence by witness testimonials about the
cures they had performed.\footnote{See e.g. Cotta, Short Discoverie of the Unobserved Dangers, 1 and Primrose, Popular Errours, 43.}
When published, such narratives about disease and cure, particularly if revealing the identities of the patient and of the witnesses, were regarded
as advertising. Advertising was unbecoming for a learned physician since it was the
means the medical empirics employed to sell their nostrums.\footnote{See Todd H.J. Pettigrew, “Profitable unto the Vulgar”: The Case and Cases of John Cotta’s Short
Discoverie”, in Elisabeth Lane Furdell, (ed.), Textual Healing: Essays on Medieval and Early Modern Medicine, (Brill, Leiden, 2005, 119-137).}

A learned physician justified his medical practices principally by his theoretical
learning.\footnote{Lane Furdell, Publishing and Medicine, 135-154, Porter, Quacks, 133-181. See also Cook, Trials of an Ordinary Doctor, 136-157.}
When he presented a narrative about a particular case, its function was often
to show how his theoretical knowledge formed the basis for his rational practice.
Whatever the actual reasons for publishing medical particulars were, the learned
medical community tended to be suspicious towards authors who presented too many
particulars. In addition, for a learned physician, a narrative about a particular case of
disease and its cure by a novel method was an uncomfortable piece of proof.\footnote{Pomata, ‘Praxis Historialis’, 124-127.}
an account of an ordinary case provided no convincing proof. Instead, a narrative about an
extraordinary and difficult case, such as that Thomas Sydenham presented in his
Methodus Curandi Febres, was required. Sydenham’s patient died but he continued to
experiment until he found a cure for the ‘strange fever’.\textsuperscript{457} However, for a learned
physician, a narrative about a trial-and-error experiment was an ambiguous piece of
proof when no satisfactory theoretical explanation for the success of his method could
be given. Trial-and-error experiments were not based on medical theory. Since the
difference between a physician and a quack lay on the former’s knowledge of theory,
these experiments were often associated with empirical medicine or outright
quackery.\textsuperscript{458}

Medical theory, however, could not be employed to decide the dispute between the
iatrochemists and the College of the Physicians. Both parties agreed that ‘Rational
Physicians’ were men ‘who from their knowledge of the essential Principles of things
do so form their Medicaments, that they have a certain ground wherefore they put in
this or that, and prepare things thus or thus, from solid reason leading them by the hand
towards the accomplishment of their work.’\textsuperscript{459} As Andrew Cunningham has noted, in
medical disputes, ‘everyone is on the side of both reason and experience, and reason and
experience are on the side of everyone, but they mean different things to different
people.’\textsuperscript{460} Both the iatrochemists and the defenders of the traditional medicine claimed
that the combination of their kind of theory and experience led to the best and safest
practice.

The disagreement arose about who possessed the true ‘Essential Principles’, that is, the
valid medical theory. George Thomson suggested that clinical success and an outright
trial were the best means for deciding between the competing theories.\textsuperscript{461} Moreover,
Thomson suggested that, in addition to basing their therapies on a valid medical theory
– in Thomson’s case provided by van Helmont’s iatrochemical theory – all physicians
should follow his example and test their medicines on themselves before prescribing

\textsuperscript{457} Sydenham, Methodus Curandi Febres, 201-203. See above p. 101.
\textsuperscript{458} Wear, ‘Epistemology and Learned Medicine, 162-172.
\textsuperscript{459} M.N., Medela Medicinae, 453.
\textsuperscript{460} Cunningham, ‘The Transformation of Hippocrates’, 107.
\textsuperscript{461} Thomson, Galeno-pale, 87-88.
them to patients.\textsuperscript{462} Hence, the ‘fashion of experiment’ is visible in the physicians’
treatises as well. The iatrochemists were eager to align themselves with the recent
developments in natural philosophy. Thomson emphasized the significance of
experiment in medical practice. In \textit{Medela Medicinae}, Nedham discussed disease in
relation to the Bills of Mortality recently gathered by John Graunt and, in addition, gave
detailed accounts about several experiments and observations conducted with a
microscope.\textsuperscript{463} As for George Castle, he admired the anatomical discoveries of William
Harvey, Nathaniel Higmore and Thomas Willis.\textsuperscript{464}

Despite their references to the new philosophical and medical currents, however,
Thomson, Nedham and Castle rather followed the conventions of the medical literature
than wrote similar detailed accounts of experiments as Boyle did. Lay audience might
have preferred the detailed narratives of extraordinary cases of disease and cure but the
physicians tended to present only a few brief particulars without identifying their
patients. Moreover, they produced particular instances at the end of their discourse after
the stronger proof of reason and authority. Thomson did use some narratives of disease
and cure as proof in \textit{Galeno-pale} but rather than presenting detailed accounts he
referred to these particulars only briefly. He noted that he had ‘sound Arguments
deduced from some experimental Demonstrations (which we would set down at large, if
succinctness which we aim at did permit)’.\textsuperscript{465} Likewise, George Castle presented a few
short narratives about individual cases in his \textit{Chymical Galenist}. His particular instances
accounted either his own cases or originated from the treatises of renowned medical
authors, such as Thomas Willis or Francis Glisson. In addition, Castle presented the
testimony of his ‘honoured, learned Friend, Dr. Cox, Physitian in Ordinary to His
Majesty’ who had visited a patient that died after ‘taking a Vomit from an \textit{Emperick}’.\textsuperscript{466}

\textsuperscript{462} Thomson, \textit{Galeno-pale}, 88.
\textsuperscript{463} M.N., \textit{Medela Medicinae}, 42- 51, 191-197.
\textsuperscript{464} Castle, \textit{Chymical Galenist}, 3-4.
\textsuperscript{465} Thomson, \textit{Galeno-pale}, 52.
\textsuperscript{466} Castle, \textit{Chymical Galenist}, 22-23.
Nevertheless, although presenting a large number of individual instances was regarded as unsuitable for a physician, some particulars were expected. In order to cast doubt on Nedham’s medical qualifications, Sprackling pointed out that Nedham’s references to his own medical practice in *Medela Medicinae* were obscure. He insisted that Nedham should have proved his medical competence by case histories which identified his patients. Sprackling pointed out that ‘it is unreasonable to exact our belief of such particulars, unless you named the persons on whom you have practised, and therefore you should bring other confirmations of your assertions, than your own private praetended experience; which is as questionable, as your boasted speculations.’

Thomson identified his patient by name in the ‘*History of three large Stones excluded the Colon by Chymical Medicines*’ appended to *Galeno-pale*. He published the narrative to assure his readers of the efficacy of his chemical medicines as well as of the inefficacy of traditional galenic remedies in curing the common and painful disease of ‘Stone’. In addition, he wanted ‘to encourage all *Ingenious* and *Industrious* Artists in their labours’. In the text, he revealed neither the details of the treatment he had used nor the recipes of his medicines. Instead, he stated that he was willing to ‘enter upon a direct proof’ and demonstrate the efficacy of chemical medicine in front of ‘impartial Judges’.

As far as I know, the collegiate physicians ignored the challenge of experiment proposed by Thomson and the other iatrochemists. The learned physicians placed no value in the iatrochemists’ experiments since they were based on a wrong theory. As a consequence, the medicinal experiments of the iatrochemists were also dangerous. George Castle’s discussion about medical experiments in *Chymical Galenist* shows how complex an issue experiment was in medical discourse. Castle defended learned medicine but also advocated chemistry and experiment as a means for the development

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of the field. He argued in a common manner by emphasizing the difference between the experience of a physician and an experiment of a quack. In *Chymical Galenist*, he replaced the term ‘quack’ with a ‘pseudo-chymist’. He claimed that since the ‘pseudo-chymists’ based their medicinal experiments on a false theory, their experiments were dangerous for patients. Castle made the demarcation between safe and dangerous experiments principally with his choice of words. He pointed out that ‘no lesse will those Medicines, which the constant trial of the World has recommended as effectual, remain serviceable to Physitians, before such as are imagined by the touchy head of M.N. or any other whimsical Inventer of Secrets and Remedies.’ Moreover, ‘medicines were at the first found out by a frequent Triall of each Medicine upon sundry Persons. I have shew’d how dangerous it is for ignorant Quacks, to Experiment Medicines (especially such as are hazardous) upon the Bodies of men.’

In *Medela Ignorantiae*, Sprackling pointed out that Nedham’s ‘private experience’ was not convincing. Instead of their own private experience, learned physicians often stressed the significance of the common experience of their profession for medical practice. For instance, George Castle pointed out in his *Chymical Galenist* that the ‘Maxims and Remedies in Physick’, which the iatrochymists attempted to refute, had been ‘established by the long and infallible experience of the World’. Hence, when bringing empirical material into his argument, Castle rather referred to the common experience of physicians than to the particular instances from his own medical practice. ‘The common experience of physicians’ was a testimony of a particular kind; it was parallel to ‘public opinion’, a testimony of the multitude. The ‘common experience’ implies rather authority than matter of fact; it is the testimony of the many, of the wisest and of the best. George Thomson’s claim of having experimented on himself before prescribing medicines to his patients was a shrewd move. When arguing for a novel medical theory and practice, the proponents of iatrochemistry, such as Thomson and

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471 Castle, *Chymical Galenist*, 16-17.
472 Castle, *Chymical Galenist*, 129.
474 Castle, *Chymical Galenist*, 17.
475 E.g. Cicero, *Topica*, XX 78.
Nedham, could hardly appeal to the ‘common experience’ of physicians. In their case, it was experience of a wrong kind.

Previously, in Chapter 1, we saw that Boyle advocated rather experience-based than theory-based therapeutics.\textsuperscript{477} Boyle, however, acknowledged the value of the common experience of physicians and ‘would not willingly dissent from them, about those notions in their own profession, wherein they seem generally to agree’.\textsuperscript{478} Although the demarcation between a physician and a quack was not a crucial issue for Boyle, he considered the issue when participating in medical discourse. We saw earlier that when publishing medical information, he often stressed the role of a physician in curing disease. In the medical \textit{Usefulness}, he likewise distinguished his specific medicines from the cure-all remedies of empirical practitioners; he was ‘not so much a Mountebank as to recommend’ his remedies he ‘as certain Cures in the Cases wherein they are proper’.\textsuperscript{479}

3.4. Authority and Experiment in Boyle’s Medical Rhetoric

And tho in Matters Philosophical I am little sway’d by mere Authority, yet the concurrent suffrage, of many eminent Physicians, may in this controversy be ... considerable.\textsuperscript{480}

Boyle’s medical works offer an excellent material for an examination of his manner of using and assessing testimony and the credibility of witnesses. This section examines Boyle’s use of testimony in medical discourse and focuses on his medical \textit{Usefulness}, in particular. According to Boyle, in an ‘affair in which propriety holds the first place together with profit, the arguments by which most men are chiefly moved are derived

\textsuperscript{477} See above p. 42-43.
\textsuperscript{478} Boyle, \textit{Usefulness II, sect.1}, 415.
\textsuperscript{479} Boyle, \textit{Usefulness II, sect.1}, 531.
\textsuperscript{480} Boyle, \textit{Specific Medicines}, 362.
from examples and authorities. In the medical *Usefulness*, Boyle aimed at proving his readers that his kind of experimental philosophy produced knowledge which also had practical applications useful in everyday life. Medicine functions as an example of a field where experimental inquiries had already produced important innovations. To convince his readers, Boyle employed an extensive selection of different kinds of proofs. These include items such as narratives about various kinds of medical experiments, descriptions of the medical practices of foreign nations quoted from travel books, practical instructions and medical recipes. In addition, Boyle appealed both to ancient and modern medical authorities.

In this section, I seek to show that in an expert field, such as medicine, the naked matters of fact were not persuasive enough. Even if Boyle might have preferred to prove by matters of fact, his readers were accustomed to appeals to authority and would probably not have been convinced by the mere facts. Medical authority was a powerful means of persuasion and hence an indispensable factor in persuasive medical discourse. Nevertheless, Boyle’s use of medical testimony differed from that of physicians. He presented no theories of medical authorities but rather quoted their opinions on more general medical issues.

Boyle also published numerous medical particulars in the medical *Usefulness*. These medical matters of fact function as examples in the work. Likewise, the recipes and instructions for medical preparations present practical examples of the uses of experiment for medicine. At the same time, they function as certificates for Boyle’s authority and expertise in medical matters. In addition to Boyle’s own experiments, the medical *Usefulness* also contains numerous witness testimonies about interesting medical phenomena. Experiment provided Boyle with a means of testing both the truth of the matters of fact and the honesty and sincerity of his information sources. Boyle’s manner of using medical testimony involved a complex interplay of matter of fact and authority; in his accounts of particular instances, matters of fact tend to intermingle with

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the authority of the people involved in the case.

I

Seventeenth-century writers generally referred to figures of intellectual authority for purely polemical purposes.\textsuperscript{482} One of these purposes was to establish the author’s \textit{ethos}, in other words, his reliability and expertise in relation to the subject matter of his discourse. Quentin Skinner has pointed out that, as for questions of knowledge, already at the end of the sixteenth century there had occurred ‘an explicit rejection of this assumption [of the importance of establishing \textit{ethos}] as an obvious irrelevance in the case of science’. Skinner regards this as the principal meaning of the Royal Society motto \textit{nullius in verba}. He notes that ‘whatever may be necessary in legal or political argument, there is no need in reporting scientific findings to establish one’s ethos in this way, since the force of the argument should be such as to persuade anyone capable of following it.’\textsuperscript{483} By contrast, Steven Shapin has argued that Robert Boyle made a powerful effort in order to establish his ethos as a Christian gentleman who studied nature with no professional interest.\textsuperscript{484}

Throughout his medical works, Boyle presented himself as a gentleman and a natural philosopher whose work could also benefit medicine and therapeutics, in particular. He acknowledged that his perspective to medical matters was that of an outsider. Although his status as a natural philosopher made him a competent judge of medical knowledge, he also appreciated the practical medical knowledge of medical practitioners. Consequently, he pointed out that although in natural philosophy he was not persuaded by authority, in medical discourse he listened to the opinions of the medical profession.\textsuperscript{485} Boyle, however, was himself also involved in practical medicine although these activities of his were not widely known. Therefore, displaying his thorough knowledge of the learned medical literature provided him with an effective means to

\textsuperscript{482} Kroll, \textit{Material Word}, 143.
\textsuperscript{484} Shapin, \textit{Social History of Truth}, 126-192.
\textsuperscript{485} Boyle, \textit{Usefulness II, sect. I}, 415.
prove his ability to practice medicine and to write medical books. The medical *Usefulness* was Boyle’s first and most extensive medical work. Therefore, in order to convince his readers of the usefulness of experiment for medicine he also had to show them that he was a competent judge in medical matters. Displaying his knowledge of medical literature was one of the means to do this.

In the medical *Usefulness*, Boyle aimed at persuading both by the medical matters of fact and by the opinions of medical authorities. He explained that he had ‘somewhat contrary’ to his ‘Custom’, ‘frequently enough allledged the Testimonies of others’ since ‘even among professed and learned Physicians, scarce any thing is more common, then on Subjects far less of kin to Paradoxes ... to make use of the Testimonies and Observations of other approved Writers, to confirm what they teach.’ He appealed to the works of ancient authorities, such as Galen, Hippocrates and Celsus, in particular. Although Galen and Hippocrates were the most valued of the ancients, Celsus was the most useful for Boyle’s agenda of promoting experimentalism. He quoted Celsus several times to show that the ancients had regarded experience as the basis of the art of medicine. However, contrary to the physicians discussed in the previous section, Boyle did not quote the medical theories of these medical authorities. Instead, he employed their views on more general medical issues whenever these agreed with his argument.

When discussing the dangers involved in experimentation on human subjects, Boyle pointed out that ‘in his Comment upon the Aphorisms, where having mention’d the danger of trying conclusions upon Men, by reason of the nobleness of the Subject’, Galen concludes: ‘*In corpore autem Humano ea tentare, quae non sunt experientium comprobata periculio non vacat; cum temerariae experientiae finis sit totius Animantis internecio.*’ Likewise, when considering the complexity of the causes of disease

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489 Boyle, *Usefulness II*, sect.1, 297. ‘But I dare not try those things upon Humane Body, which have not been before try’d upon former Experiences, For the End of such rash Experiments may be the ruin of all Lives.’, (541).
Boyle appealed to ‘the authority of Hippocrates himself, both in other passages, and especially where he says, Non calidum, frigidum, humidum, aut siccum, esse quod magnum agendi, vim habet, verum amarum & salsum & dulce & acidum & insipidum & acerbum, &c. are the things which, though inoffensive to the Body, whilst they duly allay each other, prove hurtful to it, and distemper it, when any of them comes to sever it self from the rest, and grow predominant.’\(^{490}\)

However, although Boyle quoted ancient authorities in his medical *Usefulness* more than he did in his other medical or natural philosophical works, these authorities form only a minor category of proof in the work. Furthermore, he combined the opinions of authorities to narratives about medical experiments and observations. Moreover, he tended to conflate authority with facts in a subtle manner. For instance, he described William Harvey’s extraordinary method of curing ‘tumors’ in a manner which, in addition to employing Harvey’s authority, advocated the Helmontian chemical medicine. The acceptance of William Harvey’s theory about the circulation of the blood had made Harvey the leading modern authority in English medical discourse. In the latter half of the seventeenth century, there hardly was a medical treatise published in England where Harvey’s name is not mentioned. George Castle, for instance, regarded Harvey as ‘an Oracle’\(^ {491}\).

Boyle’s description of Harvey’s method of curing ‘tumors’ provided an affirmative answer to his rhetorical question of ‘whether there may not be a sort of others [medicines] that operate, in a more wonderful and extraordinary way?’\(^ {492}\) Boyle commended

the curiosity of Dr. Harvey, who, as rigid a Naturalist as he is, scrupled not often try the Experiment mentioned by Helmont, of curing some Tumors or Excrencies, by

\(^{490}\) Boyle, *Usefulness II, sect.I*, 317: ‘...that it is not heat, or cold, or wet, or dryness that has the great power of action, but the bitter, the salty, the sharp, the insipid, the acerbic ...’.

\(^{491}\) Castle, *Chymical Galenist*, 72.

holding on them for a pretty while (that the cold may thoroughly penetrate) the Hand of a man dead of a lingering disease; which Experiment, the Doctor was not long since, pleased to tell me, he had sometimes try’d fruitlessly, but often with good success.\textsuperscript{493}

The description of Harvey’s method of curing ‘tumors’ proves that also extraordinary therapeutic methods were worth trying in practical medicine. Generally, Boyle regarded learned physicians as too cautious and conservative in their attitudes towards novel therapies. Boyle argued strongly for therapeutical innovations and hence found the unorthodox practices of such a traditional physician and an Aristotelian natural philosopher as Harvey highly persuasive. If even a ‘rigid Naturalist’, such as Harvey, was open minded enough to try Helmont’s extraordinary way of curing ‘tumors’, there was no reason for why the more ordinary physicians should not employ medicinal novelties in their practice. Although to function as proof a testimony had to be plausible, it is evident that Boyle’s purpose was not in the first place to convince his readers by the fact that ‘tumors’ had been successfully cured by the touch of a dead man’s hand. Instead, he set Harvey as an example of a learned physician and a natural philosopher who was also willing to employ uncommon therapies in his medical practice. Boyle presented Harvey’s extraordinary method of curing ‘tumors’ again in \textit{Specific Medicines}. In that work, Boyle referred only to a single case of disease and cure where the method was employed to prove ‘that outward Medicines may operate upon inward Distempers.’ Boyle did not mention Harvey’s name but described him as ‘one of the skillfullest and candidest Physicians of the Famous Colledge of \textit{London’}.\textsuperscript{494}

Although the rhetorical use of authority is a minor feature of Boyle’s medical works, his manner of using witness reports as proof always involve the question of the credibility of the witness and the truth of matter of fact. The matters of fact delivered by a testimony were connected to the authority of the source until proven true by other witnesses or by practical means such as experiment. Experiment was an effective means

\textsuperscript{493} Boyle, \textit{Usefulness II, sect. I}, 434.
\textsuperscript{494} Boyle, \textit{Specific Medicines}, 399.
of proving the truth of matters of fact and thus separating facts from the authority of the source. In addition, the matters of fact proven true by experiment contributed to the authority of the source as well. We can observe this kind of interplay between authority and fact in the medical *Usefulness* where Boyle recommended the chemical medicines of van Helmont. Boyle had experimented on several medicines he had read about in van Helmont’s treatises. Consequently, although he found ‘much of *Helmont’s Theory scarce intelligible*’ and took ‘great exceptions at many things in his writings’, he recommended van Helmont’s ‘Medicines upon his Authority’:

I must here confess to you once for all, that ... I have not seen cause to disregard many things he [Helmont] delivers, as matters of fact, provided they be rightly understood; having not found him forward to praise Remedies without cause, though he seem to do it sometime without a measure, and having more than once, either known, or even had, considerable effects of Medicines he commends.496

For Boyle, van Helmont was an authority only in the restricted area of remedies. Van Helmont’s skill and experience in practical medicine made him no authority on all medical issues. On the contrary, Boyle regarded his theoretical ideas as ‘scarce intelligible’ and ‘frequently extravagant’.497

Those, that are least capable of Reason, are most sway'd by
Example.\textsuperscript{498}

In the medical \textit{Usefulness}, Boyle employed medical authority with proofs of other
kinds. According to him, ‘the surest & most obliging way to make Men value it [the
reall Learning], is to let them see by its reall & usefull Productions how vast a Disparity
there is betwixt experimentall & notionall Learning’.\textsuperscript{499} Hence, Boyle built his argument
on a large number of examples of the ways the experimental approach to medicine had
produced important medical innovations. Narratives and anecdotes about various kinds
of medical experiments form the major category of proof in the medical \textit{Usefulness}.
Since a singular example was not persuasive, Boyle often presented a combination of
several kinds of examples to prove his point:

\begin{quotation}
I shall not trouble you with many Instances to prove this
Doctrine ... but yet some Instances I suppose you will here
expect, and therefore I shall present you with a few of
those that at present come into my minde.\textsuperscript{500}
\end{quotation}

Boyle also published the recipes of some of his favourite medicines in the medical
\textit{Usefulness}. While distributing useful medical information to Boyle’s readers, these
recipes and instructions also provided practical proof for his argument. As Antonio
Pérez-Ramos has pointed out, ‘no ‘proof’ excels production’.\textsuperscript{501} The use of recipes and
practical instructions as proof required a detailed account of the preparation process.
Since lay people commonly prepared medicines, a recipe of an experimentally
discovered effective medicine provided concrete proof of the usefulness of experimental
natural philosophy. The successful preparation and use of a medicine, such as Boyle’s

\begin{footnotes}
\item[499] Robert Boyle to John Evelyn, 23.5.1657, \textit{Correspondence}, vol. 1, (213-215), 214.
\item[500] Boyle, \textit{Usefulness II}, sect.1, 383.
\item[501] Pérez-Ramos, \textit{Bacon’s Idea of Science}, 177.
\end{footnotes}
Enser Vera for instance, was a more effective means of persuasion than any textual experience could ever be.

Boyle’s contemporaries read the medical Usefulness as a work which advocated chemical medicine. In the ‘Therapeutical Essay’ of the work, Boyle described how he, together with an ‘Industrious Chymist’, had been reading van Helmont’s treatise and ‘resolv’d to try, whether a Medicine, somewhat approaching to that he made ... might not easily be made out of calcin’d Vitriol’. The narrative about the invention of the medicine – Enser Vera – functioned as proof for his argument that by experimenting with medicines it is possible to discover simple and inexpensive ways of preparing effective chemical remedies.\(^{502}\) Boyle briefly described the preparation process but since the medicine required ‘more care, not to say skill, to Prepare it well’, he referred the reader to the appendix where ‘many of the Particulars relating to the Preparation of it’ are given.\(^{503}\)

Boyle often spoke for the open distribution of useful medical information. He published recipes and instructions for medicinal preparations in his medical works where these provided additional proof for his argument. Medical men, by contrast, often kept their medicines and other therapeutic methods as trade secrets. Furthermore, publishing recipes or detailed narratives of disease and experimental cures encouraged lay readers to experiment with medicines. Learned physicians, such as George Castle and Robert Sprackling for instance, wanted to restrict the administration of medicines in the hands of university educated physicians. In their dispute with the College of Physicians, the iatrochemists likewise emphasized that chemical medicines could be dangerous if unskilfully prepared and prescribed. Many learned physicians, such as George Castle for instance, advocated medical chemistry. However, the iatrochemist George Thomson noted that the correct administration of chemical medicines required a thorough knowledge of chemical theory and, consequently, no galenic physician could safely

\(^{502}\) Boyle, Usefulness II, sect. 1, 388.

\(^{503}\) Boyle, Usefulness II, sect. 1, 391-393.
Boyle was not consistent in his statements about the role of a physician in treating disease. On the one hand, he stressed that even a good medicine could not replace the skill of a physician; ‘for Medicines are but Instruments in the hand of a Physitian, and though they be never so well edg’d and temper’d require a skillful hand to mannage them; and therefore I cannot but admire and disapprove their boldnesse that venture upon the Practise of Physick, wherein it is so dangerous to commit Errours, barely upon the confidence of having good Receipts.’ On the other hand, however, he published a significant number of medical recipes and other practical information in his works. Moreover, the medical Usefulness overtly encouraged ladies and gentlemen, who had ‘out of Charity or Curiosity or both, begun to addict themselves to Chymistry’, to tamper ‘with Spagirical Remedies’. Accordingly, no physician was required to prescribe Boyle’s Ens Veneris; ‘an Excellent Person ... cures the Rickets generally in Children of several Ages and Complexions without having hitherto fail’d (as she professes) in any one, by prescribing no other Remedy than the single use of the above describ’d Colchotharine Flowres’.

The narrative about the discovery of Ens Veneris functions also as an example of how experimenting with medicinal substances may result in the discovery of novel remedies. The narrative reveals stage by stage how the experiment proceeded from Boyle’s and the ‘Industrious Chymist’s’ reading of Helmont’s treatise to the attempt to prepare the medicine and Boyle’s subsequent experience about the efficacy of the medicine in various diseases. In the medical Usefulness, Boyle presented over a hundred brief narratives and anecdotes about various kinds of medical experiments and interesting cases of disease and cure. These narratives were ‘particular instances’ or examples; their power to prove inheres in the fact that they represent some general idea, phenomenon or

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504 Thomson, Galeno-pate, 35-38.
505 Boyle, Usefulness II, sect. 1, 534.
506 Boyle, Usefulness II, sect. 1, 484.
507 Boyle, Usefulness II, sect. 1, 538.
508 Boyle, Usefulness II, sect. 1, 500-505.

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event. Because a single example provided only weak proof Boyle used several ‘loose Observations ... being drawn up together into one Treatise’ and wished that ‘their Union might enable them to make a greater Impression’.

The particular instances presented in the medical *Usefulness* are miscellaneous narratives and anecdotes about various kinds of experiments and observations. Boyle’s experimentalism did not involve an idea of making a large number of experimental repetitions to be used as a basis for formulating generalizations. Instead, Boyle collected all kind of medical information about various kinds of phenomena. The abundance of miscellaneous particulars published in the medical *Usefulness* almost obscures the general argument of the work. Boyle employed the rhetorical induction and aimed at proving by compiling examples for some probable conclusion. The probability of the conclusion was associated first and foremost with people’s reasonable beliefs and expectations; it was based on the idea that the examples referred to events which had happened and were likely to happen again.

Boyle pointed out that his ‘Condition as well as Disabilities’ prevented him from practising medicine. Therefore, he also published numerous testimonies gained from other people and literature. However, it was not enough that Boyle himself trusted his witnesses and believed in the truth of their testimonies but he had to present them in a manner that would convince his readers as well. His manner of describing and identifying his information sources, the witnesses of medical experiments and the people he co-operated with shows that the experimental matters of fact and the authority of the people involved formed a complicated whole. Instead of identifying his witnesses by name, Boyle often presented them only with qualifications, such as an ingenious gentleman, a pious lady or a learned physician, for instance. In particular, when using

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information gained from notorious sources, Boyle had a habit of describing his sources as skilled chymists or famous empirics, for instance, rather than using their names. Nevertheless, although Boyle constructed some authority for his anonymous witnesses by describing them as greatly learned or eminent and experienced, their testimonies had ultimately to be accepted on his word. He also pointed out that due to his reliance on witness testimonies in medical matters, he did ‘not set down Medicinal Experiments, with the same positivenesse’ as the ‘Physiological ones’.  

Boyle preferred to publish narratives about extraordinary cases of disease and novel therapies rather than to discuss common cases. Both physicians and the gentlemanly readers were interested in medical ‘curiosites’. In the case of uncommon diseases and unorthodox methods of cure, the question of the plausibility of the testimony was crucial. Moreover, Boyle occasionally used the testimonies of witnesses whose reputation was questionable and whom he himself also regarded as unreliable. Additional witnesses and proof were required in the case of such suspicious witnesses and their testimonies about uncommon phenomena.

Boyle’s account about a rejuvenating medicine, which originated from Paracelsus’s treatise De renovacione et restauratione, offers a case in point. In general, Boyle was suspicious and critical towards Paracelsus’s views and works. In the case of Paracelsus’s Primum Ens, however, ‘that Ingenious, and Experienc’d, Monsieur L.F. who was the French kings Chymist’ had convinced him of the truth of Paracelsus’s testimony. The observable effects of the Primum Ens were, however, extraordinary and, therefore, Boyle considered them in detail. According to Paracelsus, whose testimony was subsequently confirmed by other more reliable witnesses, ‘first of all, the Nailes of their Fingers, then those of their Toes, afterwards their Hair, and Teeth, fall off, and lastly, the Skin be dri’d and exchang’d for a new one.’ Boyle suggested the medicine to be tested on animals and heard that this had already been done on ‘an old Hen ... about the sixth

513 Boyle, Usefulness II, sect.1, 531.
day she began to moult her Feathers by degrees, till she became stark naked; but before a fortnight was past, she began to regain others, which ... appear’d fairer, and better colour’d then the first ... besides that, her crest was rais’d, she also laid more Egges, then she was wont.”

The description of the effects of Paracelsus’s rejuvenating medicine provided proof for Boyle’s argument about the usefulness of chemical experiments for discovering effective medicinal novelties. However, since Paracelsus was a controversial figure and the effects of his medicine were somewhat extraordinary, the issue of his credibility as a witness also arose. Boyle solved the problem by using an additional testimony of a more respectable chemist and appealed to ‘the ingenious Monsieur L.F.’ whom at least the London physicians and virtuosi were easily able to identify as Nicaise Le Febvre, the apothecary to Charles II and the Royal Professor of chemistry In addition to Le Febvre, Boyle presented anonymous witnesses who confirmed the observable effects of Paracelsus’s medicine: ‘Your ingenious acquaintance [Le Febvre] assured me several times, and once, in the presence of a famous Physitian, and another Virtuoso, to whom he appeal’d, as knowing the truth of what he sayed; that an intimate Friend of his, whom he named to me’ had ‘made the Trial upon himself’.

All the examples in the medical Usefulness are not as circumstantial as the narrative about Paracelsus’s extraordinary rejuvenating medicine. Especially in the case of common cases of disease and familiar therapies, Boyle referred to particular instances only briefly rather than anecdotes than narratives. The medical Usefulness contains numerous brief descriptions often reduced to a sentence or two. For instance, Boyle described the effects of smelling salts only briefly: ‘we have more then once by barely unstopping and holding under her Nose a smal Phial of highly rectified Spirit of Sal Armoniack, or even of Harts horn almost presently recover’d a Young Beauty ... out of strange Fits that were wont to take her more suddenly then those of the Falling

517 Boyle, Usefulness II, sect. 1, 408.
Sicknesse, and were look’d upon as Epileptical, though perchance they were not meerly so." Most of the particular instances in the medical *Usefulness* fall somewhere between detailed narratives and brief anecdotes. The following passage is typical when it comes to the length and the amount of detail:

I shall now only mention the last Observation of this kind I met with, which was in a Gentleman ... who being in for some Months much troubled with a difficulty of breathing, and having been unsuccesfully treated for it by very Eminent Physitians, we at last suspected, that ‘twas not the Lungs, but the Nerves that serv’d to move the Diaphragme and other Organs of respiration, upon whose distemper this suppos’d *Asthma* depended, and accordingly by a taking or two of a Volatile Salt of ours, which is very friendly to the *genus Nervosum*, he was quickly freed from his troublesome distemper, which afterwards he was fully perswaded did not proceed from any stuffing up of the Lungs.\footnote{Boyle, *Usefulness II*, sect. 1, 458-9.}

Boyle’s narratives were not typical instances of *historia medica*. Even though a description of a case of disease was often part of these narratives, the emphasis was rather on medicinal experiment and on the novelty it had produced than on the disease or the patient. The physicians, by contrast, instead of experiment and novelty, emphasized the success of their rational therapies when publishing case histories as proof. They stressed that their therapeutic methods were based either on the valid medical theory or on the common experience of the profession instead of the trial-and-error experiments of medical practice.

\footnote{Boyle, *Usefulness II*, sect. 1, 449.}

\footnote{Boyle, *Usefulness II*, sect. 1, 458-9.}
SUMMARY

The new style of writing was one of the central features of seventeenth-century English experimentalism. The experimentalists rejected the embellished rhetorical style and the rhetorical argument from authority in philosophical matters. Instead of the traditional authorities, the experimental matters of fact became regarded as the best category of proof. However, the shift of emphasis from authority to matters of fact presented the double question about the truth of matter of fact and the credibility of the source. Boyle’s general criteria for evaluating witnesses were familiar from the rhetorical theory; the two most important factors contributing to the credibility of a witness were his moral qualifications and his expertise. However, experiment provided Boyle with an additional means of assessing witnesses and their testimonies; a successful repetition proved the truth of matter of fact and also contributed to the authority of the witness. In practice, Boyle evaluated witnesses and their testimonies in a complicated context formed by other facts, the reports of other witnesses and their qualifications as witnesses, relevant circumstances and theoretical knowledge about the subject matter.

The subject matter, the literary conventions of the disciplines and the intended audience of published treatises had an impact on their style and argument. In medical discourse, both lay and professional authors tended to emphasize their expertise and medical knowledge. Several means were available for this purpose. The authors of popular medical works – such as the treatises examined in this chapter – wrote in English but inserted Latin or Greek quotations in their text. The theories of ancient and contemporary medical authorities provided physicians with an excellent means of displaying their medical learning and expertise. Boyle likewise aimed at establishing his ethos as a medical author by displaying his knowledge of the traditional medical literature, such as the works of Galen or the Hippocratic corpus.
The physicians used testimony in a traditional manner and built their argument on the theories of approved medical authorities. By contrast, Boyle made an attempt to combine the experimental matters of fact to the medical authority. The physicians likewise referred to experiment and the new philosophical trends of the day. Although experiment played a minor role in the treatises of the physicians, they recognized it as one of the means to demonstrate empirical truths. However, physicians tended to be cautious in their references to experiments and clinical particulars in their published works. Boyle presented numerous narratives about his own and others’ medicinal experiments and, furthermore, published the recipes of his favourite remedies. By contrast, for learned physicians, clinical success was an awkward piece of proof. Publishing narratives about particular cases of disease and cure indicated empirical medical practices. In the physicians works, clinical success usually took the form of the ‘common experience of physicians’ which appealed to the authority of the medical profession.

Boyle’s medical Usefulness aimed at showing the advantages the experimental natural philosophy and experiment in general could and already had produced in the field of medicine. Boyle wrote principally for lay readers and, therefore, particular instances provided him with an excellent means of proof. Example was a recommended means of proof in a popular discourse. Moreover, Boyle’s readers probably found the narratives about extraordinary cases of disease and cure more persuasive and entertaining than the subtleties of medical theory. However, in medical discourse, authority was of great significance. Medicine was an expert discipline and, therefore, an author of a medical work had to display his medical knowledge and expertise. The naked matters of fact were not a sufficient means of persuasion in medical discourse. Boyle did not possess a similar authority in medical matters as in natural philosophy and, as a consequence, he built the argument of his medical Usefulness on a complex interplay between fact and authority.
4. EXPERIMENT AND THEORY

This chapter studies experiment as a means of discovering and proving theoretical explanations about the causes of natural phenomena. In general, Boyle’s attitude towards theory construction and definite conclusions was diffident. Nonetheless, his experimentalism was a philosophy which was concerned with the investigation of the hidden causes of phenomena. Boyle’s *New Experiments Physico-Mechanical, Touching the Spring of the Air and its Effects* (1660) and later writings about the air-pump experiments participated in theoretical discussion about respiration physiology. *Spring of the Air*, in particular, made an important contribution to contemporary physiological investigation. The work contains reports about Boyle’s experiments on respiration and a section discussing contemporary theories about respiration physiology.

This chapter explores the manner experiment was employed in the investigation into respiration physiology. In it, I aim at showing that in the respiration research and discussion, no shared notion of experimental evidence existed. Although the use of experiment occasionally came close to the modern notion of scientific evidence, the respiration physiologists held various views about the nature of the inference from experiment and its probatory force. Boyle placed experiment in a rhetorical argument and weighed it with several kinds of proofs in order to create the concurrence of probabilities. By contrast, the physicians engaged in the research on respiration physiology regarded anatomical experiment as a particular kind of demonstration. Consequently, they conceived experimentally gained knowledge to have a high degree of certainty. Furthermore, they extended their strong faith in the probatory force of anatomical demonstration to other kinds of experiments as well.

I begin with an introduction of the main features of seventeenth-century anatomical studies. Due to sixteenth-century developments in anatomy, experiment had established its role as a means of discovery and proof in anatomical studies. The first section introduces the main features of the physiological explanation and the role of experiment in it. In addition, I discuss William Harvey’s discovery of the circulation of the blood.
Harvey’s work formed both the basis for the subsequent respiration research and a model for the English anatomical studies conducted in the latter half of the seventeenth century. The section also examines Boyle’s views about Harvey’s experimental approach and the Harveian model of anatomical explanation. Boyle appreciated Harvey’s work and often referred to Harvey’s example in his medical works. Moreover, Boyle approved of the search for final causes and the teleological explanatory model in anatomy. However, Boyle and the late seventeenth-century respiration physiologists did not adopt the Harveian model as such but combined Harvey’s experimentalism with the chemical and mechanical ideas about nature.

Section 4.2. moves to examine the English investigation into respiration physiology and Boyle’s contribution to it. The section explores Boyle’s experiments on respiration published in Spring of the Air (1661). In addition, the theoretical digression where Boyle discussed contemporary theories about the mechanism and the purpose of respiration is examined in this section. The examination introduces the principal theories about respiration physiology and discusses Boyle’s manner of using experiment for evaluating the validity of theoretical explanations. The introduction functions as the basis for the examination of experimental evidence in 4.4.

Section 4.3. discusses the concept of evidence and the degrees of certainty. Modern historians have shown that during the seventeenth century, major changes occurred in the concepts of knowledge, probability and evidence. The concept of evidence was gradually changing its meaning from the condition of being evident towards the modern notion of a sign from which inferences can be drawn. However, although experiments were used for making inferences about causes in the respiration research, the participants did not use the concept of evidence when referring to experiment. Boyle associated ‘evidence’ in a traditional manner with the condition of being evident. For him, ‘evidence’ was something that was evident to the mind. Evidence produced certainty; the truth of evidence was impossible to doubt. Experiment, by contrast, when used together with proofs of other kinds produced the concurrence of probabilities, which added up only to moral certainty. Contrary to Boyle’s diffident attitude towards

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experimental proof, the physicians regarded anatomical experiment as an act which showed in concrete (ostensio); it demonstrated and made evident the structure and the function of an organ or a body part. Hence, the physicians conceived experimental demonstration capable of producing knowledge with a high degree of certainty.

The final section examines Boyle’s experimental proof and the medical notion of experimental demonstration. The section focuses on the argument from experiment. Although different, both Boyle’s and the physicians’ manner of using experimental proof were regarded as rhetorical modes of argument at the time. The community of physiologists hardly intended to engage in a rhetorical enterprise when presenting their explanations about the causes of respiration. Nevertheless, arguments other than a formal demonstration tended to be conceived as rhetorical. I end the chapter with an examination of Boyle’s and Thomas Willis’s discussion about the connection between air, fire and life. A brief comparison between Boyle’s and Willis’s manner of interpreting experiments contrasts Boyle’s somewhat diffident interpretation to the more confident attitude towards the probatory force of experiment that one of the leading anatomists of the time had. Although experiment functioned in the respiration discussion as a means of theoretical discovery and proof, no consensus about the nature of experimental evidence existed. Neither was any satisfactory theoretical explanation for the purpose of respiration reached. The experimental proof was not persuasive enough to decide between different theories about respiration.

4.1. Anatomy and Experiment

This section presents a description of the main features of anatomical investigation and explanation. In addition, it discusses William Harvey’s work on the circulation of the blood, which functioned as a model for the subsequent anatomical and physiological studies in England. The section provides the background for the examination of Boyle’s participation in the studies on respiration physiology. Due to the English physicians’ interest in the experimental philosophy, the medical model of anatomical study and explanation had an impact on the experimental natural philosophy as well; anatomical
investigation provided seventeenth-century experimentalists with an impressive model of a successful use of experiment for the discovery and proof of theoretical knowledge.

I

In general, the medical tradition provided a strong justification for experimental approach to knowledge. On the one hand, both Galen’s vivisection experiments and the Hippocratic experiential medicine could be conceived as emphasizing the experimental and experiential nature of medical knowledge. On the other hand, however, whether dissection and vivisection could be seen as experiments constituting evidence for theories, depended on why such acts were performed and on the structure of the argument they were used in. Before the sixteenth century, the discovery and demonstration of theoretical knowledge was rarely conceived as the purpose of anatomical studies.

Roger French has suggested that particularly sixteenth-century developments in the Paduan medical faculty moved the nature of anatomical studies towards experimental anatomy. The Paduan anatomists generally accepted Andreas Vesalius’s project of correcting the errors of the ancients as a starting point of anatomical studies. Aristotle provided the general model of research in Padua. However, instead of Aristotle’s *Physics*, that was more commonly used for the purpose, the Paduan anatomical study was modelled according to Aristotle’s animal books (*Historia animalium*, *De partibus animalium*, *De generatione animalium* and two books on the motion of animals). The aim of anatomical study was to produce causal knowledge about the way animal bodies functioned. The first step of the investigation was to describe the structure of an organ or several organs which participated in the same bodily process, such as respiration or digestion, for instance. Secondly, the ‘action’ of the organ was examined. Finally, its ‘purpose’ or ‘use’ was stated. The ‘purpose’ referred generally to a process in which several organs might be involved, such as respiration, for instance. The modern term ‘function’ approximately covers the terms ‘action’, ‘use’ and ‘purpose’ of the Paduan

520 French, *Harvey’s Natural Philosophy*, 318-323.
521 Cunningham, *Anatomical Renaissance*, 78.
anatomical study.\textsuperscript{522}

An anatomical explanation followed the order of research. The explanation consisted of two parts which had their definite roles in anatomical inquiry and treatises. \textit{Historia anatomica} described the structure of an organ as it was observed during an anatomical experiment. Since an inference from structure to function was a common mode of reasoning in anatomy, \textit{historia anatomica} formed the basis of the second part of the explanation; \textit{doctrina}, which stated the causes. \textit{Doctrina} consisted of an account of the causes understood as the action, use and purpose of an organ or body part. After the action, use and purpose of an organ had been stated, the observational particulars of \textit{historia} were explained by deduction from causes. The most important of the causes was the final cause which named the purpose the body part or the organ was created for.\textsuperscript{523}

In late seventeenth-century English anatomical studies, particularly William Harvey’s anatomical work functioned as a model of using experiment and observation as an effective and convincing means of discovery and proof. Harvey’s influence on seventeenth-century English experimental philosophy and medicine was notable. The success of his experimental work presented an important example for the later anatomical studies in England. Moreover, his theory about the circulation of the blood destroyed most of the traditional Galenic physiology and, as a consequence, posed several new research questions for further physiological investigation. Harvey had studied medicine in Padua at the beginning of the century. When he returned to England, he began an anatomical study on the heart according to the Paduan model.\textsuperscript{524} His explanation of the heart started from the description of the structure and proceeded to state the causes. Harvey published his findings in \textit{Exercitatio anatomica de motu cordis et sanguinis in animalibus} (1628). The treatise presented a complete anatomical explanation of the structure, action and the use of the heart. In addition, \textit{De motu cordis} published Harvey’s theory about the circulation of the blood which, despite the criticism

\textsuperscript{522} French, \textit{Harvey’s Natural Philosophy}, 65-68, 84.
\textsuperscript{523} Pomata, ‘\textit{Praxis Historialis}’, 116-117 and Cunningham, \textit{Anatomical Renaissance}, 175-177.
\textsuperscript{524} French, \textit{Harvey’s Natural Philosophy}, 66.
it faced when published, had become widely accepted by the 1650s.

II
Anatomy, to which physiology as a doctrine of function belonged, was a common
ground for physicians and natural philosophers. Traditionally, anatomy was conceived
as part of natural philosophy. In addition, it was considered being of value to medicine
as well.\textsuperscript{525} The philosophical anatomy was a doctrine about animal bodies, whereas the
medical anatomy was concerned with the structure and function of human body.\textsuperscript{526} Also
Boyle held the generally accepted view that anatomy was located on the common
ground of natural philosophy and medicine:

And first for Physiology, 'tis apparent, That the phisitian
takes much of his Doctrine in that part of his Art from the
Naturalist ... the experience of our own age may suffice to
manifest, what light the Anatomical doctrine of Mans
Body may receive from Experiments made on other
subjects.\textsuperscript{527}

Rose-Mary Sargent has suggested that anatomical research and William Harvey’s work,
in particular, provided Boyle with an important model of experimental reasoning and
proof.\textsuperscript{528} Boyle was familiar with Harvey’s work and regarded him as ‘one of the
skilfullest and candiest Physicians of the Famous Colledge of London’.\textsuperscript{529} Boyle had
met the famous anatomist at least once and used him as an example of an innovative
physician in the fields of theoretical and practical medicine.\textsuperscript{530} In his medical
\textit{Usefulness}, Boyle mentioned Harvey several times. The physiological essay of the work
emphasizes the importance of zootomy according to the Harveian model and relates

\textsuperscript{525} Cunningham, \textit{Anatomical Renaissance}, x-xi, 1-36, 38-39.
\textsuperscript{526} French, \textit{Harvey’s Natural Philosophy}, 229-230.
\textsuperscript{527} Boyle, \textit{Usefulness II}, sect. I, 299.
\textsuperscript{528} Sargent, \textit{Diffident Naturalist}, 79-84.
\textsuperscript{529} Boyle, \textit{Specific Medicines}, 399.
writings which either refer to Harvey or to the discussions between Boyle and Harvey, (116-117).
some of Harvey’s experiments which Boyle had himself repeated.\footnote{Boyle, \textit{Usefulness II}, sect. I, 299-305.} Moreover, in the therapeutic essay of the same work, Boyle admired the open-mindedness and ‘the curiosity of Dr. Harvey, who, as rigid a Naturalist as he is, scrupled not often to try the Experiment mentioned by Helmont’ in his medical practice.\footnote{Boyle, \textit{Usefulness II}, sect. I, 434.}

Harvey had regarded his anatomical work as belonging rather to the philosophical than to the medical anatomy.\footnote{French, \textit{Harvey’s Natural Philosophy}, 3-4.} Also Boyle recognized the value of Harvey’s approach to both medicine and natural philosophy. He associated Harvey’s ‘way’ to that of Bacon; ‘our great Verulam attempted with much Skill and Industry ... to restore the more modest and useful way practis’d by the Antients, of Inquiring into particular Bodies, without hastening to make Systems ... wherein the admirable Industry of two of our London physicians, Gilbert and Harvey, has not a little assisted him.’\footnote{Boyle, \textit{Excellency of Theology}, 88.} Moreover, Boyle conceived Harvey’s Paduan model of anatomical inquiry and explanation useful. The structure of the Harveian model of experimental reasoning and proof was Aristotelian. Roger French has pointed out that Harvey’s method of discovery and proof was hardly ‘scientific’ in a modern sense.\footnote{French, \textit{Harvey’s Natural Philosophy}, 99.} By contrast, Harvey’s strict Aristotelianism is evident in his emphasis on the teleological explanation and the final causes. Also Boyle, although otherwise critical towards the ‘school’ Aristotelianism and ‘Aristotle’s doctrine’, held Aristotle’s ‘Historical Writings concerning Animals’ in a great esteem.\footnote{Boyle, \textit{Forms and Qualities}, 295.}

Boyle likewise agreed with Harvey about the significance of the final causes in anatomy; according to him, ‘there is no Part of Nature known to us, wherein the Consideration of Final Causes may so justly take place, as in the Structure of the Bodies of Animals.’\footnote{Robert Boyle, \textit{A Disquisition about the Final Causes of Natural Things}, (1688), \textit{Works}, vol. 11, (79-167), 125.} In \textit{A Disquisition about the Final Causes of Natural Things} (1688), Boyle related a discussion he had had with Harvey about the discovery of the circulation of the blood. The account emphasizes the significance of the final causes and

\footnote{Boyle, \textit{Usefulness II}, sect. I, 299-305.}

\footnote{Boyle, \textit{Usefulness II}, sect. I, 434.}

\footnote{French, \textit{Harvey’s Natural Philosophy}, 3-4.}

\footnote{Boyle, \textit{Excellency of Theology}, 88.}

\footnote{French, \textit{Harvey’s Natural Philosophy}, 99.}

\footnote{Boyle, \textit{Forms and Qualities}, 295.}

\footnote{Robert Boyle, \textit{A Disquisition about the Final Causes of Natural Things}, (1688), \textit{Works}, vol. 11, (79-167), 125.}
‘Nature’s Design’ for anatomical investigation:

I remember that when I asked our famous Harvey ... What were the things that induc’d him to think of a Circulation of the Blood? He answer’d me, that when he took notice that the Valves in the Veins of so many several Parts of the Body, were so Plac’d that they gave free passage to the Blood Towards the Heart, but oppos’d the passage of the Venal Blood the Contrary way: He was invited to imagine, that so Provident a Cause as Nature had not so Plac’d so many Valves without Design: and no Design seem’d more probable, than That, since the Blood could not well, because of the interposing Valves, be Sent by the Veins to the Limbs; it should be Sent through the Arteries and Return through the Veins, whose Valves did not oppose its course that way.\textsuperscript{538}

In general, final causes were important part of anatomical research. The relationship between the structure and the function of an organ was understood teleologically and often expressed by stating that ‘Nature does nothing in vain’. The Aristotelian notion of final cause was associated with the idea about nature as God’s creation and the human body as the temple of God. Since nature was God’s design, it was purposeful.\textsuperscript{539} The idea that the structure of an organ was ‘designed’ in the sense of being the most appropriate for its function was of great heuristic use in anatomical and physiological investigation; it provided a strong justification for the inference from structure to function. From the connection between structure and function, one could ‘draw Arguments, as well Affirmative as Negative, about the Use of the Parts of the Body; from their Fitness or Unfitness, or their greater or lesser Fitness, to attain such Ends as

\textsuperscript{538} Boyle, \textit{Final Causes}, 129.
\textsuperscript{539} Cunningham, \textit{Anatomical Renaissance}, 38-42, 206-209, 231-234. See also Boyle, \textit{Final Causes}, 130-145.
are suppos’d to have been Design’d by Nature.⁵⁴⁰

However, although Boyle appreciated the Harveian model of anatomical investigation and its Aristotelian notion of causality, he did not adopt Harvey’s model of anatomical explanation as such. Instead, Boyle and the later English anatomists took Harvey’s theory about the circulation of the blood as a starting point for their anatomical work. They likewise employed Harvey’s method of experiment in their own studies. However, the mechanical and corpuscular philosophies of these later ‘Harveians’, who often were also interested in chemistry, differed greatly from Harvey’s strict Aristotelianism. The interaction between physicians and natural philosophers moved the focus of physiological investigation and explanation from the observation of gross structure to the chemical-particulate factors present in physiological processes.⁵⁴¹ Nevertheless, despite Harvey’s old-fashioned Aristotelian outlook, his example and authority continued to have great weight in late seventeenth-century English medicine and natural philosophy.

4.2. Air and Life: the Investigation into Respiration

This section presents a general overview of the nature of the respiration discussion and examines Boyle’s role in it. Harvey’s theory about the circulation of the blood functioned as the starting point for the investigation into respiration. The theory included the idea about the pulmonary transit of blood, in other words, that the blood leaving the right ventricle of the heart circulated through the lungs before entering the left ventricle. However, no consensus about the purpose of the pulmonary transit existed. Consequently, the action and particularly the use of respiration became the central questions of respiration physiology in the latter half of the seventeenth century.

I

Harvey continued his anatomical work while living at Oxford 1642-1646 where he was associated with other physicians interested in anatomical research, such as Nathaniel

⁵⁴⁰ Boyle, *Final Causes*, 130.
⁵⁴¹ Frank, *Harvey and the Oxford Physiologists*, 16-20, 43.
Highmore and George Bathurst, for instance.\textsuperscript{542} Later in the 1650s, Oxford became the
centre of investigation into the Harveian physiology and respiration, in particular. After
the founding of the Royal Society, respiration experimentation begun in London as well.
The leading respiration physiologists were physicians, such as Nathaniel Highmore,
Thomas Willis and Richard Lower, among others. Physicians dominated the
physiological research and, therefore, the central experiments were those originating
from the medical tradition; dissection and vivisection.\textsuperscript{543}

Robert Boyle became involved in the respiration research while living in Oxford during
1655-1668.\textsuperscript{544} Although his work on respiration may be regarded as a sideline of his
broader inquiries into air and its properties, he considered the subject matter important:

That the Ayr, being so necessary to humane Life, that not
only the generality of Men, but most other Creatures that
breath, cannot live many \textit{minutes} without it; any
considerable discovery of its Nature, seems likely to prove
of moment to Man-kinde.\textsuperscript{545}

Boyle’s contribution to physiological studies, however, was extraordinary considering
the traditional methods of physiological investigation. Although he also witnessed
dissections and vivisections, he conducted his own respiration experiments with his new
instrument, the air-pump. Boyle’s air-pump experiments on respiration were first
published in \textit{New Experiments Physico-Mechanical, Touching The Spring of the Air,
and its Effects} (1660). In addition, two \textit{Philosophical Transactions} articles in 1670 and
a short tract ‘New Experiments, Touching the Relation betwixt Flame & Air: And
particularly betwixt Air, and the \textit{Flamma Vitalis of Animals’} (1672) published these
experiments.

\textsuperscript{543} Frank, \textit{Harvey and the Oxford Physiologists}, 16-20, 43-45, 52-57.
\textsuperscript{544} Frank, \textit{Harvey and the Oxford Physiologists}, 43-45, 52-57.
\textsuperscript{545} Robert Boyle, \textit{New Experiments Physico-Mechanical, Touching the Spring of the Air, and its Effects},
(1660), \textit{Works}, vol. 1, (141-301), 158.
Boyle’s *Spring of the Air* consists principally of narratives about various kinds of air-pump experiments on several subject matters. Some of these experimental reports include also a brief theoretical discussion. Respiration, however, makes an exception. The report of the ‘Experiment 41’ describes several experiments examining the relationship between air and animal life and the following digression discusses contemporary theories about the purpose of respiration and presents additional experiments on the subject matter.\(^{546}\)

We may examine Boyle’s respiration experiments by taking a closer look at the ‘Experiment 41’. The experiment aimed at proving that an animal could not survive without air. The narrative describes two experiments in which a bird was enclosed in the receiver of the air-pump and the air was drawn out. In both experiments, it was observed that the bird died with ‘convulsive motions’ in less than ten minutes. Next the experiment was repeated using a mouse which died in a similar manner. To make sure that the cause of the death of the animals was the lack of air, two experiments were made in which a mouse was enclosed in the receiver but the pump was not used to create a vacuum. These mice survived much longer until they were finally killed by the ‘exsuction’ of the air. On the basis of these experiments, Boyle made some tentative conclusions; ‘there appear’d not much cause to doubt, but that the death of the ... Animals proceeded rather from the want of Air, then that the Air was over-clogg’d by the steams of their Bodies’. Afterwards, the dead animals were dissected but no significant changes in their lungs could be observed.\(^{547}\)

In addition to the experiments performed to examine respiration, also Boyle’s investigations into the general properties of air contributed to the respiration research. Boyle used his air-pump for the most part to examine and prove his theory about the corpuscular structure of air. These investigations were also relevant to the question about the action of lungs. The traditional physiological theory explained the mechanism of inspiration by the idea about nature’s ‘abhorrence of vacuum’; because nature did not allow a vacuum, the lungs had a ‘faculty’ which ‘attracted’ air in order to prevent the

\(^{546}\) Boyle, *Spring of the Air*, 276-295.

\(^{547}\) Boyle, *Spring of the Air*, 274-276.
forming of a void in the lungs. Due to Boyle’s air-pump experiments, however, the English experimentalists had become to conceive air as a substance consisting of particles with weight and a ‘spring’. Consequently, the notion of air pressure was applied to the physical explanations of the mechanism of respiration as well.548

In Spring of the Air, Boyle himself briefly examined the action of the lungs and muscles involved in respiration to answer the question of how air entered the lungs. According to Boyle, the principal questions were firstly ‘whether the motion of the Lungs in Respiration be their own, or but consequent to the motion of the Thorax, Diaphragme, and ... Abdomen’ and, secondly, ‘whence it is that that the Air swells the Lungs in Inspiration’.549 These were not difficult questions and it is likely that Boyle discussed the topic principally because his theory about the pressure or, the ‘spring’, of the air could be employed to explain inspiration. When Boyle considered Highmore’s and Bartholins’s earlier vivisection experiments, together with the structure of the lungs, it seemed to him that the causes of the respiratory movement were ‘the Muscles of the Chest’ and the diaphragm, in particular.550 The pressure of the air explained how air entered the lungs; the muscles of the chest first dilate the thorax thereby enlarging the space inside the chest. As a consequence, air ‘rushes’ in the lungs since there ‘it findes ... less resistance to its Spring then elsewhere.’551

II

Boyle used the notion of air pressure to decide between the different theories about the mechanism of respiration. However, a more important question was the final cause of respiration, in other words, the question of why a living organism needed air. The traditional theory explained that the purpose of respiration was to provide ‘aerial spirits’ for the generation of ‘vital spirits’ in the heart. Harvey’s circulation theory placed these ‘spirits’ rather in the blood than in the heart but presented no new explanation of the

548 French, Harvey's Natural Philosophy, 343, 349 and Frank, Harvey and the Oxford Physiologists, 115-116.
549 Boyle, Spring of the Air, 277.
550 Boyle, Spring of the Air, 277-278.
551 Boyle, Spring of the Air, 278-279.
purpose of respiration. Harvey had shown that the blood circulates through the lungs but he confessed he did not know why. According to him, ‘to determine and give a reason of this is nothing else but a search for what the lungs were made.’

Harvey postulated the final cause of respiration as the central question of respiration physiology. The post-Harveian physiological research was conducted collectively; the members of the community performed experiments together, discussed others’ experiments and used them as evidence for their own theories. Nathaniel Highmore published his experiments and views about the final cause of respiration in 1651. He used Harvey’s and his own experiments to reject the traditional theory of the generation of ‘spirits’. Instead, he suggested that air had both a cooling and waste disposing function. The cooling theory was common in the ‘Schools’ and some ‘new philosophers’, such as the ‘Cartesians’, held this view as well. According to this theory, the principal purpose of respiration was to cool the heat either of the blood or of the heart. Such cooling was considered necessary for the blood to became a fit fuel ‘for the vital Fire or Flame, in the left Ventricle of the heart’.

Highmore’s theory about the cooling and purging function of air was mechanical. Later, however, instead of purely mechanical explanations, it became more common to apply chemical ideas to respiration physiology as well. Chemical explanations suggested that some chemical interaction occurred between blood and air in respiration. For instance, Ralph Bathurst’s theory about the purpose of respiration postulated such an interaction. In his lectures in 1654, Bathurst rejected the mechanical cooling hypothesis. In its stead, Bathurst suggested that the purpose of respiration was to ventilate the blood by carrying off the bodily waste in exhalation. In addition to ventilating the blood, air provided the blood with a substance, pabulum nitrosum or an aerial niter of a kind, which was necessary for animal life.

552 Frank, Harvey and the Oxford Physiologists, 2, 15-16, 40-41.
553 William Harvey, The Anatomical Exercises of Dr. William Harvey, Professor of Physick and Physician to the Kings Majesty, Concerning the motion of the Heart and Blood, (London, 1653), 34.
554 Frank, Harvey and the Oxford Physiologists, 97-100.
555 Boyle, Spring of the Air, 281.
Boyle examined the most important contemporary theories about respiration in his *Spring of the Air*. One by one, he presented these theories and refuted them using experiments and proofs of other kinds. Boyle rejected both the cooling function of the air and its role in the generation of spirits. As for the generation of spirits in the heart, Boyle pointed out that no observation of air entering the heart had been made during the dissection and vivisection experiments. He agreed with Harvey that the ‘spirits’ must be in blood itself, not in the heart. At this point, he referred also to Nathaniel Highmore’s earlier experiments.  

Boyle’s own experiments proved that the cooling theory was false; several experiments described in *Spring of the Air* showed that the evacuation of the receiver of the air-pump did not produce heat. Hence heat could not cause the death of the animals. In addition, Boyle pointed out that such ‘cold’ creatures as frogs and old men who hardly needed any ‘cooling’ nevertheless needed to breathe. Also the common observation that breathing is inconvenient in cold air spoke against the cooling function of air.  

Having rejected the cooling theory and the generation of spirits, Boyle moved to examine the different kinds of ventilation theories. The ‘passive ventilation’ theory explained that air received ‘the superfluous Serosities and other Recrements’ from the blood. This cleansing operation allowed the blood to further circulate and maintain the ‘vital fire’ of the heart. According to Boyle, the air-pump experiments ‘objected’ against this ‘opinion’. When the receiver of the air-pump was evacuated, the animals placed in it died. However, the emptied receiver could have received more waste and ‘exhalations’ than when full of air. Hence, if the purpose of air were to cleanse and to carry off the waste of blood out of the body, the animals would not have died in the evacuated receiver so soon.  

Boyle regarded the active ventilation theory, such as that presented by Bathurst in 1651, as ‘the most probable’. He believed that, instead of being a passive recipient of waste,
air actively associated with blood thereby purging it from its ‘Exhalations’. He stated ‘that the depuration of the Blood in that passage [lungs], is not onely one of the ordinary, but one of the principal uses of Respiration’. This theory seemed ‘congruous enough to that grand observation, which partly the *Phaenomena*, and partly the relations of Travellers, have suggested to us, namely, That there is a certain consistence of Air requisite to Respiration’. The comparison between experiments made on animals in the air-pump when it was emptied from air and those where it was left full indicated that a particular composition of air was necessary for receiving the excrements of the blood. Furthermore, the comparison between the experience about ‘Asthmatical Persons’ whose lungs ‘be very much stuff’d with tough Phlegm’ but who despite this lived several years on the one hand, and the observation about the sudden death of birds in the receiver when it was evacuated on the other, suggested that ‘the Air does something more than barely help to carry off what is thrown out of the Blood in its passage through the Lungs’. Contrary to the chemical theories, such as that of Bathurst’s, however, Boyle did not discuss the exact nature of the interaction between blood and air in respiration. Moreover, he was ‘apt also to suspect, that the Air does something else in Respiration, which has not yet been sufficiently explain’d’.

Boyle’s conclusions although more tentative than most of the other theories about the purpose of respiration, were not extraordinary. By 1665, the community of the English physiologists had become to favour chemical-particulate theories about the use of air for animal life. According to these theories, air consisted of particles with chemical properties. Of these, the ‘nitrous’ particles were considered as the substance necessary for life. However, no consensus was reached about the final cause of respiration. Instead, more experiments were required. In the 1660s, Boyle had continued his experiments with the air-pump but had for the most part focused on other topics than respiration. He published more experiments on respiration in two *Philosophical*  

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564 Boyle, *Spring of the Air*, 286.  
Transactions articles in 1670. However, these experiments had already been discussed at the meeting of the Royal Society in August 1662 and, therefore, the English natural philosophical community was familiar with them long before their publication.\textsuperscript{567} The articles contain no theoretical discussion but publish experiments ‘to communicate to the Curious some matters of fact, that are new’. Since Boyle published these experiments especially for the use of the physicians conducting research into respiration, he ‘purposely forebore to confirm, or confute any Hypothesis, or so much as propose any of his own’.\textsuperscript{568}

The Philosophical Transaction articles contain narratives about similar experiments to those reported in Spring of the Air but which were performed by using a larger variety of small animals. Among other things, Boyle examined whether the ‘cold-blooded’ animals, such as snakes, frogs and fish, would survive in the evacuated receiver longer than those with hot constitutions, such as cats and ducks. He considered whether the structural differences in the lungs of different animals could be significant and reveal something about the ‘use’ of the air.\textsuperscript{569} In one series of experiments, comparisons were made between the time of suffocation and drowning.\textsuperscript{570} Despite the omission of any theoretical speculations, the experiments reported in the Philosophical Transactions are related to theoretical ideas explicated in Spring of the Air and to contemporary discussion about respiration. For instance, the ‘experiment XVI’ provided additional proof for the theory that one of the uses of air is to ‘carry off in Expiration the fuliginous steams of the Lungs’.\textsuperscript{571}

The interest in respiration physiology started to fade during the 1670s when the most active physiologists became involved in other fields of study and occupations. John Mayow’s Tractatus Quinque (1674) was the last significant treatise about respiration physiology in seventeenth-century England. After the Oxford community had dispersed,

\textsuperscript{567} Frank, Harvey and the Oxford Physiologists, 148-150. See also Works, vol. 6, xxxiii-xxxiv.
\textsuperscript{568} Henry Oldenburg’s preface to Robert Boyle’s ‘New Pneumatical Experiments about Respiration’, (Philosophical Transactions, 62 and 63, 1670), Works, vol. 6, (214-257), 215.
\textsuperscript{569} Boyle, ‘New Experiments about Respiration’, 216-222.
\textsuperscript{570} Boyle, ‘New Experiments about Respiration’, 230-234.
\textsuperscript{571} Boyle, ‘New Experiments about Respiration’, 248.
the interest in respiration physiology diminished in England.\textsuperscript{572} Boyle did return to respiration physiology in his \textit{Second continuation of Spring of the Air} (1682), which, although published under his name was, however, for the most part written by Denis Papin. Papin was Boyle’s amanuensis at the time. He had also made most of the experiments with his own instruments which were more sophisticated than Boyle’s air-pump.\textsuperscript{573}

However, as Robert Frank has noted, there was nothing new about the experiments or the approach to the question of the purpose of respiration in Boyle’s \textit{Second Continuation}.\textsuperscript{574} Among other experiments, the treatise contains narratives about experiments on animals enclosed in a vacuum in a similar manner as in those published in \textit{Spring of the Air} and with similar results; animals survived better in rarefied air than in a vacuum where they died swiftly.\textsuperscript{575} The chemical theory about respiration was examined by trying the effects of different gases on animals to find out whether air in general was sufficient for maintaining animal life or if air of a particular kind was required. The experiments made with the ‘artificial air’ showed that the ‘artificial air is noxious to the life of Animals.’\textsuperscript{576} Thus it seemed that the explanation of the use of air in respiration had both a physical and a chemical aspect. Seventeenth-century research on respiration did not proceed further and, despite the diligent experimentation and theoretical discussion, no consensus about the purpose of respiration was gained.

4.3. Evidence and Knowledge

This section studies the concepts of evidence, knowledge and the degrees of certainty. In it, I examine how the use of the experimental matters of fact relates to the notion of evidence. In addition, I discuss knowledge and the degrees of certainty in order to show the difference between Boyle’s and the physicians’ views about the probatory force of

\textsuperscript{572} Frank, \textit{Harvey and the Oxford Physiologists}, 258-287.
\textsuperscript{573} Robert Boyle, \textit{A Continuation of New Experiments Physico-Mechanical Touching the Spring and Weight of the Air, And their Effects. The Second Part}, (1682), \textit{Works}, vol. 9, (121-263), 123-124.
\textsuperscript{574} Frank, \textit{Harvey and the Oxford Physiologists}, 284.
\textsuperscript{575} Boyle, \textit{Second Continuation of the Spring of the Air}, 197-200.
\textsuperscript{576} Boyle, \textit{Second Continuation of the Spring of the Air}, 191-197.
experiment. In the respiration research and discussion, the function of experiment comes close to the modern use of scientific evidence. However, the participants did not use the concept in this context. At the time, the philosophical notion of evidence referred to the condition of being evident and, as a consequence, was associated with a high degree of certainty. Since Boyle associated experiment with probability and moral certainty, he did not regard the concept of evidence as relevant to experimental discourse.

By contrast, the physicians’ idea about experimental demonstration associates the certainty of the old notion of evidence with experimental proof. In the physicians’ treatises about respiration physiology, we can observe how the physicians regarded anatomical experiment as a concrete demonstration which produced knowledge with a high degree of certainty. Moreover, in the vernacular medical works, the certainty of an experimental demonstration is occasionally connected with the condition of being evident. Hence, despite the collective nature of the respiration investigation, Boyle and the physicians conceived the probatory force and the argument from experiment differently. No commonly shared idea of experimental ‘evidence’ or of an ‘experimental method’ was employed in the investigation into respiration physiology. However, despite the differences in their methodological views, both Boyle’s and the physicians’ actual use of experiment in the respiration investigation has much common with the modern idea of scientific evidence.

I

The modern concept of ‘evidence’ is ‘an appearance from which inferences may be drawn; an indication, mark, sign, token, trace’. In addition, ‘evidence’ is ‘ground for belief; testimony or facts tending to prove or disprove any conclusion’ (OED). Hence, the modern concept of evidence has two aspects. On the one hand, it is a means of discovery; a sign from which inferences may be drawn and, on the other, it provides grounds for belief. Hence evidence has a special relationship to knowledge; it is used both for the discovery of new knowledge and for constructing arguments to prove the truth of new knowledge thus acquired. As for the relationship between evidence and
facts, Lorraine Daston has pointed out that according to a commonplace modern view, facts and evidence are distinct categories; ‘only when enlisted in the service of a claim or a conjecture’ facts ‘become evidence, or facts with significance’.\(^{577}\)

In seventeenth-century respiration discussion, the concept of evidence can hardly be found; William Harvey, Robert Boyle and Thomas Willis, for instance, did not see the concept relevant when publishing their experimental findings or defending their theories. Richard Serjeantson has shown that the concept of evidence gradually changed its meaning during the seventeenth century. The old meaning of ‘evidence’ in philosophical and theological discussion was close to the Latin \(\textit{evidentia}\) which means ‘the condition of being evident’. Another old meaning for \(\textit{evidentia}\) is found in rhetoric where it referred to ‘vivid description, specifically word-painting’. Hence, ‘evidence’ commonly referred to something that was evident and thus implied a great degree of certainty.\(^{578}\) Serjeantson has suggested that the modern positivist usage of ‘evidence’ originates from common law. In common law, ‘evidence’ referred to testimony either of things or people. The new concept of evidence became part of the rhetorical category of testimony. Hence the development of the meaning of ‘evidence’ was a consequence of the change in the role of testimony from ‘supplying confirmation’ to ‘providing facts for information and subsequent argument.’ This change was related to ‘the growing insistence that reason should be applied to authority or faith.’\(^{579}\)

Henry Van Leeuwen has discerned this change of the meaning of ‘evidence’ in seventeenth-century religious discourse. He has argued that the change of the concept was a slow and gradual process. At some point, ‘evidence’ was understood as a large category consisting of testimonial proof of different kinds.\(^{580}\) John Wilkins, for instance, conceived the category as including matters of fact with various degrees of certainty; evidence arising from the testimony of senses and the nature of things themselves compelled assent, whereas evidence of a weaker kind was capable only of proving

\(^{577}\) Daston, ‘Marvelous Facts and Miraculous Evidence’, 93.

\(^{578}\) Serjeantson, \textit{Testimony, Authority and Proof}, 115-117.

\(^{579}\) Serjeantson, \textit{Testimony, Authority and Proof}, 104-145.

‘beyond reasonable doubt’.

Boyle used the concept of evidence in his religious and moral writings where it has its old meaning of the condition of being evident. For instance, we find ‘evidence’ in *Occasional Reflections* where Boyle writes that there are ‘certain Truths, that have in them so much of native Light or Evidence, that ... it cannot be hidden’. The old notion of *evidentia* or *certitudo* was further divided into objective and subjective. Objective evidence was a quality of a thing or a proposition, whereas subjective ‘certainty’ was rather a state of mind. Boyle understood ‘evidence’ principally as something evident to the mind; he associated the concept with knowledge gained without the intermediation of the ‘rules of reasoning’, that is, without interpretation or inference. In ‘Things Said to Transcend Reason’ (1681), he made a distinction between the things comprehended by induction and those being intuitively evident in the mind:

> I think a clear light or evidence of perception shining in the understanding, affords us the greatest assurance we can have ... of the truth of the judgments we pass upon things ... it is not by *induction*, but by *evidence*, that we know, that *ex vero nil nisi verum sequitur*. By which it appears, that the *innate light* of the rational faculty is more primary, than the very *Rules of Reasoning*.

Boyle further explained that ‘there are some things that the Intellect usually judges of in a kind of Organical way, that is, by the help of certain Rules, or Hypotheses, such as are a great part of the Theorems and Conclusions in Philosophy and Divinity.’ However, ‘there are others which it knows without the help of these Rules more immediately, and as it were intuitively by evidence or perception’.

It thus seems that Boyle held to the old notion of evidence. Therefore, in his natural philosophical or medical works, he did not associate experiment with evidence. The meaning of experiments, for instance such as those made with the air-pump, were anything but intuitively evident in the mind. Instead, they gained their meaning when interpreted in a complex framework of circumstances, theories and other experiments. Moreover, an experimental fact did not compel assent by itself but, in order to be persuasive, it had to be placed in an argument. For Boyle, ‘evidence’ was a stronger concept than the experimental proof; the ‘clear light of evidence or perception shining in the understanding affords us the greatest assurance we can have ( I mean in a *natural* way)*.\(^586\) ‘Evidence’ implied a high degree of certainty, whereas experiment belonged to the level of probability and moral certainty.

Although experiment was not associated with the ‘clear light of evidence’, Boyle regarded experiment as a means of discovery and proof. When employed in the context of theoretical knowledge, his idea about the function of experiment approximates the modern idea of scientific evidence. The physicians, who participated in the respiration research, likewise used experiment as a means of discovery and proof for physiological theories. However, Boyle’s and the physicians’ ideas about how and what kind of grounds for belief experiment warranted were different. The physicians’ idea about anatomical demonstration comes closer to the old notion of evidence understood as the condition of being evident. Anatomical demonstration produced visual experience by concretely showing the structure of an organ or a body part. It provided objective evidence, a visual testimony of the things.\(^587\)

The connection between anatomical demonstration and the old notion of evidence can be observed more clearly in the vernacular than the Latin medical works. For instance, George Castle associated experimentally gained anatomical knowledge about the structure of organs with evident demonstration. He wrote in *Chymical Galenist* (1667) that ‘the shape and fabrick of the Heart and Valves, the waterworks of the Kidneys, the admirable workman-ship of the Brain and Nerves, and the Artificial Structure of all


\(^{587}\) Cunningham, *Anatomical Renaissance*, 207-208.
other parts do evidently demonstrate the Mechanism of mans Body, and the usefulness of Knowledge in Anatomy. Castle’s remark originates from a vernacular polemical work. By contrast, the physicians’ treatises about respiration physiology were written in Latin. In his works, Thomas Willis, for instance, referred to experiment as ostensio or demonstratio.

Although the facts gained by anatomical experiment could not be used in dialectical or logical demonstration, the term ‘demonstration’ in itself implied a high degree of certainty and hence added the prestige of the experimental work of the anatomists. In anatomy, demonstration referred to concrete proof gained by showing as in a public anatomy. An anatomical demonstration was a means of ‘pointing out, in the anatomist’s sense of involving personal visual experience of what was being described’. A dissection was conceived as a demonstration particularly when performed publicly in the presence of witnesses. A public dissection demonstrated an anatomical discovery by showing the body parts and their structure in an individual body. An illustration picturing an organ or a body part aimed at functioning in a similar manner in an anatomical treatise. William Harvey had included woodcuts in De motu cordis. Likewise Richard Lower, who was one of the leading late seventeenth-century anatomists in England, used woodcuts to illustrate his detailed accounts about anatomical experiments in Tractatus de corde (1669).

II

The development of the meaning of ‘evidence’ was part of a broader change of epistemological ideas which obscured the boundaries between knowledge, probability and opinion. The possibility of conceiving and using experiment as evidence required a significant change in the traditional idea of natural philosophical and medical

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588 Castle, Chymical Galenist, 8.
590 French, Harvey’s Natural Philosophy, 20, 32-33.
592 French, Harvey’s Natural Philosophy, 338.
593 French, Harvey’s Natural Philosophy, 20, 32-33.
knowledge and, moreover, a general acceptance of this change. In the context of the scholarly disciplines, such as natural philosophy or medicine, knowledge was associated with demonstrated truths about the causes of natural phenomena. Logical demonstration was a requisite of *scientia*. Syllogism and the nature of the premisses used in it were essential factors of the logical demonstration. In addition to being causes, the premisses had to be true, necessary, universal and better known than the conclusion. The premisses were either conclusions of other demonstrative syllogisms or first principles. Thus knowledge was associated with necessary truths, whereas contingent things were connected with probability and opinion which were governed by the arts of dialectic and rhetoric. Hence, probability belonged to a different category than *scientia* and had a different object as well.\footnote{594}{Lane Patey, *Probability and Literary Form*, 9-11.}


Stephen Gaukroger has noted that Bacon’s philosophy involved an attempt to build a connection between law, rhetoric and natural philosophy. Bacon aimed at moving natural philosophy from the sphere of the contemplative life of a scholar to the area of the active life and the affairs of state.\footnote{596}{Gaukroger, *Francis Bacon*, 44-57.} Barbara Shapiro has observed the epistemological change in a wider context of seventeenth-century English intellectual life. She has shown that in addition to religious discourse, new epistemological ideas become dominant also in fields such as law, history and literature, for instance. Some ideas and notions – such as moral certainty and evidence – familiar from rhetoric, everyday life and theology gradually gained ground also in the investigation of natural phenomena and particularly in the empirically orientated natural philosophies of the day.\footnote{597}{Shapiro, *Probability and Certainty*, 9, 71.}
Rose-Mary Sargent has associated Boyle’s ideas about proof and evidence with the common law practices of constructing proof. She has noted that ‘as Boyle’s method of discovery was modelled after that used in the legal realm, so too was his method of justification’.\textsuperscript{598} For instance, in \textit{Reason and Religion} (1675), Boyle used a legal analogy to illustrate his idea of proof and the concept of moral demonstration:

And this is considerable in \textit{Moral} Demonstrations, that such may consist, and be as it were made up of particulars, that are each of them only probable; of which the Laws establish’d by God himself among his own People, as well as the practice of our Courts of Justice here in \textit{England}, afford us a manifest instance in the case of Murder, and some other Criminal Causes. For, though a Testimony of a single Witness shall not suffice to prove the accus’d party guilty of Murder; yet the Testimony of two Witnesses, though but of equal Credit, that is, a second Testimony added to to the first, though of it self never a whit more credible than the former, shall ordinarily suffice to prove a Man guilty; because it is thought reasonable to suppose, that, though each Testimony \textit{single} be but probable, yet a concurrence of such Probabilities ... may well amount to a Moral certainty, \textit{i.e.} such a certainty as may warrant the Judge to proceed to the sentence of death against the Indicted party.\textsuperscript{599}

Boyle did not discuss his views about knowledge, justification and proof in his natural philosophical works. Instead, his epistemological ideas are mostly found in his religious works; both \textit{Excellency of Theology} (1674) and \textit{Reason and Religion} (1675) discuss


\textsuperscript{599} Boyle, \textit{Reason and Religion}, 281-282.
knowledge and the degrees of certainty. According to Boyle, the highest degree of certainty was metaphysical certainty. Metaphysical truths were necessarily true in the sense that the matter being otherwise would lead to a contradiction. The next degree was physical certainty which concerned matters which seemed to be necessary truths in the physical world. Boyle’s example of a physical truth was ex nihilo nihil fit – nothing comes from nothing. Physical truths were not absolutely necessary, however, since God could interfere in the ordinary course of nature and falsify a physical truth. Moreover, Boyle suspected that some propositions regarded as physical truths in fact possessed only moral certainty. Moral certainty was associated with probability. It was based on historical evidence strong enough ‘for a wise man, and even a Philosopher to acquiesce in’.\(^{600}\) Moral certainty was achieved by concurrence of probabilities; ‘such may consist, and be it as it were made up of particulars, that are each of them but probable’.\(^{601}\)

Producing concurrence of probabilities to achieve knowledge with moral certainty was a complex procedure. The experimental matters of fact formed one category of ‘probable particulars’ which could be used for gaining moral certainty. However, the truth of experimental matters of fact could be questionable. As Barbara Shapiro has noted, truth was not a necessary quality of seventeenth-century concept of fact.\(^{602}\) Therefore, before the experimentally produced matters of fact could be used as proof for knowledge claims, they had to be proven true. Testimony was employed to persuade others about the truth of the experimental matters of fact. The experiments had to be made with utmost care and, in addition, they must be reported circumstantially and convincingly to persuade others of their truth. In the case of extraordinary matters of fact, additional testimonies of reliable witnesses were required as proof for the fact.

When it came to theoretical knowledge claims, a hypothesis or a theory had to be carefully weighed in an appropriate context in order to achieve moral certainty. The probatory force of a single experiment was weak. In order to produce concurrence of probabilities, a larger framework of theory, other experiments, circumstances and proofs

\(^{600}\) Boyle, *Excellency of Theology*, 64-66.


\(^{602}\) Shapiro, *A Culture of Fact*, 9-11.
of other kinds was required. Moral demonstrations were ‘made up of particulars, that are each of them but probable’. Coherence was one of the criteria of truth for Boyle. The truth of a proposition was to be assessed as ‘Part of a Systeme ... For a thing considered in it self may seem False, or very unfit to be believ’d, which yet when it is legitimately Deduc’d from other Truths, or is shown to have a strict Connexion with them, ought for their sakes to be freely admitted. The context of assessing the probability of causal knowledge was formed by other theories, relevant circumstances and proofs of different kinds. According to Boyle, ‘one of the Conditions of a good Hypothesis is, that It fairly comport with not onely with all other Truths, but with all other Phaenomena of Nature, as well as those ’tis fram’d to explicate.’

The probatory force of experiment depended on what kind of epistemology was endorsed. The experimental community accepted the experimental facts as evidence but those, who regarded knowledge as something with a high degree of certainty, were not similarly convinced. The epistemological discussions were often conducted in works which were concerned with particular philosophical issues, such as the existence of vacuum in nature, for instance. The epistemological differences can be observed for instance in Boyle’s and Thomas Hobbes’ dispute about the air-pump experiments. While criticising Boyle’s ‘doctrine’ about ‘the spring of the air’, Hobbes aimed at showing that the phenomena exhibited in the air-pump could be better explained by his own principles from which the phenomena necessarily followed. Hobbes did not regard anything incapable of demonstration and certainty as philosophical knowledge but mere opinion. Hence, he conceived Boyle’s experimental proof as an attempt to ‘demonstrate without the principle of demonstration.’ Hobbes regarded the experimentally produced matters of fact and historical knowledge as items belonging to a different category from natural philosophy and scientia. He likewise pointed out that science was achieved by method, not by the ingenuity of the investigators; ‘ingenuity is one thing and method [ars] is another. Here method is needed.’ Boyle, however, had not

603 Boyle, Reason and Religion, 281.
604 BP, vol. 10, fol. 36.
605 Boyle, Excellency of Theology, 89.
607 Hobbes, Physical Dialogue of the Nature of the Air, 347. Shapin and Schaffer, Leviathan and the Air-
claimed that experiment was a method of demonstration. When answering Hobbes, he pointed out that his intention had not been ‘to write Elements of Philosophy’ but ‘by competent Experiments and other Proofs’ confirm the truth of his ‘Doctrine’.\footnote{Robert Boyle, An Examen of Mr. T. Hobbes his Dialogue Physicus De Natura Aeris, (1662), Works, vol. 3, (109-188), 171.}

Boyle settled for moral certainty and experimental proof in natural philosophical and medical matters. For him, experiment was a practical matter which belonged to the uncertain practical world where a wise man had no choice but to base his actions on moral certainties. By contrast, he associated the concept of evidence with truths possessing a high degree of certainty. \textit{Contrary to Boyle’s diffidence}, the English physicians tended to have a great confidence in the probatory power of experiment. The physicians who advocated medical reform and regarded experiment as a means of advancing medicine, in particular, associated experiment with demonstration. For instance, the medical polemist Marchamont Nedham claimed that his ‘new Doctrine’ about ‘vermification’ was ‘established by Demonstration of irrefragable Experiments’. Experiments were ‘the best kind of arguments’ since they were capable of producing certain and universal truths.\footnote{M.N., Medela Medicinae, 186, 198.}

Furthermore, anatomy differed from other areas of natural philosophy and medicine when it came to experiment and its value. The developments in anatomy and physiology in the sixteenth and early seventeenth centuries had established the role of experiment in the field. Although the medical community had not reached an absolute consensus about the role of the dissection and vivisection experiments in anatomical investigation, experiment was a more generally accepted method of discovery and proof in anatomy than in most other areas of natural philosophy and medicine.\footnote{French, Harvey’s Natural Philosophy, 159-162.}

The notion of demonstration was important for the status of the discipline and its practitioners. For the learned physicians, one of the central issues of their field was whether medical knowledge was capable of demonstration or if the physicians were
forced to accept that their professional field was merely a conjectural art.\textsuperscript{611} The epistemological status of medicine had important implications for the social and intellectual status of university educated physicians.\textsuperscript{612} Marchamont Nedham, for instance, complained that it was a ‘Scandal hitherto imputed unto our Profession, that it is but \textit{Ars Conjecturalis}, a meer Conjectural Art, and the best part of the Professors but \textit{good ghecessrs}, and of little use’.\textsuperscript{613}

Seventeenth-century anatomists, however, had found a convincing model of method in Aristotle’s works. In addition, although an anatomical experiment was a concrete affair and, therefore, differed from logical demonstration, it nevertheless carried some of the certainty traditionally associated with the term demonstration.\textsuperscript{614} Moreover, the idea that nature was purposeful provided the anatomists with a strong justification for the inference from structure to function. The structure of an organ or a body part was regarded as designed for its function or purpose. Hence the structure of an organ observed in an anatomical experiment indicated its final cause, in other words, its purpose.\textsuperscript{615} Consequently, a dissection or a vivisection experiment, which concretely demonstrated the structure and the function of an organ, provided strong evidence for physiological theories. Boyle, by contrast, had no similar strong faith in anatomical experiment but regarded it like any other experiment as providing grounds for ‘probable Conjectures’.\textsuperscript{616} The differences in how the role of experiment was understood, however, were not significant enough to create discussion about the topic at the time. Instead, a general agreement about the importance of experiment in physiological investigation existed.

\begin{footnotesize}
\footnote{611}{Maclean, \textit{Logic, Signs and Nature}, 70-76 and Lane Patey, \textit{Probability and Literary Form}, 42-45.}
\footnote{612}{Daniela Mugnai Carrara, ‘Epistemological Problems in Giovanni Mainardi’s Commentary on Galen’s \textit{Ars Parva}’, in Grafton and Siraici, (eds.), \textit{Natural Particulars}, (251-273), 251, 259-265, Maclean, \textit{Logic, Signs and Nature}, 68-76 and Siraici, \textit{Clock and the Mirror}, 44-52.}
\footnote{613}{M.N., \textit{Medela Medicinae}, 228.}
\footnote{614}{French, \textit{Harvey’s Natural Philosophy}, 18-20.}
\footnote{615}{Cunningham, \textit{Anatomical Renaissance}, 38-42, 206-209, 231-234.}
\footnote{616}{Boyle, \textit{Final Causes}, 125.}
\end{footnotesize}
4.4. Demonstration and Proof in Physiology

This section examines the style and the arguments employed in some of the treatises participating in the discussion about physiological theory. I concentrate particularly on Boyle’s style and argument in *Spring of the Air* and on comparing his argument with those of the physicians. In addition, I discuss William Harvey’s *De motu cordis* as a work which provided one model of using experimental proof in anatomical writing. Harvey’s success in persuading his readers about the truth of his theory about the circulation of the blood had an impact on the structure and style of the works of the respiration physiologists. Their writings, however, did not rigorously follow the form of Harvey’s academic essay. Nevertheless, Harvey’s model of limited explanation became a favoured form of physiological explanation; instead of presenting complete anatomical systems explicating both the *historia* and the *doctrina*, late seventeenth-century anatomical works often had more restricted scope.

Boyle’s use of experimental proof differed from that of physicians. I end the section with a discussion about Boyle’s and Thomas Willis’s writings about the connection between air, fire and life. Willis used Boyle’s air-pump experiments as evidence for his own theory about the purpose of respiration. Boyle, however, interpreted the same experiments differently. Willis claimed that Boyle had experimentally demonstrated the truth of Willis’s theory but Boyle remained diffident. On the basis of these experiments, Boyle was not able to make definite conclusions but, instead, ended up asking more questions. Boyle and Willis shared no definite idea of the manner experiment functioned as a means of discovery and proof. Likewise, no general consensus about the probatory force and the argument from experiment existed in the respiration discourse. The experimental approach to respiration physiology did not produce agreement among the experimental physiologists about the purpose of respiration and the use of air for animal life.
Seventeenth-century gentlemanly virtuosi, such as Boyle, sought a middle way between absolute scepticism and the scholastic requirement of demonstrative certainty of knowledge. Like other seventeenth-century virtuosi, also Boyle aimed at establishing moral certainty – the degree of certainty sufficient to function as a basis of rational action in the affairs of daily life – as a standard of natural philosophical evidence. He considered the proofs sufficient to persuade a ‘rational man’ as adequate grounds for belief also in philosophical matters.\(^\text{617}\)

Boyle’s manner of proving by experiment was constructed around the concepts of concurrence of probabilities and moral certainty. In contemporary natural philosophical and medical discourse, however, anything short of demonstration and certainty tended to be regarded rather as opinion than knowledge. Probability and opinion belonged to the world of rhetoric.\(^\text{618}\) Hence, from the standpoint of the traditional epistemology and methods of argument, Boyle’s argument from experiment was rhetorical. Thus also Boyle may be seen as one of the representatives of the ‘new rhetoric’ which spread the application of rhetoric to both popular and learned discussion.\(^\text{619}\) Nevertheless, although Boyle was conscious of the fact that his manner of writing natural philosophical works was not conventional, he and the other members of seventeenth-century experimental community hardly conceived themselves as being engaged in an essentially rhetorical enterprise.

The traditional logical demonstration had no place for the presentation of empirical novelty. When a novelty, such as the circulation theory, for instance, was presented, a rhetorical argument was required. However, a rhetorical argument and presentation were not considered suitable for learned medical works. Nevertheless, presenting novelty tended to increase the rhetorical elements also in medical works which, at the same time, aimed at fulfilling the requirements of academic learning. Roger French has emphasized the care with which William Harvey chose his manner of publishing his

\(^{617}\) Daston, Classical Probability, 56-57. See also Shapiro, Probability and Certainty, 27-37.

\(^{618}\) Lane Patey, Probability and Literary Form, 9.

\(^{619}\) On the ‘new rhetoric’ see Howell, Logic and Rhetoric, 364-390.
theory about the circulation of the blood. Harvey aimed at persuading the learned medical community and, therefore, published his work as an *exercitatio*, which was an academic form of essay. An *exercitatio* was a rhetorical mode of presentation since it required no demonstration. Instead, the style of an academic essay was ‘judicial’ or ‘deliberative’.  

When Harvey published his work, the rhetorical argument of *De motu cordis* was criticised. *De motu cordis* is shaped by Aristotelian rhetoric in its argument, concern for the intended audience and language. For instance, Harvey used rhetorical means, such as metaphor and practical simile, firearms for instance, when explicating his view about the function of the heart. Harvey’s dissection and vivisection experiments, together with his calculations of the amount of blood passing through the body, formed the principal proof for the circulation theory. His quantitative proof, in particular, was regarded as ‘a mode of argument, or rhetoric’. Harvey presented no demonstrative proof but aimed at proving the circulation theory by the narratives of his experiments and by the inference from structure to function. Although no formal demonstration was expected of an *exercitatio*, *De motu cordis* was criticised since it also lacked demonstration in its anatomical sense of autopsia; the circulation of the blood could not be observed but had to inferred from observations of structure and action.

In addition to its rhetorical argument, also the structure of *De motu cordis* deviated from the conventions of anatomical explanation. Harvey’s explanation was conceived as an incomplete explanation since it gave no final cause for the circulation of the blood. Harvey defended his limited explanation in his ‘Second Essay to Jean Riolan’ (1649) where he emphasized the order of anatomical investigation and explanation:

> With regard to those who repudiate the circulation because

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620 French, *Harvey’s Natural Philosophy*, 94-95, 99-100.
622 French, *Harvey’s Natural Philosophy*, 92-93, 110.
623 French, *Harvey’s Natural Philosophy*, 92-93.
624 French, *Harvey’s Natural Philosophy*, 256, 310.
they see neither its efficient nor its final cause, I have to date added no reply to their query ‘Who benefits?’; but it still remains to be demonstrated. First, one ought to admit what should be investigated rather than the reason for such further study. For from the things which occur in the circulation and are set down here, the uses and usefulness of it should be investigated. Meanwhile, I will say, ‘How many things are accepted in physiology, pathology and therapy of which we do not know the causes, but of the existence of which no one doubts?’

Despite the criticism presented towards Harvey’s circulation theory, however, the medical and natural philosophical communities accepted his theory in a somewhat short time. Together with the success of Harvey and other early seventeenth-century anatomists, the experimental method of discovery and proof gained ground in anatomy gradually replacing the traditional verbal demonstration. Experimental proof became more and more required in medicine.

Harvey’s works functioned as models for both physicians and natural philosophers. Moreover, the success of Harvey’s rhetorical presentation of the circulation theory brought the academic and non-academic literary presentation closer to each other. Harvey’s emphasis on *historia anatomica* – the description of anatomical experiment – likewise tended to increase the proportion of description and narrative in seventeenth-century anatomical and natural philosophical works. Also the wider experimental community found Harvey’s work and his experimental approach appealing. In particular, Harvey’s limited explanation, which focused on *historia* instead doctrine, appealed to late seventeenth-century experimentalists. The English experimentalists

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depreciated the ideal of demonstrative knowledge and complete systems and, instead, favoured the matters of fact, probable knowledge and partial explanations.\textsuperscript{628} Nevertheless, although the Harveian style of limited explanation became accepted as a temporary stopping point which further research could be based on, the search for final causes or purpose remained an important part of anatomical studies. Boyle, for instance, appreciated the teleological model of explanation in anatomy.\textsuperscript{629}

The paths of the medical professionals and the gentlemanly \textit{virtuosi} crossed in the community of experimental natural philosophers. The investigation into respiration physiology was one of the occasions which combined the experimental natural philosophy with medical anatomy. In the respiration discourse, Harvey’s model of limited explanation was preferred; it became common to write brief essays presenting new experiments and ideas instead of presenting a whole physiological system. However, no uniform style of ‘scientific writing’ was created. The physicians followed the conventions of medical writing, whereas Boyle preferred the more loosely organized gentlemanly essay form. The physicians continued to write and published in Latin, whereas Boyle wrote in the vernacular.\textsuperscript{630} Moreover, contrary to Boyle’s experimental discourse, which aimed at proving that one theory was more probable than the others, the physicians associated experiment with demonstration.

In \textit{Spring of the Air}, Boyle’s loosely organized essay on respiration and his tentative conclusions are very different from the organized structure and tight argument of Harvey’s \textit{De motu cordis}. \textit{De motu cordis} begins with a proem where Harvey states his research problem and refutes contemporary theories of heart’s action and pulse. The work proceeds in orderly manner by showing how the circulation of the blood is a consequence of the structure and the action of the heart and blood vessels. The chapters of the book display the order of Harvey’s discovery starting with the description of the heart and its action and ending to the circulation of the blood, which is presented in

\textsuperscript{628} French, \textit{Harvey’s Natural Philosophy}, 317.
\textsuperscript{629} Boyle, \textit{Final Causes}, 125-130.
\textsuperscript{630} A Latin translation of Boyle’s \textit{Spring of the Air}, however, was prepared and published at the same time as the English version of the work (Michael Hunter, ‘Latin Translations of Boyle’s Works’, \textit{Works}, vol. 1, (lx-lxxiv), lx).
Chapter 8 of the *De motu cordis*. In *Spring of the Air*, Boyle pointed out that his discourse about respiration did not resemble the traditional form and structure of an anatomical text:

I suppose You will not expect that (as if You know not, or had forgotten what Anatomists are wont to teach) I should entertain You with a needless Discourse of the Organs of Respiration, and the variety of their Structure in several Animals; though if it were necessary, and had not been perform'd by others, I should think, with Galen, that by treating of the Fabricks of living Bodies, I might compose Hymns to the wise Author of Nature, who, in excellent contrivance of Lungs, and other parts of (those admirable Engines) Animals, manifests himself to be indeed what the Eloquent Prophet most justly speaks him, *Wonderful in Councel, and excellent in working*.632

The digression on respiration in Boyle’s *Spring of the Air* is an essay, a form he preferred when discussing experiments and their theoretical implications. An essay form was particularly appropriate for the presentation of a novelty. Moreover, the form allowed an open-ended discourse with no definite conclusions.633 Instead of starting his discussion by examining the structure of the lungs of different animals, Boyle’s discussion about respiration built upon the results of others’ anatomical experiments. As we saw earlier in 4.2., in the essay Boyle’s aim was to examine ‘the principal subject of our Engine, namely, The use of Respiration; or rather, The use of the Air in Respiration’.634 He discussed the theories about the purpose of respiration as far as his new experiments could be brought to bear on the topic. He proceeded by evaluating and refuting one theory after another in the light of his air-pump experiments and additional proofs of various kinds. He aimed at showing how his experiments and other

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631 For a detailed discussion about Harvey’s *De motu cordis* see French, *Harvey’s Natural Philosophy*, 94-113.
634 Boyle, *Spring of the Air*, 281.
phenomena refuted the proposed theories about the purpose of respiration thereby making his own explanation seem the most probable.

Although Boyle’s own air-pump experiments dominate his evaluation of the different theories about the purpose of respiration, experiments do not form the only category of proof in Boyle’s discussion. Instead, he presented other additional proofs which originated from various sources. In a similar manner as in the medical Usefulness, he employed several kinds of testimonies. For instance, he discussed the testimonies of the ‘Learned Josephus Acosta’ and ‘An English Gentleman’ who had visited ‘the top of the Pike of Teneriff and referred to more vaguely defined common experience about lead mines, pearl divers, and lung disorders. Moreover, he entertained his readers with a curiosity; the digression contains a long narrative about ‘Cornelius Drebels’ ... Vessel to go under Water’ in which some secret substance was used to ‘refresh’ the air. Finally, instead of presenting definite conclusions about the use of air, Boyle ended up suspecting that air had some use that none of the contemporary theories explained.

II

In England, respiration physiology was an interest of a community of physicians and natural philosophers. One of the advances of the co-operative work was the possibility of using others’ experiments as evidence. However, although the community of physiologists agreed about the importance of experiment in the investigation, they might have disagreed about the interpretation of particular experiments. Barbara Shapiro has noted that in the experimental community, moral certainty was ‘reached by impartial investigators after carefully judging substantial evidence.’ In respiration physiology, no moral certainty about the use of respiration was achieved. New explanations – both chemical and mechanical – were suggested but in the light of

evidence no general consensus on the subject matter was reached.\footnote{Frank, \textit{Harvey and the Oxford Physiologists}, 140-163.} The examination of Thomas Willis’s and Boyle’s interpretations of Boyle’s air-pump experiments also shows that no consensus about the nature of experimental evidence existed.

When Harvey had written and published \textit{De motu cordis} in 1628, he was able to use his own extensive experimental work as evidence. Later, it became common to use the experiments of other reliable experimentalists as well. Since experimental evidence can not be conclusive, the same experiments can be used as evidence for different theories.\footnote{Lorraine Daston, ‘Strange Facts, Plain Facts, and the Texture of Scientific Experience in the Enlightenment’, in Suzanne Marchand and Elizabeth Lunbeck, (eds), \textit{Proof and Persuasion: Essays on Authority, Objectivity and Evidence}, (Brebols, Belgium, 1996, 42-59), 57-58.} For this reason, also Boyle recommended publishing even miscellaneous experiments. The experimental matters of fact could be placed in various theoretical contexts:

If a Writer endeavours, by delivering new and real Observations or Experiments, to credit his Opinions ... let his Opinions be never so false, his Experiments being true, I am not oblig’d to believe the former, and am left at liberty to benefit my self by the later.\footnote{Boyle, ‘A Proemial Essay’, 15.}

Anatomical experiments were often technically difficult and, therefore, needless repetition was mostly avoided; for instance, dissection and vivisection, in particular, required considerable skill. Moreover, new instruments, such as Boyle’s air-pump, were expensive, rare and difficult to operate.

Others’ experiments could be used as evidence only if they were conducted by trustworthy people using methods known and accepted by the community. In the case of famous anatomists or members of the network of personal acquaintances, the questions of reliability and expertise hardly arose. In \textit{Spring of the Air}, for instance, Boyle used Highmore’s and Bartholin’s animal experiments as proof for his view about the mechanism of respiration. He referred to these experiments only briefly. No detailed
account of the experiments of such famous anatomists as Bartholin, Highmore or Harvey was required. Some of the leading physiologists, such as John Mayow and Thomas Willis, likewise used Boyle’s air-pump experiments in a similar manner when publishing their own theories about the use of air and respiration.\textsuperscript{643}

An examination of Thomas Willis’s use of Boyle’s air-pump experiments shows that Boyle’s and Willis’s ideas about experimental evidence and the kind of inference it allowed were very different. Willis extended his confidence in the probatory force of anatomical demonstration to Boyle’s air-pump experiments as well. He examined the relationship between air, fire and life in \textit{De sanguinis incalescencia sive accesione} (1670) and in \textit{De anima brutorum} (1672). The traditional physiology had combined fire, life and air in its explanation of respiration. In short, the idea was that the left ventricle of the heart was the seat of the ‘vital fire’ of animals. The purpose of the left ventricle was to produce vital spirits for the body. In this process, air was required both for cooling the heart and for the production of vital spirits.\textsuperscript{644} Hence, the traditional theory regarded life as a fire of a kind. Although Harvey and his followers had refuted the traditional theory as such, a strong suspicion about the similarity between air’s role in combustion and respiration remained. In \textit{Spring of the Air}, for instance, Boyle noted that there indeed seemed to be a resemblance between these two processes but that the matter was complicated. Therefore, although the air-pump experiments showed that ‘a new kind of resemblance betwixt fire and life’ existed, the theory was ‘not free from Difficulties.’\textsuperscript{645}

In his \textit{De sanguinis incalescencia sive accesione} (1670), Thomas Willis argued that the blood of a living animal was hot because it was ‘inkindled’. Hence also Willis postulated a connection between fire and life. Like Harvey and other contemporary anatomists, Willis placed the vital spirits and the fire of living organisms rather in the blood than the heart. His theory was essentially a chemical one and resembled Ralph Bathurst’s earlier theory about \textit{pabulum nitrosum}, the nitrous substance of the air, which

\textsuperscript{643} Frank, \textit{Harvey and the Oxford Physiologists}, 227, 235.
\textsuperscript{644} Frank, \textit{Harvey and the Oxford Physiologists}, 5-6.
\textsuperscript{645} Boyle, \textit{Spring of the Air}, 288-289.
was necessary for life. According to Willis, the ‘nitrous particles of the air’, which caused the ‘inkindling’ of the blood, were also involved in combustion. As evidence for his theory Willis used, among other things, Boyle’s air-pump experiments. These experiments, where burning objects and animals were enclosed in the receiver of the air-pump, had been published earlier in Boyle’s *Spring of the Air*.

Willis’s interpretation of Boyle’s experiments differed from Boyle’s own views. On the basis of the same experiments, Boyle had cautiously concluded that there seemed to be some kind of connection between the air, life and fire. Furthermore, he had noted that these experiments strongly suggested that besides being an active recipient of the waste of the blood, air had some other unknown use for the body. He had not mentioned any ‘nitrous substance’ necessary for life and fire in *Spring of the Air*. Nevertheless, Willis claimed that ‘the Illustrious Mr. Robert Boyle had demonstrated’ that ‘fire and flame being included in a place empty of air, expire by reason of the food of Nitre being drawn away’. Willis regarded Boyle’s experiments as important and therefore discussed them in some detail. He claimed that Boyle’s experiments showed that animals died in the evacuated receiver ‘because the vital flame of the blood is wanting of the nitrous Food of the Air’. Consequently, Willis concluded that ‘the life of a living Creature to be either fire, or something analo"gical to it.’

Boyle did not criticize Willis’s theory or his interpretation of the air-pump experiments in public. However, in 1672 Boyle published his ‘New Experiments, Touching the Relation betwixt Flame & Air: And particularly betwixt Air, and the Flamma Vitalis of Animals’. In this short tract, Boyle repeated his earlier thoughts about the relationship between respiration and combustion. He noted that ‘among other considerations’ which

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made him publish his experiments was the fact that ‘divers of our Learned men have spent both Thoughts and Discourses in inquiring and Disputing, Whether there reside in the heart of Animals, such a fine and kindled, but mild, Substance, as they call a Vital Flame, to whose preservation, as to that of other flames, the Air, (especially as ‘tis taken in, and expell’d again by Respiration) is necessary.’

Boyle’s ‘Flame and Air’ aimed at proving that the relationship between air, fire and life was more complicated than Willis’s and other contemporary theories explained. Boyle’s tract begins by reporting experiments which investigated air and combustion. Boyle found out that it was difficult both to produce and maintain fire in the vacuum. His results, however, were ambiguous and he was not able to make any conclusions about the role of air in combustion. He proceeded to investigate the similarities between fire and animal life by performing experiments where burning objects were enclosed in the receiver of the air-pump together with small animals, such as mice and birds. When the receiver was evacuated, he found out that the flame was extinguished in a few minutes, whereas the animals showed no signs of being uncomfortable at that point. The experiments were technically difficult and their results were not encouraging. On the basis of these experiments, the relationship between the air, combustion and respiration seemed to Boyle even more complicated than before. Therefore, instead of making any conclusions about the matter, he ended up asking more questions:

Whether this survival of Animals, not only to a flame that emits store of fuliginous steams ... but to that which is made of so pure a fuel as Spirit of Wine, that affords not such steams ... Whether, I say, this survival proceeds from this, That the Common flame and the Vital flame are maintained by distinct substances or parts of the Air; or that common Flame making a great waste of the Aereal substance, they both need to keep them alive, cannot so

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easily as the other find matter to prey upon, and so expires, whilst there yet remains enough to keep alive the more temperate Vital flame; or that both these causes, and perhaps some other, concurr to the *Phaenomenon*, I leave to be consider’d.\(^653\)

The contrast between Boyle’s diffidence and Willis’s more confident use of experimental evidence is striking. Boyle’s gentlemanly style of discourse aimed at proving by showing how Boyle himself had come to endorse a particular conclusion. His argument did not force his audience to assent but left the matter for the reader to be judged. As Rose-Mary Sargent has pointed out, Boyle’s manner of writing reflected experimental activity as a ‘dynamic and open-ended learning process’.\(^654\) Boyle’s experimental inquiry was a complicated interplay between experiment, testimony, the relevant circumstances and theories. Instead of conclusive evidence, it provided concurrence of probabilities and moral certainty at best. By contrast, Willis regarded Boyle’s air-pump experiments as strong evidence for his own theory about respiration; he conceived these experiments as experimental demonstrations of the truth of his theory about the connection between air, fire and life.

Generally, the physicians’ confidence in the probatory force of experiment is visible in the manner in which ‘experimental demonstration’ is used in their treatises; the use of experiment needs no justification and its role is not discussed. Instead, in anatomy and physiology its role as a demonstration of a particular kind is established. An anatomical explanation proceeded by inference from structure to function. Justification for inference of this kind arose from the idea that structure was the best possible one in relation to function. We have seen that the strong probatory force of anatomical experiment was based on its nature as a visual demonstration of structure. In the respiration discussion, the idea of anatomical experiment as strong evidence was extended to other kinds of experiments as well. Willis regarded Boyle’s air-pump experiments as strong evidence despite the fact that they had nothing to do with

\(^{653}\) Boyle, ‘Flame and Air’, 117-120.

\(^{654}\) Sargent, *Diffident Naturalist*, 181-185.
inference from structure to function. However, the difference was hardly considered important at the time since, as far as I know, it is not discussed in the published works on respiration. Boyle often warned that theories should not be based on too few experiments and probably did not regard the conclusions Willis drew from his air-pump experiments as warranted. In general, the English physicians involved in the physiological research held a strong belief in the persuasive power of experiment; the physicians’ notion of experimental demonstration implied a higher degree of certainty than Boyle’s notion of ‘probable particulars’.

SUMMARY

William Harvey’s success in establishing his theory about the circulation of the blood furnished the English natural philosophers with an important example of how to conduct anatomical investigations and to publish their results. In addition, Harvey’s theory opened a new field of study; respiration physiology. Boyle participated in the investigation into respiration physiology with his air-pump experiments. However, the experimental community conducting the investigation consisted principally of physicians. Hence the major part of the respiration experiments was performed by the anatomical methods of dissection and vivisection.

Experiment had established its role in anatomical studies and explanation already in the sixteenth century. An anatomical explanation followed the model of Aristotle’s works on animals. In the Aristotelian explanatory scheme, experiment provided the basis for the doctrine of causes. The idea that nature was purposeful and hence the organs and the body parts of animals were designed for their purpose furnished a strong justification for the inference from structure to function. Anatomical experiment demonstrated the structure and, therefore, functioned as a means of both discovering and proving the purpose of the organ. The anatomical model provided physicians with good grounds to trust the power of experiment to prove anatomical discoveries.
It seems that many late seventeenth-century physicians extended their trust in the probatory power of the anatomical demonstration also to experiments of other kinds, such as those Boyle conducted with the air-pump, for instance. Hence Thomas Willis could state that Boyle had experimentally demonstrated that air was necessary for animal life. In the respiration research and discussion, the use of experiment comes close to the modern notion of evidence. However, in the discussion experiment was not referred to as ‘evidence’. Physicians wrote principally in Latin and used terms such as *demonstratio* or *ostensio*. Boyle regarded the anatomical explanation as a special case in which the Aristotelian notion of final cause provided a means of constructing arguments from structure to function. However, he did not associate his air-pump experiments with anatomical demonstration or with the concept of evidence. When assessing contemporary theories about the purpose of respiration, Boyle used his air-pump experiments as a factor in a complex network formed by theories, different kinds of testimonies and the relevant circumstances.

Despite the established role of anatomical experiment in the explanation of causes, experiment could not provide a logical demonstration which still was often regarded as the only means of gaining *scientia*. The community of English anatomists accepted experiment as a means of discovery and proof but outsiders were not similarly convinced. Since logical demonstration and the argument from experiment were essentially different, contemporary readers and the critics of experimentalism, in particular, conceived experiment as part of a rhetorical argument. When one was not able to demonstrate, one had to settle for persuasion.
CONCLUSION

Robert Boyle was no medical man. Although he conducted a significant amount of work in the field of medicine, the posterity hardly remembers him for the results of these inquiries. The more famous medical man of the next generation, Hermann Boerhaave, did not appreciate Boyle’s achievement in the field of medicine but noted:

For, as he did not practise physic himself, his way was, upon making any new preparation, to give it to some physicians to make trial thereof; and they, it seems, out of complaisance, would speak more largely of it than it deserved. Hence, those profuse commendations he bestows upon the spirit of human blood and harts-horn in phthisical, and on the Ens Veneris in rachitical cases.655

Modern historians have only seldom discussed Boyle’s medical work. Considering Boyle’s vast literary output, medicine indeed seems to have been a minor interest of his. His interest in medical matters, however, has received some attention from the historians of medicine, who have recognized the significance of the experimental natural philosophy for the development of medicine as a discipline and the impact experimentalism had on seventeenth-century medical discourse.

Boyle introduced himself as a gentleman and a natural philosopher in his medical works as well. His socio-economic position provided him with the means and leisure necessary for the kind of creative experimental work he conducted. With the assistance of his amanuenses, he examined a variety of subjects of which medicine was one. First and foremost, however, he was a proponent of an experimental approach to natural and medical knowledge. Throughout his published works, Boyle advocated experiment as the best means of acquiring new and useful knowledge about natural phenomena. He regarded medicine as a subcategory of natural philosophy. Therefore, he suggested that

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the experimental natural philosophy was the best candidate to replace the traditional school Aristotelianism as the basis of medical knowledge. The improved medical theory was subsequently to function as the basis for the novel experimentally tested medical practices. Moreover, Boyle suggested that also medicine should become experimental. A versatile use of medical experiment would produce advancement in the fields of theoretical and practical medicine.

Boyle offered his experimental natural philosophy as a solution to what many of his contemporaries regarded as the sad state of medicine. In this study, I have examined Boyle’s medical works from the opposite viewpoint; instead of exploring the impact of experimentalism on medicine, I have studied the ways that the medical notions of experiment function in Boyle’s medical works. Seventeenth-century medicine was experimental to a somewhat high degree. My study has focused on a trial-and-error experiment of practical medicine on the one hand, and on the role of experiment in anatomical investigation, on the other. We have seen that Boyle exploited the medical models of experiment even though he did not adopt these models as such. He employed the trial-and-error experiment of medical practice in his work when inventing new pharmaceuticals. He likewise participated in contemporary investigation into respiration physiology. Moreover, he attempted to combine practical medicine to natural philosophical inquiry in his natural historical works.

Boyle’s ideas about the rationale and function of medical experiment differed from those traditionally held by the medical men. Boyle’s experimental philosophy aimed at producing both theoretical knowledge and useful practical applications. Moreover, he regarded theoretical and practical knowledge as interconnected in a complicated way. 

He employed a similar approach to his medical work as well. Besides practical innovations, he wished that his clinical trial-and-error experiments would also produce theoretical knowledge about the causes of disease and the qualities of medicinal substances. In the traditional learned medicine, no strong connection between experiment, theoretical knowledge and practical applications existed. Anatomy made an exception; the success of sixteenth- and early seventeenth-century anatomists had
established the role of experiment in anatomical inquiry and explanation. However, a
gap remained between anatomy and practical medical knowledge.

An experimental method was employed in seventeenth-century investigation into
respiration physiology. The English community of anatomists agreed on the role and
probatory force of experiment. The community likewise agreed on the nature and the
structure of an anatomical explanation. Boyle’s ideas about experiment, however,
differed from those of the anatomists. By examining the various kinds of experiments
and their functions in Boyle’s medical works, I have attempted to show that Boyle’s
experimental philosophy involved no idea of a single method of experiment. Boyle did
not refer to his experimentalism as a method. Moreover, we have good grounds to
believe that he deliberately refrained from explicating the principles of the art of
experimentation in his published works. When examined from the viewpoint of his
medical works, Boyle’s experimentalism appears as consisting of a variety of practices
and attempts to use the experimental results for various purposes. Instead of a
systematic experimental method of discovery and proof, Boyle’s experimentalism
involved a complicated system of interpretation in which the function of experiment
varied according to the context.

However, this is not to say that Boyle’s work had no method at all. Even though Boyle
employed no single experimental method in his natural philosophical and medical
activities, from the standpoint of literary genres his work appears much more
methodical. Boyle himself associated ‘method’ with literary presentation and often
apologized his lack of method. In addition to his moral philosophical and religious
works, his vast literary output consists of various genres such as essay, dialogue and
natural history, for example. In his experimental writings, he employed the existing
literary genres modifying these in a manner that placed experiment in a central position.
Boyle’s experimental essay was hardly a straightforward success. John Evelyn, for
instance, seems to have preferred the more rhetorical style of Boyle’s moral
philosophical writings. Evelyn conceived the variations in Boyle’s literary method as
advancement of Boyle’s literary skills; he pointed out that Boyle’s style ‘was much

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Improv’d in his Theodora and latter writings.\textsuperscript{656}

\textsuperscript{656} John Evelyn’s letter to William Wotton, 29 March 1696, in Hunter, (ed.), \textit{Boyle by himself and his Friends}, (84-90), 89. Evelyn refers to Boyle’s \textit{Martyrdom of Theodora} (1687) which is Boyle’s early work but which was of mostly rewritten before the publication in 1687, (\textit{Works}, vol. 11, xi-xii).
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