Paving the way for Science 2.0: top-down and bottom-up approaches

Michela Vignoli

AIT Austrian Institute of Technology, Michela.Vignoli@ait.ac.at

Peter Kraker

Know-Center, pkraker@know-center.at

Alexis Sevault

SINTEF Energy Research, Alexis.Sevault@sintef.no

Abstract: *Science 2.0 is the current trend towards using Web 2.0 tools in research and practising a more open science. We are currently at the beginning of a transition phase in which traditional structures, processes, value systems, and means of science communication are being put to the proof. New strategies and models under the label of "open" are being explored and partly implemented. This situation implies a number of insecurities for scientists as well as for policy makers and demands a rethinking and overcoming of some habits and conventions persisting since an era before the internet. This paper lists current barriers to practising Open Science from the point of view of researchers and reflects which measures could help overcoming them. The central question is which initiatives should be taken on institutional or political level and which ones on level of the community or the individual scientist to support the transition to Science 2.0.*

Keywords: *Science 2.0, Open Science, Open Access, Open Research Data, science system, transition, transformation, research culture*

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1. Introduction: on the way to Science 2.0

As Helga Novotny, former President of the ERC and current Chair of the ERA Council Forum Austria pointed out in the Open Science Panel at this year's *Forum Alpbach Technologiegespräche*[1], science is currently undergoing a transformation, which implies the rethinking of its boundaries and of how it is organised. The European Commission (2014 a) speaks of a potential *"paradigm shift in the modus operandi of research and science impacting the entire scientific process"* (p. 2). On the one hand, the internet, a powerful tool for communicating and sharing information and knowledge, is being more and more used and accepted by scientists as a means for accessing and disseminating research results, as well as for collaborating with the community. We are currently at the beginning of a transition phase in which traditional structures, processes, value systems, and means of communicating science are being put to the proof and new strategies and models under the label of "open" are being explored and partly implemented. This situation implies a number of insecurities for scientists as well as for policy makers and demands a rethinking and overcoming of practices and conventions formed long before the digital revolution.

The transition from the traditional science system to a more open science is still in the early stages, and in most cases it is not very clear which approaches will prove to be successful. The stakeholders (mainly scientists, science institutions, research funders, science publishers, and policy makers) are divided into enthusiastic adopters, attentive observers and those who actively reject the notion of Science 2.0.

In the current situation, we are faced with the discrepancy between a growing necessity and interest in more open, web-based science practices and a lack of reward or approval of Open Science efforts in the system currently in place. Next to that, in spite of the growing acceptance that the internet and Web 2.0 tools should be integrated more in research, a number of related insecurities remain and need to be addressed.

One aim of this paper is to list current barriers to practising Open Science from the point of view of researchers (e.g. publishing Open Access, Open Research Data, disseminating research results via the internet) and to reflect which measures could help overcoming them. Another aim is the attempt to identify sensible approaches to support the transition to Science 2.0, which should be taken on an institutional or political level as well as on the level of the community or the individual scientist.

2. What is Science 2.0?

2.1 Definition and context of Science 2.0

Science 2.0 is an umbrella term referring to a new form of scientific production, towards which the science system is currently trending (see Burgelman et al. 2010, European Commission 2014 a). This transformation encompasses a considerable increase of scientific production, data-intensive science, increase of number of researchers, as well as involvement of citizens in scientific processes (European Commission 2014 a, pp. 3-4). Due to the broadness of the concept there is no widely

[1] https://www.alpbach.org/vortrag/open-science-wissen-von-und-fuer-menschen-in-der-gesellschaft/, retrieved on December 1, 2014

accepted definition of Science 2.0. According to Bartling and Friesike (2014) Science 2.0 mainly refers to the adoption and use of Web 2.0 tools and services within science. Another important characteristic of the on-going transformation is the increasing application of open practices. We propose that Science 2.0 is best distinguished by a number of family resemblances; on the basis of the aforementioned sources, these characteristics are (1) adoption and use of social media in scholarly communication, (2) increased openness and collaboration, (3) use of big data, (4) alternative ways of research evaluation, and (5) stronger involvement of external stakeholders.

These trends are directly related to a broader socio-technological development, which is due to the increased availability of ICT (Burgelman et al. 2010, Kraker 2013, p. 10). Today's (Western) societies increasingly make use of digital data, computing, web resources, and Web 2.0 tools in diverse contexts (private, business, or public). Similarly these 21st century technologies start to take their place in science – in some areas only slowly, but steadily.

As mentioned above, Science 2.0 can also be understood as a paradigm shift (Kuhn 1962, p. 172) across disciplines that changes the way science is performed and communicated. The current science system is characterised by an increasing number of researchers and academics (e.g. see Schatz 2014, p. 423, McDowell et al. 2014, p. 4) as well as a rapidly evolving scientific landscape. One of the challenges in modern science is its fragmentation into increasingly specialised communities. Many current research problems, however, require large projects and interdisciplinary collaboration (e.g. see Horizon 2020, the Large Hydron Collider). These interdisciplinary collaborations struggle with a common understanding because their members need to not only have an overview of the area they are coming from, but also the other areas in the field. Therefore, advanced tools and techniques for communication, collaboration and discovery are needed.

Another context of this transformation is the severely increased journal subscription costs over the years (e.g. Tillery 2012, The Association of Research Libraries[2]). This does not only affect publicly funded universities, who are forced to drop subscriptions and limit electronic access, but also top class universities such as Harvard[3]. The Harvard Library (2012) reports annual costs for bundled journal subscriptions alone at 3.75 million dollars. This underpins the necessity for an increased use and support of Open Access, which enables better access to research publications and a better return of investments on publication costs (e.g. see Suber 2012, 133 ff.).

Finally, there is an increase in the retraction rate of articles (e.g. see Cokol et al. 2008, Van Noorden 2011). Van Noorden (2011) finds that retraction notices in the Web of Science have increased ten times in the last 10 years (from around 30 to over 300), even though literature has grown by "only" 44%. These alarming numbers show a lack of transparency and adequate quality assurance measures in science. Many research results are not reproducible due to the lack of access to data and source code[4]. This leads to an increased demand for a revised peer review system (e.g. open peer-review, see Pöschl 2012) and available Open Research Data and Open Source code.

This insight into the context of the transforming science system makes clear that there is a justified demand for more open and efficient science production and communication strategies to

[2] http://www.library.illinois.edu/scholcomm/journalcosts.html#1, retrieved on December 22, 2014.
[3] See http://www.theguardian.com/science/2012/apr/24/harvard-university-journal-publishers-prices, retrieved on December 22, 2014.
[4] See http://www.law.yale.edu/intellectuallife/codesharing.htm, retrieved on December 22, 2014.

cope with the changing circumstances[5]. Open Science strategies like Open Access to publications or Open Research Data can be seen as strategies developed for addressing these problems and adapting the science production to the technological possibilities of the 21st century. Opening up the whole research process is seen as a transparent and efficient way of facilitating and improving scientific collaboration and communication (e.g. see European Commission 2014 a, pp. 7-8).

The definition of Science 2.0 given above is very general and broad, and follows a holistic approach as it refers to a transformation of the science system as a whole. It needs to be mentioned that, as research processes and output vary from discipline to discipline, meaning and implications of Science 2.0 might vary as well. In this context, we experience that some disciplines are more advanced with Open Science practices. This can be seen e.g. in the adoption rate of Open Access. A recent study shows clear differences in the number of publications from different research fields (e.g. see Archambault et al. 2013, p. 13-17). This paper refers to the holistic definition of Science 2.0 in order to put the key barriers in relation to the big picture of the phenomenon.

2.2 Young researchers see potential of Science 2.0

The Young European Associated Researchers Network (YEAR)[6] recently conducted a consultation on young researchers' views on Science 2.0 (YEAR 2014 a). YEAR is a network of European RTOs with eight member organisations. The consultation consisted of an online survey based on the questionnaire of the Public Consultation on Science 2.0 by the European Commission (2014 b) with 15 multiple choice questions and an open field for additional comments, and 6 local debates organised by the YEAR member organisations AICIA, AIT, SINTEF, TNO, VITO, and VTT[7].

The young researchers who participated in the consultation expressed an overall positivity about the potential benefits of Science 2.0 for the research system and the individual researchers. 75% of the (in total) 196 respondents of the online survey totally or partially agreed that "*Science 2.0 activities should be taken into account for career progression of researchers*". Furthermore, 47% of the respondents partially or totally disagreed that "*Science 2.0 activities should not have any impact on the recruitment practices of research performing organisations*", whereas only 35% agreed with this statement (18% did not express an opinion, see YEAR 2014 a, pp. 4-5).

However, only a minority of the surveyed young researchers is actually practising Open Science (YEAR 2014 a, p. 2). It seems that engaging with Open Science activities is not a natural decision to take for scientists employed in research institutes or organisations. This has a number of reasons, which will be summarised below.

3. Current barriers to Science 2.0 for (young) researchers

Current barriers mainly seem to derive from the fact that the system currently in place is not geared to Open Science practices. The results are barriers on level of individual researchers as well as on level of institution managers and policy makers. This chapter focuses on identified key barriers for individual researchers. The following results are based on YEAR's consultation among

[5] There are critical positions in terms of the on-going transformations in science as well. However these cannot be reflected as this would go beyond the scope of this paper.

[6] http://www.year-network.com/

[7] See http://www.year-network.com/members

young researchers. It needs to be mentioned that, in general, the results of the YEAR consultation show similar trends to the preliminary results of the Public Consultation on Science 2.0 recently conducted by the Commission (YEAR 2014 b, 2).

In the local debates organised in the context of YEAR's consultation, the young scientists discussed some insecurities and doubts preventing them to actually put Open Science activities into practice. The two strongest insecurities, which are underpinned by the results of the online survey (see YEAR 2014 a, p. 4), are mistrust in Open Science sources due to missing quality control, and a general uncertainty about meaning and implications of Science 2.0 (YEAR 2014 a, pp. 6, 7, 9). Both aspects can be seen in the light of the colliding worlds of traditional science and Science 2.0, and a lack of awareness, respectively understanding of Science 2.0.

There are a number of discrepancies between Science 2.0 and the current research system and culture, which are being seen as considerable barriers by the young researchers (YEAR 2014 a, pp. 7-8). A majority of the young researchers agrees that current research metrics and the related reputation system, as well as missing integration of Science 2.0 activities with established research workflows, prevent them from practising Open Science (see YEAR 2014 a, p. 4). Reward and prestige in terms of academic promotion depends mainly on *"quantitative measures used in the evaluation of academic effort"* (Kieńć 2014). The current evaluation system for scientific achievements, which is decisive for a researcher's career, does not take into account Open Science activities (Berlatsky 2014, 2). Especially for researchers who are unexperienced with Open Science practices this means additional effort, which is not being accredited for in terms of career progression.

Other barriers identified by the young researchers are the currently missing or insufficient infrastructure and framework for practising Science 2.0, and the risk that industrial project partners may be reluctant to collaborate in projects requiring Open Science (YEAR 2014 a, pp. 7-8, 9).

4. Addressing the barriers: key aspects during the transition phase

It is clear that a paradigm shift towards a more open science system cannot happen overnight. It is a process with many implications which need to be addressed when planning corresponding actions. Current approaches need to be seen as first attempts of advancing and institutionalising a more open science system. The following paragraphs contain some reflections on the key barriers highlighted by the YEAR consultation on Science 2.0 and possible approaches to address them.

4.1 Raising awareness and understanding of Science 2.0

An insecurity expressed by the surveyed young researchers refers to the concept of Science 2.0 itself. On the one hand, the uncertainty about meaning and implications of Science 2.0 may be put down to a general lack of awareness of the phenomenon. As already mentioned the adoption rate of Open Science practices varies from discipline to discipline, which means that not all researchers have the same perception of relevance, applicability and progression of Science 2.0. On the other hand, and at least in some cases[8], there seems to be a lack of understanding of the concept due to its broadness and complexity (YEAR 2014 a, p. 9). Even though early and middle career

[8] See also the additional comments by the survey participants (YEAR 2014 a, pp. 12-13).

researchers are among the most vocal and active proponents of Science 2.0, it is fundamental to ensure a broad understanding of the concept to convince a large amount of researchers of the necessity and success of Science 2.0.

A reason for this lack of understanding may be due to the fact that the holistic definition of Science 2.0 given above refers to developments in the science system in general, and is not necessarily reflecting the situation of specific research fields or of individual scientists. The definition does not consider differing situations in various research areas. Increasing scientific production, number of researchers, data-intensive science, and involvement of citizens are not equally relevant in all disciplines. E.g. the Humanities are confronted with other challenges in the context of scholarly communication and publication (see Eve 2014, pp. 43-136). Moreover the referred developments have rather complex implications, which make it a difficult concept to comprehend.

To improve understanding of Science 2.0 and its implications it is recommendable to break down the Science 2.0 concept to a few concise and clear aims, and to define a roadmap towards reaching those (YEAR 2014 a, p. 9). Reflections on the various implications of Science 2.0 for individual disciplines will help bridging the gap between the holistic definition and the concrete situations and contexts of specific research areas (e.g. see Eve 2014 for the Humanities). Other important means for raising awareness of Science 2.0 are advocacy and training (see below).

4.2. Science 2.0 infrastructure

A number of commercial Science 2.0 tools and platforms exist, which can be used by researchers rather easily and with low financial resources (e.g. Figshare[9], Academia[10], ResearchGate[11]; and other tools developed not explicitly for science, e.g. GitHub[12], Twitter[13], various blogging services). All these tools are rather new, especially in terms of their usage within science. Widely approved or well established tools for scientific collaboration do not seem to exist yet (see YEAR 2014 a, pp. 8, 14, Kraker 2013, pp. 9-11).

In a comprehensive study Procter et al. (2010) report on usage of Web 2.0 tools for scholarly communication and on motivations for using these. Their conclusion is that researchers need to see a clear benefit from using tools and services (see Kraker 2013, p. 10-11). Following an exploration of research practices in the field of technology enhanced learning (TEL), Kraker and Lindstaedt (2011) concluded that, to provide these benefits, tools and technologies must either support current research workflows or solve shortcomings in existing practice. Other aspects for the successful implementation of Science 2.0 tools are to avoid duplication of functionality, and to adapt/design tools for specific practices of individual research areas (Kraker 2013, p. 47). Science 2.0 tools should have a good usability to be widely used and accepted by research communities. Finally, their sustainability is an essential factor for their usage in the long term[14].

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[9] http://figshare.com/
[10] http://www.academia.edu/
[11] http://www.researchgate.net/
[12] https://github.com/
[13] https://twitter.com/
[14] See http://openpreservation.org/technology/principles/software-maturity/, retrieved on December 4, 2014

Investing in the implementation of Science 2.0 infrastructure would support innovation in science and potentially create new jobs. Incentives at political level would substantially support this development thus helping Europe to become an innovation leader in this field.

4.3 Quality assurance of research outputs on the Web 2.0

Quality assurance is undoubtedly an important pillar of good scientific work, which is reflected in the young researchers' concerns mentioned above. New forms of science communication without the known quality assurance measures (i.e. peer-review) lead to doubts and mistrust.

The traditional peer-review system, however, is coming more and more under scrutiny. Traditional peer-review consists of three to four reviewers who decide about the inclusion or exclusion of a paper. In top-tier journals and conferences, submission has become so competitive that a single review can decide over the fate of a paper. E.g. the WWW conference only accepts a mere 13% of all submissions: in 2009, only 105 of 823 submissions were selected. Exponential growth in research output also means an exponential growth in the need of peer-review. This situation has decreased the quality of many reviews (see Smith 1999) and makes acceptance a game of luck in certain cases. A recent example of two Nature papers, which had to be retracted due to errors and plagiarism[15] show that even if scientific results are published only after they have undergone a peer-review process, this does not absolutely guarantee for their quality.

Still, it is important that innovative ways of documenting and communicating science implement innovative quality assurance procedures. In the current transition phase it is fundamental that solid means of quality control are being explored and established in order to overcome the scepticism by researchers. A possibility is to introduce features for open peer-review[16] to scientific blogs and other Web 2.0 platforms. This will support the success of such tools, as researchers will only make use of them if they are trusted and comply with current science quality standards.

4.4 Research metrics and reputation in science

As already mentioned, current research metrics mostly rely on quantitative measures like the Journal Impact Factor (JIF), which is an average journal citation rate published on a yearly base by Thomson[17]. However, most experts agree that the JIF is not a suitable measure for scientific impact (Bollen et al. 2009, 1). The San Francisco Declaration of Research Assessment (DORA)[18] that discourages the use of the JIF for the assessment of individual researchers has garnered more than 12000 signees to this date.

Alternative metrics for measuring the impact of research output on the Web 2.0, which could provide valuable additional indicators, are being explored and partly implemented (see Priem & Hemminger 2010, Costas et al. 2014). Nevertheless, most of the incentive and evaluation systems currently in place, which decide about career progression and promotion of researchers, require publishing articles in high-ranked journals (i.e. with high JIF) or books with high-prestige presses (Eve 2014, p. 44-46, van Dijk et al. 2014). The consequence is that e.g. publications in journals

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[15] See http://www.nature.com/news/stap-retracted-1.15488, retrieved on December 1, 2014.

[16] E.g. see Pöschl 2012

[17] http://thomsonreuters.com/journal-citation-reports/, retrieved on December 1, 2014.

[18] http://am.ascb.org/dora/

without impact factor are not allowed for the evaluation of researchers, disappearing from their CVs as if they never existed[19].

Under these circumstances many researchers do not dare to publish in other venues with low or no JIF, as is the case for many Open Access journals. To prevent that, current assessment mechanisms, which purely rely on conservative measures of prestige, should be changed to include article-level metrics to consider the reception of scientific work in social media channels (i.e. altmetrics), and to take into account not only papers, but all outputs of research – e.g. data and source code (see Burgelman et al. 2010, pp. 7-9). First steps in this direction have been taken, e.g. by the European Commission[20] and the Austrian Science Fund[21] (FWF). The policies of both research funding programmes require publishing research results as Open Access, which is an important step towards changing current evaluation and incentive standards.

But changing measures of reputation and prestige in science is not only a matter of policies. This change is embedded in a cultural context[22] consisting of collective practices, habits, and mindsets by the research communities. Researchers act within this cultural environment, which biases their actions. Policies may enforce and support certain actions, but policies will never successfully prevail if they are not supported by the research communities. This means that changes in existing reputation and prestige standards can only be successful if they are broadly accepted by the research communities. Therefore it is important to support a gradual acceptance and adoption of Science 2.0 from the bottom-up. The goal should be to reach a common understanding of good scientific practice and value aligned with Science 2.0 strategies and aims (YEAR 2014 a, p. 8). For this purpose it is recommendable to join forces and to build regional or national (or even more extended) initiatives to reach a critical mass and consensus, and to coordinate strategies and activities. Two examples for such initiatives are the Open Access Network Austria (OANA)[23] and the Right to Research Coalition (R2RC)[24].

4.5 Integration of Science 2.0 in current research workflows

In the current state, Open Science practices like blogging about research outcomes or their dissemination in social media platforms generally do not seem to be recognised as part of the curriculum of a scientist (YEAR 2014 a, p. 7, see also Berlatsky 2014, 2). Many of the young researchers who took part in the YEAR consultation expressed difficulties in integrating Open Science activities with established research workflows. As already mentioned, in most cases the decisive factor for personal career progression in research and academia as well as success in grant applications is publishing in high-prestige venues. Open Science activities are often regarded as additional effort, which cannot easily be aligned with the requirements and constraints imposed by the system currently in place (YEAR 2014 a, p. 7, Bruna 2014).

[19] Erin McKiernan gives a concrete example of such a situation at the end of her talk at OpenCon 2014. The video of the talk is available at http://opencon2014.org/resources#daytwo, retrieved on December 1, 2014.

[20] See the Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020: http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf, retrieved on December 1, 2014.

[21] See the Open Access Policy for FWF-funded projects: http://www.fwf.ac.at/en/research-funding/open-access-policy/, retrieved on December 1, 2014.

[22] For a definition of culture see e.g. Hannerz 1992.

[23] http://oana.at/

[24] http://www.righttoresearch.org

This can be put down to two main reasons. On the one hand the requirements and legal frameworks currently in place do not consider Open Science practices thus generating insecurities among researchers. Some of them even fear that Open Science activities could put their own success chances at risk (see Bruna 2014). Again, creating incentives for and accepting Open Science practices as part of good research practice will leverage this barrier. On the other hand, researchers often simply do not know how to integrate Open Science strategies into existing research workflows. This is due to a general lack of awareness of Open Science strategies due to missing instructions on and training for Open Science practices (YEAR 2014 a, p. 7).

One solution would be to include Open Science strategies in research education and training. This would be a crucial step towards kicking off implementation of Open Science practices in research and supporting those on the long term. This argument is supported by the results of the online survey conducted by YEAR. 82% of the participants agree that one of the most effective channels for awareness-raising of Science 2.0 is its integration in research training (YEAR 2014 a, pp. 5-6; see also McDowell et al. 2014, pp. 7-9). A current initiative which seeks to foster Open Science in the researchers' daily workflows is the FOSTER project[25].

5. Implementation of Science 2.0: the relevance of top-down and bottom up approaches

The previous paragraphs provided an overview of key barriers preventing researchers from putting Science 2.0 into practice, and possible approaches to overcome these barriers. The central question remaining is how to plan according strategies in order to support the transition of the current science system towards Science 2.0, and where the responsibilities for respective actions lay. For instance, should researchers take action regardless of the currently insufficient framework for supporting and rewarding Science 2.0 activities, thus pushing the changes from the bottom-up? Or should policy makers and managers be the decisive actors by implementing Science 2.0 policies and actively steer the transition from the top-down?

There are current examples for both approaches. The Science 2.0 movement is, on the one hand, driven by individual actors or projects who are attempting to shape or promote Open Science activities[26]. On the other hand, there are some attempts to regulate and instigate Open Access activities from top-down, e.g. national or institutional policies[27]. Most of the approaches are mainly driven locally by individual actors or public institutions. However, there are some attempts to coordinate strategies and actions on the national level and beyond (e.g. OANA, R2RC). A good example for the transformational potential of the combination of top-down and bottom-up activities is the international collaboration on open genetic sequences. It was born out of a community-driven effort which brought forth the Bermuda Rules (Marshall 2001), which state among other things that DNA sequences should be rapidly released into the public domain. The Bermuda Rules have been adopted by many journals, making the deposit of genetic sequences in one of the three large databases (as GenBank[28], European Nucleotide Archive[29] and DNA

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[25] https://www.fosteropenscience.eu/project/

[26] E.g. early-career researchers and students advocating for Open Access, Open Data, and Open Educational Resources. See http://opencon2014.org/, retrieved on December 3, 2014.

[27] E.g. see http://roarmap.eprints.org/, retrieved on February 12, 2014.

[28] http://www.ncbi.nlm.nih.gov/genbank/

Databank of Japan[30]) mandatory. The subsequent success of these databases illustrates that if publishers and conference organisers adopt new standards, they can be propagated quickly within the community.

As mentioned earlier, the transition from the current science system to Science 2.0 is embedded in a cultural context. Although corresponding policies are an important supporting element, driving the movement only from top-down will not suffice for supporting the transition to Science 2.0. Another important factor of a successful implementation is that research communities gradually accept and adopt Science 2.0 strategies and the corresponding framework in terms of a shift in science culture. As shown by the results of the consultation about young researchers' views on Science 2.0 this is not accomplished yet. This requires further advocacy and generation of best practices from the bottom-up.

Etheredge and Beyer (2011, p. 56) suggest that successful implementation strategies of new standards and processes need to build "emotional commitment". In the context of science this can be reached by pursuing and intensifying the dialogue between policy makers and actors[31]. This means that policy makers, research funders, and science publishers should remain open to suggestions and feedback from the research communities, and individual researchers should share their experiences and engage with others in order to create a basis for defining new standards. Especially in terms of implementing Science 2.0 approaches in different disciplines feedback on requirements, best practices, etc. is required from the bottom-up.

The conclusion of this paper is that both researchers and policy makers play a decisive role in the transition towards Science 2.0. Both top-down and bottom-up approaches have important effects on the adaptation of the current science system to Science 2.0. Policy makers, research funders, and science publishers, on the one hand, can take decisive decisions to rewrite outdated policies, thus creating incentives for Open Science activities and a framework for Science 2.0. Researchers, on the other hand, should help shaping Science 2.0 to be useful and effective for their specific research fields and related workflows. Science 2.0 does not only provide us with new tools, but it also presents us with the opportunity to revisit the scientific system as such – it is an opportunity we should not miss out.

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[29] http://www.ebi.ac.uk/ena

[30] http://www.ddbj.nig.ac.jp/

[31] A similar approach is currently being followed by the European Commission (see scienceintransition.eu).

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About the Authors

Michela Vignoli

Michela Vignoli is Junior Scientist at AIT, Austrian Institute of Technology, where she gained expertise in Open Research, Open Access, and Open Data (http://open-research.ait.ac.at). Her focus of interest lays on knowledge management and research in the digital era. Michela is actively promoting and advocating for Open Science practices in Austria and beyond and gave a number of presentations and workshops on the topic. As board member of the YEAR network (Young European Associated Researchers Network) Michela considerably contributed to consultation activities with the European Commission and to the organisation of YEAR events.

Peter Kraker

Peter Kraker is a postdoctoral researcher in the field of social computing at the Know-Center of Graz University of Technology (Austria) and a 2013/14 Panton Fellow of the Open Knowledge Foundation. He completed his thesis on visualizing research fields based on scholarly communication on the web at University of Graz with honours. His main research interests are Science 2.0, open science and altmetrics. Peter contributed to several EU-funded projects in these areas, including TEAM and STELLAR.

Alexis Sevault

Alexis Sevault, PhD, is a research scientist in the department of Thermal Energy at SINTEF (Norway). His PhD work was on oxy-fuel combustion and CO2 capture for power production. Since then, he has been mainly working in the field of bioenergy utilisation and notably in the management of a large national project on bioenergy innovation, where his work deals as well with research dissemination to the public at large. He has also been vice-president and treasurer of YEAR – Young European Associated Researchers' network for two years until becoming Chairman of YEAR in 2015. He played an active role in the consultation on Science 2.0 proposed to YEAR by the European Commission to investigate on the young researchers' views on Science 2.0.