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Per quelle confuse carte... The Galilean De motu in Raffaello Caverni's Reading

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Résumé : On peut, semble-t-il compter parmi les contributions liées au *De motu* et à ses enjeux, le texte obscur, verbeux et parfois inexact de Raffaello Caverni (1837-1900), l'*Histoire de la méthode expérimentale en Italie*. L'œuvre monumentale du prêtre toscan fut publiée en six grands volumes (le dernier à titre posthume) et suscita aussitôt autant d'éloges que de critiques. Au-delà des jugements extravagants et des hypothèses audacieuses, les idées de Caverni sur le *De motu* peuvent tout à fait s'avérer utiles, non tant comme « revue critique », que comme reconstruction du cadre théorique dans lequel s'inscrivait le travail de Galilée. On en tirera des hypothèses sur la façon dont Galilée a entrepris la construction de la nouvelle physique et d'une « histoire des effets » désormais plus précise.

Abstract: In my view, among the contributions related to *De motu* and its related issues, we may include Raffaello Caverni's (1837-1900) confused, "lengthy" and not always accurate writing on the subject in his *Histoire de la méthode expérimentale en Italie*. The monumental work of the Tuscan priest was published in six formidable volumes (the last posthumously) and immediately met both praise and criticism. Leaving aside certain odd judgments and risky assumptions, the Caverni's ideas on *De motu* can legitimately be considered as useful material. This is not so much the case for his "review" but rather for his reconstruction of the theoretical framework within which Galileo worked in order to hypothesize how he undertook the construction of the new physics and for a more accurate "history of effects".

1 Introduction: *De motu* and its fortune

The so-called *De motu* appeared in 1642, after Galileo's death when Vincenzo Viviani, the last follower of the great Pisan scientist, decided to collect all his writings in order to:

[...] reprint all Galileo's works in the form of sheets with greater fullness and magnificence in two columns for the two languages, the former Tuscan, in which the author wrote, the latter Latin to be translated by some of our compatriots and lastly with the addition of a great number of writings by the same author which I gathered from different parts with great difficulty. [Viviani 1674, 104–105], [Favaro 1885, 19, 158–159, my translation]

This was an onerous but rather heartfelt task¹ and led him to happen on some papers by Galileo collected in quinternions entitled *De motu antiquiora* while he was working on the bibliography of a major study on the fifth book of Euclid's *Elements*. Viviani immediately thought they were early studies of the Master about motion, already showing an independent judgment with respect to the predominant Aristotelianism and, above all, they would be included appropriately in later works [Viviani 1674, 104–105].²

The manuscript in question, along with all the Galilean papers, ended up in the hands of the abbot Jacopo Panzanini, nephew of Vincenzo Viviani (his sister's son), who ordered its bequest to the heirs Carlo and Angelo Panzanini. The latter were not particularly involved in the conservation of the manuscripts and probably happy to sell them to Giovanni Battista Clemente de' Nelli (1725–1793), a Florentine noble senator, bibliographer and scholar.³ Besides having

1. At the time when Viviani expressed this need a collection of Galileo's works had already been published in two volumes edited by Carlo Manolessi and published in Bologna in 1655–1656. [Favaro 1883b, 311–342], [Favaro 1888, 1908–1909], [Galluzzi & Torrini 1984, 160–161, 190–192, 253–254, 301–308].

2. On this and other events related to *De motu*, see the accurate reconstruction by [Camerota 1992, 17–62].

3. Nelli explained that he bought the manuscripts despite being the beneficiary of them, through inheritance, thanks to a primogeniture resulting from the testamentary disposition of Viviani. Due to the unavailability of the testamentary trusts, the legacy would go to the de' Nelli family [Nelli 1793, II, 761, 874–875], [Favaro 1887, 258–260]. As recalled by Camerota, “l'acquisto del Nelli si è rivelato decisivo per le sorti della Collezione Galileiana, tanto che al marchese può senz'altro riconoscersi l'enorme merito di aver salvato da una probabilissima, completa dispersione la raccolta dei manoscritti di Galileo. Sembra infatti che i documenti fossero stati conservati—non si sa bene se dallo stesso Viviani o dai fratelli Panzanini—in una buca dal grano della cosiddetta *Casa dei Cartelloni*, un tempo dimora del Viviani e, in seguito, abitazione degli eredi Panzanini. Questa impropria sistemazione, insieme alla completa mancanza di vigilanza o di scrupolo mostrata dai due Panzanini, sarebbe all'origine della scomparsa di un buon numero di carte galileiane, che, sottratte dal loro “nascondiglio”, cominciarono a circolare liberamente, alimentando un vero e proprio mercato” [Camerota 1992, 21–22].

patiently bought and collected the Galilean manuscripts, Nelli also had the admittedly lesser merit of having published a rich and documented biography [Nelli 1793].⁴ The texts of *De motu antiquiora* were also reported by Nelli thus:

I keep some studies carried out by the Florentine Philosopher in his youth and transcribed by him in different quinternions above one of which there is the writing *De motu antiquorum* [...]; in others there are some errors included in Aristotle's works. [Nelli 1793, II, 759]

And then referring to the 1589-1592 period in which Galileo was a professor of mathematics in Pisa, he adds:

[...] some scientific dialogues, in which [the great scientist] introduces Alessandro and Domenico as interlocutors who examine various propositions of Mechanics and especially about Motion, scattered in the Aristotle's works [...] showing them to be for the most part erroneous and false. [Nelli 1793, I, 42]⁵

The biography written by Nelli quite closely follows that of Vincenzo Viviani, especially with regard to the classification of the writings in question which are correlated, by both of them, with the dominant Aristotelian conceptions about motion. In his early work, Galileo criticized erroneous theories with these criticisms containing early arguments and opinions which he was to recall in the most famous mature works [Nelli 1793, II, 759].⁶

Once the Florentine nobleman died, the papers passed to his sons, who decided to sell them because they were not very well-off. Thus the danger of dispersion reoccurred but this was avoided thanks to the purchase of the entire collection by the Grand Duke of Tuscany in 1818. It then formed the core of the *Galilean Collection*, now kept in the National Library of Florence. Other scholars, who had access to the manuscripts in the course of the following years, agreed with Viviani and Nelli that *De motu antiquiora* was a set of various Latin texts about motion dating from the early period of Galileo [Venturi 1818-1821, II, 330], [Antinori 1839], [Libri 1841, 12-13];⁷ and in 1854 Eugenio Albèri included some manuscripts of *De motu*

4. On which, in a positive light [Micheli 1988], [Hall 1979], [Favaro 1883a] while conversely underlining a lot of mistakes and errors.

5. It is easy to recognize by the Nelli's indication the dialogue that will merge in the Galilean early writings included in *Edizione Nazionale* by Favaro [Galilei 1890-1909, 367-408].

6. It is not a matter of chance that there has been so much discussion of both Viviani and Nelli's biographical reconstructions reporting a "continuist" character. See [Micheli 1988], [Camerota 1992, 22-25, and *passim*].

7. In particular, Guglielmo Libri, Florentine mathematician and historian of science, was the first scholar to have noticed the similarity between the Galilean

in the eleventh volume of Galileo's works he edited, presenting them as *Sermones de motu gravium* [Galilei 1854, 9–80].⁸

A few decades later Antonio Favaro began the work on the *Edizione Nazionale* examining the texts of *De motu* which were not included in the eleventh volume of Albèri; and he did so with great care, despite the difficulties and the “annoying characteristics” of the manuscripts.⁹ However Favaro also initially made an error with respect to a part of the text included in the *Edizione Granducale* which he could not find in Galileo's manuscripts. This and many other problems concerning the right location and timing of the texts in question were at the basis of the collaboration between the student from Padua and the priest Raffaello Caverni (1837–1900). In view of the future *Edizione Nazionale*, Favaro took advantage of his help, recognizing him as an expert on Galileo's writings.¹⁰ Caverni collaborated very actively and can therefore be legitimately considered as an editor of the *De motu* writings to the same extent as Favaro. However his name is not present in the first volume of the *Edizione Nazionale*, due to a misunderstanding between the two authors which we shall refer back to later. It should be noted at this point that the Latin texts collected by Favaro with the help of Caverni would make up what was to subsequently be called *De motu*. As is clear in the first volume of the Galileo's works, the scholar from Padua considered the arguments present in *De motu* very close to those exhibited extensively in the major works to the extent that:

[...] we can say that in them there are in seed and sometimes specifically explained, the wonderful discoveries which already put the author much above other contemporary philosophers and show the blossoming fruits later set out in the *Discourses and Mathematical Demonstrations Relating to Two New Sciences*. [Galilei 1890–1909, 246]

De motu and that of Giambattista Benedetti. This similarity was later taken up by Raffaello Caverni according to whom Galileo did nothing more than reiterate Benedetti's thesis on motion. As we will show later, this sometimes frantic search for the genesis of Galileo's theories is one of the main limits of the research conducted by the Florentine Abbot.

8. This edition of Galileo's writings is particularly important for us as it will be the one used by Caverni for his analysis.

9. When Favaro presented the writings in question in 1883—well before they were published in the first volume of the *Edizione Nazionale*, he noted: “Frequentissime e spesso anche capricciose le abbreviazioni che si incontrano ad ogni pie' sospinto; poco chiara la scritturazione, con frequenti cancellature e interpolazioni; omissioni di parole che rendono talvolta difficile l'afferrare il senso; la punteggiatura quasi del tutto mancante o irregolare; e finalmente non pochi errori di lingua, i quali contribuiscono in non lieve misura ad aumentare le incertezze nella interpretazione dei luoghi di dubbio significato” [Favaro 1883b, 3].

10. This is well illustrated by the correspondence between Favaro and Caverni whose *regesta* is in the appendix to the excellent article by Cesare Maffioli on *Storia del metodo sperimentale in Italia* [Maffioli 1985, 23–85].

In the light of this consideration, it would seem natural to place Favaro along the interpretative axis that had indicated the seeds of the fundamental principles of dynamics in these early manuscripts which were to be subsequently reported. In fact, this view was contested because there would be no clear evidence of this insofar as Favaro gave no precise indications on the elements that were common to *De motu* and *Discorsi*. Similarly, he would have been very wary of declaring the connection between the two works.¹¹ There is indeed no specification of those themes of early doctrines which Galileo would entirely recall in 1638 but the same cannot be said about Favaro's alleged caution and, ultimately, it is impossible to definitively establish whether he considered *De motu* as the first immature text written on dynamics or as containing *in nuce* the foundations of the future science of motion. In any case, my own view is that we can exclude an understanding that tends to isolate the early writings on motion with respect to the *Discorsi* and this is confirmed in the foregoing publication where Favaro considered that:

Those unpublished writings scraped together in the Galilean collection and primarily those related to the motion, have seemed very important to me, since the beginning. Although in some of them you find only youth studies, however like Michelangelo's first scribbled drawings, in others and overall, I perceived much more relevant characters which need to be taken into account to portray the blossoming fruits in the *Discourses*. We can feel the Galilean verbosity which while perhaps not having the attraction of the familiar eloquence in the *Two New Sciences*, sickens a little but you can see, even in the form, the young man who, disdaining the succinct and concise Aristotelian doublet, went on to prefer the broad Platonic covering. [Favaro 1887, 229]

Even in this case, however, the historian from Padua does not specify the connections between the old works and the mature reports on the new science of motion thus supporting a suggestion by Caverni who in 1889 (approximately a year before the release of *De motu* in the first volume of the *Edizione Nazionale*) wrote to Favaro that if he wanted to proceed by prefixing a short foreword, then it would be better to publish the writings in fragments:

[...] but if you really persist in thinking of publishing them in that wonderful order divided by us and in which we read, as in a mirror and since the first steps, the processes of the speculations by Galileo in the science of motion and then, in order to prevent criticism [...] you cannot do so without an erudite Preface, as long as it is needed, without the ministry intervening to act as precisely as Procuste. [*Lettera di Caverni a Favaro*, dated 20 March 1889] [Maffioli 1985, 79]

11. Raymond Fredette, in particular, questioned Favaro's alignment with the views of the previous criticism expressed in various different ways and tones by Viviani, Nelli, Libri, Antinori and Albèri [Fredette 1969].

Despite Caverni's good advice and the choice to present the writings in the order agreed, Favaro published only abbreviated information. Rather than indicating a deterioration of the relationship between the two or a simple difference of opinion, this probably reveals that there was not enough critical work on Galileo's Pisan period which prevented the construction of an exact logical chronological order of *De motu*, as called for by Caverni when he suggested the "learned preface".

2 A "maverick": Raffaello Caverni and his *Storia del metodo sperimentale in Italia*

Why did Antonio Favaro decide to collaborate with a little-known priest? To answer this question, it is useful to point out two or three stages of Caverni's biography. In 1874, Caverni's first book was published, *Problemi naturali di Galileo Galilei e di altri autori della sua scuola*. The text was mainly for students of physics and, while not widely used in schools, was loved by scholars. The subject is doubly interesting because it testifies to the priest's interest in the history of science¹² and also expressed what would become a constant feature of his research—a kind of nationalism applied to the genesis of scientific discoveries or inventions:

My intention was to open as a window to help young people find a broader field and explain how some inventions and doctrines, which we think came from France and Germany, were taught us much earlier by our compatriots and to show a small part of Italy's hidden treasures to those who accuse the country of poverty. [Caverni 1874, 1]

In the same year *De' nuovi studi della filosofia. Discorsi a un giovane studente* [Caverni 1877, 40, 41, 159, 160], [Pagnini 2001, 40–50] was published, maybe "the greatest of his works because of intensity, originality and density of thought" [Favaro 1899-1900, 379]. In it, the priest from Quarate discusses the compatibility of the new theory about Darwinian evolution with the Holy Scriptures, by touching on a sore point of the relationship between science and faith. He does so with the aim of finding a settlement between the two parties and this was possible provided that something was sacrificed of the Catholic hermeneutic "prerogatives", namely to recognize and accept the distinction:

[...] in the books between the divine and the human: the former's object is the truth of faith and it is infallible while the latter's object is the science concepts acquired for the natural study of

12. In confirmation of this, ten years earlier, Caverni mentions in his diary: "L'amore che mi sento avere grande per gli studi della fisica e della matematica, scegliendo come guida negli studi presenti il divino Galileo" [Pagnini 2001, 21].

the hagiographers and which may be true or false like all things learned by the natural use of reason. [Caverni 1877, 24]

In these words, everyone will have recognized the adoption of Galilean hermeneutic criterion in which the great Pisan scientist, who was fully convinced of Copernican heliocentrism, tried to argue that the Bible was not in contradiction with scientific evidence. Indeed he claimed that such evidence was actually compatible with Holy Scriptures, provided that these are not read literally and instead are interpreted in the light of such evidence,¹³ because:

Writing often is not able simply to give an explanation but actually it requires an explanation which is different from the apparent meaning of words. [Galilei 1890-1909, 282]

Our priest would not have expected the volume to be placed on the Index of prohibited books by July 1, 1878 and, though he tried to impose his point of view, finally he had to give up. Indeed it is probable that the Sacred Congregation of the Index did not prohibit the text because it presented the evolution theory. Instead this occurred because of the Church's growing hostility to science (at least from the process to Galileo onwards), an antipathy towards the Jesuits (they always had opted for Aristotle when the new science was born under the sign of Plato) and, not least, because they had found in Galileo's work the hermeneutic canons required to interpret the Holy Scriptures [Caverni 1877, 40, 41, 159, 160], [Pagnini 2001, 40–50]. Despite being put on the Index, among the few readers of *De' nuovi studi della filosofia* were Antonio Favaro, who wrote a letter to Raffaello Caverni from Padua dated March 25, 1877. They were yet to become friends but it seems that his own reading of the text had led the scholar from Padua to deepen his friendship with the pastor from Quarate:

You seem to me a good teacher, a very good teacher, but a teacher deeply convinced of the saying: *Who loves well, castigates well*. Was I mistaken? Meanwhile this book has increased my desire to meet you personally and perhaps before long you will find me knocking at your door. If my health allows me to rest and carry out a long work which I thought about for several years before deciding, I will also want to ask for your advice. [*Lettera di Favaro a Caverni* of March 25, 1877] in [Pagnini 2001, 53–54]

This is the beginning of the friendship between Favaro and Caverni which is testified by a prolific correspondence of more than a hundred letters over more

13. This is what Galileo says, for example, in the *Letter of 21 December 1613 to Benedetto Castelli* when he writes that the truths of faith and truths of reason cannot be in conflict with each other, at most it is "ofizio de" saggi espositori affaticarsi per trovare i veri sensi de' luoghi sacri, concordanti con quelle conclusioni naturali delle quali prima il senso manifesto o le dimostrazioni necessarie ci avesser resi certi e sicuri" [Galilei 1890-1909, 283]. See also the *Lettera alla Gran Duchessa Madre Maria Cristina di Lorena* [Galilei 1890-1909, 309–348].

than a decade [Maffioli 1985, 54–71].¹⁴ As Maffioli noted “Favaro’s friendship helped to break Caverni’s isolation from the scientific and academic world” [Maffioli 1985, 28]; and although the priest was shy and tormented by many doubts and problems, the scholar from Padua’s bibliographic information often proved very valuable. On the other hand:

[...] the friendship of Favaro was pretentious and required continuous exchanges involving information and searches for manuscripts and documents, reviews, contacts with publishers and editors of periodicals and so on. From 1883 onwards, Favaro completely drew Caverni into the great project of a new edition [...] of the Galileo’s works. [Maffioli 1985, 29]

The pastor was enthusiastic and did not hesitate to advise and collaborate on these topics (Galileo) which he had shared an interest in since he was young. He had a different historiographical approach from Favaro. Both preferred the documentary aspect, but for the former this served as a platform to show the foundations and evolution of thought and tradition which had allowed Galilean science to blossom fully. The latter’s true goals were represented by the chronological reconstruction and the indisputable attribution of the writings. However, in 1887, Caverni was unexpectedly excluded by the editors of the Galilean works. He considered Favaro responsible for this which meant their personal relationship cooled somewhat.¹⁵ Although the scholar from Padua managed to convince the priest to continue their collaboration, shortly afterwards their uncertain friendship was to lead Caverni to abandon the challenge because he became increasingly convinced that he was being tricked in some way. From then on, he was to work hard on his most important and debated work—the majestic *Storia del metodo sperimentale in Italia*, to which he had already devoted part of his time.¹⁶ Until then he had worked following the indications of Favaro on the order of Galileo’s writings *De motu*, printed in

14. For a comprehensive evaluation of the intensity of the relationship between these two, all private notes and quotes in the papers and letters addressed to others should be added to these papers. Between them, besides the cultural exchanges, there were “le manifestazioni di affetto, i segni di una lunga consuetudine: il classico invio della fotografia (benché entro un opuscolo scientifico!) prima di poter fare una diretta conoscenza, i pranzi in comune, le discussioni nei caffè sul Lungarno, i fiori di lavanda per la moglie del Favaro preparati dal parroco di Quarate” [Maffioli 1985, 28].

15. The disappointment following the failed official recognition as curator along with Antonio Favaro and Isidoro Del Lungo of the *Edizione Nazionale* is a more complex affair than it may first appear. It is unclear, for example, the role of Favaro in this exclusion since it appears that the publisher Le Monnier who first worked on this job had said he was very content with Caverni. However the work of guardianship had to be paid for by the Ministry which then would have to decide on appointments made. We do not know why (simple oversight or failure to report?) two were nominated, instead of three [Maffioli 1985, 32–33].

16. As resulting from the part of correspondence between Favaro and Caverni, promptly reported in [Maffioli 1985, 37].

part in the edition of Galileo's works written by Albèri and then, for another part, by Favaro himself, in a journal.¹⁷ In a letter dated 22 August 1884, the scholar from Padua clearly asked Caverni to take care of the above-mentioned writing in order to understand:

- I. If the writings to which belong the extracts contained in the first part of that work [the unpublished works published on the magazine Editor's Note] are to be published
- II. With respect to the *Sermones De motu gravium*, how are the fragments contained in the second part of the same work to be distributed? [*Lettera di Favaro a Caverni* of 22 August 1884] in [Maffioli 1985, 62–63]

As we have noted, the priest paid attention both to the right order to be given to the manuscripts and also to their placing to correctly portray the inner evolution of Galileo's thought.¹⁸ Although Favaro preferred a philological approach in the wake of positivism, he still consulted Don Raffaello who was to provide an order for *De motu* in five books which would have required an important critical apparatus. Towards the middle of April 1887, although Caverni had already learned of his exclusion from the editors of the *Edizione Nazionale*, he still believed this to be perhaps due to a simple misunderstanding and declared himself willing to invite Favaro to his rectory to discuss "the best appearance to give to early Galileo studies on motion" [*Lettera di Favaro a Caverni* of 12 April 1887] [Maffioli 1985, 67].¹⁹ Just two weeks later, he read an article in *La Nazione* (April 11–12, 1887) which stated he had been officially excluded and wrote to Favaro that he had learned "some things which caused him to greatly change his mind and [require] important clarifications" [*Lettera di Caverni a Favaro* of 30 April 1887] in [Maffioli 1985, 67]. For almost two months there was no exchange of letters—a sign that no clarification was forthcoming or that it was insufficient. In the following months, Favaro again asked the order of *De motu* but Caverni replied coldly, until in July of the same year he made some unacceptable requests.²⁰ Therefore, after this change of course,

17. This is reported by [Maffioli 1985, 72]; where it is the precise bibliographical indication of [Favaro 1883a, 43–97, 135–157].

18. With regard to the curators of the *Edizione Nazionale*, he had no hesitation in reproaching their choice not to closely analyze the thought of Galileo for the purpose of restoring a more correct ordering of the unpublished works and to limit themselves "a mettere i punti e le virgole al loro posto, a restituire le dieresi e altri segni esquisiti, come farebbe un accademico della Crusca, a cui fosse dato a curare qualche prezioso testo di lingua" [Caverni 1895, 341].

19. Caverni, in fact, answers, that "non ha alcuna difficoltà ad ospitare Favaro nella sua canonica. Ha eseguito lo studio dei primi scritti di Galileo sul moto colla maggior diligenza possibile, per servirsene nella *Storia della Meccanica*" [*Lettera di Caverni a Favaro* of 17 April 1887, in [Maffioli 1985, 67].

20. Caverni quite curtly declared that he had thought about the work Favaro intended to give him and, given the difficulty, was hesitating before starting work, preferring to set certain conditions beforehand: "1° Che gli sia assegnato il tempo

the priest inevitably became quite critical of the *Edizione Nazionale* and, conversely, Favaro did not hesitate to criticize him more or less explicitly which fuelled—or even actually created—the widespread view that Caverni was Anti-Galilean. This does not mean that Caverni would not refrain from expressing debatable opinions on Galileo in his *Storia del metodo sperimentale in Italia*. However, according to Favaro, this work remains “the greatest collection of material for history of the Galilean School” [Favaro 1899-1900, 379].

3 A difficult task: the role of *De motu* in the history of mechanics

It was extremely important for Caverni to put the tangled web of studies, events and discoveries in the history of the experimental method into an order. The difficulties he encountered in putting the Galilean Ms. 71 and Ms. 46 into order are more understandable. Caverni sensed that those *zibaldone carte* (“mixed-up papers”) played a role in the birth and evolution of Galilean science. He was therefore committed to determining when they were written and to situating them in an ideal historian’s path of scientific ideas. As such a path they were positively considered as the roots upon which Galileo founded the new physical science while also showing how the great Pisan scientist skilfully used existing research lines and insights. The priest from Quarate mainly exposes his research on *De motu* in a chapter of the fourth volume of the *Storia del metodo sperimentale in Italia* which is primarily dedicated to the *Scienza del moto dei gravi*.²¹ At the beginning of it, as if to stress the importance of the topic, there are some general methodological considerations. Firstly, it explains how:

[...] the attribute that is given to the discoveries of Physicists or the speculations of Philosophers and is deduced from the name of a man is in all fairness an impropriety which can only be kept in the speech convention [...]. This is because the intellectual order is a consortium which is as closely linked and necessary as in the civil orders and therefore a part of science may be named after an author in the same way as a religious society or family takes its name from the hierarch or father. So saying the laws of falling bodies belong to Galileo is not to be understood

conveniente e compatibile con gli altri lavori che sta curando. 2° Che si accettino prefazioni e note da lui sottoscritte e nella misura che reputerà necessaria. 3° Che gli si assegni una congrua ricompensa. 4° Che detta ricompensa sia versata dagli editori galileiani all’atto della consegna del manoscritto” [*Lettera di Caverni a Favaro* of 17 July 1887] in [Maffioli 1985, 68].

21. Though Caverni mentions the propositions of *De motu* in other parts of the volume, he methodically reports his considerations about this in chapter VI entitled *Delle discese dei gravi lungo i piani inclinati* [Caverni 1895, 328–381].

in the way that many do, as if they were spontaneous ideas from Galileo's mind alone, [but] instead that there was a well-founded basis upon which he contributed by building the edifice. [Caverni 1895, 328–329]²²

The goal is just to prove that such a building “on solid foundations” [Caverni 1895, 328–329] and, in particular, the theory of motion expounded in *Discourses and Mathematical Demonstrations Relating to Two New Sciences*, should not be considered “a fascinating appearance” but rather that it was necessary to recognize “the bud and the little plant which engendered it” [Caverni 1895, 328–329]. It is an indisputable fact that Caverni derives several Galilean demonstrations from other mathematicians and natural philosophers such as Leonardo, Tartaglia, Descartes, etc., through not always in clear and direct ways. He recognizes, however, how Galileo's effort consists in making its dynamics independent from the principles of an essentially previous statics. Between theorems and corollaries, the pastor from Quarate encounters the demonstration on equality of spaces and times of a body in motion on an inclined plane. Torricelli had noticed how proposition VI could have been obtained in a more simple and elegant way than Galileo's [Torricelli 1644, 107], [Galilei 1890-1909, 215–226], but Caverni tells us that:

[...] carrying out the second volume of Part five of the Galilean manuscripts, [he noticed a proposition] that showed itself the properly divided order by Torricelli: it was proved therein that the times are proportional to the lengths of the surfaces and are equally high after the mechanical theorem concluded the isochronism of circles. [Caverni 1895, 328–329]

The pastor tried to find out if the script was signed or added later by a follower. Given the skilful writing of a man endowed with good eyesight and a hand which was still steady, he undoubtedly believed the first hypothesis. Studying these papers further, with increasing surprise he observed another statement about motion along inclined planes²³ and it seemed to him “to distinguish the practice of young wings, before spreading freely their own wings and the fragment published in volume XI page 56–62 by Albèri” [Caverni

22. A similarity can be noted between Caverni's work and Koyré's idea about Galileo: “Modern science did not spring perfect and complete, as Athena from the head of Zeus, from the minds of Galileo and Descartes. On the contrary, the Galilean and Cartesian revolution [...] had been prepared by a strenuous effort of thought [...]. Yet, in order to understand the origin, the bearing and the meaning of Galilean-Cartesian revolution, we cannot dispense with at least a glance backwards at some of the contemporaries and predecessors of Galileo” [Koyré 1943, 333]. It is possible that Koyré was impressed by this concept thanks to Caverni's work of which he was one of the few readers.

23. More precisely the one showing how “le tardità di due gravi scendenti per due varie obliquità di piani ugualmente elevate erano proporzionali alle lunghezze discese” [Caverni 1895, 338].

1895, 338–339]; therefore, finding in this the confirmation that the material he had encountered belonged to the early period of Galilean production.²⁴ Caverni then just needed to understand why Galileo, by publishing the treaty *Dei movimenti locali*, had repudiated the other previously processed demonstrations to adopt a new one based on an assumption; so, working hard on comparing “those mixed-up papers”:

the principles of statics were as mutually agreed with the principles of dynamics to give the right measure [when] suddenly we abandon the statics and see that the author avoids it in the manner of a person who is hiding a weapon under his clothing. [Caverni 1895, 340]

The reason for Galileo’s choice seemed inexplicable at first glance but thus it becomes clear. Sensing that the statics would not allow him to make the desired steps forward in physics, he turned his attention elsewhere and demonstrated the propositions by making exclusive use of dynamics—solution that seemed less elegant and consistent but which was to turn out to be incredibly prolific in future results. Having thus restored a sense of continuity in the production of the great Pisan physicist, Caverni seized the opportunity to criticize the *Edizione Nazionale* and its editors (without naming them) in which he said there was not enough space for all the papers in a chronological order. He also criticized the editors for being more interested in “putting full stops and commas in place” [Caverni 1895, 341] than in considering Galileo’s inner intense activity. He then makes explicit one of his key investigative tools—the comparison of calligraphic forms with the various colours of ink because:

[...] as is common knowledge, a writing hand feels the effect of the years in the same way as the movements of all the other limbs, and similarly each one can gain experience in himself by comparing the papers written at the age of thirty with those written at fifty. [Caverni 1895, 341]

It follows a long analysis of the ten *De motu* propositions in the order presented by the manuscripts of the “First Book”²⁵ which ends with the confirmation of what had been repeatedly announced, i.e., the ways:

[...] [for which] Galileo arrived in the history of science which had yet to be recorded *without violating the mechanical terms*, in order to demonstrate his undisputable conclusions. They were those

24. The text was actually included in the edition made by Albèri and entitled *De proportionibus motu ejusdem mobile super diversa plana inclinata* [Galilei 1854, 56–62].

25. Analysis that we cannot discuss here in a detailed way but which is very precise and rich in references including those necessary to Albèri’s edition of the Galilean works [Caverni 1895, 342–349 *passim*].

mechanical terms reduced to the statics and the author does not use the ten propositions making up his first treaty [...] and could not use another topic. However as the new dynamics were established in 1604, other broad paths were opened for science making it possible to reach the same desired goal through more direct and plainer paths namely to demonstrate the brachistochronism of descending bodies for many inflected strings and underlying a fourth circle. [Caverni 1895, 349]

The pastor of Quarate analyzed the second book with his usual attention and did the same with the third Galilean book *De motu*. We find the propositions gradually amended by the father of modern science and the same basic idea, namely that the manuscripts in question represent the central seed from which Galileo manages to make a new physics flourish, a physics whose most complete and mature expression is represented by the *Discorsi* of 1638 [Caverni 1895, 350–366]. According to Caverni, in 1630, the great Pisan scientist opted for the third version of the manuscript which he considered to be the best. However almost all the propositions were recast and the result was not the best it might have been with some resulting theorems declassified to the status of corollary while some corollary points were elevated to theorems. Also the order of the demonstrations had not always been respected while appearing rather obscure and long winded to some. In particular, as has been reported, Descartes was to notice that in order to execute these demonstrations, it was not necessary to be a great surveyor. However while this is true, Caverni points out that we must also note that Descartes read the *Discorsi* in 1638 without considering that the proved propositions dated from more than forty years earlier when the geometry used was still the work of the likes of Commandino, Valerio and Guidobaldo. It is these works that the Pisan scientist's work should have been compared with and certainly not with the newly-invented analytic geometry.²⁶ Furthermore,

[...] it is important to note [...] that, in the Galilean theorems, it is not simple pure geometry but geometry applied to motion science which involved a greater difficulty because the predecessors had only provided a few examples for certain points. For this reason, to make more certain of the truth of these new findings, Galileo often reduced the abstract generalities to concrete cases and called for Arithmetic to be matched with Geometry. [Caverni 1895, 372]

So while Galileo might not have been a great mathematician in elaborating the theorems on motion, Descartes himself could not deny that he was “the first to apply geometry and arithmetic [...] to prove the new properties and the several and complicated effects of motion” [Caverni 1895, 372]. Still, if Descartes and others had seen the demonstrations as they were in their first

26. On the contrary, with regard to these terms of comparison, Galileo—says Caverni—surpasses them “per una certa elegante facilità” [Caverni 1895, 371].

version, they would certainly appreciate them. For that reason Caverni can say proudly that:

We believe we have done something for the above-mentioned mathematicians and think we have also partly contributed to the fame of Galileo in publishing the three *De motu* books in their original forms. [Caverni 1895, 373]

At the end of the chapter, it is clear that Galileo's readers reproached the erudite priest from Quarate for the excessive prolixity and verbosity of his writing. Carlo Del Lungo [Del Lungo 1920, 274–277] expanded particularly this point. This problem is actually verifiable throughout the *Storia del metodo sperimentale in Italia* but it would not be the most relevant point. The main error (and the most shameful for a historian) is that the writer expressed his ideas in different tones depending on the source and displayed the “insatiable urge of persecuting Galileo in each of his activities” [Del Lungo 1920, 281], or allowing himself to be misled by his personal events during the historical reconstruction. In this paper we cannot examine whether and how the judgment is generally deserved but chapter VI on the science of motion definitely shows something of interest. The great Pisan scientist developed his science based on the “mechanical theorem by Tartaglia” [Caverni 1895, 373] but while this origin was the most famous, it was not the most important. Claudio Beriguardi and Giovan Battista Baliani were:

[...] considered by many people to be not only imitators or emulators, but actual plagiarists of Galileo. They now appear in history in their true appearance representing the various provisions of the minds open to the seed of science that the superior provident hand spread widely [...] rather than in some closed and privileged small garden. [Caverni 1895, 374]

Baliani should indeed be considered closer to Torricelli for the contribution that he gives the science of motion which consisted, among other things, in retracing more strictly and extending (despite not having read or seen it) what Galileo had produced in *De motu*.²⁷ On the other hand it should be noted that Caverni consistently maintains a certain “nationalistic” line which leads him to question the work of Huygens and the transalpine physicist Edme Mariotte. He considered that they had the merit of making some Galilean principles and theorems prolifically known but also “to a small degree, take away Galileo's merit of being [...] the first to put those theorems into work” [Caverni 1895, 381].

27. Baliani, in particular, shows in an elegant and clear manner the mechanics theorem of which Galileo “in principio si fa Autore [...] e poi lo repudia come sospetto” [Caverni 1895, 376]. The Genoan mathematician “non dà alla sua scienza tutta l'estensione della scienza galileiana, a confronto della quale, se rimane inferiore rispetto alla materia, vince però l'esaltato emulo suo rispetto alla elegante semplicità della forma. Dicemmo, e lo ripetiamo, che in ciò il Baliani, meglio che a Galileo, si rassomiglia al Torricelli” [Caverni 1895, 377].

4 Conclusion

Overall, regarding the pages thus far considered, I think we cannot charge Caverni with acrimony against Galileo. However, in the last chapter entitled *Delle libere cadute dei gravi*, there is a certain “oddity”. Among other things, in fact, we read that anyone:

[...] who even suspected that those first Galileo writings, *De motu*, are really exercises about Benedetti's books, as we qualified them, could also easily be persuaded when re-reading the chapter “In quo causa accelerationis motus naturalis in fine, in medio affertur” which is a long and bright comment on the words [written on the subject in] the book *Delle disputazioni*. [Caverni 1895, 293]²⁸

From that point, when returning to the text, there is a surprising reconstruction of Galileo. After reading the books recommended by the teacher and his erstwhile colleague Jacopo Mazzoni during the years spent in Pisa, Galileo learnt to think freely with a mind of his own rather than following the Aristotelian authority:

At the time, among the young auditors in Pisa, there was also Galileo, in whom Mazzoni recognized an unusual intellectual ability to penetrate the science of motion. He recommended Benedetti's book to Galileo, explaining the speculation thereon to him in private. The young pupil, in those lively words and in the reading suggested by the teacher, felt the first ineffable taste of freedom of thought. Also, because the intense advice and effective examples convinced him to no longer believe in the authority of Aristotle, he therefore concluded he should not follow the authority of any other philosopher either, even Benedetti himself. [Caverni 1895, 275]

So, what might seem to be a complaint about the Galilean plagiarism of Benedetti through a hurried reading proves to be a real source of inspiration which Galileo opposes in those matters that do not convince him. Perhaps Aldo Mieli is right in saying that the *Storia del metodo sperimentale* needed “to be redone” not so much because of its content or hasty judgments but rather because of its complex and obscure style. A “reading which is not critical and careful enough may often lead the reader into error” [Mieli 1920, 262]. It is worth emphasising the judgements about *De motu* that Raffaello Caverni shows in his pages, paying the necessary attention to these youthful writings of Galileo.

28. The pages of Galileo that Caverni referred to are part of *De motu* published in [Galilei 1890-1909, 315-323]; the writing of Giovanni Battista Benedetti, *Disputationes de quibusdam placitis Aristotelis*, is included in [Benedetti 1585, 168-203].

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