

Alchemy & algorithms: perspectives on the philosophy and history of open science

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Abstract

This paper gives the reader a chance to experience, or revisit, PHOS16: a conference on the History and Philosophy of Open Science. In the winter of 2016, we invited a varied international group to engage with these topics at the University of Helsinki, Finland. Our aim was a critical assessment of the defining features, underlying narratives, and overall objectives of the contemporary open science movement. The event brought together contemporary open science scholars, publishers, and advocates to discuss the philosophical foundations and historical roots of openness in academic research. The eight sessions combined historical views with more contemporary perspectives on topics such as transparency, reproducibility, collaboration, publishing, peer review, research ethics, as well as societal impact and engagement. We gathered together expert panelists and 15 invited speakers who have published extensively on these topics, which allowed us to engage in a thorough and multifaceted discussion. Together with our involved audience we charted the role and foundations of openness of research in our time, considered the accumulation and dissemination of scientific knowledge, and debated the various technical, legal, and ethical challenges of the past and present. In this article, we provide an overview of the topics covered at the conference as well as individual video interviews with each speaker. In addition to this, all the talks were recorded and they are offered here as an openly licensed community resource in both video and audio form.

Keywords

open science; history of science; philosophy of science

Date and place

Nov 31 - Dec 1, 2016 in Helsinki, Finland

List of participants

Around 100 students, scholars, advocates, and practitioners from various disciplines joined the event to discuss the philosophical and historical roots of the contemporary open science movement. The invited speakers were (in alphabetical order): [Caroline Bassett](#) (Sussex), [Scott Chamberlain](#) (rOpenSci), [Benedikt Fecher](#) (Berlin), [Inkeri Koskinen](#) (Helsinki), [Mikael Laakso](#) (Hanken), [Katrien Maes](#) (LERU), [Michael Markie](#) (F1000), [Arto Mustajoki](#) (Helsinki), [Samuli Ollila](#) (NMRLipids/Aalto), [Manuela Fernández Pinto](#) (Universidad de los Andes), [Jennifer Rampling](#) (Princeton), [Werner Reichmann](#) (Konstanz), [Camilla Mørk Røstvik](#) (St Andrews), [Koen Vermeir](#) (Paris), [Jeffrey Witt](#) (Loyola). The main organisers of the conference were Prof. Mikko Tolonen (University of Helsinki), Prof. José Filipe Silva (University of Helsinki/ERC StG holder), and Adj. Prof. Leo Lahti (University of Turku).

Introduction

The development of information technologies continues to transform science and society. This transformation is pushing the academic system towards greater openness on various fronts of the research process. The open science movement is calling for increased openness in data collection, analysis, and collaboration; in education and in publishing and evaluating academic work (Nosek 2017, Levin and Leonelli 2017, Fecher and Friesike 2013). But how does the contemporary open science movement relate to earlier ideals and pragmatic implementations of science?

Since the 17th century, the academic system has gradually evolved from a 'language of alchemy' towards a more openly communicated and collaborative discipline. While technical and institutional aspects have largely dominated the contemporary open science debate, broader historical and philosophical perspectives have received less attention. This is paradoxical, as open communication and reproducible experimentation have been cornerstones of academic practice since the early modern period or even antiquity, and many of the current opportunities and challenges are conceptually similar to those of the past. More thorough historical and philosophical analysis can help motivate and guide the

contemporary open science movement in addition to aiding it in recognising the varieties, significance, and limitations of openness in the scientific process.

Early motivations for open scientific communication in the 16th and 17th centuries ranged from ideas of Christian charity to pragmatic needs of patrons to identify and attract the best scientists (David 2008, Vermeir and Margočsy 2012). The latter was greatly facilitated by clear and transparent reporting that could be subjected to peer review, and this operational procedure has become the organized peer review that is central to the contemporary scientific process.

Openness has the potential to improve the quality and the overall efficiency of research, for instance by accelerating reuse of data, methods, reported findings, and other research outputs; by helping to avoid overlapping activities and facilitating collaboration; and by promoting transparency and reproducibility. While the histories of science in general and of open science in particular overlap and parallel each other in significant ways, it is important also to recognise the fact that openness is an exceptional feature of the scientific venture. Digitisation and the evolution of the internet have in an unprecedented way enabled, and even created in some sense, what we now call the open science movement. There are also many aspects of open science today that do not have any conceptual precedents in history. But this is by no means a reason for us not to reflect on the history of open science and study, for example, Enlightenment ideas of science. What it does mean is that understanding the nature of open science includes accepting that the story of open science is not a simple and straightforward continuum from Aristotle to SciHub.

Key outcomes and discussions

Here we see the reason that the concept of open science, viewed in light of its philosophical grounding and historical development, remains paradoxical: on the one hand openness is a central component of the definition of science; on the other hand various economical, ethical, technical, and social challenges tend to place practical restrictions. While technical innovations and the ideas of open science are increasingly utilised in the natural and social sciences as well as in the humanities (Lahti et al. 2015, Fecher and Friesike 2013, Nosek 2017), the overall role of open science in the history and present practice of science remains somewhat ambiguous. At PHOS16 (Fig. 1) we wanted to conceptualise these inbuilt tensions, economical, ethical, technical, and social, by examining open science under the following three complementary themes: as a discourse, a movement, and a practice based on the eight sessions including 15 talks and a panel, as detailed in the conference programme (Fig. 2).

Open science as a discourse

One purpose of PHOS16 was to offer complementary perspectives on openness as a core scientific value. Varying contemporary definitions of open science and their roles and limitations in academic value creation were covered by Benedikt Fecher's talk on the open

science schools of thought (“[Publishing and the Limits of Openness](#)”; see also Fecher and Friesike 2013). This talk was complemented by Caroline Bassett’s paper which considered the broader historical and philosophical context of open science, and its associated uncertainties and risks, in terms of the concept of expertise (“[Enough of Experts? Publics, public knowledge, and expertise](#)”).

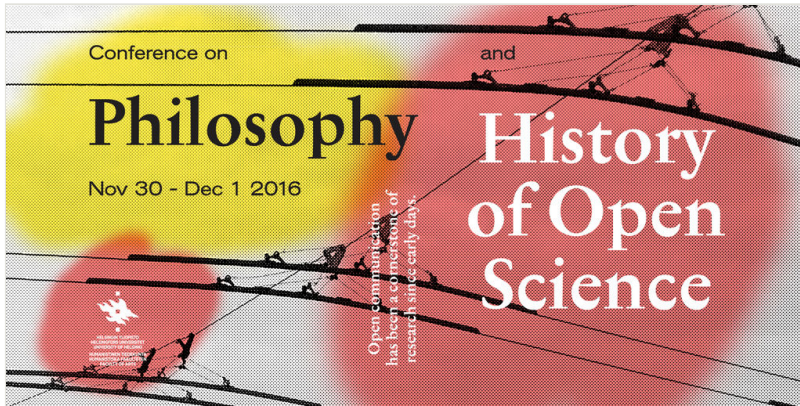


Figure 1.

Around 100 open science scholars and advocates joined the PHOS16 conference in Helsinki to discuss the philosophical and historical roots of the contemporary open science movement.

WEDNESDAY, NOVEMBER 30, 2016		THURSDAY, DECEMBER 01, 2016	
9:00 to 9:15	Welcome from the conference organisers	9:00 to 10:45	Session 1: Academic communities Chair: Kristiina Hormia-Poutanen (LIBER/National Library)
9:15 to 11:00	Session 1: What is open science? Chair: Pirjo-Leena Forström (ATT-hanke/CSC)		<ul style="list-style-type: none"> • Mikael Laakso (Helsinki): Charting the Evolving Landscape between Paywalls and Sustainable Open Access: Practices, Problems, and Solutions • Benedikt Fecher (Berlin): Publishing and the Limits of Openness
11:00 to 11:30	Coffee	10:45 to 11:15	Coffee
11:30 to 13:15	Session 2: Challenges for openness in research Chair: Antti Poikola (OKF/HIT)	11:15 to 13:00	Session 2: Open collaboration modes Chair: Eetu Aahela (Aalto)
	<ul style="list-style-type: none"> • Manuela Fernández Pinto (Universidad de los Andes): Open Science closed for business? • Isakari Koskinen (Helsinki): Commercialisation Threatening Openness in Transdisciplinary Research 		<ul style="list-style-type: none"> • Samuli Ollila (NMRlipids/Aalto): Open Collaboration Method Developed in NMRlipids Project • Jeffrey Witt (Loyola): Texts as Networks: The Promise and Challenge of Publishing Humanities Texts as Open Data Networks
13:15 to 14:15	Break for lunch	13:00 to 14:00	Break for lunch
14:15 to 16:00	Session 3: Research ethics & integrity Chair: Eero Hynönen (Heldig/Aalto)	14:00 to 15:45	Session 3: Peer review Chair: Joonas Lehtomäki (VU Amsterdam)
	<ul style="list-style-type: none"> • Arto Mustajoki (Helsinki): Open Data in the Framework of a New Approach to Research Ethics • Katrien Maes (LERU): Europe Needs Ongoing Efforts to Promote Research Integrity - What LERU Universities Contribute to the Debate 		<ul style="list-style-type: none"> • Michael Markle (F1000): OPEN SESAME - Let's Free Peer Review and the Sharing of Research • Camilla Mark Røstvik (St Andrews): 'Too Ambitious?' The History of Women and Publishing at the Royal Society in the 20th and 21st century
16:00 to 16:30	Coffee and fruit	15:45 to 16:15	Coffee and fruit
16:30 to 18:15	Session 4: Transparency and reproducibility Chair: Leo Lahti (Turku/Leuven)	16:15 to 18:00	Session 4: Science and society Chair: Mikko Tolonen (Helsinki)
	<ul style="list-style-type: none"> • Jennifer Ramplinger (Princeton): Reproducibility and the Language of Alchemy • Scott Chamberlain (OpenSci): Software and Best Practices to Facilitate Open Science 		<ul style="list-style-type: none"> • Caroline Bassett (Sussex): Enough of Experts? Publics, public knowledge, and expertise • Panel discussion with Koen Vermeir, Caroline Bassett, Manuela Fernández Pinto, José Filipe Silva, and Leo Lahti: So What? Discussion on #PHOS16
18:15 to 20:00	University reception		

Figure 2.

PHOS16 Conference Programme.

The challenges for openness were considered on both structural and microsocial levels. Examples of structural challenges include technical and institutional aspects such as funding models, science policy and regulation, and communication technologies as well as social aspects such as gender bias and family upbringing, which can remarkably limit an individual’s chances of entering and succeeding in academia. An example of the latter is

the fact that access to the scientific community has historically been largely restricted to men, as was showcased by Camilla Mork Rostvik in her talk on women and the Royal Society: "[Too Ambitious'? The History of Women and Publishing at the Royal Society in the 20th and 21st century](#)". Sociological mechanisms, technological development, and market forces are closely related issues that have been central drivers for, as well as threats to, openness in research practices since the Enlightenment. Manuela Fernández Pinto addressed these issues in her talk entitled "[Open Science closed for business?](#)" Sociological perspectives to open science include thinking about epistemic cultures and "how we know what we know" (Cetina 1999). These issues, as well as social structures in general, were discussed by Werner Reichmann in his talk "[Open Science, Epistemic Culture, and Social Structures](#)".

One hotly debated set of issues at the conference included the analysis of the concept of socially relevant knowledge, the idea of co-production, and the tensions between expert knowledge and democratization of research (Koskinen 2016). Open research practices often seem to refer to transparent reporting, equal opportunity, open communication, and the various technical aspects of research rather than to democratisation of academic research. These issues were treated by Inkeri Koskinen in her talk on transdisciplinary research, titled "[Commercialisation Threatening Openness in Transdisciplinary Research](#)".

Open science as a movement

Open science is also an active movement which is driven by an increasing number of scientists adopting, innovating, and promoting open practices to improve the quality of research, collaboration, and overall visibility of their research. There are also conscious endeavours towards explicit policy goals seeking to influence prevailing institutions: the various national campaigns to increase transparency in the current academic publishing model provide one topical example. These campaigns aim at redefining the relationship between the academic community on the one hand and commercial publishers on the other (a Finnish example of such a campaign is www.tiedonhinta.fi). Various forms of, and efforts at, democratisation constitute a crucial part of and a driving force behind the contemporary movement, including increased levels of participation, activist research, extra-academic collaboration, citizen science, or transdisciplinarity. For instance, data collection in ecology, biomedicine, and many other fields often relies on lay volunteers, and sharing research data with others is now making it possible for individuals to compare their genetic makeup or microbial fingerprints compare with others. An important related aspect is the question of authority and different kinds of expert knowledge as contrasted with citizen science. Caroline Bassett linked this question with what's called post-truth or alt-fact politics. On the other hand, citizen science enterprises can help build trust in and give insights into scientific practice. In the future, we are likely to encounter increasingly interesting and at times difficult questions about citizens who do science on the one hand and scientists who are representing the view of citizens as opposed to institutional point of view on the other.

While there have been tensions between openness and profit-seeking, secretive, and often private interests, the transition into more and more open science is ongoing on all levels within the academic community and a number of publishers and commercial companies have identified rapidly emerging business opportunities. Public interest has a remarkable role in defining the rules and regulations within the scientific community, including the standards for openness. While societal impact does not equal financial impact, open science can also be profitable. Openness can increase the overall efficiency of research and dissemination thereof, thus bringing added value to the allocation of resources. Its value can be challenging to quantify, however, and adoption of open practices has concrete costs that need to be accounted for within academic research and funding communities. Open science is simultaneously driven by various parties and that its development is in part due to the tensions just enumerated rather than despite them.

Since the early modern period, scientific endeavour has been motivated by a desire for knowledge driven by ideas, not authorship, with the result that texts have often been anonymous. Opening medieval codices, one is struck by how often they are compilations of sources on one topic rather than assembled groups of works by one author. This creates significant challenges in assigning authorship and new technologies are providing new opportunities to study medieval scholarship, for instance by cross-linking and collaborative analysis of texts, over great distances and at an historically unprecedented scale. These new collaborative methods and ways of accessing sources are significantly changing the ways in which historical sources are contextualised and understood as well as highlighting their influence in the long term. The most recent developments in this field were covered by Jeffrey Witt in his talk referencing the work done at the Scholastic Commentaries and Texts Archive ("[Texts as Networks: The Promise and Challenge of Publishing Humanities Texts as Open Data Networks](#)").

The [concluding panel](#) discussed among other things the fact that in addition to openness in academic processes having intrinsic value in itself, it also has an instrumental role in the advancing the generation, accumulation, and dissemination of knowledge which is central to the practical questions of shaping research policies and funding models.

Open science as practice

In many ways, open science is a very pragmatic concept that promotes access to scientific outputs to facilitate the process of knowledge generation. All this is facilitated by technological development, as was illustrated by Scott Chamberlain's talk on contemporary [Software and Best Practices to Facilitate Open Science](#).

Improved access to scientific research data, methods, publications as well as other outputs of scientific research will not only serve to increase transparency. It will also provide opportunities for further use, and innovative combinations, of ideas, information, and data. This in turn opens new avenues for creative thinking and scientific activity.

The recently proposed European Open Access Platform and the so-called diamond open access model have gained attention and provide one alternative that could replace the current commercial publishing system in the long term (see e.g. Fecher et al. 2017).

Modern technologies have opened up historically significant opportunities driving a culture shift in how we share, collaborate, trust, and evaluate scientific work (Levin and Leonelli 2017, Laine et al. 2015). Making peer review, including review comments, and potentially even the identities of reviewers, open and attributable can improve the quality of reviews, help to avoid conflicts of interest, and facilitate collaboration (Aleksic et al. 2014). However, further research is needed to evaluate the relative merits or potential disadvantages of opening the various elements of the review process. These issues were discussed in Michael Markie's talk on freeing peer review, "[OPEN SESAME – Let's Free Peer Review and the Sharing of Research](#)", and Samuli Ollila's talk "[Open Collaboration Method Developed in NMRlipids Project](#)".

New technologies come with remarkable practical and social challenges such as the storage of massive data collections, the need for increasingly sophisticated algorithms, and the overall dependence on technology. Culture and norms do not always follow technical opportunities. While the digital revolution of recent decades has changed the way we communicate irreversibly, many popular features of the present open science movement, such as open data or electronic notebooks, are of concern to a very specific geographically, economically, and technically privileged set. We can therefore with good reason ask the following: on what grounds should we talk about the history of open science that extends beyond the digital era? These themes were discussed from a bird's eye perspective by Koen Vermeir in his talk "[Open Science: The Big Picture](#)".

Looking back at the historical and philosophical foundations of openness in the scientific process generally will be valuable for understanding, and also guiding, the ongoing transformation of the academic system into a more open way of doing science. One way to do this is to utilise established ethical frameworks as tools for the evaluation of and decision-making about open science (Mustajoki and Mustajoki 2017). The ethical aspects of open science research were addressed by Arto Mustajoki in his talk on fresh angles on the ethics of scientific research: "[Open Data in the Framework of a New Approach to Research Ethics](#)".

We believe these kinds of well-founded and systematic approaches to open science can and should be interwoven also into discussions of open science and its role in research ethics and integrity. An example of how this might be done was provided by Katrien Maes' talk on how European research institutions can be a force in making openness in science reality ("[Europe Needs Ongoing Efforts to Promote Research Integrity – What LERU Universities Contribute to the Debate](#)").

The reasons for using cryptic alchemical notations in the 17th century have been transformed into new kinds of challenges associated with the complexity of modern information technologies. Despite this transformation, there are strong parallels between the different eras regarding issues of reproducibility, priority, scientific communication,

funding, commercialization, and other aspects of doing science. These new forms of challenges contribute both to the modern reproducibility crisis and to the push towards more open science (Pinto 2015). Jennifer Rampling's recent analysis of medieval and early modern science and medicine (Rampling 2013) explored the issues of how early experimenters dealt with problems of reproducibility. Using the historical example of alchemy, she demonstrated some ways in which this was done also in her engaging talk on "[Reproducibility and the Language of Alchemy](#)".

The complex alchemical recipes that featured in Rampling's talk were then sharply contrasted by Scott Chamberlain's aforementioned talk on the latest modern practices of shared and reproducible software as well as Mikael Laakso's talk on the latest research on exploring the ecosystems surrounding traditional scientific publishing and feasible open access ("[Charting the Evolving Landscape between Paywalls and Sustainable Open Access: Practices, Problems, and Solutions](#)"). The emergence and growth of modern open access publishing are making scientific literature available to the public at an unprecedented scale, although realised access to this literature is still limited by economical and social factors. It remains to be seen how the open science revolution will be able to shape societies in the future.

Conclusions

The open science movement has led to a transformation in the funding, regulation and communication of science with potentially far-reaching implications for the way the scientific system is organised. Open practices can help increase the quality of research and help create added value for society in the form of new economic incentives generated by enhancing the flow of information and access to digital methods, and by enabling new forms of collaboration. But where we are still lacking is in understanding the precise role of openness in the scientific process and what grounds the concept of openness. This understanding can be furthered by philosophical and historical analysis. Viewed from a broader historical and philosophical perspective, what the open science movement highlights is the importance of adapting community norms and practices in a changing world and of ensuring that core values of science can receive continued support.

Open science is a vast concept that touches on nearly all aspects of research practice and dissemination. It covers social, cultural, ethical, and structural issues as well as reflecting broader trends in science and society. The PHOS16 conference highlighted a variety of historical parallels and pointed out new avenues for understanding and promoting openness in academic research. This was achieved by linking contemporary topics with closely related philosophical and historical ideas and processes with a particular focus on the early modern period.

At PHOS16 we sketched the overall foundations of openness as a core scientific value, discussed the scope and limits of openness (Fecher and Friesike 2013), highlighted specific aspects of open science and its implications that deserve further conceptual analysis, and pointed at new avenues for promoting openness in contemporary research.

We hope that this brief perspective, as well as the associated audiovisual material, will help the reader better to conceive of the current open science movement as part of a continuum with historical roots. This conception, we believe, will serve to clarify the overall implications the open science movement has for science and society.

Audiovisual material

We are looking forward to this perspective article and the associated audiovisual material accelerating further debate on open science. Recordings of the live online streams of the entire conference are available ([day 1](#), [day 2](#)). The conference website, programme, presentation abstracts and links to all the audiovisual material from the conference are available [online](#). Video and audio recordings of individual talks as well as video interviews with each of our speakers are collected [online](#), with direct links below:

Caroline Bassett (Sussex): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Scott Chamberlain (rOpenSci): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Benedikt Fecher (Berlin): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Inkeri Koskinen (Helsinki): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Mikael Laakso (Hanken): [Video Interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Katrien Maes (LERU): [Video Interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Michael Markie (F1000): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Arto Mustajoki (Helsinki): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Samuli Ollila (NMRLipids/Aalto): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Manuela Fernández Pinto (de los Andes): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Jennifer Rampling (Princeton): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Werner Reichmann (Konstanz): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Camilla Mork Rostvik (St Andrews): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Koen Vermeir (Paris): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

Jeffrey Witt (Loyola): [Video interview](#) / [Video lecture](#) / [Audio talk](#) / [Q&A session](#)

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Hosting institution

University of Helsinki

Author contributions

LL and MT designed the text and coordinated the work. ML prepared the audiovisual materials for distribution. All authors contributed to writing and manuscript preparation, and approved the final version.

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