A physiological challenge to qualitative philosophies: the weighty matter of insensible substance

Harold J. Cook
Brown University, harold_cook@brown.edu

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The title of the book at hand might suggest a study of the work of a secondary early modern medical author and the more famous figures who read and quoted from him. But it makes a case for something much more ambitious, hinted at in the sub-title: restoring Santorio to the first rank of importance as an early advocate of the corpuscularian and experimental philosophy. Santorio was among the first to demonstrate how it was possible to draw rigorous conclusions about subtle but consistent physical changes in bodies by the use of instruments that could record and track events imperceptible to the human senses alone, which in turn gave clear evidence of matter as prior to qualities. Santorio is often taken to have borrowed much of his natural philosophy from Galileo, but the reverse would be closer to the truth. The contributions to this volume add up to a powerful case for recognizing the novelty and significance of Santorio's work and of the esteem in which his work was held by later advocates of experimental medicine. And yet, because Santorio often presented his views in the form of aphorisms, questions remain about what he really meant to say: did he mean his readers to discern a radical innovator or a reformer working to improve Galenic orthodoxy? The form, content, and context of his work all invite further exploration.

As many readers of this journal will know, Santorio has been mostly overlooked in accounts of medicine and science during the past few decades. An acquaintance of Galileo, when considered at all he was commonly seen as following the example of the more famous figure. Within the history of medicine his publications did not fit easily into narratives of

developments in anatomy and physiology, or the history of diseases, chemistry, surgery, or pharmacy. His name was mainly associated with the constant weighing of himself and everything that went into or came out of his body in order to show that some sort of insensible perspiration also needed to be accounted for: an amusing anecdote about an age that did not have the chemical and biological methods to properly explore metabolism. A couple of decades ago Santorio caught the attention of a scholar of eighteenth-century medical culture, Lucia Dacome, although until recently scholars of his own period continued to keep their distance. Then roughly half a decade ago, when studying controversies among Galenic philosophies of the late Renaissance, Fabrizio Bigotti obtained a research fellowship at the University of Exeter to work with Jonathan Barry and saw in Santorio's work an example of the medically-orientated natural philosophy of the day, grasping the significance of his quantitative investigations in support of a form of corpuscularianism. Bigotti's important study of 2019, *Physiology of the Soul*,[1] included some of his findings on Santorio. He and Barry spell them out more thoroughly here, and a number of other scholars follow their lead by taking up the various ways in which Santorio made a difference to those who came in his wake.

The two editors' main claims are set out clearly in a jointly-authored first chapter and Bigotti's independent contribution on Santorio's corpuscularian and experimental natural philosophy. (These two chapters are available in an open access form on the publisher's website.) The introduction begins by dealing with problems with the prevailing view that Santorio should be read in light of Galileo's mechanics, giving the medical professor an independent precedence based on the evidence of his life, times, and works. They lay out what is known about Santorio's biography, show that he and Galileo moved in overlapping circles of acquaintance but kept their distance from one another; make a case for recognizing him for inventing instruments for experimental investigation, clinical use, and surgical intervention; and conclude that Santorio promoted a "fully fletched programme of quantification" for understanding the life of the body, substituting quantifiable physiological processes for qualities and faculties. They also make the convincing case that Galileo's famous interpretations of the pendulum were inspired by Santorio's use of the *pulsilogium* to measure beats of the pulse, and that he also first invented the thermometer despite Galileo's claim to priority. Such examples allow them to distinguish Galileo's self-promoting behavior from Santorio's, who "was instead a patrician, reserved and not inclined to direct polemics: each criticism he levels either at Galen or at Aristotle is always pondered with great care and against a precise target. The overthrow of medicine as a whole was of no appeal to him although – as the Obizzi controversy reveals – it was clear to those who understood the essence of Santorio's methods that these had the capacity to revolutionise it" (33). Santorio argued that his methods were unknown to the ancients and yet that he was not trying to establish a com-

[1] Bigotti, *Physiology of the Soul*.

pletely new medicine, since the consequences of his studies would not necessarily apply to all medical methods. After the authors go on to describe the instruments he invented for quantifying various phenomena, the rest of the volume digs more deeply into Santorio's philosophy and those of others who grappled with the implications of his work.

Bigotti's own contribution carefully takes the reader through Santorio's arguments so as to show how his "fully fleshed programme of quantification and measurement" engaged with some of the most powerful views of the day, transforming the occult qualities of Galenic medicine into manifest qualities that flow from elemental substances. He places Santorio among the "Aristotelian corpuscularians" – Christoph Lüthy's term – such as Italian physician-philosophers of the early sixteenth century like Girolamo Fracastoro and Julius Caesar Scaliger. Santorio's own theoretical contribution to this lineage, Bigotti argues, anticipated "aspects and trends that are pivotal to the understanding of early modern mechanical philosophy in its attempt to mathematize nature by developing new theoretical and technological tools" (66). A Venetian patrician, Santorio's earliest interests in the new approach were stimulated by his teacher, Jacopo Zabarella, and by Paolo Sarpi, who advocated the reduction of qualities to "position, figure, and number". (Sarpi not only pushed for the building of the famous anatomy theater in Padua but conducted many experiments of his own in medicine, optics, alchemy, distillation, and mechanics.) By 1612 Santorio had even developed Sarpi-like views about clockwork mechanism as an explanation for contagion, and by the mid-1620s he had drafted a now-lost work with fine engravings of medical instruments that also discussed the nature of the void. One of the chief implications of such views was the ability to rid medical theory of "occult" qualities, including those of "the whole substance", which Santorio considered unintelligible. Quantity preceded quality. Physical substances possessed weight, for instance, allowing measurement of otherwise indiscernible presence and absence, as in the proof of insensible perspiration. He could dispense with faculties, humors, and other immaterial active properties that were taken for granted in medical and natural philosophy. While Bigotti argues that Santorio presented his work as bringing Aristotelian and Galenic assumptions up to date, later readers seized on it as a foundational move in the establishment of the "new and experimental philosophy".

Twelve further studies follow. Four of them look deeply into the natural philosophy of Santorio by exploring responses to his work among his immediate contemporaries. Fabiola Zurlini describes the attack on Santorio by Ippolito Obizzi, a physician and astrologer from Ferrara, who understood Santorio's *Medicina statica* (1614) to be offering a radical attack on the very foundations of Galenic medicine and went into print immediately to refute him; an account of the objections of Leonardo Di Capua in 1681 to Santorio as an exemplar of *mathematica medica* further supports the point. William Newman examines the objections of Daniel Sennert to Santorio's attempt to make occult qualities physically manifest, even though Sennert himself had openly adopted Democritean atomism in

1619. Newman sees the difference as one of mathematical or mechanical corpuscularianism versus "chymical atomism", the latter being a philosophical lineage that Newman himself has excavated with great clarity, and in which he places Sennert's approach (rather than Santorio's) as prefiguring "the modern chemical atom". Elisabeth Moreau also takes up Sennert, along with Isaac Beeckman, to explore how neo-atomism was explored in medical discussions of temperament in the early seventeenth century. She finds that in contrast to the views of the first two, Santorio never mentioned atoms or atomist philosophers and instead offered an account "of material shape, position, and number [that] was inspired from the matter theory of the Venetian theologian Paolo Sarpi" (155). Fabrizio Baldassarri goes on to examine the possible effects of Santorio's views on theories of the passions presented by Henricus Regius – a "former disciple of Santorio" – and René Descartes, who also had a "disciple" in Regius. He sees in the *Medicina statica* a quantitative approach to the analysis of the passions. In their two later works on the passions Regius and Descartes also treat mind-body as a composite. But Baldassarri's careful examination sees how Regius "advanced a theory of soul pertinent to Paduan Averroism and consistent with his medical pragmatism" (166) whereas Descartes substituted his own metaphysical foundation; both were therefore "complementary" approaches to Santorio's proposition rather than simple derivations of it.

The last group of eight contributions examines how Santorio's work continued to prompt productive responses from scholars in later years. Andreas Blank takes up Leibniz's understanding of Santorio as offering a view of the mind-body composite as emergent from a "kernel of substance" that retains its identity despite the effluvia of insensible perspiration, hence holding out the possibility of immortality. In this proposition Blank sees Leibniz to have simply deeply misunderstood Santorio's view of how new causal powers emerge from material composites. Vivian Nutton and Silvana D'Alessio co-author an account of the aphorisms Santorio wrote after the Venetian plague of 1630-31 and their effect on the work of Neapolitan Geronimo Gatta two decades later. Salvatore Ricciardo points to the inspiration Robert Boyle took from Santorio even as he circumscribed the application of mathematics for interpreting physical experiments. Fabio Zampieri uncovers the debt owed by the iatrochemist Giovanni Alfonso Borelli to Santorio, particularly in his understanding of fevers. Luca Tonetti does the same for Giorgio Baglivi's *Canones*, seeing how in his grappling with Santorio's work Baglivi was able to coherently join Hippocratic clinical empiricism with deductive theory in his "fibrous" concepts of bodily substance and *statica mentis*. Ruben Verwaal explores the writings of the early eighteenth-century Johannes de Gorter to show how Santorio's theory of insensible perspiration could provide a foundation for the new physiology and pathology of the nervous system that was gaining acceptance. Luciana Costa Lima Thomaz takes up the admiration of Linnaeus and his mentor Boerhaave for Santorio's dietetics, a part of Linnaeus's own medical concerns that is often overlooked. Lima Thomaz also shows

that Linnaeus imitated Santorio's aphoristic method as well. In the final contribution Francesca Antonelli explores the model of Santorio's use of experimental physical instruments in the development of the chemical methods of Lavoisier and his assistant, Armand Séguin, although at the same time they criticized his ignorance of the chemistry of gases, the pneumatic chemistry of their own efforts that established a fresh understanding of metabolism.

As an excavation of the views of a sadly neglected figure of early modern medicine and natural philosophy, and of the example he set for others, this collection of essays will be indispensable. The history of ideas remains fundamental to histories of early modern knowledge. One of the important interpretative moves of the recent generation of historians has been the addition of attention to the practices employed by one or more persons in establishing their claims, and in their introduction Barry and Bigotti emphasize the innovative instruments and methods employed by Santorio. But given that his working notes have disappeared (unlike those of contemporaries like Galileo or Kepler), the editors have to fall back onto his published findings and argumentative positions rather than exploring the experimental practices in which he clearly invested considerable care. Little is known about his medical practice, either, although given the substantial wealth Santorio acquired during his lifetime he clearly had a reputation for clinical ability among a sizeable group in Venice. The rest of the contributors, who approach Santorio and his legacy from the persons and places they know best, understandably focus on the views he presented in his publications that were praised or contested by other authors. Overall, a powerful case is made for setting Santorio among the first rank of the Moderns once again.

In fact, Santorio himself self-identified as a Modern, or at least as one of the Venetian "youngsters", the anti-papal and anti-Spanish *giovani.* That sets him among patricians with an agenda, opening up other avenues for interpreting his work, too. Nick Wilding's study of Galileo's good friend from among the *giovani*, Sagredo – a member of the government and a dealer in magnetic ores among other things – points the way toward comprehending his time and place.[2] Many of the biographical details carefully checked by Bigotti and presented in the first chapter describe a heady moment. In 1561 Santorio was born into a family descended on his mother's side from nobility and on his father's side from Friuli lawyers and notaries high ranking enough to exhibit a coat of arms. They moved to Capodistria (just south of Trieste in today's Slovenia) when Antonio was appointed to the important administrative post of head bombardier and "keeper in chief" of munitions for the republic. He was clearly skilled as well as knowledgeable since the position required him to teach mathematically-intensive military engineering and to test various kinds of substances for their material quality. The Santori family were also close to the powerful Morosini patricians, in whose lodgings Santorio received his early education. He became

2 Wilding, *Galileo's Idol*.

a regular member of a sub-set of the *Ridotto Morosini*, a gathering of the Venetian elite where politics, religion, and natural philosophy were among the topics under discussion. Through the Morosini he also became close to Nicolò Contarini, a powerfully innovative statesman and philosopher who at the end of his life ruled the Republic as Doge. (An older member of the clan, Giacomo Contarini, had become known as a collector of mathematical instruments.) He also moved in the humanist circle around Gian Vincenzo Pinelli, who introduced him to Paolo Sarpi. At Padua, where Santorio graduated in philosophy and medicine, among his teachers were Girolamo Mercuriale, best known for his *De arte gymnastica*, and Jacopo Zabarella, known as a humanist philosopher who pushed Aristotelianism in an empirical direction. Santorio was probably conducting his famous weighing experiments on himself from the mid-1580s. In the later 1580s the authorities recommended him on behalf of the university to serve as a physician to a Polish prince (exactly who is disputed), but he returned to the city around 1594. His first publication, *Methodi vitandorum errorum* (1603), offered an approach to certainty in clinical cases on the basis of individuals being composed of universal properties that can be discerned through the use of instruments such as his *pulsilogium*. Due to Sarpi's good offices Santorio gained the appointment as physician to the Convent of Servites in the early 1600s, too.

Santorio's connection with Sarpi is worth pausing over, since Sarpi's views are well known and important.[3] As Barry and Bigotti note, Sarpi's clockwork-like view that bodies can be explained by "position, figure, and number" was a foundation for Santorio's experimental method. This was not far from Augustine's approval of a passage in the Book of Wisdom that says "God has ordered all things *in mensura, et numero, et pondere"* (Wisdom 11.21). For figures like Sarpi, it was therefore pointless to disentangle a natural philosophy from his political and religious positions. Sarpi was absolutely clear about defending the rule of law as superior to loyalty to persons, and his opinions of the papacy were in keeping with such principles, as his only publication, the *Istoria del Concilio Tridentino* (1619), would clearly state. Some, including the utopian philosopher Tommaso Campanella, considered Sarpi to be an atheist.[4] Modern historians have sometimes agreed, favorably.[5] A more moderate line treats him as a believer "whose religio-political ideals were essentially in line with those of St. Paul, St. Augustine and sixteenth-century reformers (both Protestant and Catholic). For Sarpi, there was no difference between serving the senate of Venice and serving God".[6] Moreover, his views about an omnipotent God compared to the ignorant pride of humans who think they can know the ineffable clearly had natural

3 Because I have not studied Fra' Paolo Sarpi, the current paragraph is not meant to be current or conclusive but simply indicative of how the breadth of Sarpi's interests points to the range and depth of the patrician milieu of the time.

4 Ernst, *Tommaso Campanella*, 26.

5 Wootton, *Paolo Sarpi*.

6 Kainulainen, *Paolo Sarpi*, 1-2.

philosophical implications. Sarpi had become a Copernican as early as 1592 and by 1595 produced a theory of the tides compatible with what Galileo later set out under his own name.[7] In that period he also helped to organize the building of the permanent anatomy theater in Padua. In 1601 the papal nuncio accused Sarpi of having denied the immortality of the soul and controverted the authority of Aristotle. More generally, his naturalism held that existence emerges from substance, and "qualities are nothing but quantities", so that "essence and universality are works of the mind" that humans are prone to elaborate imaginatively, requiring the constraints offered by mathematics to demonstrate the truth.[8]

Building a robust consensus about naturally lawful phenomena held out the possibility of a Republic in which all could participate lawfully in civil society without regard to personal conscience. It was a programme that suited urban magistrates and would also suit the needs of empires and states. Chandra Mukerji has termed that kind of naturalized state activity as "impersonal rule".[9] But while the polity framed in terms of natural law might imply a natural theology in which Creation did not respond to personal prayer, the polity in turn promised bodily well-being for its members, soon identifying measures of collective improvement of populations in the language of political arithmetic and physiocracy.[10] For persons, "mind" was also naturalized in studies of the embodied passions, as indicated in Baldassarri's essay on the echoes of Santorio's mind-body composite in the works of Regius and Descartes.[11] Did Santorio see his analysis of living composites as providing a proven path for the members of La Serenissima to remain healthy and live long, thereby supplementing the naturalized politics of Sarpi and at least some of the *giovani*?

Santorio not only came of age in the same intellectual circles as Sarpi, he also supported Sarpi's leadership of Venice's successful defiance of the papal interdict of 1606-7. Following the attempted assassination of his friend by papal agents a few months after the lifting of the interdict he rushed to Sarpi's aid from his nearby residence. He also became known as a friend of the English ambassador Sir Henry Wotton (who was aiding the anti-Jesuit party) while Fulgenzio Manfredi, an informant for the Roman Curia, reported that Santorio read prohibited books and had acquaintances among heretics. In 1611, with the likes of Sarpi, Morosini, and Contarini on his side Santorio nevertheless gained the chair in theoretical medicine at Padua, from where he published new work, including the *Medicina statica*. He served as the first President of the *Collegio Veneto* (1616-18, and again in 1622-24), meant to create a path for the awarding of doctoral degrees without the

7 Naylor, "Paolo Sarpi …", *British Journal of the History of Science*, 47 (2014): 661-675.

8 This summary of Sarpi's position comes from the paeon to him found in the classic work of Bouwsma (which makes no mention of Santorio), *Venice and the Defense of Republican Liberty*, 520.

9 Mukerji, *Impossible Engineering*.

10 McCormick, *William Petty*; Vardi, *Physiocracy*.

11 For instance, see Giacomoni, "The Light of the Emotions", and Vila, *Suffering Scholars*.

need for candidates to publicly profess their Catholicism (and to get around the unregulated palatine degrees). The papal nuncio, Berlingero Gessi, fingered Santorio as a danger. Following Sarpi's death in 1623 Santorio was accused of negligence in lecturing, and although he was promptly exonerated he was refused a rise in his salary, causing him to resign his professorship in 1624. Or perhaps he decided to step aside from lurking dangers? In Rome, in the same period, the person who had seen Sarpi's *History of the Council of Trent* through the press in London, Cardinal Marc Antonio de Dominis, was imprisoned. He had returned to Catholicism and taken up his offices again but had confessed that he believed a reunion of the Christian churches to be possible. While awaiting trial by the Inquisition he died, but as a punishment his remains were dragged through the streets to the Campo dei Fiori and publicly burned, along with his books. Even in Venice itself, the nuncio had demanded that Sarpi's body be exhumed and tried for heresy.

Barry and Bigotti are cautious, simply noting that Santorio had become "a hindrance to new conservative politics as the Senate started taking a more conciliatory approach towards the Pope and Spain" (23). Nevertheless, Venice would ally with France against Spanish interests in the War of Mantuan Succession of the late 1620s, and Santorio's old friend Contarini was elected Doge in 1630, serving until his death in 1631. Santorio continued to issue newer editions of the *Medicina statica* and produced his last works in 1629, described by Barry and Bigotti as "textbooks" for medical students (one on the first part of the aphorisms of Hippocrates and one on new remedies). During a terrible epidemic of 1630 – reputed to have taken the lives of one-third of the city's population – Santorio refused to accept that the epidemic was truly the plague, perhaps for reasons related to the political needs of his old friend, now the Doge.

Stepping back, Santorio's life and work were as interconnected with Venetian conversations as were Sarpi's. He came from not only a privileged but also a practical background, and in his youth his education offered the latest Humanist critical studies while his personal circles put him in touch with the latest currents of interest, not least in medicine. At the same time, his world circulated many opinions, theories, dogmas, and ideologies that were hotly and sometimes violently contested, creating dangers. One can see many of the same kinds of reading, conversation, and threat in the work of an exactly contemporaneous patrician elsewhere, Francis Bacon, or in the less privileged and three-year younger Galileo. The obvious strength of Santorio's work – which made it of continued interest to people in other places and times – was therefore in the robustness of the physical evidence from which he drew his discrete and conclusive findings. In showing that insensible corpuscles could detected by exacting and tireless weighing, for instance, he gave some of the first experimental evidence for corpuscularianism a couple of decades before Jan Baptist van Helmont published his willow-and-water demonstration, which was itself a few years before Otto von Guericke or the Boyle-Hooke air-pump, or the Torricellian barometer. At the same time, however, his most important work was published in the form of aphorisms,

a Hippocratic form that is excellent for presenting clear and distinct information and instruction but not best for drawing out implications from the evidence. Perhaps he chose the form for his *Medicina statica* (1614) to avoid the necessity of contradicting incompatible views, thereby side-stepping controversy? But perhaps that also made it hard for others to see the natural philosophical principles to which he adhered, in the longer run condemning him to the "second rank". Should we see that as a consequence of patrician nonchalance or necessary discretion due to the growing power of the neo-Aristotelians of the day who objected so strongly to the new philosophy?

One final implication about Santorio's work should be noted, since it comes through so clearly in his volume: he was wrestling with one of the hardest problems in medicine, how to explain qualities. As readers will know, Aristotle and his followers, including Galen, derived the elements from the qualities. According to the master, the four qualities are "primary opposites"[12] known conclusively by Reason, which combine with substance in doublets to compose the four elements. (Cold and wet yield water, for instance.) In turn, an alteration of a body composed of any of the four elements is caused by "an affective quality in virtue of which a thing is said to be affected or to be incapable of being affected".[13] As Aristotle wrote in the *Meteorologia,* this even allowed for alterations in the elements themselves: "We maintain that fire, air, water and earth are transformable one into another, and that each is potentially latent in the others, as is true of all other things that have a single common substratum underlying them into which they can in the last resort be resolved".[14] Qualities are primary. Assessments of the qualitative properties of mixed temperaments in individual bodies, foods, and remedies was therefore the foundation of medical practice, whether preventative or remedial.[15] But by Santorio's generation it was possible to think that qualities could be reduced to quantities discernable according to place, shape, and weight. This would soon be called the Mechanical Philosophy. But it was clearly already alive in some places, the commercial empire of Venice chief among them. [16]This volume provides an indispensable guide to Santorio as one of the chief interpreters of that moment.

In short, the thoughtful and well-informed studies brought together here by Barry and Bigotti add up to yet another powerful case for associating the new philosophy with the profound concerns raised by medical practice and theory. Santorio's works therefore point to fundamental questions about the sources of change in early modern European knowledge-making.

12 Lloyd, *Early Greek Science*, 107.
13 Apostle, ed., *Aristotle's Physics*, 94: Bk E, 226a.
14 Sambursky, *The Physical World of the Greeks*, 90-91: *Meteor*. 339a.
15 De Vos, *Compound Remedies*.
16 Celati, *The World of Girolamo Donzellini*. Regrettably, I discovered this important recent book only after writing the review, and wish to draw it to the attention of readers interested in the politics of medical knowledge in Venice not long before Santorio.

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