BJHS **35**(4): 383–410, December 2002.
DOI: 10.1017/S000708740200479X

Natural philosophizing inside the late seventeenth-century Tuscan court

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Abstract. The Accademia del Cimento in seventeenth-century Florence has traditionally been seen as the first European organization to employ an experimental programme, thus becoming a major participant in the so-called 'birth of modern experimental science'. Such traditional accounts have also detailed the cultural, political and religious environment of the period that contributed to the Accademia's use of a supposedly atheoretical experimental method. However, despite the merits of such cultural histories, these stories do not portray the full details behind the Accademia's intellectual workings – how knowledge claims were constructed, interpreted and presented by the academicians according to their natural philosophical concerns. It is argued here that such an analysis will provide a more accurate account of the Accademia's activities than existing stories about the birth of an experimental programme or method. By looking past the experimental rhetoric produced by the academicians in their only publication, *Saggi di naturali esperienze*, we begin to see at play one of the major issues which made up the Accademia's knowledge-making process: the natural philosophical interests of this institution's participants, particularly Borelli, Viviani, Rinaldini and Marsili. Those interests are represented in the Accademia's experiments, including their work concerned with air pressure and the void.

The Accademia del Cimento formally began in June 1657, when Prince Leopoldo de'Medici invited several natural philosophers to the Pitti Palace in Florence. This group included: Giovanni Borelli (1608–79), Vincenzio Viviani (1622–1703), Carlo Rinaldini (1615–98), Alessandro Marsili (1601–70), Francesco Redi (1626–97), Alessandro Segni (1633–97), Candido del Buono (1618–76) and his brother Paolo (1625–59), and Antonio Uliva (d. 1668).[1] Under the patronage of the Medici Court, these men reportedly committed themselves to making experiments and observations. The academicians' dedication to experimentalism, it would seem, is typified in their motto, 'Provando e Riprovando', referring to the rigorous 'testing and retesting' of their own experiments as well as those performed previously by other natural philosophers of the period.[2] Yet the

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Thanks are due to those who have commented on the arguments presented in this paper. I am especially appreciative of the valuable contributions made by John Schuster, David Miller, Katherine Neal and the anonymous referees from the *BJHS* who have reviewed earlier versions of this paper. Thanks also to Paolo Galluzzi and the library staff at the Istituto e Museo di Storia della Scienza in Florence, as well as the staff from the manuscript section of the Biblioteca Nazionale Centrale di Firenze.

1 The careers of Borelli, Viviani, Rinaldini and Marsili will be very briefly discussed in this introduction. For brief biographies of all of these academicians, as well as a comprehensive coverage of the Accademia's history, see W. E. K. Middleton, *The Experimenters: A Study of the Accademia del Cimento*, Baltimore, 1971.

2 This phrase is mentioned in the Preface to the Accademia's publication by their secretary Lorenzo Magalotti, *Saggi di naturali esperienze fatte nell'Accademia del Cimento sotto la protezione del serenissimo principe Leopoldo di Toscana*, Florence, 1667, 84. All references to the *Saggi* are from its re-publication in

best testimony to their supposedly strict experimentalist approach to researching nature was their only publication, *Saggi di naturali esperienze* (1667). This text is devoted to the narration of the experiments performed in the Accademia del Cimento until its closure in 1667 and states the academicians' intentions never to stray into speculative arguments but simply to report the experiments they performed.

Indeed, the author, and the Accademia's secretary after 1660, Lorenzo Magalotti (1637–1712), expresses this aim clearly in the Preface to the *Saggi*, telling us that in studies of nature, the only way of properly linking observations with their correct causal explanations is through the use of a great deal of experimental evidence.[3] For too long, claims Magalotti, natural philosophers have been relying on the authority of past writers and have been reaching false conclusions about the causes of nature's structure and movement.[4] Since geometry, for the academicians, could not account for all the peculiarities of nature, they decided that the only way of making the proper connections between causes and their effects was through a rigorous experimental programme.[5] In other words, while studies in mathematics and geometry had long assisted Italian natural philosophers in their pursuit of knowledge, the academicians reportedly no longer saw the value of relying on such theoretical speculation and instead adopted the standard rhetoric of the late seventeenth-century 'new' experimental philosophers.[6] At one point in the Preface Magalotti states,

> if sometimes in passing from one experiment to another, or for any other reason whatever, some slight hint of speculation is given, this is always to be taken as the opinion or private sentiment of the academicians, never that of the Academy, whose only task is to make experiments and to tell about them.[7]

In recent years this experimental rhetoric and the activities inside the Accademia del Cimento have been a source of much interest for historians of Italian science. Several of these studies have focused on the cultural and political circumstances which contributed to the foundation of the Accademia in mid-seventeenth-century Florence, and the reasons for their purported devotion to the new experimental philosophy of the period. Thanks to the work of such erudite scholars as Jay Tribby, Mario Biagioli, Paula Findlen and Marco

G. Abetti and P. Pagnini (eds.), *Le opere dei discepoli di Galileo Galilei. Edizione Nazionale. I. L'Accademia del Cimento. Parte Prima*, Florence, 1942.

3 Abetti and Pagnini, op. cit. (2), 85.

4 Abetti and Pagnini, op. cit. (2), 84.

5 Abetti and Pagnini, op. cit. (2), 84.

6 The best-known early modern institutions to have used a similar experimental rhetoric were of course the Royal Society of London and the Académie royale des sciences in Paris. The statutes drawn up for these institutions upon their foundations declared their intentions only to report experiments without stating any theoretical interpretations. M. Ornstein, *The Role of Scientific Societies in the Seventeenth Century*, Chicago, 1938, 109, 148.

7 As translated by Middleton, op. cit. (1), 92,

> *se talora per far passaggio da una ad un'altra esperienza, o per qualunque altro rispetto, si sarà dato qualche minimo cenno di cosa specolativa, ciò si pigli pur sempre come concetto o senso particolare di accademici, ma non mai dell'Accademia; della quale unico istituto si è di sperimentare e narrare.*

Magalotti, *Saggi*, op. cit. (2), 86–7.

Beretta, we now have a thorough understanding of the experimental programme adopted by Tuscany's early modern thinkers and sponsored by the Medici court.[8]

In fact, these authors have argued that the Cimento's experimental philosophy, much like the experimental science that Shapin and Schaffer describe in their writings regarding the early Royal Society of London, was aimed at producing atheoretical matters of fact, that is, experiments with no speculative arguments attached, and thus clear of intellectual conflicts.[9] Therefore, as we are told by Tribby, Biagioli, Findlen and Beretta, the members of the Accademia del Cimento and their Medici patrons maintained courtly etiquette and gentlemanly decorum as well as a social standard for gaining legitimacy – both for the individual thinkers among their scientific colleagues and for the Medici court among the wider European community of royal courts. In short, some authors identify this type of rhetoric as the beginnings of a loosely articulated, theory-neutral method for accumulating matters of fact. Such an experimentalist or courtly culture supposedly replaced natural philosophical concerns and conflicts, establishing the factual and gentlemanly origins of experimental science.

These types of cultural studies have certainly helped us to understand some of the political and social circumstances surrounding the foundation of the Accademia del Cimento. As we shall see, the focus of this literature on issues of courtly patronage, etiquette and social legitimation is particularly valuable for our understanding of the presentation of the Accademia's experiments in the *Saggi*. However, it is the aim of this paper to show that other issues were also prominent in the Tuscan intellectual landscape of the time of the Cimento's foundation. It will be argued here that there is a significant difference between what the academicians actually did and how they reported their activities in the *Saggi*. As Paolo Galluzzi states, 'behind the Accademia's serene façade, there unfolded a significant and lively confrontation based on "principles"'.[10]

I shall be examining closely Galluzzi's arguments and the 'principles' that dominated the academicians' disputes on air pressure and the void. Yet, looking beyond Galluzzi's work on the confrontations that existed between the academicians, I will also be arguing that the construction of the Cimento's experiments was in fact entangled with a tradition of natural philosophical concerns and conflicts in the seventeenth century. All this is supported by the academicians' manuscripts and letters which help us to understand how, in the construction of experiments, traditional Aristotelian teachings, defended by a minority within the Florentine group, clashed with the mechanistic and corpuscularian

8 J. Tribby, 'Dante's restaurant: the cultural work of experiment in early modern Tuscany', in *The Consumption of Culture, 1600–1800* (ed. A. Bermingham and J. Brewer), London, 1991, 321; M. Biagioli, 'Scientific revolution, social bricolage, and etiquette', in *The Scientific Revolution in National Context* (ed. R. Porter and M. Teich), New York, 1992, 11–54; P. Findlen, 'Controlling the experiment: rhetoric, court patronage and the experimental method of Francesco Redi', *History of Science* (1993), **31**, 39–40; M. Beretta, 'At the source of western science: the organisation of experimentalism at the Accademia del Cimento (1657–1667)', *Notes and Records of the Royal Society of London* (2000), **54** (2), 131–51.

9 Shapin's and Schaffer's best-known works on this topic include S. Shapin and S. Schaffer, *Leviathan and the Air-Pump*, New Jersey, 1985; S. Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England*, Chicago, 1994; S. Shapin, *The Scientific Revolution*, Chicago, 1996.

10 P. Galluzzi, 'L'Accademia del Cimento: "gusti" del principe, filosofia e ideologia dell'esperimento', *Quaderni Storici* (1981), **48**, 805.

beliefs supported by the majority of the academicians. In other words, despite the impression given to readers of the *Saggi* that this was a strict experimentalist institution, our understanding of the Cimento's activities should be based on the complexities of the academicians' natural philosophical thoughts.

With this said, it is important to note in this introduction how each of the Cimento's participants were devoted to natural philosophical studies throughout their careers. While Viviani is not known for his scientific exploits, his literary contributions to Tuscan natural philosophy were valued – he devoted much of his career to restoring, translating and improving on the ancient texts of Archimedes, Aristaeus, Euclid and Apollonius. He also put this knowledge of mathematics and geometry to use in the study of physics, when assisting Galileo with the natural motion of heavy falling bodies, and when contributing to most of the Cimento's experiments.[11] Meanwhile, Borelli is very well known by historians who have taken an interest in post-Galilean natural philosophy for his strong mechanist agenda. He adopted mechanical principles expounded by Galileo, Cavalieri and Descartes to produce several texts on terrestrial and celestial motion, and even physiology, establishing a school of iatrophysicians in Pisa.[12] Therefore, throughout their careers, the two biggest contributors to the Accademia del Cimento vigorously pursued their natural philosophical interests – their concerns in mathematical, geometrical and mechanical principles.

Other important members of the Medici court at that time included Francesco Redi, and the mathematician brothers, Paolo and Candido del Buono. Redi was quite well known for his studies in the field of medicine, but his contributions to the Cimento seem to have been rather limited. A similar ambiguity surrounds the contributions of the del Buono brothers, but they are still known for their careers in mathematics and Galilean mechanics. Meanwhile, the situation was quite different for two other academicians, Alessandro Marsili and Carlo Rinaldini. Marsili had apparently met Galileo and may have even secured the chair of philosophy at Pisa thanks to Galileo's recommendation.

11 Details of Viviani's early life are recorded in some letters and manuscripts now held in the Galilean collection of the Biblioteca Nazionale Centrale di Firenze in folio Gal. 155. This includes a document written by Viviani's nephew recounting his uncle's life, and transcribed by historian Giovanni Batista Clemente Nelli in 1758 (1r–4r), as well as an autobiographical letter written to Abate Marquis Salviati in 1697, also transcribed by Nelli (5r–23r), and published by A. Fabroni, *Lettere inedite d'uomini illustri*, 3 vols., 1775, ii, 6. In addition to this, Viviani wrote about his education under Galileo in his posthumously published *Vita di Galileo* (ed. L. Borsetto), Bergamo, 1992. But the best secondary sources to deal with Viviani's education under Galileo are A. Favaro, *Amici e Corrispondenti di Galileo*, 3 vols., Florence, ii, 1983, 1007–1163; and M. L. Bonelli, 'L'ultimo discepolo: Vincenzio Viviani', in *Saggi su Galileo* (ed. C. Maccagni), 3 vols., Florence, 1972, ii, 656–88; and G. Targioni-Tozzetti, *Notizie degli aggrandamenti delle scienze fisiche accaduti in Toscana nel corso di anni LX del secolo XVII raccolte dal dottor Gio. Targioni Tozzetti*, 5 vols., Florence, 1780, i, 321.

12 The best secondary sources covering Borelli's intellectual career include: U. Baldini, 'Giovanni Alfonso Borelli e la rivoluzione scientifica', *Physis* (1974), **16**, 97–128; G. Barbensi, *Borelli*, Trieste, 1947; T. Derenzini, 'Giovanni Alfonso Borelli, Fisico', in *Celebrazione della Accademia del Cimento nel Tricentenario della Fondazione*, Pisa, 1957, 35–52; P. Galluzzi, 'G. A. Borelli dal Cimento agli Investiganti', in *Galileo e Napoli* (ed. F. Lomonaco and M. Torrini), Naples, 1987, 339–55; D. B. Meli, 'The Neoterics and political power in Spanish Italy: Giovanni Alfonso Borelli and his circle', *History of Science* (1996), **34**, 57–90; T. B. Settle, 'Giovanni Alfonso Borelli', in *Dictionary of Scientific Biography* (ed. C. C. Gillispie), 16 vols., New York, ii, 1991, 306–14.

Nevertheless, as we shall see, he remained sympathetic to Aristotelian natural philosophy and defended scholastic opinion inside the Cimento. Meanwhile, according to Middleton, Rinaldini, also a professor of philosophy at Pisa, had taught Galilean mechanics and Gassendian atomism but, as we shall also see, he seemed intent on defending some scholastic views inside the Cimento when he was not entirely convinced by mechanist explanations for the pressure of air and the existence of the vacuum. With these brief biographical details in mind, we are now in a better position to investigate the disputes that occurred inside the Cimento regarding the opposing views of natural philosophy entangled in the group's experiments.

Natural philosophical concerns and controversies were central to the Accademia's knowledge-making process: the construction and interpretation of experiments. While a courtly culture may have indeed changed the organization of early modern science, natural philosophical interests still continued to be at stake for the so-called experimental philosophers of mid- to late seventeenth-century Tuscany. I suggest, therefore, that our understanding of the Accademia's knowledge-making process should not lie solely with the supposed emergence of a 'new science'. Instead, we may benefit greatly from a closer investigation into the Florentine group's internal workings, where their cognitive and disciplinary aims and interests may be found.

The case study in this paper involves one of the Accademia's most important topics of research: the pressure of air and the existence of the vacuum.[13] The Accademia's work on pneumatics was based on the barometer, the instrument for measuring the weight of air first constructed by one of their predecessors in the Tuscan court, Evangelista Torricelli. The academicians' surviving manuscripts and letters reveal that they used the Torricellian tube, as did their colleagues in Paris, as an instrument producing authoritative results supporting mechanists and corpuscularians in their debate with the scholastics. Therefore, while looking at this case study, we shall be peeling back the rhetorical façade of a purely experimentalist organization and revealing the details which point to an institution founded on aims and issues rather more complex than the simple desire to perform experiments. But before reaching the academicians' work on pneumatics, it is important to identify these seventeenth-century natural philosophical issues and their role in early modern Italian science, beginning with Galileo.

Seventeenth-century mechanical natural philosophy

Natural philosophy since the writings of Plato and Aristotle had been based on determining the answers to the following four questions: what kind of matter does nature consist of; how is that matter organized into a cosmos; how and why do changes and motion in nature occur; what are the best ways to discover and/or verify one's answers to the first three points (the question of method)? These are the types of question that

13 The academicians also performed experiments concerning the properties and effects of heat and cold, the magnet, amber and other substances with electric virtue, projectiles, astronomy, and the motion of sound. Despite their interests in many topics, most of their attention was directed towards air pressure, the vacuum, and heat and cold. In any case, I believe that an investigation into how they researched any of these topics will reveal much of the natural philosophical interests that will be outlined in this paper.

framed natural philosophical concerns during the Scientific Revolution.[14] Furthermore, seventeenth-century thinkers faced additional tasks when answering these questions. First, their discourses had to engage with the theological, political and pedagogical issues of the period. Second, actors faced the task of linking the significance of their experimental hardware and results to their natural philosophical beliefs – their answers to the above four questions.[15] In other words, the process of constructing and interpreting knowledge claims included packaging those claims within a certain natural philosophical discourse. Finally, this type of intellectual environment, where the meanings of certain theories and disciplines were contested among contrasting cognitive beliefs, created an evolving subculture of competing natural philosophical discourses. Seventeenth-century Aristotelians were forced to argue the soundness of their claims against varieties of neo-Platonism and against the new changing versions of mechanism.[16]

The four questions mentioned above, as well as the cultural and cognitive settings they encompass, are propounded by authors such as Schuster and Watchirs and Schuster and Yeo, and are used by these authors to argue that early modern experimental method rhetoric should not distract historians from the wider intellectual interests that existed behind the experimentalist façade.[17] Therefore, as will be argued here in the case of Tuscan natural philosophy, from Galileo to the Accademia, talk of experimental method provides historians with few clues about these conceptual interests pursued by the Italian natural philosophers. Instead, a historical analysis of their mechanical and corpuscularian views regarding the structure, organization and movement of all matter, would begin to explain the emergence of Florentine theories about issues such as the existence of the void and the weight of air. That is to say, those theories were produced within the dominant mechanical and corpuscularian natural philosophical discourse of that time and group and in opposition to the traditional and still widely entrenched Aristotelian beliefs.

The rise of mechanism as such a viable challenger to Aristotelianism, and how this alternative natural philosophy gained such importance for mid- to late seventeenth-century scholars such as our academicians, can be traced back to the 'scientific humanist' movement during the sixteenth and early seventeenth centuries. The intellectual pursuits of the Renaissance since the 1300s continued for natural philosophers through the recuperation, translation and commentary of classical texts. In fact, some of the leading corpuscularians and mechanists of the Scientific Revolution, particularly Pierre Gassendi, whose reworking of classical atomism was highly respected by the members of the

14 J. Schuster, 'The scientific revolution', in *Companion to the History of Modern Science* (ed. R. C. Olby, G. N. Cantor, J. R. R. Christie and M. J. S. Hodge), London, 1990, 225.

15 J. Schuster and G. Watchirs, 'Natural philosophy, experiment, and discourse: beyond the Kuhn/Bachelard problematic', in *Experimental Inquiries: Historical, Philosophical and Social Studies of Experimentation in Science* (ed. H. E. LeGrand), Dordrecht, 1990, 14; J. Schuster and A. Taylor, 'Blind trust: the gentlemanly origins of experimental science', *Social Studies of Science* (1997), **27**, 515.

16 Schuster and Watchirs, op. cit. (15), 15.

17 J. Schuster and R. R. Yeo, 'Introduction', in *The Politics and Rhetoric of Scientific Method* (ed. J. Schuster and R. Yeo), Dordrecht, 1986, p. xii.

Accademia del Cimento,[18] studied and reinterpreted the likes of Leucippus, Democritus and Epicurus.[19]

Meantime, the geometry of Euclid, Archimides and Apollonius increasingly found its admirers among early modern thinkers. These mathematical arts were found to be useful for navigational, engineering and military pursuits in the sixteenth and early seventeenth centuries. Furthermore, they provided a foundation for a mathematical philosophy to ally itself with mechanical causality, complementing the emerging mechanical tradition in natural philosophy.[20] More specifically, according to Dear, by the beginning of the seventeenth century the practitioners of these mixed mathematical disciplines sought to improve the status and content of their work by interacting with natural philosophical concerns and yielding reliable knowledge of nature's structure and movements.[21] So natural philosophical studies began to be informed by the broadening social and cognitive aims of the physical–mathematical practitioners, such as Galileo, Gassendi and Descartes. Varying versions of mechanism began to discard Aristotelian qualities in favour of the measurement of quantifiable properties of nature, the idea that all matter can be measured through primary qualities such as size, shape, motion and density.[22] Therefore the accepted structure of the universe, for early to mid-seventeenth-century mechanists, was that all matter is divisible into quantifiable particles. This was clearly a philosophy of nature that challenged Aristotelian use of sense experience, and hermetic and neo-Platonic explanations of occult qualities.[23]

In summary, the central tenets of the mechanical philosophy were that nature consisted of corpuscles, or atoms, and that the organization and movement of these atoms was as in a machine, requiring an understanding through the application of mathematics, geometry and mechanics. Finally, method rhetoric focused on ideas of observation and experiment, adding authority to these natural philosophical claims.[24] These conceptions answered the key natural philosophical questions that were mentioned at the beginning

18 As Middleton notes, Gassendi was on the Accademia's reading list, and was mentioned several times in the *Saggi*. Middleton, op. cit. (1), 4.

19 One of the strongest indications that our early modern natural philosophers were beginning to invest quite a bit of interest in the ancient atomists is in the career of the seventeenth-century Tuscan poet and mathematician Alessandro Marchetti (1633–1712). During the Cimento's ten years in existence, Marchetti, also employed by the Medici court, was working on a translation of a poem by Lucretius, a Greek poet and atomistic philosopher in the first century BC. Lucretius' poem argued in accordance with the theories of Democritus and Epicurus that the universe is an infinite extent of empty space and consists of an infinite number of irreducible particles of matter differing only in shape, size and weight. Marchetti's translation was published posthumously, but his work still had an impact on the academicians, which is particularly reflected in his collaboration with Borelli. For a detailed account of Marchetti's life and work, see M. Saccenti, *Lucrezio in Toscana*, Firenze, 1966.

20 J. A. Bennett, 'The mechanics' philosophy and the mechanical philosophy', *History of Science* (1986), **24**, 5.

21 P. Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution*, Chicago and London, 1995, 170.

22 As Desmond Clarke states, primary qualities are the fundamental properties of nature which are not subject to biased judgements. D. Clarke, *Occult Powers and Hypotheses: Cartesian Natural Philosophy under Louis XIV*, Oxford, 1989, 71.

23 Clarke, op. cit. (22), 73–4.

24 Schuster and Watchirs, op. cit. (15), 20.

of this section and that the Italian seventeenth-century thinkers would have been asking themselves. So although mechanism took on different forms during the seventeenth century, the issue continually at stake for the likes of Galileo, Descartes and Gassendi, apart from wider social and political linkages, was that Aristotelianism could no longer account for nature's structure, organization and movements, while mathematics, geometry and mechanics provided the more efficient and accurate tools for understanding the universe.

Galileo, natural philosophy and experiment

Turning now specifically to the Tuscan setting, one may argue that Galileo was certainly not a systematic mechanical philosopher, since the boundaries of mechanism were more formally and widely established during the 1640s and 1650s.[25] Nevertheless, his aims had always been based firmly within the natural philosophical field of contention. Writers such as Koyré, Clavelin, Drake and Naylor have helped us to understand the mathematical, mechanical and geometrical issues that ran through Galileo's works on terrestrial motion and his intentions to discredit Aristotelianism.[26] Galileo's use of mathematics and geometry was thus the central factor behind his debate with the scholastics, who had different ideas on the structure, organization and movements of nature.

In the meantime, experiments came to hold a crucial position in Galileo's attempts to prove the soundness of his work. He performed experiments of different kinds, including 'thought' experiments, as well as a-priori experiences contrived to support his theories, and he presented them with more than one aim in mind: to provide a persuasive and authoritative tool for his readers and to access natural phenomena in a way which would allow his mathematical principles to be incorporated into wider natural philosophical concerns. As both Clavelin and Koyré note, the experimental proof Galileo provided in the presentation of his claims was often a justification of previously established theories, and even if he had not actually performed the experiment, he could provide the mathematical and geometrical explanations of what would happen in a hypothetical experiment.[27] According to Naylor, this helped to persuade Galileo's readers that his conclusion could only be true. This is the rhetorical role experimentalism served in two of

25 What is meant here by systematic mechanical philosophers is those who adopted a system of natural philosophy based purely on mechanical principles. Examples include Descartes's, Mersenne's or even Borelli's strict mechanistic explanations of the structure and movements of the universe.

26 A. Koyré, *Metaphysics and Measurement*, London, 1968; M. Clavelin, *The Natural Philosophy of Galileo: Essay on the Origins and Formation of Classical Mechanics* (tr. A. J. Pomerans), Cambridge, 1974; S. Drake, 'Introduction', in G. Galilei, *Discourses and Mathematical Demonstrations Concerning Two New Sciences Pertaining to Mechanics and Local Motion* (tr. S. Drake), Wisconsin and London, 1974; S. Drake, 'Ptolemy, Galileo, and Scientific Method', *Studies in the History of the Philosophy of Science* (1978), **9**, 101; R. H. Naylor, 'Galileo's experimental discourse', in *The Uses of Experiment: Studies in Natural Science* (ed. D. Gooding, T. Pinch and S. Schaffer), London, 1990.

27 The best-known Galilean thought experiment would have to be the dropping of a cannonball from the mast of a ship. For this case, Koyré explains that Galileo 'was such a good physicist that he could predict the behaviour of the cannon-ball, a priori, without making any experiments'. A. Koyré, *The Astronomical Revolution* (tr. R. E. W. Maddison), London, 1980, 470; Clavelin, op. cit. (26), 27.

Galileo's publications, *Dialogue* (1632) and *Two New Sciences* (1638). In the presentation of his claims in these texts, Galileo used thought experiments as a persuasive device, promoting a new, alternative view of nature in place of traditional, Aristotelian thought.[28] This would seem to subordinate the role of experiments in Galileo's natural philosophy, but we should not believe that he did not regard his experiments as efficacious. On the contrary, either through 'thought' experiments or in those that he actually performed, Galileo was providing universal knowledge claims, that is, irrefutable and unchanging natural phenomena that could easily be explained with the certainty and regularity provided by mathematical and geometrical principles.[29] Through experiment, therefore, came a vehicle for the mathematical and geometrical treatment of physical problems, such as terrestrial motion.[30] Galileo's sophisticated combination of mathematics and experiment was thus crucial to his constitution of terrestrial mechanics in the presentation of his work, but his use of experiments was still subservient to his mathematical, geometrical and anti-Aristotelian natural philosophical agenda. Its most significant role was as an authoritative tool, used to persuade the reader to refute Aristotelianism and support a mechanical, Archimedean physics. As we shall see, these tensions surrounding Aristotelian and Galilean natural philosophy continued to be played out amongst the Accademia's members. In other words, the central concerns of the period were not so much to accumulate disparate 'facts' or knowledge claims through an experimental programme, but to prove the validity of theories within a field of natural philosophical contention.[31]

Torricelli and the natural philosophical agenda behind the construction of the barometer

I have so far argued how the presence of complex cognitive concerns of seventeenth-century natural philosophers place experimental method rhetoric within the wider field of physical–mathematical and natural philosophical concerns and tactics of presentation and persuasion. I now look deeper into the natural philosophical issues with which the academicians were concerned in their study regarding the pressure of air and the existence of the void. I argue that this case study reveals how the academicians' natural philosophical interests and conflicts were in fact entangled in their knowledge-making process, in the construction, interpretation and presentation of knowledge claims. However, this case study does not begin in 1657 when the academicians performed their first barometric experiments, but in 1644, when Evangelista Torricelli, Galileo's successor to the position of Court Mathematician in Tuscany, claimed to have constructed the first barometer, and sparked a flurry of activity among his colleagues in other parts of Europe.

28 Naylor, op. cit. (26), 124.

29 Dear, op. cit. (21), 124–6.

30 S. Gaukroger, *Explanatory Structures: A Study of Concepts of Explanation in Early Physics and Philosophy*, Sussex, 1978, 210–20.

31 This crucial point is argued particularly well in Schuster and Watchirs, op. cit. (15), 21; and Schuster and Taylor, op. cit. (15), 515.

Torricelli described how he made the instrument in a letter to his friend Michelangelo Ricci in June 1644.[32] He tells Ricci that he filled a tube, sealed at one end, with mercury and stopped it at the mouth with a finger. He turned the tube upside down in a bowl, also filled with mercury. When he released the finger, the mercury in the vessel descended slightly, leaving an empty space at the top. What followed was an attempt to demonstrate, first, that the space formed in the tube was vacuous and, second, that the cause of the mercury's descent was due to the weight of the surrounding air, and not because of the vacuum's force.

Torricelli added water to the mercury in the bowl and began to raise the tube slowly. When the mouth of the tube rose to the surface of the water, the mercury in the vessel poured out, and the water rushed in to fill the tube to its top, demonstrating that the space had indeed been empty and that there is a clear difference in the densities and movements of the two liquids.[33] This experience was enough for Torricelli to believe that not only had he created a vacuum, but in the process had also produced an instrument that could measure the weight of its surrounding air.[34]

The implications of these two claims were quite significant. First, Torricelli was directly opposing Aristotelian doctrine that nature abhorred the production of a vacuum. This had been a controversial topic of discussion between atomists and scholastics during the sixteenth century.[35] But the weight and pressure of air was quite a different matter, as Middleton points out.[36] The reason for this is because it was less strenuously denied by Aristotelians, who simply believed that air could have weight when not in its natural place. So the notion of the weight of air did not deeply disrupt scholastic ontological beliefs as long as its advocates maintained their distance from openly pursuing anti-Aristotelian theories on matter, such as atomism.

Galileo had always been prepared to accept the existence of the void even though it could not be proven, and by 1630 he insisted that it was in fact the 'force or resistance of the vacuum' that stopped the liquid in the water pumps from rising beyond the height of approximately 10.5 metres. Galileo expressed this view in 'Day One' of *Two New Sciences* when he presented a hypothetical experiment with a piston to provide a calculation of the force that was resisting the piston from operating past a certain point. That force, he believed, could only be coming from the vacuum.[37] So Galileo still uses a

32 W. E. K. Middleton, *The History of the Barometer*, Baltimore, 1964, 23.

33 E. Grant, *Much Ado About Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution*, Cambridge, 1991, 23. Mercury, being a heavier and denser liquid than water, was also a more suitable substance for Torricelli's experiment, since it was not necessary to use long tubes that were normally required for water barometers.

34 Middleton, op. cit. (32), 25.

35 C. B. Schmitt, 'Experimental evidence for and against a void: the sixteenth-century arguments', *Isis* (1967), **58**, 363.

36 Middleton, op. cit. (32), 17.

37 Galileo talked about the 'resistance of the void' in a letter to Baliani on 6 August 1630. A. Favaro (ed.), *Le Opere di Galileo Galilei, Edizione Nazionale*, 20 vols., Florence, 1890, xiv, 127–30. He also expressed his support for the vacuum as early as in 1612 in his Venetian publication *De phenomenis in orbe Lunae*, published in ibid., iii, 350.

mathematical and mechanical demonstration to provide a quantifiable explanation of the vacuum, of its force and of why the water in a pump does not rise or fall beyond a certain point.[38]

Some of Galileo's colleagues and students meanwhile formed a slightly different point of view. For instance, Giovanni Baliani agreed on the probable existence of the vacuum, although he claimed that it could only be created with difficulty. But he also believed that the pressure on the liquid came from the weight of the air rather than the force of the void.[39] In the meantime, there were some significant contributions being made to the debate in France. According to Middleton, by 1618 Isaac Beekman had already proclaimed his belief in the elasticity, weight and compressibility of air, although he did not believe that the water pump created a vacuum.[40] Soon afterwards, Gassendi not only believed in the atmospheric pressure exerted on bodies underneath the air, but also insisted that a large vacuous space could be created in instruments such as Torricelli's. Furthermore, despite the religious controversy that corpuscularian positions brought, Gassendi openly employed the atomistic philosophies of the ancients to claim that tiny vacuous spaces existed between the particles that make up the different elements of nature.[41] Finally, René Descartes also expressed his alternative mechanistic opinion regarding the vacuum and the pressure of air. In 1631 he wrote a letter to an anonymous recipient declaring his acceptance of the notion that the pressure exerted by air sustained the level of water inside a pump. Yet he did not believe in the existence of the vacuum or any vacuous spaces between the particles of matter. Instead, he insisted that corpuscles of different sizes and densities occupied all spaces and may well be invisible to observers.[42] This is to suggest that a vacuum is not possible because the space in the water pump somehow always allowed in tiny amounts of air through the pores of the instrument or through the liquid. So Cartesian mechanists, like Aristotelians, believed that some 'subtle matter' was always in the apparent empty spaces of these tubes, including Torricelli's barometer.

This was the intellectual environment in which Torricelli entered the debate on the pressure of air and the void. The proponents of each of the varying Aristotelian, Cartesian, Gassendian and Galilean natural philosophies were asking themselves whether the vacuum could actually be created and whether it was the weight of the air that exerted pressure on the water inside the pump. Each of these groups interpreted the structure and movements of nature according to their own natural philosophical beliefs. During the early 1640s Torricelli continued to construct and interpret empirical evidence to address these natural philosophical concerns. As we shall now see, he was not only trying to support a mathematical and mechanical natural philosophy, but was also attempting to destabilize the traditional and still dominant Aristotelian view on the topic.

38 E. J. Dijksterhuis, *The Mechanization of the World Picture* (tr. C. Dikshourn), Oxford, 1969, 420–4.
39 Middleton, op. cit. (32), 9.
40 Middleton, op. cit. (32), 6.
41 Dijksterhuis, op. cit. (38), 426.
42 M. Tamny, 'Atomism and the mechanical philosophy', in *Companion to the History of Modern Science* (ed. R. C. Olby, G. N. Cantor, J. R. R. Christie and M. J. S. Hodge), London, 1990, 508.

This natural philosophical tension surrounding Torricelli's work is evident in his report of the experiment in his letter to Ricci. Before launching into a description of the barometer, he clearly declared what he believed to be the theoretical aim of the experiment and the position that he adopted in the contemporary discussions on the pressure of air. He states that the purpose of the experiment was 'not simply to produce a vacuum, but to make an instrument which might show the changes of the air, now heavier and coarser, now lighter and more subtle'.[43] He goes on to declare that this 'reasoning was confirmed by making the experiment' with two barometers, the second with a larger vacuous area. If it were the vacuum that exerted pressure on the mercury, then the liquid would stop at different heights. Since the mercury instead reached the same height in both tubes, Torricelli claimed 'that the force was not within'.[44] This went against Galileo's belief that the vacuum exerted pressure on the liquid, and instead supported Baliani's notion regarding the exertion of pressure from the ocean of air above us.[45] So Torricelli's aim is clear from the start when he declares that he had certain theoretical expectations in support of the pressure of air before having constructed the instrument.

When it came to expressing his beliefs regarding the possible creation of a vacuum, Torricelli claimed that he was showing the existence of the void inside the barometer when the water in the basin rushed towards the space in the tube. In framing the significance of this experience, he states,

> Many have said that [the vacuum] cannot happen; others that it happens, but with the repugnance of nature, and with difficulty. I really do not remember that anyone has said that it may occur with no difficulty and with no resistance from nature.[46]

In other words, Torricelli was attempting to strengthen his theory that the vacuum can be easily produced. In the process, he looked to refute both the Aristotelian claim that, since nature abhors the production of a vacuum, it simply 'cannot happen', and the opinion of Galileo and some of his followers, who regarded the vacuum as possible to produce, but 'with difficulty'. Now, despite Torricelli's opposition to Galileo on the supposed difficulty in creating a vacuum and the suggested force of the void on the limited height of the liquid, Torricelli was still insisting on an a-priori experimental approach similar to Galileo's. That is, as we have just seen from his statement that his 'reasoning was confirmed by making the experiment', he was constructing an experience that could provide a persuasive and authoritative presentation of his claim aimed against traditional Aristotelian views on the weight of air and the vacuum. Furthermore, through the construction of an instrument measuring the pressure of air, he was attempting to describe the mathematical and mechanical movements and measurements that he believed to be consistent in physics. In other words, like Galileo, Torricelli was constructing a universal experience that allowed for his mathematical beliefs to become embedded in the broader natural philosophical domain.

43 As translated by Middleton, op. cit. (32), 23.

44 Middleton, op. cit. (32), 24.

45 According to Segre, this was Torricelli's principal aim: to design 'the barometer experiment to test previous theories rather than to generate new ones'; *In the Wake of Galileo*, New Jersey, 1991, 87.

46 As translated by Grant, op. cit. (33), 23.

When it came to shaping the theoretical and natural philosophical expectations from his construction of the barometer, Torricelli was therefore calling upon the established mechanistic and anti-Aristotelian concerns of the period. He was in fact using and improving upon Galileo's natural philosophy, leaving scholastic opinion about the vacuum as his main target of criticism, and taking a mechanist view about the pressure of air as a central concern.[47] This was the natural philosophical field of contention that continued to play through the construction, interpretation and presentation of barometric experiments performed in France. During the 1640s and 1650s there was a great deal of activity, especially in Paris, as Descartes, Pecquet, Roberval and Pascal, among many others, provided further debate regarding the capability of the Torricellian tube to measure the pressure of air and whether the space in the instrument was indeed vacuous.[48]

Some may argue that this was before the advent of the experimental, fact-making philosophy. For instance, Shapin and Schaffer claim that these theoretical debates over the baromoter's function were 'a key example of scandal in natural philosophy' and how it was believed that factual knowledge was not achieved until such natural philosophical hypothesizing had been dropped from experimental research.[49] Shapin and Schaffer claim that Boyle was the first to break away from offering any philosophies of knowledge or causal enquiries and instead come up with pure experimental matters of fact regarding air pressure.[50] Furthermore, according to the cultural historians mentioned earlier, such experimental programmes were also adopted in seventeenth-century Tuscan institutions, exemplified by the Cimento, as the political and cultural advantages of supposedly neutral fact-making seemed to shift the knowledge-making landscape away from natural philosophizing.[51] As has been stated earlier and as we shall see particularly when we look at the Accademia's efforts to present their work in a theory-neutral manner in the *Saggi*, such cultural studies are crucial to our understanding of the Cimento's foundation. However, apart from these social and political linkages we shall see that natural philosophizing remained as a key concern for Galileo's followers, including the members of the Accademia del Cimento. So this case study is not an example of the triumph of the 'new' seventeenth-century experimental philosophy. Instead, once we look into the natural philosophical aims of the Tuscan academicians and their French colleagues, we may recognize the type of cognitive interests, rather than an experimental philosophy, that served as the catalyst behind the Cimento's work.

47 Adding to this field of theoretical and natural philosophical contention entangled in the construction of the barometer, Middleton believes that Torricelli even acknowledged the Cartesian point of view. Despite his belief that he had confirmed his theory by making this instument, Torricelli still seemed to note, in a sceptical tone, that it was possibile that the space in the tube only contained 'rarefied stuff', as was argued by Descartes and his followers. Middleton, op. cit. (32), 24.

48 The competing natural philosophies of these men and how those philosophies were used in their barometric studies will be discussed in the upcoming sections of this paper.

49 Shapin and Schaffer, op. cit. (9), 41–2.

50 Shapin and Schaffer, op. cit. (9), 49.

51 Tribby, op. cit. (8), 320–1; Biagioli, op. cit. (8), 30; Findlen, op. cit. (8), 39–41; Beretta, op. cit. (8), 136–7.

The academicians' mechanical understanding of the barometer: what the *Saggi* reveals

The first experiment discussed in the *Saggi* is the construction of Torricelli's barometer. The narration of the experiment is very similar to what we have already encountered in Torricelli's letter to Ricci, but our interests for the moment lie more in Magalotti's style of presentation. We have just seen Torricelli's report, where he admitted to constructing an instrument aimed at supporting his theoretical and natural philosophical concerns. In contrast to this a-priori experimentation, Magalotti gives the impression to his readers that Torricelli used an inductivist method. That is, in keeping with the experimentalist rhetoric in the preface to the *Saggi*, Magalotti now wants to make it clear that Torricelli's and the Accademia's knowledge claims concerning the pressure of air derived purely from performing the experiment. In the opening sentence, Magalotti therefore suggests that Torricelli first constructed the instrument, and then reasoned upon the cause of the mercury's movement inside the tube:

> That famous experiment with the quicksilver that in 1643 presented itself before the great intellect of Torricelli is now known in every part of Europe, as is also the high and wonderful idea that he formed about it when he began to speculate upon the reason for it.[52]

Magalotti gives the reader the impression, as he did in the Preface, that atheoretical factual knowledge is being attained purely through the use of an experimental programme. This rhetoric is seemingly supported by the air pressure and void experiments that follow the description of Torricelli's barometer in the *Saggi*, the majority of which were performed from late July 1657 until the closing months of 1658.[53] They included the repetition of some experiments performed by Torricelli himself,[54] Boyle,[55] Pascal[56] and Roberval.[57] It is important to note how Magalotti gave the impression to his readers that they performed these experiments simply to fulfil their experimentalist aim of 'testing and retesting' the notions and experiments put forward by their colleagues in other parts of Europe.[58] Indeed, although there was considerable contention amongst some of the academicians about the interpretation of the experiments and whether they actually

52 As translated by Middleton, op. cit. (1), 105,

> *E' nota ormai per ogni parte d'Europa quella famosa esperienza dell'argentovivo, che l'anno 1643 si parò davanti al grande inteletto del Torricelli; e noto parimente è l'alto e maraviglioso pensiero che egli formò di essa, quand'ei ne prese a specular la ragione.*

Magalotti, *Saggi*, op. cit. (2), 101. While Magalotti claims that the barometer was constructed in 1643, Middleton presents a very persuasive argument that it was actually almost certainly constructed in 1644. Middleton, op. cit. (32), 43.

53 These experiments were recorded in the Accademia's unpublished diary, held in the Biblioteca Nazionale Centrale di Firenze in the folio labelled Gal. 262.

54 Including placing animals inside the empty space of the barometer.

55 Although Boyle was not mentioned in the *Saggi*'s first draft, he was regularly included in the subsequent versions written by Magalotti after Boyle's writings finally reached Italy. However, it is curious why the Cimento never used Boyle's air-pump, despite their praise of his work and their testing of his claims.

56 Including the climb of the Puy-de-Dôme, actually performed by Pascal's brother-in-law, to test the difference in the height the mercury reached at different altitudes and air pressures.

57 Including several experiments with Torricelli's barometer, to test the pressure of air.

58 This approach was, of course, consistent with the Cimento's motto.

supported Torricelli's theory, Magalotti concludes in the academicians' report of their work that Torricelli's claim concerning air pressure was actually proven to be true through the sheer weight of experimental evidence. In fact, at the conclusion of his narration of these experiments concerned with air pressure, Magalotti claimed,

> Torricelli's concept of the pressure of the air on bodies beneath it now seemed well enough established by the series of experiments already described. Although it may be presumptuous and full of danger to make assertions about those things on which no lamp of Geometry shines to help our eyes, yet the presumption is never so excusable, nor the danger more certain to be avoided, than at the moment when, purely by way of many experiments all concordant, our intellect journeys to the attainment of its desire.[59]

This is a good example of how, in the presentation of the Cimento's work, Magalotti framed the construction of the Torricellean instrument within a rhetoric of experiment, dealing solely with theory-neutral artefacts, atheoretical matters of fact and a loosely articulated experimental method. Although he is prepared to report the academicians' acceptance of Torricelli's claims regarding the pressure of air, this is supposedly based purely on the acquisition of facts through experimentation. Meanwhile, the notion of nature's abhorrence of the vacuum was a cornerstone of Aristotelian natural philosophy and to publicly cast doubt on it was a certain way of creating a great deal of controversy with scholastics and ecclesiastical authorities. Since the Medici patrons of the Cimento were unwilling to threaten the doctrines associated with the Catholic Church, the acceptance of Torricelli's air pressure theory was as far as Magalotti and his editors were willing to go. That is, they would not dare to declare openly their corpuscularian beliefs regarding the causes of the mercury's movement or indeed the even more controversial anti-Aristotelian opinion that vacuum was created inside the barometer. So Magalotti concludes the presentation of the Cimento's aims with the following words: 'It has been our intention only to discuss the space filled with mercury and to understand the true cause of the wonderful balancing of its weight, intending never to pick quarrels with those who oppose the vacuum.'[60]

So in the above passages of the *Saggi*, Magalotti is fulfilling the aim he expresses in the Preface to tell about experiments with no hint of speculation. However, in what follows I pursue two arguments. First, despite the neutral style of the *Saggi*, there are strong hints in the text itself that strong natural philosophical aims and interests were present in the academicians' knowledge-making process. Second, the internal workings of the Cimento,

59 As translated by Middleton, op. cit. (1), 136–7,

> *Dalla serie delle narrate esperienze pareva oramai stabilito a bastanza il concetto del Torricelli, del premer dell'aria sopra le cose inferiori. Il che quantuque sia ardito e pieno di pericolo as asserire di quelle cose ove a' nostr'occhi alcun lampo di Geometria non risplende, pure nè l'ardire è mai sì degno di scusa, nè 'l pericolo è più sicuro a chivarsi che allora che solamente per via di molte e tutte concordi esperienze cammina nostro intelletto al conseguimento del suo desiderio.*

Magalotti, *Saggi*, op. cit. (2), 131.

60 As translated by Middleton, op. cit. (1), 109. '*Conciossiacosachè sia stato solamente nostro intento discorrere sopra lo spazio pieno d'argento, ed intendere la vera cagione del maraviglioso libramento di quel peso, con animo di non imprender mai briga con gl'impugnatori del voto.*' Magalotti, *Saggi*, op. cit. (2), 105.

as revealed in existing manuscripts and letters, show that the actual construction and interpretation of the experiments consisted of certain natural philosophical arguments competing for dominance in seventeenth-century Italy. Most of the academicians hoped that through the performance of these experiments they would be strengthening their anti-Aristotelian positions. Meanwhile, two members of the group voiced their objections to the mechanistic views of the pressure of air and the existence of the void. This indicates that far from representing a generation of new experimental philosophers in the seventeenth century, the academicians were actually still very much taking decisions and actions regarding the structure and movements of nature according to their natural philosophical aims and interests.

Finding evidence of the academicians' natural philosophical interests in the *Saggi*

One passage in the *Saggi* that hints at the academicians' natural philosophical concerns is the citation given above concluding on the certainty of air pressure 'by way of many experiments'. The reader's attention may be immediately swept away with the experimentalist rhetoric dominating this paragraph, but one may also be curious about the obvious reference to the 'danger' surrounding those assertions that do not rely on the certainty of geometrical demonstrations – 'it may be presumptuous and full of danger to make assertions about these things on which no lamp of Geometry shines to help our eyes'. It is not by chance that Magalotti made this allusion to the 'lamp of Geometry' since nearly all the academicians regarded mathematical and geometrical demonstrations as the cornerstone of their natural philosophical pursuits. Indeed, the academicians were all educated on the mechanistic example set by Galileo, Torricelli and their colleagues. This was particularly the case with Borelli and Viviani, who based their careers on the successful restoration and application of ancient geometrical and mathematical theories in opposition to Aristotelian natural philosophical beliefs. Furthermore, as we may recall from our analysis of Galileo's experimentalist image, as well as Torricelli's a-priori construction of the barometer, the academicians were performing experiments to verify certain mathematical and geometrical beliefs. What I am suggesting here is that the above-mentioned reference to the 'lamp of Geometry' may be a clue in the *Saggi* that the academicians were following the type of methodological approach we have seen in Galileo and Torricelli. That is, that they were willing to perform multiple experiments on a topic but, ultimately, those experiments were constructed simply to verify their existing mathematical and mechanical theories.

The second clue we get to the academicians' cognitive interests is early in the *Saggi*'s section on pneumatics. In fact, immediately after Magalotti gives his opening phrase regarding 'that famous experiment with the quicksilver', and before he launches into a description of Torricelli's barometer, he provides a curious insight into the corpuscular reasoning behind the notion of the pressure of air:

> When we attempt to move solid bodies … such as gravel, sand, and the like, or heaps of larger stones – they interfere with each other and pack together, thanks to the roughness and irregularities of their parts, in such a way that they hold and support each other so as to resist more strongly the force that is trying to remove them. Liquids, on the other hand – perhaps because of

> the slipperiness or the roundness of their very small corpuscles or from some other shape that may favour motion – though standing in equilibrium, yield in every direction and spread out as soon as they are pressed.[61]

For the first and last time in Magalotti's text, the reader is able to capture a glimpse of the academicians' corpuscularian natural philosophical concerns. It is evident from the above statement that they are interested in knowing the size, shape, mobility and density of the corpuscles that they believe, because of their mechanistic backgrounds, are responsible for the movement of the mercury in the barometer. Furthermore, the suggestion that matter could move 'in every direction' was clearly opposed to the Aristotelian view that all terrestrial elements moved in vertical straight lines. It is strange to find such an anti-Aristotelian statement openly expressed in the *Saggi*, and we can only assume that this paragraph somehow escaped the attention of the editors.[62] We shall now continue to see this type of natural philosophical concern entangled in the Accademia del Cimento's internal workings – their construction and interpretation of barometric experiments.

Proving the pressure and compressibility of the air

On 2 August 1657 the author of the Cimento's diary reported how the academicians began their attempts to retest the French experiments regarding the pressure of air.[63] The first of these was Roberval's construction of a barometer inside a barometer, narrated in Jean Pecquet's 1651 publication, *Experimenta nova anatomica*.[64] Pecquet claimed that after reading about this experiment, his audience 'should not continue to hold the opinion of the Ancients against the argument according to which the weight of the external air is balanced by the mercury inside'.[65] It can be clearly seen from Pecquet's

61 As translated by Middleton, op. cit. (1), 105,

> *Poichè i corpi solidi, come verbigrazia la ghiaia sarebbe, la rena e simiglievoli, o pure le macíe de'sassi maggiori, nel far forza per muovergli anzi s'incastrano e stivansi insieme, congegnandosi per sí fatto modo mercè della scabrosità e irregolarità delle lor parti, e sì serrandosi in tutta la massa loro, ch'e' s'attengono l'un l'altro e puntellansi, onde più duramente resistono alla forza che tenta smuovergli. Ma al contrario i liquori, forse per lo liscio sfuggevole o per la rotondità de'lor minimi corpicelli o per latra figura ch'e' s'abbaiano inchinevole al moto, la qual mal posi e stia'n bilico, via via che premuti sono, cedono per ogni verso e sparpagliansi.*

Magalotti, *Saggi*, op. cit. (2), 101.

62 The first draft of the *Saggi* does not contain this introductory section to the academicians' barometric studies. One may imagine that Rinaldini, an Aristotelian editor of the text and, along with Marsili, one of the two opposing voices in the Cimento to Borelli's and Viviani's mechanistic expressions, would have objected to this type of obvious reference to corpuscularianism. Indeed, as we shall soon see, these two certainly were not afraid to make their Aristotelian opinions known.

63 Gal. 262, 22v. The Cimento's diary was kept by Alessandro Segni until May 1660, when Lorenzo Magalotti replaced Segni as secretary.

64 This experiment was given the following title in the *Saggi*'s first draft: '*Esperienza riferita dal Sig. Pecquet nel libro delle sue assertazioni anatomiche a favore della pressione dell'aria nei corpi inferiori, e riscontrata nella nostra accademia nella maniera che segue.*' Abetti and Pagnini, op. cit. (3), 282.

65 As translated by Middleton, op. cit. (32), 49. Although the academicians ascribe the experiment to Roberval, Pecquet suggests that it was Adrien Auzout's invention.

words that there were some natural philosophical beliefs aimed against scholastic thought that were entangled in the construction of Roberval's experiment and in proving the pressure of air. Indeed, while we receive no more detail in the *Saggi* regarding the theoretical significance of this experience, the Cimento academicians also played upon these natural philosophical concerns in the subsequent barometric experiments.[66]

Immediately following this re-creation of Roberval's demonstration of air pressure, a determined effort was staged by the group's Aristotelians to counter the mechanist explanations of the barometer. This refers to two experiments performed by the academicians on 4 and 6 August 1657. The first proposed placing a glass jar over the barometer, supposedly keeping the full weight of the atmosphere's air away from the instrument. The second had the mercury in the vase sealed and was designed with the same intent of protecting the liquid from the surrounding air. It was assumed that if the air pressure theory were true, the mercury, under protection from the great weight of air by the glass jar, would not rise to its usual height. Interestingly, these experiments found their way into the *Saggi* under the following title: 'Experiments adduced by some people against the pressure of air'.[67]

As it turned out, the liquid rose in the enclosed barometers to its usual measurement, suggesting that the Aristotelians may have been correct in their assertion that it is not the pressure created by the weight of the air that balances the height of the column of mercury. But far from conceding this point, the mechanists in the Accademia, 'those who adhere to the doctrine of the pressure of the air' as Magalotti describes them, still claimed that 'the phenomena just recounted, far from contradicting their opinion, favoured it wonderfully' since this time the effect was believed to be caused by the compression, rather than weight, of the air.[68] This is to say that the air that remained inside the vases enclosing the barometer dilated to create the same pressurizing effect on the mercury. This is the explanation Magalotti provides in the *Saggi*, but once again we need to look deeper into the implications of these interpretations in order to understand the natural philosophical significance of these experiments.

For the first time in the *Saggi*, the reader is introduced to the notion of the elasticity and compressibility of the air. This is despite the fact that the compression of the air was mentioned in their first entry in the diary regarding barometric experiments.[69]

66 It must be noted how, in this section and in some of the following experiments, it is assumed that the vacuum exists, or at least that the space consists of extremely rarefied air. However, for the French thinkers, as well as our academicians, such assumptions, as we shall see later, still carried some very contentious natural philosophical arguments. In fact, the question of the vacuum became the main concern for these natural philosophers. According to Dear, the debate regarding the weight of the air was even of a 'secondary concern' to that of the vacuum. Dear, op. cit. (21), 189.

67 As translated by Middleton, op. cit. (1), 111, '*Apportato da alcuni contro alla pressione dell'aria*'. Magalotti, *Saggi*, op. cit. (2), 108. Although there is no direct indication of who Magalotti is referring to, we can confidently assume that 'some people' included Marsili and Rinaldini.

68 As translated by Middleton, op. cit. (1), 113, '*Ma quelli che aderivano alla pressione dell'aria, respondevano a questa esperienze con dire, che I narrati avvenimenti, anzi di contraria, favorivano mirabilmente la loro opinione.*' Magalotti, *Saggi*, op. cit. (2), 110.

69 2 August 1657: '*Si diede principio alle esperienze addotte dai Franzesi, ed altre aggiunte di nuovo nella questione della compressione dell'aria nei corpi inferiori.*' Gal. 262, 22v.

Furthermore, the compression or elasticity of the air had been used decades earlier by Beekman, Descartes, Pecquet, Torricelli and Boyle. They suggested that air was like wool that is condensed near the ground by the sheer weight of all the air above it, but somewhat more dilated at higher altitudes.[70] This was a very mechanistic notion because it strongly implied a corpuscularian structure of the universe and completely denied that any type of mystical attraction or repulsion caused the movement of the mercury, such as the Aristotelian suggestion that nature abhors the production of a vacuum and thus forces the mercury to rise in order to partly fill the tube.[71] So references to the compression of air carried with them some weighty implications against Aristotelians. Moreover, the Cimento diary, as we have just seen, hints that this mechanistic concern was precisely what was on the academicians' minds as they embarked on their reconstruction of past barometric experiments. The *Saggi* meanwhile makes no mention of these natural philosophical aims and interests.

Recreating Pascal's Puy-de-Dôme experiment

In 1648 Blaise Pascal orchestrated an experiment in which his brother-in-law, Florin Perier, climbed the Puy-de-Dôme with the barometer. As Perier ascended the mountain, he set up a barometer at different altitudes to measure whether the mercury in the tube would fall. Pascal and his brother obtained the following results: 'between the heights of the quicksilver in these two experiments, there was a difference of three inches and one-and-a-half lines'.[72] This was thus an experience not only verifying Torricelli's theory of the pressure of the air, but also obtaining a precise measurement of the height the mercury reaches at different altitudes. So the barometer was finally being used to fulfil the instrumental role that Torricelli had intended for it. According to Peter Dear, this is a crucial reflection of Pascal's natural philosophy. Through Perier's climb of the Puy-de-Dôme, Pascal was presenting a universal experience that provided standard measurements for the pressure of air at different altitudes. This was the type of supposedly secure knowledge that came from regarding the structure and movements of nature according to a mechanical and mathematical framework.[73] In other words, the construction of Pascal's experiment was based on his physical–mathematical and natural philosophical concerns. So rather than interpret this work simply as an example of how facts were experimentally contrived, Pascal was instead putting his mathematical and mechanical beliefs into practice. As we shall now see, the same may be said of the Cimento academicians when they attempted to re-create Pascal's demonstration of air pressure.

During the last weeks of September 1657, the Accademia del Cimento attempted to replicate Pascal's calculations. While the Medici court was away from Florence at the

70 Middleton, op. cit. (32), 6.

71 According to the scholastics, the rest of the instrument, the apparent empty space of the barometer, was of course said to be full of rarefied air. In contrast, mechanists argued that the vacuum too was possible because of the corpuscularian structure of air. Dear, op. cit. (21), 191.

72 As cited by Middleton, op. cit. (32), 51.

73 Dear, op. cit. (21), 193–4.

nearby town of Artiminio, it is believed that Leopoldo himself attempted observations similar to Pascal's by carrying the barometer up a hill.[74] Meanwhile, back in Florence, Borelli also retested Pascal's experiment by taking the barometer to the top 'of one of the highest towers in Florence'.[75] Both occasions were mentioned in the diary where the range in barometric readings was recorded as consistent. That is, the level of the mercury always varied in perfect proportion to the height that it was taken. As Magalotti reveals in the *Saggi*, they did witness significant variations in the readings, but these were considered to have 'occurred only because of the changes between hot and cold weather'.[76] So Magalotti concludes,

> Observations made in this way put it into the minds of some to make such an instrument serve as a very exact meter of the state of compression of the air, believing that the various heights of the cylinder of mercury ... ought to show without fail the changing pressure that it has on the stagnant surface ... , thanks to the differing heights that it has in its region.[77]

Another clue is provided in this passage from the *Saggi* that a great deal was at stake in the construction of these experiments. The range in barometric readings on both occasions was believed to support Pascal's and Torricelli's belief that the instrument provided a 'very exact meter' for the pressure of air. So the same physical–mathematical and natural philosophical concerns were present in the academicians' work as in Pascal's. We may therefore be willing to parallel Dear's story about Pascal's work with the Accademia's recordings of barometric experiments. Clearly, the mechanist academicians were not only attempting to verify Torricelli's theory of the pressure of the air, but they were also constructing their experiments according to their mathematical and mechanical natural philosophical aims and interests. Not only is there a hint of this in the *Saggi*, but Borelli and the group's mechanists were also clearly interested in promoting their work according to these cognitive backgrounds.[78]

74 The Court departed on 24 September and left the Accademia officially in suspension until 3 October. Nevertheless, their activities during this period are reported briefly in the diary manuscript. Gal. 262, 34v–35v.

75 This tower was that of the Palazzo Vecchio. Gal. 262, 35r, '*una delle più alte torri di Firenze*'. Magalotti, *Saggi*, op. cit. (2), 124. Borelli narrated this experiment in a letter to Leopoldo on 26 September 1657. Fabroni, op. cit. (11), ii, 62. According to Targioni Tozzetti, Borelli performed this experiment under the request of the Grand Duke. Targioni Tozzetti, op. cit. (11), i, 206.

76 As translated by Middleton, op. cit. (1), 130, '*che per la sola diversa temperie di caldo e di freddo accadevano*'. Magalotti, *Saggi*, op. cit. (2), 124.

77 As translated by Middleton, op. cit. (1), 130,

> *Così fatta osservazione fece animo ad alcuni d'aversi a valere d'un tale strumento per misuratore esattissimo dello stato di compressione dell'aria, credendosi che le varie altezze del cilindro d'argento ... dovessero dimostrare senz'alcun fallo il deverso premere ch'ella fa sopra il livello stragnante ... , mercè delle diverse altezze che ell'à in sua regione.*

Magalotti, *Saggi*, op. cit. (2), 124.

78 In Borelli's description of this experiment in a letter written on 26 September 1657, he was quite certain that the barometer was providing such consistent readings that eventually they 'would be able to presume the ultimate height of the atmosphere of air'. Fabroni, op. cit. (11), ii, 62. In 1670, he provided a detailed account of his readings and the proportion of the liquid's movement with regard to the elevation. G. Borelli, *De motionibus naturalibus, a gravitate pendentibus*, Bologna, 1670, 238.

Proving the existence of the vacuum in the barometer: controversy and conflict inside the Accademia del Cimento

Despite the reported certainty at having proven the pressure of the air, Magalotti was notably more cautious when dealing with the vacuum. Here, the author of the *Saggi* claims that the intentions of the academicians were 'never to pick quarrels with those who oppose the vacuum'.[79] So despite performing a number of experiments concerned with the existence of the void in Torricelli's barometer, Magalotti states, 'we do not presume to exclude from the space fire or light or ether or other very tenuous substances, either finely distributed with very small empty spaces between or filling the whole of the space that is called empty, as some would have it'.[80] There was some ambiguity surrounding the conclusiveness of vacuum experiments and there were also certainly some political reasons behind the academicians' cautious approach to this topic. But natural philosophical issues were greatly at stake in the debates over the vacuum and dominated the academicians' meetings. We have already captured a glimpse of the Accademia's natural philosophical agenda regarding air pressure and now we shall look further into their internal workings in order to appreciate how their cognitive interests remained entangled in their concern with the vacuum. The void had created a great deal of natural philosophical controversy for the French thinkers, and undoubtedly this concern was carried on by the academicians, who accommodated objections to the void from Aristotelians in the presentation of their experiments, while attempting to conceal the mechanistic agenda of the Accademia's leading contributors.

By 1648, after Perier climbed the Puy-de-Dôme with the barometer, it was widely agreed that Torricelli's instrument could successfully measure the weight of air. Nevertheless, whether the space in the tube was vacuous remained a topic of great natural philosophical controversy. As an example, the opposing camps of Aristotelians and Cartesian mechanists both provided different plenist explanations of the barometer. Aristotelians continued to believe that the air was rarefied in the tube, while Descartes claimed that the space contained 'subtle matter'.[81] In addition, the physical–mathematical practitioners also supported a mechanist agenda differing from Descartes's. So in France, at least, this issue remained unresolved by the experiments and natural philosophical arguments put forward by the likes of Roberval and Pascal, as well as by the scholastics and the Cartesian mechanists.

While Descartes's explanations may have been viable for many French thinkers, it is unlikely that he had the same authority in Italy.[82] But the same natural philosophical

79 See note 60.

80 As translated by Middleton, op. cit. (1), 109, '*Non si presume già d'escluderne o'l fuoco o la luce o l'etere o altre sottilissime sustanze le quali, o in parte con finissimo spargimento di minimi spazzi vacui, o in tutto quello spazio che si chiama voto impiendo, altri vi vogliono.*' Magalotti, *Saggi*, op. cit. (2), 105.

81 Dear, op. cit. (21), 195; Middleton, op. cit. (32), 49.

82 Despite the struggles that Cartesian natural philosophers faced in gaining acceptance during the mid- to late seventeenth century, Descartes's mechanical philosophy was not forgotten. For his supporters, the vortex theory continued to provide reason for doubting the vacuity of the Torricellian space. Just like the Aristotelian view, it could not be denied convincingly by all the barometric experiments performed at that time. Shapin and Schaffer, op. cit. (9), 86. An example of how seriously Cartesian mechanism continued to be considered in Paris, and how such natural philosophical issues did not die down with the advent of Boylean experimental

issues were still at stake for the Italians. Middleton argues that while Torricelli may not have totally discounted Descartes's 'subtle matter', his tone in his correspondence seems not to be too convinced by it.[83] Similarly, the academicians never showed much respect for Descartes's natural philosophy. In fact, in July 1660, Magalotti wrote to Ricci, criticizing the Cartesian stance against the void.[84] The problem for Descartes, according to Desmond Clarke, was that he could not provide convincing mathematical calculations for his 'subtle matter'. In other words, Descartes's metaphysical foundations for natural philosophizing may not have seemed adequate for those who demanded more mathematical and geometrical demonstrations. Descartes and his followers, such as Rohault, argued that if the liquid were rising in abhorrence of the void, as Aristotelians claimed, then it would continue to fill the length of the tube, meaning that the pressure of air did indeed regulate the height of the column of mercury. But Cartesian theories about matter and extension demanded that some 'subtle matter' had to be completely filling the space. It therefore followed that that matter had to be lighter than the atmospheric air supporting the mercury. This meant that Descartes and his followers had to hypothesize about the 'heaviness' of the matter, when the only tools they had for characterizing nature's properties referred to proportions among primary qualities usually sought by mechanists, such as size, shape, density or mobility. Therefore, for Tuscany's seventeenth-century thinkers who were educated and trained on a diet of mathematics, geometry and mechanics, Cartesian physics, despite its application of corpuscularian principles, may not have seemed like an adequate philosophy for understanding the apparent vacuum in the barometer.

So the Accademia was left with the two opposing camps of Aristotelians and Galilean mechanists. Viviani and Borelli, both corpuscularians and firm believers in the vacuist theory, argued in their correspondence and in the Accademia's manuscripts that the results from their barometric experiments complied with their natural philosophical beliefs. Borelli in particular strenuously contended that from the movement of the liquid in the Torricellian barometer, and from the mathematical, geometrical and mechanical principles taught to them by the ancient authors, the space had to be vacuous. In the meantime, Rinaldini and Marsili remained unconvinced by mechanical explanations regarding the cause of the mercury's movement in the tube and the description of the space in the barometer as vacuous. They were determined to defend the Aristotelian view which maintained the plenist argument that nature simply abhorred the production of a vacuum and that the space remained full of air – no experiment, they argued, could prove otherwise.[85]

philosophy, was the work by Jacques Rohault who introduced Cartesian principles to those who attended his weekly meetings and then provided experimental evidence in support of those principles. Desmond Clarke provides an excellent account of how Rohault and others in late seventeenth-century Paris continued to disseminate Cartesian natural philosophy after his death. Clarke, op. cit. (22), 18.

83 Middleton, op. cit. (32), 25.

84 Fabroni, op. cit. (11), i, 88. Borelli was also quite critical of Cartesian natural philosophy throughout most of his career, despite adopting physiological theories actually quite similar to Descartes's. Galluzzi, op. cit. (12), 346.

85 Galluzzi, op. cit. (12), 807–8.

Rinaldini and Marsili put forward arguments that give good reason to believe that Magalotti was referring to these two members of the Accademia when he mentioned 'those people' to have come up with some experiments in opposition to the notion of the pressure of the air. Our argument therefore now turns to the primary sources regarding the Accademia del Cimento's cognitive interests and conflicts. These are the sources that are not mentioned in the recent literature concerned with the cultural history of early modern Tuscan natural philosophy, but it is important to note that most of the arguments put forward in the following section of this paper were discussed by Paolo Galluzzi as early as 1981. Galluzzi cites from the academicians' letters and manuscripts to show how conflicting 'principles' were heavily involved in their barometric experiments. Furthermore, it will be argued that the Accademia's members contended about the interpretation of the experiments according to the contrasting natural philosophical positions of that time.

The difference in natural philosophical approach inside the Cimento came to the surface as the experiments on air pressure and the void were being carried out. Viviani and Borelli found themselves confronting the peripatetic arguments of the only two Aristotelians in the group, Marsili and Rinaldini. The first clear sign of this conflict comes from Borelli's letters to Paolo del Buono and Viviani during the last three months of 1657. As an indication of how entangled natural philosophical interests were in the academicians' internal workings, it took Borelli no more than one year in Tuscany, and only some three months collaborating with fellow academicians, to show his frustration with the group's Aristotelian sympathizers. Since late July of that year the academicians had been occupying much of their time with barometric experiments and by September they had retested Pascal's demonstration of air pressure on two occasions, a culminating point in their support for Torricelli's theory. They even rejected the attempts in August to disprove experimentally the pressure of air. Yet this was still not enough evidence for Marsili and Rinaldini to abandon their Aristotelian interests and in a letter to Paolo del Buono written on 10 October, Borelli showed his frustration with the slow productivity of the Accademia caused by one of the group's Aristotelians:

> Regarding our Accademia, which you call lycée, I wish that the laws that you imagine were in place; but the unfortunate thing is that all that is found is disorder; and this is because of the ambitions of one of the academicians, a rotten and mouldy peripatetic, who wants to appear in the gowns of a free and sincere philosopher ... I have a very great desire for these few days of October to pass quickly so that I may return to Pisa, and there occupy my time advancing the studies of my liking.[86]

86 My translation.

> *Intorno alla nostra Accademia, che Ella chiama Liceo, vorrei che in essa avessero luogo le Leggi da VS immaginate; ma il male è che solamente vi si trovano I disordini; e questo dipende dalla troppa ambizione di alcuno degli Accademici, il quale essendo Peripatetcio marcio e muffo, vuol comparire con una toga tolta in prestito di Filosofo libero e sincero ... sto con grandissimo desiderio che passino presto questi pochi giorni d'Ottobre, per andermene a Pisa, e quivi occupare il tempo che mi avanzerà, in studi di mio gusto.*

As cited by Targioni Tozzetti, op. cit. (11), ii, 440; Fabroni, op. cit. (11), i, 94.

There is little doubt from this letter that Borelli's frustration was aimed at the persistent Aristotelian opposition coming from one of the members of the Cimento. So the conflicting arguments of natural philosophy entangled in the academicians' experiments were now taking their toll on Borelli's patience, one of Italy's leading mechanists and critics of Aristotelianism. The participation of scholastic natural philosophers, according to Borelli, did not allow for the Accademia's progress, and he confided his frustrations to fellow moderns in the group, including del Buono and later Viviani.

On 28 December Borelli wrote to Viviani stating that the peripatetics in the group were 'denying the compression of the air on the mercury, something which should by now be admitted by any stubborn mind'.[87] Clearly, the opposition from Marsili and Rinaldini was quite determined and these natural philosophical concerns were continually playing through the minds of the academicians as they constructed and interpreted their air pressure and void experiments. Perhaps the strongest piece of evidence demonstrating this contentious natural philosophical culture entangled with the Cimento's activities is Borelli's statement, 'one cannot expect any profit whatsoever, nor can we ever walk together in agreement along the path of philosophical speculation, when we are so opposed in our very principles'.[88] This is the primary evidence that Galluzzi also refers to when discussing the academicians' competing principles: 'confrontation inside the Accademia between Aristotelians and innovators'.[89] Therefore, in a blow against historiographies discussing the rise of an atheoretical experimental philosophy inside the Accademia del Cimento, Borelli is saying not only that natural philosophical speculations were a crucial part of the academicians' work under Medici patronage, but also that they contended the significance of their experiments according to those competing natural philosophical interests.

Editing the *Saggi*

Regardless of the pressure from their peers inside the Cimento no longer to debate the mechanical and corpuscularian principles that were considered by many to be responsible for the movement of the mercury inside the barometer, Marsili and Rinaldini continued with their Aristotelian stance against the pressure of air and the void. In other words, they did not admit that which Borelli saw as obvious to 'any stubborn mind' and they continued with the 'philosophical speculation' that had so annoyed Borelli. This is evident in Rinaldini's correspondence with Viviani in January 1658, when he provides further Aristotelian explanations for the mercury's movement inside the barometer.[90] Rinaldini was to participate in this debate once again when the academicians began preparing their work for publication. Meanwhile, on 13 August 1660, Marsili again

87 My translation; '*negando la compressione dell'aria sopra l'argento vivo, cosa che a quest'hora dovrebbe essere ammessa da qualsivoglia ostinato cervello*'. Gal. 283, 37r; Galluzzi, op. cit. (12), 807.

88 My translation; '*non si può sperare frutto nessuno, ne possiamo mai camminare d'accordo nel corso delle speculazioni filosofiche quando siamo tanto contrari ne'principi stessi*' Gal. 283, 27v; Galluzzi, op. cit. (12), 807.

89 Galluzzi, op. cit. (12), 807.

90 Gal. 283, 41r. Galluzzi, op. cit. (12), 808.

suggested an experiment designed to be sure if the space in the barometer was not full of 'the evaporation [of very thin humour] from the mercury itself'.[91] At one stage this experiment was to be included in the *Saggi*, since it was present in Magalotti's draft of the text.[92] However, as Middleton suggests, the clumsy design of this instrument eventually led to its exclusion from publication.[93] Furthermore, considering the contentious aim of this experiment – to disprove the air pressure and vacuum theory with the Aristotelian suggestion that there were vaporous exhalations from the mercury in the tube – we may also have reason to believe that the *Saggi*'s mechanist editors would not have favoured its publication, regardless of its efficacy. Therefore natural philosophical contention was entangled in the construction, interpretation and presentation of this experiment.

The reporting of this and the other experiments underwent a rigorous editing process that continued to involve the competing natural philosophical interests of the academicians' mechanists and Aristotelians. By 1660 there were already discussions about the publication of the Cimento's experiments, and in 1662 the academicians finally got the writing process under way. In the Accademia's diary entry for 31 July of that year, it is recorded that the academicians met at Lorenzo Magalotti's house to repeat some of the experiments that they intended to include in the *Saggi*.[94] It is also mentioned in this entry that they were required to repeat the selected experiments in front of the Prince. As Magalotti went about the task of compiling the text, Leopoldo continued to supervise every move that was made. The Medici prince insisted that Magalotti consult Michelangelo Ricci in Rome on the appropriate literary style. Magalotti's drafts also had to pass through the hands of Cardinal Pallavicini in Rome, an authority on Tuscan language. This was in addition to the reviews given of the text on two occasions by three ecclesiastical censors. Furthermore, Magalotti was required to have his work edited by Borelli, Viviani and Rinaldini.

Clearly, then, following five years of natural philosophical concerns and contention entangled in the construction of the academicians' experiments, Leopoldo, as Middleton notes, was assuming 'control over the contents of the proposed book'.[95] His wish was obviously to avoid any political and religious controversy by providing a text that would be free of potentially dangerous speculations. Another reason for the Accademia's attempt to keep clear of any controversial theorizing in the *Saggi* may well be because of Leopoldo's and the academicians' search for social legitimation in the Tuscan and European royal courts that seemed to sponsor factual, experimental knowledge production. In any case, these cultural, religious and political circumstances undoubtedly were part of the academicians' compilation of the *Saggi*. This would begin to explain why a supposedly safer experimentalist rhetoric was adopted in the text. Moreover, it justifies the interests shown by cultural historians in the Cimento and its Medici patronage.[96]

91 Gal. 262, 104v–105r.

92 Abetti and Pagnini, op. cit. (2), 305–6.

93 Middleton, op. cit. (1), 266–7.

94 Gal. 262, 132r–v.

95 Middleton, op. cit. (1), 67.

96 Historians provide varying opinions about why Leopoldo preferred this atheoretical approach. Some exclude seventeenth-century concerns about religion. Galluzzi claims that Leopoldo simply had a choice between presenting the academicians' theories and simply reporting physical phenomena. According to

However, these were not all the issues at stake for these so-called experimentalists. It must be made clear that this intense participation of the prince is evident mainly during the second half of the Cimento's existence when they began their plans for the presentation of the experiments. Furthermore, during the editing process the academicians continued to voice their natural philosophical opinions. What is of interest here to our study about the natural philosophical conflict which was entangled in the academicians' construction, interpretation and presentation of experiments, is the comments made by Borelli, Viviani and, particularly, Rinaldini, in response to Magalotti's rhetorical framing of the experiments.[97]

On several occasions, Rinaldini reminds Magalotti of the Accademia's policy simply to narrate the experiments, without 'defending one opinion or the other'.[98] Rinaldini insists that they should not discount the opinions of those 'who would never believe that nature could allow a void, but instead always abhors it'.[99] Finally, his most stringent criticism comes when he objects to the conclusions arrived at from four experiments 'showing the various changes that occur in the natural state of compression of the air'.[100] On this occasion, four differently shaped barometers were prepared at the base and at the top of a tower, and on every occasion the level of the mercury was seen to vary, according to the *Saggi*, because of the ratio between the pressure of the air at the two different altitudes.[101] Rinaldini's response to this experiment and its proposed presentation in the *Saggi* was recorded as follows: 'I know that I have experienced otherwise, since with a similar instrument, having repeated the experience diligently many times at the foot and at the top of Pisa's bell tower, I have not had the fortune of reaching a conclusion.'[102] This shows, once again, how the significance of these experiments was judged according to the conflicting natural philosophical agenda between the Aristotelians and the mechanists in the Accademia.

Most of Rinaldini's objections failed to make any difference to the ultimate structure and wording of the *Saggi*. However, Magalotti's work remained true to the Accademia's 'no theorizing' policy. While the mechanist position adopted by the majority of the

Galluzzi, Leopoldo chose the latter because it meant performing a more Galilean task. Galluzzi, op. cit. (12), 802–3. Similarly, Segre suggests that rather than fear the Inquisition, the academicians simply wished to present their work as belonging to a controversy-free universal experimental philosophy. Segre, op. cit. (45), 140. Finally, Beretta curiously suggests that Leopoldo's choice to use an experimental rhetoric was simply 'fortunate intuition' rather than religious concern. Beretta, op. cit. (8), 137. In any case, I do not believe we can ignore the volatile religious climate of the Counter-Reformation, and the fact that Galileo's condemnation by the Catholic Church had only been thirty years before the academicians began their publication. It is also worth noting that one of the most controversial fields studied by the academicians, astronomy, was excluded from the *Saggi*.

97 The *Saggi*'s draft and the editorial comments have been published by Abetti and Pagnini, op. cit. (2), 272–347

98 My translation; '*non per difendere un'opinione o un'altra*', Abetti and Pagnini, op. cit. (2), 339.

99 My translation; '*che mai credettero la natura essere in qualunque caso consentiente al voto, ma più tosto aver quello sempre in aborrimento.*' Abetti and Pagnini, op. cit. (2), 337.

100 As translated by Middleton, op. cit. (1), 131. '*Descrizione degli strumenti demostratori delle varie mutazioni che accaggiono nello stato di natural compressione dell'aria*'. Magalotti, *Saggi*, op. cit. (2), 125.

101 Magalotti, *Saggi*, op. cit. (2), 125–30.

102 My translation. '*So bene che a me è successa altrimenti, perciò che con simile strumento, avendo reiterato l'esperienza più volte diligentissimamente a piè et a cima del campanil di Pisa, non ho avuto fortuna di cavarne alcun frutto.*' Abetti and Pagnini, op. cit. (2), 341.

academicians was often implied in the publication, none of the conceptual arguments that were captured in the Accademia's manuscripts and in the members' letters were recorded in the text. Nevertheless, looking beyond the *Saggi*'s experimental rhetoric, the group's knowledge-making process was entangled with the competitive natural philosophical environment of the period.

Conclusion

The Accademia del Cimento has attracted the interest of writers since the eighteenth century, when Giovanni Batista Clemente Nelli and Giovanni Targioni Tozzetti began compiling a history of Tuscan natural philosophy, including the rise of experimentalism under Ferdinando's and Leopoldo's patronage.[103] In the late nineteenth and early twentieth centuries, historians such as Abetti and Pagnini were responsible for reviving interest in the value of the Galilean manuscripts, and while their work in this area now provides us with some valuable material with which to analyse the details of the Accademia's foundations and workings, these authors did not examine the Cimento's activities beyond the experimental rhetoric posed by Leopoldo and Magalotti.

Today the Accademia continues to draw the attention of early modern historians, emphasizing the study of the social conditions that formed the rise of experimentalism. Biagioli and Beretta, for instance, argue that the key to understanding the Accademia's activities is in the manner in which experimentally produced 'matters of fact' were legitimated within the Tuscan court's etiquettes of gentlemanly behaviour. Jay Tribby and Paula Findlen support this argument by outlining the gentlemanly etiquettes which guided the activities of thinkers under Medici employment – much like the courtly life described by sixteenth-century humanist author Baldassare Castiglione, in *The Book of the Courtier*.[104] Clearly, there were strong religious and political issues surrounding the Accademia's foundations and their publication. Indeed the factual reporting of experiments and the presentation of an institution free from internal divisions and theoretical speculations provided the Medici family with an opportunity to propel the court's status as a sponsor of such efficient natural philosophical work. Furthermore, they avoided conflicts with the Catholic Church.

However, while we can be grateful to these authors for sparking interest in the Accademia del Cimento, and providing excellent accounts of the importance of the experimental philosophy to the cultural, political and religious interests of the Accademia's royal patrons, I suggest that we develop our studies of this institution by identifying the natural philosophical interests of its members. As we have seen from the Accademia's diary, and from the commentary by academicians in the *Saggi*'s draft and in letters, the natural philosophical interests of the academicians was a dominant force in their thinking and in the directions they chose to take their work. This primary material has helped us to identify the Accademia's internal conflict, and how the academicians

103 G. B. C. Nelli, *Saggio di storia letteraria fiorentina del secolo XVII*, Lucca, 1759; Targioni Tozzetti, op. cit. (11).

104 Tribby, op. cit. (8), 324; Findlen, op. cit. (8), 47.

maintained their natural philosophical positions during the writing and editing of the *Saggi*. Furthermore, we have seen hints of these cognitive and disciplinary interests in the Accademia's publication and we recognize them to have come from the strong natural philosophical backgrounds of the Accademia's members.

The presence of Aristotelians Marsili and Rinaldini in the group created a conflict of natural philosophical concerns between these two on the one hand, and the group's most outspoken mechanists, particularly Borelli, on the other. This conflict represented the cognitive and disciplinary interests that dominated the intellectual landscape during the seventeenth century. Therefore, when looking at the Accademia's process of knowledge-making, it is hoped that future studies will consider how important natural philosophical issues were to the academicians' construction, interpretation and presentation of experimental knowledge claims. The Accademia del Cimento performed many experiments in a variety of fields. A close study of their intellectual aims and conflicts in each of these fields should help us to understand that although certain political, religious and cultural issues of the time encouraged the use of experimental rhetoric, it is not plausible to believe that the Florentine natural philosophers simply witnessed the origins of a new atheoretical experimental science. Instead our academicians continued to pursue the cognitive and disciplinary interests that had dominated natural philosophizing in the seventeenth century.