Foundations of Science (2021) 26:757–790
https://doi.org/10.1007/s10699-020-09665-1

Science Outside Academies: An Italian Case of "Scientific Mediation"—From Joule's Seminal Experience to Lucio Lombardo Radice's Contemporary Attempt

Fabio Lusito[1]

Published online: 1 May 2020

Abstract
Starting from the seminal experience of James Prescott Joule, this paper aims to debate the possibility of "making" science outside universities and academies. Joule himself studied as an autodidact and did not make his own discoveries while following an academic path; on the contrary, at first, the associations and academic societies of the time tended not to recognize his works officially. All of this happened throughout the nineteenth century during the period of the first relevant tendency to science popularization. For example, looking at the second half of the England of the 1800s, we can refer to Michael Faraday's open lessons for children like The Chemical History of a Candle. Following this perspective from a historical view, this paper explores the Italian attempts to communicate science—from the '50s to the '70s—to a larger public via television and other media, also considering the political and social backgrounds behind this choice. In particular, this paper also deals with Lucio Lombardo Radice's work on TV programs and writings in social-political journals and daily newspapers, as a mathematician and pedagogist engaged on the importance of what he specifically called "Scientific mediation", as a "method" to teach and popularize science to a larger public.

Keywords James Prescott Joule · Lucio Lombardo Radice · Science communication · Science popularization and bordering academies

1 Introduction

James Joule's bicentenary, celebrated by IDTC Symposium at the ESHS 2018 London Congress, offers us the opportunity to discuss one of the most relevant projections of nineteenth century science toward the future: science communication. This is also a chance to refer to this subject through a historical review. Science communication is a substantial current problem and various scholars are addressing this issue around the world. Bauer, Bucchi, Irwin, Jasanoff, Jensen, Shukla, Trench and Weingart (Bauer and Jensen 2011;

✉ Fabio Lusito
fabiolusito@uniba.it

[1] Centro Interuniversitario di Ricerca "Seminario di Storia della Scienza", Department of Studi Umanistici, University of Bari, Bari, Italy

Bauer et al. 2012; Bucchi and Trench 2008; Irwin 1995; Jasanoff 2012; Weingart 2001; and so on) are only a few of the most active scholars that have been debating the issue in recent decades. Despite this theoretical discussion, historical analyses are explicitly fewer. An in-depth examination of the historical aspects of the question of science communication could furnish a new key of interpretation and the way to support theory on a solid historical basis (Pisano 2013, 2015; Pisano et al. 2017). Most of the time, detailed historical studies concerning science communication, public engagement and public understanding of science and technology are focused on brief and specifics periods. This is the case of the well-known instance of the rise of the popularisation of science during the second half of the nineteenth century in Great Britain. Several studies are dedicated to the Victorian age because of its renowned status. The studies of Brock, Lightman, MacLeod, Morrell, Morus and Sheet-Pyenson studies (Brock 1973; Lightman 2012, 2016; MacLeod 1996, 2000; Morrell 1997; Morus 2010; Sheet-Pyenson 1985), just to cite a few, are reinforcing and continuing a well-defined tradition. Studying this context in particular, scholars encountered two fundamental authors in these cultural and scientific panoramas: Michael Faraday—whose interest in popularisation was essential—and James Joule. Joule's studies are highly regarded today (Pisano 2012), and this bicentenary celebration provides us with the best proof of this new attention to him. IDTC's special issue represents a great opening to outline original approaches to the topic. Specifically, Joule had been investigated under his biographical—starting as early as the end of the nineteenth century (i.e. Dolbear 1890; Bottomley 1882) and more recently (Cardwell 1989, 2003)—and technical perspectives (i.e. Cardwell 1982; Rowlinson 2009; Sibum 1995, 1998). It would be interesting to scrutinize more specifically some of the original characteristics of his scientific experience. For example, Joule's complicated relationship with academies gives us a different view of his times and the occasion to reconsider the role of science outside the official channels of knowledge. Indeed, Joule's experience was not the last and only one of its type. This article tries to briefly underline this aspect, suggesting the possibility to open some links for deeper future research. More works are needed to deal with this original topic more specifically.

Taking into count this possibility, the motive to focus attention on a well-defined area of interest is provided by a reference to post-war Italy. It was a florid period for science popularisation because of its intrinsic scientific development and science's connection with political urgencies. Most of these activities were popular outside academics' rooms, and distant from laboratories and research centres. Studying this period is intriguing for the extent of its public implications. Science was intended as something that belonged to citizens and not only to scientists and experts. And, in particular, science was considered to have a great political validation. This time the topic analysed attracted less scholarly attention, perhaps because of its recent historical significance. Just recently some studies have focused on this topic, joining a theoretical approach to a historical overview. A more detailed investigation of the question is needed. This article tries to address this problem, under a historical point of view, specifically concerning the exemplary character of Lucio Lombardo Radice. Upon his death in 1982, after some earlier commemorations (Barra 1985) only a few scholars paid attention to his experience, particularly as a scientific populariser. Aside from biographical (Vittoria and Ceccherini 2005; Taviani 2004) and theoretical recognitions (Mores 2018; Natoli 2018), often regarding his pedagogical aim and his mathematical reflexions or his political involvements (Lomellini 2018), there is a lack of studies dedicated to this fundamental aspect of his thought: Lucio Lombardo Radice, probably, can be retained essentially a distinguished science populariser. Only Francesco Paolo de Ceglia has recently deepened a study of this topic pointing to the character of Lucio

Lombardo Radice (de Ceglia 2012), that supplies us with the opportunity to try to carry on the discussion.

This paper proposes an attempt to study Lucio Lombardo Radice's contribution, taking into account the seminal experience of a new modality of "science making" started by Joule and his peers (i.e. Michael Faraday) with their non-academic success. This initial example was fundamental to the future development of science popularisation and gave scientists a possible alternative for a more socially defined and politically debated science. So, this article aims to debate the possibility of "making" science outside of academies, where there is a real and deep need for science popularization. This question is linked to a specific contextualised political and social problematization, both in the case of nineteenth century Great Britain and mid-twentieth century Italy.

2 The Structure of the Paper

The paper is divided into two parts in order to introduce the theme first, and then to provide a specific "case study" description. The division is required to establish the differences between the cases and to propose two clearly distinct treatments. To run the risk of a narration that could be retained in parallel between two different historical and social settings was behind the corner. To avoid this risk, it was important to distinguish the two parts clearly. For this reason, it was considered appropriate to propose two separate treatments. In the following, the structure of the article is briefly explained, with a summary of the core of the two distinct analyses.

The first part of the paper briefly describes a panoramic view of the Victorian context, to gradually demonstrate how Joule and Faraday's experiences were symbolic of a renewed science for citizens not imparted solely by the traditional channels of education. Joule's seminal practice and Faraday's acts of popularization let us introduce the real core of this study: the historical analyses of a specific episode in the Italian history of science communication.

The second part—the most substantial one—is dedicated to this study, specifically to Lucio Lombardo Radice and his extensive activity as a scientist, politician and man of culture who was totally engaged in science popularization. As we will see, his activity was based on a concrete political plan. Close and inseparable to it, an energic scientific vivacity was the key to his pursuit of the aim of creating a new culture based both on science and thought in general. Fulfilling the "unity of culture" should be considered the most important aspect of his long and profound scientific reflection.

Definitively, this article concerns two stories, only linked by a thematic motif. The main purpose, therefore, is the opportunity provided to investigate historical events in order to propose an alternative method of investigation regarding science communication and issues related to involvement in science.

3 The Victorian Context and the Rise of Science Popularisation

The second half of the nineteenth century should be defined, in science, as an age of marvels, wonders and great discoveries. On this premise, this century's most valuable benefit is the birth and developments of science communication and popularization.

> It is very necessary that all who desire to become really proficient in any department of science should follow the beaten track, toiling more or less painfully over the difficult parts of the high road which is their only trustworthy approach to the learning they desire to attain. But there are many who wish to learn about scientific discoveries without this special labour, for which some have, perhaps, little taste, while many have scant leisure. My purpose in the present work, as in my "Light Science for Leisure Hours," the "Myths and Marvels of Astronomy," the "Borderland of Science," and "Science Byways," has been to provide paths of easy access to the knowledge of some of the more interesting discoveries, researches, or inquiries of the science of the day. I wish it to be distinctly understood that my purpose is to interest rather than to instruct, in the strict sense of the word. (Proctor 1878, iii)

This statement appeared in the preface to the 1878 first edition of *Pleasant Ways in Science*, written by the astronomer and science populariser Richard A. Proctor. As a prolific author, Proctor devoted his astronomical knowledge to the popularization of science in many of his books. We should consider Proctor not as the only example of a science populariser in the Victorian age, but as one of the several scientists engaged in this task. As Proctor quotes, his main goal was to interest people who wished to learn about scientific discoveries, people who were not involved in scientific work specifically.

Only a few decades earlier, in 1834, William Whewell coined the term 'scientist': this is indicative of what was happening to British 'natural philosophers'. They were establishing their role in society more specifically and they were moving towards a concrete professionalization of science. We could consider this professionalization as the cause of the emergence of a social division: what was emphasized was a sort of "difference" between common people and scientists. A separation between scientists and academies also appeared in this situation. For these reasons the necessity to create a glue that connected science and society emerged, and so the need to interest people in what science was turning into. All of this is what we should see in Proctor's assumption when he talked about two parallel lines of people interested in science: people who work in "any department of science" and the "many who wish to learn". The entire Victorian age was marked by the dialectical tendency that connected society to science. In this regard—consequent to the professionalization of science—science communication should also be recognized by scholars "as a socio-political process involving power and interests" (Ellis 2014, 778). Starting from these circumstances, the birth of scientific societies could be interpreted as a peculiarity of the age, which arose from a larger policy. Scientific Societies offered an alternative to Universities, intended as organized institutions and which were for a long time the only seat of scientific progress. Crossing British borders, it seems clear that there was the aim to create a sort of international "union" of science and scientists, a sort of abstract worldwide institution for knowledge corresponding to what had been defined the "republic of science". An international movement of ideas and ventures with the objective of a supranational relationship based on science. The entire nineteenth century is crossed by this will, internationally, and this is the reason why a political choice about science was intertwined with the issue of science communication and popularization. Because of this, we can look at the national/supranational dialectics that had been generating, under the same intent, the

multilanguage concept of "Science for all"[1]: *Scienza per tutti* in Italy, *Science pour tous* in France, once again *Wissenschaft für alle* in Germany and so on (Govoni 2002, 2012, 806–811).

The birth of scientific societies was the opportunity to institutionalise this incentive as a well-organized and established social activity. The choice to channel the individualism of scientists under well-defined structures such as societies (Morrell 1971), could be read as the hidden agenda of a wide political view. In this sense, societies were the means of collectivization of scientists to propose a form of 'national' science having a part in a larger international context. Scientific Societies were, in the end, also the medium through which society and science were related to each other. The inauguration of the *British Association for the Advancement in Science* (*BAAS*) in York, in 1831 (inspired by the model of the Deutch *Gesellschaft Deutscher Naturforscher und Ärzte*), gives us a clear example of the previous considerations. The *BAAS* represented an alternative to the conservative and elitarian *Royal Society*, by sharing the same intentions in practice as the *Royal Institution* created earlier, in 1799, the purpose of which was to educate the public about science and to promote the application of science in everyday life.

As mentioned at the outset, the nineteenth century (especially the second half) could be considered as an age of marvels, wonders and various discoveries: Societies played a primary role in this. The experiences of scientific theatricalization and open lessons for various audiences are only some of the many features of a lively society's request for science. In this context, we can see the importance of science presented as performance, a new way to interest people not only with words. The wide variety of science exhibitions, lectures, magazines, museums, public experiments and publications were symptomatic of a change that was involving all the science communication channels and society. Several scientists took an active role and directed their knowledge toward this "new deal" for science. Humphry Davy, Michael Faraday, Thomas Henry Huxley, John Tyndall are just some of the great names of British science who entertained Victorians with their lectures and shows. The peculiarity was that all the British social classes were included. As reported by Bernard Lightman, "Science became an important component of rational recreation for the middle class and educated members of the lower class. The incorporation of a powerful visual dimension enhanced the entertainment value of knowledge" (Lightman 2012). This was also happening because of a political plan concerning middle-class and worker-class education. Government policies were moving in this direction (MacLeod 2000, 196–225).

In parallel, the amount of science publishing increased vertiginously. Not by chance, *Nature* was published in 1869 for the first time (Lightman 2000), as "a weekly illustrated journal of science". But, before that, different journals had been published with the intent to provide a look at science and involve people: to list some of the most important, there were *The Intellectual Observer*, the *Popular Science Review*, the *Quarterly Journal of Science*, *Scientific Opinion*, and so on (Barton 1998). At the same time, the role of many specialized magazines was better defined. In this sense, scientific societies were good vehicles of promulgation. For example, *The Philosophical Transactions of the Royal Society* often offered the possibility, for amateurs, to propose their scientific works to experts, and consequently be considered for membership and receive scientific acknowledgement.

[1] The phrase "Science for all" was coined for the first time in 1877 by the journalist Robert Brown (Brock 1973, 19). Despite the late terminology of the concept, it seems clear that this explicit will was widespread yet.

It is in this prolific context that the figure of James Prescott Joule arose, embodying the connection between a non-academic interpretation of science and the social dimension of scientists' work.

4 Joule, Faraday: Two Cases of Science Outside Academies

James Prescott Joule's precarious health was the reason he received a private education, starting from his childhood. This drawback gave him the possibility to study with some of the greatest names of Victorian science. In 1834 James Joule and his elder brother Benjamin became John Dalton's pupils. With Dalton, the two brothers studied arithmetic and geometry and began to learn about chemistry. Knowledge of chemistry was useful for the running of their family brewery, which would be the future employment of the Joule brothers. Dalton introduced his pupils to the *Manchester Literary and Philosophical Society*, where his lessons took place. After Dalton's stroke, Joule's father granted him a room for laboratory work. Is in his laboratory that Joule commenced his experiments, tutored by John Davis and far away from any sort of university department. Davis was a private teacher, skilled in chemistry, mathematics and natural philosophy. He was a member of the *Manchester Literary and Philosophical Society* (*MLPS)*, where he was the lecturer in Chemistry. In 1839 David founded, with William Sturgeon, the *Manchester Royal Victoria Gallery for the Encouragement and Illustration of Practical Science*. Thanks to Davis' friendship with Sturgeon, in 1838 Joule's first publication appeared on the *Annals of Electricity, Magnetism and Chemistry*, edited by Sturgeon himself. "Description of an Electro-Magnetic Engine" was originally sent to the *Annals* as a letter to the editor. Joule's career as a scientist furnishes us with a clear example of science practiced outside of the academies: like Joule, several Victorian scientists made their discoveries beyond any type of affiliation with universities.

To work on the electro-magnetic engine, the subject of Joule's first paper, meant to work according to Britain's higher policy aimed at the development of society and industrial growth. British promotion of science was also aimed at taking on the leading role as an industrial power, with the goal of being a model for other nations with a capitalistic structure (Baracca et al. 1979, 3–8). Referring to Joule's period at *MLPS*—where he became a member in 1842—historian of science Donald Cardwell noted: "Quite naturally, therefore, his scientific concepts and methods were those of the industrial community around him" (Cardwell 2003, 5). All Victorian science was grafted in the government's scientific policy. *Annals of Electricity* itself can be counted as an example of the "electrical euphoria" that was sweeping Europe in the 1830s thanks to the "miracles" of the use of electrical devices. For I. R. Morus, electricity became, in those decades, a useful tool for crossing cultural boundaries, also essential in investigations about life matter (Morus 1998, 11). For these reasons, in his article, Joule decided to propose and build some improvements for a motor useful for the propulsion of boats and locomotives, powered by electromagnets.

Despite his promising beginning, Joule's first publication was not a success: the critics were hostile, and the engine was thought not to perform well. In this period, after his first work on electro-magnetic engines, Joule concentrated his efforts on the problem of the heat generated by the flow of electrical current. Joule's epos with institutional acceptances started here: in 1840, inspired by Michael Faraday—his new scientific landmark—Joule tried to introduce himself to the *Royal Society*. His essay 'On the Production of Heat by Voltaic Electricity' was not accepted for the more prestigious *Philosophical Transaction*

of the Royal Society, it "only" appeared in the Royal Society's *Proceedings*. Joule did not, at that time, have the authority and status to persuade the Royal Society of the importance of his investigations (Lightman 2004, 1105). Once again, in 1844, he proposed another method of analysis about the relationship between heat and mechanical forces, which he was working on at the time and, again, the *Philosophical Transactions* rejected his paper. At least, 'On the Changes of Temperature Produced by the Condensation and Rarefaction of Air' was published in *Philosophical Magazine* in the same year. In his intents, his studies were functional to counteract the waste of work, to "maximizing the conversion of heat from fuel into useful work in various kinds of engines, that is with economical duty" (Lightman 2004, 1107).

Science, outside the academies—as in Joule's case—played an important role in society and was useful for public use by citizens: this made it possible for nineteenth century England to advance in the field of applied sciences and recognize a socio-political value in the work of scientists. On the other hand, the universities also had an important role in "institutional" education but appeared unable to engage amateurs (and common people) in the national will. The case of Joule's work was particular. Despite the rejections he received, Joule was able to continue his work and to specialize thanks to his involvement in *MLPS*, which was specifically a scientific association and not exactly an official academic context like a university. Beyond these difficulties, later Joule had the opportunity to be a member of several institutions, including the Royal Society. It is important to clarify: because of the distance between academies/universities and the "popular" dimension, it had fallen to individual scientists and organized institutions to carry on the government's policies on the diffusion of science and public engagement. The connection between people and scientific facts become something controlled by the culturally lively Victorian scientists. According to Bud, the universities' perception of the need to "promote" applied science became clear only in the second half of the century. Not by chance, one of the leading universities was Manchester University: the city of Dalton and Joule (Bud 2014, 18–20). Joule's interest into a pragmatic view of science (such as applied sciences), allows us to link his practice to another great name of Victorian science which was detached from the universities: Michael Faraday.

The possibility for Joule and Faraday to meet was offered by another paper by Joule that had been rejected. This time, Joule's paper should be acknowledged as one of the most important achievements in the history of the nineteenth century science. When it was definitively accepted, "On the Mechanical Equivalent of Heat" was the conclusive summary of his previous works. Starting from 1840 (so, it included cited works) Joule repeatedly tested his idea of the reciprocal dependence of various forces, magnetic, chemical, and electrical. With his 1840 paper, he described his investigations about the distribution of heat in an electric circuit, thanks to which he concluded that heat produced results proportional to the resistance of the conductor. This is the origin of what we know today as the first law of thermodynamics. But the story did not end with the Royal Society's refusal. Faraday himself was appointed by the Royal Society as a referee to analyse Joule's work. Faraday could be recognized as the greatest proponent for Joule's acknowledgement: after 10 years of lessons and lectures and experiments, thanks to Faraday's "battle", despite his initial doubts, "On the Mechanical Equivalent of Heat" was published in the *Philosophical Transaction* in 1850. In the same year Joule became a fellow of the Royal Society.

Indeed, Michael Faraday should be considered the prototype of an engaged Victorian scientist, so much so that "in his own time he was known primarily to the larger public through his lessons" (James 2002, 225) and not for his discoveries in physics and chemistry. Member of the Royal Institution from 1813, he involved the broad public in his open

Table 1 List of lectures

Lecturer	Title of the lecture series	Year
J. Millington	Natural philosophy	1825
J. Wallis	Astronomy	1826
M. Faraday	Chemistry	1827
J. Wood	Architecture	1828
M. Faraday	Electricity	1829
T. Webster	Geology	1830
J. Rennie	Zoology	1831
M. Faraday	Chemistry	1832
J. Lindley	Botany	1833
W. T. Brande	Chemistry	1834

lessons. The Royal Institution's Theatre was the hall for Faraday's lectures for a long time. Showing the public his experiments was an integrated part of his work: for him it meant communicating science to people in a complete way and making, at the same time, the results and the utility of his discoveries manifest. A suggestive example of how science popularization was essential in Faraday's thought was his foundation in 1825 of the Royal Institution's Friday Evening Discourses. In the same year, Faraday himself introduced the Royal Institution's Christmas Lectures, which, over time, became the most popular lectures of the Royal Institutions. Two years later, in 1827, the audience attended Faraday's first lecture on Christmas Eve: it was the first of a series of 19 lectures carried on by Faraday until 1861.

The core of the Friday Evening Discourses was clearly to introduce scientific discoveries to an audience of members and their friends, through informative entertainment. The discourses were so successful that "the number of members of Royal Institutions went up considerably in the late 1820s" (James 2002, 227). This is eloquent: Faraday's idea could be seen as innovative in matter of science popularization. First of all, it had the significant peculiarity of engaging people in scientific questions. This was a functional model of science communication that started, in this way, to connect middle-class society with science for a useful purpose. The Royal Institution's idea was for the Discourses to inspire citizens, and, in this way, encourage amateurs to work on science too. As noticed by J. M. Thomas, "Faraday express the view that evening lectures should amuse and entertain as well as educate, edify and, above all, inspire" (Thomas 1991, 192).

More specifically, the Christmas Lectures were established for children. This could be deemed one of the most valuable innovations in Faraday's work: a new target, a specific one, that looked at children as potential 'men of science' of the future. Thanks to the persuasion of Faraday, several scientists took part in the Christmas lessons, so that different topics were discussed. To understand the variety of themes and the people involved we can take a look at the first 10 lessons, held in the first 10 years of the Lectures[2] (Table 1).

Besides chemistry lectures by Faraday and Brande, we can notice seven different branches of knowledge covered, by 7 diverse scientists (besides Faraday himself). Curiosity in chemistry was particularly high because of Faraday's predilection, so that, in the

[2] The full list of the Royal Institution's Christmas Lectures could be found on the Royal Institution's official website: https://www.rigb.org/docs/christmas_lecturers_18252015_0.pdf.

first 10 years, we can see 3 lessons out of 10 on this topic, as the only thematic repetition. Over time, until Faraday's last lecture in 1860, there were a total of 15 (9 of which were delivered by Faraday himself): the widespread interest in chemistry, like the other one in electricity, was characteristic of Britain's industrial developments. Not by chance, many press debates in working-class magazines were also dedicated to science. Science became useful for personal and political purposes regardless of social differences (McLaughlin-Jenkins 2001). We must not forget that these are only the Christmas Lectures (delivered to children), during the same years, over a hundred lectures were given by Faraday and about chemistry in general. The centrality of experiments—during the Christmas Lectures' series—was the most attractive aspect for the audience, especially for children.

The success of the Christmas Lecture's was so remarkable that their publication was judged useful for children's education: this was true of Faraday's last lecture *The Chemical History of a Candle* in 1860. Other Discourses (referring to the Friday Evening Discourses) were usually published in weekly periodicals like *Literary Gazette* and *Athenaeum* (James 2002, 228). Faraday's aim can be read clearly and directly in the final words of the preface to his *Chemical History*. Speaking to children, Faraday summarized his concept of science's role and his educational aims:

> Atom by atom, link by link, has the reasoning chain been forged. Some links, too quickly and to slightly made, had given way, and been replaced by better work; but now the great phenomena are known—the outline is correctly and firmly drawn—cunning artists are filling in the rest, and the child who masters these Lectures knowns more than Aristotle did.
> Among the readers of this book some few may devote themselves to increasing the stores of knowledge: the Lamp of science *must* burn: "*Alere flammam*" (Faraday 1908, vi–vii).

5 Developments Toward a Global Phenomenon: A Brief Interlude

Thanks to Faraday's original idea, the custom of Christmas Lectures still survives today: except for one brief pause during World War II (between 1939 and 1942), the Christmas Lectures have continued uninterrupted since 1825. Starting in 1966, the series of Christmas Lectures have been televised by the BBC (Thomas 1991, 192–193), offering an occasion for the education of the young. "Making" science on the screens has been emblematic of one of the most valuable conquests of science communication in the twentieth century. Various national televisions have based their original experience of science popularization for a large public on the British model. It is appropriate to specify that the British impulse to science popularization steeply increased in the early decades of the twentieth century. The scientific community was employed in facing new problems linked to science in citizens' everyday life. As noticed by the historian of science Peter J. Bowler, there was a long path that involved professional scientists in the goal of science communication during the first 20 years of the twentieth century. As recognized as useless today, they pointed on a top-down strategy, maintaining alive an opened dialectical tendency between information and entertainment. That was what the public was asking for (Bowler 2009, 3–4).

Several were the topics dealt with, unified under the peculiarity of "newness": for example, the new cosmology and physics, in the case of Einstein's Relativity, personally involved the astrophysics Arthur Eddington. He had the burden to demonstrate the theory in 1919 (Stanley 2003). His expedition caused a great debate that interested not only a

general public of lays but also had repercussions on the scientific community (Almassi 2009). For this reason, Sir Arthur Eddington was also the first to introduce Einstein's ideas to a wide community in Great Britain, with his *Report on the Relativity Theory of Gravitation* in 1920 (Eddington 1920). As an actively involved scientist, he also wrote different books in popular science—specifically on the topics of the new cosmology and new physics—that were largely appreciated because of his humour and his talent in exposition. Eddington's books became easily cornerstones of scientific literacy of the time, true best-sellers for a wide public (Bowler 2009, 98–103).

Another example is furnished by the new biology. Britain was particularly close to this theme because of the ongoing evaluation of Darwin's opera. In the 20s of the Twentieth Century Darwin's work was at the centre of a dispute, in a context in which different philosophical and theoretical approaches coexisted. Just to say, at the same time idealism, materialism, rationalism and neo-vitalism were colliding. All these views had consequences on people's everyday life, above all in religious sense. So, also in this field, a long series of books and papers were published, conflicting each other to catch the public's attention. One single contribution written by the biologist Lancelot Hogben appears very interesting because of its turning. Surpassing the bond between science and religion, Hogben's work focused on the role of science in the social order. His writings inspired many young Left-wingers scientists during the 30s. Eloquently entitled *Science for the Citizen* (Hogben 1938), his bestseller was published in 1938 and it had the aim to analyse science by a socio-political perspective. Following Peter J. Bowler's analysis:

> Hogben attacked the problem of getting people to think scientifically at a more basic level. He would build their understanding of mathematics and science from the ground up, from the most fundamental conceptual foundations. Only then would people be able to understand not only individual bits of science, but also the whole scientific way of thought—and then realize that if this were to be applied to the management of society, it would entail a social revolution. (Bowler 2009, 107).

This aspect let introduce us to a more political issue in which science started to be recognized also concerning its communication. Considering the other countries, in the same years the problem of scientific education and its socio-political implications were very actual in USSR. Briefly looking at this context as an example of a Communist society. In order to connect it to the abovementioned British context, we refer to the soviet delegation of Marxist scientists that took part at the International Congress of the History of Science and Technology held in London in 1931. The papers read in this occasion by Boris Hessen and Nikolai Bukharin influenced for a long time the future interpretations of the history of science and warned about the socio-economic role of the scientific venture (Graham 1993, 137–155; Werskey 2007). Those consequences established new interpretations of the scientific question internationally, not limited to the British background. Its importance could be considered as the most impressive push towards the successive studies in the sociology of science and general STS studies (Sheehan 2007).

Russia had a long and well-established tradition in the field of scientific education. It was a prerogative of the so called "intelligentsia", during the last decades of the Russian Empire, to cover the role of professional educators (Gordin and Hall 2008). Some of them also resisted in the following years in a Communist society—while most of them were arrested or moved away from academies and institutions because of their discordant vision of science, not conforming to the Marxist one. Indeed, with the Revolution in 1917 also the new Marxist asset recognized the urgency of a scientific education, specifically for workers. Educated people in science meant to educate workers and their

professionalization in industrial production. Most of the soviet propaganda used politically the role of science to encourage citizens in developing their interests on the matter, to forge them under the "new identity" of technicians. This phenomenon mostly increased during the Stalinist era: as science had already become what Marxism suggested, in the same way the construction of a Communist society was founded on their citizens, required to be Marxist champions too. Therefore, science had a central part in Stalin's cultural revolution. In Stalin's ideology, there was the belief that technological progress was the way to drive on a global social development.

> With Stalin's Industrial and Cultural Revolution enacted from above in 1928, something dramatic would change for the science popularization movement in Russia. In the Stalin era, Soviet state officials believed that the spread of science and technology had to coalesce with the Communist Party's utilitarian goals and needs to revive the industrial sector of the economy. This resulted in a new Stalinist technologically oriented popularization campaign that reflected the emphasis on Soviet technology and its glorification vis-`a-vis the West. In essence, the enlightened, imaginative vision of public science that crossed the 1917 divide became transformed after 1928 into applied science and technology for the masses, especially at the laboring worksites. (Andrews 2013, 516–517)

For these reasons, several scientists—which believed in the primacy of pure science (an approach retained not in accord to Marxist theory)—had to face the humiliation of their imprisonments and condemnations (Graham 1990) as a consequence of their objection to the acceptation of the leading role of applied sciences. According to the opinion of James T. Andrews, we can explicitly say that the Stalinist cultural revolution was a tragedy for soviet science and for scientific educators (Andrews 2003, 127). The Soviet situation implies a radical view on the question of mutual implications between science, society and politics. A situation in which science had to face the difficulties of a Regime and its propagandistic aims. A characteristic feature of the Soviet experience was already the crucial role played by communication of science and its popularization, here controlled by the Central committee's propaganda. This brief parallel became useful for the following analysis that had in common a Marxist approach and a Communist political reference but implanted in a democratic context. Propagandistic aims involved equally Western and Eastern societies in the context of the Second World War and then during the so called "Cultural Cold War". Easily it turned into a scientific war, while it could be generally considered a political war (Oreskes and Krige 2014, 14). A clear exemplification is represented by the space race: a global phenomenon that put face to face the USA and the USSR. Also in this case, propagandistic proposes were the ground on which this battle was distantly fought. A battle that, at the same time, concerned two models of science: a capitalistic or bourgeois one, and the socialist or proletarian one on the other side. Of course, contrasting ideologies made their own game to discredit the opposing model. In this specific case, science was at the centre of the struggle. By recognizing these particular aspects of the political use of science, of its communication and its propagandistic aspects, we can now focus on a specific case regarding the following years in Italy.

Specifically, we are now going to analyse a case study related to the experience of an Italian mathematician and his commitment to the social dimension of science and its popularization. This is the case of Lucio Lombardo Radice, Italian Communist Party member involved with the pedagogic task during some of the most delicate years of post-war Italy.

6 Rough Years and New Needs in Italy's Reconstruction

The Italian post-war context must be briefly summarized to completely understand the logics and dynamics of the rise of science communication between the 50s and the 70s in twentieth century Italy. To comprehend social factors also means to identify the causes of the widespread public engagement in science matters during these years: first of all, we can say that social validation is connected to a political motivation, specifically from a critical question that came from civil society.

Two decades of totalitarianism were a "disaster" for Italy not only from a humanitarian point of view (Crainz 2009; Gentiloni Silveri 2019) but also for the situation of scientific development and knowledge. Socially and industrially speaking, Italy seemed to be behind in comparison with other European countries (Harper 1987). This was the result of 20 years of fascism, which left a culturally divided and economically backward country. Mussolini's policies about science were—after years of studies—inconsistent and without any perspective and vision. This resulted in a crucial delay caused by a lack of interest in scientific research and scientific higher education, which is why post-war Italy lagged behind other nations and was compromised (Capocci 2011, 267–268). Fascism was the cause of the common "brain drain" of the most valuable excellencies of Italian science. For example, Enrico Fermi's case remains paradigmatic: in Giovanni Gentile's perspective, fascist science was solely practical, a sort of exaltation of techniques. Every regime has propagandistic objective, to show the outcomes of their intervention (Guerraggio and Nastasi 2010, 175). Because of the policies of Gentile—whose Idealism was considered the theoretical reference point for fascist culture—space and hopes for innovation and research were reduced.

The reverse appears true in the post-war situation: in this case, we can speak of a true "rebuilding", both economically, politically and scientifically. The recovery was slow but well directed and a share of the credit was due to international foreign policies adopted by victors of the war to lay new foundations for a world that was dismal at the time. These contributions were various and focused on different socio-political backgrounds. Under a scientific lens, the first post-war rehabilitation was linked to the *United Nations Relief and Rehabilitation Administration* (*UNRRA*)'s donations: it is thanks to these contributions that the rise of Domenico Marotta's (1886–1974) *Istituto Superiore di Sanità* (*ISS*) and the slow recovery of the *Consiglio Nazionale delle Ricerche* (*CNR*) were emblematic. But beyond the specific case of medicine, the urgency of which was crucial during the post-war moment with the re-emergence of illnesses like malaria, scientific investments were still regarded as a luxury and not a priority for the Italian government because of the more compelling social reconstruction. As underlined by historian of science Angelo Baracca, "We cannot say that Constitution, between its great values, recognized a particular role to techno-scientific development, favouring human, social and civil values" (Baracca 2017, 127). But in the 1950s the Italian economic recovery began: the well-known "economic boom", which placed Italy among the world's political powers.

The rise of the 'Economic miracle' brought a new attitude and improved welfare. The transformation of the Italians' mentality was at the origin of a great cultural and social "revolution". At this point, industries started to finance new researches and improving their technological equipment. This was the case of two great models which are the computer producer Olivetti, and the chemical factory Montecatini, that were leaders in their sectors. Both can be considered significant for the building of their high levels research centres, separate from universities. For example, in the following years, Montecatini financed the

research of Giulio Natta (1903–1979), who won the Nobel Prize in 1963 thanks to the support of these industrial funds. Regarding the improvement of nuclear physics, another important story is linked to Edison's investments in the field of technologies for civil developments of nuclear energy. With the passing of the years, nuclear physics gradually dominated Italian science: the parabola of Felice Ippolito (1915–1997) is indicative of this attention. His name is connected to the advancements of the *Comitato Nazionale per le Ricerche Nucleari* (*CNRN*)—of which he was nominated secretary in 1952—which became the *Comitato Nazionale per l'Energia Nucleare* (*CNEN*) in 1960. Felice Ippolito and the already mentioned Domenico Marotta were involved in some scandals, during the 60s, destined to generate a sort of scepticism about science in the following years. It was August 1963 when the deputy Giuseppe Saragat, from Socialist front, accused Felice Ippolito from the pages of the socialist newspaper *L'Avanti*. Saragat's doubts were related to Ippolito's management of CNEN: immediately a ministerial investigation started. One year later, on March 3 1964, Ippolito was arrested for supposed administrative irregularities. There were 8 indictments, most of which related to false documentation and misappropriation.[3] Two years later, Ippolito was released with clemency by the same Saragat, now become President of the Italian Republic. Similar accusations were addressed to Domenico Marotta. His management of the ISS appeared not clear to an office worker, who reported the fact in 1962. In the same way, a ministerial investigation by the Ministry of Health and the Ministry of Treasury started. On April 8 1964, Domenico Marotta was jailed at the age of 80. After a long trial, only in 1969 the Appeal Court sentenced Marotta to 2 years and 11 months of imprisonment (Cozzoli and Capocci 2011, 564–566). Both the scandals had been largely debated due to several doubts linked to a possible political ploy. It is relevant to note that in spite of these scandals, Marotta and Ippolito were fundamental for scientific progress during the years analysed; the role of ISS and CNEN can also be considered essential as convergence centres for the history of Italian science in the second half of the twentieth century.

What is important to recognize is that this renewed enthusiasm carried with it a new interest in scientific issues on the part of the public. This means, particularly regarding nuclear energy, an engagement in civil and socially relevant questions. Specifically, there were two sides to the nuclear issue: on the one hand, nuclear energy was indicated as the way that the nation could become self-sufficient in satisfying its energy needs. It meant a tangible impact on everyday life, with a significant reduction in consumption; on the other hand, the population had to come to grips with the word—'nuclear'—that was compromised by its negative use during the war. For this reason, nuclear energy was seen as dangerous and risky for the country. It appears evident that this was a social and political problem that was touched the population personally. At the same time, the nuclear debate was also crucial in the Cold War balance. Frequently, the fear of an apocalyptic development scared people and conditioned the public opinion. Also, for this reason, the atomic question was at the centre of public debate, widely covered by media's proposals (Ciglioni 2017, 166). Atom's image started to change during the 60s when the idea of 'peaceful Atom' and its civil purpose advanced. Made is way the concept of a nuclear path as the promise of a well-organized transformation, a fantastic mutation regarding future civilization (Ciglioni 2017, 175). Already, in this sense, the promotion of a peaceful way of atomic development was fundamental in the USA policies in the context of the Cold War.

[3] Lalli, M. (1964). "Entro 40 giorni Ippolito a giudizio". *L'Unità*, 5 marzo, 3.

1955 First International Conference on the Peaceful Use of Atomic Energy in Geneva—in the very heart of Europe—was highly symbolic of this will. According to the historian of science John Krige, "the presentation of the U.S. reactor in Geneva was a masterpiece of marketing. It was intended to demystify nuclear power and to show that anyone and any nation could exploit it safely and to social advantage" (Krige 2006, 175). The atomic topic was suspended between these two vertices, irreconcilables but coexistent in what public opinion believed through fears and hopes. It represented, also, one of the main political controversies of these years. The nuclear issue was only one of the relevant themes that were entering in discussion in the public domain.

With Italian advancements in technology and with the effects of the "miracle" that transported Italians into a new dimension and idea of living, most scientific questions began to be broadly discussed. All of this brings us to the heart of a political plan made by the Central Committee of the *Italian Communist Party* (*PCI*) in particular, determined to impose its cultural hegemony on the country, inspired by the legacy of Antonio Gramsci's philosophy—believed to be essential for a tangible political resolution. It was 1950 when Antonio Gramsci's Foundation was inaugurated in Rome, with the explicit scope of contrasting the predominant idealism and breaking with the fascist mindset of the past. In its typically propagandistic tones, the newspaper of the Party announced on 28 of April 1950: "Roman intellectuals have been reunited to honour the memory of those who known how to elevate culture and study as a valid tool for the struggle of the people".[4]

The moment had arrived for politics to analyse and discuss the relevance of science. The PCI's attention—and generally that of most of the Italian left-wing—set the scientific problem on a social dimension, interpreting people urgencies and trying to resolve social demands. To do this, the method of science popularization had been determined as the best means to spread scientific knowledge, which could be transposed into political feedback. Along these lines, we can follow the years up to the '60s and '70s to introduce Lucio Lombardo Radice, one of the most influential intellectuals and scientists of this age. He was a proud member of the *PCI*, devoted to the party line about cultural dimension, and for this reason widely engaged in scientific popularization. The role of Lucio Lombardo Radice could be recognized as crucial especially during the protest years followed by the "hot autumn" of 1969. In the specific case of Italy, we can talk about the "age of protests" for a period of 9 years between 1968 and 1977: these were difficult years with high political tension. In this period the scientific question was also criticized and harshly debated. All of this happened, once again, far away from the official national culture preserved in the universities, following a common non-academic "fight" pursued equally but h media and the public. One of the most debated themes regarded the supposed neutrality of science: these are the years of strong reassessments that led to the conclusion of an explicit non-neutrality.

7 Attempts to Change Culture

The need for widespread science information was the clear wish of a political plan established by the Communist Party. Only by bearing in mind this "superior" order can we completely understand the dynamics of Lucio Lombardo Radice's influence on society. Born in

[4] Anonymous. (1950). "Roma ha onorato Gramsci". *L'Unità*, 28 aprile, 3.

Catania in 1910, he was the son of the well-known pedagogist Giuseppe Lombardo Radice and Gemma Harasim, a literature teacher. A pedagogical background was a habit (in an ethical sense, too) that accompanied Lucio throughout his life. His father Giuseppe was one of the most renowned educators of the fascist era, author of different school programs based on Gentile's suggestions. Despite his father's earlier adhesion to fascism, Lucio's upbringing was completely contrary to that of his father in the sense that he had an anti-fascist vocation, which he reached over the course of his studies. Furthermore, his father also distanced himself from the Regime. In 1923 his whole family moved to Rome, where, in 1934, he started to study mathematics. In 1938 he obtained his degree studying with some great mathematicians of the age, such as Gaetano Scorza (1876–1939), Guido Castelnuovo (1868–1952) and Federigo Enriques (1871–1946). In this context, he had his first contacts with the communist group lead by Aldo Natoli (1913–2010), Paolo Bufalini (1915–2001), Pietro Amendola (1918–2007) and Pietro Ingrao (1915–2015). This could be recognized as the first Roman anti-fascist resistance's organisation. As an anti-fascist, Lucio Lombardo Radice was imprisoned for 2 years in 1940, and then again in 1943. Throughout this period he was developing his complete commitment to the Italian Communist Party. Having survived the war's rough years, he decided to dedicate himself to mathematics, firmly convinced of the strict relationship between maths and philosophy, and thought in general.

As he states in his *Istituzioni di algebra astratta* later in 1965, "If I had thought that mathematics was all about technique and not about culture in general, only a matter of calculus and not also philosophy and, for this, thought for all, I would never have been a mathematician" (Lombardo Radice 1965, X). This sentence describes the core of Lombardo Radice's vision about culture: science is related to different branches, capable of a multi-level conception of thought. This, also, expresses his strong personality, that of a curious man and scientist oriented toward new research and active assumption of his age's culture. Because of this, despite his education in mathematics concerning abstract algebra and geometry, in particular, he was interested in science from a more general point of view. This is the real purpose of his personal and political need to make his knowledge accessible to benefit the public.

We can say that Lombardo Radice's interest in the public dimension of his age was not limited to a scientific question. During the War years, he experienced different fronts, he was particularly involved in the building of an anti-fascist approach to culture. He also anchored his future lines of thought in this way: after the fascist experience, Lucio Lombardo Radice strongly fought to eradicate the well-rooted fascist culture of the Italian society. It was 1945 when he published his book *Fascismo e anticomunismo. Appunti e ricordi (1935–1945)* (*Fascism and anti-communism. Notes and memories 1935–1945*), an accurate autobiographical essay focused on the events of the previous 10 years. His book summarized also the spontaneous development of a new culture based on an anti-fascist belief that started to flourish in the second half of the 30s. Anti-fascism developed under "the subsoil of Italian life" (Lombardo Radice 1946, 74), established on the will of several youths that were changing attitude. Lombardo Radice was indeed one of the most influential protagonists of the anti-fascist group of Roman students aimed at ending the dominant fascist and idealistic view and launching a new season for the incoming Italian culture. As an act of resistance against fascism, this operation was primarily political, which introduce us to another inseparable aspect of Lucio Lombardo Radice's life. The historian Claudio Natoli, talking about Lombardo Radice's anti-fascist education, well described the implications of this new intellectual *milieu*, "we face the first steps of the path of an entire generation that will mark the passage from an individual approach to the political anti-fascism toward a communist militancy of many young intellectuals, whit all their moral, political

and cultural consequences" (Natoli 2018, 66). A culture born spontaneously in a friendly clique as an answer to the fascist oppression.

It was in this context that Lombardo Radice started his dialogue with the Catholic components of the Country. As taught by Antonio Gramsci, Catholics represented a substantial mass of citizens who influenced Italian culture. For Lucio Lombardo Radice these masses had to be intercepted to build a new culture that shall have developed basing on Catholicism and communism—in opposition to the idealistic and fascist culture that had impoverished the moral dimension of the Country. The possibility of a concrete dialogue between Communists and Catholics gradually became a constant that never left Lombardo Radice's cultural work. During the years the need of dialogue only reinforced itself: to cite an example, this was the same belief exposed in an article published on the Party's newspaper *l'Unità* in 1972. In his essay *Comunisti e cattolici* (*Communists and Catholics*), turning again on Gramsci's idea, Lombardo Radice realised that the union between the Communist component and the Catholic masses were setting the path for collaboration in the name of a renewed culture[5].

The cultural dimension of Lucio Lombardo Radice as a scientist can also be recognized referring to his work as a mathematician. He was elected as an assistant in Analytic Geometry in 1939, but he started to teach in University of Rome 'La Sapienza' only in 1945 at the end of the war. His first researches concerned abstract Algebras, specifically the theme of the finite groups. We can count 8 papers on this issue between 1939 and 1950. Another topic of interest was the projective geometry of graphic planes, in particular focusing on finite planes and Non-Desarguesian planes. About these issues, he published several works between 1950 and the mid-60s. Abstract Algebra and Analytic Geometry where the main field of his academic research. Thanks to his work in these years, he received the lecturing post in 1951 in Algebraic Analysis, and then the call as a professor to the University of Palermo, from 1955 to 1960, to teach Analytical Geometry. In 1960 he returned to Rome. In Rome, he was nominated vice director of the School of Mathematics and Physics from 1963 to 1966 and started to teach Algebra in 1965. In this context, he had productive collaborations with his colleague Beniamino Segre (1903–1977)—a renowned scholar in the field of the Finite Geometry—and Guido Zappa (1915–2015), which is well-known for his contribution in Group Theory studies. With Segre, Lombardo Radice also shared the interest in the history of science: in 1967 they both wrote an essay on Galileo and the mathematics. It was presented as a contribution in the occasion of the IV centenary celebration of the birth of the Pisan scientist (Lombardo Radice and Segre 1967).

Starting from the 70s to the end of his academic career, he taught Complementary Mathematics and received several roles in Number Theory or Superior Algebra and Geometry. We should also underline that another great interest was related to the Didactics of Mathematics. For a long time, Lombardo Radice encouraged the work of Emma Castelnuovo (1913–2014) and other teachers that were applying new models of didactics in their classes, in secondary schools. The teaching of mathematics was retained fundamental in the education of children and Lombardo Radice recognized the importance of this experience. He was primarily involved in the spread of didactical practices despite his academic career. As Emma Castelnuovo underlines in a letter in 1958, Lombardo Radice's role was important to engage academics in this pedagogic work. As she said, "Above all, thank you for your stirring things up; […] Academics must act in favour of, and not leave from

[5] Lombardo Radice, L. (1972). Comunisti e cattolici. *L'Unità*, 27 aprile.

schools teachers"[6]. This reference is meaningful of Lucio's task on this field, and it appears clear looking at Lombardo Radice's school handbooks. Not by chance, Lombardo Radice used to write his handbooks with the help of secondary school teachers, as in the case of *Il metodo matematico* (*The Mathematical Method*), in 1977, written with Lina Mancini-Proia (1913–2002) and *Minialgebra* (Lombardo Radice and Mancini Proia 1977), in 1972, with Giorgio Catalano (Lombardo Radice and Catalano 1972). Both were not academic teachers and previously Lombardo Radice's pupils. As we have seen, several were the cultural interests in Lombardo Radice's opera. By the means of this brief intellectual and scientific biographical portrait, we can now introduce the main theme of interest of this research.

Our attention is focused on his public personality, engaged in science communication and popularization through the media: daily newspapers, socio-political journals, books and television programs in particular. As we remarked before, *l'Unità* was the official Communist Party newspaper: founded in 1924 by Antonio Gramsci (1891–1937), it was originally conceived of as "the journal of the working left-wing", without any specific party indication[7]. Despite Gramsci's original advice, over time *l'Unità* was converted into the Communist Party's official agency. This was the situation in 1948 when Lombardo Radice started his collaboration. His first speech already focused on pedagogy: with *Controriforma della scuola* (*Counter-reform of school*)—on the 4 December 1948—he expressed a desire for a new pedagogical proposal for post-war schooling. From this time on, he was increasingly present in newspaper's pages y, not only on the topic of education, but also in the name of scientific information and popularization. On the one hand, he offered specific portraits of men of science from the past, a series of biographical and thematic topics, a real history of science "summaries" for readers; on the other hand, he frequently dealt with ongoing issues in the scientific world, significant problems often linked to the working-class needs. Just to cite an example, in 1952 he wrote two contributions: *Leonardo e Galilei* (*Leonardo and Galilei*) and *Rivoluzionari della scienza* (*Science revolutionaries*). Both allowed a glimpse of Renaissance science, a clear framework of the past based on the figures of Leonardo and Galileo. At the same time, these occasions often gave Lombardo Radice the possibility to reveal his aims and to take advantage of the opportunity to disseminate his thought. *Rivoluzionari della scienza* ends:

> […] Earth has its own history of profound transformations and changes. Science is indeed technical, but not only. As a technique, it is the secret of a few: as a form of thought, a daring logical deduction from the new facts that experience reveals to us, as a general conception of nature, its movement and its history, it can become the heritage of all.[8]

Science, for its history and its strict connection with our planet, should be considered something that concerns all humanity. For that reason, Lombardo Radice believed it was particularly important to share scientific knowledge with a wider audience: this is part of

[6] Castelnuovo, E. (1958). Letter to Lucio Lombardo Radice. *Fondazione Gramsci*, Fondo Lucio Lombardo Radice, Busta 5, 12, 31 marzo 1958.

[7] Gramsci, A. (1923). Lettera al Comitato Esecutivo del PCd'I. *Fondazione Gramsci*, Fondo Antonio Gramsci,12 settembre 1923.

[8] Lombardo Radice, L. (1952). Rivoluzionari della scienza. *L'Unità*, 30 settembre, p. 3: "… La Terra ha una sua storia di profonde trasformazioni e mutamenti. La scienza è sì tecnica, ma non solo tecnica. In quanto tecnica, essa è segreto di pochi: in quanto impostazione di pensiero, ardimento di deduzione logica dai nuovi fatti che l'esperienza ci rivela, in quanto concezione generale della natura, del suo movimento e della sua storia, essa può divenire patrimonio di tutti".

what, in another article of the same year, he called "Scientific consciousness" and its construction. A critical, shared and aware consciousness about scientific knowledge useful for citizens' decisions in socio-political affairs. A sort of encounter between science and the well-known Marxist concept of class-consciousness established for an original interpretation of the entire scientific reality of the times. Not by chance, the nickname given to Lombardo Radice by Mario Alighiero Manacorda (1914–2013), "Galilean Marxist" (Barra 1985, 14), wisely indicates the appropriate correspondence of this label to Lombardo Radice's thought. Karl Marx's critique was reputed fundamental, as a social and philosophical theory, to achieving the idea of a public, criticized and socially debated science useful to citizens. Going back to the article cited from 1952, on the contrary, when he refers to science as a mere technique for few people, he was speaking of an "official" science made in laboratories, research centres and universities. His reference to "science" (and not to technique), so, is not that specific, but was instead to another one, the science of everyday life that touches all types of audiences. That science can be recognized as habitual, incisive and capable of changing everyone's life with its effects and progress. More deeply, he wanted to pursue a science that was truly emancipated and free. To do this it was crucial to support a fight for science's independence by insisting on public awareness of it. For example, he returned to a similar theme a few months later, again in the pages of *l'Unità*, with the essay *Copernico e l'Italia* (*Copernicus and Italy*). In this case, starting from the revolutionary experience of the Polish astronomer, Lucio Lombardo Radice indicates the route for a real liberation of science, that had not yet been completed. Copernicus furnished the opportunity to reconsider a contemporary problem that still had not been solved. Through the centuries, science has never been neutral and disarticulated from power logics. Only free science, with citizen awareness about what it is and what it does, can be considered really emancipated and detached from external influences. For the author, it was necessary that we sustain the fight for science independence launched with the "revolutionary act" by Copernicus (1973–1543) and his *De Revolutionibus Orbium Coelestium*[9]. To do this meant to submit questions to people publicly, questions inherent to the subject of science. Suffice it to say that after the 1945 revamping of *l'Unità*, the newspaper started to sell over one million copies: it was addressed to a wide target, especially the working-class. It meant to attracting people's attention publicly, talking about questions considered important from a political and social point of view. Again, to engage people on the significance of science in the age of Italian reconstruction—where problems such as the use of nuclear energy (but not exclusively), as previously mentioned—were largely debated.

Simultaneously, Lombardo Radice's work was not confined to his commentaries on the Party's daily newspaper. He also spoke about science in *l'Unità*'s monthly insert *Rinascita*, a specific review of socio-political arguments, created by Palmiro Togliatti (1893–1964)—the PCI's leader during these years—to introduce an Italian interpretation of socialism. Lombardo Radice's scientific content was first published in the early years of the '60s. His *Come insegnare la scienza ai giovani* (*How to teach science to youth*) fully depicts the core of his ideal of a broad education in science. This service was also—maybe, first of all, we can say—destined to new generations of students focused on scientific studies. Making a social class aware (that of young scientists in this case) was always the primary purpose of Lucio Lombardo Radice's reflections. New scientists for new science, this was the real core of his ambitions. To have a growth in science development it was necessary, in his mind,

[9] Lombardo Radice, L. (1953). Copernico e l'Italia. *L'Unità*, 26 maggio 1953.

to bet on science teaching too. This could only be possible by adopting a new mentality, pushing for a cultural change in which science and humanities should be considered two sides of the same coin. Ensuring the unity of culture was essential for proposing a cultural revolution thanks to which a new science could arise.

> The current development of science does not imply simply an extraordinary progress in technique, but also new possibilities for reason. […] The two aspects of science, technique and thought, cannot be separated in an absolute sense. We cannot understand the essential progress of scientific thought if we not know the necessary technique; on the other hand, we cannot possess technique if we do not possess the idea on which it is based.[10]

What emerges is that to keep technique (applied science, so to speak) separated from humanism is the greatest error of scientific education. As a pedagogue, Lombardo Radice knew well where and what the problems of schools were. And once again, the crucial point was symbolized by the freedom of science. As he continues, "It is necessary that the discussion of hypothesis, of new scientific ideas, shall develop in a completely free way", because it is in light of this recognition that the question of teaching shall be established, "to say it well, of scientific education" (Lombardo Radice 1962, 27). For these reasons, he founded the review *Riforma della scuola* (*School Reform*) with the pedagogue Dina Bertoni Jovine in 1955. The pedagogical question was central in his aim, and it was strictly connected to the question of the scientific debate, moreover to the issue of a new civic upbringing that was both scientific and humanistic—the only acceptable way to "regenerate" Italian culture and to clear the idealistic *impasse* that Italy was still suffering from. This was, specifically, his permanent problem about the "unity of culture", a reflection that accompanied Lucio Lombardo Radice's meditation until the end of his days. The same concept was reaffirmed in another essay written in *l'Unità* in 1960. *La scuola della ragione* (*The school of reason*) encourages a real call to action for a new covenant of thought to defeat the growing irrationalism: conceiving of science and humanities as united areas of study was the only way to save society (and with it, the future of education and the schools) from the risk of seeing reason abandoned. It is the science-reason problem that must be addressed again, this represents the origin on which it is necessary to rethink a cultural path that is no longer purely scientific, but that takes into account in general the political and social situation.

8 Multi-level Popularization: Lucio Lombardo Radice's Popularization Writings

Lombardo Radice's work was not limited to appearances in various newspapers. In the same years he published various books with the same aim. In particular, his work was divided between a higher and a lower popularization: a part of his work was addressed to

[10] Lombardo Radice, L. (1962). Come insegnare le scienze ai giovani. *Rinascita*, 1 dicembre 1962, p. 27: "Lo sviluppo attuale delle scienze non implica soltanto uno straordinario progresso tecnico, ma anche nuove possibilità per la ragione. […] I due aspetti della scienza, tecnica e pensiero, non possono essere separati in un senso assoluto. Non si possono comprendere i progressi essenziali del pensiero scientifico se non si conoscono (in una certa misura) le tecniche necessarie; d'altro canto non si può dominare una tecnica se non ci si è impadroniti dell'idea in essa sottesa".

the introduction of relevant mathematical questions into the expert community; his greatest effort was dedicated to the debating of scientific issues for a higher audience of non-expert, as workers and citizens. On the one hand, he translated and edited many foreign "classics" of mathematics, introducing relevant contributions in Italy for the first time. He also debated, by means of his books, many of the "greatest" scientific queries of his age. On the other hand—like Faraday—part of his practice was also focused on a "lower" popularization for children. This intense activity started in the '60s and increased during the '70s. We are going to discuss these two important approaches briefly.

Referring to his deep commitment to translation and the introduction to foreign works, he focalised his attention on the history of mathematics and on the geometry of the last years of the nineteenth century. It was a florid period, rich with new concepts and historical turns. The very roots of mathematics were renewed and re-thought at this time: Lombardo Radice's main interest concerned the revolution caused by non-Euclidean geometry. His translation of the *Nuovi principi della geometria* (*New Principles of Geometry*) by Nikolaj Ivanovič Lobačevskij (1792–1856) was set in this context. In 1974 (40 years after its first publication) Lombardo Radice reintroduced, with his work, a fundamental but forgotten milestone of Soviet mathematics. Dedicating his efforts to this topic was not fortuitous. Lobačevskij's Russian origins were not an unimportant aspect because they served, at the same time, to affirm the great relevance of Soviet culture. For a staunch Marxist like Lombardo Radice, it meant to refer to a contemporary model (in his days) that implied a well-defined socio-political structure: the Soviet and Marxist one. Not by chance, his relationship with Russian (more generically, those under the Soviet influence) mathematicians, scholars and men of culture was intense and fertile. In his introduction to *Il perché di una scelta* (*The reason for a choice*) he insists on the idea of the "permanence" of classics in the history of the culture: it is the reason why some books can be interpreted as new in all ages. *I nuovi principi della geometria* by Lobačevskij seemed to exceed his original context and seem up-to-date and modern despite the passage of time. In Lombardo Radice's interpretation, the timeless nature of Lobačevskij's discoveries could also be understood as philosophical. Thanks to Lobačevskij and the other authors of the non-Euclidean *milieu*, geometry had the chance to pass "from being to thought, and not from thought to being", and this appears to be "the true route of geometry, as the same of all the other sciences" (Lobačevskij 1994, 43). Lobačevskij seems to be like a current philosopher because of his fight against formalism, a priori metaphysics and his revolutionary idea to overpass the conception of mathematics based on ideal entities. In this sense, Lobačevskij had the same prerogatives of materialism. So, *ça va sans dire*, Lombardo Radice's actualization speech highlighted the "eternal battle" between materialism and idealism, one of the unavoidable points of his reflection: Lobačevskij forestalls materialistic planning. The history of culture is full of these episodes of opposition to "bad" idealism and this is the motive for this strong criticism and the reason why the cultural revolutionary struggle must continue. As we can observe, Lombardo Radice always faced theoretical sparks even in different contexts. Reaffirming his will to discuss the contrast between idealism and materialism meant talking to his audience about contemporary problems of social and political pertinence. He found no reason to do his work without the presence of a socio-political implication: it would only have been an empty job and a pointless exercise.

With the same intention to fight in the name of a renewed culture that went beyond the domain of idealism, Lombardo Radice dedicated his attention to the whole history of mathematics in 1976. This time *A History of Mathematics* by Carl B. Boyer (1906–1976) was translated and introduced in Italy for the very first time. Originally published in 1968, thousands of years of mathematics were summarized and well narrated in this epochal

work: it covers the entire branch of knowledge from its ancient origins to the newest developments. Beyond its important worldwide success, it was very important to present *Storia della matematica* by Boyer to Italian students and a general audience in a controversial period. Paradoxically, Boyer's book was destined to become a modern "classic", and it is considered as such today. We can say that Lombardo Radice had good intuition on this occasion: obviously, mathematics remains the most appropriate field of his investigations.

"The publication, in Italy, of this great work by Carl B. Boyer seems a remarkably important event" (Boyer 2017, XV) because we should consider it as a "history of the history of mathematics" with a "socio-historical collocation of the treated mathematical developments", not indifferent to the philosophical significance of mathematical thought's highest moments (Boyer 2017, XVI). For these reasons, Boyer's book is part of the Italian 'new culture', the one delivered over "the end of the leading role, often of the dictatorship, of idealism" (Boyer 2017, XIII) and finalized to rethink science not exclusively as technique, but as something equipped with its own history, "humanity" and social relevance. For Lombardo Radice, the greatest merit of Boyer's book is the following:

> Carl B. Boyer managed to write a complete work, sufficiently analytical to satisfy the needs of those who want to go deep, even from a technical point of view, and, at the same time, sufficiently concise ad to be legible—at least in the first approximation—and to a large extent—even to those who are not "mathematics technicians" (Boyer 2017, XV)[11].

In brief, a book for everyone, useful for technicians to study history and believed to be an accessible tool for a wider audience, young students in particular. Already, Lombardo Radice's intention was not addressed to academics and experts. His mind was focused on increasing general culture for a new generation. To introduce new mathematical arguments and to refresh historical science pertinence is part of his political and educational plan for a greater citizen awareness about scientific matters. Once again, scientific consciousness means to have competence as citizens and to be active players in society's dialectics.

Returning to the question of the unity between thought and science, specifically between mathematics and philosophy, lead us to another important translation. Previously, in 1972, with his *Presentazione* to the *Mathematical Manuscripts* by Karl Marx, Lombardo Radice introduced an extensive but underestimated topic in Italy. It was the occasion, for Marx, in a letter to Engels in 1881, to discuss the foundations of infinitesimal calculus (Marx 1975). Lombardo Radice's presentation wanted to shed light on the purpose of *Manuscripts* from a philosophical point of view: Marx's aim, in Lombardo Radice's interpretation, was to find "a decisive argument against a metaphysical interpretation of the dialectic's law of the negation of the negation" (Lombardo Radice 1972a, b, 275; see also Dauben 1998; Kennedy 1977, 1978). With the same assumption, at the very beginning of his scientific parabola, in late 1950 he had first translated Engels' *Dialectics of Nature*: it represents, with the precedent *Anti-Düring*, the most important reflection by Engels about science (Engels 1968). Simultaneously, these two essays were strong attacks against the law of dialectics. Specifically, the *Dialectics of Nature* tried to "abolish" the negation of the negation furnishing a naturalistic interpretation of the mathematical differential. It was

[11] "Carl B. Boyer è invece riuscito a scrivere un'opera completa, sufficientemente analitica per soddisfare le esigenze di chi vuol andare abbastanza a fondo, anche dal punto di vista tecnico, e nello stesso tempo sufficientemente sintetica per risultare leggibile—almeno in prima approssimazione—e in gran parte—anche a chi «tecnico della matematica» non è".

conceived of as a physical indivisible just like molecules and atoms (Lombardo Radice 1972a, b, 277). It realises the chance to underline how a science, mathematics, can be useful to thought, philosophical thought, and vice versa. Marx and Engels' theorizations were "completed" by the scientific evidence, so that "the *Mathematical Manuscripts* give us a convincing methodological indication about the relationship between science and philosophy" (Lombardo Radice 1972a, b, 277). In the final lines of his presentation, Lombardo Radice emphasised how this relationship is fundamental to keeping science and thought connected so as to overcomes "the block between the two cultures" in the name of a unique reciprocal enrichment.

The real intention to popularize mathematics is found in Herbert Meschkowski's *Mutamenti del pensiero matematico* (*Wandlungen des mathematischen Denkens*) originally printed in Germany in 1960. The first Italian version of the book appeared in 1963: 10 years later Lombardo Radice presented the book again as a volume for the publisher Bollati Boringhieri's "Biblioteca di cultura scientifica" (Scientific Culture Library) series. For the editor, it meant that in 1973, 10 years after the first edition, a cultural mutation had already begun in Italy.

Meschkowski's book is an attempt to "translate" difficult mathematical theories into common sense language, as it was in a prevalent view of the times. It is important to point out that this is an outdated vision of popularization: as noticed by several scholars, it is a traditional and problematic oversimplification, which cannot perform a real spread of knowledge. It may entail the risk of distortion between what an expert said and what a non-expert understands, so to have as result a distortion of science itself and the disadvantage to pursue only its political legitimacy (Hilgartner 1990). This approach was not in line with the most recent methodolo gies based on a participatory and dialogical view, developed starting from the 80s (i.e. Shinn and Whitley 1985) and still timely today (Einsiedel 2008; Bucchi 2008; Irwin and Jensen 2012).

As the author declared in his *Introduction*, it is possible to permit scientific "lay people" to understand scientific knowledge seriously on the model of contemporary English men of science (Meschkowki 1976, 14). On this, Lombardo Radice underlines how it was reasonable, throughout the '60s, to create a real scientific "consciousness" thanks to the efforts of a delicate process of cultural elaboration. A process to which he was not extraneous, as we have seen. So it happened that Meschkowski's work was destined to a "new mass of readers" (Meschkowki 1976, 3) reached over the years and now asking for scientific clarification. In this sense, "Mathematics is (should be) *one* of the unification elements" between technique and thought (Meschkowki 1976, 8). The importance of scientific popularization became essential for the creation of a new cultural path, the united one that Lombardo Radice pursued along the lines of his full reflection.

Is this cultural operation imagined just for the new masses and the making of their scientific consciousness and social awareness? The answer, for Lombardo Radice, is no. Because of this, he also turned his consideration to a "lower" popularization. The best way to realize a new cultural pact is to address the young generations. The precept of Gramsci's theory of cultural hegemony, reveals how important it is to start to create a new scientific consciousness in children's education, too. We must not forget, as we said previously, that Lombardo Radice's membership in the Communist Party, and, in particular, his role as a member of the cultural committee, was important for understanding the logic of his activities.

Pedagogy and scientific popularization were related and were judged urgent in the situation of change that Italy was undergoing. The protests in 1968 declared a new popular for a revolution in customs that overwhelmed the entire culture. Close to the working-class, the

main protagonists of the protests were students. They were asking for a modernised culture that could be appropriated to the contemporary situation of that time. This push from below was intercepted by the communist party, although not always with the right interpretation. Lombardo Radice, on the contrary, was one of the best interpreters of the situation. His *Educazione e rivoluzione* (*Education and Revolution*), published in 1976, referred back to some of his 1968 writings originally published in *Riforma della scuola*. Its pedagogical analysis has been studied at length. This is why 8 years later, in 1976, it was necessary to publish his interventions again. For the same reason, the problem of education of the youth was discussed again in 1962 in *L'educazione della mente* (*Education of Mind*). It is important to notice that one of the main chapters of the book is dedicated to the role of toys in education. To play is intended as a means of "knowledge and expression" (Lombardo Radice 1972a, b, 48), a way of growing that precedes school education and invites children to participate in self-formation. Drawing, painting, watching a film or a cartoon, inviting them to do scientific activities, to play with reasoning and entertaining them with riddles and brain-teasers are all good ways to encourage children's mental activity and exercise their creativity.

In 1971 *La matematica da Pitagora a Newton* (*Mathematics from Pythagoras to Newton*) was specifically addressed to children. An "adventure" of thought that started with antiquity and continued up to the time of Newton. The book is written for younger readers, intentionally "short and easy". The only requirements are care and interest (Lombardo Radice 2014, 12). Besides the "adventure" of mathematics and its knowledge, the book invites children to experience of the theories of the great mathematicians of the past. The young readers are advised to keep a pencil and a paper close by to try calculus, drawings and reasonings. A cultural operation can be glimpsed in an intellectual operation that makes the child the protagonist of the history narrated, thanks to a didactic call to self-education.

in the name of the great cultural "epopee" of *Ulisse*, with the name of the ancient Greek hero symbolic of the virtues of knowledge. *Ulisse* was imagined as an encyclopedia for children. Specifically, as newspapers like *Corriere della Sera* on 30 May 1976 entitled the encyclopedia for communist children, a Marxist version of Ulysses[12]. It represented the effort to keep avant-garde researches accessible to elementary culture. Several men of science like Carlo Bernardini (Physics, 1930–2018) and Adriano Ossicini (Psychiatrist, 1920–2019) participated on the editorial staff. The encyclopedìa's ten volumes were also admirable not only for their contents but also for the innovative graphic editing. The presence of draws and illustrations was essential to describe to children the topics covered. Some paintings by Renato Guttuso and the illustrations by Amedeo Gigli were created for the occasion. At the same time, works of Soviet realism portrayed moments of everyday life. The volumes aimed to introduce children to the scientific world, to inspire them with an active reading preparatory to a self-guided understanding. The long and voluminous work was conceived of by Lombardo Radice as an inevitable push in the direction of a regenerated culture that should begin in childhood. Today's children are the men of the future: this was the objective of his intentions. A new mass of conscious and scientifically prepared men could be built only by raising a new generation "cradled" in a specific sociopolitical context: that of a new culture that bases itself on the roots of the unity between science and the integration of the different branches of thought. To do this, every means

[12] Larco, R. (1976). Ulisse marxista, *Corriere della Sera*, 30 maggio, p. 11.

was useful for reaching the goal. One thing was clear: science had now become something that should no longer be limited to academia and laboratories. It had to break down the doors to these rooms to become a shared problem. As we are going to see, also television resulted fundamental to "move" culture outside its classical channels and let it turn into something available for all the citizens. Acknowledged masses were retained more important, socially and politically, of a few elites of experts. This, in the end, could be regarded as the real democratic core of Lombardo Radice's activity.

9 Television as the Most Effective Media

Lombardo Radice's cultural production was not limited to the editorial sphere. Starting in the '60s, television became the most influential instrument of communication. In Italy, it was the principal vehicle of information and entertainment. We can say that television was the main means of Italy's "great transformation": culturally, socially and politically (Monteleone 1999). In a word, television can be considered the most influential instrument of Italian "modernization". Different cultural models were established and then adapted to society as references to search for a new identity (Bechelloni 1984, 122). The appropriation of the term "mass" for this media was symbolic of a real situation. Naturally, it raised the interest for a political plan. It follows that the urgency for widespread education was assimilated by the Italian political class and television stood out as the best means for its practical realization. For example, *Non è mai troppo tardi* (*It's never be too late*) was broadcast for the first time in 1960. Through this program, RAI (Italian Radio-television public service) wanted to bring literacy to the large percentage of illiterate Italians who were lagging behind the new speed with which the country was moving forward. Thanks to on screen lessons by "Maestro" Alberto Manzi a huge number of people learned to write and to read. It is estimated that over 1.5 million people were able to earn their elementary school diploma with this methodology. The social role of the program was inestimable.

Symbolically, the year 1960 was a watershed. From here forward—based on the previous experiences—a stable project could start (Grasso 2019, 188). On the wake of this success, RAI's pedagogical plan (in accord with the Education Minister) increased, so that it became necessary to increase the number of channels in 1961. Responding to different needs, the second channel (Secondo Canale) was launched on 4 November, initially with only 2 h of programming (Piazzoni 2018, 71). Television, for Italy, represented a real means of social integration. It was so clear that the future "game" for interception of the masses was going to be played on this pitch in all settings. The report of a deeply changing society was exclusively recounted by the power of the cathode-ray tube and by the means of the new protagonists who had the responsibility to keep citizens aware and informed on what was happening in all areas. The screen revolution was a cultural revolution in the real sense of the word. In the decade between 1956 and 1965, the timing of Tv programming passed from 1.977 to 4.708 h; cultural type programs covered from 38 to 47% of the broadcasts, with a vertex of 53% in 1962. At the same time, in 1966, transmitters were able to provide the service for 98% of the population. The greatest marking of these changes is furnished by the hike of the number of televisions in Italians' houses: from 3% in 1956 to 43% in 1965 (Farné 2003, 20). It was necessary to take this change into account for a correct and adequate interpretation of the times.

Science also had the opportunity to be the "subject" on the screen. As to the pedagogical motive wanted by politics, it was best to formulate original formats able to engage

people on scientific themes. It is important to underline that the English BBC's programs furnished the model on which scientific topics were developed. The English broadcasting company's productions were various and well-organized. Just to cite some examples, *The Prizewinners* and *Horizons* provided leading standards. As we remarked before, the idea to broadcast the Royal Institution's *Christmas Lectures* started at the BBC. Science communication was of primary importance in the English post-war years.[13] On Italian screens, one of the first and most successful programs was *Orizzonti della scienza e della tecnica* (*Science and Technique Horizons*) presented by Giulio Macchi (1918–2009). It was first broadcast in 1966 and ended in 1973, and was a genuine moment of scientific popularization. Usually, Macchi wanted to link the great topics of science with everyday life problems. One of his main aims was to make the figure of the scientific researcher more "human", to underline that there were no divisions between scientific research and life (Grasso 2019, 306). Science was popularized in the function of its application, to do it in the best way sometimes different characters from the scientific world of the time, even great names on the international scene, like the Nobel-Prize winner Jacques Monod, were involved. It is important to highlight that Giulio Macchi was not an academic, but only a director (de Ceglia 2011, 339). Because of this, entertainment was emphasized, to capture the audience's attention.

Several other opportunities to put everyday problems linked to science on the screen were furnished by prevailing topics like the revolution of Franco Basaglia (1924–1980) in radical psychiatry or the debate on the use of nuclear power. Audiences paid great attention to one of the most important events of the century: American astronauts lading on the moon on 21 July 1969. The public television service dedicated 25 h of non-stop live recording to this event. Still today it represents the longest marathon in Italian television history. Scientists and public characters were invited to several studios to debate, dream, and hope while watching the first human step on the Moon. Because of the number of viewers throughout the entire country, that night holds the record for there being no robberies in all of Italy. It was also the first interactive show: many reporters were sent to Italian places to interview common people and various telephone lines were dedicated to spectator's questions. A real 360° event of science popularization. Starting the same year, another great operation of science communication was launched with the series *Sapere* (*Knowledge*). It was a more generic format about general culture including diverse specific programs on science. Just to cite some examples, *Pianeta Terra* (*Planet Earth*), *Uomini dello spazio* (*Men of space*), *Le grandi invenzioni* (*Great Inventions*) and *L'età della ragione* (*The age of Reason*) were some of the titles involved. These episodes are only indicative of a more developed production. We must not forget that a series of tv movies were produced, often portraits of the greatest scientific characters of the past. It was connotative of a generic cultural process that wanted to engage people in scientific matters and generate shared knowledge at the same time.

A large production implies a large inquiry from the public, but undoubtedly the manifest intent of television producers to educate the public following a wider political demand. Probably, the audience' request was related to a more general social request for knowledge and education, developed in the context of national television's pedagogic goal. Lucio Lombardo Radice—the man who was fighting for a public dimension for science consciousness—could not have been indifferent to the possibilities offered by the power of

[13] We can't face here this important topic. For this reason we consider useful a reading of the following references: Boon (2008, 2018), Jones (2001), and Farry and Kirby (2012).

television. Over the years, he also tried to bring science into Italian homes thanks to his radio programs. But the immediacy and efficacy furnished by television were more useful for his intents. So, during the 70s, he began to organize a series of television shows, speeches and movies capable of creating an efficient strategy for public understanding.

10 Science Must Be Shown: Lombardo Radice and Television

Once again, mathematics was his first attempt to test new media experiments in an original way. In the circumstances outlined, Lombardo Radice's pedagogical aim had to take into consideration the newest resources. Indeed, his Party had also clearly understood the range of this technological revolution that was absorbing Italians' lives. What better than a tool strongly inclined, through its shows and new forms of entertainment, to fully involve the masses of the country? To get the message to the people was Lombardo Radice's fundamental concern. The very heart of his intellectual pursuit could be channelled in effective teaching to a broader audience. And to do this, all means were acceptable.

As we said, his operation could start with a mathematical proposal. *Dall'uno all'infinito* (*From one to Infinity*) was broadcast for 12 episodes on national television starting in 1971. The program was an introduction to mathematics, both theoretical and historical. The problem of infinity was significant in Lombardo Radice's reflection. The choice of the title already referred to the historically unsolved issue of mathematical entities. For this reason, the coexistence of a double approach—both "purely" mathematical and both historical—was necessary. Angelo D'Alessandro (1926–2011) was the program's co-author, he was one of the most active RAI directors and screenwriters during the 70s. *Dall'uno all'infinito*'s aim was to complete a sort of mathematical introductory path by the means of its 12 episodes, furnishing at the same time a detailed analysis and an overview of the contemporary debate. The education plan of RAI and the ministry was perfectly suited to what he was trying to do.

Another critical point of Lombardo Radice's reflection was connected to the theme of "revolution", particularly concerning the cultural meaning of this concept. We can't ignore the use that the term "revolution" acquired with the well-known *The Structure of Scientific Revolutions* written by Thomas Kuhn (Kuhn 1962). The publishing of Kuhn's book, in 1962, strongly influenced the future idea of 'scientific progress', drawing attention on the tight bond between the history of science and its sociological aspects. The book furnished a new interpretation of scientific development, based on a historical analysis which refused the prevailing idea of cumulative progress. For Kuhn, the history of science develops with interruption, with moments of discontinuity compared to the previous normality of science. The birth of 'anomalies' is what starts a scientific revolution. And this mechanism—the same in every interruption of a paradigmatic state—is the same in actual science as it was in the past. Is this the reason why Kuhn's approach is, first of all, historical and consequently sociological and political. Kuhn's essay inaugurated a new conceptual scheme that wouldn't be ignored in the following decades. A model in which also a political reading of science facts resulted conceptually re-organized.

That's why Lombardo Radice's *Le rivoluzioni della scienza* (*The Revolutions of Science*) began in 1972 with the intent to highlight how cultural revolutions were possible and essential drawing inspiration from the past. In this case, the narration was primarily historical. Four episodes were dedicated to the greatest scientific developments in history and the long path necessary for their realization. The Heliocentric revolution was the object

of the first broadcast in *La rivoluzione eliocentrica* (*The Heliocentric Revolution*). It was the long story that commenced with Ptolemy and ended only in the sixteenth century with Copernicus' battle, after a travail that lasted over one thousand years. The second episode, *La rivoluzione atomistica* (*The Atomistic Revolution*), covered an even longer period: it began with the Greek philosopher Democritus in the fifth century BC and concluded with the Danish physicist Niels Bohr at the beginning of the twentieth century. This episode analysed the developments and the progress in atomic theory. Second to last, shorter in its historical treatise than the others, was *La rivoluzione evoluzionistica* (*The Evolutionist Revolution*), dedicated to the topic of the advancements in evolutionary matters. Since the eighteenth century—starting from Linnaeus taxonomies—continued on to Charles Darwin's theorization. Darwin was specifically seen as a specimen revolutionary who had changed not only a scientific view but also the socio-political conception of humanity itself. The last episode was devoted to a dissertation on physics. Its focused on the intricate progression of the "new" physics after Isaac Newtons' discoveries. It concluded with Albert Einstein's (1879–1955) relativity and had as its main object of investigation the issue of gravity. It was entitled *La seconda rivoluzione fisica* (*The Second Physics' Revolution*), which indicates the topic of the second physics revolution.

Students and youths were favourite spectators. Once again, Lombardo Radice's objective cannot be ignored: he wanted, with his programs, to start a cultural reaction useful to spread an original response of public value. As noticed by Francesco Paolo de Ceglia, for Lombardo Radice "the term «revolution», in all its Marxist significance, reappeared almost obsessively. Science was intended as an intrinsic political power" (de Ceglia 2012, 223). All of this should also be considered valid for Lombardo Radice's most important television work, *Uomini della scienza* (*Men of Science*). "Men of science", in English, was a five episodes series, more specifically, a set of five movies that narrated the biographies of five different scientists who lived between the eighth and the nineteenth centuries. It was originally formulated in 10 episodes. Its initial intent was to start from Archimedes and arrive at Einstein's recent contribution. Furthermore, it was originally programmed for the year 1972. It saw the light only in the autumn of 1977 after an endless series of difficulties and controversies (de Ceglia 2012, 221–228).

Going deeper into the matter, the movies were preceded by a brief introduction by Lombardo Radice, who described the most distinctive scientific features. Sometimes experts and scientists specifically knowledgeable about the subject participated in the introduction. His aim was to propose science with scientists, and at the same time for men and their property. Real "raids" into the history of science were brought to life. Theoretical debates then followed the movie's broadcast. For example, the author addressed the theme of science neutrality, dear to him, at the end of *Ipotesi sulla condanna a morte di A. L. Lavoisier* (*Hypothesis on A. L. Lavoisier's Death Sentence*).

> The authors of the TV movies did not present a thesis, they only wanted to present hypotheses. More than ever, therefore, a conclusive debate is needed. This time the debate must necessarily be on the relationship between science and political society, on the neutrality of otherwise of science. This is one of the central issues under discussion today both outside and inside the world of scientists (Archivio RAI Teche, G54059).[14]

[14] "Gli autori del telefilm non hanno esposto una tesi, hanno solo voluto presentare ipotesi. Più che mai, quindi, è necessario un dibattito conclusivo. Questa volta il dibattito deve essere obbligatoriamente sul rapporto scienza—società politica, sulla neutralità o meno della scienza. E questo è uno dei temi centrali in discussione oggi fuori e dentro il mondo degli scienziati".

The episodes combined high-level information with the spectacle of a film, offering the opportunity to conduct deep debating about current topics in the scientific world, and, at the same time, the socio-political dimension.

The episodes were structured as biopics: biographic portraits carried forward what was happening on the screen. As we said, only five of the ten planned episodes were broadcasted in the end. In the following order, episodes were broadcast on the experiences of Jean Baptiste d'Alembert, Lazzaro Spallanzani, Antoine-Laurent Lavoisier, Alessandro Volta and Gaspard Monge. The first episode, *Il sogno di d'Alembert II* (*D'Alembert's Dream*), examined the intellectual conquests of the Enlightenment's encyclopaedism, outlining the crucial role of the French philosopher. *La ballata dell'abate Spallanzani* (*The Ballad of Abbot Spallanzani*) treated the eighteenth century's experimental biology, by examining the controversial figure of Lazzaro Spallanzani, both a man of faith and a scientist. The next episode presented a portrait of Lavoisier, a great experimenter and chemistry revolutionary, in *Ipotesi sulla condanna a morte di A. L. Lavoisier*. Continuing, *La luminosa carriera del prof. Volta* (*Professor Volta's Bright* Career) was conceived of as an overview of Volta's brilliant character. His electrical discoveries offered the European society of the times a great opportunity for progress, and this was underlined for its intrinsic political reach. Lastly, the series ended with *Elogio di Gaspard Monge fatto da lui stesso* (*Gaspard Monge's Acclaim made by himself*) about the French mathematician Gaspard Monge, who was the father of descriptive geometry. Only this last case presented a character belonging to the world of mathematics.

It is curious to note that *Il sogno di d'Alembert*' caused a real political affair. Several workers were invited by Lombardo Radice during the post-show debate to discuss the possibility of a workers' science. The workers' intervention created an unexpected misunderstanding because of their unconventional approach. The presentation of the program was different from how the project had previously been imagined, and—despite Lombardo Radice's noble intent—the workers lost the opportunity to seriously debate with him. As the philosopher and jurist Norberto Bobbio (1909–2004) said from the pages of the newspaper *La Stampa*, it was "a missed opportunity".[15] A cruel offensive against Lucio Lombardo Radice began with this event. The attack was not just scientific, it provided the possibility to attack the entire Communist Party's political program. Apart from this, it proved itself as a clear aggression against Lombardo Radice's ideas, a sort of evidence of his failure about his deep socio-political dreams.[16] Despite the problems surrounding this episode, as we have seen, the series continued through its programmed schedule. This project was possible thanks to the help of the director Ansano Giannarelli. Another affair in Lucio Lombardo Radice's life is tied to his name. With the same Giannarelli, again in reference to the portrait of a great mathematician, Lombardo Radice undertook the project of a single movie, destined to be presented at the cinema. It recounted Évariste Galois's last days. The movie presumed to be an explicitly political production. The same Galois, who was connected to the events of the French Revolution, provided an excuse to address a political cause and to ascribe it to science. Évariste Galois was one of the pioneers of abstract algebra, a branch well known and dear to Lombardo Radice. His scientific consultation

[15] Bobbio, N. (1977). Quando all'accademia si fa cultura. *La Stampa*, 12 Novembre, p. 3.

[16] For a complete description of the event and for a deeper analysis, see: de Ceglia (2012). "Il fattaccio dell'Accademia". Lucio Lombardo Radice, la storia della scienza in televisione e le polemiche dei compagni. In de Ceglia, F. P. and Dibattista, L. (Ed.), *Semi di storia della scienza. Saggi in onore di Mauro Di Giandomenico,* Milano: Franco Angeli, 213–246.

was fundamental to the movies' success Conceived of in the year 1971 and presented at the Cannes *Festival* during 1972, after a long series of polemics, criticism and censorship, it was screened on Italian television definitively in 1977. It was entitled *Non ho tempo* and was definitively broadcast as a sort of docufiction in three episodes. In previous years, the question was strongly debated in newspapers. It became a problem of freedom, as noticed by Lombardo Radice's article *Libertà per Evaristo* (*Freedom for Evaristo*) in *l'Unità* on 25 March 1973. The truth is that it was difficult to screen a movie that encouraged student protests against the authority of teachers and the institutions during those difficult years of Italian history. To explain it, it is necessary to understand how the cultural operation of Lucio Lombardo Radice was inscribed into the weft of the society in which he lived. He was already conscious of the danger that this type of movie could trigger. But in his mind, even by means of radical actions, no one should be able to limit his pursuit of the freedom of science and the achievement of his pedagogical objectives. There was a need that was rising from the youth, from the new generations and from all levels of society, too. To be indifferent to this situation not possible for Lombardo Radice. In part for the Party, but to fulfil his idea above all, he had to ride the wave of a rising new culture.

11 Conclusion: "We Need Scientific Mediators"

In the end, we can say that Lombardo Radice himself embodied the cultural battle to achieve a new scientific scenery. His activities did not stop at a mere ideological intent, despite his political affinity. Nor can we say that it was reduced only to writings and daily news comments. His purpose was deeper and his actions more concrete: they concerned an undertaking of civic and social significance, in which involving the people in political and scientific aspects was the same as having as a precise vision of society and culture. There is no need to list the large number of conferences and conventions carried out thanks to his tireless efforts. It would be worthwhile to carry out another specific study to analyse his work with children in Italian schools and his affiliation with pedagogical activities in the didactics of math (specifically with Emma Castelnuovo and the *Riforma della Scuola*'s group). We have not even the chance to talk about his early radio experiences. All of these are themes that should motivate future studies.

What it is important to stress is that his strong determination moved him to represent one of the essential cultures of Italian scientific communication. He personified the figure of a man completely absorbed in his role as a great intellectual engaged in society's problems, who wanted to change the reality of his era with concrete actions of civil significance. Gramsci's dream of "creating" an aware citizen as "specialist + politician" adhered perfectly to what Lucio Lombardo Radice's plan implied. We can say that Gramsci's warning was certainly at the origin of his thought, as is demonstrated by reading one of the most lucid analyses between *Educazione e rivoluzione*'s pages:

> *Specialist plus Politician*. This is the formula used by Antonio Gramsci, in his *Notebooks from Prison*, for the intellectual, in particular for the intellectual who is organically linked to the revolutionary class. I would like it to become the fundamental operative word in the education of men for a future society in which everyone will be intellectuals, all citizens (Lombardo Radice 1976, 24).[17]

[17] *Specialista più politico*. È questa la formula usata da Antonio Gramsci, nei suoi *Quaderni dal carcere*, per l'intellettuale, in particolare per l'intellettuale organicamente legato alla classe rivoluzionaria. Vorrei

For these reasons, it was necessary to communicate science, to engage people with it and to involve the masses in a positive activity that was at both political and professional. A conscious society starts from a conscious man: there is no alibi and there are no alternatives. A true citizen would be such only through a revolution of mentality, which would bring with him, more generally, a cultural revolution.

It was the "dream" pursued by Lombardo Radice. To create—uniting specialization and common sense—a utopian society for a better future based on scientific knowledge. In one of his last interviews, before he died while he was participating in an anti-nuclear manifestation in Brussels, he focused his attention on a hoped-for social figure capable of making his desired revolution possible. Referring to his hope for the birth of an organized movement of "scientific mediators" he seems to leave us his intellectual heritage in the following words stated in an interview for *La Stampa*.

> I believe that today more than ever that mediators between science and common thought are therefore necessary. If it is true, as it is true, that scientific thought is thought tout court […] then there must be those who, by profession, learn from science what thought is, what interests the "common mind". At the same time, there must be those who are systematically responsible, by trade, for the choice (continuously renewed) of the special technical notions indispensable for understanding the scientific thought to be taught in school for everyone, and the best way for them to be understood and assimilated. There must be the epistemologist mediator, the historical mediator of science, the mediator specialized in teaching the exact and experimental sciences. The logico-mathematician, mediator between philosophy and mathematics must exist; there must be a psychologist, mediator between pedagogy and biology. The unity of culture is realized […] in the new form, typical of our times of the "working group", of the collective intellectual.[18]

These last words totally show Lucio Lombardo Radice's radical loyalty to science and briefly summarize the good intentions of his intellectual depth. He consecrated his life to politics, to education and science popularizations because of their correlations: what was considered to be his personal way for a new society should be constructed from this interlacing. Analysing this experience, he provides us with an account of the importance of a historical overview also useful for analysing mere theoretical problems. Encouraging new analyses starting from a historical case can be considered useful for a more in-depth focus and help to propose alternative solutions. Moreover, following a non-academic path, for a true encounter between the community and the experts, could promote the growth of

Footnote 17 (continued)

che divenisse la parola d'ordine fondamentale nella educazione di uomini per una futura società nella quale tutti saranno intellettuali, tutti cittadini.

[18] Lombardo Radice, L. (1980). Lombardo Radice: ora ci vogliono i mediatori, *La Stampa*, 12 luglio, p. 4: "Io credo che oggi più che mai siano perciò necessari i mediatori tra la scienza e il pensiero comune. Se è vero, come è vero, che il pensiero scientifico è pensiero tout court […] allora ci deve essere chi, per mestiere, enuclea dalla scienza ciò che è pensiero, ciò che interessa alla «mente comune». Nello stesso tempo, ci deve essere chi si occupa sistematicamente, per mestiere, della scelta (continuamente rinnovata) delle nozioni tecniche speciali indispensabili per comprendere lo stesso pensiero scientifico da insegnare nella scuola per tutti, e del modo migliore per farle comprendere e assimilare. Deve esistere il mediatore epistemologo, il mediatore storico della scienza, il mediatore specialista di didattica delle scienze, esatte e sperimentali. Deve esistere il logico-matematico, mediatore tra filosofia e matematica; deve esistere lo psicologo, mediatore tra pedagogia e biologia. L'unità della cultura si realizza […] nella forma nuova, tipica dei nostri tempi del «gruppo di lavoro», dell'intellettuale collettivo".

argumentations and genuine new educational paths. Lucio Lombardo Radice's experience, in particular, reminds us of the possibility of trying radical ways to "savor" the true meaning of a conscious dissemination of popularisation, with its profound social and political meaning in which citizens are truly engaged and involved in scientific practices, considered true protagonists in democratic dialectics.

In conclusion, this paper wanted to represent just a single effort of reflection. At the same time, the main purpose was to describe a case study that could be considered an example of historical focus connected to the public understanding of science debate and to the variety of modalities of engagement in science. The characterisation of a non-academic experience—started with Joule and Faraday (and many others) long ago in Victorian England—followed this line. Many other studies will be necessary starting from the bases that have recently been developed by some scholars who are fortunately focusing their attention in this direction.

References

Almassi, B. (2009). Trust in the expert testimony: Eddington's 1919 eclipse expedition and the British response to general relativity. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics, 40*(1), 57–67.

Andrews, J. T. (2003). *The Bolshevik State, public science, and the popular immagination in Soviet Russia, 1917–1934*. College Station: Texas A&M University Press.

Andrews, J. T. (2013). An Evolving scientific public sphere: State science enlightenment, communicative discourse, and public culture from imperial Russia to Khrushchev's Soviet times. *Science in Context, 26,* 509–526.

Baracca, A. (2017). *Storia della fisica italiana: Un'introduzione*. Milano: Jaca Book.

Baracca, A., Ruffo, S., & Russo, A. (1979). *Scienza e industria 1848–1915*. Roma-Bari: Laterza.

Barra, M. (1985). *L'unità della cultura. In memoria di Lucio Lombardo Radice*. Bari: Dedalo.

Barton, R. (1998). Just before *Nature*: The purposes of science and the purposes of popularization in some English popular science journals of the 1860s. *Annals of Sciences, 55*(1), 1–33.

Bauer, M. W., & Jensen, P. (2011). The mobilization of scientists for public engagement. *Public Understanding of Science, 20*(1), 3–11.

Bauer, M. W., Shukla, R., & Allum, N. (2012). *The culture of science: How the public relates to science across the globe*. London: Routledge.

Bechelloni, G. (1984). *L'immaginario quotidiano: Televisione e cultura di massa in Italia*. Torino: ERI.

Boon, T. (2008). *Films of fact: A history of science in documentary films and television*. London, England: Wallflower.

Boon, T. (2018). 1962: 'What manner of men?' Meeting scientists through television. *Public Understanding of Science, 28*(3), 372–378.

Bottomley, J. T. (1882). Scientific worthies: XX—James Prescott Joule. *Nature, 26,* 617–620.

Bowler, P. J. (2009). *Science for all: Popularization of science in early twentieth-century Britain*. Chicago and London: University of Chicago Press.

Boyer, C. B. (2017). *Storia della matematica*. Milano: Mondadori.

Brock, W. H. (1973). *Science for all: H.E. Armstrong and the teaching of science, 1880–1930*. Cambridge: Cambridge University Press.

Bucchi, M. (2008). Of deficits, deviations and dialogues: Theories of public communication of science. In M. Bucchi & B. Trench (Eds.), *Handbook of public communication of science and technology* (pp. 57–76). London and New York: Routledge.

Bucchi, M., & Trench, B. (2008). *Routledge handbook of public communication of science and technology*. London: Routledge.

Bud, R. (2014). 'Applied science' in nineteenth-century Britain: Public discourse and the creation of meaning, 1817–1876. *History and Technology, 30*(1–2), 3–36.

Capocci, M. (2011). Politiche e istituzioni della scienza: Dalla ricostruzione alla crisi. In C. Pogliano & F. Cassata (Eds.), *Scienze e cultura dell'Italia unita* (pp. 265–294). Torino: Einaudi.

Cardwell, D. (1982). Industry, thermodynamics and society in the Nineteenth Century. *Entropie, 18,* 13–20.

Cardwell, D. (1989). James Prescott Joule and the idea of energy. *Physics Education, 24*(3), 123–127.

Cardwell, D. (2003). *The development of science and technology in nineteenth-century Britain*. Aldershot: Ashgate Variorum.
Ciglioni, L. (2017). Italian mass media and the atom in the 60s: The memory of Hiroshima and Nagasaki and the peaceful atom (1963–1967). In E. Bini & I. Londero (Eds.), *Nuclear Italy: An international history of Italian Nuclear policies during the cold war* (pp. 165–179). Trieste: EUT.
Cozzoli, D., & Capocci, M. (2011). Making biomedicine in twentieth-century in Italy: Domenico Marotta (1886–1974) and the Italian Higher Institute of Health. *The British Journal for the History of Science, 44,* 549–574.
Crainz, G. (2009). *Autobiografia di una repubblica: le radici dell'Italia attuale*. Roma: Donzelli.
Dauben, J. W. (1998). Marx, Mao and mathematics: The politics of infinitesimals. *Proceedings of the International Congress of Mathematicians, II,* 799–809.
de Ceglia, F. P. (2011). La scienza al cinema, alla radio, in televisione. In F. Cassata & C. Pogliano (Eds.), *Annali della storia d'Italia* (Vol. 26, pp. 321–348). Torino: Einaudi.
de Ceglia, F. P. (2012). "Il fattaccio dell'Accademia": Lucio Lombardo Radice, la storia della scienza in televisione e le polemiche dei compagni. In F. P. de Ceglia & L. Dibattista (Eds.), *Semi di storia della scienza: Saggi in onore di Mauro Di Giandomenico* (pp. 213–246). Milano: Franco Angeli.
Dolbear, A. E. (1890). James Prescott Joule. *Proceedings of the American Academy of Arts and Sciences, 25*(May), 346–351.
Eddington, A. S. (1920). *Report on the relativity theory of gravitation*. London: Fleetway Press.
Einsiedel, E. F. (2008). Public participation and dialogue. In M. Bucchi & B. Trench (Eds.), *Handbook of public communication of science and technology* (pp. 173–184). London and New York: Routledge.
Ellis, H. (2014). Knowledge, character and professionalisation in nineteenth-century British science. *History of Education, 43*(6), 777–792.
Engels, F. (1968). *Dialettica della natura*. Roma: Editori riuniti.
Faraday, M. (1908). *The chemical history of a candle. A course of lectures delivered before a Juvenile audience at the Royal Institution*. London: Chatto and Windus.
Farné, R. (2003). *Buona maestra TV: La RAI e l'educazione da Non è mai troppo tardi a Quark*. Roma: Carocci.
Farry, J., & Kirby, D. A. (2012). The Universe will be televised: Space, science, satellites and British television production, 1946–1969. *History and Technology, 28*(3), 311–333.
Gentiloni Silveri, U. (2019). *Storia dell'Italia contemporanea 1943–2019*. Bologna: IL Mulino.
Gordin, M. D., & Hall, K. (2008). Introduction: Intelligentsia inside and outside Russia. *Osiris, 23*(1), 1–19.
Govoni, P. (2002). *Un pubblico per la scienza: La divulgazione scientifica nell'Italia in formazione*. Rome: Carocci.
Govoni, P. (2012). La scienza e il suo pubblico. In U. Eco (Ed.), *L'età moderna e contemporanea* (Vol. 11, pp. 444–449). Milano: EM Publishers.
Graham, L. R. (1990). *Science and the Soviet social order*. London: Harvard University Press.
Graham, L. R. (1993). *Science in Russia and the Soviet union. A short story*. Cambridge: Cambridge University Press.
Grasso, A. (2019). *Storia critica della televisione italiana*. Milano: IL Saggiatore.
Guerraggio, A., & Nastasi, P. (2010). *L'Italia degli scienziati: 150 anni di storia nazionale*. Milano: Bruno Mondadori.
Harper, J. L. (1987). *L'America e la ricostruzione dell'Italia 1945–1948*. Bologna: IL Mulino.
Hilgartner, S. (1990). The dominant view of popularization: Conceptual problems, political uses. *Social Studies of Science, 20*(3), 519–539.
Hogben, L. (1938). *Science for the citizen: A self-educator based on the social background of scientific discovery*. London: George Allen and Unwin Ltd.
Irwin, A. (1995). *Citizen science: A study of people, expertise and sustainable development*. London: Routledge.
Irwin, A., & Jensen, T. E. (2012). The good, the bad and the perfect: Criticizing engagement practice. *Social Studies of Science, 43*(1), 118–135.
James, F. A. J. L. (1998). 'The civil-engineer's talent': Michael Faraday, science, engineering and the English lighthouse service, 1836–1865. *Transactions of the Newcomen Society, 70*(1), 153–160.
James, F. A. J. L. (2002). 'Never talk about science, *show* it to them': The lecture theatre of the Royal Institution. *Interdisciplinary Science Review, 27*(3), 225–229.
Jasanoff, S. (2012). *Science and public reason*. Suffolk: Routledge.
Jones, R. (2001). "Why can't you scientists leave things alone?" Science questioned in British films of the post-war (1945–1970). *Public Understanding of Science, 10,* 365–382.
Kennedy, H. C. (1977). Karl Marx and the foundations of differential calculus. *Historia Mathematica, 4*(3), 303–318.

Kennedy, H. C. (1978). Marx's mathematical manuscripts. *Science and Nature, 1,* 59–62.
Krige, J. (2006). Atoms for peace, scientific internationalis, and scientific intelligence. *Osiris, 21*(1), 161–181.
Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.
Lightman, B. (2000). The story of nature: Victorian popularizers and scientific narrative. *Victorian Review, 25*(2), 1–29.
Lightman, B. (2004). *The dictionary of nineteenth-century British scientists*. Bristol: Thoemmes.
Lightman, B. (2012). Victorian science and popular visual culture. *Early Popular Visual Culture, 10*(1), 1–5.
Lightman, B. (2016). Popularizers, participation and the transformations of nineteenth-century publishing: from the 1860s to the 1880s. *Notes and Records: The Royal Society Journal of the History of Science, 70,* 343–359.
Lobačevskij, N. (1994). *Nuovi principi della geometria*. Torino: Bollati Boringhieri.
Lombardo Radice, L. (1946). *Fascism e anticomunismo. Appunti ericordi 1935–1945*. Torino: Einaudi
Lombardo Radice, L. (1965). *Istituzioni di algebra astratta*. Milano: Feltrinelli.
Lombardo Radice, L. (1972a). Dai «Manoscritti matematici» di K. Marx. *Critica Marxista Quaderni, 6,* 273–277.
Lombardo Radice, L. (1972b). *L'educazione della mente*. Roma: Editori Riuniti.
Lombardo Radice, L. (1976). *Educazione e rivoluzione*. Roma: Editori Riuniti.
Lombardo Radice, L. (2014). *La matematica da Pitagora a Newton*. Roma: Editori Riuniti University Press.
Lombardo Radice, L., & Catalano, G. (1972). *Minialgebra*. Milano: Feltrinelli.
Lombardo Radice, L., & Mancini Proia, L. (1977). *Il metodo matematico*. Milano: Principato.
Lombardo Radice, L. & Segre, B. (1967). Galileo e la matematica. In AA.VV (Ed.) *Saggi su Galileo Galilei* (pp. 3–38). Firenze: Barbera.
Lomellini, V. (2018). Lucio Lombardo Radice e il Pci: il coraggio di dissentire sul «dissenso» nei paesi dell'est. *Studi Storici, 59*(1), 115–140.
MacLeod, R. (1996). *Public science and public policy in Victorian England*. Aldershot: Ashgate Variorum.
MacLeod, R. (2000). *The 'Creed of Science' in Victorian England*. Aldershot: Ashgate Variorum.
Marx, K. (1975). *Manoscritti matematici*. Bari: Dedalo.
McLaughlin-Jenkins, E. (2001). Common knowledge: Science and the late Victorian working-class press. *History of Science, 39*(4), 445–465.
Meschkowki, H. (1976). *Mutamenti del pensiero matematico*. Torino: Bollati Boringhieri.
Monteleone, F. (1999). *Storia della radio e della televisione in Italia: Costume, società e politica*. Venezia: Marsilio.
Mores, F. (2018). Ipotesi su Lucio Lombardo Radice. Materialismo e modernismo (dal 1976… al 1921). *Studi Storici, 59*(1), 93–113.
Morrell, J. B. (1971). Individualism and the structure of British science in 1830. *Historical Studies in the Physical Science, 3,* 183–204.
Morrell, J. B. (1997). *Science, culture and politics in Britain, 1750–1870*. Aldershot: Ashgate Variorum.
Morus, I. R. (1998). Galvanic cultures: Electricity and life in the early nineteenth century. *Endeavour, 22*(1), 7–11.
Morus, I. R. (2010). Worlds of wonder: Sensation and the Victorian scientific performance. *Isis, 101*(4), 806–816.
Natoli, C. (2018). La formazione antifascista di Lucio Lombardo Radice. *Studi Storici, 59*(1), 63–91.
Oreskes, N., & Krige, J. (2014). *Science and technology in the global cold war*. Cambridge: The MIT Press.
Pearce Williams, L. (1971). *The selected correspondence of Michael Faraday*. London: Cambridge University Press.
Piazzoni, I. (2018). *Storia delle televisioni in Italia: Dagli esordi alla web tv*. Roma: Carocci.
Pisano, R. (2012). On the birth of electromagnetic theory. Faraday and Maxwell. In *The circulation of science and technology: Proceedings of the 4th International Conference of the European Society for the History of Science* (pp. 514–515).
Pisano, R. (2013). Science, society and civilization in the history of science. *Problems of Education in the 21st Century, 55,* 4–10.
Pisano, R. (2015). *A bridge between conceptual frameworks. Science, society and technology studies*. Berlin: Springer.
Pisano, R., Anakkar, A., Pellegrino, E. M., & Nagels, M. (2018). Thermodynamic foundations of physical chemistry: Reversible processes and thermal equilibrium into the history. *Foundations of Chemistry, 21*(3), 297–323.

Pisano, R., Franckowiak, R., & Anakkar, A. (2017). Reading science, technology and education: A tradition dating back to science into the history and historiography. *Transversal: International Journal for the Historiography of Science, 3,* 77–97.
Proctor, R. A. (1878). *Pleasant ways in science*. London: Chatto and Windus.
Rowlinson, J. S. (2009). James Joule, William Thomson and the concept of a perfect gas. *Notes and Record of the Royal Society, 64,* 43–57.
Sheehan, H. (2007). Marxism and science studies: A sweep through the decades. *International Studies in the Philosophy of Science, 21*(2), 197–210.
Sheet-Pyenson, S. (1985). Popular science periodicals in Paris and London: The emergence of a low scientific culture, 1820–1875. *Annals of Science, 42*(6), 549–572.
Shinn, T., & Whitley, R. (1985). *Expository science: Forms and functions of popularisation*. Dordrecht, Boston: D. Reidel Publishing Company.
Sibum, O. H. (1995). Reworking the mechanical value of heat: Instruments of precision and gestures of accuracy in early Victorian England. *Studies in History and Philosophy of Science Part A, 26*(1), 73–106.
Sibum, O. H. (1998). Les gestes de la mesure. Joule, les pratiques de la brasserie et la science. *Annales Histoire, Science Sociales, 53*(4–5), 745–774.
Smith, C. W. (1976). Faraday as referee of Joule's royal society paper "On the mechanical equivalent of heat". *Isis, 3*(September), 444–449.
Stanley, M. (2003). An expedition to heal the wounds of war. The 1919 eclipse and Eddington as Quaker adventurer. *Isis, 94*(1), 57–89.
Taviani, E. (2004). Lombardo Radice e gli intellettuali del dissenso. *Studi Storici, 45*(3), 837–871.
Thomas, J. M. (1991). *Michael Faraday and the Royal Institution. The genius of man and place*. Bristol: IOL Publishing.
Vittoria, A. (2014). *Togliatti e gli intellettuali: La politica culturale dei comunisti italiani (1944–1964)*. Roma: Carocci.
Vittoria, A., & Ceccherini, P. (2005). Lombardo Radice, Lucio. *Dizionario biografico degli italiani, 65,* 544–548.
Weingart, P. (2001). *Die Stunde der Wahrheit? Zum Verhältnis der Wissenschaft zu Politik, Wirtschaft und Medien in der Wissensgesellschaft. Weilerswist*. Germany: Velbrück.
Werskey, G. (2007). The marxist critique of capitalist science: A history in three movements? *Science as Culture, 16*(4), 397–461.

Fabio Lusito is a Ph.D. Student in History of Science at Centro Interuniversiario di Ricerca "Seminario di Storia della scienza", University of Bari (Italy). He has a Master's Degree in Philosophy. His research interests are history of science in the XXI century—especially in Italian context—the relationship between science, society and politics, science communication and popularization of science by media.