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Open science: revolution or continuity?

Will scientific discovery become as quick and immediate as a tweet? For Michael Nielsen, quantum computing expert and open science advocate, we are in the middle of a transition towards a new scientific era, an era comparable to the 17th century Scientific Revolution and the transition to the modern age. According to Nielsen's book *Reinventing Discovery*, thanks to the Internet we have a chance to radically transform the way in which knowledge is produced (2012). The US scientist highlights two directions in which networks have impacted science: an acceleration in the speed of scientific discovery, and a profound change within science and society relationships. This increased epistemic and social efficiency is based on the impact of openness on the scientific enterprise. "Open science" is a very broad concept that encompasses several different practices and tools linked to the use of collaborative digital technologies and alternative intellectual property tools. Some inclusive definitions propose that open science embraces practices as different as open access to scientific literature, digitally-mediated forms of open collaboration, as well as the use of copyleft licenses to foster reuse of scientific results and protocols. For example, FOSTER, a project recently funded by the European Commission to set in place sustainable mechanisms for EU researchers to embrace open science practices, defines open science as "the conduction of science in a way that others can collaborate and contribute, where research data, lab notes and other research processes are freely available, with terms that allow reuse, redistribution and reproduction of the research."[1] The taxonomy tree of this concept branches into several directions (see also Fecher and Friesike 2014). The website lists at least five different classes of issues or topics related to open science: Open Access, Open Data, Open Reproducible Research, Open Science Evaluation, and Open Science Policies. Each of these themes can be subdivided in many other subtopics that represent the whole spectrum of difficulties you face in an open science framework. Not to consider Research Data Management, and finally Ethics and Legal Issues.

This complexity might partially explain why, in spite of Internet apologists' emphatic tones, some scientists seem to be reluctant in the adoption of the opportunities networks offer. Twenty years after the birth of the World Wide Web at CERN, in Geneva, scientific research is embracing change at a slower pace than other fields of cultural production. For example, physics might seem to be one of the disciplines that have taken the most advantage of the opportunities offered by digital and connective technologies: since the dawn of the modern Internet physicists have inaugurated preprint archives in which any researcher can deposit and make freely available the draft versions of scientific articles before submitting them to an academic journal. Yet in recent initiatives in the field of physics that deploy huge organizational and financial efforts, as well as strong promises of

[1] https://www.fosteropenscience.eu/foster-taxonomy/open-science-definition, accessed January 19, 2015

innovation, the reproduction of traditional practices seems to prevail. On January 2014 physicists have launched the SCOAP3 consortium (Sponsoring Consortium for Open Access Publishing in Particle Physics[2]), an unprecedented initiative towards an open access publishing model in particle physics. The consortium includes some of the most important scientific institutions of the field, CERN in primis. These institutions pool money that would normally be allocated to journal subscriptions or to "gold" open access journal fees. The SCOAP3 consortium then distributes those resources on a pay-per-article model, thus guaranteeing funding for the publishing cost of the most important particle physics journals. Thanks to SCOAP3, anyone with a computer connected to the Internet is able to access articles published in the field, that are made freely available online by publishers.

Obviously, the SCOAP3 model might be difficult to export to other disciplines: particle physics is a relatively small and cohesive field, with a limited number of journals and a strong culture of sharing. Also, while this switch to an open access model might be the first one involving an entire scientific field, the main change introduced by this initiative is at the level of the financial relation between publishing houses and universities, rather than the modalities of scientific knowledge production. SCOAP3's final goal is in fact the scientific paper, a form of knowledge exchange that hails back to the 17th Century. In this case the core phenomenon is re-mediation, i.e. the transposition of an old medium (the scientific paper published by a scholarly journal) onto a new technology (the scientific paper published online by web-based scientific journals)(Bolter and Grusin 2000). This is anything but a revolutionary process. But digital technologies offer a much broader spectrum of possibilities: collaborative writing and design (Wikipedia and Linux), distributed rating systems (Amazon and Yelp), trend automatic analysis based on big data (Twitter). While some similar tools and technologies are being adopted by other scientific disciplines, especially biology, change seems to be slower than the disruptions lead by digital technologies in other cultural industries. Why does the field that invented the web appear so slow in adopting the opportunities it creates? Why is it not driving Internet's evolution anymore?

Some open science activists seem to be puzzled by the slow pace of change, as they take for granted that "science wants to be open." But considering all those variables and problems, it is difficult to support a position that portrays science as teleologically directed towards more openness. In our opinion, the transformations related to the emergence of digital media needs to be put in a historical perspective. Open science is not necessary, but rather one among many possible evolutions that depend on several factors that include but go beyond technological evolution and adoption, and even cultural change. Understandably, most approaches to open science tend to highlight the dimension of novelty and change. While we do not deny the cultural importance and productivity of those vantage points, we would like to stress that other perspectives should be taken into account. Here we sketch out three issues that we believe should be acknowledged as core problems by any research agenda that analyzes open science and the impact of digital technologies on the production and circulation of scientific knowledge: the resilience of communication formats over time, in this case the scientific paper; the increased importance for science to maintain its social boundaries; and finally the broader social positioning of scientific research and its communication practices.

[2] http://scoap3.org/, accessed January 19, 2015

First of all we should consider that regardless of hegemonic descriptions of digital scholarly communication as "revolutionary," change in media (and thus in publishing systems) often maintains a balance between continuity and discontinuity (Borgman 2007). The concept of re-mediation accounts for the evolution of new media technologies while explaining the persistence of communication formats: should this lesson be applied to the scientific paper? This is what the history of scholarly communication seems to reveal. This idea is put forward by scholars who have analyzed in detail the emergence and evolution of the scientific article, focusing on the changes in the style, organization, and argumentative structure of scientific communication over time. More interestingly for the scope of this paper, authors such as Gross et al. (2002) speculate on the currency of the scientific article in the digital age, showing also that there are historical and epistemic reasons to account for its lasting influence. In this scenario, the problem of establishing new forms of reward for practices such as data sharing or blog posting might be of secondary importance. The centrality of the peer reviewed paper as the final product of scientific research might respond to the need of communicating complex scientific information according to established reading and learning modalities. For example, the main effect of the digitization of books has not been the fragmentation or decomposition of reading, but rather the digital transposition of forms of linear and in-depth reading onto environments that make books easy to port, socialize or modify. Not surprisingly, then, old practices seem to fold into new technologies and shape them continuously. For example, physicists claim that the online preprint repository arXiv, which since its emergence in the early Nineties has become the main medium for scholarly content circulation in a number of disciplines such as physics and mathematics, mimics the traditional practice of shipping preprint articles to colleagues in other universities. Physical copies of the preprints were posted to a departmental bulletin board so that faculty and students could read them and hopefully send written comments or critiques back. Christopher Kelty makes a similar argument about open source synthetic biology by tracing the genealogy of its sharing practices back to newsletters for model organisms (Kelty 2012).

Second, we would like to highlight the importance of the boundaries of the scientific enterprise. Over the three centuries since the birth of the first scientific journal, science has often confronted the need to construct and defend the boundary between inside and outside, between scientists and non-scientists, scientific and non-scientific knowledge (Gieryn 1999). Today we are witnessing an unprecedented re-negotiation of the boundaries of science's cognitive authority, i.e. its ability to present itself as knowledge's depositary, hence the resistance to change. According to a growing body of scholarship, scientific knowledge and the 'experts' that represent it no longer command the unquestioned authority and public trust that was once bestowed upon them (Maasen and Weingart 2006). Networked open science has the potential to foster a transformation similar to the one that followed the invention of printing. Yet this is a tortuous process which might need decades before a new equilibrium is found. In the 17th century, print has unveiled new characteristics of knowledge and has facilitated social and political transformations within the world of research. The same is happening with open science: like Galileo's telescope, it shows us that what we knew about knowledge and its dynamics might be wrong. As previously noted, the Gutenberg-era science was based on a final product, often in form of the peer-reviewed article published in a scholarly journal. Imagining the creative process as an open and collective enterprise might be one of the main obstacles behind the slow pace of the open science "revolution." Digital media and networks, for example, show scientific knowledge as being in a perennial beta version, never concluded and always open to modification, and its output as composed by a number of different objects that are characterized by their unclear status as publications, such as datasets, notebooks, software, etc. This is the opposite of the traditional scientific paper, which has one or more recognized authors, is stable, and can be deposited in libraries (or archives) where it will be discussed and contested, but not modified, incremented or improved, thus reinforcing the social boundaries of scientific research.

Finally, there are deeper reasons for the difficulties experienced by contemporary open science. The public dimension of science that emerged in the 17th century answers natural philosophers' expectations of economic success and reputation accumulation much better than "closed" models of information circulation. The price to pay is a loosened control over produced knowledge. But this side effect is accepted because, in exchange, natural scientists earn a new social role (and the corresponding benefits) accessing wealthy and powerful European patrons' courts (David 2001). The apparent irony of making widely available the results of one's work without any direct economic compensation can be explained with mathematics' and natural philosophy's growing sophistication in the 16th and 17th centuries. Patrons, anxious to embellish themselves with the best scholars, did not have the knowledge necessary for understanding and evaluating their quality and thus needed to root their choices upon a collective judgment expressed by the expert community. Thus natural philosophers needed to adopt new practices of knowledge exchange, circulation and validation. In order to be reliable and verifiable, knowledge must be transparent and visible. This happened through correspondence exchange, journal publishing, comments and critiques that were based upon the emerging print system. Technological innovation was the necessary precondition for the passage from a world of mysterious and secret knowledge about Nature to a new public and collective mode of scientific production. Yet today, as in the 17th century, technological change is not the only force behind an overall transformation of science communication practices. Through a survey about the obstacles to the adoption of open science practices, Scheliga and Friesike (2014) highlight how openness can be seen as a *social dilemma* where "what is in the collective best interest of the scientific community is not necessarily in the best interest of the individual scientist." While researchers seem to agree upon the positive repercussions of a more open scientific process, they also point out the need to overcome both individual and systemic obstacles. Among individual obstacles, the authors identify fear of free–riding and reluctance to make public parts of the research process such as negative results. Systemic obstacles seem to be pinpointed as institutional constraints and limitations, for example lack of appropriate evaluation criteria to include open science practices or need of better standardization for new forms of publishing. Obstacles, in sum, seem to be related to a difficult integration of open science in the social contract of scientific research rather than to cultural resistance from individual scholars.

We would like to wrap up this chapter by looking especially at the crucial importance of both the boundaries that maintain scientific authority and the social and economic incentives that drive it. We propose that research on the scholarly communication system, and in particular on digitally-mediated open science, should incorporate more explicitly concerns related to power over scientific knowledge and to transformations of established social contracts of science. Through such a lens, the emergence of communication practices that renew the system of scholarly communication might be seen as attempts at confirming the boundaries of science while intervening to overcome problems related to the management of scientific communication - i.e. the problem of who controls and profits from it. For example, online preprint archives or open access initiatives such as new journals or new funding schemes for scholarly journals appear as ways to construct forms of public legitimation that are redeemed from the economic power of commercial publishers. These considerations are related to more comprehensive evaluations that support the idea of a *coevolution* of science, society, and communication systems. Scientism tends to represent society as lagging behind science, and non-experts as a possible obstacle to scientific and technological innovation. According to this view, science and society live in different domains and do not understand each other. Similar viewpoints mirror the ideal of tight and cohesive scientific communities, characterized by a strong cultural and ethical homogeneity. This model probably never reflected the reality of scientific practice, and it would be even more difficult to apply it to the profound changes that have pushed some scholars to describe a "new contract" between science and society. This new settlement, that has emerged after the end of the Cold War, is characterized by a social configuration that "affects modern science in its organization, division of labour and day-to-day practices, and also in epistemological cores" (Gibbons 1999). In this framework, today's scientific innovation becomes a non-deterministic activity in which the relation between communication systems and practices of knowledge production is all but linear.

Nevertheless, any great discontinuity in scientific inquiry's social organization goes hand in hand with an intellectual and cultural change which expresses the desire to share knowledge, often regardless of economic incentives. In order to produce the radical transformations prefigured by open science, both cultural and institutional change - in the 17th century as well as today - needed to be fed and stabilized. Interactive digital media are the precondition for a transformation of knowledge's nature, as print was in the 17th century, as long as science will be able to define material and reputational incentives that could make their massive use significant. Often times today's open science apologists focus on the desire for a more collective and productive scientific production while neglecting institutional economic logics (Tyfield 2013). The history of the Scientific Revolution teaches us that the two paths must converge if change is to emerge. For example, will new systems of evaluation and communication enable science to conserve current forms of social legitimization? Old problems might emerge in new forms: as in the past, open science shows a new facet of scientific knowledge. Yet its emergence might be a lengthy and painful process.

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