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Joining Networks in the World of Open Science

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Abstract

Whereas the first digital revolution of science by digitisation changed the scientific practices of data collection, analysis and reporting of results, the second digital revolution, i.e. open science, will also challenge the current roles of researchers, research organisations, libraries and publishers. From the early days of development, research libraries have joined different networks and been among the most active stakeholders working towards open science. Cohesive networks are needed for coordinated actions and support, whereas bridging networks can provide new approaches and novel information. The Finnish Open Science and Research Initiative is presented in this paper as an example of joining networks, motivating individuals and organisations to deliver high-quality services, infrastructures and competence building to promote a transition towards open science. This paper also presents milestones such as the publication of the academic publishing costs of Finnish research organisations and the maturity level of open science operating cultures in HEIs. Based on the experience of the Finnish open science initiative, joining different networks at the national level on an open mode of operation can significantly speed up the transition towards the era of open science.

Key Words: open science; digital revolution; networks; Finland

1. Introduction

There are many transformations, such as the computer revolution (1962), the information revolution (1974) and the information society (1981), that

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have fundamentally changed not only societies (Beniger, 1986) but also the way science is conducted. Today, analogue materials such as letters can be converted into digital forms, and less time is needed for the collection of new data. We now have many more tools to digitally analyse data, and it has also become much easier to write an article as word processors have ousted typewriters.

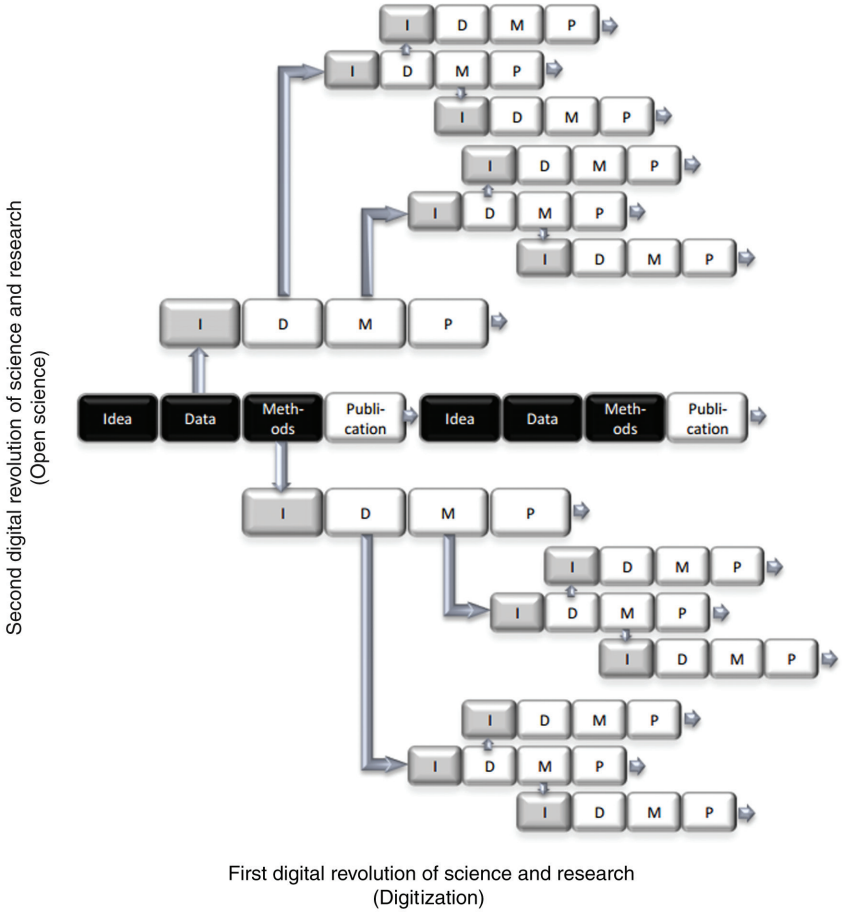
The digitisation of scientific processes, or the first digital revolution of science as it can be called, has in many ways changed the daily scientific practices of data collection, analysis and reporting of results. Digital technology nowadays provides plenty of opportunities for faster and more effective scientific processes, and it also shortens the time from idea to scientific publication. However, although the first digital revolution of science also led to the emergence of the first e-journals in the late 1980s, it did not fundamentally change the tradition of sharing research outputs either via scientific publications or via oral communication. The rest of the scientific process starting from the idea stage before publication still remains largely a black box for outsiders (see Figure 1).

Although scientific publications have significantly increased the dissemination of research outputs, more importantly, they have enhanced access to information when new studies are planned (MacKenzie Owen, 2007). Information can be transferred more widely than before via open access publications, enabling even wider use and inspiring new studies. Furthermore, open access of publications can increase the visibility of scientists and provide new opportunities in academia and beyond (e.g. McKiernan et al., 2016).

As digitisation has been embedded in most scientific processes, researchers, research funders and decision-makers have started questioning the traditional way of sharing research outcomes only via publications or oral communications. It is now possible – and called for – to promote openness and share various types of research outputs.

For instance, at the conference "A New Start for Europe: Opening up to an ERA of Innovation" in June 2015, Commissioner Carlos Moedas said the following: "*Although Europe generates more scientific output than any other region in the world, in some areas we fall behind on the very best science. At the same time, there is a revolution happening in the way science works. Every part of the scientific method is becoming an open, collaborative and participative process*." (Moedas, 2015).

Fig. 1: The first digital revolution of science made work easier and faster but the idea (I), data collection (D) and methodology (M) still remained as black boxes for outsiders before publication (P) (in the middle of the figure). In the second digital revolution of science (open science), data, methods and publications can be openly shared, which significantly will increase the possibilities for inspiring new research and increasing the impact of science beyond academia, too.



Digitisation, together with the possibilities provided by the worldwide web, has fundamentally changed the traditional mode of research – from idea to data collection, analysis and publication, inspiring further scientific work. Releasing all of these types of outputs to a wider audience is now possible at a level never

before experienced by the scientific community. The second digital revolution calls for scientists to adopt open science principles in their daily work.

In a revolutionary way, scientists can now open up their data and methods immediately – even before their scientific papers on the study in question have been published. This increased openness in the research process provides food for thought not only for new research ideas but also for society at large. Openness has the potential to significantly increase the impact of scientific work, since it not only expands the research outputs so that they can be exploited by other researchers for their own work but it also makes the outputs available much faster than before. Open data and methods can also contribute to the development of unexpected new research, such as by including open data into larger datasets or by using the open method in a different scientific discipline (see Figure 1).

Whereas the first digital revolution of science changed established practices, the second digital revolution of science – as we see it today – deeply challenges the consolidated roles of researchers, research organisations, libraries and publishers. Open science is considered to include not only increased access to research outputs but also more possibilities for different stakeholders to participate in scientific processes with increased transparency (Lyon, 2016; OECD, 2015).

The scientific society is international by nature, and it is essential to anticipate the potential impacts of decisions and actions on open science from local, national and international perspectives. Cooperation within different types of networks is therefore essential in order to ensure well-informed and effective decision-making and implementation by different stakeholders. After setting the scene of open science development, this paper presents the Finnish Open Science and Research Initiative as a case where joining networks and motivating individuals and organisations have over a relatively short period of time enabled the delivery of high-quality services, infrastructures and competence building for a transition towards open science. This paper is based on a keynote presentation given at the Liber 2016 Conference in Helsinki.

2. Towards Open Science

Open science is still in many ways an open goal yet to be reached. In order to progress, it is important also to understand what has brought us to the situation we face today.

In May 2016, the EU Competitiveness Council committed to accelerating open science: "*Member states agreed to common goals on open science and to pursue concerted actions together with the Commission and stakeholders. Delegations committed to open access to scientific publications as the default option by 2020 and to the best possible re-use of research data as a way to accelerate the transition towards an open science system*." (Council of the European Union, 2016).

Looking back a few years, it is no wonder that some people have called this a life-changing decision. Only 15 years ago, academic and research libraries established the Scholarly Publishing and Academic Resources Coalition (SPARC) to make open access the default for research and education (Association of Research Libraries, 2016).

Fourteen years ago, the Budapest Open Access Initiative of the Open Society Institute stated that "open access to peer-reviewed journal literature is the goal" (Budapest Open Access Initiative, 2002) and the University of Southampton's School of Electronics & Computer Science (ECS) became the first in the world to adopt an official self-archiving mandate (eprints, 2003).

Thirteen years ago, the Bethesda Statement on Open Access Publishing in Biomedical Research (Bethesda Statement, 2003) and the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities highlighted the need to move towards open access. The Berlin Declaration says: "*The Internet has fundamentally changed the practical and economic realities of distributing scientific knowledge and cultural heritage. For the first time ever, the Internet now offers the chance to constitute a global and interactive representation of human knowledge, including cultural heritage and the guarantee of worldwide access*." (Berlin Declaration, 2003).

Since then, we have witnessed the emergence not only of thousands of open access journals (see the DOAJ[1]) but also of many new important players in the field, such as Open Knowledge International,[2] ResearchGate[3] and Academia.edu.[4] UNESCO has also encouraged governments and organisations to develop open access policies (Swan, 2012).

In addition to open access to scientific publications, there has been significant progress as regards open data. Initiated already in the 1950s in the area of geophysics (ICSU, 1963), the idea of open data reached an important milestone with the completion of the Human Genome project 13 years ago (NHGRI,

2003). This was followed by the Organisation for Economic Co-Operation and Development Declaration on Access to Research Data from Public Funding (OECD, 2004) and by CERN launching its Open Data Portal ten years later in 2014 (CERN, 2014).

During the present decade, many important steps have been taken in developing new infrastructures to support open science. For instance, the pan-European infrastructure providing research data services, training and consultancy was established in 2011 (EUDAT[5]). Currently, we are discussing the Commission's communication on the European cloud initiative (EC, 2016b).

All these developments have produced many different ways to support those who want to openly share their scientific work. Whereas "*openness can be [thus] defined by a continuum of practices, starting perhaps at the most basic level with openly self-archiving postprints and reaching perhaps the highest level with openly sharing grant proposals, research protocols, and data in real time*" (McKiernan et al, 2016), it is indeed a fundamental change that concerns not only scientific work but also more widely life beyond academia.

Important milestones for motivating scientific communities in terms of open science have been reached when funding organisations such as the National Institutes of Health (NIH, 2009; Rockey, 2012) and the Bill and Melinda Gates Foundation in the US (Bill and Melinda Gates Foundation, 2015) and Horizon 2020 (EC, 2016d) in Europe have announced and tightened their requirements for open science.

Over the past few years, many key associations such as the Association of European Research Libraries (LIBER, 2014) and the League of European Research Universities (LERU, 2015) have strongly advocated open science. Important milestones have also been reached during the Netherlands' EU Presidency in 2016 (Council of the European Union, 2016; EC, 2016a; EU NL, 2016) as well as in the US, where the White House concluded that "*policies to make data and publications resulting from federally funded research publicly accessible are becoming the norm*" (The White House, 2016).

And many, many more actions throughout the world at the international, national and local levels have been taken. It has at times been quite difficult to keep track of everything.

3. Finland's Open Science and Research Initiative

Considering the development of open science as well as national needs, the Finnish Ministry of Education and Culture (MEC) has set out the Open Science and Research Initiative (known as the ATT Initiative) for the years 2014–2017 (ATT Initiative, 2016a).

According to the Ministry's Open Science and Research Roadmap 2014–2017 (MEC, 2014), the vision for 2017 is as follows: *"Open research leads to surprising discoveries and creative insights. This means a situation in which research data and materials move freely throughout society: from one researcher or research team to another, between disciplines, to innovative business, and to decision-makers and citizens. Information flow is facilitated by clear policies and best practices, and by providing services to safeguard the availability of scientific and research results. Openness is a joint operating model. Openness has given Finnish research an international competitive edge."*

The ATT Initiative will be successful only if open science becomes a natural part of the daily scientific work in all research organisations in Finland. To achieve this, two important starting points were identified. Firstly, the scientific society is international by nature. Therefore, it is very important that any actions or decisions at the national level be adjusted to the international developments in open science. On the other hand, Finland also wanted to enhance its own impact on international forums.

Secondly, there are – by nature – many divergent views within open science. This is of course only natural, since the second revolution of science will change not only the practices but also the values and roles of the different players involved. Therefore, we wanted to find a way of working where we could identify the questions we need to ask, the problems we need to solve and the players we need to engage with at the local, national and international levels.

In fact, we wanted to establish a way of working where competing targets and contradictory views would be turned from obstacles into strengths.

In order to ensure a speedy transition towards open science, there were three questions in particular: How can we motivate and inspire organisations and

people? How can we ensure bridging between different networks? How can we deliver infrastructures, services and support for competence building?

3.1. Motivating and Inspiring Organisations and People

Many of us have witnessed the power of the initiatives and statements from Budapest (Budapest Open Access Initiative, 2002), Bethesda (Bethesda Statement, 2003) and Berlin (Berlin Declaration, 2003). They have motivated and inspired many organisations and people to proceed towards the open science era.

3.1.1. Open Science Operating Culture of Peers

In addition to statements or declarations, we can also inspire organisations and people amid divergent changes by showing them examples of their peers. In 2015, the ATT Initiative therefore analysed the current maturity level of the open science operating culture of Finnish higher education institutions (HEIs). The material used in the analysis consisted of public information on the institutions (websites, strategies, policies, principles and guidelines) and the responses provided by the organisations for the draft report.

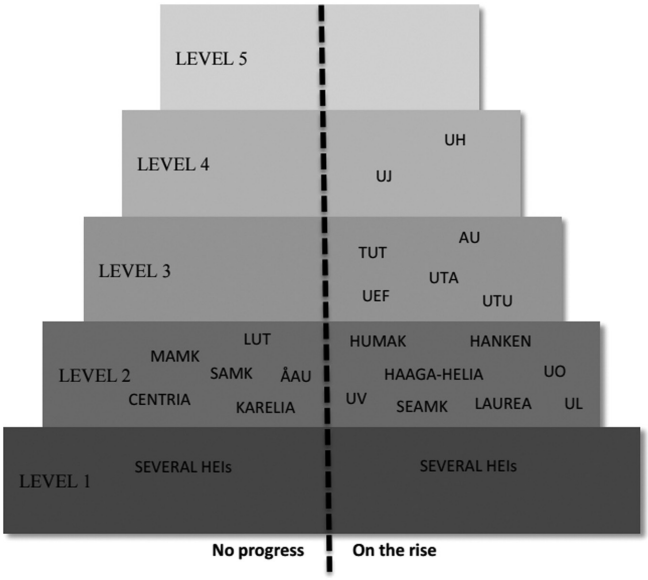
The data were compared with the responsibilities of research-performing organisations for promoting open science as described in the Open Science and Research Roadmap of the ATT Initiative (MEC, 2014). The analysis examined the openness of HEIs in four categories: strategic steering, policies and principles, supporting openness, and competence development.

Operational cultures were scored for five maturity levels starting from the unmanaged level where no systematic development towards openness could be identified. The highest, strategic level of openness presents a situation where "*an open operational culture is publicly encouraged on the entire organisational level and openness has been defined as a core value in the organisation's strategy and policies. Activities are open, and are developed in accordance with the principles of openness and in cooperation with other actors. Openness has also been linked to the long-term planning and management of activities. The organisation is always able to ensure that it is moving towards its goals, and is learning*

and adapting. Key benchmarks are in comprehensive use and are continually checked. Personnel are aware of their targets and the organisation's progress towards openness" (ATT Initiative, 2015).

Although none of the HEIs were yet at the highest level of openness (the strategic level), many of them had already promoted open science (see Figure 2). After the results of this first survey were published, many – if not all – of the HEIs have taken swift action. Comparing the maturity level of institutions with that of their peers seems to have had a positive impact, since it showed that some universities were already progressing well and inspired the other institutions to take actions of their own, too.

Fig. 2: Distribution of Finnish higher education institutions (HEIs) based on their overall maturity levels of an open science operating culture in 2015 (n = 38). The abbreviations refer to different HEIs. Source: report from Open Science and Research Initiative, licensed under the Creative Commons Attribution 4.0 International Public (ATT Initiative, 2015).



Level 1 Unmanaged	Level 2 Partly managed	Level 3 Defined	Level 4 Managed	Level 5 Strategic
No systematic development towards openness	Partial policies and tools	Processes have started	Collective, well-managed development	Proactive, systematic actions

Therefore, the evaluations of the maturity level of an open science operating culture will continue. The national target in Finland is that 10 per cent of higher education institutions will be in the highest category of openness by 2017 and that 50 per cent of the institutions will have reached the strategic level by 2020.

3.1.2. Open Science Policies of Peer Organisations

In Horizon 2020, open science is illustrated by the general principle for open access to scientific publications. Since Horizon 2020 is the biggest EU research and innovation programme ever, this approach works as a high-level incentive for all of those who would like to apply for Horizon 2020 funding – and far beyond.

One way to analyse the impact of Horizon 2020 is to look at the information provided by the Registry of Open Access Repository Mandates and Policies.[6] At present, the ROARMAP has registered more than 700 open access policies. This database gives an interesting overview on open science policies. In Europe, the percentage of individual policies aligned with the Horizon 2020 Open Access Policy varies between 31 and 73 per cent. Importantly, more than 70 per cent of these policies have been registered by research organisations. This implies that the policies likely have an impact on the daily scientific work of these organisations. Finland, with its five million inhabitants, is among the top ten countries in the number of open access policies registered.

The Academy of Finland – the research council of Finland – is also committed to promoting open science and the ATT Initiative (Academy of Finland, 2016). Academy-funded researchers need to make sure that publications produced with Academy funding are made openly available, where possible. The Academy's recommendation is that researchers publish articles following either green or gold open access. Academy funding is also available for research costs arising from publishing research results.

Applications to be submitted to the Academy of Finland must include a data management plan. We require that Academy-funded research projects' data are stored and made available through major national or international archives or storage services that are important in the fields concerned. These include the Finnish Social Science Data Archive (FSD), the FIN-CLARIN

consortium, services by the ATT Initiative, CERN's Zenodo service and the EUDAT data infrastructure. Data may for justified reasons, however, come in varying degrees of openness, ranging from fully open to strictly confidential (Academy of Finland, 2016).

3.2. Bridging between Different Networks

Motivated and inspired organisations and people can change the world. However, in times of divergent change (such as the emerging era of open science), working together with international and national networks is essential in order to be able to deliver. Cohesive networks are needed for coordinated actions and support whereas bridging networks can provide new approaches and novel information (Balkundi & Kilduff, 2006; Battilana & Tiziana, 2010).

When engaging with a highly clustered network where people know each other, it is easier to build trust and acquire mutual support, both facilitating communication and coordination of actions. Working with these kinds of networks is often comfortable. It is nice to discuss with people who have similar interests and worries. Cohesive networks can exist, for instance, between libraries or universities. However, such cohesive networks may also be rather homogeneous and redundant. This may hinder taking actions to change the course of actions. Therefore, in times of divergent change, working only with cohesive networks will not be enough. Proactive bridging with other networks will help both to identify the magnitude and direction of changes and to enhance actions to be taken by many different players in various areas.

For instance, the Netherlands' EU Presidency has very successfully encouraged bridging between different networks. The conference "Open Science – from Vision to Action" in April 2016 resulted in the Amsterdam Call for Action on Open Science (EU NL, 2016). Importantly, the input was built on the outcomes of preceding international meetings and reports as well as on the stakeholders participating in the conference.

3.2.1. Bridging in the Open Science and Research Initiative

The basic organisational structure of the ATT Initiative by the Finnish Ministry of Education and Culture consists of a strategy group, an expert group and

several working groups. Based on the analysis of the affiliations of the members of these various groups, it is clear that four organisations very closely associated with the Ministry participated in all three groups. These organisations are CSC – IT Center for Science, the National Library of Finland, the Academy of Finland and the University of Helsinki (see Figure 3).

This highly clustered network, where people know each other from before, has acted as the core and cohesive network promoting the ATT Initiative in many ways. In addition, three different approaches have been taken to enhance bridging between different networks.

Firstly, we invited to the strategy group not only the members of the cohesive core group including four organizations closely associated with the MEC and the National Institute for Health and Welfare, but also Seinäjoki University of Applied Sciences, Open Knowledge Finland, and nine out of twelve Finnish ministries, which is quite an exceptional number for these kinds of initiatives. This helped to align the work of the ATT Initiative with different actions ongoing in other disciplines – for instance, the programme of open knowledge run by the Finnish Ministry of Finance, which encourages research institutes to open up their data.

Secondly, we have actively engaged both the expert group and the working groups with many HEIs, research institutes, academic libraries, archives and databanks as well as with networks such as the Network of Finnish Universities, the Rectors Conference of Finnish Universities of Applied Sciences, the Federation of Finnish Learned Societies, the Finnish Museums Association, the Society of Swedish Literature in Finland and the Finnish Partnership for Research on Natural Resources and Environment.

Thirdly, many individuals working for the ATT Initiative are also active in international networks and in the EU, the Nordic countries, the OECD and UNESCO. A recent example of the strength of this networking is the nomination of two Finns among the 25 members of the High-Level Advisory Group's "Open Science Policy Platform of the EU," one of them representing LIBER (EC, 2016c).

A smooth flow of information, resources and persons across organisations ensures a highly effective network (Provan & Milward, 2001). Ensuring bridging between different networks and supporting open dialogue are also

Fig. 3: Organisations and networks joined in various groups of the Open Science and Research Initiative in 2014–2016. The cohesive core group is marked by a circle in the middle of the figure.

essential in order to progress towards the vision of the ATT Initiative where research outputs move effectively within and across society (MEC, 2014).

3.3. Delivering Support for Open Science

Despite motivating and inspiring people and engaging with different kinds of networks, open science will not become a natural part of daily scientific

work unless local, national and international infrastructures and services are delivered and available.

3.3.1. Infrastructures, Services and Competence Building

At the national level in Finland, the services already provided by the ATT Initiative support the storing, finding and downloading of open data. The ATT Initiative also supports publication archives, thesaurus and ontology services and the Language Bank of Finland (ATT Initiative, 2016a). In addition to the provision of reference architecture for open science and research, services under development include the digital preservation of research results, a data management planning tool, a metadata editor, services for green open access publishing and a databank on research infrastructures.

Already from an early stage, the ATT Initiative has used an open mode of working with key stakeholders to develop the Open Science and Research Handbook. It gives guidance for researchers, research organisations, decision-makers and funders on the principles and tasks in promoting open science and research (ATT Initiative, 2014).

The ATT Initiative also promotes competence building by organising open science training for experts. The training is provided free of charge and open to all, and all training materials are made available on the ATT Initiative website. Recently, the ATT Initiative also developed an open online course for open science and a self-testing tool. In addition to materials provided by the ATT Initiative, there is also a publicly available list of links to other national and international training opportunities for open science as well as contact details to national open science experts.

3.3.2. Open Publishing Costs Dataset 2010–2015

The business models of open access publishing are currently evolving (e.g. Ilva, Laitinen, & Saarti, 2016; LERU, 2015) and orientation in this turbulent landscape needs to be supported by data. The network built by the ATT Initiative reached a milestone in June 2016 with the publication of an open

dataset on academic publishing costs of Finnish research organisations in 2010–2015 (ATT Initiative, 2016b; Open Knowledge Finland, 2016; rOpenGov, 2016).

In summer 2014, a representative of Open Knowledge Finland requested information on publishing costs from a Finnish university. After the Helsinki Administrative Court ruled that the prices of subscription contracts are public information, the ATT Initiative network and the FinELib consortium took joint action. FinELib[7] is a consortium that centrally acquires electronic materials for its member organisations, which are Finnish universities, universities of applied sciences, research institutes and public libraries.

The publishing cost data (almost 6,000 lines) are now openly available (ATT Initiative, 2016c). The material includes the costs of hundreds of publisher titles for all universities and dozens of other institutions. Based on the analysis, publisher costs have risen by some 10 per cent per year, and the total sum in 2010–2015 exceeded 130 million euros. After this two-year process, Finland is now among the first countries where publisher-specific prices over several years have been made public in detail (ATT Initiative, 2016b; Open Knowledge Finland, 2016; rOpenGov, 2016).

4. Conclusions

The idea of open science has come very far from its early days and developed in leaps and bounds. Open science and research can significantly increase the quality and impact of science in academia and beyond (ATT Initiative, 2016a; EC, 2016a; LIBER, 2014; McKiernan et al., 2016; OECD, 2015). However, it is a revolutionary change that not only affects the way science is done but also challenges the roles of researchers, research organisations, libraries and publishers.

From the early days of development, research libraries have joined different networks and been among the most active stakeholders working towards open science (Association of Research Libraries, 2016; Bethesda Statement on Open Access Publishing, 2003; Budapest Open Access Initiative, 2002; EC, 2016c; LIBER, 2014). The libraries have indeed shown their capacity and willingness to be even more important contributors to the scientific process than before.

In order to be successful, we need to join different networks to build visions and gain inspiration as well as ensure the delivery of high-quality services, infrastructures and competence building for a transition towards open science. The Open Science and Research Initiative (ATT Initiative, 2016a), set out and funded by the Finnish Ministry of Education and Culture, has been assigned this task at the national level in Finland. Joint actions by different networks can also yield unexpected results, as was the case with the publication of the dataset on the academic publishing costs of Finnish research organisations. Benchmarking with peers is another way to boost confidence in going forwards in each organisation, which is why the evaluations of the maturity level of the open science operating culture in Finnish HEIs will continue.

The ATT Initiative, which builds on previous work and was started in 2014, has already produced tangible results. For instance, Professor Sverker Holmgren, who prepared the report *Open Access to Research Data – Status, Issues and Outlook* for NordForsk, said the following: "*We see from the Finnish example that it is possible to come far in a short period of time. If you have clear leadership, can set aside enough resources and engage the main stakeholders, you can work together towards a common goal*." (NordForsk, 2016).

Open science is a revolution in the way scientists work. For some, it can be a terrifying development. Based on our experiences, however, open dialogue on concerns and problems, joint production of services and infrastructures and increasing knowledge inspires and encourages people to move forwards. Although each and every research-performing organisation will need to address open science in its own strategies, only joint actions and working with different networks will ensure that open science is prudently incorporated into our scientific society.

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Notes

[1] DOAJ (Directory of Open Access Journals): https://doaj.org.

[2] OKI (Open Knowledge International): https://okfn.org/about.

[3] ResearchGate: www.researchgate.net.

[4] Academia.edu: www.academia.edu.

[5] EUDAT: https://eudat.eu.

[6] ROARMAP (Registry of Open Access Repository Mandates and Policies): http://roarmap.eprints.org.

[7] FinELib: www.kiwi.fi/display/finelib/In+English.