From Science 2.0 to Open Science

Turning rhetoric into action?

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Abstract- Open Science is enjoying great popularity at the moment. The European Union has recently adopted the term Open Science in its research framework programme. However, at the same time being mainstreamed into policy and administration it runs the risk of remaining empty rhetoric. The article examines terminological and actual realms of Open Science. It aims to identify gaps in the current discourse on one hand, and on the other to draw upon the potential of Open Science practices and its precursors. Situating Open Science in a broader picture of cultures of sharing helps to understand its promising role as change maker in traditional academic settings if necessary appreciation, skills and infrastructures are developed timely.

Keywords - Open Science; Open Research; openwashing; science policy; cultures of sharing

"What science becomes in any historical era depends on what we make of it" - Sandra Harding [1]

I. OPEN SCIENCE IN POLICY

Only recently it was announced that the European Commission would from now on use the term "Open Science" pervasively for what was formerly known as "Science 2.0". The European Union is pushing Open Access since 2006 and including it actively in the 7th framework programme. The new framework programme Horizon 2020 makes Open Access a mandatory practice for funded research. The official move from "Open Access" to "Open Science" seems just consequent, adding a broader picture and tapping into the all-encompassing potential of the openness paradigm. However, a closer look reveals a certain indetermination in the use of terminology. So far there is only a definition for Science 2.0 on the Commission's website, but none for Open Science: "'Science 2.0' describes the on-going evolution in the modus operandi of doing research and organising science. These changes in the dynamics of science and research are enabled by digital technologies and driven by the globalisation of the scientific community, as well as the need to address the Grand Challenges of our times. They have an impact on the entire research cycle, from the inception of research to its publication, as well as on the way in which this cycle is organised." [2]. This definition is one hand very general not giving any details but on the other hand it is obviously directing our attention to the drivers of the alleged change: digital technologies and globalisation, as well as the need for a problem-oriented science. Therefore Open Science has been included into the "Science with and for Society" work programme of Horizon 2020, the current research framework programme of the European Union. Calling for innovative projects in text and data mining, communication of research results and measuring of impact. Open Science is regarded as the solution to a better, more transparent and effective science, one that eradicates fraud, enhances reproducibility, and confronts redundancy. We read "Elements of Open Science will also gradually feed into the shaping of a policy for 'Responsible Research and Innovation' [3] and contribute to the realisation of the 'European Research Area' [4] and the 'Innovation Union' [5], the two main flagship initiatives for research and innovation."[6]

Policy rhetoric is furthermore closely linking Open Science to a specific concept of innovation and the potential of economic growth and targeting all markets including the job market. While reading the respective work programme [7] one gains the impression Open Science might also just serve as empty container for still to be defined concepts, as it appears only twice in the document, without being clearly defined. Maybe it also leaves space for later alignment with the hottest item on the European Digital Agenda: the "Digital Single Market" [8]. Removing the barriers that block free flow of online services and entertainment across national borders, boosting music download business, online payments and online consumer security, while regulating copyrights and infrastructural neutrality. In an European Research Area or "ERA of Innovation" [4] science needs to "open up" to new ideas of information flow and collaboration in the service of society. "There is concern within Europe that its extraordinary science base is not leading to enough industrial application of the new science. In addition to the institutions that promote Open Science, we may also need to consider institutions that promote the application of that science in the commercial realm." [9] Potential for commercialisation is mainly ascribed to the technical innovation deriving from the Open Science movement.

Likewise, the focus towards the technological dimension of Open Science is confirmed by the results of a public consultation in 2014 "Science in Transition" [2]. For a majority of respondents (98% out of ca. 500 respondents totally or partially agreed), "the availability of digital technologies and

their increased capacity were key drivers for Open Science" [2]. On the basis of this consultation the Commission adopted the term of Open Science. It was selected from six options by 43% of respondents as well as discussed in several stakeholder workshops as the most convenient terminology. Other suggestions for marking the current transitional phase in science included "Participatory Science", "Science Highway", and "Better Science". Others recommended a terminology that does not exclude social sciences and humanities such as "Open Research", and "Open Scholarship". However, the majority of respondents has decided for "Open Science", and from now on at least until 2020 this will be the official terminology to address challenges of science as well as the academic world and research practices in transition, such as collaborative infrastructures, intellectual property rights and their applicability, evaluation systems and alternative metrics, sustainable data repositories, and last but not least dismantling the institutional knowledge silos in academia for interdisciplinary and transdisciplinary cooperation. Bearing in mind the performative power of language and the potential to realise what it says, this article looks further into other terminological realms of Open Science, before discussing what aspects are missing in the current discourse and how to engage with Open Science realising promising alternatives to the policy perspective above.

II. Open Science precursors

"If I have seen further it is by standing on the shoulders of giants" Isaac Newton [10]

The commitment to Open Science is nothing new, indeed. We could trace it back until the beginning of science itself. Historic concepts of Open Science highlighted either the ever growing body of knowledge produced by the community and therefore every scientist standing on the shoulders of giants by building knowledge on previous findings or the importance of "disinterestedness" [11] in scientific knowledge production - demanding to act and study free of ideological influence or social distraction.

A. Open Source and E-Science

Today's Open Science movement dates about 25 years back and takes inspiration both from the history of "open source" [12] and the ideas developed for research collaboration in the context of "e-science" [13], both approaches referring at first sight mainly to the technological dimension of opening up science by creating necessary technologies and tools. Opening up science often takes the form of a technological liberation and change of techniques in respective discourses. However, keeping in mind that science and technology "are politics by other means" [14] - offering other means of power - it is vital to turn to the embedded politics of Open Science and its precursors.

E-science with its committed research community brings issues of infrastructure to our attention. Concepts for coordinated sharing of resources and grid-computing form the basis of collaborative research infrastructures. They have involved cooperation of computer science with domain experts in interdisciplinary settings, science administration and funding to act together on supra-national levels, and - en passant - accompanied new open publishing modes, such as the platform ArXiv (launched in 1991) or triggered a new understanding of quality of content, e.g. with the Semantic Web. The Open Archive Initiative is regarded as one of the main forerunners of Open Access to scholarly communication [15]. In 2002 the Budapest Open Access Initiative [16] initiated a global campaign for Open Access to all new peer-reviewed research, articulated a definition and a set of requirements and sensitised science policy for the topic. Followed by numerous other initiatives and declarations Open Access has successfully manifested itself into research strategies on national and global level. There is even evidence that Open Access positively impacts citation behaviour and makes scientific publications and data more visible [17].

Yet, the open source community and here especially the Free Software movement [18] teach Open Science another important lesson: they promise "a sequence of [...] values: experimentalism and creativity, provisionality and modifiability, rectification and refraction, dissent and critique, participation and obligation" [19]. Even though such values are also inscribed in all scientific practice, it was and still is not very common to open up and to make them explicit. Moreover, we could learn from this community how not only facts and figures, but also "values and principles to be turned into material objects" [12] and even into standards and rules, such as the 1980s GNU project and the GPL (General Public License). Today those values are continuously realised in the Creative Commons licence model, which also applies to scientific publishing - even though it is still not very popular in academia due to the fact that it is simply not known. The third lesson to be learned concerns dialogue and empowerment of users: where free software facilitates free usage, the possibility of examination, change and reuse, Open Science introduces new modes of agency and questions epistemological governance.

B. Citizen Science

This stance is also taken by the Citizen Science movement or the idea of the scientific citizen [20]. Even though technologies enhancing participation and exchange are playing an important role in those approaches, they are not the core focus. The notion of openness is more importantly embracing all modes of involvement of society in science, therefore strengthening democracy also in the societal segment of science. Equal cooperation of scientists and voluntary members of the public - with or without respective scientific training - in research entails the notion of potential engagement: scientists as citizens, citizens as scientists becoming active not only in the epistemological realms, but also in governance and decision-making. In brief: "Citizen Science can and should involve the public in the development and design of projects addressing real-world problems" [21].

Historically, amateur astronomy, ornithology or palaeontology are famous early examples of collaborations of scientists and citizens, e.g. opening science also to female contribution. Today Citizen Science topics are manifold and impressively prove how science and science funding can learn from other knowledge practices. From opening science to early education, creating interactive museums, bringing people into

the "laboratory", to involving citizens in the design of research projects and research questions, we find projects in manifold research fields, such as environmental or life sciences, public health, urban studies, anthropology, cultural heritage or literature studies. Critics of amateurs' involvement in scientific discovery have always doubted the quality of output. The "social swarm" would disturb the search for scientific truth. But quite the contrary: studies have shown that non-professional scientists tend to be rather precise and follow strict rules of discovery and research objectives if motivated rightly [22] [23]. And we have also learned that scientific truth is not the only goal when it comes to real world-problems.

"Extreme Citizen Science" pushes the boundaries even further. Think about the Do-It-Yourself movement in Synthetic Biology, activist groups creating scientific evidence showing the harms of fracking or shale gas exploitation in their neighbourhoods, or patient groups launching massive Open Science studies, such as PatientslikeMe and Sage Bionetworks [24]. From garages to massive collaborative platforms, people exchange ideas, codes, materials, processes, sometimes even without the visible involvement of "professional science".

FabLabs (fabrication labs) are kitchens of both techno-scientific and social innovation. The Happy Lab [25], situated in Vienna in the basement of a house, is a very small organisation publicly funded. It is run by a group of people that are not only winning international robotic sailing boat challenges against big players like universities, they are also providing test beds and spaces for discussion. The Happy Lab has a 3D printer, laser cutters, and many other fascinating stuff, and is open to anyone interested in trying out and discussing new technologies. There is no strict differentiation between science, technology, society and so forth. Visitors as well as Happy Lab members become not only "informed citizens" but also aware of the challenges surrounding those new technologies or concepts, like synthetic biology. Certainly not all of them will become activists or start campaigning, but they can build very strong opinions and participate in governance or safety debates.

Citizen Science is currently massively present in political rhetoric. However, it seems neither policy makers nor science administration are fully aware of the potential of Citizen Science to co-shape current transformations of science itself and of how we tackle societal challenges in general [20] [26]. Often Citizen Science is confused with building trust in and acceptance of science and technology. The information deficit model appears to prevail, attributing scepticism to a lack of information and hence a lack of understanding. Orientation towards openness requires that we appreciate the substantial value of citizen expertise, and thus the capacity of citizens to be involved in research processes and the formulation of research questions. Participatory democracies need not only informed citizens but also skilled participants.

III. Open Definitions? Open practices!

"We are held back by the lack of vision, and our solution lies not in science, but in humanities. We lack a communal goal, communal values." Peter Murray-Rust [27]

Openness in terms of sharing expertise without epistemological hierarchies, sharing of instruments, methods, materials, results, encompasses a multitude of approaches, skillsets, resources and arenas of negotiation and practice. Unlike the rather unidimensional policy focus on technological innovation, markets, and control, we find a broad range of positions and objectives when scanning the scientific literature for approaches to Open Science. Benedikt Fecher and Sascha Friesike identify five schools of thought in the Open Science movement as explicated in the table below [28]. The authors conclude that Open Science "encompasses almost any dispute about the future of knowledge creation and dissemination, a term that evokes quite different understandings depending on the viewpoint of its respective advocates and leads to many quarrels under the same flag - yet with varying inducements and targets."

TABLE I. Five Open Science schools of thought

School of thought	Central assumption	Involved groups	Central Aim	Tools & Methods
Democratic	The access to knowledge is unequally distributed.	Scientists, polititians, citizens	Making knowledge freely available for everyone.	Open Access, intellectual property rights, Open data, Open code
Pragmatic	Knowledge-creation could be more efficient if scientists worked together.	Scientists	Opening up the process of knowledge creation.	Wisdom of the crowds, network effects, Open Data, Open Code
Infrastructure	Efficient research depends on the available tools and applications.	Scientists & platform providers	Creating openly available platforms, tools and services for scientists.	Collaboration platforms and tools
Public	Science needs to be made accessible to the public.	Scientists & citizens	Making science accessible for citizens.	Citizen Science, Science PR, Science Blogging
Measurement	Scientific contributions today need alternative impact measurements.	Scientists & politicians	Developing an alternative metric system for scientific impact.	Altmetrics, peer review, citation, impact factors

Table 1 taken from [28]

The table above points towards the complexity of the current transition to Open Science practices. "In many instances Open Science appears to be somewhat like the proverbial electric car-an indeed sensible but expenseful thing which would do better to be parked in the neighbour's garage; an idea everybody agrees upon but urges others to take the first step for." [28] Most of the mentioned aspects are still waiting for their realisation, depending upon a multitude of factors, such as tools, policies, funding, but most importantly socio-epistemic skills that support necessary practices.

Despite this distributed and broad discourse, the obligatory passage point for Open Science novices in the search for Open Science know-how seem to be definitional access points. Most highly cited documents in the Open Science discourse are websites providing definitions, such as Wikipedia, OpenDefinition.Org or the Panton Principles of Open Data in

Science. One would dismiss a unifying definition for all different aspects of openness we find in science and elsewhere as impossible. However, some have tried to converge as many dimensions as possible into a set of definitions and lists of requirements.

The Open Definition lists principles ascribing openness to data and content via knowledge production to ensure compatibility of different sources and quality of content: "Knowledge is open if anyone is free to access, use, modify, and share it - subject, at most, to measures that preserve provenance and openness." [29] It is based on definitions of open source and the definition of Free Cultural Works [30]. It entails terms like "work" for transferrable knowledge items and "licence" for legal conditions of making such items available. When it comes to defining the openness of Open Science, we need to deconstruct this umbrella term [31], even broadening it a bit to "open research" to involve Social Sciences and Humanities, as well as Citizen Science. Open research practices include: Open Access, open data and open research data, open source, open methods, open instruments, open education, open evaluation, and all forms of Citizen Science. It instantly becomes clear that we should rather speak of the "open multiple" instead of unifying all those dimensions, especially when dealing with different epistemic cultures, velocities, skills, institutional settings and so forth.

The Panton Principles for Open Data in Science [32] refer to freely available research data on the public Internet "permitting any user to download, copy, analyse, re-process, pass them to software or use them for any other purpose without financial, legal, or technical barriers other than those inseparable from gaining access to the Internet itself. To this end data related to published science should be explicitly placed in the public domain." The authors are endorsing several principles for making data openly available, which make explicit the inscribed values and the intended users and usages:

- Publishers should make an explicit and robust statement (waiver, licence) of their wishes and expectations with respect to re-use and re-purposing of the data and subsets of it.
- Many licenses are not appropriate for data or collections of data, such as CC apart from CCZero. Publishers are requested to use licence models promoted by the Open Definition, such as PDDL, ODC-BY, or ODbL [33]
- Furthermore limiting commercial re-use, re-purposing or excluding particular uses or users is discouraged e.g. because of potential data preservation.
- Publicly funded research data should be explicitly placed in the public domain via the use of the Public Domain Dedication and Licence or Creative Commons Zero Waiver.

Those principles are explicitly tackling technical issues mainly from the perspective of re-use and re-purposing, as well as focus on the double face of researchers: being research producers as well as research users.

However, such principles and definitions do not tackle at all the challenges of Open Science in terms of skill sets and social and communicative relations. Furthermore, they do not sufficiently explain **HOW** to access, use, modify, and share knowledge.

Know-how is needed to adapt such principles for e.g. data in the social sciences with severe privacy issues if put in the public domain, interoperability or documentary issues of qualitative data, or data in the humanities that build on copyrighted materials. With their rather technocratic appeal and the tendency to create a unifying concept, they drive off potential publishers. Similarly, definitions of Open Education or Open Evaluation do not help at all when first users or Open Science novices are confronted with them, especially people lacking technical skills and overview about available tools and infrastructures. One cannot blame the authors of definitions and principles for that. Their approaches are important and very timely. They provide a checklist or benchmark for specific dimensions of openness that can be used in investigating and identifying so called "open washing" of scientific practices, where the terminology of openness is strategically misleading.

On the contrary, we need to focus more on the systematic blind spots of Open Science, such as skill sets necessary for designing and conducting open research, or the special requirements of Social Sciences and Humanities. Right now projects like FOSTER [34] appear to the outsider as generally emphasising library and archive practices, as well as the fields of STEM (science, technology, engineering, medical science) and big data. What about other research areas, how to work with open research data in Citizen Science projects, how to include open education in alternative evaluation systems, and so forth.

One possible solution for the handling of the complexity of Open Science is suggested by employing Open Science administrators or IT experts, who allegedly handle all the legal and technical issues arising with e.g. open research data. Besides the fact that most institutions cannot afford such positions at the moment, or do not yet understand the need for such activities at all, the institutionalisation of Open Science officers would be a misunderstanding and underestimation of the transitional potential of Open Science as a practice!

A very different stance takes the Open Knowledge Foundation, now simply called Open Knowledge: "We promote the creation, dissemination and use of open knowledge in all its forms, from genes to geodata and from sonnets to statistics. Our projects, groups and tools work with this principle in different and varying ways to increase user access and ensure transparency." [35] This global organisation is organised in regional chapters and groups to promote open knowledge and respective practices, as well as to endorse projects and the development of tools, standards and licence models. It acts in a coherent but distributed way and embraces the much broader picture of knowledge cultures. In science Karin Knorr Cetina labels them "epistemic cultures". "Those amalgams of arrangements and mechanisms - bonded through affinity, necessity and historical coincidence - which in a given field, make up how we know what we know. Epistemic cultures are cultures that create and warrant knowledge." [36] As such they encompass specific norms or conventions of

sharing knowledge, of cultivating their boundaries or modes of transgression and change.

IV. Now what? Opening Science to Cultures of Sharing

But even within those limits, the openness I am advocating would be a giant cultural shift in how science is done, a second Open Science revolution extending and completing the first Open Science revolution, of the 17th and 18th centuries. Michael Nielsen [37]

When we regard Open Science as a methodological revolution in science [38] in the sense of Thomas Kuhn [39], we could see competing paradigms in place: open vs closed. "When it was simply open vs closed it was a clear distinction. Openness was good, closed was bad".[40] As the revolution is currently succeeding by mainstreaming terminology, norms and roles into policy and administration, we witness the convergence to a new paradigm. This paradigm, the "open paradigm" is currently in the making, still fluid and shifting, so it is the right time to intervene and participate in its closure. Revolutions and paradigms are terminologies of a macro perspective. On the micro-level it is still very messy and it will probably always be. Here Open Science is nothing revolutionary, it is a long and slow development and entailing processes of different velocity and status beyond questions of open vs. closed. The grand struggle is not over just because Open Science has reached policy and research funding. Besides the complexity of open publishing and licencing models and institutions adopting Open Access policies in snail pace, we are facing many problems: how to advocate Open Science practices when it does not get rewarded? How to establish a culture of sharing as alternative to a knowledge capitalism already deeply embedded in epistemic cultures? How to make sharing mandatory, efficient and fun at the same time? How to enshrine the idea of precompetitive commons and alternative knowledge markets in policy?

Research communities should continue to take part in the shaping of science in transition and not wait for administration or policy to come up with top-down and often technocratic frameworks that allow for exploitation of technical or legal gaps, such as gold Open Access (pay to publish) or hybrid Open Access models and the openwashing (inspired by the term greenwashing) of traditional commercialisation of science, such as claims of data publishers of openness, even when data is just available under limitations. Such openwashing practices should lead to consequences and undoubtedly need to be sanctioned by funding agencies, research organisations and scientists. Nevertheless instead of creating a counter control apparatus and clearing offices for openness [41] we need to focus on the establishment of a cultural perspective on Open Science, one that - instead of providing unified theories and rules - embraces scientific practices in all their complexity.

We can learn what Open Science is from radical "Open Notebook Science" as well as from Predatory Open Access Journals - charging publication fees without proper peer review and editorial services. We can comprehend its potential when analysing the history of massive open online courses (MOOCs) as well as when following controversial, hacking-inspired projects such as Contentmine, which aims to "liberate facts from scientific literature" [42]. Likewise studying open epistemic practices in the context of local activism, such as protecting the honey bee or collaboratively annotating romanticist literary works. When taking a closer look we will even find manifold epistemic practices not labelled Open Science but embracing similar concepts, especially in the Social Sciences and Humanities, such as inter-institutional repositories of political data, repositories of the collaborative curation of cultural heritage materials, advocating patient communities research objectives in public health. Maybe they will not satisfy the ideal of total openness, but observing them closely could help to initiate reflection on the epistemological politics coming with different modes of openness.

Examining the rearrangements of relations between science and society through the Open Science movement, we need to further consider that they are embedded in a currently broadening trend: the Internet and Social Media have brought about new modes of socially produced knowledge and the creation of new socio-epistemic spaces. Across all social fields people and institutions are experimenting with modalities of shared production, (re-)use, and (re-)distribution of knowledge and common goods, information flows conforming to the rhythms of the World Wide Web and mobile communications. Thus, we should treat Open Science as being part of this new Cultures of Sharing movement: observing of new socio-epistemic spaces, analysing their underlying infrastructures and technologies as well as the skills necessary to participate or lacking skills or technicalities and social obstacles responsible for being left out.

Furthermore, we need to understand that Open Science brings about many different publics, often also non intended ones. Therefore, making science open also means to reflect on the publics created by this move. At the same time, we need to be aware of established communities that either call for the opening of science or have already opened up knowledge production, such as the Do-It-Yourself movement in synthetic biology, the idea of open design or open source software.

Last, but not least Open Science is a vital element in the concept of Open Innovation based on the idea that commons are not beyond, but complimentary to the state and the market. Applying alternative knowledge production- and governance models cleverly will help to increase the pace of societal development especially in areas of pressing concern. Open Science could serve as experimental space testing the complexities of such configurations. The interesting questions are thus *how* Open Science is realized, *how* it is shaped by socio-technical arrangements and vice-versa, and how this is embedded in or brings about cultural change.

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