Report on "Visions, needs and requirements for (future) Research Environments: An Exploration Series with Science Fiction Authors"

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The *Exploration Series on Visions, Needs and Requirements for (future) Research Environments* was driven by the following rationale: We believe that the more one thinks about preferred futures, the more one learns about the present. Thus, obtaining a better understanding on how research is changing to elaborate visions on how research may be conducted in 10 to 15 years is crucial to shape desirable ways into that future.

In this respect, perspectives on the future of (European) research (infrastructures) should be broadened through continued exploration. We therefore hope both to establish continuous exchange and discussion beyond the end of the project, and to initiate systemic changes in the long term. Against this background, the present report identifies starting points for debate that are important to shaping research environments, rather than singling out the one path to the future of research by collecting immediate needs and requirements for (future) research environments[1].

1 Explorations with Science Fiction Authors

The European Open Science Cloud[2] (EOSC) initiative aims at supporting over 1.7 million researchers in their activities as well as it aims at fostering interdisciplinary research in Europe. In order to support that goal, the EOSCSecretariat[3] partner TU Wien[4] organized a sequence of diverse activities[5] to elicit visions, needs and requirements for research environments - among them an *Exploration Series.* The key objectives were to collect input from stakeholders and to reach out to researchers and their communities via multipliers and testimonials, all while ensuring that **(i)** all scientific domains were reasonably covered, **(ii)** researchers at different career stages got involved, **(iii)** a wide variety of perspectives would be considered as well as **(iv)** geographic spread and gender balance.

[1] All findings of the discussion are shared with potential stakeholders and feed directly into the work of the EOSC governance bodies (https://www.eoscsecretariat.eu/eosc-governance) and the EOSC Working Groups (WGs) (https://www.eoscsecretariat.eu/eosc-working-groups) providing input crucial for the development of the EOSC.

[2] The EOSC is an initiative launched by the European Commission in order to provide support to researchers and foster (interdisciplinary) research as well as global cooperation, within academia and industry. Thus, it shall be a virtual environment with free at point of use, open and seamless services for storage, management, analysis and re-use of research data across borders and scientific disciplines: https://ec.europa.eu/digital-single-market/en/european-open-science-cloud

[3] EOSCsecretariat.eu addresses the need for the set-up of an operational framework supporting the overall governance of the European Open Science Cloud (EOSC): https://www.eoscsecretariat.eu/node

[4] See https://www.tuwien.at/en/

[5] *Researcher Engagement Activities* performed by TU Wien include a workshop with researchers from a variety of disciplines (report: https://zenodo.org/record/3701194#.X2Mhr2gzaUk; key takeaway messages: https://zenodo.org/record/3701269#.X2MhrmgzaUk), a workshop with members from university networks and experts in Open Science (report: https://zenodo.org/record/3693914#.X2Mhs2gzaUk; key takeaway messages: https://zenodo.org/record/3701269#.X2MhrmgzaUk), a discussion with Science Europe (key takeaway messages: https://zenodo.org/record/3701269#.X2MhrmgzaUk), an Online Session with experts in the Healthcare domain (report: https://zenodo.org/record/4015121#.X1NdI8gzaUl; key takeaway messages: https://zenodo.org/record/4030301#.X2Mg7WgzaUk) and interviews with high-profile researchers (report: https://zenodo.org/record/4336705#.X9t5Y9hKiUk; key takeaway messages: https://zenodo.org/record/4337176#.X9t7cNhKiUk) and Science Fiction Authors around the globe.

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This report aims at summarizing one part of these activities – namely, discussions held with academics who are also successful Science Fiction-Authors. Preparatory work and discussion phases started in summer 2020. Six authors with different scientific backgrounds (Computer Science, Economics, Biology, Intellectual History, Psychology, and Computer Engineering) were interviewed. In terms of geographical spread, Canada, China, Europe and the U.S. were covered. The interviews are published in sequence, one per month, starting with January 2021, both on Zenodo[6] and as blog entries on the EOSCSecretariat Website[7].

Through this series of interviews, a completely new perspective on the role of research and research infrastructures in a societal context was obtained, as all interviewees are familiar with academia as it either played or still plays an important role in their professional paths, but are not dependent on it for their careers. In this respect, the primary aim of these discussions was to consider a wide variety of perspectives when planning for (future) research environments.

2 Preparing for the Future: Discussion Points

The following starting points for on-going discussions were identified during the course of activities: Competition and collaboration, issues of trust in technologies, research systems and people in power, ways of counteracting monopolies, rules and regulations and, last but not least, the importance of education as well as of science communication.

2.1 Competition and Collaboration

Historically, competition and collaboration in research have both contributed to and hindered important scientific advancements. Competition takes place between colleagues in a lab, between labs in an institution, between institutions in a country, between countries and regions and between disciplines. Intensive collaboration at all these levels is required to tackle global, societal and interdisciplinary challenges. For this reason, **too strong an emphasis on competition tends to ruin potential achievements**.

In the context of (future) research environments, this refers, for example, to scarcity in terms of resources, battling for access to data and in-fighting for positions[8]. The current (research) system is setting up hierarchical structures that favour professionals who strive to occupy important positions within this system. In contrast to them, researchers who are primarily concerned with research work and the production of results have fewer opportunities to occupy top positions. Being in a better position, however, does not only bring along higher social status but also increases the chances of getting further funds, access to data, or other seemingly scarce resources. Against this background, the reason why, e. g., Project Investigators want to own research labs, or aim to have their names as first authors on papers is **competition in what is essentially a zero-sum game for scarce resources**. That, however, is going to cripple any attempts to build any kind of improved research environment, unless research systems can somehow be proven resilient

[6] Interviews published so far include an interview with Cory Doctorow (https://zenodo.org/record/4452335#.YAgm8ehKiUk), Karl von Wendt (https://zenodo.org/record/4506912#.YB1O2-hKiUk) and Peter Watts (https://zenodo.org/record/4580897#.YEDXH2hKiUk)

[7] For already published interviews, please see https://www.eoscsecretariat.eu/news-opinion/visions-needs-requirements-computer (Cory Doctorow), https://www.eoscsecretariat.eu/news-opinion/visions-needs-and-requirements-karl-von-wendt (Karl von Wendt) and https://www.eoscsecretariat.eu/news-opinion/visions-needs-and-requirements-future-research-environments-exploration-biologist-and (Peter Watts)

[8] In-fighting for position due to too strong an emphasis on competition was also identified as a major issue during the *Exploration Series with Researchers*. Over-crowded research environments as well as the singling out of individuals based on their publications, citation counts, or grants was viewed as hindering "research as a collaborative effort that is societally beneficial and that maximizes knowledge" (see https://zenodo.org/record/4336705#.YDdmBuhKiUl, p. 8).

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against such exploitation. For example, an **environment in which funding for research was less constrained might drive different organizational structures**.

2.2 Issues of Trust

2.2.1 (Information) Technologies

With the development of (information) technologies, AI reasoning and computational processes became so complex that some are not fully understood. That, in turn, poses fundamental obstacles towards trusting (new) technologies and their outcomes, with low acceptance levels when provided by incomprehensible AI algorithms. One way to (re-)establish trust in (information) technologies is to **establish regulations to control the development of technologies** to some extent.

However, in order to be able to control technologies in the broadest sense and to create appropriate regulations, developments need to be understood in the first place. In this context, their **development could be accompanied by an impact assessment as well as debates and analyses on possible (side) effects at micro and macro level**. Questioning the impact of technologies on society have made this area a research field in its own name, applied to other fields of studies, like, for example Science and Technology Studies (STS). However, these two areas of activities are only loosely connected, fields where technologies are promoted and developed not allocating resources for - however shallow - analyses of their impact outside their field. When brought together, further developments could be proactively managed to minimise risks and undesirable side effects. Moreover, such debates should be integrated with the activities to **communicate the relevance of science, research and technology to the general public** (see also *3.4 Education and Science Communication*).

2.2.2 Current Research Practices

There is a lot of concern about the rise of false beliefs such as conspiracy theories concerning the Covid-19 pandemic, the modern flat Earth movement, or diverse claims made by Anti-Vaxxers. While these theories are put into focus at times, the mechanisms by which people arrive at such beliefs are under-theorized. This development may well express **a collapse in society's ability to trust the institutions that adjudicate conflicting research claims**, meaning that, irrespective of how good the conclusions of the research community are, the ability to act on them will be severely hampered by the lack of consensus about whether they are trustworthy. One way out of this dilemma may be the **establishment of legible processes to publicly display conflicting claims, evaluate them and come to conclusions about them**. Additionally, a **failure mode** is to be set up for the situations in which, when new facts come to light, **a mechanism allows for revisiting those conclusions**. Such adjudication processes are in place already, but are currently hampered by the market power of individual companies and industries (see also *3.3. Monopolies*).

Further frequently mentioned points of criticism are **structural problems** including the fact that **negative results are not being published**[9] (which leads to researchers doing the same research repeatedly), **statistical malpractice,** and the **difficulty of reproducing research results**[10] when necessary data, software, etc. are not

[9] The need to present science as a process as well as to allow for failure within such processes was also discussed during the Exploration Series with Researchers (see also *2.1.2 Publish or Perish*, https://zenodo.org/record/4336705#.YECc4GhKiUl)

[10] The reproducibility of research is also an important topic in the *Report on the online session on visions, requirements and needs for Future Research Environments in the Healthcare domain* (see *2.3.2 Reproducibility in Research: Access to primary data*, https://zenodo.org/record/4015121#.YEAJ2mhKiUm). This report notes that access to primary data is crucial to reproduce research and support robust research. This in return relates to the demand to support open data initiatives, so that published research results can be checked and re-viewed (see *2.2.3 Open Data*, https://zenodo.org/record/4336705#.YEAJzmhKiUl)

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accessible. That last issue is increasingly addressed by European funding agencies by **supporting initiatives that require Open Access** from (research) day one and making it the norm in the long run. Complementary to the Open Access and transparency research methodologies, **solutions need to be devised** for dealing with sensitive data. On the one hand, subjects should not be put at risk (e.g. through re-identification). On the other hand, results cannot be trusted without access to the underlying information.

In terms of statistical malpractice, **machine learning can help to spot massaged statistics** as much as it could be used to massage them in ways that are hard for humans to catch. Thus, some **formal set of criteria to be used to (re-)evaluate statistics to find malpractice** should be introduced.

2.2.3 Positions of Power

Apart from the fact that society needs to be able to trust institutions as well as systems, trust in people who occupy top-positions, who make decisions with far-reaching consequences and who benefit from current systems and therefore support them is also an issue. Points that were often mentioned in this context are for example politically, socially and racially biased data as well as the motivation behind people controlling AI, rather than the use of AI. These problems are inherent in the system and can be partially counteracted through putting less emphasis on quick results by a change of reward systems[11], and giving citizens control over who gets to see their personal data in an anonymized form:

As long as having results first leads to **advantages in terms of wealth, status, finances/funding, access to limited resources** (see also *3.2.2 Research Practices),* people will be tempted to cut corners and might bring forward research and/or outcomes that are less beneficial, or even harmful for (parts of) society. If ways of accumulating **such benefits are reduced**, however, such situations could be prevented to at least some extent.

On a trivial local level, governments, bureaucracies, academic and research institutions should get access to anonymized data to the largest extent possible without undue risk to individuals. In an ideal system, **citizens should be enabled to get a look at every data that everybody has about them anywhere and for which purpose**.

2.3 Monopolies and Oligopolies

As mentioned in *3.2.2 Research Practices,* society appears to be facing a collapse in its ability to have trust in research results presented. One reason for this may stem from (perceived) dominance of certain stakeholders controlling specific sectors in oligopolies. A way to restore trust in institutions is to address the market forces that facilitated the afore-mentioned developments by having reduced pluralism. Consequently, **strategies to disempower monopolies need to be developed and implemented**. For example, mergers could be prohibited, initiatives to de-monopolize and pluralise policy spaces could be supported,

[11] The need to change reward systems is a key point that has been raised again and again in discussions and workshops. Details can be found in the report on the exploration series with researchers: (see *2.1.1 Sustainable research environments* https://zenodo.org/record/4336705#.YEAJzmhKiUI). The actual reward system was also criticized during the discussions with experts from the healthcare domain as it puts too much emphasis on e.g. first publications instead of stressing benefit-increasing mechanisms such as maximizing knowledge (see *2.2.3 Civic Data Cooperatives*, https://zenodo.org/record/4015121#.YEAJ2mhKiUm).

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and monopolistic conduct could be pursued aggressively. In the context of research, this means to e.g. **re-consider the dominance of scientific publishing houses**[12].

When building future systems, the following points can serve as starting points for further debate: First, monopolies do not (necessarily) prevail because they are most efficient but because they "got there first". In a way, **acts of manipulation as a feature of any future system**, could thus **contribute to pluralistic structures by constantly resetting the conditions needed to succeed within market economies, research systems and infrastructures** because - in the face of constantly changing structures and rules of the game - already accumulated (market) power would no longer be a competitive advantage. Additionally, such systems may well keep each other in check and prevent each other from growing too big. However, a safeguard of some sort needs to be introduced, so that research results are not affected.

Second, trimming everything to optimization, standardization and efficiency leaves systems vulnerable as they may have only one single point of failure. The messy bits and pieces, such as seemingly unnecessary redundancies, by contrast, might lead to higher resilience and robustness. Against this background, **a trade-off between a resilient system and a highly optimized needs to be taken into consideration when building research environments**. Apart from this, it is unclear which systems will be needed in the distant future, it is therefore advisable to **invest in the ability to adapt**, rather than into systems that are adapted for the moment.

Third, in some markets like pharmaceutics and food, there already are sophisticated **systems of safety measures** in place. Thus, if other markets, such as the information sector, need to be regulated in relation to personal data, there already are examples for functioning structures that could be used as blueprints or showcases for the development of regulative procedures and institutions.

2.4 Education and Science Communication

Little knowledge and misconstrued pop science are dangerous things as almost anything can be claimed nowadays, all while attracting people regardless of the actual truth of such claims. Two approaches can help to counteract this: **(i)** Ensuring quality education for all, and **(ii)** establishing a dialogue between the broader public and the world of science.

A large group of people are not educated in a way that makes them feel comfortable with science, and/or broadly imparts the skills needed in the 21st century. The latter, for example, refers to basics in the handling and manipulating of data, basics in data science, or raising awareness in terms of educational technologies, privacy issues and (personal) data[13]. **Introducing data literacy[14], digital literacy and education around privacy concepts into school curricula** is therefore a necessity that the EOSC initiative should implement. Furthermore, (science) teaching at school should **present science as an investigative process**, **convey**

[12] The report on *Visions, requirements and needs for Future Research Environments: An Exploration Series with Researchers* also emphasizes the need to start initiatives that may change current publication systems to increase knowledge and benefits for society. For details, please see the full report available on Zenodo (see *2.1.2 Publish or Perish,* https://zenodo.org/record/4336705#.YEAJzmhKiUl).

[13] Please see https://www.eff.org/deeplinks/2017/02/school-librarian-caught-middle-student-privacy-extremes, for an article on the tension between educational technologies and student privacy,

[14] This issue was also raised during other engagement activities, namely the online session with experts from the healthcare domain and the explorations with top-level researchers. Details can be found in the reports: https://zenodo.org/record/4015121#.YEAJ2mhKiUm (healthcare, see *2.1.1 Data Literacy (EOSC@School)*) and https://zenodo.org/record/4336705#.YEAJzmhKiUl (explorations, see *2.2.2 Big Data*)

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scientific reasoning, teach how to **make connections between pieces of knowledge** and bring the **appreciation of complexity and uncertainty** closer to pupils and students.

Apart from teaching, **establishing a dialogue between the broader public and the scientific world** is another important means to increase the impact of science on society. In this context, **Research institutions as well as researchers have to take responsibility for science communication**: They should actively engage in finding ways of supporting and increasing people's understanding of research and science. Moreover, open exchange and the promotion of science (via public relation workers, events, shows) may reach people who are not close to science at all and stir further discussions. In order to do that, however, **ways of communicating science from the very technical and difficult to grasp down to a level where the average person is able to understand it need to be developed**.

3 Summary: Starting Points for further Discussion

The table below lists all potential discussion points as well as all proposed services and solutions mentioned in *3 Preparing for the Future: Discussion Points* and summarises them in short descriptions.

Discussion Points	Services and/or Solutions	Descriptions
Competition and Collaboration	An environment in which funding for research is less constrained might drive different organizational structures	Too strong an emphasis on competition tends to ruin potential achievements. In the context of (future) research environments, this refers, for example, to artificial scarcity in terms of resources, battling for access to data and in-fighting for positions. Being in a better position increases the chances of getting funds, access to data, or any other seemingly scarce resource. This leads to competition in what is essentially a zero-sum game for scarce resources. That, in return, is going to cripple any attempts to build any kind of improved research environment, unless research systems can somehow be safeguarded against such exploitation
(Information) Technologies	One way to (re-)establish trust in (information) technologies is to establish regulations to control the development of technologies to some extent. In order to be able to control technologies in the broadest sense and to create appropriate regulations, developments need to be understood in the first place. In this context, their	With the development of (information) technologies, AI reasoning and computational processes became so complex that some are not fully understood. That, in turn, poses fundamental obstacles towards trusting (new) technologies and their outcomes, with low acceptance levels when provided by incomprehensible AI algorithms.

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	development could be accompanied by an impact assessment as well as debates and analyses on possible (side) effects at micro and macro level. Moreover, such debates should be integrated with the activities to communicate the relevance of science, research and technology to the general public.	
(Information) Technologies	Accompany the development of technologies with impact assessment as well as debates and analysis on potential (side) effects on both micro- and macro-scale Such debates should go with attempts to communicate the relevance of science, research and technology to the general public	In order to be able to control technologies in the broadest sense and to create appropriate regulations, developments need to be understood in the first place.
Trust issues in Research Systems	Establish legible processes to publicly display conflicting claims, evaluate them and come to conclusions about research results, all while allowing for a failure mode and a mechanism to revisit conclusions. Deal with structural problems such as the non-publication of research results, statistical malpractice and hardly reproducible research. Machine learning can help to spot massaged statistics, but needs to be supplemented by some formal set of criteria to be used to (re-)evaluate statistics because it can also be used to massage statistics in ways that are hard for humans to catch.	This point of discussion refers to a collapse in society's ability to trust the institutions that adjudicate conflicting research claims, meaning that – irrespective of how good the conclusions of the research community are – the ability to act on them will be severely hampered by the lack of consensus about whether they are trustworthy.
Positions of Power	Against the background of the artificial scarcity of resources, people will be tempted to cut corners for as long as reward systems favour quick results and individual performances. If reward systems are changed, or artificial scarcity is reduced, that kind of situation might be somewhat improved. Enable citizens to get a look at every data that everybody has about them anywhere and for which purpose.	Trust in people who occupy top-positions, who make decisions with far-reaching consequences and who benefit from current systems and therefore support them is an issue: e.g. politically, socially and racially biased data as well as the motivation behind people controlling AI, rather than the use of AI.

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Monopolies / Oligopolies	Develop and implement strategies to disempower monopolies: For example, mergers could be prohibited, initiatives to de-monopolize and pluralise policy spaces could be supported, and monopolistic conduct could be pursued aggressively. In the context of research, this includes e.g. to re-consider the dominance of scientific publishing houses or other industries that dominate certain fields of R&D. Implement acts of manipulation as a feature of any future system in order to contribute to pluralistic structures by constantly resetting the conditions needed to succeed within market economies, research systems and infrastructures. Trimming everything to optimization, standardization and efficiency leaves systems vulnerable as they may have only one single point of failure. A trade-off between a resilient system and a highly optimized needs to be taken into consideration when building research environments.	Dominance of a few players establishing quasi monopolies or oligopolies serving their own (legitimate) interests, which do not necessarily match the interests of society. This results in mistrust of society in new technologies, developments and their underlying research.
Education	Introduce data literacy digital literacy and education around privacy concepts into school curricula. Present science as an investigative process, convey scientific reasoning, teach how to make connections between pieces of knowledge and bring the appreciation of complexity and uncertainty closer to pupils and students.	Little knowledge and misconstrued pop science are dangerous things as almost anything can be claimed nowadays, all while attracting people regardless of the actual truth of such claims. Two approaches can help to counteract this: **(i)** Ensuring quality education for all and **(ii)** establishing a dialogue between the broader public and the world of science.
Science Communication	Research institutions as well as researchers have to take responsibility for science communication. Develop ways of communicating science from the very technical and difficult to grasp down to a level where the average person is able to understand it.	

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4 Appendix I: Short Biographies of Authors[15]

Cory Doctorow[16] holds an honorary doctorate in computer science from the Open University (UK). He is an MIT Media Lab Research Affiliate and a Visiting Professor at the Open University (UK) and the University of South Carolina's School of Library and Information Science. He is known for *Down and Out in the Magic Kingdom* and *Little Brother*. Doctorow won several awards for his work, including the *John W. Campell Award* and the *Sunburst Award*.

Katharina Flicker is a project employee at TU Wien. In connection with the EOSCSecretariat project, she is co-ordinating, monitoring, reporting, organising and disseminating activities related to researcher engagement.

Gwyneth Jones studied European history of ideas at the University of Sussex in England, and is most known for the *Bold as Love*-Series. Jones won several awards for her work, including the *Arthur C. Clarke Award* and the *World Fantasy Award*.

Cixin Liu[17] studied at the North China University of Water Conservancy and Electric Power in China, and is most known for the *Remembrance of Earth's Past*-Series. Liu won several awards for his work, including the *Galaxy Awards* and the *Hugo Award*.

Florina Piroi is a senior researcher at Technical University of Vienna, Faculty of Informatics and Research Studios Austria, Data Science Studio, leading and working in various Data Science and Information Retrieval research projects.

Andreas Rauber is Head of the IFS research unit at TU Wien. As a computer scientist, he has been focusing on machine learning as well as long-term access to digital data. He is responsible for researcher engagement within the EOSCSecretariat project.

Adrian Tchaikovsky studied Zoology and Psychology at the University of Reading in the, and is most known for the Shadows of the Apt-Series. Tchaikovsky won several awards for his work, including the *Arthur C. Clarke Award* and the *British Fantasy Award*.

[15] in alphabetical order

[16] Portrait by Jonathan Worth https://jonathanworth.org/photography/

[17] Portrait by Li Xiaoliang

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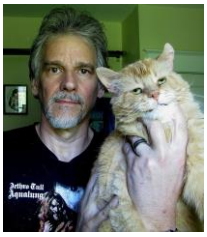
Karl von Wendt studied Economy at the University of Münster in Germany, and is most known for the *Boy in a White Room*-Series, written under his pen name *Karl Olsberg*. He was nominated for the *Kurd-Laßwitz-Award* and the *German Youth Literature Award*.



Peter Watts studied Zoology and Resource Ecology at the University of British Columbia in Vancouver, and is most known for his book *Blindsight*. Watts won several awards for his work, including the *Shirley Jackson Award* and the *Hugo Award*.

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