Patience, Diligence, and Humility: Epistemic Virtues and Chemistry in the Eighteenth Century Dutch Republic

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Abstract

This paper discusses the connection between epistemic virtues and chemistry in the eighteenth century Dutch Republic. It does so in two ways. First, it presents the virtue epistemology of three Dutch university professors and natural philosophers: Herman Boerhaave, Petrus van Musschenbroek, and Johannes David Hahn. It shows how their criticism of *a priori* philosophy and their defence of experimental natural philosophy is connected to a specific virtue epistemology. Four epistemic virtues are central for these authors: intellectual patience, diligence and humility, and impartiality. This virtue epistemology informs their presentation of chemistry as an exemplary discipline. The practice of chemistry instils these key epistemic virtues in its practitioners. Second, the article shows how these epistemic virtues also play a role in later debates regarding the reception of Lavoisier's work in the Dutch Republic. This article hopes to provide an example of what Ian Kidd has called a 'deep conception of epistemic vice [and virtue]'. It also argues for the fruitfulness of applying a virtue epistemic framework to the study of the Chemical Revolution.

Keywords

History and philosophy of science

Chemistry

Chemical Revolution

Virtue Epistemology

Epistemic virtues

Epistemic vices

Introduction

On September 23, 1723 the Dutch natural philosopher and experimentalist Petrus van Musschenbroek delivers an academic oration on the occasion of the start of his appointment as a professor in philosophy and mathematics at the university of Utrecht. In the oration, which bears the title 'On the certain method of experimental philosophy', van Musschenbroek defends an inductive, experimental approach in natural philosophy as the only method that can lead to certainty, in contrast to the rationalist, *a priori* method favoured by the Cartesians (1723). At the end of this oration, van Musschenbroek gives a laudation of the discipline of chemistry and defends its place within experimental philosophy. Even more than that. The newly appointed professor of mathematics states:

No [part of physics] is more outstanding than chemistry […] so that I doubt whether [chemistry] or mathematics has attributed more to the progress of physics. Chemistry would have won the match if her practitioners, with their propensity to fantasize, hadn't defiled [this] most beautiful art with their miserable fictions. (van Musschenbroek, 1723, 49)

This positive assessment of chemistry, and the comparison of its merits with those of mathematics, is a recurring motif throughout van Musschenbroek's writing. What is striking is that van Musschenbroek himself never took up a professorship in chemistry, nor did he pursue active research in this field. This raises the question as to the reasons for or possible sources of this emphasis on the exemplary status of chemistry. Van Musschenbroek was not the only one to praise chemistry in this way. His own mentor, Herman Boerhaave praised the discipline of chemistry in similar ways. Van Musschenbroek's own student, Johannes David Hahn repeated and elaborated upon van Musschenbroek's laudatory remarks regarding chemistry. Boerhaave and Hahn did occupy positions as professors of chemistry. The case of van Musschenbroek however shows that more was at stake than a mere defence of one's own academic discipline. In this article, I argue that in all three cases, the defence of chemistry should be

seen in the context of a broader epistemological framework that can be described as a type of virtue epistemology. Chemistry is praised because practising it instils certain key epistemic virtues on the practitioner and helps to counteract specific epistemic vices.

Virtue epistemology has become an established tradition within epistemology. Various approaches and positions exist, with different views on the nature of epistemic virtues, the aims of virtue epistemological analyses, and the relationship between virtue epistemology and traditional questions in analytic epistemology (for recent overviews see Turri, Alfano & Greco (2021); Kelp and Greco (2020)). Despite differences in approaches, two defining characteristics are often identified. First, virtue epistemology takes epistemology to be a normative discipline. Second, virtue epistemology is characterised by a focus on the epistemic agent (and sometimes community). This is often described as a 'reversal of the direction of analysis': a belief's or an epistemic action's status is appraised based on the properties of the knower, not the other way around. (Fairweather, 2014; Turri, Alfano & Greco, 2021). In section 1 we will see that the three central authors discussed in this article (Boerhaave, van Musschenbroek, Hahn) fit this minimal definition of virtue epistemology. All three use virtue language to confer praise or blame on epistemic agents and all three see the possession of relevant epistemic virtues as a necessary condition for the acquisition of knowledge, both by individuals as well as by the epistemic community. In recent years, virtue epistemology is being fruitfully applied to issues beyond the classical questions of epistemology. The application of virtue epistemology to education is for example a lively topic (Baehr, 2015, Kotzee, 2013). More closely related to the topic of this paper are recent attempts to connect virtue epistemology with philosophy of science (Fairweather 2014; Paternotte & Ivanova 2017), the philosophy of mathematical practice (Aberdein, Rittberg & Tanswell, 2021), and the history of science (Hicks & Stapleford, 2016; Kidd, 2014; Kidd, 2017).

The first aim of this paper is to present the specific virtue epistemology of Boerhaave, van Musschenbroek, and Hahn and to show how it is connected to their views on the exemplary status of chemistry as a discipline that instils key epistemic virtues in its practitioners. Similar work has been done on different seventeenth century authors. Although he does not make the connection with virtue epistemology, Matthew L. Jones (2006) has shown how René Descartes (1596-1650), Blaise Pascal (1623-1662), and Gottfried Wilhelm Leibniz (1646-1716) saw science and mathematics as cognitive and spiritual exercises that helped to develop a virtuous character. Similarly, Sorana Corneanu (2011) has argued that the epistemological and methodological writings of Francis Bacon (1561-1626), Robert Boyle (1627-1691), John Locke (1632-1704), and several members of the Royal Society should be situated within the so-called *cultura animi* tradition. For these authors, the practice of science was a "regimen" or "culture" of the mind which could cure the corrupted human mind and instil virtues. Unlike Jones, Corneanu does draw the connection with contemporary virtue epistemology (2011, 163-

165). This is perhaps no surprise, given that authors such as Robert C. Roberts and W. Jay Wood for example present their own version of virtue epistemology as a return to a seventeenth century tradition of regulative epistemology of which Locke is a clear example (2007, 22). Linda Zagzebski likewise finds inspiration in the history of philosophy, including the work of Bacon and Locke (1996). The aim of this paper is modest. I do not intend to defend or criticize certain positions within contemporary virtue epistemology. But given the way the history of philosophy has shown to provide inspiration for virtue epistemologists, I can only hope that the historical material presented here might do the same. A further relevance of the work presented in this paper lies in the fact that when it comes to the connection between virtue epistemology and early modern philosophy most attention has gone to the seventeenth century. Despite some notable exceptions (Hanley (2012) on Rousseau and O'Brien (2018) on Hume) (Hume is also mentioned several times by Zagzebski (1996), as well as in Turri, Alfano & Greco, 2021), the eighteenth century remains somewhat overlooked. In my discussion, I will also point at the connection between the virtue epistemology expounded by the three authors and their religious views (including the accompanying theology and world-view). As such, the current paper also answers to Ian Kidd's call for studies that not only 'explore the historical development of various virtues in social, religious, and intellectual context,' but also look at the role of metaphysical sensibilities and the grounding of intellectual virtues in worldviews (2017, 11-12).

The second aim of this paper is to show how the virtues and vices discussed in section 1 are invoked in discussions related to the reception of the work of Antoine Lavoisier (1743-1794) in the Dutch Republic. I show how both defenders and critics of Lavoisier's work refer to the same epistemic virtues and vices to make their point. This suggests that a virtue epistemological framework might be a useful tool to complement recent revisionist literature in history and philosophy of science on the Scientific Revolution.

The paper is structured as follows. In section 1, I discuss the virtue epistemology of Boerhaave, van Musschenbroek, and Hahn. I first provide a historical introduction to these three figures and give a general outline of their philosophical and methodological views. In section 1.1 I show how the three authors use virtue language to criticise *a priori* philosophy and defend their own experimental approach in natural philosophy. In section 1.2 I discuss specific key virtues and vices identified by Boerhaave, van Musschenbroek, and Hahn. They argue that certain intellectual vices are common to all humans and that they stand in the way of knowledge. The development of specific intellectual virtues, by means of exercise and habituation, is therefore necessary for the acquisition of knowledge. The three key virtues discussed in section 1.2 are intellectual patience, intellectual humility, and intellectual diligence. These are presented as counterparts to the epistemic vices of impatience, arrogance, and laziness. These form a cluster which are related to a specific vice identified by

Boerhaave, van Musschenbroek, and Hahn, namely *fingendi licentia* ('the unrestrained propensity to fantasize'). In section 1.3 I focus on the virtue of impartiality, which is central in the three author's criticism of *a priori* philosophy and their defence of experimental natural philosophy. In section 2 I turn to the exemplary status of chemistry and its role in instilling virtues. I show how chemistry is presented as a discipline that instils the virtues identified in section 1.2 and 1.3 and counteracts our innate intellectual vices. In section 3 I turn to the reception of Lavoisier's work in the Dutch Republic and show how the vices and virtues discussed in section 1 are invoked by both critics and defenders of Lavoisier. In the concluding section, I draw some general conclusions and make suggestions for further research on the Chemical Revolution from a virtue epistemic point of view.

1. Boerhaave, van Musschenbroek, and Hahn on epistemic virtues and vices

In this section, I discuss the views on epistemic virtues and vices of Herman Boerhaave (1668-1738), Petrus van Musschenbroek (1692-1761), and Johannes David Hahn (1729-1784). All three figures have strong connections with Leiden University, both as student and as professors. They are also part of an academic genealogy: van Musschenbroek was a student of Boerhaave and Hahn a student of van Musschenbroek.

Herman Boerhaave is probably the most well-known figure of the three. In 1701, Boerhaave became medical lecturer at the University of Leiden and slowly gained popularity amongst the student population for his lectures. Eager to keep this popular lecturer, the university promised Boerhaave the first professorship that became vacant in the faculty of medicine. This was the professorship in botany which Boerhaave obtained in 1709 (Boerhaave, 1983, 121). In 1714 he was given the responsibility of teaching clinical medicine, and in 1718, he obtained the professorship in chemistry which at the time was also part of the medical faculty (Boerhaave, 1983, 180). His student Albrecht von Haller (1708-1777) posthumously gave him the title of *communis Europae praeceptor* ("teacher of all of Europe"), which testifies to Boerhaave's popularity as a teacher and his international reputation which drew students from all over Europe to Leiden. However, Harold J. Cook (2000) has argued that the picture of Boerhaave as someone who singlehandedly revolutionized medical teaching at the university should be mitigated. Leaving aside the question of the novelty or revolutionary character of Boerhaave's interventions, it remains a fact that he shaped the teaching provided at the medicine faculty in Leiden and that subsequently Leiden was seen as an *exemplar* in other universities across Europe (Powers, 2012, 1-2; Verwaal, 2020). John C. Powers has argued that Boerhaave's chemistry teaching (and especially his textbook) had an important influence on chemistry teaching in the eighteenth century and played a crucial role in the development of chemistry as a discipline (2012). Boerhaave was also an important reference point for Antoine Lavoisier (1743-1794) (Powers, 2014; Beretta, 1995, 88).

Petrus van Musschenbroek obtained his doctorate in medicine in Leiden under the promotorship of Boerhaave in 1715. He took up positions as a professor in mathematics, philosophy, and medicine in Duisburg (1719-1723) and Utrecht (1723-1740) and returned to Leiden in 1740 for a professorship in philosophy and mathematics (de Pater, 2012, 140-141; Present, 2019, 2-5). Van Musschenbroek is most known for his discovery of the Leiden Jar in 1745 (Silva & Heering, 2018; Present, 2022). Like his mentor Boerhaave (Ducheyne & van Besouw, 2017), he is an often discussed figure in the literature on eighteenth century (Dutch) Newtonianism (Ducheyne, 2015; de Pater, 2012; Present, 2020). Although less known today, in his own time van Musschenbroek was a celebrated natural philosopher and experimentalist (de Pater, 1979; Beck, 2023).

Johannes David Hahn is probably the least known of the three authors. Born in Heidelberg, Hahn came to Leiden university to pursue his studies and obtained a doctoral degree in philosophy and the liberal arts in 1751 after defending a dissertation on a chemical topic under the promotorship of van Musschenbroek. He obtained a professorship in philosophy, astronomy and experimental physics in Utrecht in 1753, to which a professorship in medicine, botany, and chemistry were added in 1759. In 1775 he returned to Leiden after accepting a professorship in practical medicine and chemistry (Snelders, 1972, 183-184). Hahn was the promotor of several doctoral dissertations on chemical topics. One of these dissertations, defended by Diderik de Smeth (1754-1799), played an important role in the work of Lavoisier. In his first monograph, the *Opuscules physices et chimiques*, Lavoisier devoted the complete fourteenth chapter to a detailed, critical discussion of De Smeth's dissertation (Lavoisier , 1774, 86-108; for a discussion see Snelders (1972)). In section 3 I will discuss the connection between the virtue theory discussed in this section and the reception of Lavoisier's work in the Dutch Republic.

Before turning to a discussion of the virtue epistemological views of Boerhaave, van Musschenbroek, and Hahn, I will provide a short overview of their shared general philosophical positions. I will specifically focus on those views relevant for understanding their epistemological and methodological views. I focus on Boerhaave and van Musschenbroek, as there is no secondary literature (and only a handful of primary literature) available on the general philosophical views of Hahn. However, as will become clear during the discussion of Hahn's views in the next sections, for the topic at hand, his general philosophical outlook can be assumed to align with that of Boerhaave and van Musschenbroek.

As is often the case for early modern thinkers, the methodological views of Boerhaave and van Musschenbroek are closely intertwined with their theological and religious views.[1] Both share a

[1] For a detailed discussion of the connection between Boerhaave's Calvinism and his chemistry, see Knoeff (2002). For a discussion of van Musschenbroek's religious views in relation to his philosophical views and scientific work,

voluntaristic outlook which emphasizes God's will.[2] In contrast to theological intellectualism, which posits that God was constrained by certain 'coeternal principles' when creating the world, voluntarists hold that God was completely unconstrained and free to shape the world according to his will (Henry, 2019). Both Boerhaave and van Musschenbroek combine this voluntarism with an emphasis on the variety of nature. Nature is complex and heterogeneous and this should be seen as an expression of God's infinite power. The study of nature's complexity is therefore seen as an exercise in piety, an investigation of God's will as it is expressed in nature. The emphasis on God's omnipotence was combined with a strong commitment to epistemic humility. We should always be aware of the vastness of nature and not think too quickly to have understood nature. These ideas fit hand-in-glove with Boerhaave's and van Musschenbroek's criticism of *a priori* philosophy. Both deny the existence of innate ideas and criticise (mostly Cartesian) philosophers who try to understand nature based on assumed *a priori* principles. (Knoeff, 2002; Ducheyne & van Besouw, 2017; Present, 2019, 43-94; Beck, 2023, 114-127)

The experimental method in natural philosophy should therefore be favoured. But even then, we should display the necessary epistemic humility. Given the complexity and heterogeneity of nature, we should not think too quickly to have understood nature or to have sufficient empirical grounds to make general theoretical claims. Both Boerhaave and van Musschenbroek put an emphasis on the particularity of individual species and bodies and the need to study all these empirically. They thus repeatedly warn against hasty generalizations and the premature formulation of theories. From Bacon, they take the notion that an elaborate collection of empirical facts, in the form of so-called natural and experimental histories, needs to be constructed before any theoretical work can be done. (Klein, 2003; Beck, 2023)

In what follows, I show how these philosophical and methodological views are intimately connected with a virtue epistemic outlook. None of the authors develops a systematic account of epistemic virtues and vices. To reconstruct their views, I will mostly make use of academic orations that they delivered on several occasions. University professors were expected to deliver an academic oration at key moments in their career, for example when taking up a new position. These academic orations often had a strong moral character. Professors could use the occasion to defend their preferred philosophical position and criticise those of others. Often, this was coupled with a defence of their

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see de Pater (1979), 314-330. For a discussion of van Musschenbroek's indebtedness to Bernard Nieuwentijt (1654-1718), an influential proponent of physico-theology, see Ducheyne (2019).

[2] The connection between theological voluntarism and the emergence of the natural sciences is an important topic in the historiography of science and still a matter of debate. For a recent overview of (and a specific position in) these debates, see Oakley (2019).

own virtuous character.[3] As will become clear in what follows, these orations are drenched in virtue talk.

In section 1.1 I discuss Boerhaave, van Musschenbroek and Hahn's general use of the notion of epistemic virtues and vices in their criticism of *a priori* philosophy and defence of experimental philosophy. Most attention will be devoted to Hahn, who provides the most explicit formulation of a virtue epistemic outlook. He explicitly draws the analogy with moral virtue, sees intellectual virtues as traits acquired by exercise and habituation, and sees them as a necessary condition for the acquisition of knowledge. In section 1.2, I discuss the most recurring epistemic vices and virtues in their work. The central epistemic vice for the three authors is the so-called *fingendia licentia*. Difficult to translate, this vice can be characterized as referring to both the innate human tendency towards fantasizing and constructing theories and the inability to sufficiently constrain this tendency of the human mind. The vice of *fingendia licentia* is often discussed alongside three other epistemic vices: intellectual laziness, intellectual arrogance, and intellectual impatience. These are the central vices that are connected to *a priori* philosophy. As can be expected, the main virtues connected to experimental natural philosophy, the method favoured by the three authors, are intellectual diligence, intellectual humility, and intellectual patience. In section 1.3 I show how the three authors connect experimental natural philosophy with another key epistemic virtue, namely impartiality. Taken together, this section provides the groundwork for section 2 where I show how chemistry is presented as a practice which instils the aforementioned key epistemic virtues in the practitioner and helps to alleviate the corresponding epistemic vices.

1.1. Boerhaave, van Musschenbroek, and Hahn as virtue epistemologists

Boerhaave, van Musschenbroek, and Hahn consistently frame their criticism of *a priori* philosophy and their defence of experimental philosophy in terms of epistemic virtues and vices. In an oration in which he discusses the problems encountered in the discipline of medicine for example, Boerhaave argues that these are due to epistemic vices which are common to man:

Ignorance (*inscitia*), imprudence (*imprudentia*), [accepting] a doubtful hypothesis on the basis of false principles, idleness (*desidia*) [by which people] incline towards [giving their] assent [to a proposition] rather than [doing their own] work, [these are] the vices (*vitia*) of man [in general], not just the times (Boerhaave, 1709, 6)[4]

[3] See van Miert (2003), Wiesenfeldt (2016), and Present (2020) for the nature of early modern academic orations and their use as source material.

[4] In what follows, the translations of the Latin texts of Hahn and van Musschenbroek are my own. In the case of Boerhaave, there is an English translation available which I will mostly use when citing Boerhaave (Boerhaave,

In another oration, Boerhaave likewise calls the propensity to construct general theories on the basis of a few observations 'a vice (*vitium*) [which] is common amongst the learned' (Boerhaave, 1718, 17). Van Musschenbroek argues in one of his orations that 'that vice (*vitium*) [which makes people] want to appear to know everything' has a detrimental effect on science (1731, 45). And as I will discuss in more detail, Hahn talks about 'a vice (*vitium*) of mathematics that is brought into physics' and that can be countered by the practice of chemistry (1768, 76).

Of the three authors, only Hahn provides a more systematic reflection on the nature of these epistemic virtues and vices themselves. He explicitly draws the analogy between moral and epistemic virtues. In an oration delivered in 1753 Hahn begins his discourse by referring to a typically Aristotelian notion of virtues as the mean between extremes:

As humans, we are built in such a way, that we almost turn towards extremes. Because while prudence (*prudentia*) guides us towards the centre, where virtue (*virtus*) dwells, we are pulled away by the force of our inclinations […] finding ourselves then at one extreme, then at the other (Hahn, 1753, 2).

There are some people who always idle away their time, doing nothing, while there are other people who push themselves too hard, hurting their minds and bodies. There are people who, in their avarice, try to gain as much things as possible by all means necessary, whereas there are other people who imprudently give away what they have (Hahn, 1753, 2-3). Only a minority of people are able to develop the necessary 'moderation of the mind (*animi moderatio*)' in order to 'constantly and everywhere maintain the golden mean (*aurea mediocritas*)' between extremes (Hahn, 1753, 2). Hahn states that 'this leaping nature of the mind is not only seen in moral qualities, but in all human endeavours' (1753, 3).

This sets the stage for the remainder of the oration, where he will paint a picture of the 'true philosopher (*verus philosophus*)' and his epistemic virtues (Hahn, 1753, 12). This picture of the true philosopher is part of Hahn's attempt to attain the goal he had set himself in the oration: to show how 'natural science can be cleansed of the mistakes [found] in observations and experiments (1753, 10)'. Hahn explicitly presents the remediation of the vices of the practitioners of experimental philosophy as a necessary condition for the production of knowledge:

1983). However, I did not always find the translation satisfactory and therefore sometimes provide my own translation. When only a reference to the original Latin text is given, this means that the translation is my own. When I have changed only part of the translation found in (Boerhaave, 1983), I put the changed passage between square brackets and add a reference to the Latin original on which my translation is based. Throughout the article, I put key Latin concepts (e.g. the names of the relevant virtues and vices) between brackets in the translation. The English translation of Boerhaave's oration does not provide these terms. Where I have added these, I also add a reference to the original Latin passage where the terms can be found.

We wait in vain for those happy times, in which an uncorrupted discipline of physics will flourish, as long as fickleness (*levitas*), laziness (*socordia*), rashness (*praecipitantia*), preconceived opinions (*praeconceptae opiniones*), stubbornness (*contumacia*), envy (*invidia*), the disparagement (*obtrectatio*) of the glory of others, and finally greed (*avaritia*), will, as powerful incentives, besiege and corrupt the minds of observers. But how difficult it is to defeat those obstacles to our knowledge and tranquillity! It has befallen few and will befall few to be so happy, that they bring themselves to the contemplation and investigation of the nature of things, having put aside all other worries, with a quiet mind, purified of all impure affects, having composed the powers of their mind and body. But as long as all these impediments have not been taken away, there will be no room for improvement (1753, 21).

The 'true philosopher' is not born, but made. Throughout the oration, Hahn describes how the epistemic virtues possessed by the true philosopher are obtained through training and habituation. Because there are no innate ideas, and all knowledge and truth is based on sensory observation, the true philosopher should be able to use his sensory organs in most unimpaired (*integerrimus*) way possible (Hahn, 1753, 13). To develop this ability, the philosopher should 'perfect the faculties of sense by means of art and exercise,' because 'the more someone is exercised in sensing, the more he will be suited towards observing' (1753, 13). But aside from trained senses, the philosopher also needs attention (*attentio*) and patience (*patientia*). Attention is needed to attend to what is happening and be aware of all the details that can be found in the observation. Certain processes evolve slowly over time, and others depend on specific circumstances which can only be discovered by repeated observations. Hence the need for patience. One should also have an acute power of judgment (*acre judicium*) in order to separate what is observed from the inferences that the mind immediately draws from the observations. Care should be taken that both are not mixed. Hahn summarizes all this under the banner of having diligence (*diligentia*) and constant attention (*assiduitas*) (1753, 14). In section 2 below, we will see that Hahn sees the practice of chemistry as the best way to develop patience and attention.

1.2. 'Fingendi licentia', laziness, arrogance, and impatience

One of the central vices in the work of the three authors is the so-called *fingendi licentia*, which can be translated literally as "licentiousness in making up this". According to the *Oxford Latin Dictionary*, the term *licentia* can be translated 'lack of restraint' or 'immoderate or unruly behaviour, disorderliness, wantonness, licence' (Glare, 2012, 1131). A better translation of this vice would thus be "a lack of restraint of the imagination". This translation in terms of a lack of constraint can be supported by several passages from Boerhaave in which he describes the *fingendi licentia* as being caused by a lack of restraint (*castimonia* (1715, 44), *temperare sibi* (1718, 6)). Because the translation

is somewhat cumbersome and there is no English equivalent, I will use the Latin term *fingendi licentia* in what follows. The term is repeatedly used by all three authors to refer to the propensity of natural philosophers to construct theories without having performed the necessary empirical and experimental research (Boerhaave, 1709, 9; 1715, 23-24; 1718, 6; van Musschenbroek, 1723, 44; Hahn, 1768, 73). This *fingendi licentia* is rarely discussed on its own. Most often, it is coupled with other epistemic vices which can be either seen as the cause of or as factors reinforcing the *fingendi licentia*.

In an oration on the discipline of medicine, Boerhaave gives the example of anatomists who display their *fingendi licentia* when they 'imagine, but not observe the structure of the body'. This is caused by their 'negligent laziness (*supina oscitantia*)' (1709, 9). As a contrasting virtue, Boerhaave mentions the diligence (*industria*) with which more virtuous anatomists actually observe the human body and its parts (ibid.). In another oration delivered a few years later, Boerhaave claims that intellectual laziness often co-occurs with intellectual arrogance. People are 'disgusted by the slow investigation' of nature that is needed to get to truth, and because they are also 'think so highly of their own far-sighted intelligence' , they do not commit themselves to the hard labour of empirical investigation and think it is enough just to appeal to their own reason (Boerhaave, 1983, 155). Boerhaave singles out those natural philosophers working in the rationalist, *a priori* manner of Descartes.[5] These people lack the virtue of intellectual humility, because they think they are able to gain knowledge of the workings of the universe solely by means of their individual reasoning.[6] These people are 'lacking in self-knowledge

[5] As one of the anonymous reviewers remarked, one can of course question whether this criticism of Descartes's (and other Cartesians') natural philosophical programme is fair. Assessing this issue would take us too far and lies beyond the scope of this paper. An extended discussion of different forms of "Cartesian empiricisms" can be found in a collection of essays edited by Dobre and Nyden (2013). In one of the contributed essays, Sophie Roux points out that in the *Regulae*, one of Descartes's earliest writings, he criticises 'philosophers who neglect experiments and believe that truth must come from their own brain, like Minerva from the head of Jupiter' (Descartes, cited in Roux, 2013, 52). In the same work, Descartes praises Bacon. In his later and seminal *Discourse on Method*, he invites his readers to go and observe a dissection of a heart with their own eyes (Roux, 2013, 52). Roux also traces the emergence of the cliché 'that Cartesians neglected experiments in favor of hypotheses and speculation' at the end of the seventeenth century (Roux, 2013, 47). Present (2020) provides a discussion of van Musschenbroek's anti-Cartesian rhetoric and situates it within its broader intellectual and institutional context. For the connection between this anti-Cartesian rhetoric and the (perceived) threat of Spinozist atheism, see Present (2020) and Ducheyne (2017; 2019).

[6] The virtue of epistemic humility is probably one of the most discussed virtues in the literature. It lies beyond the scope of this paper to provide a detailed discussion of the relationship between Boerhaave, van Musschenbroek, and Hahn's views on epistemic humility and those found in contemporary virtue epistemology. Colin J. Rittberg's paper (2021) on intellectual humility in mathematics contains not only an overview of the latter, but provides an important call for more historically informed and context-sensitive treatments of virtues. In his own discussion, Rittberg calls attention to the entanglement between ethical and religious notions of humility and epistemic notions of humility. As discussed in section 1.1, the philosophical views of Boerhaave, van Musschenbroek, and Hahn (including their virtue epistemology) cannot be separated from their religious views. In the context of her discussion of the relationship between Boerhaave's religious views and his chemistry, Rina

(*ignarum sui*) […] [and] destitute of modesty (*verecundia*)' (Boerhaave, 1983 [1715, 6], 157). Thinking that one can mentally reconstruct the universe by means of one's reasoning faculty implies that one considers oneself equal to God, an impious display of arrogance (*superbia*) (ibid.). A bit further in the oration, Boerhaave defends the idea of the existence of preformed, active seminal principles in nature against the Cartesian reduction of natural processes to mechanisms. In this passage, he explicitly presents the *fingendi licentia* as arising from a combination of intellectual laziness and intellectual arrogance:

Yet from these seminal principles, and well-nigh from them alone, arise the phenomena, on the studying, collecting, and explaining of which the diligent zeal (*sedula diligentia*) of physicists is mainly employed. Mad arrogance (*vesana superbia*), guided by fallacious sloth (*decidia*) and liable to deviate from the labour of enquiry into licentious fantasy (*licentia fingendi*), has in the past wrongly announced that the fecundity of child-bearing nature has no need of these aids. This arrogance, forsooth, had foolish dreams of formless atoms that could unite *via* blind collision […] All observations runs counter to this idea – so much so that it seems incredible that this wicked error has beguiled and misled so many people. Would that they had not given in so much to sluggish negligence (*supina oscitantia*), but that they had rather given heed to the mature wisdom of nature's oracles, in order to gain from these knowledge about the same nature (Boerhaave, 1983 [1715, 23-24], 165-166).

Van Musschenbroek likewise connects the *fingendi licentia* with a lack of epistemic humility. He criticises the 'inconstancy of the doctrines of reason,' which have plagued philosophy since Thales because philosophers have allowed themselves to be carried away by the *fingendi licentia* (van Musschenbroek, 1723, 44). This led different philosophers to posit different hypothetical explanations of observed effects, purely based on reasoning. This was connected to these philosophers' desire 'to hide their ignorance' (van Musschenbroek, 1723, 45). Van Musschenbroek contrasts this rationalistic method with 'the method of philosophizing (*philosophandi methodum*)' of Newton, in which of course the famous *hypotheses non fingo* took centre stage (1723, 45). Whereas the rationalist philosophers try to hide their ignorance, the followers of Newton's method 'candidly confess their ignorance', which 'instructs [their] ratio about its own ignorance' (van Musschenbroek, 1723, 46). Van Musschenbroek here echoes the notion of a 'learned ignorance (*docta ignorantia*),' a specific form of epistemic humility that was championed by his compatriot and inspiration Bernard Nieuwentijt (1654-1718). (see Ducheyne, 2017)

Knoeff (2002) repeatedly treats Boerhaave's emphasis on (epistemic) humility. A similar analysis has been performed for van Musschenbroek and his inspiration Bernard Nieuwentijt by Steffen Ducheyne (2017; 2019).

Aside from laziness and arrogance, a third vice with which the *fingendi licentia* is associated is intellectual impatience. In an oration on chemistry (which I will discuss in more detail below), Boerhaave laments the fallacious theories which had been introduced into chemistry due to the *fingendi licentia* and which had been too easily accepted due to 'headlong haste (*festinando praeceps*) and blind impetuosity (*caecus impetus*)' (Boerhaave, 1983 [1718, 8], 196) Van Musschenbroek likewise sees intellectual haste as one of the vices associated with *a priori* philosophy:

Can we be said to have even a morsel of prudence (*prudentia*), when we want to immediately understand the complete nature of things based on the few things that we know? I believe that there is hardly anything more harmful to our knowledge (*scientiae*), than that itch (*pruritus*), because of which we all desire to compose universal systems, and derive everything *a priori* from them. This is a premature haste (*intempestiva festinatio*) of the understanding (van Musschenbroek, 1723, 39).

The study of nature itself provides a way to tame the impatience of our mind and to instil epistemic humility. The study of nature shows 'how many things remain, which surpass the power of our understanding, so that we are astonished by [our] former ignorance' (van Musschenbroek, 1723, 40). In the oration in which he paints the picture of the "true philosopher", Hahn likewise uses the term "itch (*pruritus*)" to refer to the tendency of certain natural philosophers to assign causes to phenomena, even though these are not clearly observed in the experiment. During an experiment, a lot of causes concur to produce the phenomenon under consideration. People suffering from this itch take a partial look at the experiment and then invent hypotheses (*hypotheses fingunt*) about the causes of the experiment (Hahn, 1753, 31-32). Because of this, 'the worst observers are system philosophers' (1753, 33). These philosophers suffer both from a lack of patience and epistemic humility:

What rashness (*temeritas*) do these philosophers have, who think that they have exhausted the incredible variety of nature by means of their weak mind and their light work of a few years, who dare to draw limits around this [variety of nature]! (Hahn, 1753, 34-35)

1.3. Impartiality and (dis)agreement

As we have seen, Boerhaave, van Musschenbroek, and Hahn share a criticism of *a priori* philosophy, which they think is a form of philosophy plagued by several epistemic vices. Cartesian philosophy is often invoked as the more explicit target for their criticism, but all three see the *a priori* rationalistic method as *the* method that has been followed in philosophy since the time of Thales. Francis Bacon (1561-1626) is consistently presented as a rupture in the history of philosophy, and the herald of a

new, empirical way of practising philosophy (Boerhaave, 1983 [1715], 178-179; van Musschenbroek, 1723, 34; Hahn, 1753, 7-8).

The discussion of Bacon is often connected with an emphasis on the virtue of impartiality. Boerhaave for example presents Bacon as the figure who by 'his advice or his example, exertions or liberality' and his 'warnings, […] precepts, and experiments' put natural philosophy on the right track again (Boerhaave, 1983, 178-179). The *a priori* method led to the proliferation of individual opinions and schools, but Bacon showed us how 'to free ourselves from the bondage of sectarianism' and return to the investigation of nature itself (Boerhaave, 1983, 178).

The three authors associate sectarianism in philosophy with the proliferation of opinions and disagreement. Boerhaave says that the *a priori* method in philosophy leads to

Such an inconstancy of slippery doctrine – either if you look at the principles assumed, or if you turn your mind to the theories derived therefrom; with the result that what is approved of as excelling all other things by one person, is immediately repudiated by another. This is why physical science changes into a thousand different shapes, consequent upon varying opinions, diverse periods, upon the increasing authority of someone, or upon one particular notion captivating the minds; in this respect it seems more versatile than Proteus (Boerhaave, 1983, 173).

Van Musschenbroek likewise repeatedly contrasts the 'firm and certain' nature of a natural philosophy based on experiments with the 'uncertain, infirm, [and] fleeting' nature of *a priori philosophy* (1723, 10).[7] The stability and firmness of the method of experimental natural philosophy also reflects back on the community of practitioners. Whereas the community of philosophers using the *a priori* method is characterised by strife and disagreement, the community of experimental philosophers is described by van Musschenbroek as being 'engaged in studies free from all disputations and controversies' (1723, 42).

Impartiality is also an important intellectual virtue for van Musschenbroek. We can see how seriously van Musschenbroek took this virtue by looking at the changes in his self-presentation. At the beginning of his academic career, van Musschenbroek presented himself as a follower of Newton, or more specifically, Newton's method of philosophising. As could be expected, this led some people to use van Musschenbroek's rhetoric against him. In an oration from 1730, van Musschenbroek mentions critics who say that he and his fellow Newtonians are 'only mindful to attraction, because [they] follow a faction in philosophy, applying this [term] only thanks to the British, who have not doubted to use this

[7] For a more elaborate treatment of van Musschenbroek's criticism of *a priori* philosophy and his defence of experimental natural philosophy, see Present (2020).

word very frequently in their teachings' (1731, 33). From then on, van Musschenbroek will increasingly avoid presenting himself as a Newtonian. Instead, he presents himself as a virtuous impartial and truth-loving follower of the experimental method. In his personal copy of the printed version of this oration, van Musschenbroek added marginal notes on the necessity of 'casting of prejudices (*deponere praejudicia*)' and 'favouring no sect (*sese nulli sectae addictum gerere*)'. Being a prejudiced follower of Newton is put on the same footing as being a Cartesian or Aristotelian: 'the same thing is looked upon in another way by an Aristotelian, in another way by a follower of Descartes, in another way by one who is a servant to the opinions of Newton or Stahl' (n.d. MS, recto side of folio glued to p. XI). After this shift in his self-presentation, van Musschenbroek will repeatedly emphasize that he 'takes no sides, only that of the truth' (1741, 4) (see also Present (2020)). In the preface to the first Dutch translation of his Latin textbook, he also defends his own intellectually virtuous character:

I have never followed any sect; those who try to accuse me of doing so, are doing a great injustice to me: embracing the truth is my only goal, no matter who has found her. My using the terms "attracting" and "attractive force" is not a sign that I have surrendered myself to some sect, as some scholars feel I do, but on the contrary a true sign, that I am not doing any such thing, and am only taking into consideration the phenomena of nature, observing her with accuracy and effort, devoting my time to making many experiments; but not producing some chimeras in my study, nor trying to squabble about phenomena from vain presuppositions. Somebody is following a sect, when he accepts certain presuppositions which have been invented by others without proof, and builds upon these. But he who builds on solidly proven truths, or clear and simple grounds, which in physics are experiments and observations, [he] is not committed to any sect. (van Musschenbroek, 1736, preface, 5)

Having discussed Boerhaave, van Musschenbroek, and Hahn's general take on epistemic virtues and vices and having provided an overview of what for them are the key epistemic vices and virtues, it might be worthwhile to return to Hahn's more general discussion on the nature of the virtues. Of the three authors discussed in this paper, Hahn is the only one who explicitly provides such a discussion and in doing so uses an Aristotelian notion of virtues as means between extremes. It is striking however that the specific discussions of virtues and vices by the three authors (Hahn including) do not seem to fit the Aristotelian mould.[8] Boerhaave, van Musschenbroek, and Hahn identify intellectual laziness, arrogance, and impatience as central epistemic vices and present intellectual diligence, humility, and patience as the correlative virtues. These virtues themselves however are never presented as means between two extremes. That is, they do not mention the possibility, or provide examples of being too

[8] Many thanks to one of the anonymous reviewers for pointing out this tension and suggesting that this be addressed more explicitly.

patient, too diligent, or too modest. It is unclear why Hahn chose to explicate the concept of a virtue in a way that seems to be at odds with his own use of it. As to the question what kind of general virtue framework the three authors are working with, I would suggest that a fruitful comparison could be made to the framework found in the so-called *cultura animi* literature. Sorana Corneanu (2011) has provided a detailed discussion of this tradition and has argued that the work of Bacon and the later Royal Society experimentalists should be read as being part of it. With regard to the nature of virtues, this tradition moves away from a strictly Aristotelian-Thomist framework and instead works with 'an eclectic approach that interweaves Stoic, skeptical, and Christian virtues' (Corneanu, 2011, 8). Characteristic of this literature is the idea that the human mind is plagued by certain innate "distempers" or "diseases" which are seen as both moral and epistemic failures. In order to counteract these distempers, a deliberate process of habituation is needed in order to develop mental virtues which counteract these innate vices, a process often described as a "regimen" or "medicine" for the mind (Corneanu, 2011, *passim*). A detailed comparison between the views of the three authors discussed here and the authors discussed by Corneanu lies beyond the scope of this paper. Two points can be made to suggest that such a comparison would be fruitful. First, the fact that all three authors regularly refer to Bacon and Royal Society *virtuosi* like Boyle, makes it probable that they work within the same general virtue theoretical framework. Second, we have seen how Boerhaave provides a list of recurring epistemic vices and states that these are 'the vices of man [in general], not just the times' (1709, 6). They are thus seen as general and innate properties of the human mind. All three authors mostly discuss the key epistemic virtues in tandem with the corresponding epistemic vices, suggesting that they should indeed be seen as the result of a process of counteracting habituation which "cures" the innate vices.

I will now turn to Boerhaave, van Musschenbroek and Hahn's discussion of chemistry as an exemplary discipline. I show how for all three authors, chemistry is the discipline par excellence that is able to counter the vices of intellectual laziness, arrogance and haste. Not only that, it also instils the key virtues of intellectual diligence, humility, patience, as well as the virtue of impartiality.

2. **The virtues of chemistry**

In 1718 Boerhaave delivers an oration which is completely devoted to the topic of chemistry. He delivered this oration on September 21, when he took up the professorship in chemistry after the death of his predecessor Jacob Le Mort (1650-1718) (1983, 181). The oration was titled 'Discourse on chemistry purging itself of its own errors'. Boerhaave defends the discipline of chemistry by granting that there are many errors and blemishes to be found in it, but that it has also cured itself of these same defects. Boerhaave also presents the practice of chemistry as an activity which, when performed properly, cleanses the intellectual vices and defects of the practitioner.

But what are the "errors" that Boerhaave thinks chemistry is burdened with? A first problem that Boerhaave discusses is the tendency of some chemists in the past to mingle theoretical chemistry with theology, two domains which should have been kept apart. Certain chemists have even displayed a lack of 'self-restraint (*temperare sibi*)" by reading the holy scripture as alchemical metaphors (Boerhaave, 1983, 195 [1718, 6]).[9] But these excesses are caused by a more general fault found among chemists, namely the *fingendi licentia* (Boerhaave, 1718, 6) Instead of investigating nature, chemists in the past have developed elaborate theories, which Boerhaave derides as being only a mixture of inherited superstitions, Persian fire worship, and magical thinking (1983, 196-197). The reason why these theories were so easily accepted was due to 'headlong haste and blind impetuosity' (1983, 196).

But chemistry has cleansed itself from these superstitions by returning to experiments. Boerhaave refers to Roger Bacon as the one who 'demonstrated that human diligence (*industria*), taking counsel with nature, surpasses whatever others feign to bring about through an ineffectual appeal to incantations, demons, and conjuring-tricks' (1983, 198 [1718, 11]). Then Boerhaave praises Robert Boyle as someone who combined a tireless experimental study of nature by means of chemical experiments with a pious attitude (1983, 198-199). Having thus argued with examples that chemistry can cleanse itself from superstition by means of experiments and that it is possible to keep chemistry separated from religion, Boerhaave moves to a general consideration of the place of chemistry within natural philosophy. He now provides a very optimistic assessment of the status of chemistry: 'this discipline plays a crucial role in the advancement of physics – no other science is more capable of revealing the secrets of nature' (1983, 200).

But here, haste again poses problems. In the process of unravelling the secrets of nature, chemists fell into the trap of making hasty generalizations:

[9] As one reviewer remarked, there seems to be a tension between Boerhaave's criticism of these chemists and the fact that his own methodological views on chemistry are informed by his theological voluntarism. Why would it be problematic for the Bible to inform chemical theories? A first response would be that in this specific passage Boerhaave is actually criticising the use of chemical theories as a hermeneutical tool to read the Bible, he is not necessarily criticising the use of the Bible as a tool for chemical research. The main problem with these chemists is that their hermeneutics distort the plain moral and religious message of the scripture, which has detrimental spiritual results. As to the need to distinguish theology from (theoretical) chemistry, this should be understood in the context of a distinction that was made between the so-called "Book of Nature" and the "Book of Scripture". God not only gave us the Bible. Nature itself is a parallel form of revelation. "Reading" the Book of Nature, i.e. empirical investigation of the natural world, then becomes a religious exercise in its own right. In the Dutch Republic, the need to clearly distinguish between these two types of Books and the way they should be read became a pressing issue in the aftermath of the outrage caused by the writings of Baruch Spinoza, who questioned the separation of theology from (natural) philosophy. For further discussion, see Force & Popkin (1994), and Ducheyne (2017).

[E]ach time people discovered in the course of their experiments an activity proper to this or that individual body, they assumed this natural force, found to exist in one particular case, to be a universal phenomenon. It was then rashly asserted that this property was common to all bodies everywhere. (Boerhaave, 1983, 200).

A bit further in the oration, this haste to make generalizing claims is described by Boerhaave as an intellectual vice (*vitium*):

How prone is human nature to move from a few things which have been well established, from a few singular things, towards a general theory! One can complain that this vice (*vitium*) is common among the learned, but nowhere has this mistake (*peccatum*) been made as much as by chemists. Because this lax licentiousness of interpreting (*interpretandi licentia*) [results] has been so prevalent up until today, that, if chemistry itself had not put some limits on it, the whole of physics would have been completely reduced to a few chemical laws. (Boerhaave, 1718, 17)[10]

However, due to its experimental nature, chemical research automatically led to results which showed that the theoretical generalizations made on the basis of a few experiments did not hold water. Again, chemistry purged itself of its own mistakes (Boerhaave, 1983, 201). But chemistry not only purifies itself. By practicing chemistry, the practitioner himself is also cleansed from this inherent haste towards making generalizing claims and learns that the proper method of performing natural philosophy is a patient one:

[I]t was established by the brilliant, useful, and delightful discoveries of chemists that one needs an enormous store of observations, a most cautious scrutiny of this material and, finally, a careful mutual comparison of all data, before one is entitled to postulate a universal rule that is valid for all natural reactions. It has become clear that nothing is more fallacious than to explain everything from a single point of similarity, and to measure one and all by that single yardstick. It may be a recurrent characteristic of the beginner to assume that all effects come about in one and the same manner; but advanced age, schooled by a more mature experience, only approves of true and sound science; and this requires that one should go forward with slow steps and most deliberate caution, painstakingly scrutinizing each single detail, before one is able as a chemist to give an opinion on natural phenomena. (Boerhaave, 1983, 202)

Boerhaave concludes by arguing that chemistry has not only purged itself from its errors, but will also instil epistemic virtues in those studying the discipline:

[10] The word “peccatum” also has a moral undertone and could also be translated as “sin”: ‘Nowhere has this sin been committed as much as by chemists’.

[A]nybody who now trains his mind [by following] the precepts of this discipline ends up having a refined insight into the secrets of nature and medicine. He will avoid the snares set up by the wayward cleverness of rhetorical tricksters; he will not be a blind follower of any master, nor even an inept supporter of any particular sect. (Boerhaave, 1983, 211 [1718, 38])

Unlike Boerhaave, van Musschenbroek does not devote a separate oration to the topic of chemistry. His student Hahn however, did deliver such an oration in 1768. In this oration, Hahn will also take up the question of the relationship between mathematics and chemistry. The oration is titled 'On mathematics and chemistry and their mutual assistance (*De mathesi et chemia, earumque mutuo auxilio*)'. Although one might expect an oration on the mathematisation of chemistry, the oration is actually more concerned with the effects of the study of mathematics and chemistry respectively on the student.

Again, Hahn is more systematic and even more explicit than Boerhaave and van Musschenbroek in developing a virtue based defence of the utility of chemistry. He begins the oration by invoking the virtues:

May the deities Truth (*Veritas*), Faith (*Fides*), Simplicity (*Simplicitas*), Order (*Ordo*), Diligence (*Industria*), Constancy (*Constantia*), and the other virtues (*virtutes*) which are needed to perform things well and prudently (*prudenter*), inhabit and protect this workshop! Because the philosophy to which this place is consecrated is supported by these [virtues] and receives all her power and dignity (*dignitas*) from them. (Hahn, 1768, 8-9)

Echoing the oration we discussed above, Hahn adds that one of the goals of (experimental) philosophy should be to 'free the mind from impure affects, especially from ignoble fear (*illiberalis metus*) and arrogant rashness (*arrogans temeritas*)' (1768, 9). This can be done by a diligent (*diligenter*) investigation of nature, by means of which one will discover the will and counsel of God as it is expressed in the order of the world. This will make the performance of physics a source of virtue itself:

If physics does these things well, then she will be worthy to carry the name of Virtue (*virtus*), with which the stoics were wont to furnish her. By teaching how great God is, and how little man is in contrast, she generates veneration of God and piety (*pietas*), and moreover modesty (*modestia*), moderation (*temperantia*), and justice (*justitia*), while at the same time leading to agreement (*concordia*) and mutual charity (*ad mutuas caritas*). (Hahn, 1768, 9)

Hahn states that he sees it as his goal as a teacher to 'bring forth the genuine fruits of virtue in himself and in his audience' (1768; 10).

Hahn then tells his audience that he will talk about chemistry. This might be surprising, since his audience might think that this has nothing to do with mathematical physics. (Hahn 1768, 10-12) To convince them of the contrary, he refers to his teacher van Musschenbroek. At the beginning of this article, I have cited the passage where van Musschenbroek said that he doubted whether mathematics or chemistry had contributed more to physics. Based on his acquaintance with van Musschenbroek, Hahn suggests that near the end of his life, van Musschenbroek doubted no more:

Because I remember, a few years before his death, hearing van Musschenbroek say repeatedly, after long practice had taught him what each discipline contributed to [our] knowledge of nature, that natural science needed chemistry more than mathematics. (Hahn, 1768, 13)

Both in his academic orations, as in his experimental work, van Musschenbroek will indeed repeatedly point at the necessity to take into account the limits of the utility of mathematics in physics (Ducheyne, 2019; Beck, 2023). But like his mentor, Hahn does not think that this entails that mathematics is disposable. He will therefore set out to show what exactly the contributions to natural science of mathematics and chemistry are respectively. Most of his attention will go to the way these disciplines form the mind of their practitioners and instil certain virtues (and potentially certain vices).

With regard to mathematics, Hahn emphasises that it teaches one how to reason well and judge things, especially the discipline of geometry. The latter can therefore be called 'practical logic', which is the reason why it has from ancient times been deemed a necessary part of the education of the young (Hahn, 1768, 26). It 'changes the mind in an admirable way and brings forth a habit (*consuetudo*) of meditating and remaining unyieldingly with the same topic' (Hahn, 1768, 26). It also teaches the mind to clearly see what does and what does not follow from certain assumptions, so that it will not 'take things to be true, which do not follow from them' (Hahn, 1768, 26). It thus teaches the mind to be consistent in its judgement, which according to Hahn, is necessary to develop prudence (*prudentia*) (Hahn, 1768, 26).

But Hahn also points to the limits of mathematics, along the lines of van Musschenbroek. Mathematics does not treat real objects, but abstract ideas. As such, mathematics is a form of hypothetical reasoning. All mathematical certainty is therefore hypothetical, and does not in itself tell something about the world (Hahn, 1768, 27-28). He therefore turns to chemistry. Echoing Boerhaave, he provides an overview of the history of chemistry and all the faults that can be found in its history (Hahn, 1768, 37-44). But as Boerhaave had shown, chemistry had purged itself from its errors, which according to Hahn led to the birth of 'philosophical chemistry (*chemia philosophica*)':

which does not serve vicious desires (*prava cupiditas*), does not delight in astrological trifles, does not promise life to be prolonged forever with empty arrogance (*inanis arrogantia*), but modest (*modesta*)

and eager for truth (*veritatis studiosa*), constantly explores natural things and compares them with each other, joining, separating, and changing bodies with tireless zeal (*studium*). (Hahn, 1768, 44)

It is this kind of chemistry which Hahn thinks needs to be combined with mathematics. He dreams that this combination will make it possible that one day 'the mathematical principles of chemistry will finally be established by another Newton' (Hahn, 1768, 60). But like his teacher van Musschenbroek, Hahn is weary of the abuse of mathematics and emphasizes the enormous amount of empirical work that needs to be done for such a mathematical treatment to be possible. During his discussion of this empirical work, the contrast between the abstract ideas used in mathematics and the concrete, particular nature of chemical investigation is drawn repeatedly. Hahn states that physicists often work based on 'a mathematical abstraction (*mathematica abstractio*)' and therefore assume that 'matter is uniform and simple'. Differences are explained away by saying that these arise from the specific configurations of the atoms composing the body (Hahn, 1768, 47). Hahn argues however that we need to take differences between substances and bodies seriously. Therefore, different substances 'should not only be known generally, but they should be diligently distinguished in their species, and the various relationships that they have either amongst themselves or with the human body, should carefully be examined' (Hahn, 1768, 48).

Although Hahn praises the way mathematics can form the mind, it also has the potential of instilling intellectual vices in its practitioners. The practice of mathematics leads to 'a habit of abstracting (*abstrahendi consuetudo*)', which becomes 'second nature' for the practitioners (Hahn, 1768, 70). And even though the practice of mathematics can lead to the development of diligence (*diligentia*), this does not automatically transfer to domains beyond mathematics. We therefore often see physicists applying mathematics to physics in a way that lacks the due diligence. Moreover, their 'desire for reasoning (*ratiocinandi cupido*)' leads them to develop 'a distaste for slow empirical [work]' (Hahn, 1768, 72). This 'negligence towards observing' is made worse by their intellectual overconfidence (Hahn, 1768, 72). Their 'propensity towards reasoning' in turn leads to the feared and loathed *fingendi licentia* (Hahn, 1768, 73).

It is for these reasons that Hahn 'wants to recommend the study of chemistry' (1768, 74). This is explicitly presented as a cure for the vice (*vitium*) that mathematics brings into physics (Hahn, 1768, 76). Practitioners of chemistry develop certain virtues which counteract the aforementioned vices of mathematicians. Chemists have always been known to be those 'most observing (*observantissimus*) Nature' (Hahn, 1768, 74). They also display constant attention (*assiduitas*) and patience (*patientia*) when performing difficult experiments (Hahn, 1768, 75). Hahn therefore hopes that mathematicians will also spend some time in the chemical laboratory. The work they perform there 'will gradually temper that eagerness for abstraction (*abstrahendi libido*)' and move their mind from abstractions to

real things, 'from universals to particulars, from inventing hypotheses to the judgements of nature, from contemplation to action' (Hahn, 1768, 76). The continuous confrontation with nature will repeatedly show the practitioner of chemistry that the ideas that he had formed in his mind about the bodies he is investigating were wrong. This will teach him caution. He will also be confronted with nature's variety and the heterogeneity of matter. This will instil the diligence (*diligentia*) needed for the proper study of nature (Hahn, 1768, 76-77). Finally, the practice of chemistry will teach the mathematician 'how much harm is done by haste (*festinatio*), which is always improvident, and often utterly blind' (Hahn, 1768, 77). All these examples show that chemistry 'strengthens the mind, so that it can avoid the errors towards which a mathematical temper of mind has drawn many interpreters of nature' (Hahn, 1768, 68).

Having thus discussed the specific way in which chemistry (according to Boerhaave and Hahn) makes its practitioner into a more virtuous epistemic agent, I now turn to the introduction of Lavoisier's ideas in the Dutch Republic. I show how some of the epistemic vices and virtues that were discussed above played a role in debates between proponents and opponents of Lavoisier's work.

3. **Epistemic Virtues and Vices and the Chemical Revolution**

The earliest adopter of Lavoisier's theory in the Dutch Republic was Martinus van Marum (1750-1837). In 1784, van Marum (together with collaborators) conducted a series of experiments with an electrostatic generator, which were published in 1785 (Snelders, 1988, 126). Some of these experiments were of a chemical nature, namely those related to the study of gases (van Marum, 1785, 113-134) and those related to the calcination and reduction of metals (183-205). At this point, van Marum interpreted his results in the framework of the then widely accepted phlogiston theory.

On the basis of this publication, van Marum was invited by the *Académie Royale des Sciences* to present his research. In June 1785, he travelled to Paris, where he met Lavoisier. When he returned to the Netherlands, van Marum had not yet accepted Lavoisier's new ideas. He resumed his experimental research in November 1785. During this research, he became convinced of the correctness of Lavoisier's theory and therefore rejected the phlogiston theory. In 1787, van Marum explicitly expressed his conversion to the oxygen theory in letters to Lavoisier (Snelders, 1988, 128). In that same year, the results of this research were published as a follow-up to the 1785 publication. Van Marum added an appendix to the work, titled 'A Sketch of Lavoisier's Teaching' (1787).

In line with the emphasis on experimental proof and the criticism on the invention of hypotheses, van Marum tells his reader that he became convinced of Lavoisier's theory because 'every basic proposition of this theory has been confirmed by conclusive experiments,' whereas in the case of the phlogiston theory such experiments are lacking and 'things have only been assumed, in order to

explain many phenomena' (van Marum, 1787, 233). The phlogiston theory therefore gets the label of being a 'mere presupposition (hypothesis)' (van Marum, 1787, 234) Despite his enthusiasm for Lavoisier's theory, this same emphasis also led him to be cautious towards Lavoisier's "caloric". Although van Marum thinks there are 'findings that are such that they make [the existence of caloric] probable,' he feels forced to add that 'this idea cannot be confirmed by directly confirming experiments in the way this was possible for the previous propositions [of Lavoisier's theory]' (1787, 249).

But not all Dutch chemists and natural philosophers were as quick to accept Lavoisier's theory. Whereas van Marum's rejection of the phlogiston theory and his defence of Lavoisier can be seen as an example of the virtuous avoidance of the *fingendi licentia*, others accused Lavoisier of displaying exactly this vice. In the first volume of the Dutch scientific journal *Chemische en physische oefeningen* (Chemical and physical exercises) a translated letter written by the German chemist Johann Christian Wiegleb (1732-1800) appeared, in which Weigleb attacked Lavoisier's system. According to Wiegleb, Lavoisier had treated Stahl's system unfairly and had not considered all the available experimental evidence. The reason for this was that Lavoisier was only motivated by 'pride and self-love (*sic*) for his fantasies (*trots en eigenliefde voor zijne verbeeldingen*)' (Wiegleb, 1792, 449). Blinded by his 'prejudices (*vooroordelen*)' he tried to overthrow Stahl's system in favour of 'these children of his imagination' (Weigleb, 1792, 449).

Wiegleb provides a summary of Lavoisier's research trajectory and the way he ultimately arrived at his theory. He does not contest the results of the experiments that Lavoisier performed, but criticises the way Lavoisier 'was seduced by prejudice to draw false conclusions' from these experiments (1792, 434). By tracing back Lavoisier's steps, Wiegleb tries to show how Lavoisier only performed a limited number of experiments, often drew conclusions based on one experiment, failed to experimentally investigate alternative explanations for his experimental results, and was led by the hasty conclusions drawn from a limited number of experiments to interpret later experiments in a very specific light (1792, 434-442). Experimental evidence contradicting his conclusions was explained away 'by forging a hypothesis' (1792, 443). Wiegleb explicitly states that the aim of this reconstruction of Lavoisier's research trajectory was to show how his theory stands on shaky grounds because Lavoisier arrived at his conclusions in a problematic way (1792, 466).

From a virtue theoretic standpoint, we could say that Wiegleb tries to cast doubt on Lavoisier's theory by showing how it was not produced by the exercise of the proper epistemic virtues. This reading can be substantiated by the fact that Wiegleb's follows this statement on his aims by giving a portrait of Lavoisier's character. He praises the 'cleverness, precision, effort, and financial sacrifices' that Lavoisier demonstrated in his research, which showed the chemical community that Stahl's original phlogiston

theory was in need of improvement (1792, 466-467). In a somewhat patronising tone, he says that Lavoisier could probably be excused that he was carried away by 'the lively strength of his imagination' at the beginning of his research trajectory, because he still lacked the necessary experience then (1792, 467). What is problematic however, is that Lavoisier was later still unable to admit that he had drawn faulty conclusions. It was this tenacity that ultimately led him to pile prejudice on prejudice while constructing his theory. This was due to a lack of epistemic humility. Wiegleb thinks all this could have been avoided, had Lavoisier kept an eye on the wisdom of the dictum '*Nos sumus homines*, we are only humans' (1792, 468)

The journal in which this letter appeared was edited by the apothecary Petrus Johannes Kasteleyn (1746-1794). Lissa Roberts states that although he is less harsh than Wiegleb, Kesteleyn agreed that 'Lavoisier violated the inductively cumulative and practical approach that [he] thought was so necessary to achieve progress in chemistry' (2006, 265). In his commentary on Wiegleb's letter, Kasteleyn refuses to make a final verdict, saying that there is evidence in favour of both sides (1792, 470-472). This non-partisan stance was common in the Dutch Republic, especially in the first years after the spread of Lavoisier's theory (Roberts, 2006, 270; Roberts, 1995, 97-98; Snelders, 1988, 131, 133-34).

In this context, it might be worthwhile to explicitly emphasize Roberts's critical reading of van Marum's "A Sketch". She wants to mitigate the way this text has been presented in the literature as a flagship of the "new" chemistry. According to her, we should take more seriously the fact that 'van Marum presented Lavoisier's "teaching" primarily in an inductive manner – as a set of related, empirically based claims rather than as the system that Lavoisier himself proposed in his *Traité élémentaire de chimie* of 1789' (1995, 91). She also draws a contrast between the way van Marum 'viewed Lavoisier's work as a clarifying extension of chemistry that followed unproblematically from what preceded it, rather than constituting a break with the past' (1995, 93). Lavoisier, in contrast did present his work in the latter way.

In these examples, we can see how many of the virtues discussed in the orations above play a role in the discussions surrounding the relative merits of the phlogiston theory and Lavoisier's theory. The non-partisanship is in line with the criticism of "sects" in philosophy and the need for independent thought. Van Marum's more "inductive" presentation of Lavoisier's views and the contrast with Lavoisier's own presentation of his work tallies with the criticism of system philosophy and making hasty generalizations. Wiegleb's critique of Lavoisier likewise invokes the idea of unvirtuous haste, criticises Lavoisier's inability to constrain his imagination, and suggests that he lacks the proper intellectual humility. It is a potentially fruitful avenue for further historical research to see how big a role the reluctance towards grand systems and the emphasis on epistemic humility played in the

resistance towards Lavoisier's ideas. As the work of Hasok Chang shows, it was not only in the Dutch Republic that people refused to take a side in the debate. He gives a list of "anti-anti-phlogistonists" who for several reasons decided not to (completely) adopt Lavoisier's system or decided to remain undecided (2012, 30-32).

The example of van Marum and Wiegleb shows how two people can appeal to a similar set of intellectual virtues, but still differ in their assessment of a scientific theory. For van Marum, it is the phlogistonists who accept hypotheses without experimental grounds, whereas for Wiegleb it is Lavoisier who is carried away by a *fingendi licentia*, leading him to draw conclusions which do not follow from his experimental results. We can thus see that in this specific case the intellectual virtues are susceptible to the observation that Kuhn made regarding intellectual values: 'values may be shared by men who differ in their application' (1970, 185).[11]

But if we look at Priestley and Lavoisier, we can see two conflicting views on the epistemically virtuous practitioner of chemistry. As Victor Boantza has shown, Lavoisier and Priestley can be seen as exhibiting two different 'styles of experimental reasoning'. Both differ in their views on how conclusions should be drawn from experiments (Boantza, 2007). In an often quoted passage from his 1774 *Opuscules*, Lavoisier says that Priestley's work is 'but a tapestry of experiments, which is almost never interrupted by any reasoning' (1774, 110, own translation). In a similar vein, Lavoisier refers to the experiments found in the doctoral dissertation of one of Hahn's students, Diderik de Smeth. Lavoisier praises Smeth's experiments as being 'well executed, and for the most part exact and true' but at the same time states that '[Smeth's] system is not always in accord with his own observations' (1774, 108). What Lavoisier saw as a problematic lack of structured reasoning, Priestley would however see as a virtuous epistemic attitude. Although he had no problem with the heuristic use of hypotheses as means to think of new experiments to perform, like our Dutch natural philosophers, he also warns against the common human tendency of being 'too much in haste to *understand*' and appeals to his readers to 'content ourselves with the bare knowledge of new *facts* and suspend our judgment with regard to their *causes*' (Priestley, cited in Boantza, 2007, 519, emphasis in original).

In the preface to his *Traité*, Lavoisier does seem to subscribe to some of the views that we saw in section 1. Lavoisier says that 'the imagination tends to continuously draw us away from the truth' and that 'self-love and self-confidence [...] lead us to draw consequences which cannot be derived immediately from the facts' (1789, ix-x, own translation). To avoid this, 'we have to constrain or simplify as much as possible our reasoning,' while at the same time 'putting [our reasoning] to the test by

[11] Chang uses this passage from Kuhn to make a similar claim regarding the role of scientific values in the Chemical Revolution (2012, 22-28).

means of experiments' (ibid., x). It has already been remarked that Lavoisier regarded the method of experimental physics (with which our Dutch philosophers also identified themselves) as a model that should be adopted in chemistry (Donovan, 1993, 45-73; Kim, 2008, 285). Therefore, it is not surprising to observe a similar rhetoric regarding the need to restrain reasoning by means of experiments. However, Lavoisier does not share the Dutch (and Priestley's) distrust towards theoretization and generalization. As Arthur Donovan remarked, 'Lavoisier looked forward to formulating theories having all the certainty associated with deductive and demonstrative rationality' (1993, 53). Mi Gyung Kim has more recently suggested that this tendency was due to the fact that Lavoisier began his chemical research as a relative outsider. He was not a trained chemist and therefore 'approached chemistry from a theoretical rather than a practical point of view,' leading to 'a theoretical and systematic perspective [with the aim to] ascertain the transcendental truth of nature' (Kim, 2008, 289-290).

In the same preface to the *Traité*, Lavoisier refers to mathematics as providing the model for the kind of unbroken chains of reasoning that were needed in chemistry in order to arrive at the truth of things (and that he had seen lacking in the work of Priestley and De Smeth when he wrote his *Opuscules*) (1789, xi). We can thus conclude that van Musschenbroek and Hahn made a different assessment of the relationship between chemistry and mathematics in regard to the question of epistemic virtuous behaviour in chemical research. Van Musschenbroek and Hahn thought that chemistry could be used to counter the vices of problematic abstraction and theoretization that were inherent in the practice of mathematized experimental physics. Lavoisier however thought that mathematized experimental physics provided an example of epistemically virtuous theory construction.

Conclusion

In this article, we have seen the connection between epistemic virtues and chemistry in the eighteenth century Dutch Republic. This was done in two ways. In the discussion of the virtue epistemology of Boerhaave, van Musschenbroek, and Hahn, we saw that the three authors regarded chemistry as an exemplary discipline. They defended its practice because it instilled certain key epistemic virtues and helped to alleviate specific epistemic vices. This was related to their criticism of *a priori* philosophy and the epistemic vices that were associated with it.

A central vice for all three authors was the so-called *fingendi licentia*, the (inability to constrain) the mind's innate propensity towards fantasizing. This central vice was connected with three other vices: intellectual laziness, arrogance, and impatience. Intellectual laziness makes people reluctant to undertake the empirical work needed to ground theoretical statements. This vice leads people to *a priori* philosophy, because it seems to promise an easy (and therefore attractive) way towards knowledge. This relates to the vice of epistemic impatience. By nature, people are hasty and eager to

draw conclusions. Empirical work is not only hard, but it also takes time. *A priori* philosophy promises a much faster route towards a general theory of nature. The promise of this general theory in turn is linked to the vice of arrogance. *A priori* philosophy appeals to humans' tendency to think that they are able to reduce the complexity of nature to a single theory by the power of their own mind.

The fact that Boerhaave, van Musschenbroek, and Hahn think that *a priori* philosophy is problematic and the fact that they single out these specific vices, cannot be seen separately from their voluntaristic theology and their general worldview. They emphasize the omnipotence and free nature of God's will, which expresses itself in the complexity of nature. *A priori* philosophy forgets to take into account this complexity of nature when it thinks (too quickly) to have reduced the world to a few metaphysical principles. For Boerhaave, van Musschenbroek, and Hahn, the vices of *a priori* philosophy are therefore as much epistemic failures, as moral and religious ones. Conversely, the practice of chemistry and the virtues associated with it, has both an epistemic and a moral character. By providing this analysis of the work of the three Leiden professors, I hope to have provided an example of what Ian Kidd calls a 'deep conception of epistemic vice [and virtue]':

One might expect interest in the metaphysics of epistemic virtue from those philosophers interested in epistemic virtues – virtue epistemologists. But, surprisingly, very few of them explicitly explore the grounding of the virtues of the mind in such things as worldviews, or indeed their history. Honourable exceptions are Bob Roberts and Jay Wood, who throughout their book, *Intellectual Virtues*, remark that '(epistemic) virtue and vice concepts' are tacitly 'indexed' to 'metaphysical commitments', 'world views', or a 'conception of human nature'. The intelligibility and salience of certain virtues and vices can only be explained by reference to the particular 'worldview' or 'metaphysical background', which those epistemic concepts 'presuppose' (2007, 155, 82, 22). When an account of a vice acknowledges its historical and metaphysical grounding, call it a *deep conception of epistemic vice*. (Kidd, 2017, 12)

I also hope to have shown that an understanding of the virtue epistemology of Boerhaave, van Musschenbroek, and Hahn, and their views on chemistry based thereon, have potentially broader implications. The second way therefore in which this article looks at the connection between epistemic virtues and chemistry in the eighteenth century Dutch Republic, is by showing how epistemic virtues and vices were invoked by both proponents and opponents of Lavoisier's work when it was being introduced in the Dutch Republic.

Van Marum defended Lavoisier's work by appealing to the fact that Lavoisier did not invent any hypotheses, but only based his theoretical findings on the available experimental evidence. Compared to Lavoisier himself, van Marum also presented Lavoisier's work less as a system, but rather as a series of teaching or empirical claims which had been reached in an inductive way. This dovetails well with

the criticism of the *fingendia licentia* and the vices of system philosophers voiced by Boerhaave, van Musschenbroek, and Hahn. However, we also saw how Wiegleb appealed to these same virtues and vices to criticise Lavoisier and his work. Given the way the epistemic virtues discussed in section 1 could be used to both defend and criticise Lavoisier's work, it is perhaps no surprise that a Dutch chemist such as Kasteleyn remained undecided until the end of his life.

The analysis provided in section 3 of course has its limits. In sections 1 and 2 I have only discussed three Dutch authors. The question remains how widespread and shared the virtue epistemology of Boerhaave, van Musschenbroek, and Hahn was. Of course, Boerhaave was an iconic figure in eighteenth century chemistry, van Musschenbroek's work was well known and read throughout Europe, and Lavoisier deemed the work of one of Hahn's students important enough to devote an entire chapter to it in its first monograph. This, combined with the fact that certain of the key virtues discussed by the authors re-occur in later debates, at least provides a clear motivation for further research. I have ended section 3 by suggesting that the debate between Priestley and Lavoisier can also be seen as a difference in opinion regarding the nature of the virtuous natural philosopher or chemist. There has been a growing revisionist literature on the Chemical Revolution in history and philosophy of science which tries to move beyond the narrative of a quick and unproblematic acceptance of Lavoisier's work by the chemical community. Instead, they point at the reasons actors might have to still see merits in the phlogiston theory or why there might have been good reasons to be reluctant towards a full acceptance of Lavoisier's system (the work of Boantza, Kim, and Chang cited in this paper can be seen as good examples of this literature). Based on the work presented here, I would like to end this article by suggesting that a virtue epistemological framework might provide a fruitful tool for further analyzing eighteenth century debates regarding the acceptance of Lavoisier's work.

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