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About Open Science and Autonomy of Science (Postprint)

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Abstract

This article invites us to a concise walk through the past, offering insights defined by the major challenges science encountered during the centuries. Some lessons for today and tomorrow are enumerated in the three sections of the article, and they go beyond the relatively few perspectives offered by today' s Data Science: Open Science (OS) is what has always happened and is nothing new, because science has always sought to be open. Esthetical values played a relevant role in the past. Former scientists recognized the intrinsic relation between the way they opened science and the way they followed the principles of beauty and the sense of esthetic. Their groundbreaking heritage still inspires us in being ready to open new ways in science. Whereas Latin was the original lingua franca of European science, and English is the recent lingua franca, the new lingua franca is software. Pieces of software are the filter, which connect researchers to the world, through layers of data. They assist in observing, in choosing, and in selecting. Open scientists should be aware of the fact that their autonomy in science depends on the quality of these pieces. Another lesson is that ethics –regarded as a source of innovative activities–must be a core component of innovative processes in OS, because society needs a responsible use of data and algorithms in corresponding practices that serve OS.

Full Text

Preamble

About Open Science and Autonomy of Science

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Abstract

This article invites us on a concise walk through the past, offering insights defined by the major challenges science encountered across the centuries. Some lessons for today and tomorrow are enumerated in the three sections of the article, and they go beyond the relatively few perspectives offered by today' s Data Science. Open Science (OS) is what has always happened and is nothing new, because science has always sought to be open. Esthetical values played a relevant role in the past: former scientists recognized the intrinsic relation between the way they opened science and the way they followed principles of beauty and the sense of aesthetic. Their groundbreaking heritage still inspires us to be ready to open new ways in science. Whereas Latin was the original lingua franca of European science and English is the recent lingua franca, the new lingua franca is software. Pieces of software are the filter that connects researchers to the world through layers of data; they assist in observing, choosing, and selecting. Open scientists should be aware that their autonomy in science depends on the quality of these pieces. Another lesson is that ethics—regarded as a source of innovative activities—must be a core component of innovative processes in OS, because society needs a responsible use of data and algorithms in corresponding practices that serve OS.

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Walking beyond Present Time, Interpreting Past Time in Order to Understand the Future of Open Science (OS)—The Relevance of Tradition, Regulatory Frames, Ethics, and Sense of Beauty for OS

Preliminary statement: In this article OS is defined as illustrated in the article "Can open science change the world?" [1]. Talking about science means to talk about observation, to reflect on how to preserve the results of observations, and to define how to create access to these results.

Science is observation, related to both written and oral communication that refer to the results of observation itself. This is what science has done for centuries—for example, deepening knowledge on how to cultivate grapes and produce wine, how to conserve it, how to practice medicine, and how to create buildings for schools, theaters, palaces, churches, houses, universities, streets, and bridges—thus promoting and enriching societal knowledge. In this sense, science is part of the so-called cultural heritage [2][1]. Amazingly, this has always been considered to be open.

One of the most relevant expressions of our modern research performing organizations (RPOs) are universities. Our Western "flagship universities" have

been shaped according to models inherited from the monastic tradition, whose foundation was based on oral tradition that passed knowledge from generation to generation. The mechanisms of monastic transmission of knowledge and behavior from master (male) to scholar (male) have been extensively explored by anthropologists [3][2].

The vehicle that accompanied this scientific tradition is the library—the agglutinating center of knowledge. Modern people call this a "knowledge hub," which can be any kind of information center. Both teaching activities and libraries characterized knowledge management and access to knowledge.

The Benedictine architectural models of knowledge and buildings shaped European knowledge management and access to science. With their libraries, skills and training development, and especially their botanical gardens (starting from Saint Gall, Switzerland, founded in the 8th century), the Benedictines fostered modern pharmacy and medicine throughout Europe. This model was then exported to Peru in the 16th century[3], spreading from there throughout the Americas[4].

Of particular relevance is how science was created and transmitted in medieval times. The *Schola Medica Salernitana*—Medical Salernitan School—founded in Salerno, Italy, in the 9th century (also a Benedictine creation), became the most important source of medical knowledge in Western Europe at that time. Arabic medical treatises, some translations of Greek texts and others originally written in Arabic, were accumulated in Benedictine libraries, where they were translated into the then scientific lingua franca, Latin.

Particular attention should be paid to the language of science. Latin was highly relevant and has preserved its importance until today[5]. Latin was the predominant language of communication across Europe. Of the editions from the XVI century that have survived, it is estimated that 21,329 are in Latin, 3,308 in German, 2,433 in Italian, 1,780 in French, 571 in Dutch, 437 in Spanish, and only 240 in English [4].

While in medieval times the Medical Salernitan School included women in their medical and teaching staff, over time women were largely excluded by the holders of data from the transmission mechanisms of science and knowledge.

OS and non-OS are not exclusively about digital data stored on carriers or disks resulting from observations. Oral tradition has always competed with written tradition, and in a world governed by data we tend to forget or diminish the relevance of oral traditions[6].

Access to and dissemination of science changed dramatically through the impact of the printing revolution[7]. This is a perfect example of how technological evolution changed dissemination of science: while it opened science, it also introduced heavy commercial interests and interfered with the purposes of scientific work, operating directly in the value chain of scientific processes[8].

Deriving from the above-mentioned viewpoint, we can differentiate diverse categories of players in science in the past: the observing actors (scientists), then the custodians of science, who preserved knowledge for future generations by structuring it, categorizing it, sometimes studying it, teaching it, and closing access to it. We always tend to forget that custodians of science also operated —and in some cultures still do—by memorizing knowledge by heart rather than recording it in books. By doing so, they become single points of entry to certain disciplines and therefore represent forms of restricted access to science.

Over time, new players joined the above-mentioned categories: the traders of science. These were entities that intermediated results and findings, trading science and regarding it as a commodity. Today we experience further new categories of players in science, also due to evolutions stemming from the digital data revolution.

Regarding today' s science: who produces knowledge? Researchers—and who else? How is science produced?

In the last 30 years, more than 800 European universities have experienced tortuous developments marked by diverse mentality shifts, and the change of direction toward OS is just one of them.

The Typographic Man, grown up through centuries of the Gutenberg Galaxy [5][9], has become a Digital Man. Yet we are still missing the generation of Digital Rectors who think digitally.

The evolution is still taking place, at different speeds. We are witnessing generation gaps that are hard to bridge. The next generation of colleagues (the younger one) is faster in this movement[10], while representatives of the former generation are followers.

To follow means to lag behind evolution. Some of these followers pretend to be digital but are mostly just literally translating analogue thinking into digital thinking, which is why many processes in data management are so slow or inefficient. The COVID-19 pandemic is unveiling this situation inexorably. Decision makers at universities are awaiting changes, while the vast majority of citizens and industry are actively contributing to the creation of data pools, which are then managed through huge centralized enterprises that act globally following one single clear policy and can require all users to comply with it at a global scale. Data are important, and so is information[11].

Manifestly, only a handful of European RPOs decree a data management policy, maintaining their sovereignty on services and data, including their own publications. They are not able to decide when and how access to data (and publications) is managed, even though the data are produced within a framework that virtually should be under their control.

Furthermore, the majority of the 27 member states (MSs) of the EU and the ten associated countries participating in the European Open Science Cloud (EOSC)

have neither OS policies in place, nor policies for educational resources, nor cultural heritage policies [10].

RPOs are struggling and caught in their efforts to fulfill their institutional missions—first, second, and third mission (that is, teaching, research, and public service). Universities' missions are to be considered multilayered, therefore dynamic and fluid. The mission of transformation is not contemplated in this kind of Trinity, nor is the mission of transnationalization. However, the Internet and digitization are open and transnational by definition. A Web of FAIR Data and Services, populated by virtual machines whose processes are governed by algorithms, is not foreseen in the present conceptual framework of European universities or by their skilled decision-making personnel. Their data and services are not machine actionable, and the actual digital revolution is rapidly disrupting structures.

RPOs and their funders ask themselves: who is really producing knowledge? Obviously researchers, but who else is participating in knowledge production? And now the crucial question: who is actively participating in the current OS challenge? What can we say about the involved machines? What, for example, is their legal status (IPRs) in this transnational context? What are the rules of participation in this race? Is it desirable to use machines, or rather, what are the prerequisites for using machines in order to preserve the concept of OS?

The dominant role of infrastructures and e-infrastructures becomes increasingly evident. An actual example (July 2020): two of the four founding members of the European Open Science Cloud (EOSC) Association are representatives of infrastructures[12].

Their role is crucial in enabling, securing, and maintaining research processes and in communicating science. The integrated communication techniques they offer ensure that during the COVID-19 pandemic, all of us are transmitting scientific communication via devices, thereby contributing more and more to the data deluge.

This method of communication in science has, of course, collateral effects. High-level decision makers are not fully aware of the implications derived from e-infrastructures in the daily research and educational process (second and first mission). Also, the impact on cultural heritage (third mission) is not clear.

Avoiding deterioration of content from source of data to destination of data is the next grand challenge. Machines are indeed filtering the communication processes between two or more humans, sitting between them like a sandwich. They receive, take over, and transform voice into data, then transport, filter, translate, and deliver it.

As stated, Latin was the dominant carrier of scientific knowledge. At first glance, English is considered the new lingua franca in science, but this is wrong—or at least only partially true. Indeed, the most relevant language in science is software, which uses English terms. Whoever owns this language (software)

rules the scene, and machines do.

RPOs are also experiencing a cognitive decline, which can be defined as a form of digital dementia[13].

The decision makers of the oldest European universities are able to search and find valuable information concerning the academic life of their institution in their archives, even if this information relates to scientific processes or facts that occurred 600 years ago. These institutions remember very well what happened in their youth. However, as they age, they experience memory loss and huge difficulties in intelligently retrieving valuable data related to events that came into existence in their institutions, for example, 15 years ago. These events were generated via "modern means of communication" whose content, formats, or language have been lost forever, being never or incorrectly recorded [11][14].

In this context, particular relevance is assigned to the roles of legal frames, policies, and ethical issues, especially when the focus lies on the data life cycle. Along this cycle, data may experience different kinds of attributes. Data can start their life as Open Data (OD), be transformed into non-OD, experience the status of restricted access data, and in the end be exposed to the Internet once again as OD.

The challenges for OS are neither the preservation of data nor the sharing of data. The real challenges are: (a) ensuring permanent access to data; (b) ensuring the correct sharing of access to data; (c) ensuring the correct interpretation of data through either machines or humans; (d) the deletion of data, including the right to oblivion; (e) the identification of the correct use of legal means; (f) the correct understanding of the role of ethical issues; (g) the awareness of the subordinate role of technical issues in this context.

Our modern Western societies, especially in Europe, recognize through their legislation the autonomy of science, underlining the fact that science is of crucial relevance for our societies and societal development, including academic teaching, research, and cultural heritage (as mentioned, the three pillars of OS). Constitutional systems, mainly European ones, explicitly recognize freedom of research and teaching in arts and science[15].

Some reflections on the resurrected relevance of ethics: nowadays when we talk about ethics, we refer to the ancient Greeks and their concepts that were discussed more than 2000 years ago (by the way, many of them were working and reflecting in geographical regions we today call Greece, Turkey (mainly Mediterranean coast), Egypt (and its famous libraries), or Sicily (mainly Syracuse)).

At that time, scientists like Archimedes (Syracuse) observed and used their senses to produce science. Using their faculty of perceiving by means of sensory organs, they then decided about the actions they would undertake.

This was the way they interacted with the world—a mechanism very similar to what we are doing now. We have machines equipped with sensors and specialized functions or mechanisms (such as machine-actionable sight, digital hearing,

tasting, smelling, and touching) by which a machine receives and responds to external or internal impulses. Archimedes could cover all these processes by himself; we, however, are not able to do so, although the mechanisms are very similar.

Why? For a simple reason: between our scientists and the real world, there is a huge layer of data.

This amount of data is such a mountain that the scientist needs a filter to help find a way through in order to reach out to the world, and this is provided by something we call software. So between science and the world, we now have data and the software related to these data. But we usually tend to forget that these data are not necessarily reality—data are only an expression of reality.

At the moment we start to interfere through this software or with these data in another person's life, we need clear and understandable rules that are recognized and accepted by everybody. We define this as a legal frame, which is also related to ethical concepts.

Laws without ethics are like reading a text while winking. The view on the page must take place without interferences, like an observation done in science, which must be clear from the moment it starts until it matures into findings. Science must be developed without interferences. Therefore, we need regulations, legal frames, and ethical guidelines that enable OS and maintain it alive —principles that govern a scientist' s behavior or the conducting of scientific activity, including infrastructures and related services. If these codes of conduct are enriched with a sense of beauty, then we will offer a valid contribution to future generations, adding further value to the world' s heritage.

An example? The COVID-19 pandemic is the contextual frame that surrounds us in this historical moment. Following the COVID-19 urgent calls of the European Commission, we are producing so-called COVID-data for COVID-vaccines. Humanity needs access to these data, not only because some obey utilitarian logics, but because we should also follow sets of ethical principles or systems of ethical values. This knowledge concerning the COVID pandemic must be freely accessible to all, as must the vaccines. We all need these as a foundation for common knowledge and a common sense of shared knowledge.

Written in bold: No innovation without ethics, therefore no OS without ethics.

3 OS and Autonomy of Science: Lessons Learned from the Past and Conclusions

As already mentioned, OS is what has always happened and is nothing new. Both teaching activities and libraries characterized knowledge management and access to knowledge; however, subsequent to the appearance of the traders of science, something slightly changed in scientific processes. Nowadays these stakeholders are intrinsically included in scientific processes, such that they are

perverting the meaning and direction of scientific work, thus threatening OS. Furthermore, they are constantly draining valuable resources for their economic interests. They first focused on controlling dissemination mechanisms (publishing), then controlling ownership of publications, and they are now literally grabbing the data. RPOs should reclaim their sovereignty over their intellectual properties and reappropriate them. The adoption of policies is needed, and they are excellent instruments, but RPOs should request from their governments the protection they need, requiring that established constitutional rights concerning freedom of science, arts, and academic teaching be translated into legal frameworks with the purpose of repressing economic interferences in scientific processes and reinforcing the autonomy of science.

In order to ensure autonomy, access to OS should be free at point of use, meaning free from economic pressure.

Modern societies have understood the relevance of science for citizens. Therefore, several levels of protection are given to freedom of science: at a first basic level, this freedom receives the same protection given to all other fundamental rights—and here we also refer to freedom of thought and expression; at a second level, we can recognize specific and expressed constitutional recognition for such a fundamental freedom; and finally, at a possible third level, the State is engaged in promoting scientific research in an inclusive way [12]. The difference from former times is that the fruition of these constitutional rights regarding freedom of science, and the explicit connection to arts and artistic creation, are reserved to all citizens, independently of provenance, race, religion, and above all gender[16]. OS should always show and preserve its inclusive character.

Legal frames are mostly an emanation of constitutional law. Good government models and codes of conduct in RPOs are the translation of these legal frames into daily research life. They should reflect the aims of OS, and each researcher should be aware of their relevance.

The mastery of literacy is fundamental for OS, as is possession of language structures. Open scientists should be aware that the lingua franca of OS is software. Pieces of software are the filter that connects researchers to the world through layers of data. They assist in observing, choosing, and selecting. Open scientists should be aware that their autonomy in science depends on the quality of these pieces, which also assist in intelligently retrieving and analyzing valuable data.

The findings derived from science have always had great societal impact (e.g., in architecture, arts, medicine, or legislation). A visible expression of this impact is the foundation of more than 800 European universities and their contribution to World Cultural Heritage. Although not every citizen had the opportunity to be included in these processes, each society was (and still is) proud to show the sense of beauty that inspired the creation of its cultural heritage.

Cultural heritage must be seen as part of OS, and its vital energy feeds the reservoir of new recruits in science. “Wide spread literacy and the dissemination

of knowledge are distinctive traits of modern societies. They have high impact on values of the society, especially expressed through their inclusive character. This goes with understanding, preservation and dissemination of the cultural heritage which made it possible" [17].

We must review and reinvent roles in the OS movement. Research processes are complex, requiring collaboration at equal level between researchers and research support, as well as improved collaboration between humans and machines, and codified collaboration in machine-to-machine interaction.

Open scientists living in the early time of the printing revolution—among them Leonardo da Vinci, Pico della Mirandola, Leon Battista Alberti, and later Galileo Galilei, Claudio Monteverdi[18]—truly opened science, building upon knowledge created by earlier scientists (randomly chosen for this text, like Archimedes, Vitruvius, and Fibonacci), offering knowledge to all future generations of scientists and interested citizens. Their groundbreaking heritage still inspires us to be ready to open new ways in science. Besides their various fields of action, they had features characterizing all members of these groups of early open scientists: (a) they were very mobile; (b) they performed in cities that felt "free" in the sense that they were not submitted to the jurisdiction of a king, and their good governance models were aware of the importance of universities and academies[19]; (c) there is an intrinsic relation between the way they opened science and the way they followed the principles of beauty and the sense of aesthetic; (d) they were aware of the perennial theological and philosophical disquisitions about "the sense of and relevance of beauty."

Beauty and the sense of aesthetic must find a place in the modern OS movement. They should be regarded as essential elements of scientific work because the idea of beauty has always been part of Western culture[20].

Two final comments and a wish arise from personal observations related to the current COVID-19 pandemic. The first is: let us open science using "open" as a verb—science should be opened. The second—starting again from the point of view of ethics: ethics is not only important in OS, but it should be the source of innovative activities. OS does not need unethical tools. The recommendation would be to focus on ethics, especially as there is a new branch of ethics concerned with the responsible use of data and algorithms in corresponding practices that serve OS. The wish is: OS should be aesthetically beautiful.

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Author Biography

Paolo Budroni is a member of staff of the University of Vienna (since 1991) in Austria and is currently on a long-term sabbatical. Since September 2019, he has been a member of staff of TU Wien Library and is in charge of International Projects. Paolo Budroni holds a PhD in Philosophy, Art History, and Romance Philology (University of Vienna) and also completed his education degree in Foreign Trade (Vienna University of Economics and Business). He holds a postgraduate degree in European Integration for Public Administration. Paolo Budroni has worked in the fields of architecture of research information systems and data and knowledge management for the last 30 years. From 2002 to 2004, he was professor for marketing at the graduate level at the Università degli Studi di Perugia (Scienze della Comunicazione).

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Appendix A: Names Cited in the Article and References (in Alphabetical Order, According to First Name)

Archimedes of Syracuse (c. 287–c. 212 BC), mathematician, physicist, engineer, inventor, and astronomer. He is regarded as one of the leading scientists in classical antiquity. Considered to be the greatest mathematician of ancient history and one of the greatest of all time, Archimedes anticipated modern calculus and analysis by applying concepts of infinitesimals and the method of exhaustion to derive and rigorously prove a range of geometrical theorems (e.g., area of a circle, surface area, volume of a sphere, area of an ellipse, area under a parabola, the volume of a segment of a paraboloid evolution, and the area of a spiral). Reference: https://en.wikipedia.org/wiki/Archimedes

Claudio Giovanni Antonio Monteverdi (1567–1643), composer of both secular and sacred music, string player, choirmaster, and priest. He was a pioneer in the development of opera and is considered a crucial transitional figure between the Renaissance and Baroque periods of music history. Reference: https://en.wikipedia.org/wiki/Claudio_{Monteverdi}

Fibonacci (c. 1170–c. 1240), mathematician, considered to be "the most talented Western mathematician of the Middle Ages." Fibonacci popularized the Hindu-Arabic numeral system in the Western World primarily through his composition in 1202 of *Liber Abaci* (Book of Calculation). Reference: https://en.wikipedia.org/wiki/Fibonacci

Galileo di Vincenzo Bonaiuti de' Galilei (1564–1642), polymath, astronomer, physicist, and engineer. Galileo has been called the "father of observational astronomy," the "father of modern physics," "father of the scientific method," and the "father of modern science." Galileo studied speed and velocity, gravity and free fall, the principle of relativity, inertia, and projectile motion, and also worked in applied science and technology, inventing among other things the thermoscope and using the telescope for scientific observations of celestial objects. His contributions to observational astronomy are countless. In 1615 he was investigated by the Roman Inquisition, and after a long trial he was placed under house arrest, where he remained for the rest of his life. Reference: https://en.wikipedia.org/wiki/Galileo_{Galilei}

Giovanni Pico della Mirandola (1463–1494), philosopher. He is famed for the events of 1486, when, at the age of 23, he proposed to defend 900 theses on religion and philosophy, for which he wrote the *Oration on the Dignity of Man*, which has been called the "Manifesto of the Renaissance." The 900 Theses was the first printed book to be universally banned by the Catholic Church. Reference: https://en.wikipedia.org/wiki/Giovanni_{Pico}*{della}*{Mirandola}

Leonardo da Vinci (1452–1519), polymath. He is widely considered one of the greatest painters of all time. He is also known for his notebooks, in which he made drawings and notes on science and invention: these involve a variety of subjects including anatomy, cartography, painting, and palaeontol-

ogy. Leonardo' s collective works compose a contribution to later generations of artists rivaled only by that of his contemporary Michelangelo. Reference: https://en.wikipedia.org/wiki/Leonardo_{da}_{Vinci}

Leon Battista Alberti (1404–1472), humanist, author, artist, architect, poet, priest, linguist, philosopher, and cryptographer. He epitomized the Renaissance Man. Alberti' s writings on architecture continue to influence modern and contemporary architecture, stating: "The organicism and nature-worship of Wright, the neat classicism of van der Mies, the regulatory outlines and anthropomorphic, harmonic, modular systems of Le Corbusier, and Kahn' s revival of the 'antique'are all elements that tempt one to trace Alberti's influence on modern architecture." Reference: https://en.wikipedia.org/wiki/Leon_{Battista}_{Alberti}

Thomas Aquinas (1225–1274), Dominican friar, Catholic priest, and Doctor of the Church. Immensely influential philosopher, theologian, and jurist in the tradition of scholasticism. He was the foremost classical proponent of natural theology and the father of Thomism. His *Summa Theologica* is among the most influential documents in medieval theology and continues to be the central point of reference for the philosophy and theology of the Catholic Church. His influence on Western thought is considerable, and much of modern philosophy developed or opposed his ideas, particularly in the areas of ethics, natural law, metaphysics, and political theory. Reference: https://en.wikipedia.org/wiki/Thomas_{Aquinas}

Vitruvius (Marcus Vitruvius Pollio, c. 80–70 BC –after c. 15 BC), commonly known as Vitruvius, was a Roman author, architect, civil and military engineer, known for his multi-volume work entitled *De Architectura*. His discussion of perfect proportion in architecture and the human body led to the famous Renaissance drawing by Leonardo da Vinci of the Vitruvian Man. He was also the one who, in 40 BC, invented the idea that all buildings should have three attributes: *firmitas, utilitas, and venustas*, meaning strength, utility, and beauty. Reference: https://en.wikipedia.org/wiki/Vitruvius

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[1] See [2]: "Cultural heritage does not end at monuments and collections of objects. It also includes traditions or living expressions inherited from our ancestors and passed on to our descendants, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts."

[2] Compare: Ida Magli, in *La sessualità maschile*, 1989, see chapters "Una società monastica" and "L' omosessualità mentale dei monaci."

[3] University of Lima, Peru, founded in 1551—the very first university ever founded in the Americas (official name: Universidad Nacional Mayor de San Marcos, UNMSM).

[4] For further explorations concerning the monastical models, which act as "islands in society," please refer to point 4) "Benedictine architectural models of knowledge."

[5] Compare: Francoise Waquet, *Le latin ou l' empire d' un signe. XVIe-XXe siècle*, 1998. Starting with the XVI century, and for more than two centuries, Latin became the language of modern science, literature, diplomacy, and culture.

[6] A further good example is the performing arts and scientific data and information related to these disciplines. Another example is instruments, any kind of instruments/tools. Best products are the instruments that are created based on research processes, which in turn are based on observations and traditions, preserving knowledge orally passed from master to scholar. The same is true in medicine: cardiac surgeons demonstrate innovative techniques and instruments to scholars, etc.

[7] See also: Cristina Dondi (curator), *Printing Evolution, 1450–1500, Fifty Years that Changed Europe*, 2018.

[8] It is amazing to observe how around the year 1500 several manufacturing entities (booksellers and publishers) based in the Republic of Venice transformed and widened access to science, dramatically changing the destiny of manuscripts. We are now witnessing a similar dramatic process, triggered globally by an American company, Amazon. We should never forget that the success of Amazon originated in the trading of books.

[9] The Gutenberg Galaxy: The Making of Typographic Man offers an analysis of the effects of mass media, especially the printing press, on European culture and human consciousness. It popularized the terms Gutenberg Galaxy, which we may regard today with reference to the accumulated body of recorded works of human art and knowledge, especially books; and global village, which refers to the idea that mass communication allows a village-like mindset to apply to the entire world. In the present article the "village" is metaphorically populated by the researcher' s community and the research supporting units (like libraries). Reference: https://en.wikipedia.org/wiki/The_{Gutenberg}_{Galaxy}

[10] Compare: "Needs and requirements for future research environments with researchers" [6]. Supplement to: "Co-creating EOSC: University Networks shaping EOSC" [7]. The goal of this series of workshops was to elaborate in 2020 visions on how research will be conducted in 5 to 15 years and what the effect and impact on research infrastructures will be. The findings were fed directly into the work of the EOSC Executive Board (EB) and Working Groups (WGs), thus providing crucial input for the development of the EOSC.

[11] Some examples: US-based discovery services (search engines) collect information related to 96.68% of all queries worldwide. Chinese discovery strategies serve less than 2%. Figures from September 2019 –September 2020, compare: Search Engine Market Share Worldwide [8]. According to Social Media Stats Worldwide, the market share at global scale of Facebook in October 2020 was

71.85%, and YouTube 4.47%. Compare [9].

[12] The four members are: CESAER https://www.cesaer.org/, CSIC https://www.csic.es/, GEANT https://www.geant.org/ and GARR https://www.garr.it/en/. The EOSC Association was founded in July 2020.

[13] RPOs are also experiencing a cognitive decline, which can be defined as a form of digital dementia.

[14] See this example [11]. Full report: Researchers and Their Data. Results of an Austrian Survey (PDF Full Report/en): https://phaidra.univie.ac.at/detail_{object}/o:409318. The survey shows among others: when researchers leave the institution, only 43% of data remain at the institution; 54% of researchers share research data through means like e-mail or flash drives, and not through repositories; access to data is offered only in 14% of the cases, which means that in 86% of the cases a (theoretical) approach to data through machines would not be possible. Similar results are obtained through similar surveys in other countries. This figure highlights further aspects of digital dementia occurring at our RPOs.

[15] For instance, article 5 of the German Constitution states that "Art and science research and teaching are free," article 33 of the Italian Constitution establishes that "The arts and sciences as well as their teaching are free," and article 59 of the Slovenian Constitution states that "Freedom of scientific research and artistic endeavor shall be free." The Italian Constitution also states that "The Republic promotes cultural development and scientific and technical research" (art. 9), the Spanish Constitution enacts that "public authorities shall promote science and scientific and technical research for the benefit of general interest" (art. 44), and the Greek Constitution, whose article 16 establishes that art, science, research and their teaching are free, and their promotion is mandatory for the state. The same situation exists in Switzerland (art. 20) and in Austria, where "science and its teaching are free" (art. 5) and according to article 17.a of the Austrian constitution "artistic creation, the teaching of art and its teaching are free."

[16] First female author in print in Latin was Cassandra Fidelis, University of Padua. The work was printed again in Nuremberg in 1489 with a woodcut by Albrecht Dürer (reference: Cristina Dondi (curator), *Printing Evolution*, 2018, p.102). First woman to graduate in western universities (philosophy) was Elena Lucrezia Cornaro Piscopia (in 1678, Padua, reference: https://www.unipd.it/elena-lucrezia-cornaro-piscopia).

[17] Compare, Cristina Dondi, *Printing Evolution*, 2018, p. 147.

[18] Note concerning the chosen names: their relevance as open scientists are illustrated in the annex 1—Names cited in the article and references.

[19] Among them: Padua, Milan, Pisa, and Florence.

[20] Compare: Umberto Eco, *Arte e bellezza nell' estetica medievale*, 1987; Thomas of Aquin, Umberto Eco, Vitruvius.

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Note: Figure translations are in progress. See original paper for figures.

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