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OSEC 2022

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ABSTRACTS

For more than twenty years, the international research community has affirmed its support for open and collaborative practices that improve the quality, transparency, reproducibility and inclusiveness of science. In France, this orientation has been reflected in the adoption of two National Plans for Open Science, in 2018 and 2021.
In this context and on the occasion of the French Presidency of the Council of the European Union, France organised the Open Science European Conference (OSEC) on 4 and 5 February 2022. This conference on the transformation of the research and innovation ecosystem in Europe was an opportunity to address in particular transparency in health research, the future of scientific publishing and the opening of codes and software produced in a scientific context, but also the necessary transformations of research assessment, summarised in the Paris Call presented during the event and calling for the creation of a coalition of actors committed to reforming the current system.
This international event was organised was organised by the French Académie des sciences, the Ministry of Higher Education and Research, the French National Center for Scientific Research (CNRS), the National Institute of Health and Medical Research (Inserm), the High Council for Evaluation of Research and Higher Education (Hcéres), the National Research Agency (ANR), the University of Lorraine and the University of Nantes.

EDITOR'S NOTE

All the material associated with the conference (video recordings, media used by the speakers and from which the illustrations in this book are taken, additional data, etc.) is available on the OSEC website: https://osec2022.eu/en/accueil/

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Opening of the Conference

First Inaugural Speech

Frédérique Vidal
French Minister of Higher Education, Research and Innovation

What is open science? Quite simply, it is the unfettered dissemination of the results, methods and products of scientific research, particularly through the development of digital technologies and products. Why is it important? Because it fosters collective progress, by allowing science to incorporate practices of reproducibility and collaboration. Also, because it leads to a democratisation of access to knowledge, by taking scientific publications and methods out of their traditional field, and by demanding more transparency. You know how important it is to me that scientific culture, which is too often impoverished in our society, should be universally shared and should be able to enlighten the decisions and consciences of citizens. Finally, because it promotes the multilingualism of scientific knowledge, which is no longer an obstacle thanks to the growing power of deep learning translation software and the potential plurality of scientific editions. And this diversity, which guarantees a plurality of ways of thinking and allows for a fairer evaluation system, is the only way to preserve scientific integrity and to produce a science that is up to the challenges of today.

This is not the first time that we have wanted to take strong political action in favour of open science in Europe, and this conference is part of a line of major milestones. Firstly, there are milestones at a European level since the European Commission recommended the generalisation of open access to scientific publications as early as 2012[1]. In 2016, the Amsterdam Call to Action for Open Science was launched, calling for action on open science in all European countries[2]. The European Open Science Days that I have the honour of inaugurating today, organised under the French Presidency of the European Union, are part of this legacy.

But we have also initiated major advances at national level. Together we have launched a first then a second National Plan for Open Science in 2018[3] and 2021[4], and progress is already being made. Our invaluable French Open Science Monitor[5], the latest edition of which was launched last week, now shows almost 62% open access, which is significant progress. During this period, we have managed to create a Committee for Open Science[6], and a National Fund for Open Science[7]. We have integrated into the Law on Research Programming[8] the objective of achieving 100% open access to scientific publications. We have also included these concerns in the

decree of 3 December 2021 on scientific integrity[9]. Finally, before the summer, we will launch the national platform for research data[10], which I announced last July.

At international level, UNESCO recently issued a recommendation on open science[11], which in many respects shares the concerns I mentioned earlier. It showed that open science is not a matter of convenience, not an option or even a fashion, but a necessity that can save lives, and I would like to pay tribute to UNESCO and to all the member countries that discussed the details of this fine text, with great rigour and always in the collective interest. Having a global recommendation on open science confirms in many respects its universal importance, not only French or European.

Obviously, there is still a long way to go, and that is why initiatives like these are important. We still need to discuss, debate and decide on a number of issues such as the transparency of health research, the evolution of research evaluation, or the essential contribution of new technologies to open science. The subject of health in particular, during a global pandemic, was bound to come up. It is necessary, at a time when lives may depend on the effectiveness of the solutions proposed, to identify ways of improving practices for communicating results, and the French Open Science Barometer has been a decisive tool for assessing the transparency of health research. Even today, although the rate of openness of health publications is higher than the national average, the results of clinical trials and observational studies, particularly those that are negative, are still not made public enough. This problem is not specifically French, it can also be seen on a European and international scale. We need to improve collectively on this point.

Another possible point of improvement, and in this I agree with the UNESCO recommendation, is scientific publishing. I strongly support the principle of bibliodiversity[12], and I am convinced, like many of you, that publishing diversity is an element that contributes both to academic freedom and to the dissemination of knowledge in society and among scientists. The publishing landscape sometimes suffers from its great concentration and could be more diverse and more balanced, and we must work in this direction so that everyone can find their place.

I would also like to talk to you about the reform of research evaluation, an evaluation that focuses more on quality and concrete impact than on the quantity or format of publications. With the Paris Call[13] launched today, we are committing the scientific community, within the framework of the French Presidency of the European Union, to reflect on a fairer and more relevant method of evaluating research, one that better promotes the quality of research work. The European Commission's recommendation

for a reform of the research evaluation system, published last November[14], is also along these lines.

Finally, this diversity of research activities, which we hold dear, is only made possible by the fundamental role of digital technologies in sharing knowledge for all. For this reason, we wanted to focus in this conference on research software that are first-class contributions to research, discovery and knowledge, and we were keen to reward their actors. Thus, the Director General of Research and Innovation, Ms Claire Giry, will present the first six open science prizes for free research software tomorrow on my behalf. Without, of course, revealing the names of the winners in advance, I would like to pay tribute to them and say how privileged we are to have such talented people in our universities and research organisations who have chosen to develop their software under a free licence so that it can be used, modified and improved by everyone. This was an essential contribution to the digital heritage of humanity.

I therefore wish you collectively for these games to be able to raise awareness, to rethink, to find innovative solutions for a more open and more universally shared science. This is the future of European and global research, the only way to ensure that this research is equal to the challenges that await us.

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Second Inaugural Speech

Mariya Gabriel
European Commissioner for Innovation, Research, Culture, Education and Youth

This conference on open science is covering many aspects of strategic relevance to build the future of Europe, a future based on knowledge leading to more opportunities for younger generations to express their talent in attractive research careers, be it in universities, research organisations or industry. Some sessions will be dedicated to discussing the assessment of research and researchers' performance, which affects their behaviours. This debate is timely and justified.

Most researchers are used to measuring in their labs when collecting and processing data. Scientists have to measure with accuracy to produce reliable and verifiable results. The Nobel laureate Richard Feynman started one of his famous lectures challenging his students about the complexity introduced over the centuries by using different measurement units. Measuring research and researchers' performance is of a different nature and more complex in many ways. It has direct impact on people and a far-reaching policy dimension for the European Research Area. We therefore agree on the need to ensure objectiveness and fairness as guiding principles and we can use assessment methodologies to support broader policy objectives, considering that we live in times of change, including in the scientific methods and the public perception of the role of science.

Research processes are in constant evolution, accelerated by the current pandemic and the transition to a resilient, green and digital economy and an inclusive society. The variety of activities making increased use of advanced technologies puts us in a situation where research deliverables are richer and not limited to delivering and counting publications. Modern science delivers other outputs, mostly digital, like datasets, software, algorithms or protocols, and it delivers highly skilled people through specialised education and mentoring. Multidisciplinary collaborations are required to address new scientific questions arising from increased complexity and that is another aspect of this evolution. More and more researchers from different domains, from biology and physics to economics, anthropology or humanities, work together in the boundaries of areas of knowledge.

These types of change invite us to question the system of rewards and incentives and it would be interesting to have feedback from all stakeholders on issues such as whether researchers are too dependent on publications, not reflecting the wider and deeper *raison d'être* of the scientific mission, which includes the dissemination of knowledge and mentoring of new generations. Do we have unhealthy and disproportionate competition between individual researchers? Are we heading to a vicious circle in which more publications translate to more funding, penalising the critical review of the scientific substance and limiting the access of newcomers? Are we risking a lack of rigour, preventing fully enabled peer review in favour of expediency and are we undervaluing research results other than publications and weakening the capacity and willingness of researchers to collaborate?

These issues have existed for a while, but we have an opportunity now following the signature of Member States of the Pact on the new European Research Area and the recent Strategy for Universities. Our opportunity here is to deepen the debate and start acting. Beyond cultural and methodological aspects, opening science and innovation to citizens requires adequate infrastructures, like the European Open Science Cloud, new sets of skills for researchers and for academic and research organisations. We can make progress in designing a conducive assessment system for researchers, research projects and research institutions. An assessment system embedding values such as ethics and integrity, which encompasses excellence and opens new opportunities for the research community through collaborations.

To attract more people to science, particularly women and younger people, we need to increase trust in science among our citizens, and to find a good balance between curiosity-driven and more downstream impact-driven research. 2022 is the European Year of Youth. We should avoid putting young generations in a vulnerable position. Any reform of the assessment systems should have a positive impact on the quality of research and improve the attractiveness of researchers careers and make such careers more accessible.

One of the actions included in the first Policy Agenda for the European Research Area, for the next three years 2022-2024, is to advance towards the reform of the assessment system for research, researchers and institutions to improve their quality, performance and impact. We consulted a variety of stakeholders in 2021, including organisations representing researchers, public funders, private funders, universities, research centres, academies, national evaluation agencies and policymakers, and we received strong support for the objective of ensuring a combination of qualitative and quantitative indicators to evaluate research and researchers without compromising on objectivity and peer review.

The European Commission has started the process to engage over 150 European organisations interested in this work. We aim to advance this year on the commonly agreed principles for assessment and commitments for implementation within concrete timelines. After this initial phase, the work will continue to pilot the updated evaluation criteria and associated processes. Let's expect that the European Universities alliances, for example, will contribute and test the proposed reforms on the ground.

These transformations will require systemic and cultural changes and we cannot dissociate this work from what happens in the rest of the world given the strong collaboration interconnections researchers establish internationally. I ask for all stakeholders to be closely associated to the design and implementation of the proposed changes and to take ownership of them. Good coordination of efforts will be crucial. I expect concrete results and I look forward to working with you because we share the common objective to make science an example of transparency, openness, integrity and opportunities. We all aim to have an inclusive scientific culture that permeates our society through education and disseminates knowledge and our values.

Third Inaugural Speech

Shamila Nair-Bedouelle
Assistant Director-General for Natural Sciences, UNESCO

The Paris Open Science European Conference comes at a critical juncture for science. Never before has the need for universal access to science seemed as evident as during this current pandemic. Timely access to science has proved to be key to designing an effective response to COVID-19.

More broadly, we know that timely access to science is a vital factor in tackling the myriad of environmental and medical issues that the world faces today. In fact, access to scientific knowledge and its benefits is a human right enshrined in Article 27 of the Universal Declaration of Human Rights. It is also a question of equality, not just equality between countries and within countries, but equality between men and women. Yet there remain inexcusable divides. We are confronted with a digital divide, a technology divide, a knowledge divide, a knowledge divide between and within countries. As countries call with an ever-greater insistence for these gaps to be closed, transitioning to open science has never been more urgent. Indeed, open science is one of the transformative tools at our disposal to reduce inequalities in science, technology and innovation and fulfil the human right to science and accelerate progress towards the sustainable development goals of the United Nations. Open science not only improves the quality and efficiency of the scientific process, but it makes the process more transparent, more inclusive and more democratic.

It was in recognition of this transformative power of open science that UNESCO's 193 Member States adopted the first international standard-setting instrument on open science in November 2021[1]. This Open Science Recommendation of UNESCO came together after two years of discussions between scientists, librarians, data experts, young researchers, coders, publishers, engineers, innovators, decision-makers and indigenous people around the world, who worked hand in hand in a true spirit of compromise to develop a ground-breaking international framework for open science. This Recommendation considers the specific challenges that scientists and other actors face in developing countries, in particular in embracing open science, and this recommendation provides the first internationally agreed definition of open science. It presents key objectives for enablers of open science, but it accommodates the fact that open science cannot be fairly and equitably implemented around the world with a one-size-fits-all strategy.

Building on the four pillars, namely open scientific knowledge, open science infrastructure, open science engagement of societal actors and open dialogue with other knowledge systems, the UNESCO Recommendation on Open Science, the first ever, defines open science as the various movements and practices set out to make multilingual scientific knowledge openly available. It is also set out to boost scientific collaboration and sharing of information for the benefit of science and society, to ensure that no one is left behind. Finally, it extends the processes of scientific knowledge, creation, evaluation and communication to societal actors which operate beyond the traditional scientific community.

For the first time in history, we have a text which presents a set of shared values and principles for the operationalisation of open science. The Recommendation proposes innovative approaches at different stages of the scientific cycle and therefore calls for the barriers to open science to be removed, particularly those barriers relating to research and career evaluation systems.

We are confident at UNESCO that this Recommendation will ensure that open science does not replicate the failures of traditional closed science systems and makes a difference for society. We are conscious of the challenges that our Member States will face in implementing this Recommendation, such as the need to fully understand the challenges and benefits of open science for the various actors and to understand how countries can develop appropriate open science policies, strategies, infrastructure, financing and monitoring frameworks and how they can also finance and provide incentives for implementation.

The transition to the global open science model has only just begun. Countries and scientists across the world will need support, your support, and guidance every step of the way. Science is mankind's greatest enterprise, and we need to promote a scientific humanism. The role of UNESCO and its intergovernmental international scientific programmes have promoted access to the benefits of science and technology for the last 75 years to ensure that no one is left behind for a more peaceful world. Louis Pasteur, one of our greatest scientists of all time, said, 'Science has no motherland because knowledge is the motherland of humanity'. These conferences represent a critically important initiative in that sense.

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Fourth Inaugural Speech

Antoine Petit
CEO of the French National Center for Scientific Research – CNRS

This conference is the first in a series of events to be organized by France on scientific research and innovation, coinciding with the EU French presidency. The French National Centre for Scientific Research (CNRS) is the leading player in research in Europe, and will be mobilised during these six months by organising and contributing to a number of events that will discuss, and challenge, this Europe of scientific research and innovation. This first Open Science Day has already attracted more than 2000 participants across Europe, which demonstrates, if it was necessary to do so, how important open science is. It is a revolution, a very much needed revolution, for research, a revolution in which CNRS is particularly voluntarily involved. Back in November 2018, CNRS published its own roadmap for open science[1], as well as a plan for research data a year later[2].

The topics that will be developed today are of critical importance, and I would like to thank the staff of CNRS who helped organise this conference. Our speakers for these next two days come from all over the world, because the issue of open science can only be properly understood in an international logic.

Let's mention some key actions of the CNRS in the service of open science:

> 100% of publications from CNRS units must be open access. Thanks to the involvement of the scientific communities, this action is gradually being achieved. Just under 50% of these 45,000 yearly publications were open access in 2017. Today, this is the case for almost 80% of them, with a particular progression of 10% in 2021, as a result of a strong policy in favour of the French national open archive HAL[3]. Since 2019, CNRS researchers have to deposit their publications in this platform. This measure has also had an exemplary effect, judging by the latest figures from the French Open Science Barometer[4], deployed by the Ministry of Higher Education, Research and Innovation (MESRI), which shows a 10-point increase, with a rate of 62% of French publications in open access. This shows that opening science to all is possible.

At the same time, the CNRS supports numerous publishing models, such as the Diamond Open Access model, which will be at the heart of the conference discussions,

with high-quality platforms such as the Centre Mersenne[5], developed in Grenoble, OpenEdition[6], essentially in the field of social sciences and humanities, as well as epi-journals[7], which are backed up by open archives: from manuscripts deposited in HAL and examined by peers, articles are selected for an epi-review. The rise of these publishing models is absolutely essential for open science.

However, we must be careful as these models must have a reasonable cost and be centrally financed by the academic community. This is what will be discussed in the session on scientific publishing, which will demonstrate that there is an alternative to the so-called Gold Open Access model of publication, which involves the payment of publication fees directly by authors to publishers. This model is not sustainable, neither financially nor ethically. Open access publishing is not synonymous with payment of publication fees, and the CNRS intends to go further to counter the drift of these additional fees imposed by publishers.

In order to profoundly and sustainably change the landscape of scientific publishing, an indispensable step is to modify our individual evaluation practices. CNRS is working on this in a long-term effort, which involves convincing the communities to no longer systematically rely on quantitative bibliometric criteria such as journals' impact factors or authors' h-index. It is necessary to change our practices collectively, and our institutions, universities, research organisations, funding agencies or means agencies must be proactive. It is only at the cost of this collective effort that we will convince scientists to stop trying to publish as much as possible, and only in high-impact journals. To this end, beyond the DORA[8], signed in 2018, the CNRS has proposed new, more qualitative criteria, which aim to stop relying on journal rankings and to emphasise the fact that we need scientists with diversified profiles. Those who are champions of innovation, of interaction with society, and of open science also deserve all the attention of CNRS, and an evaluation that considers all the professions of researchers.

For individual evaluation practices to evolve, a consensus is needed, and I welcome the current effervescence around the issues of evaluation, whether at national or European level. A text entitled Paris Call for Action on Scientific Research Assessment[9] has been prepared by the Open Science Committee and published on the Open Science European Conference (OSEC) website. This follows a text proposed by the European Commission in December 2021[10].

The CNRS wants to be part of the reflection undertaken by the European community. This subject of evaluation is another key topic of the OSEC days, in a dedicated conference with many speakers from very different backgrounds.

As this conference today shows, the challenges of open science go beyond the national and even the European perimeter. But it is particularly up to the European communities to set an example and to exchange more, to collectively assert their interest to decision-makers and to research and innovation stakeholders.

It was in this spirit that the CNRS formed the G6 a few years ago, an informal European club that brings together, in addition to the CNRS, the Italian CNR[11], the Spanish CSIC[12] and the Max-Planck Society[13], the Helmholtz Association[14] and the Leibniz Association[15] in Germany. This network brings together some 135,000 multidisciplinary research staff and aims to represent the interests of research communities to European decision-makers in Brussels. Open science and research evaluation is an important issue for the G6, which recently issued a declaration in favour of open science to reiterate its common position and to emphasise six priorities that will help accelerate the movement towards open science, and hence research excellence:

1. Open access to scientific publications as the default mode of academic publication;
2. Research data to be “as open as possible, as closed as necessary”, in line with the FAIR principles;
3. Extension of open science principles to research software;
4. New evaluation procedures and criteria, compatible with the principles of open science;
5. The development of new skills with appropriate training;
6. Appropriate and available infrastructures and services within Europe and internationally.

Some of these priorities will be addressed in the sessions in the course of today and tomorrow. I wish you a great conference.

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Fifth Inaugural Speech

Patrick Flandrin
President of the French *Académie des sciences*

When the project to organise the Open Science European Conference 2022 was launched, the *Académie des sciences* enthusiastically offered to host it in the Palais de l'Institut de France, in its beautiful André and Liliane Bettencourt auditorium. We had long hoped that this would be possible, with its promise of direct exchanges and informal meetings. Unfortunately, the prolongation of the Covid-19 pandemic decided otherwise, and we had to move from presence to distance.

It is obviously with regret that we had to give up meeting 'in real life' but, to look on the bright side, we can say that what we lose in conviviality, we gain in terms of greater participation than our on-site capacity allows... The registration figures - over 2000 - speak for themselves in this respect, underlining, if it were still necessary, the great interest that the scientific community has in opening up science. Presence or distance, the *Académie des sciences* is happy and proud to be co-organiser of the event that brings us together during these two days and, on its behalf, I am particularly pleased to welcome you all to this moment of sharing!

When we talk about open science, there is in fact a long association between many of the principles underlying it and the *Académie des sciences*. Since 2009, the *Académie* has been committed to thinking in a very general way about the issues surrounding scientific publications. Under the impetus of Jean-François Bach and Denis Jérome in particular, it has issued several opinions and reports in this regard, both on the conditions of access to scientific production[1] and on publication and research evaluation practices[2].

With regard to access first of all, open science aims to make the products and results of research, most of which come from public funds, «as open as possible and as closed as necessary», in order to democratise knowledge and share scientific advances with as many people as possible. This desire, made possible by digital advances, was clearly stated by the *Académie des sciences* in 2018[3], in a statement affirming its support for free and universal access to scientific publications. It was then renewed on the occasion of an international colloquium on Open Science Foresight that it organised in the spring of 2019[4], during which the

diversity of disciplinary customs and the need to take them into account for any implementation of the principles of openness were appreciated.

It is one thing to be able to access as many research products as possible as freely as possible, but scientific production is constantly increasing. We can be pleased about the increase in knowledge that this represents, but we can also be concerned about the proliferation of information of all kinds that this generates, which can quickly overwhelm us. Today, no one can hope to read everything that is written in their field!

As in any jungle, in order to find one's way, one needs to have some reference points that help to separate the essential from the superfluous, to extract useful information from the noise. To do this, it is very tempting to rely on purely quantitative indicators: how many publications? in which journals? how many citations? While such criteria may be useful, the *Académie des sciences* has repeatedly expressed its reservations about an overly accounting approach to evaluation, stressing that, rather than being quantitative, evaluation must be qualitative, based on the intrinsic quality of what is at the heart of the work and not on figures derived from impersonal, simplistic metrics: excellence cannot be read in an Excel table and it is up to researchers to reappropriate the evaluation activity!

This approach is demanding for evaluators, but it should prevail generally in the higher education and research ecosystem. Favouring the qualitative over the quantitative is not only virtuous, it is also an essential springboard for encouraging fewer but better publication, for the greater benefit of all. This is a position that the *Académie des sciences* defends relentlessly, confident that positive developments in this direction are possible, and it is in this sense that it has signed DORA, the San Francisco Declaration on research evaluation[5].

However, various obstacles are holding back this virtuous movement, which can be explained in part by the very high costs of disseminating scientific knowledge and the preference given to certain closed journals considered to be very prestigious for the promotion of researchers' careers and work. To overcome this obstacle, the *Académie* insists, in a very recent opinion that it has just published[6], on the need to change publication practices and research evaluation methods. In particular, it recommends improving the system for publishing research products and encouraging bibliodiversity. The *Académie* recognises that the visibility of validated research results on institutional servers must be taken into account fairly by evaluation committees. As such, it is natural that it should align its own practices with its recommendations. For example, the *Comptes Rendus de l'Académie des sciences*, a historical publication founded by Arago in 1835, has been available online for more than two years under the Diamond Open

Access formula, which makes all articles permanently available worldwide, at no cost to either the readers or the authors. This is of course only possible thanks to institutional support, and I would like to thank the CNRS via the centre Mersenne[7] [8].

Opening science and making it the ordinary scientific practice of tomorrow is a matter for all of us, and for the younger generations. We must make as many researchers as possible aware of the advantages and methods of open science and evaluation, starting with doctoral studies. Training students in evaluation and scientific integrity, and encouraging the introduction of teaching modules on these subjects in all doctoral schools, is essential.

The presentations and round tables of these two days will be as much a testimonial of what exists as an incentive to push further the principles of open science that we are calling for.

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Health Research Transparency

Transparency of Health Research

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I would like to start this presentation by referencing a paper that was published by Alessandro Liberati[1], who was a great epidemiologist, very much involved in the Cochrane collaboration, wherein he reported his experience as a multiple myeloma patient. When his disease relapsed, he had to make a very difficult decision and decide whether he would get a second transplant. As a methodologist he wanted to base this decision on evidence. He searched for evidence; identifying four completed randomised control trials. However, none of them provided fully published results. Consequently, he was forced to make his decision knowing that information was somewhere but not available and he was unable to make an evidence-based decision.

Access to clinical trial information is essential and is actually an ethical requirement. In the Declaration of Helsinki[2] which states the ethical principles for medical research involving human subjects, it is clearly stated that every research study must be registered, and that authors have a duty to make publicly available the results of their research and are accountable for the completeness and accuracy of their reports. There is also now some legislation in place. In the United States we have the FDA Amendments Act[3], which requires that all trialists who have at least one site in the US in their trials must post the results of their trials, no later than one year after the completion of the study. We have similar requirements in Europe with the need to post the summary results of clinical trials in the EU Clinical Trials Register[4].

Do we, however, have access to clinical trial information? A study was done that evaluated the public availability of results of trials assessing cancer drugs in the United States[5]. All the trials selected were governed by the FDA Amendments Act and were supposed to post their results. However, three years after the study was completed 69% of the trials had no results posted at the ClinicalTrials.gov register and half of them had no results publicly available, meaning no results that were either posted or published.

We also now have access to data for France thanks to the French Open Science Monitor[6] whose last edition was made public last week. It shows that only 57% of the clinical trials with at least one site in France have their results available, with some difference according to the sponsor: 76% for industry-led trials and 31% for academic-led trials.

A very important initiative and tools have been developed by Ben Goldacre and his team at Oxford University[7]. They developed the TrialsTracker[8], which identifies all the studies that have to post their results on ClinicalTrials.gov and on the EU Clinical Trial Register and data mines whether they actually fulfil the law. The number of trials overdue, meaning that they should have posted their results but have not, increases over time. Compliance, meaning posting results one year after the study was completed, has increased slightly, but remains low and currently stable at 40%. When you assess the compliance with the requirement to report on the EU Clinical Trial Register the team evaluated 7,274 completed trials and they found that only 49% actually reported results, 68% for industry-funded trials and only 11% for academic trials.

What are the consequences? Of course, first, we do not have access to the results and cannot make evidence-based decisions. However, we also have some evidence that the fact that results are published depends on the actual results and there is some evidence of publication bias. Erick Turner showed this in a paper published in the *New England Journal of Medicine*[9]. He identified 74 clinical trials assessing antidepressant treatments that were submitted by the pharmaceutical industry to the FDA to obtain marketing approval. He systematically searched for publications for these trials and found that in one-third of the trials there was no publication. Then he looked at the results and showed that when the trials were positive, showing that the treatment was beneficial, 97% of the trials were published. When the results were questionable, meaning we do not really know whether the treatment is beneficial, half of them were not published and the other half were published but with a conclusion that was not consistent with the FDA decision. When the results were negative, showing that there was no evidence the treatment had any effect, 68% were not published.

Further, the author tried to do a meta-analysis, summarising all the data, using first only the data that were published and compared it to the data including all trials that were published and not published. This showed that meta-analysis of journal dataset, using only data that were published, showed an increase in effect size of 32%, from 11% to 69%, according to the individual drug evaluated.

What could be done? We are meta-researchers and so we always try to find easy low-cost interventions that could improve research. Here we propose to send an email reminding trialists of the legal requirement to post results on ClinicalTrials.gov. We identified 379 trials that met the FDA requirements but did not post their results on the registry one year after the completion of the trials[10]. These trials were randomised. Half of them did not receive any intervention and the other half received an email that was presented like a survey to try to understand why they did not post

their results, and in the survey they were reminded that it was a legal requirement and that there could be a fine of USD 10 000 per day of delay. Our outcomes were the percentage of studies with results posted, which showed, at least at six months, an increase in the percentage of results posted when they received the email. The effect of this intervention is small, an increase of 10%. However, we could imagine that the effect would be larger if the FDA instead of a French research team sent the email.

When results are made available through publication one question is whether the reporting is complete. Do we have enough information to be able to critically appraise the trials and use and interpret the results? We have some reporting guidelines, such as the CONSORT statement[11], which consists of a checklist indicating all of the essential information that should systematically be reported in a report of a randomised control trial. These guidelines are widely endorsed by editors who request compliance with the guidelines in their recommendations to authors.

How complete is the reporting of the literature? This was assessed in a very large study evaluating more than 20,000 trials that were included in Cochrane's Systematic Reviews[12]. When we do a Cochrane systematic review, we always try to evaluate the methodological quality of the study and we evaluate the risk of bias. In this particular study the evaluation of the risk of bias was impossible in a large percentage of trials because the reporting was incomplete. On the positive side, reporting is improving over time.

We are currently doing a large living systematic review the evaluation of which includes all randomised control trials involving potential treatments for COVID-19[13]. This is an open review where we put all the results online. Here we are trying to evaluate transparency indicators and the completeness of reporting of the first trials that were included in the review in the first 17 months of the pandemic. The results show that transparency indicators are not well fulfilled. Only 55% of the trials were prospectively registered. Protocol and statistical analysis plans were available in only 39% and 29% of the trials respectively. Nevertheless, 68% reported a data-sharing statement. In terms of completeness of reporting, results were also very disappointing. Only one-third completely reported the primary outcome. 58% provided essential information related to the conduct of the study. Half reported the results adequately and only 15% adequately reported harm in terms of the safety of the treatment.

One question is: what is the role of the peer review process? Is the peer review process able to improve transparency? This was assessed in a study on 93 published randomised control trials[14] where it was possible to have access to the first papers submitted, to the peer review documents and to the published articles and to

compare completeness reporting before and after the peer review process. There is some improvement for some domains related to the methodology, such as sequence generation, allocation concealment and blinding, but other domains did not improve at all after the peer review process and overall the reporting remains very poor with information available for these important items in less than 60% of the trials.

What can be done? We tried to provide some tools. First, we developed an online writing aid tool entitled COBWEB[15]. This tool aims to guide authors when they are writing the first draft of their manuscript by providing the CONSORT items, explanations about the CONSORT items and examples of adequate reporting. We showed in randomised control trials that when authors were using the writing aid tool, they produced a more complete manuscript than when they did not have access to the tool. We also developed an online peer review tool that is dedicated to early-career researchers and associated with a training programme. We showed that when early-career researchers were using this tool they were more likely to detect inadequate reporting during the peer review process than the usual peer review process.

Completeness of reporting is important, but the reporting also needs to be accurate. In the protocols in particular, investigators have to specify primary and secondary data that will be assessed and analysed in their trials. We expect that these results are consistently reported in the published reports. However, there is some evidence of selective reporting of outcomes[16]. For example, in the studies that systematically compared the outcomes reported in the registry, which are the outcomes that are planned in the protocol, to the outcomes that were reported in the manuscript there was some discrepancy in one-third of the randomised control trials, and these discrepancies favoured statistically significant results.

Finally, there is some evidence of spin in publications[17]. Spin is a specific way of reporting that might distort the interpretation of the study results. For example, the authors will present the results to convince the reader that the treatment is more beneficial than is actually shown by the results. There is evidence of spin and quite a prevalence of it in published manuscripts in clinical trials, observational studies and systematic review, whatever the study design. This is problematic because there is some evidence showing that spin can impact readers' interpretation. This was assessed in randomised control trials where we randomised readers to read an abstract with spin or the same abstract reported without spin[18]. We found that readers were more likely to believe that a treatment would be beneficial when they read the abstract with spin.

Another important topic is access to individual patient data, mainly to be able to reproduce the results, to reproduce the analysis and to check whether we can trust the results. It is also very important to develop other types of research and to synthesis the trial's research in individual patient data meta-analysis. These types of analysis are very useful, particularly to identify the patients who are more likely to benefit from the treatment.

Some journals, such as *The BMJ* and *PLOS Medicine*, have a very strong policy in that they require data sharing as a condition for publication of clinical trials in their journals. A study led by Florian Naudet published in *The BMJ* in 2018[19] evaluated whether we actually had access to this data. He selected 37 published randomised control trials, requested the individual patient data from all of the authors, but could access the data in only half of the trials.

I would like to finish this presentation with a quote from Professor Doug Altman, who was a Professor of Statistics at the University of Oxford, founder of the Equator Network[20] and one of the great leaders in the field of transparency and meta-research. He wrote that the scientific community and the public at large deserve an accurate and complete record of research. We need to make changes to ensure that we will get one.

To go a step further

"Particularly when we look at compliance with the law, pharmaceutical companies are doing better than academic researchers because I think it is more in their process – there is a law, and they need to follow it – and they probably have more support internally to be able to do it. On the other side, for academic trialists there is definitely a lack of incentive to comply with this requirement of posting results. This is linked to the fact they are not as interested and some of them feel that it is additional administrative requirements. They are going to publish their results, so why should they also post them? There needs to be better understanding in the community and, all the more, more incentives and greater recognition of people who actually fulfil this requirement."

"All of the stakeholders have an important role. Institutions have a huge role in decision-making in terms of the criteria they will use to promote their researchers, and currently transparency and good research are not among the criteria they use. They also need to set up strong support for sharing individual patient data because this is currently not at all well organised. The funders have an essential role. Some

try to implement some actions. For example, the NIH I think requests that access is given to all individual patient data, and in the UK that is also the case, but we need more recognition and support from the funders."

"An important point to remember is that researchers want to do good research. Then there are some incentives that will make them go in some directions more than others, and perhaps we need to play with these incentives. We definitely need to be very careful in the way we want to change the system and to be very careful in the way we are going to implement these changes. The way things are implemented, and how well understood the reasons are, is going to be very important to achieve a successful outcome."

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How Psychology deals with Open Science. Principles and practices

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I will start with reference to a 2015 study that got wide attention that looked at the reproducibility of psychological science[1]. They took 100 experiments in three top psychology journals and tried to replicate them with larger sample sizes while following the procedure as exactly as possible. Comparing the original effect size and the replication size show that the original effect size was almost all higher, much higher in some cases. The mean was that the replication effect size was about half of the original effect size. This led to the question of whether we really know how much of the science in psychology is replicable and whether some of our key findings may in fact just be artefacts or things that were not robust enough from the beginning.

From this, two main ideas started. One is the idea of open science, which very generally means making everything transparent and accessible in terms of both the content of the evidence you have produced as well as the process by which you produced it[2]. Related to this is the concept of reproducibility[3], which can apply to different things: are your methods reproducible? Can somebody redo the exact same study and get the same results? Are your results reproducible? If I run a new study and follow your methods exactly, do I get the same or very similar results? Finally, the hardest one, are your conclusions reproducible? Do I draw the same conclusions if I follow the same methodology and get the same results you did?

The paper exploring these ideas is a manifesto. What should we be doing to make science, and particularly psychological science, more open and more reproducible? First, the authors identified what they call threats to reproducible science. Several of these have been known for years. What would explain results such as the open science collaboration paper I referred to at the beginning? Why do we have so much psychological research that does not prove to be reproducible?

One idea that has been studied for a while is the idea of publication bias, the fact that you run more experiments than you publish, and you just keep some in the so-called file drawer. Nobody knows you ran those experiments, and nobody knows what results you got and so they do not inform the literature. Another very well-known

phenomenon that has been studied a lot in psychology is that you look at your data and you see what patterns you have in your data and then you modify and tamper with your hypothesis so that your hypothesis is supported by your data. Alternatively, you apply some sort of filters to your data, using different data analysis tools, to make the data match your hypothesis. This is called p-hacking and HARKing[4]. There are other biases, which I will not go into due to time constraints.

There is also the positive side. A set of proposals and initiatives were suggested around five main topics: methods, reporting and dissemination, reproducibility, evaluation and incentives. What could we be doing to make progress in this field? The rest of my presentation will be about some of these initiatives, and I will always present two things: first of all, the initiative and then evaluations that look at whether or not it works. This is a key point in my presentation because as a meta-researcher I want science to get better, but I also want to make sure that the initiatives and the tools we use are effective for sure. Sometimes things seem like a very good idea, but then prove to not be so effective or to be even harmful.

The first one I will talk about is of course registration. Professor Boutron talked about registration of clinical trials, known as prospective registration, mandatory in journals affiliated with the International Committee of Medical Journal Editors since 2005. Basically, this means that you would need to publicly document your trial protocol before you even enrol the first patient. There is a very similar thing in psychology[5]. Preregistration, you declare your study plan, so your hypothesis, methods and analysis, in a public register, something that can be consulted by the public, before starting the study. The definition is very similar. We just use a different name.

What function would this serve? As I said before, there are two ways in which you can make your results and your hypothesis match. There are so-called evidentiary degrees of freedom, which means that you can make so many decisions in data analysis and thereby you can basically make your results fit your hypothesis. For instance, you can exclude participants so that your results look better, or you can do your statistical procedure in varying ways and so on. You can also adapt your hypothesis. You look at your data, see the pattern it shows and you say, 'Well, actually this is exactly what we were expecting for this and this reason'.

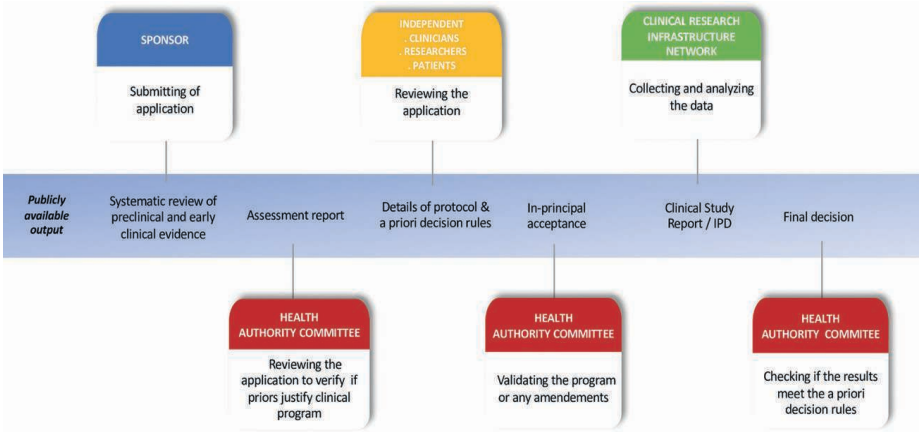
Preregistration declarations would help with both because it would allow decisions about what you do with your data to be independent before seeing the results. Therefore, if you, for instance, want to exclude a certain type of participant you have to say this before you look at your data, and if you have certain hypotheses you must declare them before you look at your data. This would also calibrate confidence

because people that come after, meta-researchers like me, would have the possibility to assess what you initially planned and what you decided to do after.

Of course, this all depends on how completely you put all these decisions in your preregistration. Evaluations of preregistrations have also looked at this. I would present two examples. One is one that our group did where we looked at psychological treatments for depression with trials that started enrolment after the mandate was made compulsory[6]. The results showed that only 40% of these trials were prospectively registered, but even out of these 15% did not specify useful information in the registration. They would say things like, 'We will measure depression', without saying the scale or the assessment timeframe and so on. Another evaluation looked at the phenomenon in psychology[7]. It took studies that had been vetted to be preregistered. It showed that only two of 27 studies had no deviations, but even more worryingly only one study disclosed all of the deviations. There were a lot of undisclosed deviations in terms of analysis.

Preregistration therefore does not seem to work very well for now because when people do it, they do it in a perfunctory way, a superficial way. A solution that was proposed is to have a particular set of empirical publications. In this you would evaluate and accept study proposals before research is undertaken[8]. You would basically submit the protocol for peer review and if it is accepted then you collect the data and write the report. The report is then accepted regardless of what the data looks like if you follow the protocol. This should help to reduce publication bias because then there would be no more pressure to only publish positive results. We recently proposed a version of this to apply to drug approval, wherein we proposed that any trial that is submitted for drug trial be published afterwards in a registered report and then the entire process follows the rules of the registered report[9].

Fig. 1: Overview of the registered drug approval pathway



Source: Florian Naudet et al., *« An Open Science Pathway for Drug Marketing Authorization– Registered Drug Approval »,* PLOS Medicine *18, n° 8 (9 août 2021): e1003726, https://doi. org/10.1371/journal.pmed.1003726. CC BY 4.0*

How do registered reports work? Do they increase transparency? An initial evaluation, conducted in 2018[10], showed that even if their numbers are increasing what seems to be happening is that in a significant percentage, one-third, the initial protocol, so the protocol that was accepted, is not publicly available. This means that essentially, we the readers or researchers, have no way of evaluating whether or not indeed the final publication followed a declared protocol, because we do not have access to what has been declared first. In a way it fixes one problem, that is the protocol becomes more complete because peer reviewers evaluate it, but it leaves a hole in another, that is the protocol is not public.

Another set of studies looked at another important question: are registered reports better in terms of methodological quality than standard reports[11]? This matters because all this peer review effort goes into evaluating protocols. Does this increase the tension associated with better quality? It seems like it does. The comparison between registered reports and non-registered reports showed that in all aspects regarding methodological rigour and quality of methods and so on registered reports seem to be better. Of course, this is an observational study and it has a lot of limitations, but even before seeing the results, the methods are still described better.

Another study[12] interestingly tried to tap into the question as to whether registered reports reduce publication bias in a way that, since you are no longer pressured to make

your findings positive or pretty or interesting, leads you to publish more studies where your primary hypothesis result is not confirmed, and it does seem like that is the case.

Finally, in terms of incentives, what can we do to make researchers implement more of these open science practices? One idea came in the very simple form of badges that would acknowledge that in that paper the researcher followed open science practices[13]. Badges that have been proposed include ones for preregistration, having registered a protocol previously, having shared your data, having shared your material and so forth. It is like in kindergarten when kids do something good, and they get a point. It is that same very simple principle.

Do badges work? An initial observational study on the issue showed that with the introduction of badges the percentage of papers that shared data, which was the variable of interest in the study, increased a lot. It therefore seems to point that it works. However, later as the researchers ran a randomised trial at a journal that has a policy asking for data sharing but does not mandate it – it asks to discuss if you are sharing your data or not and why – they had two conditions. In one they just gave the extent of the information and in the other, there was the possibility to also get this nice open data badge with your paper. In the primary outcome they looked at the rate of data sharing, how many papers out of the total really shared their data, and this outcome was only considered met if you really shared the data, so not just saying it is available upon request or 'contact us for the data', but saying where it is and checking whether you can find it. The results were very disappointing because out of 160 articles, 80 in each group, only two datasets were shared in each group, so very, very little and no difference[14].

To this point, and this is my last point, the importance of always evaluating the initiatives and proposals – we must make science more reproducible – and there is a final example. This has not yet been studied in a randomised trial. It is a tool called Discrepancy review[15]. This is a peer review intervention that would try to reduce undisclosed discrepancies between registrations and publications. They have a set of guidelines and they would have a separate reviewer who would basically check all these aspects. They would do nothing else. They would not review the rest of the paper. They would just be checking whether the paper disclosed deviations from the final publication in the registry. For now, the author has just run a feasibility study, but this is an example of a tool that could be tested in a future randomised trial.

To go a step further

"A lot of work has gone into making ClinicalTrials.gov work, but what seems to be the crucial issue is that even when authors are mandated to register their trial or their study and so forth you also need to have oversight as to whether or not they give all the necessary information. For instance, do they say exactly when they measure what they will measure? Do they say how? Do they say out of 10 tools, which is the primary one? ClinicalTrials.gov is improving in that in the sense that recent registrations are better, but there are still problems there."

"With data sharing, again clinical trial platforms would be a great tool, at least for aggregate data sharing, where, although it is not individual patient data, it is still crucial for meta-analysis and reviews. However, even there again you have to always have in mind that it is not enough to have a registry. You need oversight. There are many examples from ClinicalTrials.gov of researchers or whoever completes the study record putting inadequate information, incomplete information, unusable information and so on. I think the tool could be used, but again what we need to fix is the problem of how we offer support for implementation and from whom. This is the same for journals. Who checks that you did what is required?"

"In experimental clinical psychology, the first step of a PhD is you try to get results that are similar, in the same ballpark, as the seminal studies that inspired you. During my own PhD, I was not. I was getting the opposite results. This was one of the first things that drew my attention. I was starting to look for explanations. I noticed that so many things were not really reported in the original papers I was using, so it was impossible for me to know what I was doing wrong or differently because there was not enough information. Then working on my own data, I noticed that there are a lot of things you can do in terms of data analysis choices, justified choices, so not that you say, 'Well, these participants look bad, I will exclude them', but a certain way of excluding outliers. There are more methods. If you use one and run the study the results of the analysis look more statistically significant. I noticed that is so much in my power to change what the outcome looks like. Of course, I was working on a very small scale, but I started to wonder how many of the papers we are reading are in fact the result of that, and if you start looking for this you start to notice, even with the little information that is given, that there are a lot of these kinds of idiosyncratic decisions or decisions that are clearly *post hoc*. That created a kind of crisis of confidence for me. Later, talking to fellow meta-researchers, many of us have similar stories. We wanted to get the golden findings of experimental research and change the field and then we realised that it might all be just a big house of cards."

"Young researchers and master's students must be trained to open science practices in order to make it by default behaviour, and in a lot of psychology programmes this is happening now. Reproducibility is getting more attention as something that is vital. I see a shift in perspective and in training at all levels, including the undergraduate and graduate levels. The younger generation is very onboard with open science. In psychology replication projects are becoming the norm as student projects. A lot is happening in terms of training in this space, and I am very hopeful that the direction is correct."

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Publication and reporting bias: a long history towards open science

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Both previous speakers have used the terms reporting bias and publication bias many times. I hope to bring them into the historical context and provide a review of the history of the research into reporting biases.

The problem of selective reporting has been recognised for hundreds of years. Reporting bias refers to or occurs when the direction and nature of the findings influence how research findings are being disseminated. Early in the 17th Century Francis Bacon noted that, 'The human intellect is more moved by affirmatives than by negatives'. Robert Boyle, the chemist, lamented the common tendency among scientists not to publish their results until they had a system worked out with the result that 'many excellent notions or experiments are, by sober and modest men, suppressed'. Many other scientists across many different fields have recognised the problem of selective reporting over the years[1].

More recently, in 1956, the father of medical statistics in Britain, Austin Bradford Hill[2], wrote, 'A negative result may be dour, but often it is no less important than the positive and in view of that importance it must surely be established by adequate publication of the evidence'. American psychiatrist Seymour Kety[3] wrote, 'A positive result is exciting and interesting and gets published quickly. A negative result or one, which is inconsistent with current opinion, is either unexciting or attributed to some error and is not published, so that at first in the case of a new therapy there is a clustering towards positive results with fewer negative results being published. Then some brave or naive or non-comformist soul, like the little child who said that the emperor had no clothes, comes up with a negative result which he dares to publish. That starts the pendulum swinging in the other direction and now negative results become popular and important'.

These historical quotes provided you the background of how long we have recognised this problem. Systematic research into selective reporting began in education and psychology in the 1950s. Selective reporting of healthcare research was identified in the early 1980s, but the importance and the consequence of that was not recognised

until a decade later. It has gained a lot of importance as a result of rapid development of research synthesis methods, such as systematic review. Systematic reviews are based on a complete survey of the literature on a given topic. They inform healthcare decisions and policies. When the systematic reviews are based on a selective subset of studies rather than all the studies out there, the findings could be biased. The need to have access to complete information about the methods and results of research is strong motivation for study into selective reporting.

Reporting bias arises when the dissemination of research is influenced by the nature and direction of findings[4]. The nature and direction of findings refers to the statistical significance of the results, the magnitude of the effect and whether the results are in favour of a particular hypothesis. Statistically significant results are results that are unlikely to be due to chance. Instead, some kind of cause is more likely. Selective reporting can manifest in many different ways. To broadly categorise selective reporting, it may concern not reporting studies at all, also known as publication bias; reporting studies in part, also known as selective outcome reporting; reporting in a manner that is difficult for others to access or reporting without transparency, such as duplicate publication or spinning. Spinning means undermining or overemphasising certain results.

Mary Lee Smith[5] likely first mentioned the term 'publication bias' in a manuscript where she compared the meta-analytical results based on published studies with those that were not published. A comparison of the protocols of studies before they actually initiated with the publication – we call those inception cohort studies – provides a reliable estimate of the association between the nature and direction of findings with the publication status. Based on two cohort studies approved by research ethics committees or included in trial registrations, only 49% to 60% of randomised trials were published and the findings were three times more likely to be published when the results were statistically significant[6]. This is a huge problem.

What are the consequences of publication bias? First of all, it is not scientific. It may alter the evidence on the benefit and harms of treatment. One example is a comparison of reboxetine with placebo[7]. If you compare the published results with the unpublished results for both the efficacy and safety outcomes, the published results overemphasised the beneficial effect of reboxetine, which may not exist at all, and underestimated the harmful effects of reboxetine. As an example, with regard to the outcome 'remission', only one published trial showed that reboxetine is 2.5 times more likely to reduce remission, whereas six other unpublished trials showed no evidence of effect. In other words, published results are more than two times more likely to show the efficacy of reboxetine, which the efficacy does not exist.

Failure to publish is also unethical. Participants enter research studies with the understanding that their involvement will contribute to generating new knowledge and to science. Failure to publish breaches the trust of the participants. Lastly, failure to publish research studies constitutes research waste. It is not informative because they never made it to the public domain. It was estimated that on average about 12 000 randomised control trials that should have been published each year were not published.

The second form of reporting bias is outcome reporting bias. Outcome reporting bias manifests in different forms when the reporting of the outcome is influenced by the nature and direction of the findings. An-Wen Chan and his colleagues have conducted quite a few studies[8], which definitely characterised outcome-reporting bias in healthcare research. Outcome reporting bias manifests in different forms, for example, not reporting pre-specified data in the protocols, reporting primary outcomes as secondary outcomes and vice-versa, introducing new outcomes or reporting outcomes such that they are differentially accessible. In other words, outcome reporting bias occurs when the authors cherry pick what they decided to show to the public.

I was involved in a study that examined outcome reporting bias in industry-sponsored trials of gabapentin for off-label use. We had access to the internal company documents as well as the publicly-available documents for 21 randomised trials that compared gabapentin with placebos for off-label use. We compared protocol to publication for the statement of primary outcome[9]. We identified 21 primary outcomes in the protocol. Those are pre-specified primary outcomes. Eleven were reported without changes in the final publication. Ten were not reported or reported as secondary outcomes. In addition, 17 new primary outcomes were introduced. In terms of the p-values for the protocol-defined primary outcomes in those research reports, nearly all of them are non-statistically significant at the 0.05 significance level. However, through selective outcome reporting, by switching outcomes, introducing new outcomes, or omitting outcomes, in the primary publications the p-value became statistically significant. In other words, regarding the efficacy of gabapentin, dependent upon where you look, you may find very different results.

That was one case study. There are many studies like this. When you take all studies together in a systematic review[10], it yields empirical evidence for publication bias and outcome reporting bias. In summary, statistically significant outcomes were more likely to be reported in full for both efficacy and harm outcomes. About 40% to 62% of studies had at least one primary outcome changed, newly introduced or omitted when trial publications were compared with protocols.

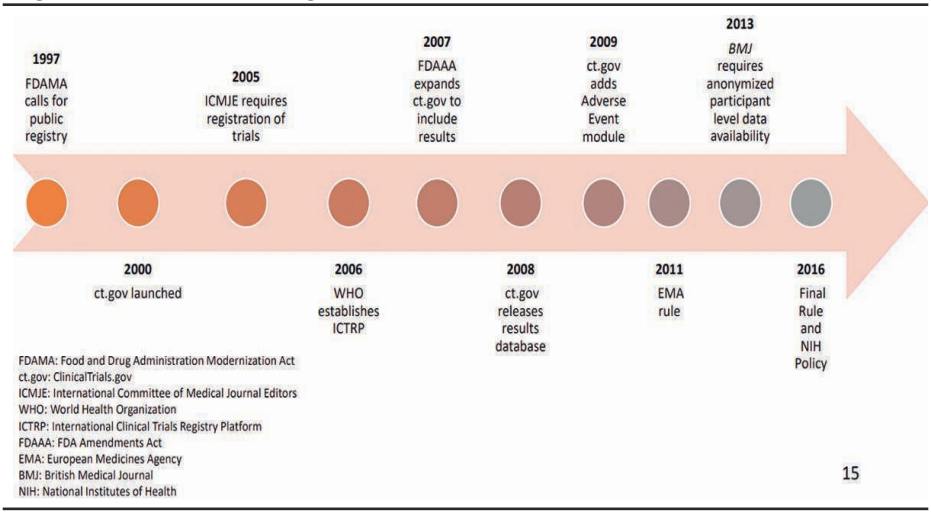
The third form of selective reporting is reporting in a manner that is difficult for others to access. One study conducted by a colleague of mine[11] looked at full publication of results initially presented in conference abstracts. We all go to conferences. Disseminating your findings at conferences is a great way to reach a broad audience. However, the conference abstracts are usually limited by the word limit, and they do not provide a full depiction of the study methods or the results. This systematic review examined over 307 000 abstracts presented at conferences. The authors found that only about 37% were subsequently published in full, such as in a journal article, and that number was slightly better for randomised trials, again definite evidence for outcome reporting bias and publication bias. Significant results were 1.3 times more likely to be published in full. Positive results, defined as a result favouring the experiment treatment, were 1.2 times more likely to be published in full.

Now you may start wondering whose problem is this? Who contributes to biased reporting of clinical trials[12]? Numerous surveys and other types of studies of researchers have found that investigators' failure to submit trial results for publication was the primary reason for unpublished clinical trials. The frequently quoted reasons are they are not interested in the results and they do not have time to submit results for publication. The reasons for selective outcome reporting mirror those of publication bias. Investigators' misconception that the editors favour positive results was the main reason for not publishing the results. Also, there is an unawareness of the seriousness of underreporting. On the other hand, there is no evidence that peer reviewer suggestions or the editors' decisions are influenced by the nature and direction of the findings. In summary, it was mainly the researchers' problem. We should always submit our results for publication regardless of the direction and the nature of the finding.

To end on a high note, how do we address reporting biases? Both speakers have touched upon trial registration and a result database. I will discuss data sharing and access to study documents. There are also reporting guidelines and core outcome sets that people can follow.

Beginning with the early studies, it became quite clear that to address reporting and publication bias we need to have a full account of all the studies from its beginning. The study of publication reporting biases and their consequences has led to legislation and policy mandating trial registration.

Fig. 2: A timeline of trial registration seminal events



Source: Li, "Publication and reporting bias: a long history towards open science". Media used during the presentation (available on the conference's website).

In 1997, the Food and Drug Administration Modernisation Act required that all the drug trials of severe and life-threatening conditions must be registered. As a result, in response to that legislation, the National Library of Medicine of the National Institutes of Health in the US launched ClinicalTrials.gov, the trial registration database in 2000. However, the registration had not taken off until the International Committee of Medical Journal Editors (ICMJE) made a requirement of prospective registration of trials before the trial results can be published by the ICMJE journals.

In 2006, the World Health Organisation launched an international initiative to establish the International Clinical Trials Registry Platform. The platform provides one-point access to different registries across countries. In 2007, the FDA Amendments Act (FDAAA) expanded the registration requirements – for all drugs, biologics and devices subject to FDA regulation, the FDAAA requires that the registration be done as soon as the trial is initiated. The results should be posted within 12 months of the completion of the trial or within one month of approval of the product. In response to that requirement, in 2008 and 2009 respectively, ClinicalTrials.gov released the results database and also added an adverse events module.

In the European Union (EU), the European Medicines Agency (EMA) took a more open policy compared with the FDA. In 2011, EMA required that all the trials conducted in the EU should be registered and make their results available within 12 months. As

mentioned earlier, the journals also play a very critical role in the transparency of clinical trial research. In 2013, *The British Medical Journal* put in place a requirement for a statement about anonymised participant level data availability at the time of manuscript submission. In 2016, the final rule made by the US Department of Health and Human Services further clarifies the types of trials that need to be registered on ClinicalTrials.gov and the National Institutes of Health (NIH) also issued a policy to promote the sharing of clinical trial data, requiring that any trials that received funding entirely or partly from the NIH should be registered before the start of the trial and have their results posted in a timely fashion.

Access to study documents is also very critical. In a study where we examined adverse events for gabapentin[13], we compared the number of different types of adverse events that appeared in the public domain with the number of different types of adverse events in the hidden documents, the documents not publicly available, such as clinical study reports. In the first trial[14], there were only seven different types of adverse events mentioned in the publication, whereas 100 different types of adverse events were mentioned in those hidden documents. It does not look better for the serious adverse events. Public access to protocols, including the statistical analysis plan and clinical study reporting, is essential for preserving the societal value of clinical trials.

Publication was traditionally the way of sharing the results from clinical trials. Increasingly the clinical trial increases our knowledge and influences our decision-making through both the summary level and the individual participant level data being shared and reused by the public. Data sharing increases the scientific value. Evidence has shown that it also increases citation. Furthermore, there is a moral obligation to share the data. Participants of trials become more vocal demanding that their data be shared and reused amongst the broader scientific community in order to leverage the data to maximise the knowledge and value that can be gained from their contributions to the trials. Surveys of patients also showed that most people welcome the idea of data sharing if safeguards are in place for their data safety[15].

Increasingly, funders are mandating data sharing. For example, the Gates Foundation and the Wellcome Trust require their awardees to share their clinical trial data and individual participant level data. Journals are also making requirements of making a statement about data availability and data sharing at the time of trial registration, and those statements will be published when the trial reports are accepted for publication.

In summary, the move towards clinical trial data sharing is part of a wider movement towards open science. Reporting of medical research is biased when it is influenced

by the nature and direction of the findings. That is the definition for publication bias and outcome reporting bias. They can take many different forms. Reporting bias typically involves spurious exaggeration of beneficial effects and suppression of harmful effects of interventions. Clinical trial registration, access to protocols and statistical analysis plans, guidelines for transparent and complete reporting, adoption of core outcome sets and data sharing are critical to prevent reporting biases.

To go a step further

“In several studies, including one of our own, we found that the data collected in ClinicalTrials.gov is a minimal requirement and it does not capture everything you would like to know about the trial, especially with regard to the methodology and with regard to all the results data. It is definitely a first step, and how reliably they can be used for data analysis in systematic review and meta-analysis, I believe we still have a long way to go, but at least we know the existence of trials, so we know if we are missing results or the publication of certain results, we have a place to look. We are getting there.”

“The funders have a very important role. In the US, for example, when you are submitting a new grant if your previous publications are not in the public domain, you cannot even submit the grant. It comes down to how different stakeholders play together. The institution has a huge role. The funders have a huge role. However, there are so many studies that are not funded, so that is becoming more problematic, and the public has to get involved and demand transparency in research and demand open science. All the players need to work together to make this happen.”

“Negative results are as important, if not more important, than positive results in the sense that if they are hidden away, information in the public domain is cherry picked. It looks rosier than it actually does, which is very problematic. Negative results will help us to use fewer medications.”

“Most people would agree that open science is a great idea, but it requires resources to get there. For most research funders, you could build data sharing into the costing of your study; so there are resources available for researchers to share their data with the public.”

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Concluding keynote: Opening and Transforming Biomedical Research

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Charité – University of Medicine of Berlin

My talk will focus on the need to transform biomedical research. My key point will be that institutions have a key role in this transformation. I will exemplify this with three practical examples of how such a reform could be successful at an institutional level.

Why do we need to transform biomedical research in the first place? As we have already heard a lot about this from the previous speakers, let me just emphasise this with a few examples. Researchers are actually acutely aware that there is a problem in academic research. According to a *Nature* survey of researchers in many domains[1], 90% of researchers are of the opinion that we are in the midst of a reproducibility crisis. That means we have problems in reproducing the work of others or even our own work. Isabelle Boutron has already mentioned the very influential series of publications that were published in *The Lancet*[2]. One article in it posited that up of 85% of health research might actually be wasted. I am not sure about this is exactly the number, but it is quite clear that there is tremendous waste in this field.

Let me just give you two more examples that I think illustrate the problem. One is from preclinical research. Ioana Cristea told you about a large scale collaborative study that tried to reproduce key research results in psychology. Analogous to this study in psychology, very recently the Centre for Open Science has undertaken a massive project which sought to replicate 50 seminal, highly cited papers in cancer research[3]. The results were very similar to the psychology study: the effect sizes of the replication studies were much smaller, in fact 85% of the original, and only less than 40% of the studies were able to reproduce these findings on a statistically significant level.

What is also shown by this seminal publication is that the problem goes much deeper. In fact they tried to replicate, as I said, 50 studies and in the end they could only undertake this with 23 because data was not available for sharing, because the reporting of details, e.g. of the statistics, was not appropriate, analytical code was not

available, key reagents were not shared or clarifications of protocols were not given. The results demonstrate the importance of transparency and openness of research.

A second example, and this is very much along the lines of what we have heard just now from Isabelle Boutron, comes from Germany and from our own studies. Daniel Strech and his group of the QUEST Centre have systematically investigated the timely reporting of clinical trial results of German university medical centres. We have heard about what is mandated in this respect. I will bring another stipulation to your attention another one, one from the World Health Organisation: summary results of clinical trials must be uploaded in registries within 12 months of completion of the study and a full publication should be available within two years. The study regarding German university medical centres shows that the numbers are very much congruent with those we have heard from Isabelle. About 60% of studies are not available within two years, and this has not changed over the years. I think that this is unethical.

We all have heard about these problems. We are reading about them. All major journals are running articles about it. I have stopped collecting clips of those articles for my slide because practically every week there are additional papers exposing the problems we are talking about. These issues have also percolated into the general public, they can read about it in newspapers and magazines. In fact, one could speculate that this has actually contributed to some of the mistrust in scientific results and how they are applied to policymaking during the pandemic. It is a serious problem.

How can we improve the situation? My main point here is that while funders and researchers are important stakeholders, the key role must be played by the institutions[4]. They can and should have internal policies and guidelines on all of this, informed, for example, by DORA[5] and by the Hong Kong Principles[6]. They should be much more transparent about how they are acting to increase the transparency, trustworthiness and openness of their research. We have heard about external tracking by the UK TrialsTracker[7], for example, but this needs to be done also by institutions on their own. The institutions also need to assist researchers in open research practices because they are demanding and resource-intense. A good example are so-called data stewards who can help scientists to share their data in a FAIR, that is findable, accessible, interoperable, and reusable manner. Maybe even most importantly, institutions need to incentivise and reward open practices in hiring, in tenure, in promotion and also in intramural programmes.

In essence I think we need to change from a situation where researchers are basically mostly evaluated and rewarded on the basis of where they publish – very often it is

just the impact factor as a very abstract number or the h-index – and by the sum of their third-party funding to a situation where we, in addition at least, value open and responsible practices. We have heard about them during the symposium already. We are talking about preregistrations, about replication studies, about publishing open access, all the items that are contained in the umbrella construct "open and responsible science".

There is a lot of knowledge on this already. In fact there are many manifestos, principles, frameworks and declarations. We all know the San Francisco Declaration on Research Assessment[8], which was one of the starting points of this movement. I should also mention that the European Union has been very proactive over the last years, coming up with surveys and recommendations on novel metrics and indicators, and demanding that we should be more open in science. What just came out as part of this conference, the Paris Declaration on Research Assessment[9], should I think be endorsed by everyone. These declarations are very important.

I was involved in one of them, which was produced in a participatory way, so I know a little bit more about it, but they are all very similar, and so I can just mention what is usually recommended. The Hong Kong Principles[10] prototypically call for assessing researchers on responsible practices, valuing accurate and transparent reporting, valuing practices of open science, valuing broad ranges of research and scholarship, which, for example, includes replications and meta-research, and also to value other contributions of responsible research, such as mentoring, outreach and knowledge exchange.

How can we make these recommendations become a reality? What can institutions do about this? I would like to share a few examples with you from an institution where I work, the Charité University Hospital and the Berlin Institute of Health. Remarkably, the Charité recently has come up with a strategy for its next 10 years or so[11], and in this strategy we have anchored responsible practices in hiring, and transparency and openness in research, etc. I think that such institutional strategies and policies are a first important step for an institution.

What does this look like? What can we do? One thing I would like to tell you about is a change that has happened in the way we hire professors. Our dean, Axel Pries, is a real champion of this project. If you apply for a professorship at the Charité right now you have to go to a portal where you will be asked many questions[12]. You have to upload your CV and all those things you would expect, but things appear now which you might not expect and which I think are very important. It usually starts with an explanation, like: 'The Charité attaches great importance to transparent replicable

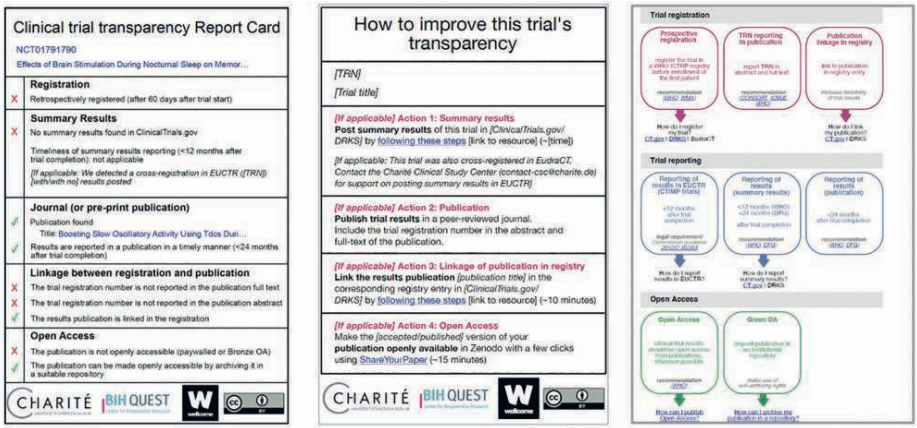
research and supports the objectives of open science'. This includes the registration of studies in registries, the publication of negative and serial results, all the things that we have heard in the previous talks. This is just to explain to our applicants what we are interested in. Then comes the interesting and relevant question: 'How have you been pursuing these goals so far and what are your plans for the future'? Obviously we also use other criteria, but I think these narratives are very important for the hiring and tenure commissions to get a full picture of candidates and make a fair selection.

As second example I would like to tell you about an online dashboard of open and responsible practices that the Charité has developed for its own benchmarking[13]. In a way it is very similar to the Open Science Barometer that the French have now put up, which I think is just great if this is done on a national level. Here it is done on an institutional level. Institutions need to show how they are faring. They need to monitor it. They need to be transparent about it. Our dashboard is constantly updated and curated to keep track of how we are progressing with open access, how we are doing with sharing of open data, open code, preregistrations, timely publications. And all of this is visualised from past years to now to see whether these things are going up or down, so in essence to see whether we are really achieving anything. This allows our own benchmarking as well as benchmarking within a country or between comparable institutions.

My last example is an intervention because, as we have heard from other speakers, we need to make sure that the things that we are changing – and we often have these brilliant ideas of what can be done – are changed for the better, that these ideas really work and that they are not just eating up resources or that they have unintended consequences. Therefore, our activities need to be complemented with implementation research and with meta-research.

As an example I have picked al project[14] by Daniel Strech and his group, in particular Maia Salholz-Hillel and Delwen Franzen, which is funded by the Wellcome Trust. In this project we are approaching our clinicians and researchers performing clinical trials and show them how they are faring in their studies. They will receive a 'transparency card' which has information on a number of items, including timely publication, a link to registries, preregistration etc. to show how they have doing with a particular study. However, it does not stop there. They also get a complementary card, which lays out specific steps on how they can improve on the reporting of that specific study. We are going to check after six months whether this has changed practices and whether this makes any sense, or whether our approach can be improved.

Fig. 3: Improving timely reporting and transparency of clinical trial results



Source : Dirnagl, 'Opening and Transforming Biomedical Research'. Media used during the presentation (available on the conference's website). CC BY 4.0.

In conclusion, the general theme of this session is that we desperately need to reduce waste and increase value in biomedical research. I posit that institutions need to play a very important role in all this and that key to this is changing incentives and rewards. We also need to enable our scientists by providing tools, resources and a opportunities to apply to open science practices. We also need more meta-research to find out what really works and what does not work and how our resources are best spent. My last point is: yes, I think it can be done. We have a lot of bad news, but this is good news. It can be done and I think this conference is a very nice example of how things are moving forward in this space.

To go a step further

"One of the problems in all this is that if one institution is changing practices like this, if others are not following suit this may be a problem for those who work in the institution. We may judge them with different criteria which would no longer apply in the outside world and would actually potentially disadvantage them. This is why it takes courage. It also takes courage because it takes resources and needs investment. I think it is very important therefore that there is outside pressure from the European Union to do this, which could lead many institutions to come together to do it jointly."

"There are resistances in the scholarly community against what we propose, and I think part of that resistance is understandable because, rightfully, one can point to the fact that the system somehow works. Take COVID-19: we have a vaccine, we are saving lives of critically ill patients. It is therefore a system that works. Some people are afraid that by changing it we may fare worse. The point here is, yes, we have a system that in principle works, but it could work much better and we need to be aware of the waste that we have. This is where implementation research is so important because we need to convince those people, and partly also ourselves, that these changes make sense and make science better. We need to convince those who are critical with real evidence, not just opinions."

"Observational studies can make big contributions and the mandates for preregistration and for timely reporting should be extended to those. An interesting question which may also come up in this context is whether this should also be mandated for preclinical research. It is certainly more challenging, but studies that are more confirmatory in this space, and hopefully there are more confirmatory studies in the future, should actually have all those qualities. This means they should be preregistered and should have timely reporting and so forth. We have good examples for this. I think these mandates should be extended to more classes of dissemination, but probably not to all."

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The future of scientific publishing

Academic Publishing and Open Science – Where do we stand?

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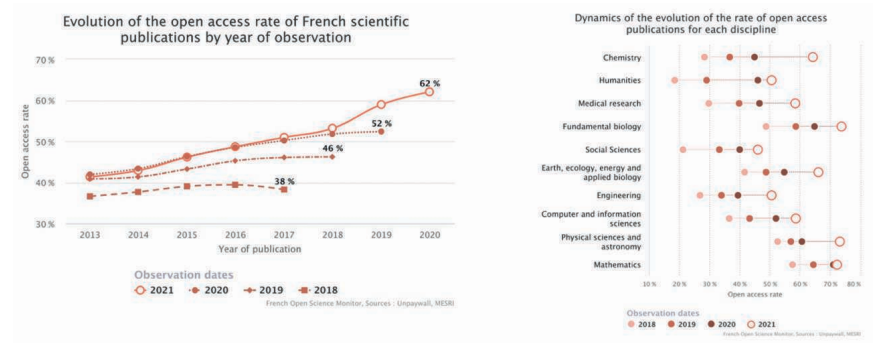
OpenEdition/OPERAS

20 years after the Budapest[1], Bethesda[2] and Berlin[3] declarations (the B Declarations) open access seems to be no longer a matter of activism, controversial, marginal or even political. Open access reached its tipping point several years ago and entered a new stage of development as a mainstream practice, almost the default way of publishing research results. As a matter of introduction, I propose to take a look at these dynamics after and maybe beyond the tipping point.

In 2013, the European Commission published a press release[4] presenting the results of three studies by Science Metrix[5] showing that in Europe at least more than 50% of the articles published two years before were open access. 10 years after having reached that tipping point it could be useful to assess where we stand and what happened to the dynamics that were identified.

A few days ago, the French Ministry of Research published a new version of its Open Science Monitor[6] based on diverse sources, such as Unpaywall[7], the Directory of Open Access Journals (DOAJ)[8] and various repositories. I encourage you to have a look at this interesting instrument developed by Eric Jeangirard and his team with open source technology, open data and a lot of results as food for thought. In particular, the monitor evidences the strong global dynamic of OA adoption across the whole French research community, with 62% of the papers authored by at least one researcher affiliated with a French institution published open access. Of course, OA adoption is different from one discipline to another, and the strength of this adoption can be different, but it is clearly present and high.

Fig. 4. 62% and counting in France



Source : Mounier, «Academic Publishing and Open Science: Where do we stand?», media used during the presentation (available on the conference's website). Data from Unpaywall, MESRI.

The same dynamic can be observed in other European countries, such as in Germany thanks to the Open Access Monitor[9] funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG[10]). The data provided by the German OAM are not comparable of course with the French Open Science Monitor because they do not proceed from the same methodology. However, for example, we have data showing a proportion of 61.4% of articles authored by researchers affiliated with a German institution being published open access in 2020.

The platform openaccess.nl[11] proposed yet another methodology to monitor the adoption of open access among researchers affiliated to Dutch universities, and here again the dynamics are consistent with the other countries, with a 62% threshold already reached last year. In conclusion, it is interesting of course not to precisely compare the data because they do not proceed from the same methodology. We see that even with three different methodologies we observe the same dynamic in three different European countries.

However, behind the global dynamics it is necessary to dive into the details and try to identify the logic of models that support this movement. Several routes were identified quite soon in the history of open access, starting with the difference between depositing articles in open repositories, the so-called Green route to open access, and articles published directly on the publisher's platform, the so-called Gold route. The landscape became even more complex when the hybrid concept emerged referring to articles published open access in non-open access journals. Then of course there is the Diamond model, referring to Open Access (OA) journals, free for both readers and authors, meaning no charging article processing charges or subscriptions.

What are the respective dynamics of those models of open access? The traditional opposition between the so-called Green and Gold routes theorised by Stevan Harnad 20 years ago is becoming less and less relevant in the current context. Following the multiplication of policies and institutional strategies, there is a growing number of articles made available open access both on the publisher's platform and in an open repository. This evolution, partly but not only due to the role of PubMed Central[12], renders the long-time debate between the two routes to open access somewhat obsolete. It opens the possibility to think of both routes not as in competition but rather as complementary to each other. Each route brings its own way to open access publishing practices. In my opinion this type of evolution is a sign of the maturity of community regarding OA.

However, on the other side, despite multiple disincentives from funders and library consortia that consider hybrid publication as perpetuating the status quo and introducing the risks of double dipping in open access funding, the model is still present in the landscape as evidenced by the hybrid OA dashboard proposed by Najko Jahn[13]. Hybrid publication is indeed a flexible model that accommodate well with the contradictory requirements between the mandates to publish open access and the need of researchers to publish in the existing recognised journals of their discipline. In fact, hybrid is not a model. It is certainly a temporary adaptation to a transition period and that is probably the reason for its permanence until now.

At the same time, the multiplication of so-called transformative agreements (Tas) gives a solid push to hybrid publication[14]. The ESAC Registry[15] that records most of the TAs gives evidence of this growth. This is really an important shift in the landscape with the tremendous growth of articles freed by the TAs according to ESAC figures. However, a recent study that surveyed 197 TAs concluded that globally those agreements do not provide any real transformation in the business model of journals, nor did transformative agreements help to flip these journals to open access. That is mainly because this is not in fact the primary intention of the stakeholders signing the contracts.

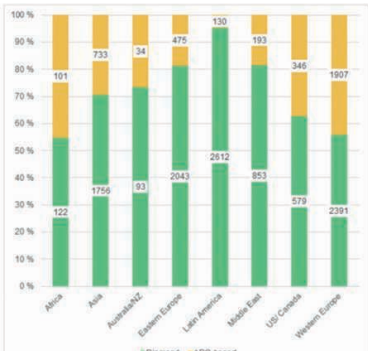
Which model will survive and wipe the others out from the market? From what precedes it is already obvious that each model brings its own type of success and addresses a specific need in a specific situation, even temporarily. That is not, however, the end of it of course because recent years have brought into focus other open access publishing models that have slipped under the radar so far. The first one is of course the Diamond model, which designates those publications that are free for both readers and authors. In other words, they do not charge

authors for publishing their articles in open access. A recent study brought to light the important contribution of this model to the global development of open access worldwide.

Here again the reality is more complex than what we think, and it would be a mistake to consider Diamond and Diamond journals as an exclusive product of Latin America and social sciences and humanities, where it is indeed extremely important. In fact, what a study reveals[16] is that the Diamond model is prevalent in many disciplines and most of the regions of the world, including Europe. In other words, while most of the open access discussions were focusing on the glamorous model of the publishing landscape, the Gold APC model, the vast majority in fact of open access journals were frankly adopting another model, the impact and importance of which was wrongly being overlooked by most observers.

The Diamond journals represent an overlooked and neglected part of the OA landscape because by nature they are not involved in the most inflammatory debates related to the stronghold of commercial publishers over scholarly communication. Most of the time Diamond publishing venues are owned by scholars through their universities, research organisations and scholarly societies. In fact, they represent the quiet adaptation to the digital age of a long tradition of scholarly publication. They constitute a remarkably persistent model of open access publication with a stable number of articles published throughout the years, and in that sense the comparison with the evolution of articles published OA in exchange for payment of an APC is striking.

Fig. 5: Shares of OA Diamond and APC-based open access models in DOAJ-listed journals



Source: Jeroen Bosman et al., *« OA Diamond Journals Study. Part 1: Findings » (Zenodo, 9 mars 2021), https://doi.org/10.5281/zenodo.4558704, Data from DOAJ.*

The Open Access Diamond publishing model stands outside of the capitalistic economy of for-profit publishing and is therefore insensitive to market incentives. In addition, the OA Diamond publishing model does more than simply address the needs of researchers. It represents an idea of autonomy and self-rule of the scholarship community in the new digital context.

One of the gems uncovered by the Diamond OA study was this continued innovation throughout the whole sector, with a diversity of initiatives across different disciplines, languages and countries, with scholarly communities working constantly on inventing and adapting their communication practices to their needs, taking full advantage of the possibilities the open web offers. In the Diamond study already mentioned a series of open questions were submitted to almost 1 200 open access journal editors about their motivations. Ethical and political values appeared prominently as key drivers for their professional and personal investment in open access. I would like to share with you one of the most compelling answers we received in this study: 'Our open-living ethos is not just about open access, open software, open review. We are committed to living, discussing, deciding and failing in public. We discuss and develop our project values and policies openly as our public message'.

Beyond the necessary complementarity of the different routes to open access, new types of debates have emerged in recent years around the concept of diversity in the open access movement. Several voices in the community have called out to take a step back and try to reflect more on the why and not only on the how of open access. They highlight that through its inclusion in institutionalised open science policies the open access movement could fail its original purpose at the very time it seems to be succeeding.

It is true that driven by innovation the adoption of open science led to a strong diversification of technologies, formats and workflows in academic publishing, at least in appearance. The number of new services proposing new ways of creating, assessing, disseminating, discovering and reviewing research results is staggering. 20 years ago, Stevan Harnad's modest proposal[17] to radically transform scholarly communication by sky writing research on the Internet had many offspring: preprints, mega-journals, digital editions, overlay journals, next gen repositories, publishing platforms, data papers, living books, micropublications and of course 50 shades of open peer review. This fascinating world of innovation in scholarly communication has been wonderfully well charted by our colleagues Jeroen Bosman and Bianca Kramer from Utrecht University with their project 101 Innovations[18].

However, at the same time, we have understood that open science and its powerful push for diversification through innovation does not prevent the concentration of power in the academic publishing system. Somehow, like the cyberlibertarian utopia of the open web suddenly reverted to the dreadful control of every means of communication by the GAFAM, many articles have shown that a limited number of commercial companies are in a position to control the entire academic knowledge production workflow through strategic mergers and acquisitions in the open science context. This led to a number of position papers and initiatives, such as the call for action that Kathleen Shearer published last year[19] providing a number of recommendations to foster bibliodiversity in scholarly communication.

This leads us to consider academic publishing from a different perspective. Our colleague Leslie Chan recently gave a striking presentation at the FORCE2021 conference[20] to encourage us to challenge structural racism and systematic biases in knowledge production. In his talk he showed how paywalls are just the most visible part of a system of power in knowledge production that prevents the full adoption of open science practices. In other words, he encourages us to look beyond the different routes to open access, beyond the business models that support it, beyond the publications themselves and to start questioning the knowledge infrastructure that lies beneath the surface, including peer review practices, editorial practices and also the way in which the standards, the tools and the technology, nurture a monoculture of thinking in academia and stifle the diversity of epistemes that are essential in a true open science.

As Leslie rightly points out, infrastructures have a crucial role in ensuring diversity or, at the opposite end, providing the backbone for monopolistic strategies leading to epistemic exclusion in scholarly communication. In recent years the role of infrastructures at all levels of open science have become more and more apparent. Because open access publishing is primarily digital publishing, even before being open, the question of sustainability is of utmost importance, but the question of openness applies here as well to ensure that the infrastructure does not recreate enclosures behind the door. It was well put by Geoffrey Bilder, Jennifer Lin and Cameron Neylon, the authors of the Principles of Open Scholarly Infrastructure[21]: 'Everything we have gained by opening content and data will be under threat if we allow the enclosure of scholarly infrastructures'.

Where do we stand after 30 years of development of open access, 20 years after the B declarations, 10 years after the tipping point? An observer coming back after 30 years of absence from the field would probably be horrified by the level of complexity it has reached since then. The multiplication of economic models, the continuous

creation of new formats, new tools, new platforms as a consequence of permanent innovation and the intricacies of digital services interacting with each other apparently transformed academic publishing into a maze where it is easy to get lost.

To better grasp the situation and identify the challenges before us I would like to propose, finally, to take a step back again and consider academic publishing from a different perspective. First, I would like to refer to a book published by one of my colleagues at the French School of Advanced Studies in the Social Sciences (EHESS), Valérie Tesnière. Her book *Au bureau de la revue*[22] tells the long history of academic publishing in France during the 19th and 20th Centuries. This long history made of many extraordinary and diverse stories perfectly illustrates the true nature of academic publishing in its diversity, with an incredibly high number of different formats, practices and products constantly renewed throughout the decades. It is an history of constant innovation and creativity in connection with the changing needs of the scholarly community and society itself. This history reminds us that giving access to knowledge through publications is a longstanding effort that started long before the open access movement itself. The relatively short history of open access should be placed in the continuity of the longer history of scholarly communication.

Second, I would like to refer to another book[23] published by another of my colleagues at EHESS, Christian Jacob. In his research Christian studies what he calls places of knowledge, the places of knowledge of these all these objects, tools, frameworks, instruments that support the creation and the circulation of knowledge in various cultures and ages. Christian considers a place of knowledge as intimately linked to its social context and to other places of knowledge. In his view, knowledge cannot be considered independently from the culture and the society it comes. Knowledge should always be understood as part of the social fabric where it finds its meaning. My proposal to you is to consider academic publishing as a network of places of knowledge, a public garden of knowledge with many bifurcating paths, crossroads and meeting places that should be understood as such.

The peculiar situation we are currently collectively living in led many of us to question the meaning of our activities. What are we doing exactly? Why are we doing it? What is important? As a social activity, knowledge production is not exempt from these kinds of questions. Our colleagues running the journals surveyed in the context of the Diamond study answered, in my opinion, very simply to that question: 'Free access to scientific information is an essential element for economic and social development. We have in mind our firm commitment to the democratisation of knowledge. We should not put a price tag on ideas and public knowledge'. Therefore, the challenge ahead is quite easy to understand. It is not to guess what the future

of publishing will be. It is not to bet on the future winner of the race between OA models and new technologies. It is not to declare obsolete traditional forms of scholarly communication that are essential to valued scholarly communities.

The challenge ahead in my opinion is rather to efficiently support all those places of knowledge and continue to open them all for the benefit of society. We do need smart policies and strategies that support STEM and SSH, the journals and the books and the proceedings as well and the different languages in which researchers communicate with their peers and with society. We need to have the traditional and native publishing venues supported on their journey towards open access. We need to support those who want to experiment beyond the traditional formats as well as those who continue working on longstanding editorial collections in a cumulative way. We need to support diversity and to preserve it from predation as well. In other words, we need to increase and improve coordination across disciplines, communities and countries. We need to consider ourselves as partners rather than competitors, support each other, learn from one another and consider ourselves as serving the same goal each of us in our own way.

Finally, I think we need a coordinated open science ecosystem where the different ethical and sustainable academic publishing practices are supported equally. They are the building blocks of the knowledge infrastructure, and we are not there yet.

To go a step further

“The economic model of Diamond publishing is supported on three legs:

- The volunteering coming from researchers themselves, who invest a lot of their time and energy in running their journals, because that is so important for the scientific community.
- The strong institutional support provided by personnel seconded to these editorial venues by the institutions and the research-performing organisations.
- Funding, coming from grants particularly.

There is therefore in fact an economic model. It has been mostly invisible so far, so one of the outputs of this study was to bring light to this economic model, and now what we need is to have better and more efficient institutional strategies

and policies to support more efficiently and in a more sustainable way this kind of economic model."

"The time spent by researchers on managing a scientific journal is necessarily time lost for research in the field. Therefore, it is fundamental that this editorial work be recognized as research work."

"Researchers are undoubtedly at the heart of Diamond Open Access, as pilots, but they are not alone. They are accompanied and supported in their editorial activities by robust and diversified infrastructures, which are sometimes complicated to talk about because of their technical nature. It is necessary to better understand and valorise these infrastructures and the indispensable role they play in the dissemination of knowledge, to support them financially and to pay attention to their governance, so that they best meet the needs of researchers."

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New forms of publication. Why? How? How far?

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I am going to talk about new forms of publications from a perspective within the life sciences, but I think the quote that I am about to share applies to all disciplines of scholarship: "Science is not article-shaped" (Louise Page, former Publisher of PLoS). I think that we have been pushing science for centuries into a format that can be copied by a printing press, mailed out to a library to then sit on a shelf. I acknowledge, as Pierre has pointed out, that there are certainly situations in which this is a robust and powerful model, but scholarship can also be quite nonlinear, evolving and it can encapsulate code, data and many other types of media.

All these traits are supported by the potential associated with digital publishing. The web makes it possible to copy, exchange and disseminate information at very low cost. It enables more people to participate in the creation of knowledge and the ownership of the structures that provide that capability, and it enables new versions to be added, for these versions to be tracked over time and for the community to exchange in open dialogue synchronously or asynchronously. Of course, texts can be integrated with other types of objects, like data or code, and it enables free and rapid dissemination, which is a point that I would really like to highlight today.

Even though we have all these amazing capabilities for rapid dissemination, it is actually taking longer than ever to disseminate some forms of science. Looking at data from a life science graduate programme in the US, it is now taking students a year longer to come out with their first first-author paper[1]. This is not only holding back the careers of the young scientists, but it also stunts discovery overall. Because science builds on knowledge created by others these delays in publication affect not only the individual paper but every subsequent paper that references it. Why is this happening? One possible reason is that over the same period the number of panels – not figures, but the panels – in many journals has increased dramatically, even when we ignore the new phenomenon of supplemental data. This is widespread.

We are collecting more data, but publishing slower. Why is this happening? I believe the answer lies in the fact that traditional publishing bundles together three different

functions: the dissemination of science, peer review and curation. A journal does not disseminate work until it has peer reviewed it and decided that it is worthy in a sense to be disseminated under its name and to achieve the sort of prestige that is associated with it. As a result of this authors are incentivised not to share until they build up a big story that will get published in an impactful journal.

The need to bundle these three functions, especially this prestige that will determine funding and jobs, is understandable in a world where it is necessary to print on paper and ship out copies, but we can change this now. I want to talk today about four different approaches to doing that, the first being micropublications. They are a form of publication which are explicitly short. The best-known example is probably microPublication.org[2], which has over 400 outputs, but other experiments like PLOS Currents[3] and Science Matters[4] also fall into this category. In this model researchers are explicitly encouraged to submit short works. They are peer reviewed and published in a standard way. There is no need for an overarching story to tie together many findings and the outputs are recognised in databases like PubMed and Europe PMC.

A second innovation is preregistration and registered reports. Preregistration is reporting the design of a planned study in an open registry, sharing the methods ahead of time. Registered reports[5] go a step further. Over 300 journals have agreed to review and publish papers based on the design of the study and its methodology, not the findings. This removes selections for only positive results and bases the publication of the paper, and therefore its prestige or perceived prestige, on the design, not the findings. However, it may not be suitable for all types of outputs, especially those where there is a rapid iteration between hypothesis and experiment.

A third innovation takes the article beyond the PDF as researchers are sharing data, code and visualisations that cannot be printed in a traditional article through the web. Many journals have been hosting supplemental files for many years, but some are going a step further than that. eLife has launched a feature called executable articles[6]. This allows readers to play with the code and regenerate the figures during the paper itself as they are reading it, which is built with Jupyter Notebooks and R Markdown. Many journals do not directly support these objects, so researchers must publish them separately and possibly link them from the publication. There are therefore researchers creating custom websites to host and visualise complicated data and sometimes this is released at the time of journal publication, but it can also be done before.

That brings me to the fourth innovation I want to talk about today, which is the publish, then review model. It separates the functions of publishing. Scholars share

information prior to peer review and the functions of peer review and curation can then be performed later. This dissemination can be in the form of code on GitHub, data in a repository, open lab notebooks or preprints, which are articles posted to a public server prior to peer review, and these have gained significant momentum in recent years. A preprint server, rather than performing peer review, allows the papers to undergo a lightweight screening process to ensure the manuscript is in fact scholarly work. While it does not have to be, this manuscript is often the same one that is submitted for peer review at a journal. While that paper is undergoing possibly multiple rounds of review over months, or even years, the paper on the preprint server can be updated with new versions and it is open for the entire community to discuss and provide feedback on, and it is freely accessible to anyone around the world.

Most people are posting preprints around the time of journal submission, but the property of versioning enables preprints to be used in a new way, which is really to share work well ahead of journal submission. All of these are good reasons for why in the last eight years or so nearly 400 000 life sciences preprints have been posted. Life scientists are late to the game. Preprints have been around for over 30 years in physics and math, and they have also been used extensively by social scientists and economists. This adoption in the life sciences has been helped along by both private and public funders which have adopted policies to formally recognise preprints. This started with the Simons Foundation[7] in 2016, followed by many other agencies. Recently preprints related to COVID-19 have started appearing on PubMed, along with the fantastic coverage representing preprints on Europe PMC. Last year the journal eLife announced it would move to a preprint-based form of publishing in which it will review only preprints.

I think it is also important to note that, unlike in physics and math, life science preprints are distributed across a range of servers which offer different features, and they are owned by different types of entities, including institutions, societies and commercial publishers. Integration with these publishers is likely introducing new people to pre-printing because they are invited to post when they submit to a journal, but it also raises questions about publisher lock-in, the governance that affects server policies and also the free access to metadata.

Preprints are not adopted equally in all disciplines around the world and in all countries around the world. According to data from prior to the pandemic[8], there were major disparities in preprints as a fraction of the total scientific outputs from various countries, with some being quite overrepresented and others being underrepresented. Of course, given their ability to rapidly communicate new science, it is no surprise that preprints were extensively used early in the COVID-19 pandemic[9],

but the preprints as a fraction of the total scientific outputs declined over time. Why is this? One clue might come from a small survey that we conducted in 2020[10] in which we asked researchers and others about their concerns with pre-printing. I do not think this would have come up as a top concern had we done this a year later, but the biggest worry that we found was about premature media coverage of preprints. Researchers are probably sensitive to the fact that there is now a lot more public and media attention to preprints than ever before, and this information can sometimes be taken out of context or amplified in a way that is unhelpful.

One case study to look at here is an example of a preprint that was posted early in the pandemic reporting a connection between COVID-19 and HIV[11]. This demonstrates that a powerful way to address this potential challenge is to surface expert feedback, comments and peer reviews publicly on the preprints. Within hours of posting this preprint, dozens of researchers posted comments on bioRxiv[12] and they weighed in on Twitter, both of which are prominently displayed on the bioRxiv page. Influenced by this feedback, the authors withdrew the preprint within 48 hours and, as pointed out by STAT news[13], this is much faster than could have been achieved in a traditional workflow. That is an example of how public feedback can lead to quick self-correction. While there is a lot more public feedback happening on preprints than journal articles, a lot of this feedback is happening privately in a way that is not visible and useful to readers. Right now, just 6% of bioRxiv preprints have public comments on the server.

How can we encourage this important activity of reviewing preprints? There needs to be cultural change that embraces this public dialogue. I think there are three ingredients for this. There need to be communities, these communities need to be visible and they need to be recognised. Fortunately, there are already many peer review communities in the life sciences which together have created over 3 000 reviews on bioRxiv preprints. I should mention that the life sciences journal eLife is also posting those reviews directly on preprints, along with other journals, and have done this thousands of times. These reviews are also starting to be more visible. On bioRxiv, certain reviews are visible alongside the preprint and there are two initiatives, eLife's Sciety[14] and EMBO's Early Evidence Base[15], that act as aggregators for this type of information. Importantly, because there is so much innovation and experimentation happening in all these different models, it is important to have terminology and to understand the difference between them.

These models fit into the publish, then review model in different ways. For example, Review Commons, which we launched together with EMBO, does a single round of review and then it transfers this refereed preprint to affiliate journals, who agree not to restart the peer review process from scratch. These journals then finish the peer

review process, typically using the same reviewers, and then decide to publish the article, effectively performing curation according to this more traditional model. On the other hand, Peer Community In[16], which is supported by the French National Open Science Fund, operates in communities in many different disciplines and performs the entire peer review process. It is also compatible with the traditional system as journals can choose to publish the article or not, and the journals then perform a curation role. However, PCI issues a recommendation for the article itself, so that is its own form of curation, and excitingly this is starting to be formally recognised. There are 18 doctoral schools in France that have recognised PCI outputs equivalent to journal articles[17].

Moving forward, what can we do to help this ecosystem develop? I think we need to explicitly invite listing non-peer reviewed outputs on CVs as evidence of productivity. There is already a lot of momentum for preprints, but code, data and open notebooks also need recognition. Furthermore, we need to recognise review of these preprints and other outputs, and we also need to support new models of feedback and curation, which includes moving towards some kind of agreement on what and how to formally recognise.

To go a step further

“Frequently, various information concerning the protocol, the data or the results of a study are published in open access on various platforms and in various forms. A crucial objective to enhance the value of these different works is to manage to link them, and preprint servers play a fundamental role in this direction. The OpenScience Framework, for example, provides authors with a very intuitive interface when submitting a preprint, allowing them to include links to all the works associated with their manuscript. This kind of reciprocal linking would greatly benefit from being generalized to all bibliographic databases.”

“Micropublications are most useful for scientific communities in which the deposit of research data in disciplinary repositories is already a common practice. The micropublications associated with these repositories allow them to be valorised by giving them the form of scientific articles, which allows them to be better known.”

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Academic Publishing and Latin America

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It is well known that South America enjoys a stronger and more coherent ecosystem around non-commercial scientific publishing. I want to mention a few important points about this ecosystem, its networks, the challenges we face, and the future we see for all of this in our work.

First, I would like to talk about what scientific publishing means in Latin America, beyond the numbers, the business models and the sustainable models. I would like all of us to keep in mind that in Latin America, scientific publishing is being researched, reflected upon, and there is a dynamic community. These objectives, which are eagerly sought at the international level, are already being achieved in Latin America. We organize annual congresses and conventions about publishing, we are innovative, we are promoting developments. There are challenges and opportunities, but also threats to this system. However, it is a very special system that has been around for some time and has a durability that other models of scientific publishing do not have.

It is in fact an ecosystem set up by the scientific community where journals are developed by researchers, professors and university and academic staff, but with the very important peculiarity that it is not only a voluntary work, but a prestigious work, widely recognized. The most prestigious journals are directed by the most eminent researchers. This publishing work is part of a research ecosystem, which generates more knowledge. Of course, young researchers during their studies also participate, as well as all those who wish to train themselves by participating in this ecosystem, so that knowledge can be transferred through this exchange between generations. These links are very intricate and complex, but essential to the maintenance of this ecosystem.

The interesting thing about Latin America is that we have not moved from academic publishing to commercial publishing. This has not happened yet, although it is happening with some projects. The Latindex platform[1] currently hosts over 30,000 journals, of which over 11,000 are active online. About 2,000 of these are journals that have been recognized for their high quality by a variety of criteria on different

platforms. Around scientific publishing, there is a lot of work, as Pierre Mounier mentioned about the three pillars that support open access, but in Latin America it is much more complex than that. Scientific publishing does not only mobilize researchers, academic staff and national agencies, although their support is essential to the system. It also mobilizes different organizations, platforms and infrastructures that complement the work of universities. We have platforms such as Latindex, Redalyc[2] and SciELO[3] that examine the quality of scientific journals and suggest ways to improve their editorial quality to meet international standards, without this being experienced as an extra workload for the journals. There are also organizations such as CLACSO[4] that have created communities around open access and have worked to integrate it into national policies, particularly in the context of scientific evaluations. This is a very complex ecosystem in which the roles are well distributed in a way that generates benefits for all. This means benefits for Latin American researchers, but also for the world. Latin American journals are publishing more and more articles from many foreign countries, all for free.

This makes it even more important for this system to be recognized for its true value, as it is run completely free of charge, with immediate open access and on a not-for-profit basis, by actors who belong overwhelmingly to the academic world. Among them are about 100 universities and dozens of platforms, which implies several challenges in terms of collaboration, especially in terms of the agreements that need to be made to support this ecosystem. It is therefore particularly important that this work and involvement be recognized.

Unlike in other regions, open access publishing in Latin America is the subject of a very coherent ecosystem, where scientific publication is not only a means of communicating science, but also a research object. Many individuals, platforms, and institutions dedicate their attention and energy to it.

Thus, science communication can be considered a true common good, and not only on the scale of Latin America taken in isolation. The ecosystem we have put in place can also act in favour of multilingualism, bibliodiversity, immediate open access, immediate involvement of the academic community. Everyone can have the opportunity to participate in debates, to become informed, in a way that works towards greater epistemic justice, inclusion, greater participation, and greater equity, because there are no barriers to reading, no barriers to publishing.

Technology is an important central axis to bring scientific publishing to a higher level of maturity. In this, the Diamond Open Access (OA) invites us to reflect on the best way to avoid that science becomes a mere commercial commodity. The first

Latin American transforming agreement has just been concluded in Colombia: it is important to keep in mind that these agreements do not only transform scientific publication, but science itself, turning it from a common good into a mercantile object. They also transform the way we spend scarce resources, replacing capital expenditures with one-time expenditures in the case of Article Processing Charges (APCs), for example. They also transform what we consider valuable and important, what we want to control. Who is going to control the scientific communication? Who is going to own the data published in scientific journals? All these aspects are really transformed by transforming agreements.

This transformation also affects what we can consider to be open. In Latin America, we consider everything that is shared in a public way as open, in the framework of common investments, of a global cooperation for the same cause. Transformative agreements lead us to believe that open access must be paid for. Yet Diamond OA allows the scientific community to own, control and drive scientific research. It does not force the elimination of the copyright retention strategy, because there is no upfront payment for copyright. Diamond OA does not impose any of the restrictions sometimes hidden or retroactively imposed by commercial open access. These restraints include embargoes, constraints on the choice of the place of deposit (in particular, for the deposit of preprints in institutional repositories) or on the search of texts and data, etc. Indeed, it often happens that resources available in open access with APCs cannot in fact be freely searched, whereas these methods are essential for the development of new metrics and new points of view on the evaluation of research.

Academic community-driven Diamond OA also allows for improved interoperability and executability of resources, to provide new tools for information discovery and exploration, for optimizing editorial workflows, for research evaluation, for linking open data to publications, etc. All these benefits are not found in other scientific communication models.

It is important to emphasize that this model is not limited to Latin America but is being extended to other countries. The collaboration of these countries with various Latin American institutions and infrastructures allows them to develop an open access that remains firmly rooted in the academic community, without drifting into the commercial side of this activity.

One example is a cooperation initiated between Mexico and Angola around Diamond OA, which forces the question of how a state with limited resources can best invest in its universities to create appropriate mechanisms for scientific communication and encourage the creation of national platforms and repositories, as well as, more

importantly, how to sustain in the long term and strengthen a collective work around this ecosystem of non-commercial open access.

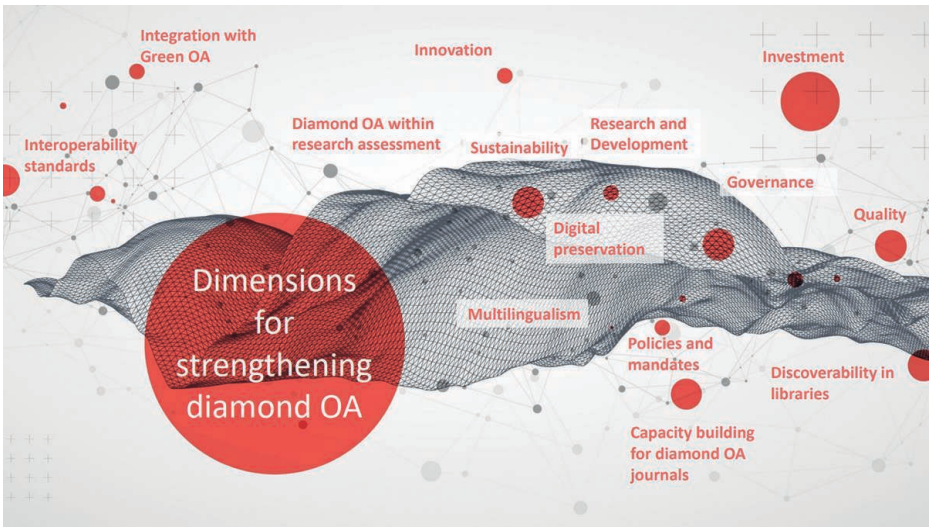
It is important to recognize that across regions there are different levels of maturity of Diamond OA. The Latin American system is robust, coherent, and dynamic, thanks to the participation of the entire academic system: researchers, journal publishers, governments, institutions, open infrastructures, repositories, libraries, national and regional networks (which often mandate open access repositories), etc. In Latin America, this entire system was created before the concept of "open access" even appeared. Thus, the obligations for open access did not exert any coercion since open access was already perfectly obvious.

The evolution of scientific communication towards commercial open access in other countries of the world, however, has forced us to explicitly impose on the research community to publish in open access, when in fact it was our natural way of doing things. In the era of APCs or commercial open access, such obligations serve primarily to ensure that researchers opt for non-commercial open access.

It is important to understand that it is possible to do things differently, and to start from the basis of scientific publication and its needs. In other parts of the world, Diamond OA is less robust, more dispersed, where creating a scientific journal is primarily a matter of individual will and less of institutional support, unlike in Latin America.

I would also like to emphasize that it is essential to support this open access economically. It is very healthy to invest in non-commercial scientific communication, to engage as an economic market player, to fight against the constitution of oligopolies to keep this activity under the control of the academic world. In this way, unlike in some other parts of the world, we can avoid dependence on commercial markets, commercial open access journals with APC or restricted access journals with subscription. Open access managed by the academic community acts as a natural regulator of commercial markets, so it is important to strengthen it and to identify the issues at stake, so that we do not lose our control over scientific communication.

Fig. 6: Dimensions for strengthening Diamond OA



Source : Becerril García, « Academic Publishing and Latin America ». Media used during the presentation (available on the conference's website).

We have many challenges to meet in order to strengthen academic open access, in connection with a few important axes: identify the different levels of maturity of this Diamond OA around the world, innovate to better integrate open access, move towards more interoperability, collaborate more closely, articulate open access and research evaluation, think about the sustainability of this model, its modes of governance... Research policies must keep in mind that open access journals can also be high quality journals, with contents that are often more robust than those of commercial journals.

It is also important to integrate Diamond OA in libraries, research tools and educational platforms, whose users must not be forgotten when talking about open access to scientific knowledge. It is necessary that all collaborate to disseminate scientific publications more widely throughout the world.

It is fundamental to recognize that it is possible to have a quality scientific publication on a non-profit basis, without charging APCs, in a cooperative approach where everyone benefits from each other's investments. The financial funds invested are for the benefit of all, not just the person who invested the funds. 15% of the articles indexed in Redalyc are funded by donors from other parts of the world.

The transition to Diamond OA can also allow reinventing scientific communication, not only to fill existing gaps, but to build or strengthen knowledge as a common good.

This is an ideal time to return to the essence of science, which promotes epistemic justice and methodological, linguistic, geographic and content diversity, to combat the current biases and inequalities in the system and to envision a future where Diamond OA piloted by the academic community has much to contribute.

To go a step further

"If we want to encourage countries where open access is still beginning, the challenges to be met concern first and foremost research itself, which must be developed in a multilingual perspective. In Latin America, too, the resources devoted to scientific research and publication are low, and the commercial stakes are sometimes very delicate. It is important not to ignore them, even in countries where scientific communities are only beginning to be structured."

"Continuous innovation is a necessity if we want to make science a real common good. It is also crucial to ensure that academic publishing is better valued, at a time when the supposed prestige of some commercial journals continues to capture the attention of researchers."

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An Action Plan for Diamond Open Access

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Johan Rooryck
cOAlition S

Lidia Borrell-Damián: We came up with this idea of an Action plan based on a study commissioned by cOAlition S, funded by Science Europe, and run by OPERAS (cf. infra), because we thought that the moment was right to create a community that would strengthen the Diamond Open Access (OA) sector. We thought that we could support this community to achieve a system that is better organised, coordinated and sustainably funded to support these researchers in their dissemination efforts. Moreover, we wished to provide the means for the diamond sector to develop its full potential in the context of open science and in the context of the scholarly communication system at large. We also thought that the moment was right at a practical level to develop this community to provide a common set of actions to better define a communication ecosystem and the infrastructure for scholars.

We wish to further aid Diamond OA journals and platforms that share the same principles, guidelines and quality standard. We want to advance the capacity of those journals and platforms to provide increased and improved services. It is a well-rounded initiative that we think is perfect to advance scholarly communication.

It has been defined by many speakers before me. Diamond OA means free of charge for authors and readers. It is community-driven, academic-led and –owned, which is very important, and since there is no fee, it provides equitable access for all, which is of tremendous importance for the results of research. It also involves the concept of bibliodiversity that is in development, and it respects all large- and small-scale multilingual and multicultural scholarly communities.

We now know much more, but with this in mind, about one year ago Science Europe issued a call for tenders to conduct a study on Diamond OA because we wanted to understand the landscape. We wanted to know more about this system that is so fragmented, and therefore so difficult to bring together in a way that provides a space

and a coherent voice to those concerned in the progress of the scholarly publishing system. A consortium led by OPERAS[1] was the winner of that. I will mention a few key results of this very extensive study[2].

What is important in this study is that they surveyed 1 619 journals, together with focus groups and interviews, which indicated that there are around 17 000 to 29 000 journals. 60% of them are in social sciences and the humanities, 17% in medicine and 22% in other scientific disciplines. Also, what is important to note from this study is that about 44% of the articles published in open access are published in diamond, so it is a non-neglectable size. Moreover, that represents 8-9% of the total publishing volume, compared to 10% of what represents the Gold Article Processing Charges. I think this is a very important figure because it signals the importance of a sector that normally has been underestimated. As Pierre himself confessed, this is not even a fully exhaustive study taking account of everything. It is possible that there is even more data that would give us increased and improved information, and we know that there are other researchers now taking this forward. This puts the importance of this sector of scholarly publishing into context.

What this study identified is that there are four main challenges. One is purely technical. You will hear more about it. Another is about the management. A third one is about the visibility, which we just addressed. A fourth one is about sustainability, which some of my colleagues have also addressed. This is a comprehensive way of presenting the challenges of the Diamond OA sector.

There are several recommendations to address these challenges. One major one is that indeed we need more dialogue and commitment between researchers, research funding organisations, research-performing organisations, university libraries, university presses and departments, scholarly societies, and ministries for all the reasons that you have heard very well presented by Arianna. It was on this basis that we decided to convene a group of experts in a meeting two days ago, with the support of the Ministry of Higher Education, Research and Innovation in France to precisely provide a shape to these four challenges. The study is available, and it is of course in open access. You can seek it out for more information. There are many more recommendations. It is a very in-depth study and I highly recommend that you read it. My colleague Johan will now take over and present to you the principal activities that we have decided to undertake to try to meet these four main challenges.

Johan Rooryck : As Lidia said, we came together a few days ago to discuss an action plan for Diamond Open Access and the discussion among the experts was specifically

focused on four central elements: efficiency, quality standards, capacity-building and sustainability. I will review those to tell you what we alighted on.

The first element is efficiency. We think that Diamond OA journals and platforms would benefit from sharing several common resources. That means aligning quality standards, in a flexible way of course. This is because you must to take into account various traditions across disciplines and various cultures, and research cultures as well. We need to create sustainability and build trust for all stakeholders via shared infrastructure standards, policies, practices and funding streams. That also means making the technical services more accessible, more interoperable and more streamlined. We know that the technical capacity of the existing diamond journals varies a lot from one journal to the next, and this is something that we would like to assist editors and journals with.

We would also like of course to create synergies between diamond journals in the same disciplines, in the same languages, in the same geographical locations, according to their needs via existing organisations, groups and societies. Basically, what we want is to federate and align in a flexible way without imposing standards, but by inviting everyone to participate and co-create these new standards.

The second element is quality standards. Quality of course needs to be flexibly aligned, like I said. It is not something where one standard fits everyone. However, we need to specify quality standards for the core components of publishing operations and services. That is in terms of, for instance, reviewer policies or author guidelines, or in terms of what a reviewer can expect, what a reader can expect, what an author can expect when they submit a paper to a diamond journal. At least there we should have some guidelines that are relatively identical across disciplines and languages and that can be flexibly aligned. That is why we want to align nontechnical standards, non-technological standards, and best practices for open access publishing into what we have called temporarily a European Quality Standard for Institutional Publishing. We also want to develop a self-assessment tool that can allow journals and editors to assess the quality standards for diamond journals to assist progress, to allow journals to progress towards this quality standard.

Thirdly, we want to focus on capacity-building. We want to enhance editorial and management skills across the various disciplines, languages, and countries by creating tools for open access publishing in diamond, training materials for institutional editors and service providers, quality standards for journals, authors and review policies and guidelines that will all become available from a common access point. To that end we

would like to create a capacity centre for diamond publishing that provides technical, financial, and training services for these journals and platforms.

Finally, there is the issue of sustainability, and this was already mentioned by various speakers before me, namely we need to investigate the revenue streams, the legal status and the governance of Diamond OA journals and platforms. That needs to be stabilised. For instance, we need to ensure that the operational costs of diamond publishing are carried by a network of institutional actors, like Arianna mentioned in the presentation before me. We need to develop a coordinated financial mechanism that will deliver various sources of funding both to the central capacity centre and the individual journals, infrastructures, and platforms. We must make sure that the legal status of these various journals clearly states that they are scholar-led, scholar-owned and –governed and that their titles are protected in a legal manner. This also requires that we seek a better understanding of the costs of Diamond OA and promote transparent financial and administrative good practices to inform all stakeholders. Clearly it is not just about open access, but it is also about open governance here.

In conclusion, as mentioned earlier, this action plan was developed by the participants in the workshop on 2 February. This workshop was organised by Science Europe in collaboration with cOAlition S[3], OPERAS and ANR[4]. It was sponsored by the French Ministry of Higher Education, Research, and Innovation in the context of this Open Science European Conference. What is important and encouraging news is that a consortium of 23 organisations was awarded a capacity-building grant for 3 million by Horizon-Widera[5] to develop institutional publishing and diamond publishing in Europe. That will certainly help towards realising this action plan. However, of course we need much more participation from various organisations, not only across Europe, but also across the world, and this is why we will launch an appeal in the next few weeks to sign this action plan to the various organisations and journals who are willing to support it. We certainly need a community of organisations worldwide to bring this action plan for Diamond Open Access forward. We are planning a conference in June 2022 to discuss the implementation of that action plan.

To go a step further

“The agenda for the next two years is to achieve a consolidated network of research centres, funders, researchers, research infrastructures and service providers willing to contribute to the consolidation of the diamond sector. This is a very healthy option for academic scholarly publishing.” (L. Borrel-Damián)

“We would also hopefully have a much better overview of the data of all the journals that exist, what their quality criteria are, how they are subsidised and how they function so that we are able to have a better understanding of this intricate landscape.” (J. Rooryck)

"A quality-certified journal is first and foremost a researcher-run and owned journal that does not require money from either readers or authors. Some services such as the DOAJ can provide a more accurate assessment of such journals." (J. Roorick)

"All disciplines are affected by Diamond Open Access. It is simply a matter of researchers changing the way they think about the dissemination of their work and taking ownership of that dissemination." (L. Borrell-Damián)

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Research Assessment – First Session

The Intersections between DORA, Open Scholarship and Equity

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In 1969, the BBC broadcast a landmark television series called *Civilisation*[1]. It was one of the first television series to be broadcast in colour. In it, the art historian Kenneth Clark traced the rise of Western European civilisation through an examination of its art through the centuries. In an early episode he observed that there had been three or four times in history where Man had made a leap forward that would have been unthinkable under ordinary evolutionary conditions. He is thinking of the 12th Century in Europe as one of these times, when there was an eruption of architectural creativity, which created treasures like Notre Dame. He also observed that this forward leap was due to the rise of confidence in the future that is needed to push through a long-term project. Without wishing to put too much weight on it, I think we are at a similar moment in history regarding research assessment and open science.

The evolution of this opportunity that I think we face now and that this conference is discussing was identified even back in 1999 in a paper by Michael Gibbons where he was analysing the interactions between science, industry and government[2]. He recognised back then the need for a new contract to ensure that scientific knowledge was socially robust and relevant to society. That required its production to be both transparent and participative. This paper was published before the terms 'open access' or 'open science' were in common parlance, but in fact the whole paper is infused with the idea of openness. It is the realisation of that vision that I think we are here today to try and push forward.

The ideas that Gibbons talked about have started to enter the development of public policy. There have been several key documents since then that have talked about research assessment and open science. In the beginning, and the San Francisco Declaration on Research Assessment[3] (DORA) was one of the first movers here, policy and recommendations around research assessment did not explicitly talk about open science. It is not really mentioned in DORA, in the Leiden Manifesto[4], the Metric Tide[5], or in the Hong Kong Principles[6]. However, it is in more recent pronouncements and policy documents, such as in a paper for the Global Research Council[7], that the European Commission Scoping Report[8] helped to set the scene for this conference. In

the UNESCO recommendations on open science[9] that we heard about this morning, the intertwining of research assessment and open science is seen as essential. I think we need to develop a new vision in evaluating science if we are to move forward with this.

When we talk about what we value about science, and we have already heard quite a bit on this subject today, then I think it is interesting to take on board the thinking of philosopher Michael Sandel[10]. In a talk he gave in 2018, he primarily reflects on politics and society as it is now, but he has observed, and I think he is right to do so, the outsourcing of public policy by many governments to commercial organisations. This has been particularly intense in the 1980s in the UK and the US, but I think this is also reflected in the EU project. This has led to a diminishment of the idea of a public good, and a loss of faith in or sight of the collective responsibility for overall wellbeing. I think it is these ideas that we now want to see brought back, not just into society, but into the academy.

We have seen that what has market value in academia now is very much driven by metrics. This is an infusion of the ideas of marketisation into public policy around higher education and research. There is a legitimate demand from governments and public funders for accountability from the academy. But market value in academia has got tied up with the over over-metrication of research assessment and that has led to many unintended and harmful effects. We have a hypercompetitive environment that slows down publication and that can lead to biases in important clinical trial analyses, and we see a culture in which many academic activities are devalued. There is stress on academics as a result. There is a focus on the “what”, not the “who” or the “how” or indeed or the “why”. There is incentivisation within the system of fraud which is undermining public trust. That is something that we really need to guard against.

Within DORA we have a different vision of what research values should look like. I think these values are widely shared. We have heard many similar expressions, and one can see that this resonates very strongly with what we read in the UNESCO report. We are looking for reliable, rapidly communicated, high-quality research that transforms our understanding of the world and can change it for the better. For this, we need researchers who collaborate and feel a duty to care for their group members. We need a research system that values the people within it, cares about their quality of life and seeks out the creative vigour of diversity.

Now, this is a very grand vision. The hard part is to think about how we implement this vision. This is where I see the intersection between research assessment and open science. I do personally believe that we need to talk about how open science can

be better science. Many of the speakers today have already spoken about different aspects of this.

In the last session, we heard about preprints. I am a big fan of preprints. They lead to faster communication. They focus on the content, not the container. Open access, open data and code sharing create a global audience. They maximise a public good within and beyond the academy. They have the potential to increase the scrutiny and reliability of data. Now, there are questions about these innovations. They are not magic solutions, they are not silver bullets, and we have already heard today about questions of reliability and the misuse of preprints. Particularly, in the last session focusing on Diamond Open Access, we heard about the issue of how we need to ensure equitable access for authors. I was very encouraged by what I heard in the previous session.

Generally, and this would be the stance I think of the EC Report and the UNESCO report, open science is better for a changing world. It is making science better and more relevant to more people. In DORA, we are playing a part in that, and increasingly, although our focus is primarily on research assessment, we have to recognise that we are operating in a complex landscape and there are intersections with open science and open scholarship. Although open science is not mentioned in the DORA Declaration, our focus on recognising a broader range of contributions to the academy within research and to society resonates very much with the philosophy of open scholarship. We also have to recognise how biases that operate within research assessment are propagating historical inequities and stereotypes that still to this day exclude women. They exclude people from ethnic minorities and exclude disabled researchers from the academy. Equally, considerations of equity and inclusion interact with open scholarship because it forces us to ask who the academy is open to, and right now it is not sufficiently open to all people.

It is important to have a vision to meet these challenges, but we do have to be realistic, and we must not be naive about the pressures on the system. Pressures that have distorted our incentives and that can lead to disincentives of good practice and the difficulties with regard to time and resource pressure which the major actors need to bring to this party. We do need to interact with funders, with governments, with universities and with our researchers. We have to be very much open to dialogue, to hear their concerns about the change. Change brings many different challenges. However, at the same time, we must not lose sight of our vision, but already I hear in many of the contributions to today's conference the willingness to roll up our sleeves and get stuck into the hard work of doing that.

DORA is very much joining in with that effort. We are a relatively longstanding organisation. We received a significant funding boost in 2017 and that has allowed us to have a much more international profile. Our funding is international, and our steering committee now is absolutely international because we know that this has to be a worldwide conversation. DORA has three priorities in its strategy: to promote the declaration and to extend the global and disciplinary reach of the declaration, but the most important one is to develop and promote best practice. We bring a very practical lens to this effort. It is not just about criticising people for misusing impact factors or other aggregate indicators. We want to be part of finding workable solutions to the problems that we face.

A summary of a few of the resources that we have been developing over the years includes briefings we produce, meetings and workshops we convene, webinars we run and articles we publish. If you look at our website, we are collating and curating a resource library of good practice from universities and organisations around the world and in collaboration with SPARC Europe[11] and EUA[12] we launched a series of case studies last year. I am a great believer in the philosophy that nothing succeeds like success. I think in this sector there is a great willingness to embrace open science, but a great hesitation to know how to take the first step, and we need to identify and promote those in the vanguard who are willing to experiment, and learn and share the lessons with the rest of the community so that we can all move forward together.

We are an extremely small organisation. We have two members of staff plus an intern. They are fantastic people and do a really great job for DORA, but we enhance our impact by collaborating with many other organisations, with the Royal Society on developing the narrative CV[13], for example. We recently ran a workshop looking very critically at narrative CVs, because again there are no silver bullets in this game and we must be wary of any dangers that are introduced by the reform of research assessment practices, even if the vision obviously is to make them much more robust and much more fit for purpose. We have helped develop policy in the Wellcome Trust[14] and worked with the Research on Research Institute[15].

Project TARA[16] is one of our latest and most exciting initiatives. It is funded by Arcadia[17], a charitable fund of Lisbet Rausing and Peter Baldwin. This is largely an infrastructure development project. The most important component of it is the development of an online dashboard with which we aim to track the adoption and implementation of responsible research assessment practices worldwide, and by doing so we hope to do an even better job of discovering and promoting those that are really embracing the reform of research assessment and open science practices to then encourage others. Ideally when this launches, and an initial version will be launched this year, we

hope that this will stimulate an enormous worldwide conversation and I very much hope that people will be banging on our doors to tell us about the good work going on in their institutions that they want us to include in the dashboard.

There is lots of work that we are doing, and we are very much open to collaboration with many other organisations, not least the EC and the good work being done here through the Paris Call. But we recognise, and we have heard some notes today, that there is resistance to this change. We have certainly seen that with the announcement of Plan S, and we have seen that with the announcement of changes and reform at the University of Utrecht, for example. We have heard that Plan S is too risky, unfair and a violation of academic freedom[18] and Professors Poot and Mulders are obsessed with the impact factor and very concerned that it will lead to harm to Dutch science[19]. I think these fears are overstated and misguided, but nevertheless it is important that we hear them. I think they represent a genuine concern for the quality of science across Europe and across the world and we must be ready to enter dialogue. I believe, along with Atul Gawande[20], that people talking to people is still how the world's standards change, and that is very much what we are doing here today.

Coming back to what I started my presentation with, something that represents an update and the trajectory of history that we are talking about today, a year or two ago the BBC remade the *Civilisation* series that it had first broadcast 50 years ago, but it did so in a much more open way. Rather than focusing just on Western Civilisation, the series embraced all of human civilisation and is titled *Civilisations*[21] – plural – as a result, and was presented not just from the perspective of one white man but from a diverse range of experts, and that created much more value in the documentary series. It created a series that was richer and much more relevant to a worldwide audience. We must learn that lesson. That is the promise of open science, which we need to get to through reform of research assessment, and ultimately what we are trying to do here and what we hope to do is to create a *new* 'new social contract', to refer to Michael Gibbons' original paper. I hope that through the Paris Call that is being announced at this conference then we can start to write that social contract.

To go a step further

"Despite its very young age, DORA has already gained such prominence that it is now considered the new standard for research evaluation. The declaration has been signed by over 18,000 individuals and 2,500 organizations."

“Academic freedom is about being able to publish what you want, with freedom of conscience and expression. However, it does not necessarily mean being able to choose the journal in which one publishes, and all publicly funded research carries with it the moral responsibility to make the results of that research available to all, to maximize its impact and act in the most ethical manner possible.”

“It is difficult to ask researchers to be innovative (or not) in their work. However, it is fundamental to place the robustness of research at the forefront of evaluation.”

“We must remember that even citations based on numbers are subjective, not objective. There are biases within citation practices.”

“In the US we have noticed that there are relatively few institutional signatories, certainly universities, that have signed. Some American scholars I have talked to say they have a good system, and it is the Europeans who are obsessed metrics. I am not sure that that is true. That is not necessarily what I hear from young American researchers. That is one of the things that we are going to explore in Project TARA. There is a role for national funding agencies here to think about the leverage that they can operate to promote good practice. Funders should not necessarily be afraid about trying to set the standard for what good research looks like.”

“If one is doing research assessment based on numbers it certainly is quick, but it is not effective. It is missing out on evaluating many other important academic activities that get discounted in a system that relies unduly on metrics. We do need to think about the workload involved because researchers are very busy. I think the narrative CV format, which is something that we have been helping to promote, is a very promising way because that provides a structured and concise way to allow individuals to give a good account of the variety of activities that they have contributed to the academy, not just their impact factors.”

“The impact factor is a good way to assess journals, but it is not a good way to assess individual papers or individual researchers. We ask for individuals and their work should be assessed and we say that they should not be assessed via a proxy that is a simplistic and often skewed number. We see that there is no real correlation between the importance that people attach to their work and the impact factors of the journals that they publish in.”

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Open Science Needs No Martyrs, but We Must Recognize the Need for Reform

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My perspective is primarily that of a researcher. I am an associate professor, I do research. I run a small research group, but I also do some policy work for the Initiative for Science in Europe[1]. One could say the title of my talk is a little bit provocative. It comes from a recent interview I gave for the ERC magazine[2]. As long as the incentives in science are not aligned with the robustness, transparency and reproducibility of science, doing that kind of work actually is not a career benefit. Each individual is in a very competitive system. The numbers vary from country to country and field to field, but let us say 10% of PhDs ever get a permanent position. It is a very tough competition and I think everybody who manages to succeed in that system knows how to play by the system's rules, and so we should not expect individuals to put their own self-interest completely aside and martyr themselves, and in the worst case not have a career. Instead, we have to change the assessment system so that people's self-interests and the interests of science align much better than they do now.

We have already heard a lot about what open science is and why we want to have it. The UNESCO statement[3] is a very important milestone on this. My focus as a researcher is on its open scientific knowledge part, and one should note that this is about a diversity of practices, not just publication, but data, code, methods and so forth. All these things serve to make scientific dissemination and scientific knowledge much more robust and reusable. Accordingly, there have been a lot of aspirations and policy statements. In particular, the European Commission has been very actively promoting open science in its funding programmes.

For many years we have had very strong-worded statements saying that open science must be embedded in every level of the scientific endeavour and all stakeholders must take responsibility for this. This is all well and good, but the fact is that researchers still get hired and promoted to a large extent on the names of the journals where they publish. I have personal experience with hiring processes

at four different European universities in the last five years and not even one would have rewarded me for doing open science. Instead, journal impact metrics and the number of publications were explicitly mentioned. I managed to succeed in that system. I have also managed to support open access and open data, but it has always been a balancing act between that and playing the career game successfully.

There are signs that this is slowly changing. For example, the European University Association said that in 34% of European institutions there were no open science elements[4], which means at least in the rest there were some elements. I am surprised that it is even that high because, as I said, my personal experience is that journal prestige is still very much the career currency. This is a systemic problem, and the problem is that governments distribute public funding based on rankings and aggregated indices to the research institutes and universities, and that of course drives the strategy of these institutions because they want to receive funding and they do need it. Then those research institutions use metrics like journal impact factor, quartile ranks and h-indices to do their hiring and promotions, and thus these metrics flow all the way down to the individual researchers to drive recruitment and promotion.

It is a very easy to use and globalising system in some sense, but it has several serious flaws that DORA and others have highlighted for a long time. From my personal perspective, and I think DORA also recognised this, the most pernicious problem is the misuse of these journal-based impact metrics and the prestige that they signal to individual researchers. I should clarify here. For the individual, this is not irrational. If I have a prestigious publication that really is valuable to me in my career, it is not just an illusory thing. It is a very rational choice to chase those types of publications. That is what needs to change for the whole system to be able to change.

It is a difficult problem for researchers, especially early-career researchers. Many of us have some level of idealistic thinking. We want to do open data, open methods and software, try different things and collaborate a lot, but we are still hired and promoted based on how fast and how prestigiously we publish. Of course, having incentives so badly misaligned with aspirations is bound to not give us the results that we would want for the science system as a whole. That is why we really need to reform research assessment and change the evaluation culture that comes with that.

I have been working on science policy issues in recent years, especially at the Young Academy of Europe[5]. We collaborated with other researcher organisations,

namely Eurodoc[6] and the Marie Curie Alumni Association[7]. Early last year we published an opinion piece[8], which got quite a lot of attention, where we highlighted this problem that we are locked into this system if we want to have a career. I pointed out that even if I have tenure now, I have trainees, post-doc and PhD students. I must worry about their careers, I cannot make my idealistic choices and have their careers suffer consequently. In this opinion piece we tried to think of ways in which the system could be changed. The very first thing we all need to do is we need to be very realistic and honest about the current reward system and its flaws, regardless of if we got hired and promoted in that system. We must recognize what the system is and actually in some sense how absurd it is.

Beyond examples of evolving practices, and there are good examples to highlight, as DORA importantly does, there needs to be a lot more urgent discussion, an internal dialogue, within the research community and between its different segments on what we want to reward and how we want to evaluate people. The status quo simply is no longer acceptable and now is the time to start being very concrete about how we change the system.

To this end, the Initiative for Science in Europe was running an open science working group. We had a virtual workshop in March 2021 with a very diverse set of stakeholders and we tried to think together about how we should reform the system. The draft report from that work has just been put online[9]. In this report we make a few main points. The main one is that researchers really should be central to how we reform research assessment. The time to act is now. The report explores which routes could be taken, at which levels change could happen and what steps different stakeholders could take to achieve comprehensive change while respecting any valid differences, such as between different disciplines. Evaluation in chemistry and medieval history probably is not and should not be the same, and so those differences should be respected.

We propose several policy options for different stakeholder groups. For research communities themselves, we urge that you need to have these conversations right now. You should have had them years ago, but now is better than never, and you must come up with concrete proposals. The message is: you cannot keep on using impact factors. What will you use instead, concretely? You have to decide, because if you do not decide, these impact metrics will continue to be misused or, as seems increasingly likely in Europe due to the activity of the Commission and other funders, new indicators will be imposed on you without your participation. You really must get involved therefore in a very concrete way, right now.

We also identify four essential principles, the main one being that researchers should be engaged in all decisions regarding changes to research assessment, and all stakeholders should engage with them from the beginning in their decision-making processes. Fortunately, there is already a strong researcher representation in the core drafting group for this European Commission initiative to reform research assessment.

We have to end the use of inappropriate metrics. DORA has said this for 10 years and now we just must do it. Honestly there is no valid reason to delay this any further. Of course, the hitch has been that we have known for a long time what we do not want, but we have not known what we want instead, and that is what we need to decide now. We need to agree on appropriate ways of assessing research and researchers in discipline-specific ways. There needs to be an appropriate balance between qualitative and quantitative evaluation. With metrics and indicators, some of them may be good and some of them may not be, so we have to evaluate them in each discipline and other contexts separately.

Finally – this is more for policymakers, universities, and funders – we have to all recognise that reforming assessment requires resources. We may have to come up with new systems. We may just need more time for evaluation, so perhaps we have to also consider whether all of the current forms of evaluation are needed or whether we could, for example, pool evaluations from different funding programmes and so forth.

Of course, we have seen that change is hard and changing entrenched mindsets is really hard. I have a personal anecdote that illustrates how hard this really is. Last year we achieved a very cool piece of science from my ERC project that we published open access with open data, and we tried to initially submit it to a very prestigious journal that has a glamorous brand. They said it was not novel enough. Fine, that is their subjective judgement, and maybe they are right. So we ended up publishing in a respected journal, a solid journal, that is just not as prestigious. Even I then caught myself thinking it was probably not worth a press release because it was not such an impressive journal. I really had to stop myself and realise I was caught in the same kind of thinking myself, even though I really should know better. Then I said to myself that it was the same research and exactly the same results and that I should make the press release. The university agreed and we got some nice publicity for the work.

Change is hard and it will take time to change the culture. I am not sure if we will be able to bring everybody along with us, but we certainly should try. However, it really is time to stop doing this to ourselves. Unlike publishing, evaluation is largely done by and to the research community itself. Of course, governments play a role,

but where do the governments get their ideas on how to evaluate? That comes from the scientific community in the end. There is a lot of power within the research community to change this and it really is now the time to start doing so. I am very happy to see the Paris Call, the European Commission effort, and statements from different university groups. There is a lot of momentum and I think we really have a shot at making this happen.

To go a step further

"Senior researchers who are in policymaking positions, who are heads of scientific societies, who are in academies of science, have a lot of prestige and they really should use that prestige and that power to help change the entire system."

"The best form of government is democracy, so the best form of evaluation is peer review, and of course we should be the experts in our own discipline on what is good science and what is not."

"The point of DORA is not to enforce. It is to inspire and to motivate. The European Commission's proposal to form a coalition to reform research assessment will be based on a set of pledges. Signatories will sign up and there will be some form of monitoring. What form consequences would take is part of what is still being discussed. However, the idea is to take it one step further from an aspiration and from a soft power declaration."

"What might have kept DORA and research assessment reform back is that there was a huge focus on open access. Access to research is important. There are questions to solve, there is work to be done, but I think a lot of people's focus has now shifted to assessment, because changing assessment will also unlock so much more innovation in the publishing sphere. It will probably also trigger kind of a new wave in open access."

"We may need some balance of indicators, but ones that are more responsible, more transparent, and more useful, and then perhaps put increasing emphasis on qualitative peer review. That may take some more time."

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To What extend are Early Career Researchers the Harbingers of Change ?

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The work presented here is a long-term research, which was initiated thanks to a study commissioned by Europe, in which we investigated the practices of young researchers around social networks[1]. This study gave us the opportunity to discover a demography in its own right, designated by the dedicated keyword "early career researchers" in English, which can be used as such for bibliographic research. This demographic category is that of the digital natives who have highly developed digital practices, as well as trajectories and career paths that are at the heart of the attention of various players in the academic world, such as large groups of scientific publishers, funding agencies, but also social networking platforms, for example.

It is a social category in the academic world, which has a particular status and position, always in between: between seniors and the very young, between different communities, in the making in terms of career, but also at the hinge of two worlds. And it is around this community that we launched a research project that was funded by the Sloan Foundation and the Publishing Research Consortium over a long period, between 2016 and 2022, and which includes the current pandemic and looks at several countries around the world: France of course, Great Britain, Spain, the United States, China, Russia, and Malaysia. The study constituted an observatory around which we selected 168 young researchers, with whom we conducted semi-structured interviews throughout this period, every year, and every six months since the pandemic. 23 themes were explored in depth, since the interviews could last up to three hours, by exploiting their CVs and their accounts on academic social networks. These researchers were spread across the fields of life sciences, hard sciences, and social sciences, but not the humanities.

While the results show differences between countries, between researchers and between disciplines, where all the results converge in a particularly significant way is that there is a very significant alignment of researchers' practices and representations around research evaluation issues. This alignment comes from the

fact that there is a cult and a culture of scientific production around the article in high-impact journals, very early in the career of young researchers, from the Master's level onwards. As Toma Susi pointed out, the career starts very early, and it happens that Master 2 students are involved in research work and are authors of articles. From the Master's level onwards, students are involved in this logic of submitting articles, thinking in terms of articles, and producing articles in the best journals, the highest ranked ones, what we call A-rank journals with the highest impact factors, to constitute a form of distinction that will enable them to embark on a research career.

There is a real impact factor culture in the way we train young researchers, and this culture is sometimes negotiated between young researchers and senior researchers: am I going to submit this article to this journal with a high impact factor, or have a safer strategy and submit to a journal with a lower impact factor, or the opposite? These strategies, which are found from one young researcher to another, from one country to another, are really structured around the impact factor and the international databases, I am thinking of the Web of Science, Scopus, which are there to root for and justify this strategy.

We can speak of a culture in terms of scientific production, of "Publish or Perish". This focus on articles in high-impact journals, because there is a common terminology, has absolutely similar configurations and normative principles that really mobilize the same practices, actions and the strategies among all the young researchers that we have been able to interview over all these years, strategies that are moreover exacerbated with time. When we give them the floor, young researchers say that "you are what you publish". This title is only a verbatim of a young researcher interviewed. At the heart of this representation, the paper, the famous article, is an infinite quest since the collaborations built, the visits, the scientific stays, the mobilities, the post-docs that one goes to do in different countries, the methods that one learns, the protocols that one develops, have a common destiny: to be published in a journal with a high impact factor. There is also a particularly interesting phenomenon, which is the zombie paper, the zombie article, which is always late, which we always try to finish, and no matter how long it takes, we carry it around with us. It is possible to finish a contract, to go on to another research funding, and despite that, to keep trying to finish it, because this paper will have to justify a line in the CV.

Another point is the drift that this can lead to, namely the "Publish and be wrong", in the sense that by trying to publish quickly and easily, one sometimes targets a bad journal, which is not necessarily a quality journal, or results that are not

consolidated. In other words, we don't take the time to make sure that the positive results we had the first time are repeated and confirmed, and we publish too quickly results that are ultimately invalid.

Another issue concerns what can be called the mythology in CVs, carried by the injunction that young researchers must absolutely demonstrate a long list of publications in impact factor journals. When they all align themselves with this strategy, and then present themselves to a recruitment committee, what makes the difference? When they all have the same CV, having published in the right journals, with the right people, having done postdocs in the right prestigious places, what makes the difference? That's one aspect that really challenges these strategies.

There are also all these tasks, all these activities, all these things that you do around the work cycle of a researcher that are not mentioned in a CV, that are not taken into account.

It should also be pointed out that when young researchers develop an interdisciplinary, multidisciplinary profile and then publish, they often find it difficult to find journals with a high impact factor that are able to accept research that conveys this interdisciplinarity. The logic of valuing multidisciplinarity on the one hand, and not always finding an adequate, prestigious publication venue with a high impact factor on the other, is sometimes problematic, and it produces epistemic inequalities between researchers. And then there is the famous Matthieu effect, the law of cumulative advantages that says that when you have published once in a prestigious journal with prestigious authors, you have a better chance of publishing in other prestigious journals and of being integrated into prestigious groups. This is a mechanism that young researchers integrate very quickly, without particularly knowing the name or the principle.

How to change the rules? How to confront the peers? How to question these rules, even though with these peers, there is the image of two roped climbers who climb a wall and are connected by a certain solidarity. The seniors look after the interests of the juniors and, for example, recommend that they publish in prestigious journals because that's how you get into the system. They see themselves as the guardians of the temple and want to maintain this tradition, this way of working, and they want the young researchers to reproduce it. And in fact, what the results of the Harbinger project show us, especially today, is that the revolution will necessarily take place without the peers, without the seniors, because you have to take risks, you have to seize opportunities, the preprint servers are proof of that. We have to encourage activities, work that is not sufficiently valued for the moment, such as the work that is

done around data. The pandemic has also shown how important it is to deal with data, to value it and to share it. I draw a parallel with an 18th century literary work, Carl Von Carlsberg, a novel about a young university assistant in Germany who couldn't get a permanent position, and after a while confided in one of his peers who said, "You just have to marry one of our daughters, since we have many daughters. So if you want to join the circle, you have to join it by marrying one of our girls." The novel is known for this, and I find the parallel particularly interesting.

Another point I would like to quickly go over is that this injunction to publish a lot of articles in high impact factor journals, since there is a very strong focus on articles, can create confusion and misunderstandings, which social networking platforms have been very good at exploiting since the digital practices of young researchers mean that they are browsing the web, on platforms, and they sometimes lose their bearings between these platforms and the differences between them. It is not uncommon to see young researchers who are very happy to use social networks such as ResearchGate to seek visibility, to seek social capital, and to observe how communities function because they find their peers and colleagues on these platforms, to the point of confusing these social network platforms with open archives. Besides, if we take the SciHub phenomenon, some researchers justify it by saying clearly that they participate in a form of opening of scientific publication, since it is closed and it must be opened, and that SciHub contributes to it. So, this leads to these confusions, which are ultimately real obstacles to legitimate and official models of open access and open science.

How to open up the game? First, on an individual and collective scale, these young researchers we've talked to over the years don't believe in the impact factor. They play with it, as they say, they have to deal with it, but they don't believe in it and they don't share the logic of the impact factor. They question it, and are very aware that neither the impact factor nor the new indicators are the solution to the system. Some of the young researchers interviewed are gamers, who say they know very well how to "game" the system, how the indicators work, and how to play with them. In fact, the arguments they put forward are the arguments of DORA, without mentioning DORA, which they do not necessarily know. So we are in a very troubling alignment when we analyse the interviews, because they are already compliant with what we claim, but without wanting to name it.

I will end with an extremely important point, namely the results of the pandemic period of the study, which showed to what extent the pandemic has very significantly modified the practices, representations and strategies of the young researchers we knew until then or who joined the study. New trajectories are emerging. The

pandemic showed this generation how far science was in an ivory tower from society. They were very mobilized, very attentive, and very interested in observing the way in which information about the virus circulated in the media, the way in which the debate about vaccines occupied our daily lives, and the debate they made was that by dint of chasing publications, chasing impact factors, science had finally forgotten to address society, the citizens. The question of the debate on science in society, of the dissemination of knowledge to society, has become for some the absolute emergency, to the point that they have changed their career path and do not wish to join the academic world, but rather the world of knowledge dissemination and scientific mediation. We are facing a generation that is changing its career objectives, and that says that science should have the possibility, the right to be wrong, and to recreate scientific debate because the system as it works today does not allow for debate. It just allows for publication in high impact journals to prove that one is right. Finally, they want the way science communicates to adapt to today's world, to allow more diversity in the forms of knowledge, in the new skills that can be valued today, and in the new forms of value that allow us to take into account the complexity of science today, which is not the same as it was at the beginning of the 20th century, not the same as it was at the time of Pierre and Marie Curie in any case.

To conclude, I would like to quote a researcher who left the system saying that he no longer recognized himself in this game, that he wanted to "stop playing" because the pandemic has shown on a worldwide, globalized scale that the ultimate goal of science is to advance knowledge, not to advance egos, indicators, figures or business figures.

To go a step further

“Scholarly publication should not be restricted to journals and articles. It is a question of how to bring value to other skill sets and to other areas of expertise which do not necessarily result in the publication of a paper.”

“In the change of paradigm, heading towards research assessment which is more quality-based, what you do is you make it possible for researchers to be active participants in this assessment. You ask researchers what fields of research and which research activities they consider to matter most over a period of time. You get indicators based on the opinions of researchers rather than ones provided by very costly databases owned by hegemonic commercial players.”

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Research Assessment – Second Session

Research Assessment and Open Science in a Diverse World

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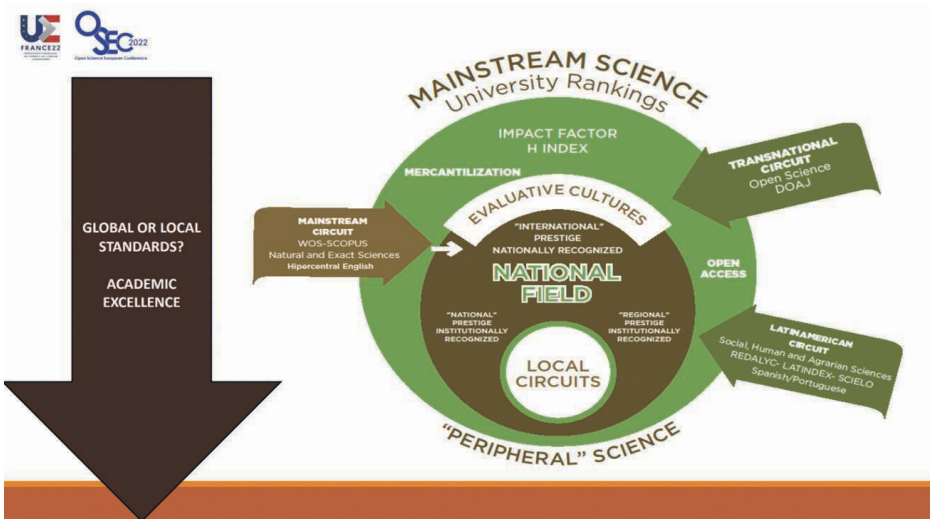
I would like to start by recalling that the Open Science project has been in existence for decades, although we can say that it has entered a consolidation phase in recent years. The Unesco Recommendation for Open Science[1] is a step in this direction. It provides a general framework, a definition that tends towards a global consensus, a set of principles and values and, finally, a list of actions to face. Among the latter, it is important to mention the need to align the incentives of the research evaluation systems with the progress of open science. How can we promote open science through the evolution of research evaluation modes?

Among the various points concerned, it is fundamental to consider all the missions of universities, beyond publication activities, which we assimilate to research activity. I am referring to teaching, but also to what we in Latin America call *extensión universitaria* (third mission). When working on the Unesco Recommendation, the experts realised that there was not a general consensus on the instruments of promotion and recognition of open science in research evaluation. It is therefore essential to recognise the plurality of incentives that exist, and to consider them in context.

The Unesco member countries that participated in the making on this recommendation also discussed at length one critical issue in the road to open science: inequalities. There are indeed visible inequalities today between what is commonly called the North and the South, between countries that could be described as peripheral or semi-peripheral and central countries. There is a significant digital divide, particularly in terms of infrastructure. The increase in these inequalities can also be seen in the transition to open access as it is currently taking place in European journals, particularly in connection with the move to the Article Processing Charges (APCs) model. In Latin America, this model represents a huge difficulty, due to the very high amounts involved. The Recommendation also defends multilingualism because English is unfortunately often the only code for interoperability between and across databases.

I would also like to mention another asymmetry that is important for the transformation towards openness in research assessment, namely the very notion of excellence. I have tried to represent in a diagram the way in which the differentiated vision of the North and the South can be seen in the power relations of the academic system. At the top is academic excellence, also more appropriately called 'research quality', which has been identified with mainstream science, frequently identified with the main stream of scientific publishing. At the very bottom of the hierarchy is the so-called peripheral science, i.e. everything that falls outside the circuit of what is rewarded in the traditional research evaluation system. Alongside this, there are various transnational circuits (notably the Latin American system), which were born directly out of open access, with a desire to open up the academic dialogue, as well as national circuits, which continue to exist. In these peripheral or semi-peripheral countries of the South, different levels of prestige conferred by publication have thus arisen: a national level of prestige (which I am observing here mainly for Latin America), a regional or international level of prestige, with different evaluation cultures for each.

Fig. 7 : Traditional representation of the academic system



Source : Beigel, "Research Evaluation in the Southern Road to Open Science" (Media used during the presentation (available on the conference's website) and Fernanda Beigel, "Circuits and fields. The multi-scale process of academic prestige-building", in Keim, W. et al., Handbook On The Circulation of Academic Knowledge. Forthcoming.

There is a boundary between the different evaluation cultures, which distinguishes between what might be called national prestige, but which is in fact only recognised within the institution of origin and in a particular country, and what is called

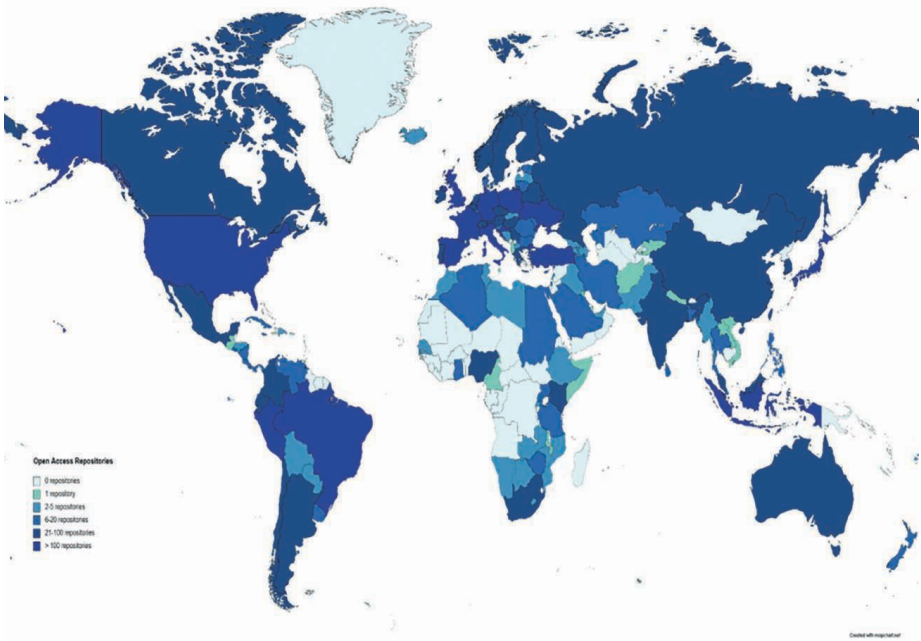
international prestige, but which, due to inequalities between countries, is in fact reduced to the scale of prestige specific to the country concerned. In Latin America, there is also a certain type of international prestige, which is truly shared within a group of countries, and which can therefore be described as regional, in connection with a very specific publishing circuit.

The left arrow on my diagram represents the fact that when we ask what academic excellence is, we are in fact asking what the best science is: the one that has the most impact? Given that this notion does not originate in this region of the world this is how academic excellence has been defined in the countries of the South. I have shown it separately from the diagram, because it is partly imposed from outside, due to the internationalisation of the academic research system developed from the 1990s. Open science places a precise challenge to this inequality in terms of the autonomous definition of the research agenda.

Let us mention the case of China, in relation to the notion of imposed excellence. In the reforms currently underway in China, we recognise the perverse effects that this type of heteronomous imposition can have, notably through the very rapid adaptability that Chinese researchers have shown, with the generalisation of the use of English and the advent of a fracture between research concerns and societal concerns, all in the name “impact”, but eventually embodied in the Impact factor. It is therefore important to emphasise that the reform underway in China shows the need to support national policies to assist local scientific publication.

If we now look at the other relevant concerns of experts and Member States when developing the Recommendation for open science, we see that these were essentially related to global inequalities in access to resources and infrastructures.

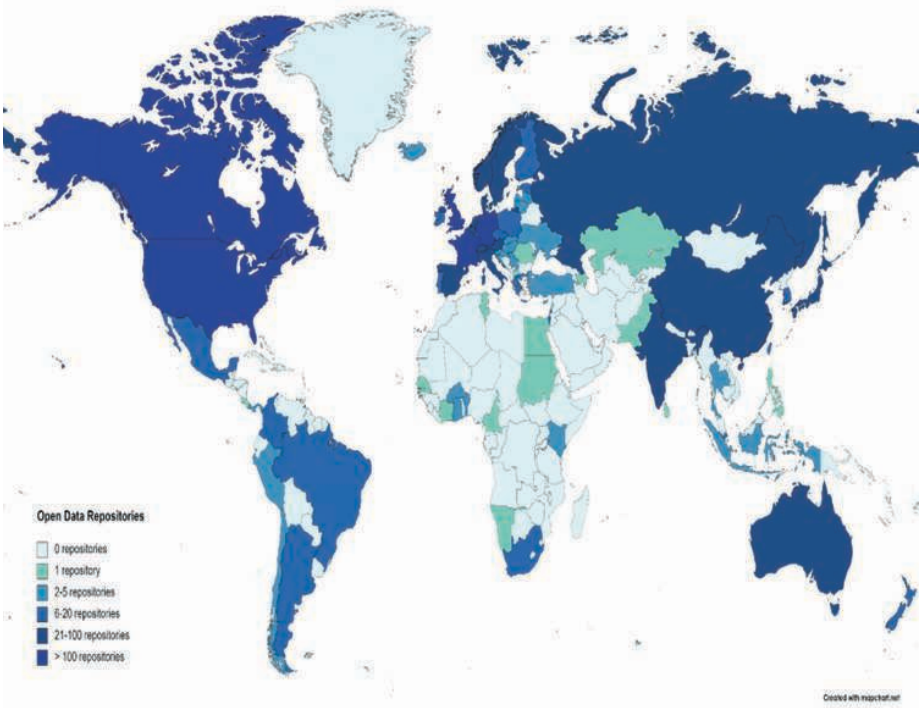
Fig. 8 : Open Access Repositories



Source: Beigel, "Research Evaluation in the Southern Road to Open Science". Media used during the presentation (available on the conference's website). Based on data extracted from re3data.org - Registry of Research Data Repositories. https://doi.org/10.17616/R3D, accessed January 2022.

To go further in this study of global inequalities, let us look at the global landscape of repositories with scientific production in Southern countries. It can be seen in Figure 8 that there are not yet many publication repositories in Africa, but that Latin America is among the best equipped countries in the South. On the other hand, if we look at Figure 9, that is open data repositories, we can see a glaring difference in the number of repositories between the North and the South, including in Latin America, even if the contrast is still greatest with Africa.

Fig. 9: Open Data Repositories



Source: Beigel, "Research Evaluation in the Southern Road to Open Science". Based on data extracted from re3data.org - Registry of Research Data Repositories. https://doi.org/10.17616/R3D, accessed January 2022.

Other inequalities can be observed in the current global distribution of research information systems or CRIS (Current Research Information System), which allow for the fully integrated administration of all kinds of information that are currently managed independently within the countries of the South, i.e. interfaces for the management of scientific policies, human resources or research projects on the one hand, and open archives or open data warehouses on the other. CRIS systems link the repositories and information databases, providing highly interconnected and interoperable open science data. There are about 950 CRISs listed in EuroCRIS[2], most of which are located in Europe and northern countries.

Next is another type of global asymmetry, affecting to publications, which can be seen when looking at the distribution between Diamond Open Access journals and open access journals with APCs. South America has 2,612 diamond journals listed in DOAJ and only 130 APCs journals, which is a peculiarity of this region. Western

Europe has nearly 4,300 journals, of which 1,907 are open access with APCs. The latter are generally the most prestigious, and therefore the most sought-after by scientists in the South. But how will they pay individually for an average 2.000 dollars to publish a paper?

I would now like to focus more on the linguistic face of the global inequalities in science. There are a number of tangible initiatives around the main challenges facing our continent, namely multilingualism and the hypercentrality of English. There are initiatives such as the Helsinki initiative[3], the Latin American Forum for Research Assessment[4], which launched CLACSO, or the Jussieu Call[5], which insists that to have a real impact on society, research must be multilingual. Let's look at the particular strengths and weaknesses of Latin America in terms of bibliodiversity and open access. There is a strong historical regionalism since the 1950s, with the early development of national information management systems, although, as mentioned earlier, these systems were disconnected from other bases such as open access repositories. Regional indexing systems have also been set up, allowing the professionalisation of thousands of diamond open access journals. Latin America also has a very strong and dynamic publishing industry, with books published since the 1930s, and a very long tradition of non-commercial open access.

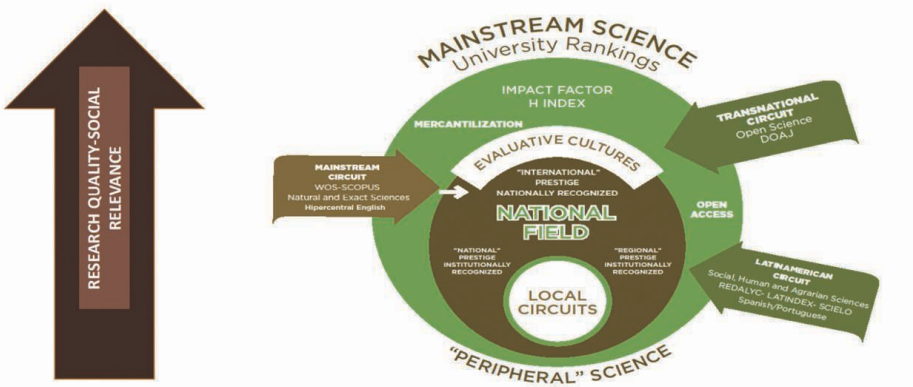
In addition to these strengths, there is legislation in several countries in favour of open publications and open data, and a federation of repositories with more than 790 institutions in more than 10 different countries. An initiative led by CLACSO, which lists the different actions carried out in Latin America, gathers interesting data on this theme, and specifies that there are 57 instruments relating to open science policies, the majority of which are based on collaborative infrastructures. I also would like to briefly delve in an important tradition of citizen and participatory science, the so-called extension universitaria (or third mission of universities), which has a long history of co-production of scientific knowledge in collaboration with the social sector. All these interactions must be highlighted in the research assessment systems but also revalued in the transition to open science.

One of the key points in this respect is multilingualism. The hyper-centrality of English is now absolutely clear in the research world. However, although English is a dominant reality, it is not the only reality, and in South America we have a number of channels for the circulation of knowledge that bypass the use of English. For example, if we search Scopus or the Web of Science, we find Spanish and Portuguese articles as marginal shares. In contrast, the OLIVA[6] database, which combines entries from SciELO and Redalyc and has 345,391 entries in Spanish, more than the Web of Science (270,632 entries) and almost as many as Scopus (373,419 entries). The same observation can

be made in BIBLAT[7] and LA Referencia[8], the latter database containing many more references in Portuguese than Scopus and the Web of Science.

Well now, how "aligned" to these strengths are the rewards promoted by the research assessment systems in Latin America? we can observe a contradiction, even a form of "alienation" between these regional potentials for open science and the orientations led by the evaluative policies regarding individual careers, institutional accreditation and research funding. There is indeed a certain dichotomy between robust and highly developed public infrastructures and an evaluation system, which relies largely on the impact factor and other criteria imposed by the North, but which are supposed to represent a universal standard, that of the large mainstream journals. In effect, the national classification for researchers and the national funding agencies use the impact factor or the h-index to assign positions or resources. It is necessary to start changing our perspective. We used to represent our arrow as going from North to South: now let's go from bottom to top, focusing on the quality of the research and its relevance to society. We can start to see that there are different possible production and circulation channels, which promote research and interaction with society, and can contribute to citizen science. It is this diversity of practices that research evaluation must address.

Fig. 10: To invert the path to defining research quality



Source: Beigel, "Research Evaluation in the Southern Road to Open Science" and Beigel, "Circuits and fields. The multi-scale process of academic prestige-building".

Eventually one of the main challenges in South America is to invert the path towards defining research quality autonomously in accordance with a public ecosystem with a robust infrastructure and highly developed resources, which supports diamond journals, as well as many alternative circuits, especially at the local level. The current

evaluation system pushes researchers to look up to mainstream criteria, and distances them from regional ecosystems of scientific production and communication. This is why we need to set up a regional CRIS, which already exists in Peru, Brazil and Argentina. Datasources are a fundamental issue to broaden up the landscape of scientific production under assessment, as is the need to really stimulate the multilingualism of local productions by giving them more visibility in international databases such as SciELO, Redalyc or BIBLAT.

In South America, there are many small-scale journals published by small research teams or universities. At the opposite end of the spectrum, mainstream bibliographic databases include very few Latin American journals. Latindex, SciELO, Redalyc and BIBLAT show it is possible to publish quality journals, with a level of excellence defined collectively in the academic community with a necessary balance between local standards and international criteria, a balance that must be pursued through horizontal and not vertical imposition.

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Open Science and Research Assessment. Trends and State of Play in Europe

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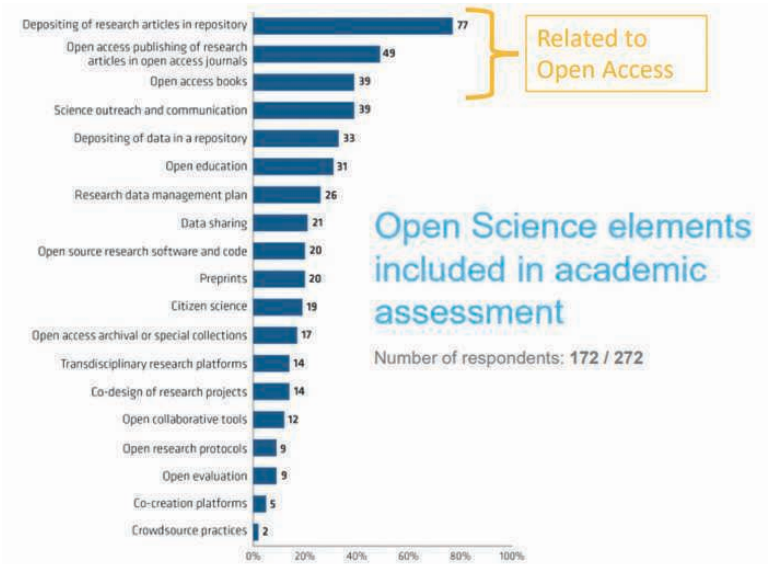
I am very pleased to join the discussion on how important it is to change and reform research assessment in order to make open science a reality. However, let me also stress a point the other way around: open science is also the main driver for this new way of assessing researchers and research that is more comprehensive and that pushes us towards better science. The open science movement has brought us here today and we must acknowledge that.

I am going to give you an overview of the current situation of open science in research assessment from an institutional point of view, so I am going to focus on European universities. To do that I am going to tell you the results of the work we have been doing at the Expert Group on Open Science at the European University Association. We have been following the trends and the evolution of open science for about a decade, and our Expert Group has itself been evolving in following those different trends. In fact, we have just published our new vision and new key priorities for the years to come, and research assessment is key within that.

We have been following this evolution through different surveys, asking universities whether they were implementing open science, and these surveys have also evolved with time. We started in 2014, just asking publications about open access. Then when we incorporated FAIR data and in 2017 we included research assessment. What I am going to tell you about is a combination of the two last reports and surveys from the EUA[1], and it is worth noting that those surveys were answered by university leaders, or by responsible open science units, or departments at the universities, so it is not a bottom-up approach and it is not the way academics in universities think about things, but it is a top-down approach from the university leaders. The other thing I want to note is that all these results and all these surveys were done just before the European Commission started this discussion with the stakeholders, so it is going to be very interesting to see what happens after the debate we are currently having.

Let us start with open science. The good news is that open science is more and more present within the strategic priorities of European universities and in fact a huge majority of them have specific open science institutional policies or are developing one. However, when we go deep into the detail of how these open science policies are organised, there is an important difference between the different open science areas. For instance, open access to publications is given the highest level of importance and of implementation, whereas evaluation is not seen as important.

Fig. 11: Limited role of OS in university academic assessment approaches



Source: European University Association et al.*, "Open Science in university approaches to academic assessment", December 2021, https://www.eua.eu/resources/ publications/999:open-science-in-university-approaches-to-academic-assessment. html.*

This is also reflected in the limited role of open science in the academic approaches that universities have. When we asked universities what open science elements were included in these academic assessments most of the respondents responded with elements that were pretty much related to open access of articles and books. Moreover, nearly one-half of respondents did not incorporate open science aspects in their academic assessments at all. When we asked specifically about research career assessment the results showed that open science and open access are given the least importance among the activities for research career assessment, whereas the most the two most important activities are, first, research publications and, second, attraction of research funding.

When we asked for the assessment methods for a research career we found two main aspects that are followed by most of the institutions. Assessment is therefore a combination of the metrics based on the number of publications and citations and the peer review assessment. The main metrics used are those of journal impact factor and h-index. This is the reality at European universities right now because there is a time lag between the open science strategy and open science being incorporated in the research assessment. Also, the main difficulty is that university leaders and administrators like to use this metrics-based approach for research assessment. When we go deep into the details of this main difficulty, most of them are related to practical implementations, so they have seen that incorporating this reform is a complex issue and they perceive that they have a lack of institutional capacity to do it. There are also concerns about increases in costs. There is also another very important concern which is that universities perceive there to be resistance to research reform from researchers. This is a key point. It is very important to bring researchers into the conversation. We cannot just have a top-down approach. We need things to be bottom-up as well in order to create and to move all the reforms we need.

Let me share with you the struggles we have, and I have myself as a vice president in a university, trying to change things and struggling with the balance between what we want to do and what we can actually achieve. There is always this dilemma. It is difficult to navigate through the context, the environment we are in, the lack of incentives, the lack of guidelines, the lack of different policies, the differences between countries and between disciplines, and the question of how we as academics are we going to do this without damaging researchers, particularly early-career researchers. However, when we ask about the future most of the respondents say that open science is going to be more and more present, including within academic assessment.

There are many organisations rethinking how we can improve academic assessment and I am going to give you some examples of some of them. I am going to start at an institutional level. I am going to give you examples of three universities that started working on these issues some years ago. I am going to start with Ghent University, which published that vision statement in 2016[2] looking towards a more comprehensive evaluation system. That vision was followed by a rethink and reshape of the evaluation system of academic staff, which is now seen more as a professional development and not just as a control and evaluation process. There is another very good example from Utrecht University[3], where the medical school embraced an open science strategy, incorporating a more qualitative and descriptive portfolio of what is going to be taken into account in order to make assess researchers and groups.

I will also explain to you a little bit about we are doing at the Open University of Catalonia with our own Open Knowledge Action Plan that we approved in 2018[4]. We decided to incorporate research assessment as a way to move forward to open science. As a first step, we created a taskforce that did a lot of work to see whether we could accomplish what DORA[5] advocated in not using journal impact factor for assessing researchers and research. After that, we signed it and we started implementing a more narrative curriculum in our internal evaluations, discarding the journal impact factor in our internal course.

There are also some very good initiatives at the national level. There is the Dutch Universities initiative that has incorporated a very interesting way of including asymmetry, for instance, in the assessment[6]. In Finland, some years ago, the Responsible Research network published a nice recommendation set stressing the need for change in assessment in order to incorporate the new ways of producing and communicating in science[7]. Also, universities in Norway came out with the evolution of the open science career assessment matrix[8]. The way they did it is very interesting, taking into account the different disciplines and a bottom-up approach, and they set up a toolbox giving us some indicators, both quantitative and qualitative, and included a reflection on this.

All those examples are also present in the work that DORA, the EUA and SPARC Europe have been doing[9]. These are the individual initiatives that have led us to be heard by the European Commission and now we are gaining momentum in convincing all the actors that these changes have to be made. It is very important that the new European Research Area Policy Agenda for the coming years has a specific action for reform for research assessment. The Scoping Report is also an important step[10]. We are now working all together in this process with the Commission as a facilitator in order to create the critical mass that we need. Let me end by saying that change is just ahead. We have room for creating more and more actions in order to move to a more comprehensive, more transparent and fairer way of assessing academic research for better science and I think the opportunity is here.

To go a step further

“The European Commission, with a set of stakeholders, are now drafting a global agreement on the reform of research evaluation. They have also opened an expression of interest for those institutions that want to be part of this change. More than a hundred institutions have already volunteered, with the aim of ending up with

an agreement with specific actions to be taken, and hopefully also some support measures which are needed."

"We know what we do not want, but we are also pretty much aware that open science is not going to be a universal solution for all. It should be adapted to the context, to the country, to the university, to the researchers and to the disciplines. At the UOC, we started small, and we are going step by step and with joint action learning between all the universities, between all the stakeholders. That is why these UNESCO recommendations are so important, because the global scale is very, very important for us in order to give this real momentum there. Open access of research publishing is easier because we have been discussing open access to papers for many years, and we know how to incorporate them, and we know how to open this access. We should now learn how to do the other things."

"Not everybody is aware of the limits of metrics measuring research, such as h-index, within the academic community. We should open this debate more, raise awareness and bring everybody in, in order to know all of these drawbacks."

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Making Room for Everyone's Talent

Kim Huijpen
Universities of The Netherlands

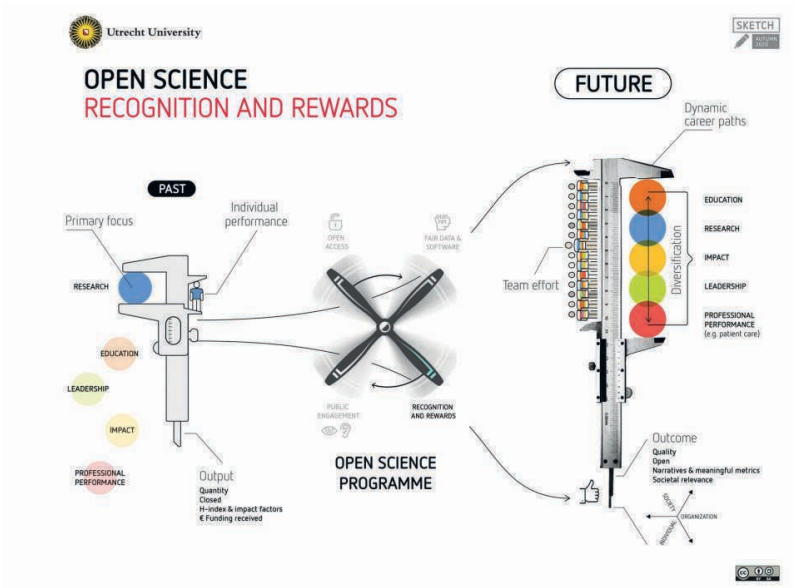
We had a Recognition & Rewards Festival in the Netherlands yesterday. This was a very inspiring event where all our colleagues involved in our national programme, and some of our international colleagues, I am glad to say, shared good practices. We inspired each other in a plenary programme and 17 workshops co-created with the people I work with every day. I am very happy that I could join you here in Paris and explain a little about how we like to make *Room for everyone's talent* in the Netherlands.

This is our ambition. We aim for a healthy and inspiring environment for our academic staff where all talents are valued – teaching, research, impact, patient care and good leadership in academia – and we hope to see this not only in the Netherlands but all over the world.

What I will be sharing today is why we think we need this change, what we want to change, how we think we will be able to achieve this change in the Netherlands and beyond, and also how you might contribute to this change in academic career assessment.

Why do we think change is needed? We can see in academia that we have a broad mission as universities, research institutes and university hospitals, but we only reward our academics for research output and publications, or even just a small set of indicators.

Fig. 12 : Open Science Recognition and Rewards



Source: Utrecht University, Open Science Recognition and Rewards, https://www.uu.nl/en/research/open-science/tracks/recognition-and-rewards. Accessed 15 May 2022. CC BY-SA 4.0.

What we see is a mismatch, that Utrecht University translated in this beautiful visualisation comparing a calliper and a very simpler measuring instrument measuring only research as the primary focus of academic assessment. Our ambition is for this measurement instrument to be a little bit more advanced so that we can measure all aspects of what an academic, scholar or scientist does, and that is not only research. It is also teaching and impact. We also need good quality leaders in academia.

What do we want to change? There are five key aspects in our 'Room for everyone's talent[1]' position paper of 2019:

What we strive for is that there will be more diverse career paths in academia, so that there is a career for you if you are good at doing research and publishing in the right journals, but also if you are good at teaching and at working together with organisations, society, and industry. We hope that we can form teams - and we think there already are teams - based on these different types of talent in academia, but we really want to recognise all these different talents.

We think that there should be a better balance between the individual and the team, so we strive for team spirit and teamwork. And I think we should focus more on the quality of the work. Because good scientific research increases scientific knowledge and contributes to solving societal challenges, and that is what we aim for. Of course, we want to stimulate open science. This is the Open Science European Conference, and we all know that if we want to stimulate open science we really should reward scientists who publish in open access journals, who work on research data management and share their data, software or materials. The fifth element of our approach is that we would like to stimulate good quality leadership in academia, and we think this is also key to make this change in academic career assessment.

How do we think we will be able to achieve this change? We set up a joint programme in the Netherlands and we work together and share good practices. We share experiments and are building an online community to make this possible, which we also already did in joint meetings. Every university, research institute and research funder has set up a recognition and rewards committee. We bring the chairs of these committees together in meetings, including at our Recognition & Rewards festivals, where we share good practices and co-create new work. Mutual learning is also key to our approach. The committees themselves translate our national position paper, 'Room for everyone's talents', into their own visions based on their own context and the missions of their organisations[2]. Our approach is therefore both bottom-up and top-down because we think that it is important to bring researchers into the conversation. We cannot make this change if there is no dialogue with the academic staff themselves. We also, however, involve the important leaders in academia in the Netherlands. That is important, in order to have ambassadors of this change movement.

The guiding principles of our approach are as follows. We think that we are working on a culture change, which is a fundamental change of beliefs and not just a change in the rules of the game. What we need therefore is also patience to make this change. It will not happen overnight. We need this broad dialogue in academia, and we need to involve the academic community to make sure they are able to decide themselves how they are assessed. We need to share good practices. We are striving for a balance between giving room for ideas and then bringing them together, and to make this change, good leadership in academia is really, really necessary.

We need to work together, so we have to follow all the international initiatives (and there are a lot these days – I agree that we are gaining momentum) and share

our own experiences at conferences like this. We all have the same vision and are striving for culture change, but we need diversity in approaches, and we need communication and we need to share good practices to make this change possible.

I would like to give a little idea of the lessons we have learned so far in the Netherlands because we are not there yet. We really make sure that academics are involved. We are not advancing too quickly. It is very important that some people speed up the process, but it is also very important to be patient as well because we do not want new tools that lead to the same box-ticking exercise. We really want a change that is fundamental.

To end my talk, how can you get involved? I hope you will start a dialogue in your own context and listen to the concerns of your colleagues and peers. Perhaps you could even start a small experiment yourself, and I am very proud of a couple of PhD students who did this at Utrecht University. They just started at some point with a form they did not like, with a form that did not fit the way they thought about academic career assessment, and they changed that form. I think these small experiments are key to make this change happen.

In conclusion, we think we need a better balance in how we recognise and reward academics to help us achieve excellent education, research, impact and leadership, as well as the highest level of patient care in our university hospitals. However, we cannot change academic career assessment on our own. We need to work together in Europe and beyond to change the way we recognise and reward academics.

To go a step further

“The Dutch national approach of research assessment is broader than the open science approach because it also includes teaching, leadership and societal relevance or societal impact. It is very important because an academic, a scholar, is more than a researcher. Teaching is key to the mission of universities, so it is fundamental to invest in the quality of teachers and to give them room to grow in academia and have a career path as well.”

“In the Netherlands, some professors and even ECRS have written open letters to return to the old assessment system. We see this as the academic community sharing concerns, so I think we should really involve the academic community and start a dialogue. We did this by inviting one of these people, the first author of one of these letters at a round table at our Recognition & Rewards Festival yesterday. And

we had a really, really good dialogue with him and with the board members involved in our initiative. I really understand that a lot of researchers, a lot of scientists, are concerned about their careers. And we are experimenting. We do not know what it will look like in a few years. So I think we should really take these concerns seriously, start a dialogue, keep this dialogue going and make sure that we all do that on a national level and on the level of a university, faculty or research unit."

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Open Science, Research Assessment and HSS (Humanities and Social Sciences)

Emanuel Kulczycki
Adam Mickiewicz University in Poznań

In my talk I aim to show how to effectively address one of the key challenges of open science and research evaluation, which is multilingualism. The perspective of social sciences and the humanities helps me to show that supporting multilingualism is the foundation of research impact.

Almost half of Europeans are not able to speak any foreign language well enough to hold a conversation. Only a little more than one-third are able to do so in English, the most widely spoken foreign language. Thus, if research is communicated exclusively in English, it is inherently limited. This is apparent during the COVID-19 pandemic in Europe and globally. We observe a widespread need for scholarly communication, not only between researchers, but to enable research to reach decision-makers, professionals, and citizens. The problem is that we have made the publications open, but we see that our societies are not fully able to use them. This can only be possible if research is communicated in multiple languages, including those used in speech and writing locally.

In the ongoing reform of the research assessment system, the call for multilingualism is the most notable omission. Making science actually open requires promoting diverse, multilingual and relevant research accessible for different audiences. Machine translation is not a substitute for publishing research results in multiple languages to different audiences. This is primarily because major corporations and publishers target languages with the largest number of users and translate mostly from English to other languages. Languages with fewer users are too often overlooked and thus become invisible. Exactly the same is true for publications in languages other than English in the largest citation indexes. Therefore, open science and research evaluation must support researchers in publishing research in multiple languages.

Not all local publications need to be translated into English and not all publications in English need to be translated into local languages. The call for multilingualism is

not a call to prioritise local languages over English. It is a call to recognise that the quality of research does not depend on whether the research is communicated in English or not. In the social sciences and the humanities, we study societies and analyse them using their own words and their own concepts. Thus, local languages are needed to express the entire culture and historical heritage. Moreover, in many of the so-called hard sciences, like physics or chemistry, research can be expressed in a fewer number of words than in history or sociology because a lot of work is done by figures, charts, and formulas. This is not the situation of the humanities, where the linguistic diversity plays a key role.

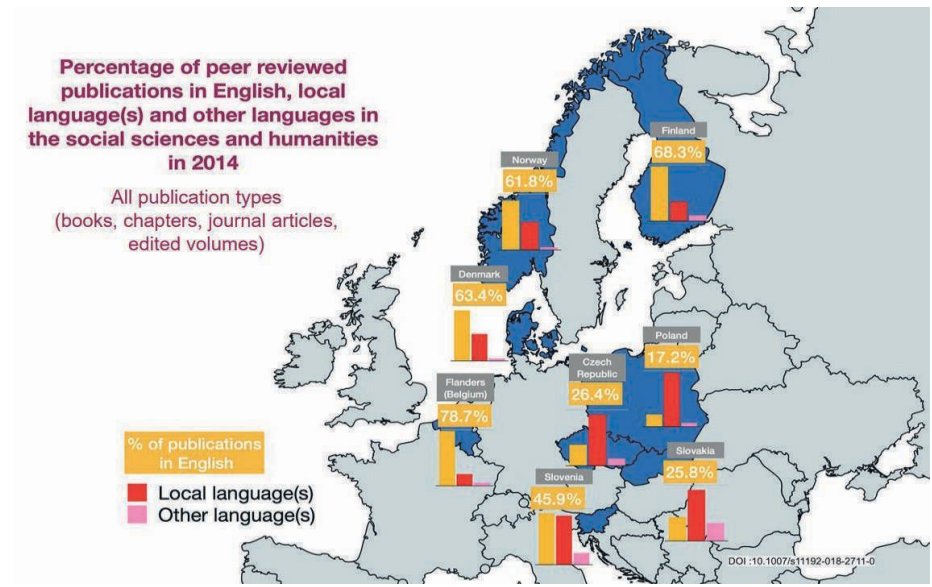
I build my talk around scholarly communication through the lenses of researchers from the social sciences and the humanities. Talking about open science, we regularly reduce it to open access to publications and forget about the researchers who are the actual creators of science and subjects of open science. Therefore, I focus on various ways of publishing research results and highlight that communicating through scholarly books, publications and local journals is crucial for researchers from the social sciences and the humanities. Nonetheless, researchers publishing books and articles in local languages face different challenges than researchers from the so-called STEM fields, natural and technical sciences, among others. I argue that when we reorient our focus from publications to researchers who publish those publications, we will spot that multilingualism and language bias are crucial challenges for open science and research assessment. That is a key message of the Helsinki Initiative on Multilingualism in Scholarly Communication[1], which aims to make language a nonissue in assessment. I am going to present an evidence-based picture of publication patterns of researchers in Europe. I draw on recent studies of the European Network for Research Evaluation in the Social Sciences and Humanities.

Evidence from eight European countries[2] shows that the Web of Science database covers only a small part of all peer-reviewed publications in SSH. Scholarly book publications have been an important way of communicating research, but they are invisible in the Web of Science or Scopus databases. For instance, only 15% of all publications of Polish scholars from SSH are indexed in Web of Science and only just over 50% of Danish scholars. Fortunately, for over a decade, various European countries have been using national current research information systems, thanks to which we can obtain a good picture of the whole publishing landscape in academia.

There was a study of the percentage of peer-reviewed publications published in English, local languages and other languages in the social sciences and the humanities in eight European countries. In this study, we have taken into account all publication types and the results are not limited to publications indexed in the largest

citation databases. In the Nordic countries most publications are in English, but in the Central and Eastern European countries the local language is dominant. The size of the country, the diversity of disciplines and the size of the market for academic publications are insufficient explanatory factors. Historical and cultural factors still play a major role.

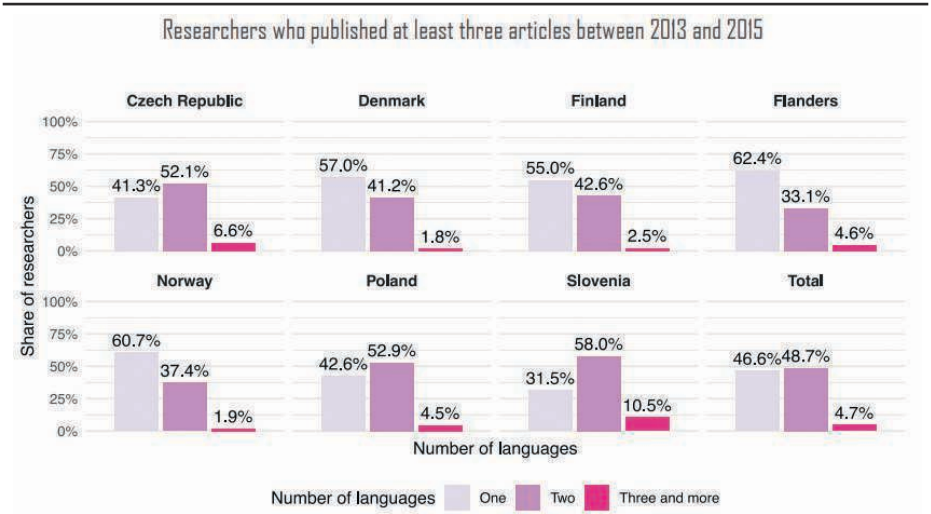
Fig. 13: Percentage of peer reviewed publications in English, local language(s) and other languages in the social sciences and humanity in 2014



Source: Emanuel Kulczycki et al., *"Publication Patterns in the Social Sciences and Humanities: Evidence from Eight European Countries",* Scientometrics *116, no 1 (July 2018): 463-86, https://doi.org/10.1007/s11192-018-2711-0.*

This picture focuses on scholarly communication through the lens of publications. One can say that researchers from Poland or the Czech Republic are less internationalised, that is they publish less in English, than their colleagues from Denmark or Norway. However, as I said earlier, we need to reverse this focus and look at scholarly communication from the perspective of researchers.

Fig. 14 : Language patterns of article publishing on the researcher level across countries



Source: Emanuel Kulczycki et al., "Multilingual Publishing in the Social Sciences and Humanities: A Seven country European Study", Journal of the Association for Information Science and Technology 71, nº 11 (November 2020): 1371-85, https://doi.org/10.1002/asi.24336.

We turn now to the results of the study focused on multilingual publishing of journal articles in seven European countries. This picture is built around individual researchers, not their publications. In a three-year period, over a half of Polish, Czech and Slovenian researchers published in at least two languages. Some of them in this period published in three, four and more languages. As other studies show, multilingual publishing includes not only articles but also books.

Evidence shows that the Web of Science and Scopus databases cover only one-fourth of all peer-reviewed journal articles published by researchers from these analysed countries, and only a small percent of the articles published in local languages. In this way, intended or unintended language priorities in assessment may lead to a systemic undervaluation of SSH research and researchers. The clearest example of the everyday language bias comes from the manuscript peer review, where it is frequently reported that reviewers judge research based on the quality of non-native English speakers' writing instead of the content of the manuscript. In this way, the excellence of research is too often equated with English-language publications, especially those published in journals having an impact factor.

What can we do to improve this situation? Making the link between multilingualism and assessment clear has been one of the main goals of the Helsinki Initiative on Multilingualism in Scholarly Communication. The initiative promotes language diversity in research assessment, evaluation, and funding systems. Ideally, language is a nonissue in assessment and researchers should be recognised and rewarded according to their results and the impact of their research. Language biases are produced in evaluations based on research metrics, as well as in evaluations based on expert assessment. Thus, all actors involved in research assessment should make sure that in the process of expert-based evaluation high-quality research is valued regardless of the publishing language or publication channel. Moreover, when metrics-based systems are utilised, journal and book publications in all languages should be adequately taken into account. The selection of evaluators and their language skill should be a relevant concern in the assessment.

Many decades ago, we gave away, as researchers, the publishing of journals and books to small commercial publishers. This was a well-functioning relationship for a long time, but today 75% of European spending on scientific journals goes to the big five publishers. On top of this we can see new mega-publishers emerging from the new author payment model for open access. These mega-publishers treat publishing research mostly as a means of increasing profits. By doing this, they have been demolishing the idea of open science, making it just another way to increase their own profits. In such a business model, multilingualism is just an obstacle because it is easier to publish and sustain infrastructure only in English. The losers are both scientists and citizens. Therefore, reclaiming communication channels and owning them by the academic community and learned societies is a crucial step in maintaining and achieving the goals of open science. Only in this way will we be able to fully open up the publications and the metadata used in research assessment.

To achieve a fully open science, we must, among others, make sure that national journals and book publishers are safeguarded in the transition to open access. Policymakers and the academic community must make sure that not-for-profit journals and book publishers have both sufficient resources and the support needed to maintain high standards of quality control and research integrity. Taking into account all the presented arguments, I want to highlight that multilingualism is integral to accessibility and should be part of the European research assessment reform.

To go a step further

"It is crucial to describe, discuss and talk in various languages if we want to reach different audiences, to show them that they are analysed and understood in their own language. English is not enough."

"Our aim is not to produce the Tower of Babel. The aim is to recognise that researchers already publish in many languages. The aim of the Helsinki Initiate is not to force researchers to learn new languages and publish in more languages – of course it would be great if they did so – but to acknowledge in the current existing systems that researchers actually publish in many languages. For example, when we analysed data from the current Polish national research information system, we saw that the humanists over a six year period published in seven or eight different languages. They are not translations. They publish in so many languages because they analyse various classical literature and ancient history texts. The idea therefore is not to push to publish in many languages and translate evidence in various languages but to use, for example, machine translation to facilitate reading."

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Round Table – Research Assessment

Roundtable participants:

- **Jean-Éric Paquet, Director-General of DG Research and Innovation, European Commission**
- **Maria Leptin, President of the European Research Council - ERC**
- **Marc Schiltz, President of Science Europe and CEO of the Luxembourg National Research Fund - FNR**
- **Michael Murphy, President of the European University Association - EUA**
- **Bert Overlaet, on behalf of the President of the League of European Research Universities - LERU**
- **Thierry Coulhon, President of the High Council for Evaluation of Research and Higher Education - Hcéres**

Animator: Paul de Brem (scientific journalist)

Animator: A few months ago, open access was made a legally mandated requirement for all projects funded by Horizon Europe[1]. Three months ago, the European Commission published a report called 'Towards a reform of the research assessment system[2]'. One month later, the European Commission released a Call for interest[3] in order to create a coalition on reforming research assessment. Jean-Éric Paquet, how many signatories did you get?

Jean-Éric Paquet: It is still ongoing, but we are way beyond 160 in a matter of a few weeks. I expect that to mushroom now and that we will have many more. We hope to rally as many actors as possible in Europe around that call, and across a spectrum of organisations. We want researchers and the organisations that represent them, universities, evaluation actors in the national systems research centres and research funders, to be part of it. We need this participation across the spectrum, and we already have a wide range of actors in the 160 plus signatories so far, so this is really looking good. We have a few non-EU countries already represented, but we now largely have all EU member states. We do not have all of them yet, but I think we are above 22 out of 27. I have no doubt we will get there.

There is amazing momentum behind open science. The assessment of research, the assessment of research organisations and the assessment of researchers themselves is very much at the heart of a systemic change in open science practices, which is why it is so important. Beyond that, we have seen in the pandemic management that open science is an absolute must. The impact that open science has had on scientists around the world, particularly in Europe, in making a difference has been amazing. The Commission, together with the European Molecular Biology Laboratory and other organisations, created a data platform through which thousands of researchers shared their data and viral sequences. This accelerated the knowledge sharing around COVID-19. Also, publications behind paywalls were made available in immediate open access. With open science the world has moved remarkably fast in dealing with the pandemic, and the vaccine is one example. It is therefore a necessity, but it is also a process which is decades old. There was a lot of frustration at the lack of action, as open science is a systemic effort with many different components which largely need to move together to be relevant and impactful, which explains why it was so difficult. The European Commission can have an impact in terms of policy frameworks and funding, but we cannot do it in isolation. Today's momentum really started with cOAlition S[4] about open access to publications, which created some momentum, including for research assessment

It started with ministers agreeing that the European Research Area needs a new momentum. A key component for ministers is indeed open science and, within that, they identified research assessment as a critical component. It is very clear that when you look at research assessment this is not just about looking at and grading individual scientists or labs or institutions. It is about fundamentally looking differently at how we are producing science and how we are organising ourselves to do so. The Commission did a rather deep dive into the issue in the course of 2021 and produced a report[5] at the end of last year setting out the key elements of a process which could lead us collectively to really change the way research is assessed. That was then the basis for a call we launched on 16 December 2021, which now has real momentum.

The idea of working together is to produce a coalition agreement in order to make proposals for concrete reforms of research assessment, and the Paris Call is a direct contribution to it. It calls for organisations to come together and commit to research assessment reform, and to helping us to produce this coalition agreement. We will use last year's report as a strong starting point, and we are now working with Science Europe and the European University Association to start putting a text together. The Paris Call will be a key input into it. We will

of course make this work available as it progresses, and it will be a work of co-creation with many actors participating. I hope we will have it by the summer of 2022, and we will then have a very strong basis to start, act and deliver.

This coalition should certainly be open to participants beyond Europe, which would be fully aligned with the UNESCO open science recommendation[6] released a few months ago. The hard work starts with like-minded European players, but we are open to see key players from around the world join. It makes sense because science is global. There is no doubt a need to have players from beyond Europe joining. I think the work will be strong enough to attract big players from outside of Europe, especially given the concrete and practical step-by-step delivery process.

There will no doubt be roadmap elements. This is not just a declaration of principle. We need to move beyond that to delivery, which is challenging because it is very broad as an effort. It is disruptive and it will change practices, habits, and the positions of actors. It is not something which is neutral at all. It is a deep disruption for the better, but it requires us to create a large coalition and genuine ownership with the actors of that coalition, and that we then have a real practical way forward with well-planned steps and strong momentum within a reasonable timeframe. With Horizon Europe we will play our part by changing the way we assess proposals. We will move away from the use of journal impact factors in particular and look much more at the content of research.

Animator: Maria Leptin, the essence of your organisation, the ERC[7], is to select excellent researchers who will get fantastic grants over a period of many years, and they will be able to create their own teams and pursue their own scientific ideas. I guess that every scientist in the world would like to have an ERC grant and I guess that you must be challenged as an organisation as to how to assess these candidates and the work they have done?

Maria Leptin: It is indeed a challenge. First of all, a logistics one, because there are thousands of applications coming in each year and only between 10% and 15% of them can be funded, so the selection is very tough. The ERC relies on top experts in all fields of academic thought and research, so we need a large number of experts. The challenge is of course how to identify the best. We do rely on experts who look at the science. They spend a lot of time. They read the grants in detail. We get external assessments as well, expert views on details. They meet to discuss them, and they meet again to interview the short listed candidates. It is a huge amount of work and a huge amount of intellectual input.

The ERC really looks at the content and not so much at metrics. The ERC has been a signatory of DORA[8] since last year. We have completely banned the use of impact factors. Their use has been discouraged for some time. The committees are told not to look at other metrics, such as whether researchers work in glamorous institutions or whether they have a high h-index. They are really encouraged to look at the essence of the work. There are a number of things that matter that have not actually come up in some of these discussions. For example, not only the impact factor of where you publish but the overall output can vary a lot, and it can vary a lot depending on the location where you are. If you are in a very supportive huge centre of research, it is easier for you to be productive and to train good people, because the good people flock to these places, than if you are in a smaller place. We urge our panels to pay attention to that and they do.

The Scientific Council, which has 22 researchers from throughout Europe and which represents all fields, can monitor the way panels assess these researchers by sitting in on the panels and listening. They are not allowed to say anything. They are not allowed to influence. They sit in, monitor, and get feedback. They thereby collect evidence from the panels and then report it back for discussion and review, so we constantly self-criticise and get feedback. Some people may fall into traps, but reminders are given to try to prevent that. We make use of narrative CVs. Researchers are allowed to choose individual papers they want to highlight and to tell the panels and the referees what to use. But there is still room for reform. As a researcher myself I would never say what I do is perfect and ready. It never is. It has to evolve.

There is still a lot to be done in an organisation such as ours for research assessment. When we talked about this before, we were talking about open access. We are now talking about research assessment. They are very different. What is happening right now, and I really welcome this, is that we are getting feedback about what we are not getting right and where we can do things better. We are about to set up a taskforce within the ERC Scientific Council to also look into this. When it comes to open access, which I fully subscribe to, the ERC demands publication in open access. In other words, any work funded by the ERC has to be published in open access venues. However, the entire community still needs to look for additional solutions.

I welcomed yesterday the highlighting of Diamond publication. Diamond Open Access is defined as a method where the researcher does not pay to publish and the reader does not pay to read, which means that somebody else has to pay. There are very good examples of that, but they are restricted to researchers who are funded through particular venues. What about all the other papers out there? If we want global open access, we need to find a way of doing that. These are big issues that remain to

be solved, but it is good to see an impetus going in that direction. I do not know how things will pan out with what we and the community come up with in terms of recommendations for research assessment, but I am sure there will be similar logistical issues and possibly also financial issues.

If the Scientific Council decides so, it would be possible for the ERC to, for instance, response positively to the Paris Call and join the coalition, as we already signed up to DORA. We have created a taskforce, that is not fully formed yet, but we met in preparation of this meeting. We will look into what the Scientific Council thinks, with feedback from the panels, about what is needed for and works for the ERC. Once we have formed a view of the best way forward, we hope we will lead in implementing the reforms that will come from the consultation with the community.

Animator: What about open science and partnership between the academic and private sectors? In other words, how to reconcile open science with the incentive to file patents by certain research institutes?

Maria Leptin: I would simply say that question is not for the ERC to answer. Researchers at the ERC are free to publish whenever they like and whatever they like. They are also encouraged to consider patenting and bringing their research to the next level of application. I think human curiosity is the driving force of discovery and invention, so it does not have to go anywhere. However, researchers are encouraged to think about that and are helped to do that. There are specific grants that help people to get patents. Then there is the great transition to the EIC[9]. Proof of concept is within the ERC, but then there is a different agency, the European Innovation Council, that does the next step.

Animator: Marc Schiltz, Science Europe[10] is an association that brings together many funding agencies. You have 38 member organisations from 29 countries. You told me that when it comes to reforming the assessment system, we know what we do not want anymore, but more difficult you say is what we want to replace it with, because the question is so complex and because we are trying to assess people engaged in so many various activities. How are you going to compare all these people?

Marc Schiltz: I think that we should not, and we will not replace a narrow, simplistic and monolithic evaluation model with another one. The question is not so much what the new evaluation system will be. I do not think we should go for a unique new evaluation system. I think that is the wrong question. Here I can make a reference to open access. With cOAlition S, one of the reasons we started on that was to liberate

the scientific community from a monolithic publication model, but we were not saying which one should be the new one. However, we needed to be liberated from those chains and, as we heard yesterday, there is now innovation in the publication industry. With research assessment, it is the same. We need to be clear on what we do not want and what we wish to abandon.

Where we can agree on a future assessment system, and this is what is written in the Paris Call, is that we should recognise that researchers' activities, for both individuals and institutions, are much broader than what is measured through some current narrow metrics. That is the first principle. For example, in the COVID-19 crisis many researchers have advised governments and many scientists have been on TV and on radio. This public outreach and scientific communication have suddenly become extremely important. That is just one example of taking a broader view of what researchers do and what should be valued.

What we also need is what is called research on research. Because I think if we are going to introduce new ways of assessing, we should also give ourselves the means to assess these new methods and these new approaches because we do not want to introduce new biases. We have to be very careful. We know that our current system is heavily biased, but we need to be careful that evaluation systems or methods involve critical self-reflection. My funding agency (the Luxembourg National Research Fund) has introduced narrative CVs, as have others, but we are now collecting feedback on that. We need to assess the impact and effect of narrative CVs to make sure that we are not making things worse. We must experiment, and I do not think there will be a one-size-fits-all evaluation method. Different institutions will adapt it to their needs. We can be creative here and it is the community itself which should mainly define these things. But the question is what we value in science, and it is more than just publication. We have to take care of the science system itself by being open, by sharing results and by caring for each other, including actions like training, mentoring and reviewing. The individual institutions know more or less what they want, but we have to get rid of these chains which we have put ourselves into. The ERC is a very good model of not looking at simplistic metrics and its participation in the coalition would be welcomed.

Jean-Éric Paquet: One element to note is the diversity of research activity, which Marc touched on. What we really need to value more and reward more is the work which scientists do on data, which also includes software, and then making it available to the community. This is never looked into. It is very, very time consuming. It requires a lot of resources and if we do not reward it and assess it this will never bring us to where open science wants it to be.

Animator: In your opinion, can you lock in the increased openness in scholarly communications that we have seen during the pandemic? Is there the political will in your opinion?

Marc Schiltz: There certainly is from the funders' side. The planned policy is to make everything immediately open access. Publishers – even legacy publishers – have agreed that this is the case for everything related to COVID-19. Then we can arguably ask why just COVID-19? Is cancer research not as important? Why should cancer research be locked up behind a paywall for 12 months? I think publishers have in a sense admitted their defeat because what holds for one topic necessarily holds for the other. We cannot have an artificial hierarchy on what deserves to be immediately open access and what not. So we will see what happens, but certainly the funders in cOAlition S have always supported immediate open access without embargo for everything – not just COVID-19. So we will stick to that.

Jean-Éric Paquet: The funders do not allow anymore publications not to be immediately accessible. Under Horizon Europe, any research funded will need to be in open access at publication.

Animator: Michael Murphy, do you have the feeling that universities are ready to think and create this research assessment system that we are looking for, a flexible one of course, not a monolithic one? Do you have the feeling that they are eager to have such a system reformed?

Michael Murphy: I do, because we have lots of evidence to justify reform. The EUA and specialist groupings of universities, most of which are in the EUA as well, have been working on the Open Science agenda for well over a decade and we have been monitoring the evolution of the application of open science within the sector. Visiting here for the past day or so one can see the consensus among the breadth of society represented here and the enthusiasm to move on this agenda. Open Science is a moon-shot, something we do not because it is easy, but because it is hard, and it is something that our species needs to do.

Society as a whole is embracing on sustainability. The UN Sustainable Development Goals[11] effectively encapsulate our societal and sectoral objectives and open science is a critical tool for achieving the SDGs.

Adoption of open science principles and practices should be one of the sector's contributions to the UN SDGs by 2030. I think one of our failures to date is that we are afraid to set targets. The targets have to be realistic and that is why I am looking

at 2030. Yes, the universities are committed, and we have strategies and in most institutions we have policies, but the implementation gap is what we now really have to focus on.

The question now for us is how do we close the implementation gap between our aspirations and what we need to do? We are working as a sector, and with all the societal partners who have influence on our sector, to adopt collective approaches to reform academic assessment as an enabler of Open Science. The Paris Call is a wonderful example of collaboration. We have a tough job ahead of us because of the complexity of the matter. It is critical that in our work with the Commission, a key partner, we arrive at agreed implementation principles among all the actors and that we are realistic in the timeframes that we adopt.

In addition to accommodating complexity, we need to accommodate diversity. The needs of people in various disciplines are not the same regarding research assessment. Whatever frameworks we adopt, we have to be sensitive to that diversity. If we are to be fair in rewarding people , we have to make sure that our methodologies exhibit equity, which will be very difficult because the metrics in STEM can be very different from those in the humanities. But many of the measures that we will use are common to both. We also have to recognise that countries differ in terms of available resources, regulatory frameworks and opportunities to exhibit leadership.

EUA released a refreshed open science agenda a few days ago covering 2022 to 2025[12]. It sets out our open science strategic priorities and addresses assessment reform as well. It begins with an endorsement of UNESCO's open science definition. This is quite important as the open science agenda spans the globe in its application. The challenges that we are trying to face are global and require that we engage talent everywhere in the world to combat them. Having a body such as UNESCO aligned with what we are trying to achieve in Europe is really, really important. Some countries and some institutions have been braver than others in the steps that they have taken. We as global bodies, or at least pan-continental bodies, have a responsibility to try to make sure that the gap between the leaders and followers does not become a disincentive to the latter to keep on pushing. It is critical that we are all in this together.

Animator: Bert Overlaet, you were the lead author of a paper published recently[13]. What does it say?

Bert Overlaet: LERU has been dealing with research assessment for some time and trying to move forward. We exchanged all these experiments and novel ideas we had about that and turned it into a sort of new framework that is described in

the paper that was launched last week. It is a way of trying to create a picture of the future of the assessment of researchers. We are not complaining about what we did before. If we want to go forward then we need to have a multifaceted and much broader perspective in assessment, which means that we must go away from the single-minded and very narrow measurements often used today. That is one element of the paper, and it describes the complexity and the variety of the duties of a researcher today in a university.

The ERC is here today. Another great European institution is the European Institute of Innovation and Technology[14], where you have these networks of sometimes 400 partners trying to move research forward in the European context. We need researchers who are able to work inside these kinds of coalitions. Networking is becoming so important. In the COVID-19 era it has become clear that leadership, collaboration, and innovation are topics that are coming much more to the foreground. It is not sufficient anymore to be a good researcher. You are also expected to be a good teacher in universities because we do not only produce patents and papers. Most importantly we produce people. We produce young people with research training, who are well trained to play a role in society. This diversity is therefore described in the paper along with the experiments we are doing in LERU.

Some universities have used narrative CVs for as long as 15 years, but we are still working on them, making changes and trying to improve the format because every format has its advantages and disadvantages, and it is difficult to strike the right balance. The aim is to be precise, efficient, and also nonexclusive. If narrative CVs are too long, then there are complaints that they take too much time to fill in. If they are short and concise then the risk is that those with a typical profile will be more easily remarked on by the panels than those with an atypical profile. At the heart of our paper and our endeavour is that we want to recognise and reward all the different contributions people now make in the research area, which is much more than just publishing. We want people who stimulate progress in their field of work, and they can contribute to that in so many different ways.

Animator: How do we concretely get around university rankings driving us back to a monoculture?

Bert Overlaet: Ghent University was mentioned earlier. Ghent is the closest competitor and colleague of the University of Leuven. The difference between the two is that at some point in time Ghent decided that the quantitative criteria for funding used by the Flemish government should translate into the assessment of the researchers themselves and they got a bonus for each publication they made because

they got bonuses from the government. This is the trickle-down principle that was used there. This is something that Leuven has never done. There is a Chinese wall between the funding of the university and the assessment of the researchers. We do not want the same criteria to apply. At some point, Ghent reformed and returned to the old situation because they came to see the trickle-down effect as destructive for the quality of science, the culture and the organisation. I am sure that if you have a good assessment process, you will achieve a collective form of excellence that will lead to good funding, but I think it is a devastating strategy to couple them directly, which has been shown in some places.

Michael Murphy: Rankings are like death and incomes taxes. They are inevitable. It is regrettable that those with the most influence are copper-fastening the importance of metrics that we are now trying to abandon in this reform agenda. Universities as a sector must encourage the evolution of a ranking system or ranking systems that deliver support to open science and our broader agenda. One that exists, that goes back to the last French Presidency, funded by the EU, the U-Multirank[15], is I think the closest to that objective, though it too needs to evolve. It behoves us to work to support and evolve a methodology that helps us attain our open science agenda.

Marc Schiltz: To the rankings, we also have to be careful that we are not ending up again in a situation, as with open science, that we give our very precious data away to these entities that establish these rankings. That's what is currently happening: we give all this data over when it would be much better utilised for our own research on research purposes.

Bert Overlaet: There is one dimension I would like to mention as well, which is elaborated on in the paper and was already mentioned by Maria here. It is contextualisation. Today rankings, individual assessments of researchers and metrics are happening in a vacuum. If you are in a very good environment, it is easier to get publications than when you are in another institution. We have avoided contextualisation so far and one of the elements that we would like to focus on more in our assessment of research in the future is how to deal with this contextualisation without getting in a situation where you cannot decide anymore. We still have to make decisions about hiring and promotions, but how can we incorporate this context more than we do today?

Animator: Thierry Coulhon, you are President of the High Council for Evaluation of Research and Higher Education (Hcéres[16]). It is an independent public body in France which is in charge of assessing institutions, universities, national

research bodies and so forth, but you do not evaluate people. How do the open science principles apply to an organisation such as yours?

Thierry Coulhon: The world is changing as far as research is concerned. There is a movement at the European level. There is a French movement as well and we are fully on board. How are we concerned? As you said, we do not assess only research. We also assess institutions and curricula. This means that we can ask the institutions whether they have an open access policy, whether they have an editorial policy, whether they have repositories and so forth. Also, as you said, we do not evaluate individuals and we do not evaluate research projects. Nevertheless, I think that we have to be coherent with the evolutions of the funding agencies and the institutions that hire and promote.

How do we work? We evaluate *ex-post*. That is the first thing. We evaluate every entity on a five-year basis, with the country divided into five geographical waves. We set up guidelines for each category of entity, namely the institutions, universities and national research bodies. There are guidelines for curricula and for research teams. On the basis of these guidelines, we ask questions about the open science strategy of the entity. Then the entities write a self-evaluation report. Then we set up a committee and the committee writes an independent report.

How do we comply with the open science movement? First, we hunt down impact factors in order to replace them with an assessment of the quality of journals and productions. This is not the most difficult part. Also, we tend to cover all the aspects of research activity. Of course, we do ask for research outputs, but all the kinds and categories of research outputs. We also ask for information regarding connection with society, outreach and so forth. We are also keen to take care of the diversity of disciplines. For each set of disciplines, we have a guide of products and activities of research outputs. These guides are elaborated by the communities, and they heavily depend on the discipline. Finally, we tend to move from quantitative data to qualitative analysis. Of course, we ask for quantitative data, on which we build the peer review. We recently started this for the current wave. We ask research teams for a portfolio of research outputs they want to set forward and the experts read them and assess them.

Let me insist, finally, on two things. We also have the mission of taking care, through a specific office, of the issue of science integrity. It is fair to say that France has been late on this issue and that we are trying to catch up. We host the French Office for Science Integrity[17] and it has a scientific council. They try to disseminate good practices and to animate the community of scientific integrity throughout the various

institutions. This is one thing. On the other hand, I wanted to emphasise the fact that we not forego quantitative analysis at the proper level and the proper level is the integrated level. In the High Council we have a Science and Technology Observatory[18] and they recently published a paper on the French scientific position[19]. At this level you can certainly count publications and study scientific profiles and so forth.

Things have to become collective in order to make the reform of the research assessment system happen. All French actors have been coordinated by the French Ministry, which has done a terrific job on this issue. We elaborated the Paris Call together. That is one thing. Second, at the European level there is a strong push by the Commission, and we discussed things with the people from the Commission. All this is happening at the same time. What I meant is that we have to be coherent. The High Council does not have the most difficult part. The most difficult part is when you hire and promote and there you should not take the easy solution of just counting and looking at easy metrics. However, of course when we do evaluate the ones who hire and promote we should be coherent with that. That is what I meant by the idea of moving all together, albeit maybe not at the same pace. I am fairly optimistic.

We are at the beginning of a landslide. I must say it is a matter of age also. I spent most of my career in another world when one used to count the h-index and the number of publications and so forth without asking questions, and I must say that a few years back I was still sceptical about some things. The model of diffusion of scientific knowledge would change, but one did not know when and how. Also, yes, the assessment system could change, and it did change. One can observe this at the French level and at the European level. It is now inevitable. It is being done.

Animator: Your job is to evaluate research infrastructures. They are key players in implementing open science concretely. These research infrastructures are key players. Could you say a few words about your ambition concerning the evaluation of research infrastructures?

Thierry Coulhon: Let me emphasise the fact that it is relatively new for us. We were not in charge of evaluating research infrastructures, and the recent law on research gives us this mission, so we are working on it. We already evaluated research infrastructures at the European level inside a consortium called ERIC[20]. I therefore will not be able to give many details since we are currently working on it. However, it is of course extremely important because research infrastructures collect a lot of data and the question of openness of data is crucial at this point. It is very much connected to what we are talking about today, but more is to be seen.

Animator: A question from Tunisia for Mr Paquet: 'We are from a data-engineering and semantics research unit at the University of Sfax in Tunisia. We have an idea of innovating research assessment through the use of open knowledge graphs. Can we contribute ideas to the coalition now'?

Jean-Éric Paquet: Tunisia is a research and innovation country and system which is very closely interacting with us. They are absolutely welcome, and any instrument is certainly worth looking into. Yes, please look up the call for expression of interest, which is on the website of the European Commission, and then connect with it to the effort.

Animator: People in the comments provide support to the Open Research Europe[21] initiative. Could you explain this initiative?

Jean-Éric Paquet: This is essentially a publishing platform which has been put in place by the European Commission to help researchers under Horizon 2020 and Horizon Europe comply with the obligation to make their publications immediately open access. We do not prescribe those researchers where they should publish - and some will still want to publish with legacy publishers, which have great journals but not open access yet. And so, these researchers could still publish there but they also need to make the article available in open access. So Open Research Europe, as an open access publishing platform, is a facilitation. Moreover, I think there is no doubt also that the ambition to use our publishing platform is for all its other aspects of open science. As we move forward, it might also become a useful place to help with changes in research assessment.

Animator: We have seen yesterday that publication bias, that is non-publication of negative results, is a longstanding issue in science. How could researcher assessment tackle it?

Bert Overlaet: One idea that we already apply in some of our universities is that we ask candidates for promotion or for hiring to say something about one of their failures, because maybe you tried something, and it failed. What did you learn from that and how does it affect your future project in science? How does it affect you as a scientist? This is the innovation that I mentioned earlier that is missing. We are all looking at the past and the outputs that have been produced in the past, and we can make that broader and anything you want, but we also have to look at what the potential of the person is for the future. That is what we base our decisions upon.

Maria Leptin: I think it is a wonderful initiative and all these kinds of different assessments are great, but negative results are not failures. They are work done with a clear outcome, and if it is important I think that can be rewarded. It should be published and there are repositories. Of course, it seldom goes into a high-visibility journal, but it should be put into the repositories and cited. That is perfectly clear.

Michael Murphy: In this regard there is a responsibility on university leaders to make sure that, within their institutions, there has been pre-registration of all studies and prior publication of the protocols. Ethics committees within universities too must follow up on all studies that have been examined for ethical compliance to ensure that publication has taken place. Publication of all results is an ethical requirement in the conduct of research.

Animator: Mr Schiltz, you have shared your interest in research on research. Is not now the time to set up an initiative on this topic? The Research on Research Institute[22] has done a great job assessing the impact of COVID-19 on open science.

Marc Schiltz: We are joining the Research on Research Institute, as have a number of other funders and members of Science Europe. For instance, the Swiss National Science Foundation[23] and the Austrian Science Fund[24] have already been members since phase one. There will be new members now. We at the Luxembourg National Research Fund[25] are part of it in phase two. Europe-wide, this is probably the major initiative to move forward because here again it is also about sharing our experiences and sharing data. Take again the narrative CV project, which funders have to some extent set up and tested independently from each other, but most of it is based on the narrative CV model that was issued by the Royal Society[26]. I think most of us have taken that up and then have tailored it to our own needs. However, now that we have experience with this model for one or two years, we should all sit together and discuss what lessons we take from that.

It is, however, more than that. The Research on Research Initiative is really also about conducting research, so having projects where we trial new methods for evaluation, but we do it in a scientific way so that we put this whole process and these methods on more of an evidence-based approach. It is interesting that we are scientists, but when it comes to our own peer review and assessment methods, we have not really based them on any scientific evidence. There is virtually no evidence that things such as journal impact factors really are valuable and correct assessment methods and yet we continue using them. It is more a religious belief in a sense, so we need to move away from that as well.

Animator: What exactly is a narrative CV? What do you expect from it?

Marc Schiltz: The narrative CV is where we do ask the researcher to describe much more broadly the contributions, not just to the scientific field, but also to the scientific community because that is something which is valuable, like mentoring people, like sharing data, participating in open science initiatives, reviewing, which are services to the scientific community. Then the third pillar I think is service to society. How do you engage with society? Of course, it is more important in some fields than in others. If you are in the field of medical research, you should engage with patients and patients' associations. If you are involved in more theoretical physics maybe that is less important, but still there are other aspects. It is not just engaging society. It is also communicating. It is public engagement, communicating about science, teaching the wider public. It is largely left open to the research institute to decide what to put into a narrative CV. To some extent we leave it to them. It is therefore not just a long list of publications. We have probably all had a 60-page CV with a long list of publications in front of us, which most likely no one reads.

Bert Overlaet: The advantage of this narrative is that it is open-ended. It is not predetermined. It does not tell you to do this or that. We started by asking people what the five most important publications are. That was 30 years ago. Now we ask people what their five most important achievements are. Achievements can be totally different things, and people can immediately focus on their strengths. It also means that it is not necessary to have 60 criteria and that the committee has to grade all of them for every candidate. However, the major advantage is that the candidate can propose himself or herself in the best possible way.

Marc Schiltz: COVID-19 again is an example. Our government at some point decided to set up a scientific advisory mechanism and, even beyond that, really a taskforce to provide them with modelisations and simulations. Some of the scientists spent lots of their time, and at some point they asked questions: 'I have now put aside my normal research, and what I am doing now will probably not end up in a high-level publication, so will it hurt me in my career?' These are the kind of questions which we no longer want to see. If you can contribute to solving such an important topic as the pandemic, as a scientist you should not have to ask yourself, 'Is it going to hurt my career because I have set aside my other research'?.

Michael Murphy: When you examine a CV or an application for a grant, you are looking for evidence of excellence. but you must also look for evidence of what a person is doing or what a group are doing to sustain excellence, and the evidence that they adduce to show sustainment of excellence.

Animator: One recommendation of the Initiative for Science in Europe[27] (ISE) is to engage researchers in all decisions regarding changes to research assessment. How can we do that? Does Europe want this as well? In the Paris Call they say at the end that all researcher organisations should be involved of course.

Maria Leptin: I fully subscribe to that. We have had our careers and it indeed does not matter where my next papers are published. It really does not matter for us, but it does matter for the young ones. We are sitting here pontificating. We have to engage. I will therefore encourage the taskforce at the ERC to talk to these communities. There is Eurodoc[28], there is ISE and there is the Young Academy of Europe[29]. All these groups should think for themselves and let us know. I mean they should obviously contribute on our webpage, but we will specifically listen to them.

Jean-Éric Paquet: They are part of the coalition now. The very construct of the coalition entirely covers associations of researchers. I mean without them this cannot happen properly. You need ownership and you need input. That is the way this is structured and therefore again, individual scientists and associations at national level and at discipline level should join up for the coalition.

Marc Schiltz: Yesterday we had a presentation by Cherifa Boukacem that I found very inspiring, about the study that she has conducted on early-career researchers. It is very clear that they have a feeling that they have to play the present game of journal impact factors and so forth, but they are profoundly opposed to it - or at least it - does not align with their own values. That makes me very optimistic in a sense because I think we can build, and we must build on them.

Michael Murphy: Just a thought reflecting on the conversation: it is all about the positive steps that we must take to achieve open science. One subject that we have not touched on is avoiding the creation of new barriers to open science. It is very important that national governments, regulatory agencies, and the Commission should "open science-proof" any new legislation or regulations. An example I am thinking of right now is the Digital Services Act[30]. The Act has the potential to create new barriers to what we are trying to achieve, and it is really important that the Act is "open science-proofed" in the remaining weeks in legislation development.

Bert Overlaet: If you are looking at the Paris Call in terms of assessment or researchers, it is important that we avoid mechanisms that lead to all kinds of box-ticking bureaucracy. One of the things that always strikes me is that if you look at the last 15 to 20 years we have made a lot of progress, and recently we have included general equality plans in the Horizon Europe application forms. These are

all steps forward. However, if you then finally get a financial audit on your project, and if you have invested in educating your young researchers it is rejected because it is not research. We have to make sure that the institutions get sufficient support in different forms for these efforts that they are making in experimenting with new ways to assess researchers. LERU wants to call upon the Commission to have a more active role as a sort of facilitator than was initially projected. If we want new tools to be developed, I think we need some European support in order to avoid them being given out again to commercial players. There is still a lot of work to do there, and we would ask for stronger support from the European Commission in that respect.

Jean-Éric Paquet: The Commission is indeed positioning itself now as the coalition is progressively emerging as a facilitator and that is the way we should position ourselves now. Obviously as the coalition comes together, as we draw out the coalition agreement and move to implementation there should be no doubt that we will move into executive mode as well. We will be available for that.

Animator: Mr Coulhon, France has published a decree about research integrity[31]. The High Council, over which you preside, hosts the French Office for Research Integrity too. Is this office also connected to open science?

Thierry Coulhon: As I said earlier, it is very helpful to have this French Office for Research Integrity inside the High Council because it does have influence on our guidelines. This institution could be and probably will be independent someday, but we host, develop and nurture it in the meantime. It influences us in a positive direction.

Animator: Mr Paquet, do you have the feeling that Europe is taking the lead at the moment on open science?

Jean-Éric Paquet: Yes, we are. I think we are leading on science generally and I think we are also leading on open science, starting with cOAlition S and now moving on research assessment, of course benefiting from global frameworks, which are a very strong foundation, but moving I think in very practical implementation. We are leading, and we will obviously only be able to lead if we really come together in this coalition, so, for the third time now, please join it. We all agree and now that we need to engage and commit time, resources, and attention. There is always a step between the two. You asked Thierry earlier about whether the landslide is happening. I think the landslide is indeed probably happening. We do not see it yet, but it is happening, and therefore the Commission will put very significant

resources in terms into supporting the building of the coalition as a facilitator and then supporting what we will construct together.

Animator: Are you all confident that the open science principles will be broadly put into reality?

Michael Murphy: Everybody in the system needs to have a good understanding of the purpose of Open Science, how it is going to happen, how they can contribute and how it is going to impact them. There is a lot of communication work to be done and a lot of leadership development and informing to be done. We all need to have a common sense of what a realistic timeframe is and commit to it.

Marc Schiltz: It is to some extent a culture change that we are implementing. Culture changes cannot be dictated. I am very optimistic, but culture changes take time. We must discuss and discuss and discuss again with all those involved. Culture changes are successful if there are leaders, but they must be co-created by these leaders and that is the way we should embark on this.

Animator: Co-created is what we are looking for, and we can see here on this panel and more broadly that stakeholders are sticking together, rising up and working together in order to propose a concrete implantation process. It is now happening, part of the fate of science is at stake here and I understand that failure may not be an option.

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The Software Pillar of Open Science

Building the Software Pillar of Open Science

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Thanks a lot for having me here today. It is a real pleasure to open this session about the relevance of software in open science. Let me start by providing a little bit of context. If we look around us, we see software everywhere. It powers our industry, fuels innovations and is essential to academic research. It is the fabric that binds our digital and professional lives together. It is thanks to software that we are able today participate in this conference despite the fact that we are in the middle of a pandemic. However, when we talk about software, sometimes we forget that it does not come out of the blue. It is not just a piece of data that comes out of an instrument. Software is written by human beings in the form of source code, which is a precious form of knowledge. It is actually a very unique form of knowledge, because it is built to be understood by humans and executed by machines. As Professor Abelson from MIT wrote in a beautiful book in 1985, 'Programmes must be written for people to read, and only incidentally for machines to execute[1]''.

What did he mean by saying this? Maybe it is easier to understand if we think of some particular examples of software source code. A piece of source code which is old is a fragment of the source code used on the lunar-landing module of the Apollo 11 mission that allowed us to put a man on the moon. Some of its text is very complicated to understand because it was assembly language of the kind used on the early machines of the 1960s. However, alongside the assembly code we find comments in human language that describe what the software is meant to be doing. This is a message from humans to humans. It is not just a message for a machine. More recently, if you look at programmes that are written with a higher level of programming language, like C, you can find beautiful pieces of software where the language has evolved over time. You have a name for the variable, a name for the function, but again you need comments to understand what is going on, although sometimes even with the comments it is not so easy.

Len Shustek, the founding chairman emeritus of the Computer History Museum, beautifully stated in his seminal 2006 paper on preserving software, 'The access to source code provides us with a view into the mind of the designer[2]'. This is very important to know because again it is human ingenuity that produces all this. It is not

just a tool. It is much more than that. The history of software is quite short, unlike many other disciplines. In the 1960s we had the chance to put a man on the moon, and this was done, by the way, thanks to a woman, Margaret Hamilton. She led the team of engineers who developed 60 000 lines of code used in the mission. Those 60 000 lines of code were enough to send a man to the moon and bring him back. Today, some 50 years later, a Linux kernel with over 20 million lines of code is one of the many components fount in the phones that we have in our pockets that allows us to send a smiley to a friend, or to send a message to somebody.

The reason why we had this lightning-fast growth is of course because software is changing the world we live in, but also because there is the open source software movement that started over 30 years ago. This led to an incredible collaborative effort by tens of millions of developers worldwide to work together and build the incredible software infrastructure we all use today. There is an old saying that we should build on the shoulders of giants, and we are doing so by reusing over and over again many components of previous work done by others in the very same spirit of open science, albeit this movement started much earlier than the term 'open science' was actually getting noticed.

I am particularly stressing this because sometimes you still find people who think that software is just a piece of data, a sequence of zeros and ones. It is not. It is much more. It is very special, very different. Software projects evolve over time. Some software projects may last for decades. The development history of how we changed it, who changed it, what, when and how is key to its understanding. The software we use today exhibits incredible complexity in different forms. It may be complex because it is a big piece of software with millions of lines of code. It can be complex because even a tiny programme may rely to perform its function on a broad spectrum of other subcomponents and subroutines, and each of these dependencies may be developed by a large number of other people. We should bear in mind that the software we use in research is just a thin layer on top of the general incredible set of software components developed by many developer communities around the world. To finish up on this point, again software is the fruit of human ingenuity. You cannot compare software source code to just a bunch of numbers that you got from one of your instruments. It comes from people working together! And even from the legal point of view, it falls under copyright law, unlike what happens with data.

Now that we have established the general picture, let's focus on the fact that software is fundamental in science too. People have started to notice how software is now essential in all disciplines. It is not just a matter of computer science: most of the research software we see is not written by computer scientists. It is written by

colleagues in many other disciplines. Today I think it is important to bring forward the message that when we are talking about open science, we really need to recognize that there are at least three essential pillars: of course open access to the articles published by our colleagues, and unfettered access to the data that is used in our experiments, but this would not be complete without a third essential pillar, which is the source code of the software which is used to manipulate, create and keep this data. It is the software pillar of open science.

Software in research is a multi-faceted object. It can be a tool used by somebody to create and analyse data. It can be the outcome of a research effort as proof of a result or because it embodies new algorithms or revolutionary data structures, or it can even be the object of research to see how software is built correctly. No matter which facet we look at, we need to have access to the *source code* of the software and so open source, which you could call something like open access to the source code, but it is much older than that, is really necessary. It is necessary to avoid reinventing the wheel and to accelerate scientific discovery, and for that we need to keep the history of all the source code built to enable reproducibility of research results, And this is essential to make it easier to accept the result of research because you can access the tools used to get these results.

If we look at the academic world, what kind of needs can we identify around software and source code? Depending on who you are – you may be a researcher, you may be a team leader or responsible for a laboratory, you might be running a big research organisation – you will need to have places where you archive and reference the software you are using in an article to make sure somebody else can find the same result you did. You want to get credit of course for what you did if somebody is using your software. You might want to reproduce a result from a colleague or build on top of it. These are all the kinds of things you need if you are a researcher. If you are head of a laboratory or of a team you usually need to produce a report, know what software is developed, maintain a webpage and track the software contributions. If you are a research organisation you need to know what software you are using, and what software you are contributing to, because it is important to have technology transfer in order to get an idea of what your impact on society is, because software built in research, as we will see later, is not just for research. Sometimes it has a direct impact on society. This is also needed to establish a funding strategy and to use for career evaluation.

In order to address all those needs there are many, many things that need to be done. I would like to start with what we could call the easy part. Of course, we need an archive, that is a place where you can actually store software and be sure that

you will be able to retrieve it later on. This is not what you can do by using the typical code-hosting platforms that everybody uses to develop software: projects stored there come and go, and even the platforms themselves come and go, they are not archives.

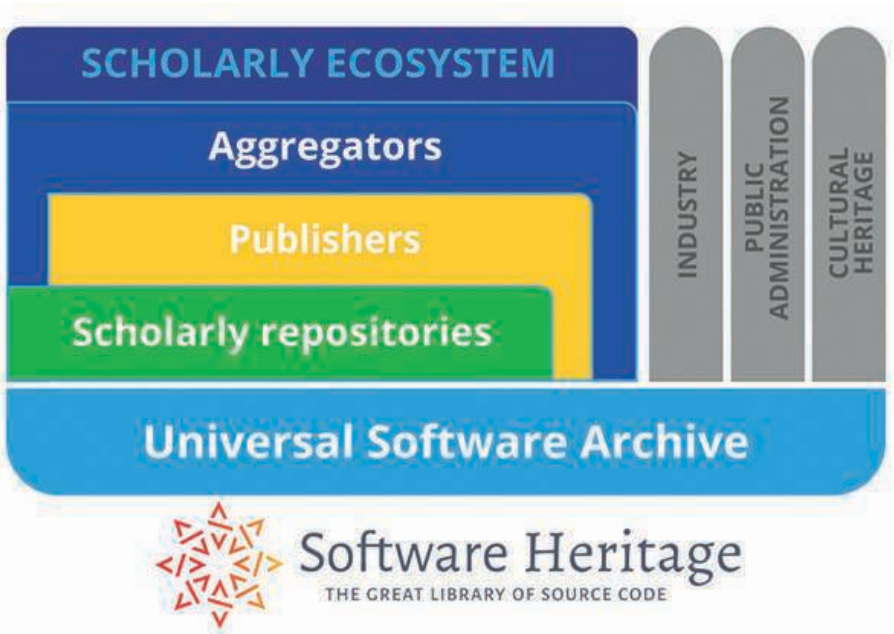
We need a way of referencing exactly, precisely the software artefact that we are interested in using to make sure that when we run it again, we can reproduce a result. Then we need to provide a proper description and proper metadata to make it easy to discover and reuse these artefacts. Finally, and this is touchier because it is connected to evaluation, we need to find the proper way to actually credit the contributions of those contributing to research software, which is not the same as just referencing a piece of software.

If we want to do this, a starting point is to have a look at what kind of infrastructures we need to support these kinds of cases in research software. Software is all over the place, so there are many ecosystems involved in software. There is a scholarly ecosystem, the one we are interested in today, and there are many others involving, for example, industry, public administration, cultural heritage and so forth. As analysed in a report published in 2020[3], after six months of work by a very broad European working group, you can identify scholarly repositories, like open access repositories, as well as publishers and aggregators that are all collecting and exchanging data. Their mission used to be focused on publications , and is now extending to data, but what about software? If you want to properly address software you need to base your work on a universal software archive that connects the scholarly ecosystem with all the other ecosystems and ensures that we get archival and reference, not just for the thin layer of source code that is developed in the research ecosystem, but for all the other components that are necessary to make it work.

The Software Heritage Initiative we launched some seven years ago comes into play here by archiving everything that is available around the world. It provides the common layer on top of which the scholarly ecosystem provides this added value that comes from curation, description, citation, credit and so forth. Here in France, we have been working for many years to implement this vision. There is a real workflow that can be used by researchers today in France to automatically archive their software and the software they need, not necessarily just theirs, into the Software Heritage archive[4]. They can also deposit proper metadata, which is curated, into the HAL national access portal[5]. This allows you to get a beautiful presentation of a software project with proper attribution, with reference to the institute that funded it, with a precise description of how to cite it and with a pointer that brings you to the universal archive, which is

Software Heritage, that provides you a full view of this software as another piece of research results and not just as a bunch of zeros and ones.

Fig. 15 : Research Software Infrastructures: Overall Architecture



Source: EOSC Executive Board Working Group (WG) Architecture Task Force (TF) SIRS, "Scholarly Infrastructures for Research Software", Website (Publications Office of the European Union, 7 December 2020), http://op.europa.eu/en/publication-detail/-/publication/145fd0f3-3907-11eb-b27b-01aa75ed71a1/language-en.

This example shows that these interconnections can be successfully established, and is also showing how to do it properly. If I may, I would like to make a call here to other people, other organisations, and other countries to join forces in the same kind of initiative. Let us try to avoid the major risks and major mistakes we have been taking and making in other areas, for example, falling into the trap of balkanisation. We should not build a multiplication of different and incompatible infrastructures and silos all over the place. Unfortunately, it is a big temptation for everybody to "just build his own archive", but then the result is that you will end up with duplicated objects in different archives with different identifiers and then you will need to spend a lot of money, time, and effort to try to build a federation after the fact instead of before the fact. We should avoid using closed or for-profit platforms that we cannot control, and we also should avoid using project money to fund operations, which are a completely different issue, in the research sector.

That was a look at things that can be done at the infrastructure level, but let me take a step back and focus now on the broader policy issues we also need to address. If we really want to have software playing its main role in open science, it is important to have policies for the dissemination and reuse of software developed for doing research. We really need to set the default to open source for research software. Open source creates value: look at the industry sector, where it is creating billions in value, and you will see that it is not incompatible with technology transfer. We just need to adapt our traditional way of doing technology transfer to open source.

We also need a framework for evaluation and recognition of researchers because unfortunately many countries still spend time developing beautiful high-quality software that is needed for research, yet it does not count in a research or engineer's career, and this needs to change. However, when we do this for evaluation, we need to avoid the mistakes that we have already made in the publication systems: in particular, we must avoid relying only on quantitative indicators, which are even more damaging in software than in other places. We also need to address the issue of the sustainability of open source on the technical, organisational, and financial levels.

There is, however, good news here because awareness is rising. In 2018, some 40 experts from all over the planet came to Paris to work on the Paris Call on Software Source Code as Heritage for Sustainable Development[6]. If you look at this Call, which was published on the UNESCO website back in 2019, one of the points it puts forward is the need to promote software development as a valuable research activity and recognise it in the careers of academics if they produce high-quality software. More recently, the report on Scholarly Infrastructures for Research Software from a working group created under impulsion of the European Commission called to make research software available as open source unless there are strong reasons not to do[7]. Moreover, in the recently published Open Science Recommendation from UNESCO[8] there is a call to use only non-profit, long-term infrastructure for open science and to operate on a community-based scale.

Implementation of these high-level recommendations has started already in France. If you look at the French 2nd National Plan for Open Science[9] there is now a chapter fully dedicated to software, which is on par with publication and data. Among the many recommendations is for creating a charter for research software policy at the national level and for recognising software development. This second point is already implemented, as you will see in the software awards just after this session, and there are many other significant provisions that I do not have time to delve into right now.

There would have been so many other things to say, but I needed to pick some that I think are very important. If you look at the road ahead, of course we need to spend more energy, money and time on building proper infrastructure for research software and recognising software as a key enabler of research, not just as a tool. This has many implications and I think Professor Lucke's talk will address some of these in the next presentation. Then of course we need to connect with the scholarly ecosystem, by linking software with publications and data. Here the role of the publishers is fundamental, but I would ask the publishers to take the time to consider that software is a noble research output, not just a piece of data, so you need to use specific infrastructures and identifiers.

Last but not least, at the institutional level we need representation and support, the same way this has been done for the other aspects of open science. We need an office in charge of the strategy around research software and open source, and not just in terms of technology transfer. We need to help our colleagues to do proper funding, governance and so forth. Finally, as for incentives and recognition in evaluation, valuing quality research software is possible, but again, beware of quantitative indicators. We do not want to have an s-index, as a software index, like the h-index in publication. There are other ways of doing this. For example, one is the software awards ceremony you will attend today. We really need to build the software pillar of open science together. The time has finally come. As always in academia, change takes time, but I firmly believe that together, if we work coherently together, we really can make it.

To go a step further

"The next step would be to see European or international collaboration in which academic institutions and research organisations would actually put together their effort and build on the common ground on archiving software, on referencing software, on providing proper metadata, on credit and citation, and on finding the right way to credit researchers for what they do in software development."

"The national awards given on the OSEC occasion represent the first time that at the highest institutional level we are putting in the limelight the people who have spent an incredible number of hours building the software that is essential for research today."

"Outside the fields of academia there are too many areas where software was seen as just a tool, and you do not have much respect for something that is just a tool. When you realise software is more than just a tool then you start noticing that you should

pay attention. We therefore now need that impulse. We have vice presidents for open science in universities, however, we do not have a vice president for open source in academia."

"There are many awards for free software in general, but this is the first time we are setting up an award for free software in research at the level of a ministry of research. The objective is to put the spotlight on the importance of software for research. It is a way of giving recognition to researchers who have done an incredible job over a very long time without proper recognition in academia. Software is very broad. It is used all over the place. Of course, we have prizes for software in other places, but we need them in academia because we need to build the software pillar of open science."

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The role of Infrastructure for Software in Open Science

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Let us first dive a bit deeper into the issues related to research software before we find out how a proper infrastructure might help us here. Software is a complex thing, and it can be different. It can be an artefact we create in our research, a tool we use in our research, or the subject of research itself.

The last perspective of those three is computer science, but let us have a closer look at the other two, which are relevant for others disciplines, too. Unfortunately, there is no common pattern that research software follows. Research software is as diverse as the disciplines are. Based on an overview of software used for research[1] as analysed by the French Ministry of Research, there are only a few, rather generic tools broadly used (dominated by proprietary office software) and then a broad spectrum of other different software. Some are rather tools, meaning software that is used for research as it is. For others, researchers are also involved in the production of that software as a part of their research process. Both have their own challenges for sustainable maintenance of that software.

These challenges keep us from being effective at the moment. Long-term availability of research software is crucial for the reproducibility of research results, a key factor for quality assurance in research. However, many studies have revealed that reproducibility is often hindered by missing availability of the used software.

The results of a study carried out by Daniel Nüst and others in 2018 in the field of geosciences[2] showed that even if data is available, there is little or no reproducibility of the overall results. Throughout the pipeline of research from input data, pre-processing and analysis of that data, over code to the computational environment and the final results, there is a leakage with the code or, latest, with its execution. Christian Collberg and his colleagues had already identified reasons for this leakage in 2014 for the field of computer systems[3]. More or less the same picture exists today. If available at all, and this is still the main problem – software is not available, neither in an archive nor by email – the code of that software simply fails in terms of being built to an executable program or this programme is not executable anymore on a new platform.

Therefore, a finding could be that more emphasis should be put on the quality of developing, publishing and maintaining that software. The methodological basis of software engineering could help here. Software engineering is not the same as mere coding. It is more like a structured design process, and it could help to overcome such reproducibility issues. Software engineering is a professional activity requiring significant effort, training, and skills. It is not enough to just write 100 000 lines of code to deserve recognition, but it is the usability of that software by others that makes this a result to be recognised.

One could argue that we do not have such problems if we use existing tools; not to develop our own software, but to use existing ones and just rely on that basis. For instance, the presentation that I gave on this topic at the conference was designed with MS Office 2013 and I rely on that, aware that this might result in conflicts with other tools. Many developments of virtual reality applications in my group are developed in Unity, version 2019 at the moment, and they will hardly run with any other tool. Another example: one of the very top-ranked tools in the French Ministry's list of tools referred to earlier is MS Excel, again another proprietary tool that might prevent us from sharing our research. Unluckily, many groups, associations, work packages or task forces in open science still use proprietary tools instead of open tools, because it is simply so easy. We need to put much more effort into highly functional, comfortable and interoperable open source tools and then the situation might change.

You might say store it as comma-separated values and, yes, indeed, that helps, but it is not enough. Depending on the version of whatever software you are using to process your data, to visualise your data, things may change. For instance, depending on the number of bits used to store the data in your computer, decimal positions might be cut off or rounded up or down using different algorithms. That's why data is always closely tied to the very special version of that software you used to generate it, to process it, to visualise it. There is no way to completely separate data from software.

To make things even worse, there is not a single software or tool that we use for a certain research project. We are using more likely a complex IT environment as a matter of course. Most of the components are hidden beneath the surface. There are, for instance, operating systems. I assume you know if you are working on Windows, Linux or Mac, but do you know which drivers, libraries and codecs you have installed? Do you know which execution environment your software is using? Typically not, and to be honest I do not want to know that. Should this not be hidden? However, if you would really draw an image of all the software components

you are using in your research environment, it may look like a wobbly tower of bricks. And I bet that somewhere there is this one tiny little component on which everything else is built – and that makes everything crash if it fails.

Do you remember in 2014 the bug in that openSSL encryption, that we all use for communication on the Internet, that caused a security breach called 'Heartbleed[4]' and our local data was put at risk? Do you remember in 2016, there was a bug in the fMRI software that was broadly used to analyse neuroimaging[5]? There was no security reason, but brain areas were declared as active, but in fact they were not. This is a research issue. Do you remember in 2021 the bug in log4j[6], just a few weeks ago? You could say writing a logbook, is that critical? Yes, it is if that piece of software opens a backdoor to let others enter our computers. Such issues are typical for software that is not well maintained, and this puts our research at risk.

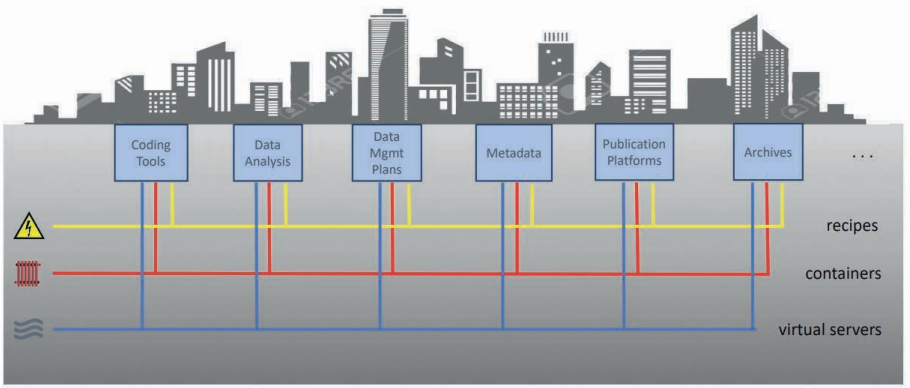
That, however, is enough of the bad news. Let us come to the good news. First, there is a technical approach common in data centres to help tackle such problems. Software, along with the data processed by it, along with the whole computing environment around the software, can be packed into containers, technically boxes. Those containers can be easily moved to other systems, can be easily updated if new versions of any components are released and can be easily recovered after a crash. That is huge progress. You might be reminded of those Jupyter Notebooks[7]. You just put together the data, the code and the documentation and press 'execute', and this is possible because of the standardised infrastructure below that software that enables you to easily run and share your research results, including your software.

Using such a container helps not only to maintain but also to publish and reuse the software. Publication comes along with curation, assuring a certain level of quality and, moreover, running software in such a sandbox prevents your system from being damaged.

At the moment, within the German National Research Data Infrastructure my colleague Michael Goedicke and I are preparing such a solution for computer science in Germany[8]. You might compare this approach with the infrastructure we use for electricity, water, the Internet and so on. There is an invisible network of pipelines, cables and switches beneath the surface of our streets, and we just use the outlets in our walls. Plug the device in and everything works, as long as we have the right power adapter in place when we are at a conference oversees. We do not see all the pipelines, cables, and switches. We do not see the many people taking care of it. We just pay our monthly fee and go ahead. This situation can be compared to the IT infrastructure used for research software. Having powerful servers with virtualisation

technology in place and having this container technology in place, your software works. If there is an additional layer to handle your recipes – yes, this is like cooking – you can easily set up different combinations and configurations of software in those containers[9]. This can be used for all the tools we already have in our research portfolio and for all the research software that we will continue to develop.

Fig. 16: Digital Research Infrastructure



Source: Lucke, "The role of Infrastructure for Software in Open Science". Media used during the presentation (available on the conference's website).

This sounds difficult, does it not? Do not try to copy this at home. Let the data centre do their jobs. They are professionals for that infrastructure. We are professionals in research. We only have to know how to do our research, not how to maintain such a containerised infrastructure. However, yes, we should finally know how to use such an infrastructure, how to put our software and data in that box and deploy it, or how to maybe adapt what somebody else deployed and use it for our own research. This means additional education and training will be necessary for researchers to achieve these digital skills.

Again, there is good news. There are successful examples, like a series of hackathons carried out by a colleague of mine[10]. Peer Trilcke is one of the leading researchers in digital humanities. He makes use of software to answer questions from philologies through mainly quantitative research. That is why he is also teaching his students how to do that, how to install a computing environment, how to design an algorithm and how to answer their research questions with that. He does it in a very practical way, using textual data, like Drama Corpora, or visual data, like urban graffiti, or audio data from Spotify – cultural data in a broader sense. He creates a kind of data culture from this, and students love that and learn a lot.

Since students are able to learn how to work this way, whatever their research field is, researchers should be able to learn that too. We are currently preparing a systematic evaluation of the competencies that the students gained over the past three years from these hackathons. At the moment, there is such an introductory course established across different fields of study in that discipline, and a broader one is in preparation. I hope it will be available online free for other fields, too, maybe in forms of micro-credentials to easily invoke it. That way future researchers can be trained in using such kind of infrastructure for their later work.

If you were the good fairy and you asked me what I wished for, I would mention the following three things:

- First, recognise the production of research software as a result of research. This affects the time that we need for preparing high-quality code on a project, which requires both funding and certain skills.
- Second, recognise the availability of research software as a valuable outcome. We have to extend our assessment beyond publication count and metrics towards open data and software and we have to consider these, for instance, in our appointment procedures when we select new professors.
- Third, recognise the quality of research software as an important issue. This means that we have to evolve practices for coding towards professional software engineering and to establish effective IT infrastructures and support structures for research software.

This is all about software as a key enabler of research and I think there is no way around it. However, as I told you, software does massively benefit from a proper infrastructure. Is the fairy still in the room? Maybe three more wishes.

- Number four: increase the maturity and integration of current infrastructures and tools. For this we have to identify and to further promote the promising approaches that already exist.
- Number five: adapt the funding instruments to digital infrastructure so we have to add development and maintenance costs to the funding where currently human costs are predominant.
- Finally, number six: establish an international collaboration in infrastructure for research software.

Let us bring together all the relevant stakeholders to support their work. This would bring research significantly forward. And some final good news: we do not have to start from scratch. As we have heard before, there are so many initiatives on the

international level, the European level and the national level involving many smart and dedicated people with many great ideas. Let us please therefore just come together and cooperate, as we are doing here today.

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Open Science, Publications and Code

Melissa Harrison
EMBL-EBI

I am a publisher and have been a publisher for most of my career, including working at eLife. I now work at EMBL-EBI managing an open access repository. We have over 7.5 million full-text articles and preprints, the COVID-19 preprint subset and some others. The perspectives I have gained from those two different roles are interesting. From the perspective of an open access publisher, one of the problems that we encountered at eLife when trying to encourage responsible behaviours such as the use of software and its citing, is that when you are trying to do all these things, you are asking your authors to do yet another thing. There was the response from authors: 'How do I cite code'? Quite often we found that one of the issues is that when we were trying to dig out what the code is that people were talking about, they would just give us the citation to an original research article publication instead, and that is not really the point. We need to get access to and promote the actual source code underneath and it is not just about research publications. Software does not fit the usual citation styles and publishers do not know how to tag them or how to deal with them. It is a problem that I have been looking at.

Also, as mentioned, software is not static, so it is not like a research publication where you get your DOI, you publish it and then it is done. It is also not the same as data. These are all problematic issues for us as publishers trying to deal with citing code. One solution that has been very popular within the publishing community is the link between GitHub and Zenodo. Authors of code can quite easily archive their code on to Zenodo and they get a DOI. DOI is very publisher-centric and they understand what this is. We have been using DOIs via Crossref for journal articles for a long, long time and it is easy thing for publishers to recognise, and the code is archived somewhere, so it feels like a winner to everyone in that situation. Then Zenodo can also link back to the GitHub site, so if there are changes people can see what is there.

Using some work from a data scientist at Europe PMC, we mined 7 000 random XML documents we had, and we found 300 000 citations. Of that large number there were 10 citations to Zenodo that we found, using a Zenodo DOI. As Roberto was talking about earlier, having a dedicated archive for software, Zenodo is not that. Of those 10 citations, three were datasets, one was a journal article, and the rest were software.

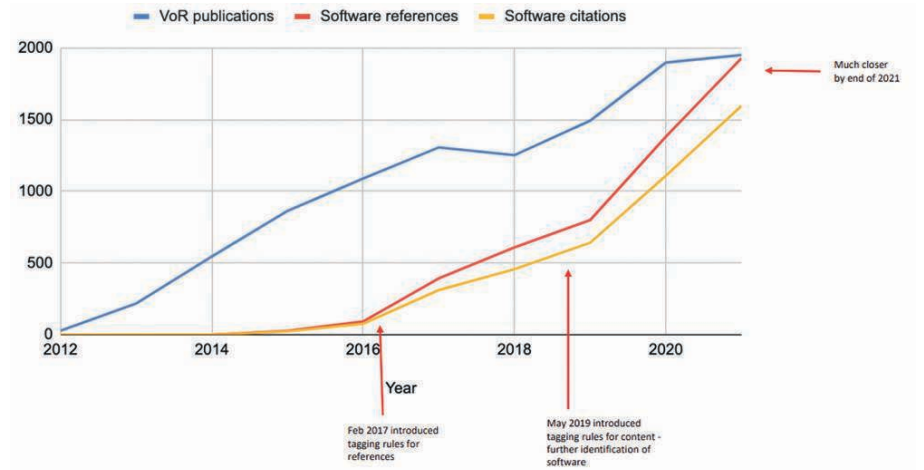
However, looking at what the publishers called that content when they tagged the citations within their XML format, there was only one that was identified as software and the others were all a mishmash of different things, which is problematic if we are looking for proper credit, attribution and reuse of software.

One of the issues that I have often thought about is that “Zenodo” does not equal “code”, so it is not possible for publishers to say, ‘Okay, fine, there is a Zenodo DOI there, tag it as code’, because it is not that simple. Zenodo holds lots of different things.

Publishers are very familiar with Crossref. It is a publisher organisation. They have DOIs and they craft and use the tools there to validate reference, check them and pull in extra metadata if it is missing, or use it to add DOIs to their publications if authors have not provided them. DataCite is the DOI provider for Zenodo and a lot of publishers are not using the tools of DataCite to crosscheck their references, so if there are Zenodo-based DOIs they are quite often not getting the extra validation steps that would allow the publisher to add in the fact that it is code, data or something else.

Another solution, other than the Zenodo solution, is the Software Heritage solution, as you have heard Roberto talk about. This was the way that eLife went. There was a strong feeling within the team that DOIs were publisher constructs, and they were not necessarily the way forward to reference and archive all the different varieties of software. Software Heritage is archiving all this content from a vast number of different sources. Software Heritage links to specific parts of the code and it is reingesting, creating updates, and it indexes more sources. The other thing key thing for eLife was that we did not have to ask the authors to do the work to create the Zenodo link and archive their code themselves. We could do it for them, and that was a key thing for us because, as you know, my first point was, ‘Oh, yet another thing they are asking me to do’. We felt that we did not want to insist that they did the extra work. We were doing it for them.

Fig. 17: Software citations in eLife overtime



Source: Melissa Harrison, «Open Science, Publications and Code». Media used during the presentation (available on the conference's website).

In terms of the eLife experience, I am really proud of how many changes we made. Regarding the VoR (version of record) publications that we published over time, eLife is a modest-sized journal compared to all of the content now that I now deal with at Europe PMC, but by the end of 2021 the number of software citations matched the number of VoR publications. That is not to say that every article we published had a software citation – some might have had two or three and some might have had none – but it is a far cry from where we were at the beginning, so this is really great to see. However, this takes time and effort and eLife, because of our mission-driven status, had the resources and time to look into this. We introduced quality control, instructions, and documentation. There was training for our staff and vendors. We introduced automated checks. We wrote a lot of code to make sure all of these things were being discovered, from finding a GitHub link within an article and identifying that, asking the author for the reference to also validating and checking all software references as well. The editorial team, as well as the production team, were putting a lot of effort in at the beginning as well, which was great.

Just going back out to the wider concept again, using the skills at Europe PMC and the archive that we have there, using that same 7 000 XML documents, the random documents we found at the beginning, 15 of them had a software publication type, and these only came from eLife and PeerJ, representing a tiny fraction of the citations we are finding. Having found that, my colleague then just looked at eLife and PeerJ

publications, and we found 6 205 software references that were identified. Out of the top sources identified, 46% were not available and then it was GitHub and then a variation below that. There was then a long, long tail of unique sources.

One of the things I am very involved with as a publisher is JATS for Reuse[1], which I still chair. Most publishers that are creating full-text context use XML to produce that and JATS, the Journal Article Tagging Suite, is a standard that most people use. Because it is a standard for so many publishers there is a lot of variety, and it has to be effectively loose so that anyone can use it, so JATS4R is a group that has been developed for reuse. The original group that developed this was comprised of open access publishers, thinking about the interoperability and the mining of all this information from that content.

A Software Citation Working Group worked from 2017 to 2020, and we published our recommendation in November 2021[2]. This recommendation is still relatively new, but I remember that when we first set up the working group, a lot of publishers were saying they did not know how to cite software, that there was not a code or term for them to use. eLife was using one, because we invented it and we just went with it, but we realised that that was a blocker for a lot of publishers. One of the key things about the recommendation therefore is giving the publishers the ability to recognise a reference as software and indicate that in the XML so that that is then clear to anyone who is reusing that or who needs to mine for software references.

The other thing about this recommendation was that it had to be as minimal as possible, because the more complexity you add to these things the harder it is for people to take them on. eLife put a lot of effort into very full-structured references, but it is hard. The next thing is that we wanted a pub-id. That is a well-known ID and an identifier for something that is properly archived. GitHub unfortunately does not fit into that remit, but Zenodo and Software Heritage do. In that subset of articles that we looked at from eLife and PeerJ we found that 202 had a pub-id and they were all to DOIs. Failing at that, the next best thing is to find an external link. We all know that external links are not great. It is much better to have a system identifier within the reference, but failing that, an external link works, and so we found in our subset 2 524 external links. However, the sad thing is that 3 834 had no pub-id or external link, which makes them so much harder for people to find, to reuse and just to investigate on the references.

This leads to my conclusion that there is a long road ahead of us and we recognise that, but a lot of progress has been made. Software citation is gaining traction. The fact that it is one of the pillars here as we speak today shows how important it is and

how important people think it should be. Within the publishing world, the fact that I had such a large group within the JATS4R working group who were interested in creating this recommendation and driving it forward was notable. One of the issues I see for people is which path to take. For instance, at eLife we took the Software Heritage route. There is also Zenodo. I am sure there will be more coming up and different ways of dealing with things, and that does cause problems in itself sometimes. You have to reach that tipping point where people all go down one way, but at the moment we are not quite sure yet.

There are many contributors to all of this. It is not just publishers, it is not just authors, it is not just the researchers. There are so many moving parts here, and a big issue is educating people, from publishers to researchers, and everybody needs the education. We also found that when we were talking to our vendors, we had to explain the production and editorial issues, and the feedback loops are extensive, as well as updating on tooling. So, from a publisher perspective, using DataCite and automating checks between, would help with this cause a lot.

To go a step further

"The hardest thing to overcome to improve software citation probably was the authors' resistance, when trying to explain to them how important it is to get to the source code and cite that rather than a paper associated with it."

"Software is very different to data, there are different infrastructures involved and it is a different environment, but I definitely would say that I did learn a lot from the implementation of data citations and applying them to software, even though it is a different type of content."

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Policies to support Open Source and Open science

Sayeed Choudhury
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Software is a pillar of open science. The universities produce basically three of these pillars: articles, data and software. Those are connected and in many ways those three pillars of open science and the connections between them relate to what Roberto described as the scholarly ecosystem. In large part, those are the projects that universities do through their research. They are typically funded through grants and other kinds of external funding, and are very much the things that happen within the walls of the university. At some point, if you wish to move the impact of research and education outside the walls of the university then you have to translate them. It is useful to publish papers and to search data. It is also extremely useful to share the software.

Over the last two years we have all been experiencing COVID-19 and there has been a lot of discussion about how open science led to the vaccines that have made it possible for us to deal with it. I would submit that the most important piece of that was actually not the sharing of articles or even the data being shared, but rather the software, the code that people were using to analyse the data associated with the vaccines that we eventually developed.

The open source programmes office, or OSPO, is a university organisation that can support this translation function. It is the unit that we have created within Johns Hopkins[1] to help our researchers translate their research and their education activities outside the walls of the university. One of the ways that we have advanced the work of the OSPO is what you heard from my previous panellists, this statement or affirmation that software is a primary research object. If you ask people within a university, either researchers or administrators or even students, 'Do you care about open source software'? you will get different responses, but if you ask them if they care about research, every one of them will say, 'Yes, of course I do'. Therefore, being able to make this argument that open source software supports research, is a tool, but is also a research object as we have heard, has been incredibly important in terms of advancing the work of this OSPO within Johns Hopkins University.

We have also made the case, as you heard earlier today, that software is a better way to understand what data are being produced rather than the articles that cite those data. The citation or the connection between an article and a dataset is one way, is often a direct mechanical kind of link, but the connection between data and software is much richer. If you look at the software, you can actually understand a great deal more about what data are being used and how those data are being analysed. I will talk about a specific example that describes this.

We created at Johns Hopkins this open source programmes office, or OSPO, and this is something that is used in the private sector by companies, technology companies, but also companies like American Airlines and Walmart, which are not technology companies, to manage their open source software. While there are some common elements between the OSPO in a private sector company and in a university, the OSPO at the university is also doing unique things that are important in the context of research and education and translation. We are helping with a lot of the best practices that you heard in earlier talks, which have to do with things like how to engineer your software, what licences to choose, what risks you may be introducing with those choices and how you will in fact work with publishers and even directly with society at large. The OSPO is therefore building on what has happened in the private sector, but it is expanding and extending this in the context of the university.

I am also pleased to note that while Johns Hopkins created the first OSPO in a university in the United States, there are now at least three others at the University of California, Santa Cruz, at the Rochester Institute of Technology and at the University of Vermont. It is my understanding that there will be additional universities creating these OSPOs, so we can see ourselves coming together as a network of these organisations.

Johns Hopkins is involved in a project called the Observational Health Data Sciences and Informatics, or OHDSI project[2]. Paul Nagy is a researcher in our School of Medicine who is involved in this project. He approached me after hearing about our OSPO saying that they needed help. What he explained was that when it comes to health or medical data it is very difficult to share outside of your research team. You typically have to create a very complex legal agreement. It has to be approved by every party that signs that agreement, and this can be a time-consuming process. What the OHDSI group did instead was create open source software and share that software with each other, and by sharing the software they actually learned more about what types of data each of them were using and what types of analysis they were using on those data. This goes back to the earlier point I made where software

has that richer connection with data, and that is something we have heard from previous panellists as well.

Ultimately what happened is OHDSI then ended up with a great deal of open source software and they were not managing them very well, so they came to the OSPO and asked for help, and through the OSPO we provided the kind of engineering support, management support and infrastructure support that are necessary to organise the software. I agree completely that researchers should learn about the infrastructure. They should learn about the issues. Education is very important. However, I do not believe researchers should support the infrastructure or sustain it. We heard earlier from Roberto that grants should not be used for operational expenses. I could not agree more. The OSPO is therefore the unit that helps with the education, helps with raising awareness, but that ultimately supports a team like OHDSI. What I heard clearly from our researchers was that 'I do not want to be an expert in open source software, I just want to learn about it and then I want the experts to take over the maintenance and support'. In some sense therefore the OSPO is a centre of excellence, a centre of knowledge or a centre of information.

In the education realm, in this past semester of fall 2021, we conducted a course at Johns Hopkins called the Semesters of Code. This was taught by Stephen Walli, a Microsoft executive with over 40 years of experience with software engineering. He mentioned to me that while graduates from universities like Johns Hopkins have very good skills, companies have discovered that it takes anywhere from three to six months to retrain them to understand how to work in an open source project, how to work as part of a team. The idea therefore is that if we can start the educational process earlier in their undergraduate career then they will be better prepared to work at places like Microsoft. However, we also recognise the tremendous impact and value to them learning these skills regardless of whether they work for a company, become a researcher or work in a non-profit.

The open source software was the framework through which we talked about software engineering practices. In addition to the lectures, where Stephen covered topics that were not necessarily related to engineering, like the legal issues, the economic issues, the history of open source, each student was assigned to a project, a real world open source project, where individual contributors and developers from those projects were mentors. The students worked on the projects, and they were given direct access to a mentor who guided them through the project, who helped them learn about the project and who then helped them work their way through their particular assignments. We received the evaluation and feedback a few weeks ago and I am pleased to note that the students very much enjoyed this. We actually had

one student who had to drop the course because he is graduating, and he could not fit the course into his work, but he continued to work on the project. We had another student who did not finish the work he had decided to do, but then he said, 'Can I do this independently'? and continued working with the mentor. The students therefore really enjoyed this opportunity to focus on real world projects.

One of those real world projects is called Lutece[3], an open source digital services platform in the city of Paris. It has been used for many years to provide services to the citizens of Paris, and students at Johns Hopkins have worked on the code with Lutece, made contributions to that. Our OSPO took those contributions, engineered them and updated them, and contributed back to Lutece. We are using this at a community centre in West Baltimore called the St Francis Neighbourhood Center. You therefore have a software platform developed in Paris, worked on by students and software engineers at Johns Hopkins and being used in a community centre in West Baltimore. I mention this to highlight that if we had to sign a legal agreement to have Paris, Johns Hopkins and this community centre work together it would have taken a very long time. Instead, the open source licence of Lutece is the legal agreement under which we did our work.

One other point I therefore wish to make about open source, particularly as it relates to impact outside of universities, is it is a much easier way to partner. You do not have to have a grant. You do not have to have a legal agreement. You have the open source licence itself, which is the way in which you can conduct work with other partners.

I had mentioned that there are multiple universities within the United States now that are forming these kinds of OSPOs. There is a network called OSPO++ that has been created as a community and as a network of these OSPOs[4]. It is not only within the United States. We have participants from Europe and other parts of the world who are coming together to talk about how OSPOs can continue to support the kinds of activities within universities and to increase the amount of impact beyond the university itself.

Recently, OSPO++ has worked on a best practices guide through the United States National Academies of Science. The NAS, as it is called, recently had a committee look at open science and as part of its final report produced a primer on open source software. The OSPO++ brought together representatives from universities, companies and governmental and nongovernmental organisations, including the Open Forum Europe, which is a think tank that has worked closely with the European Commission, to update and create this primer on open source software[5]. An important policy recommendation that has been made by this NAS report matches a recommendation

made within the European Union to create 20 of these so-called OSPOs, both within universities and government, and have those OSPOs work together in a coordinated way. The hope is that the United States will create a network of OSPOs, Europe and other parts of the world will create OSPOs, and we can start to coordinate that activity, start to work towards more common policies, best practices and help our researchers manage their open source software.

To go a step further

"There is a very important growing movement around ethics in data. The same is true of software. We sometimes talk about biases that are embedded within data, within the tools or algorithms used to process those data through software. There is absolutely an ethical component to working on software, even if it is open source, but one of the good things about open source software is it is transparent, so we have a better chance of seeing what is actually being done in terms of analysing the data."

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Open Science Awards Ceremony and Conclusions

Claire Giry
Director General for Research and Innovation, French Ministry of Higher Education, Research and Innovation

Daniel Le Berre
Université d'Artois

Claire Giry: Our ambition for open science is to really open up the entire research process: publications, which has been done for a little longer than the rest, data, and source codes. In this way, we want to contribute to a more cumulative, more robust and more reproducible science. Every year, we measure the results of this openness, using an Open Science Barometer to gauge how far we have come since 4 July 2018, when we launched our National Open Science Plan. We have just presented the results of this 2021 barometer, and we now estimate that 62% of the 166,000 French scholarly publications published in 2020 were open access in December 2021. That is an increase of 10 points in one year: we are very satisfied to see that the scholarly community is following the trend and that things are moving forward. Our ambition is to eventually reach 100% of publications in open access. We are gradually approaching this, but data sharing remains a challenge to ensure reproducibility of research results, reduce the effort needed to reproduce data and foster new innovations. The aim of open science is to make all results, methods, source codes and software easily accessible. This is why we will later enrich our Open Science Barometer with indicators on the openness of data and software codes.

The Paris Call, which brings us together during this two-day European conference, aims to recognise all forms of research production in order to engage research teams in active sharing, openness and collaboration practices in a sustainable way. With the second National Plan for Open Science announced in July 2021, we wanted to recognise the diversity of contributions to open science and the diversity of its forms. In this second Plan, our ministry has committed to creating and awarding three open science awards each year to reward teams, professors, researchers, but also all contributors involved in research or who support research, and who carry out exemplary work in open science. The three families of awards that we will be giving are the Open Science Award for Open Source Software, the Open Science Award for

Research Data and the Open Science Award for Thesis. The call for entries for the Open Science Research Data Award is underway, and we will grant this award by summer 2022. The first edition of the Open Science Award for Thesis will take place in 2023. We can use this conference days to honour the winners of this first edition of the Open Science Research Awards.

Free software is a pillar of open science. It dates back to the early 1980s, long before we started talking about open science, so it has a very pioneering side. Research software is a tool that participates in the research process, in the processing of data and in the creation of knowledge, but it is also in itself an object of study and a research result, so it is very complex. Through this award, we wish to distinguish open source research software that is useful to large communities, to reward teams that for years have designed this software by making it accessible to all, by documenting it so that it can be reused, by creating and animating communities of contributors to encourage more collaborative and innovative developments, and to go ever further. We are very pleased with the success of this first edition, with 129 software candidates from all fields of research. The jury underlined the very high quality of the free software candidates for this award. This is a first panorama that really shows the commitment of French research in the production of free software, the richness of this production in different fields of application, and this for about fifteen years already. The format of today's ceremony does not allow us to present the winners with their Open Science trophy, but we will do so when the context is more favourable.

Daniel Le Berre: 129 candidates, 4 awards at the end, how to do? It was very difficult for the jury. We have 3 award categories, which can be seen as 3 dimensions, plus the jury award. We were a bit frustrated, because ideally, we would have liked to award 129, but that was not possible, so we had to find criteria. The first of these criteria is the scientific recognition, the recognition of the peers towards the scientific and technical part, because this is what is important in science. It can be measured by the citation, as it has been said throughout this day, or by the fact that these softwares are used in society. In some fields of science, sometimes only the specialists, the people who created the software, can modify it, but then many people can use it. Moreover, in some communities, there may be many more contributors than in others, which must be taken into account if we want to make comparisons. Finally, the weak point of free software is generally the documentation. This is especially true for free research software, which is a proof of concept that is made available. When it finally starts to be used, if you haven't done things right from the start, you have problems afterwards... So we had to take this aspect into consideration as well, so we created a category "Documentation associated with software". If some software

is going to be used for decades, then the documentation really has to be important, both for the users and for the developers and future developers.

It was difficult to find winners. We had such a diversity of profiles that we have winners who are the best on the dimension we were trying to study, but also remarkable software. The accessits are not given to the runners-up, but to all the remarkable software that the jury wanted to highlight.

Open Science Awards for Open Source Research Software

Scientific and technical category

Winner: The Coq proof assistant (https://coq.inria.fr/)

Accessit: Coriolis VLSI CAD Tools (http://coriolis.lip6.fr/)

Community category

Winner: Scikit-learn (https://scikit-learn.org/)

Accessits: Vidjil (https://www.vidjil.org/) and WebObs (https://ipgp.github.io/webobs/)

Category Documentation

Winner: Faust (https://faust.grame.fr/)

Accessit: OpenViBE (http://openvibe.inria.fr/)

Jury Prize

Winner: Gammapy (https://gammapy.org/)

Accessits: GAMA (https://gama-platform.org/) and SPPAS (http://www.sppas.org/)

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