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Trust Within Science: Dynamics and Norms of Knowledge Production

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About this Series

The ALLEA Discussion Paper series is an initiative to provide up to date and informed perspectives from the academic world on some of the most pressing issues facing societies across Europe and beyond. The objective is to contribute to and connect debates in the fields of science, society and policy. It serves as a transnational forum of the academies of sciences and humanities for outstanding scholars to present and discuss their work within ALLEA. Issues may draw on workshop reports, statements and position papers by ALLEA working groups or other ALLEA initiatives. The series provides an intellectual space to reflect on complex questions and potential solutions and seeks to inform policy decisions as well as the public debate.

About the ALLEA Working Group "Truth, Trust & Expertise"

The ALLEA Working Group "Truth, Trust and Expertise" is a platform for perspectives on the nature and relationship between truth, trust and expertise in the field of science and research. The expert group, chaired by Baroness O'Neill of Bengarve and Professor Ed Noort, aims to interrogate and explore current and past dynamics of public trust in expertise and contested norms of what constitutes truth, facts and evidence in scientific research and beyond. Central themes of the group include: the alleged loss of trust in science and evidence, questions of how valid knowledge can and should be acquired and communicated, and how different academic disciplines are dealing with these challenges.

About ALLEA

ALLEA (All European Academies) is the European Federation of Academies of Sciences and Humanities. It was founded in 1994 and currently brings together almost 60 academies from more than 40 countries in the Council of Europe region. Its Member Academies are self-governing communities of leading scholars and researchers across all scientific fields. Independent from political, commercial and ideological interests, ALLEA contributes to the improvement of framework conditions under which science and scholarship excel. Together with its Member Academies, ALLEA addresses the full range of structural and policy issues facing Europe in science, research and innovation. Via its interdisciplinary and international working groups, various public engagement activities, and by participating in pan-European projects, ALLEA informs European policy and society through evidence-based advice.

Executive Summary

In the following paper, the issue of re-establishing trust between science and society, which is the focus of the ALLEA Working Group Truth, Trust and Expertise (TTE), is tackled through a closer look at trust-enhancing practices within scientific research. As the conceptual analysis developed in Discussion Paper #1[1] reveals, trust means "deferring with comfort and confidence to others, about something beyond our knowledge or power, in ways that can potentially hurt us."[2] The ways in which science is produced are thus extremely relevant to establish and re-establish trust in science, at least for two reasons: (1) Trust *within* scientific research encourages the comfort and confidence among researchers needed to share results and rely on each other's work and methods; (2) Trust in the practice and production of science is socially relevant for resolving public controversies and enhancing a comfortable general acceptance of scientific results.

Raising awareness of the norms and good practices that govern scientific production, as well as monitoring the possible distortions that these practices may undergo due to internal and external pressures that come from the societal, technological, political and economic transformation of research practices, is thus a crucial step towards the construction of trust in science.[3]

The aims of this paper are twofold. On the one hand, it reflects on some specific approaches that academic research can adopt towards the common goal of producing reliable, reproducible and hence trustworthy scientific evidence. On the other hand, it will take a normative stance by reaffirming the need for: (a) more articulated and context-sensitive standards of research integrity; (b) greater as well as better inter-, multi- and transdisciplinary collaboration; (c) re-adjustments in the evolving system of scientific publishing; and (d) the importance of ethical guidance as a shaping asset for trustworthy research.

To begin with, the paper investigates what good evidence and trustworthy science mean for different academic disciplines. What is trustworthy science? What is sound evidence? To respond to these questions, researchers have to acknowledge different ways of producing and communicating knowledge and ask themselves how to engage in truly inter-, multi-, and transdisciplinary cooperation in order to produce well-rounded research results. The point at stake here is to understand and value the different methodological approaches that inform knowledge production.

What can different scientific disciplines learn from each other? Are there common research standards that are clearly shared by all disciplines and constitute the 'backbone' of scientific practice? Can these standards be easily communicated to a wider audience? Is science still an 'exemplary' activity, a model of human solidarity,[4] a way of enhancing epistemic virtues and fighting parochialism, and biased or unjust world views? Has it ever lived up to this claim at all?

The following reflections point out that the way in which trust in science is constructed does not depend on reason and logic alone. The sense of belonging to a community depends also on the way in which this community is articulated in terms of norms, social roles, cultural backgrounds and institutional

1 See ALLEA (2018), Loss of Trust? Loss of Trustworthiness? Truth and Expertise today, *ALLEA Discussion Paper 1*. http://www.allea.org/wp-content/uploads/2018/05/ALLEA_Discussion_Paper_1_Truth_and_Expertise_Today-digital.pdf (accessed 5/12/2018)

2 Whyte, K.P. and Crease, R. (2010), Trust, Expertise, and the Philosophy of Science, *Synthese* 177(3): 411-425, p. 412.

3 Throughout this paper, 'science' is used in its wider, *Wissenschaft* sense of the word, including all forms of academic research, and thus explicitly includes the humanities and social sciences.

4 See, for example, the debate around the role of science as a model of solidarity and democratic exchange of ideas in Rorty, R. (1991), *Objectivity, Relativism and Truth*, Cambridge: Cambridge University Press.

contexts. Fair science allows the expression of human differences, takes into account gender, race, culture and social positions, and articulates the historical, geographical and cultural settings in which science is produced and experienced. In short, fair science is aware of the context.

The paper also discusses new dynamics in scientific publishing that have sometimes resulted in a misperception of scientific activity as a too 'business oriented' endeavour instead of a sphere of disinterested inquiry. Mechanistic regulatory systems of accountability and transparency appear to contribute more to a loss of trust in expertise than they have encouraged it.[5]

Contemporary scientific publishing practices are influencing trust in science, not only from the perspective of the general audience, but also from the scientific community's point of view. The way in which scientific knowledge is produced and transmitted has been dramatically affected by a series of recent major techno-societal transformations, namely the introduction of new bibliometric measures such as citation indexes and impact factors. The 'business-like' model of producing science, further amplified by the competitive norm of 'publish or perish' in career-track academia, is poorly understood by the general public and heavily criticised from within the community.

The final part of this paper deals with factors affecting trustworthiness from an ethical perspective. It is suggested that ethics should not only set 'limits' of research when there is a potential conflict of values and norms. Rather, ethics needs to be framed as a shaping asset for research, understood as an inherent part of science from the beginning and throughout the whole research cycle. Ethics should be involved in posing the right questions, in asking the questions correctly, in the way of collecting data and the way of reasoning and interpreting insights and data in order to produce knowledge. By providing a long-term perspective on the world we want to live in, ethics should contextualise and scrutinise assumed concepts, shape our way of reporting and publishing, and, ultimately, make sense of how new knowledge and new technologies are applied to our daily lives.

It is important to distinguish between an internal ethical dimension of science, that is, the ethical norms that guide scientific practice, and an external ethical dimension, that is, the societal norms, values and priorities that must be taken into account by researchers and research funding agencies in order to make scientific research relevant and useful.[6] These two levels are often confused in the debate on the ethical dimension of science: if the replicability crisis is a clear-cut example of the first ethical issue, the climate change debate and the public controversies it raises are an example of the second. Scientists can be held responsible for unethical behaviour within the community, as for example in cases of plagiarism, the manufacturing of data, insincere report of results, or sloppy methodological standards.[7] However, academics alone cannot be held directly responsible for the societal consequences of scientific research, or for the lack of efficacy of science to solve societal problems: responsibilities in this second case must be shared with all the stakeholders: experts, policy makers and funding agencies. To improve public understanding of science, there should be a clear difference between these two crises of trust.

5 See ALLEA Discussion Paper 1 for a more elaborated discussion on the unintended consequences of regulatory systems.

6 See Merton, R.K. (1973), The Normative Structure of Science, In: Merton, R.K. (Ed.), *The Sociology of Science: Theoretical and Empirical Investigations*, Chicago: University of Chicago Press: 267–278.

7 The 'replication crisis' started in 2016 when 1500 scientists raised awareness on the difficulty to replicate results especially in psychology, social psychology and medicine. See Baker, M. (2016) 1500 Scientists lift the lid on Reproducibility, Nature 533: 452-54.

Good Evidence and Trustworthy Science

To what extent is trust in science really contested? This fundamental question lies at the heart of the debate around the alleged loss of trust in expertise and in the so-called 'post-truth' era.

Recent technological, social and political transformations are challenging the traditional role and perception of science. In some instances, those transformations increasingly lead to misrepresentation, denial or outright dismissal of scientific research results. Many blame the rise of right-wing populism for this development, others the 'commercialisation' of all aspects of society, including science; others then claim that these challenges are nothing new. What is clear is that scientists and non-scientists alike fear that one of the central missions of science is under threat: achieving progress through a steady and incremental increase of our common stock of knowledge.

However, threats coming from broader social and political transformations outside the scientific community are only one aspect of an alleged loss of trust in science. That is why this paper takes a closer look at the dynamics within science and seeks ways that may contribute to trustworthy knowledge production – and thus form a precondition for establishing public trust in science. The ALLEA Discussion Paper #1 reflected more generally on how societal trust in expertise is placed and refused, as well as why and how trustworthiness is being contested in general. It looked at how trustworthiness is perceived and how it translates into trust. One of the conclusions is that it is important to not trust blindly, but intelligently. Trust can be well-placed or ill-placed, particularly when it comes to science, which is entirely built on the premise of not taking anything for granted and critically questioning everything, especially one's own results and ontological, epistemological and methodological biases. Here, we have the makings of a fundamental paradox: Creating new knowledge through the disruption of established knowledge under conditions of intended uncertainty challenges 'trust-building'.[8]

At the same time, individual and systemic failures within the scientific community together with their increased public visibility make it harder for science and scientists to be perceived as trustworthy. The challenges for the scientific community that come along with the slightest occasional lack of research integrity, well-intended but misplaced measures to counter it with a rigid regulatory framework of standardised accountability and transparency, as well as mostly economic incentives to 'publish or perish', pose a serious threat to the scientific community's actual and perceived trustworthiness.[9]

In this regard, the Discussion Paper #1 concludes that we should reinvest in science with a moral economy that values creativity and curiosity. How do we do that? The first and most important step is to acknowledge and value diversity. Between and within a seemingly endless number of academic fields and disciplines, one can find a plethora of approaches dealing with the challenge of producing trustworthy knowledge in different ways.

Science and expertise are not monolithic. Just as there is no single, homogenous 'public', there is no one and only true way of conducting scientific

8 See also Alexander von Humboldt Foundation (2018), *Trust in Science and Scholarship – A Global Societal Challenge. Proceedings of the 11th Forum on the Internationalization of Science and Humanities*, Berlin: DUZ.

9 See All European Academies (2017), *European Code of Conduct for Research Integrity*, for an exemplary attempt to tackle these problems. http://www.allea.org/wp-content/uploads/2017/03/ALLEA-European-Code-of-Conduct-for-Research-Integrity-2017-1.pdf (accessed 5/12/2018)

research, while some of these ways may even be at odds with each other. Yet, in order to explore ways to produce trustworthy knowledge and thus foster societal trust in science, this paper presents and reflects on a number of ideas that originate from different disciplinary perspectives. What is trustworthy evidence and what counts as good evidence in different scientific fields? Which dynamics within science contribute to the production of scientific knowledge? What are the main challenges within the scientific system and what are possible ways to tackle them?

This second paper reflects on 'trust-building' practices within science. After the working group's first paper, a conceptual analysis of the role of trust in expertise, and the present paper on the dynamics of 'trust-building' within science, the third paper provides an analysis of trust that connects scientific results to communication with society in a rapidly changing media environment.

Trust *within* Science

Overall, compared to other public institutions, scientific institutions and scientists continue to enjoy a relatively high degree of trust, although some anti-scientific attitudes are emerging on specific issues such as climate change, vaccines, and research on genetically modified organisms.[10] Unfortunately, and particularly in relation to techno-scientific developments, scepticism in the form of legitimate questioning and critique is all too often labelled and dismissed as 'anti-scientific'. Nevertheless, more so than in almost any other field, epistemic trust is a precondition for scientists to practice their science and to have people actually believe their methods and results. Yet, how do we, the public and the scientists themselves, know that we can have confidence in this work, that we can trust the outcomes?

While the public's trust in science remains considerably high, the scale and complexity of modern science also requires scientists to place a lot of trust in their peers. They trust them to act in a trustworthy manner, to behave as honest scientists and to comply with accepted standards of research integrity. Ideally, academics are held accountable by a system of procedural checks and balances, deployed and safeguarded by institutions. However, some recent scandals have shown that the system of checks and balances does not always work and, in a global, interconnected and competitive mode of production of science, it should be revised and adjusted. The replicability crisis, for instance, called for a collective reflection on the norms of replication and practices of describing the given conditions in experimental science.[11]

Trust in the work of other scientists is a fundamental condition for the flourishing of a scientific system and for trustworthy knowledge production. It is essential in situations where there cannot be full knowledge or control of what others have done. For instance, no single person can replicate even a tiny fraction of the evidence base that underpins modern science. Science has become so complex that we are forced into narrow specialisations – the days of the polymath are gone. In addition, some observations are by their nature unique, or so rare that we only might have one chance to experience them. Moreover, some areas of big science are nowadays so expensive that there is effectively only one lab left (e.g. in the area of particle physics). High costs are also an issue for

10 Cf. Funk, C. (2017), Mixed Messages about Public Trust in Science, *Issues in Science and Technology, 34(1)*, online source: https://issues.org/real-numbers-mixed-messages-about-public-trust-in-science/ (accessed 5/12/2018)

11 Cf. N.N. (2018), Editorial: Checklists Work to Improve Science, *Nature*, 556: 273-274.

large research infrastructures, libraries and art in general.

The behaviour of peers in line with standards of research integrity is, therefore, of central importance. Being trustworthy, however, does not automatically imply being trusted by others unconditionally. After all, one of the classic Mertonian norms of science is organised scepticism. Scientists do not and should not place absolute faith even in their own results. All claims and results, including their own, must be constantly and critically reviewed. The way these revisions are implemented should be self-reflective and shed light on unconscious biases and subjective factors that undermine the integrity of scientific research. 'Gate keeping', 'critical peer review', 'promoting dialogue', and 'rites of passages' – e.g. awarding of a PhD – are therefore significant mechanisms in order to define and organise the scientific community, its behaviour and knowledge base.

Why is the implementation of safeguarding measures that help control systematic errors and correctly evaluate statistical relevance so crucial? The reason is simple: A number of actions can go wrong in the research process and may lead to unreliable and even incorrect, thus untrustworthy results. Box 1 outlines a list of challenges to a trustworthy research process and how they are tackled.

The expectation that scientists behave in an ethical and trustworthy manner is valid for all areas of science. Processes and standards need to be constantly refined in order to ensure, as far as possible, that ethical standards are maintained and promoted. Scientists should be able to trust their research peers to work in a responsible and

Box 1: Challenges to a trustworthy research process and countermeasures

Challenges

- Exciting but marginal results reported by groups just before a funding review.
- Hierarchies leading to inexperienced students delivering results their professors would like to see.
- Small groups lacking the resources for effective self-evaluation.
- Pressure from journals and institutions to see 'breakthrough results' and 'high impact' work.
- Little support for replication studies by funding agencies.
- Negative research results are systematically under-reported.
- In some fields, there is a major concern over p-hacking, post-hoc hypothesis definition, and poor use of statistical tools.
- Conflicts of interest with commercial or political funders and the non-publication of unwelcome results.
- Predatory and fake journals, conferences, etc.
- Occasional outright fraud.

Countermeasures

- » The pre-registration of studies, with their underlying methodologies, should rapidly gain ground in areas heavily reliant on statistical analysis and hypothesis testing.
- » Proposals to reform peer review and publication procedures should be advocated for (e.g. to publish referee reports), as should proposals to promote more replication studies.
- » Removal of the misleading incentives associated with impact factor metrics.
- » Support the general trend towards open publishing and open data, including the publication of metadata.
- » Efforts to strengthen research integrity, e.g. through a generally accepted and implemented code of conduct.
- » Making replication studies and journals/funding for replication research more popular.

ethical way; they should be trustworthy in their testimony, even if, over time, their results are proven wrong, as long as the methods used are beyond reproach given the circumstances. In turn, this requires social structures and mechanisms that reward trustworthiness and encourage the development of a 'shared' culture of trust that crosses disciplinary boundaries. Hence the importance of a cross-disciplinary scientific culture that reinforces an awareness across the scientific community of belonging to the same 'research culture'. Ideally, the education of performing research in a responsible manner should be at the core of a researcher's career and start early on. From the very beginning of their scientific careers, students could receive training on the ethical obligations of conducting research. Ethical norms could help to create an open climate in which hypotheses can be challenged and critically assessed, where a diversity of views is encouraged, and where critical views and a healthy dose of scepticism are permitted.

One of the fundamental aims of moving towards the promotion of a trustworthy culture within science should be to raise awareness that knowledge acquired through academic training goes beyond the establishment of 'hard facts'. The production of reliable knowledge is a fundamental collective endeavour to preserve a knowledgeable community with integrity that produces and shares knowledge as a precious common good. Hence, more emphasis needs to be put on the myriad of ways in which knowledge produced in academia relates to society. Courses on communication, on the history, philosophy and sociology of science, and on the ethics of research integrity need to become obligatory components of university curricula.

Trust between Disciplines

> *"Science is not only a particular kind of knowledge formation defined by theories, methods and special criteria of rationality to which theories and methods are subjected, and an institution, that is the social form in which science is realised as a particular kind of knowledge formation, but it also has a moral form."*[12]

'Trustworthiness' and integrity in science are not given the same attention in every discipline. This can lead to a misperception of scientific research as a series of 'sub-cultures', each one with its own norms and practices. For example, the gap between the 'two cultures',[13] the humanities and the natural sciences, is still perceived as a major obstacle for creating a common sense of belonging to a united community of people dedicated to research. Yet, the focus of the humanities is to understand the role of the human element in a broad variety of aspects of life: "The Humanities focus on 'the human element' in the physical, biological, mental, social and cultural aspects of life. They attempt to provide insights into how knowledge arises from the constant interaction between individual and society."[14]

All fields and disciplines of science have undergone significant changes and are confronted with new challenges regarding both the creation of trustworthy knowledge, and contemporary notions such as Open Science or Grand Challenges.[15] The challenges are, per se, interdisciplinary. The humanities and social sciences have a key role to play in bridging the gap between domains and disciplines. Achieving cohesion and synergies between different kinds of knowledge may be a way to enhance trustworthiness of research. In this perspective, a better integration of the humanities and the natural sciences could be a way of enhancing trustworthy research.

The communication of scientific results should, as far as possible, always be negotiated with the larger societal context it is embedded in. These cultural and community values may differ significantly between countries, but also between different classes, genders, ages, ethnic and religious groups within a single country. Even where scientists may have sought and received the individual consent of their research subjects, they may lack a collective consent of their larger target groups, leading to skewed or rejected research and ultimately a loss of trust.

For a true cross-disciplinary research culture to be successful over different methodological, cultural and social contexts, we might have to acknowledge that we are still at an early stage of developing such a culture, where research communities are only beginning to work together and value one another. Thus, we require an even bigger effort within the research community to train scientists in a way that they become aware of the 'bigger picture' in which scientific research is embedded. Moreover, a systematic inclusion of social sciences and humanities in research funding grants would

12 Mittelstrass, J. (2012), Science and Values: on Values and Credibility in Science and Scholarship, *Rendiconti Lincei. Scienze Fisiche e Naturali 23 (1)*: 29-33, p. 29.

13 The expression 'the two cultures' is the title of an influential essay by the scientist and novelist Snow, C.P. (1959), *The Two Cultures*, London: Cambridge University Press.

14 European Science Foundation Standing Committee for the Humanities (2007), *Position Paper 2007, p. 5.* http://archives.esf.org/fileadmin/Public_documents/Publications/SCH%20Position%20paper_01.pdf (accessed 5/12/2018).

15 The European Union is focusing on six Grand Challenges: Health, demographic change and wellbeing; Food security, sustainable agriculture, marine and maritime research and the bio-economy; Secure, clean and efficient energy; Smart, green and integrated transport; Climate action, resource efficiency and raw materials; Inclusive, innovative and secure societies. See Kuhlmann, S. and Rip, A. (2014), *The challenge of addressing Grand Challenges*, https://ec.europa.eu/research/innovation-union/pdf/expert-groups/The_challenge_of_addressing_Grand_Challenges.pdf (accessed 5/12/2018).

encourage scientists further to consider the transdisciplinary aspects of their research.

Reason and Rhetoric

The natural sciences have long been perceived to be the dominant, if not the exclusive, voice in the acquisition of valid, universally applicable, knowledge. The most audacious claims were made by the logical positivists at the beginning of the 20th century, in their dismissal of all forms of knowledge production other than the analytic and natural scientific.[16]

The loss of trust in science has typically been portrayed as a trend to be countered by 'public education' in this line of thought. Such explanations are consistent, despite growing recognition of the complexity and contingency of science-society interactions. As indicated in Discussion Paper #1, when applied to societal trust in science and expertise, the 'information deficit model' derived from such an overly rationalist perspective has proven to be insufficient. Affective and contextual features that influence scientific priorities should also be taken into consideration, aiming at 'civic epistemologies', that is, "understandings of what credible [knowledge] claims should look like and how they ought to be articulated, represented, and defended", in order to achieve a mode of production of science that meets citizens' expectations and emotions.[17]

In addition to reason, rhetoric becomes important for scientists and communicators of science. Reason and rhetoric, although often opposed, may in fact be used in complementary fashion. Reason and logic, Thomas Hobbes long ago posited, needed to be supplemented with the art of rhetoric if opponents were to be persuaded.[18] Scientists in areas of controversy need to accept that knowledge and reason alone do not suffice to generate public trust in scientific findings. Rhetoric, therefore, is increasingly important for scientists to convince the public of scientific evidence, as is the appreciation of social and cultural values in communicating science. A better fluency in communicating science must be developed not only for communicating science to a non-scientific audience, but also within the scientific community in order to strengthen the sense of a collaborative endeavour to face the challenges collectively that an uncertain and changing future poses to researchers and citizens alike.

Science communication should also address the intrinsic uncertainty of scientific results and present it as a strength instead of a weakness of the scientific method. Scientific research could then be widely perceived as a way of enhancing critical thinking and reaffirming the importance of reasonable scepticism in society. It would furthermore help people to get a more realistic and thus better picture of the world and to foster a science-related societal debate.

Scientists, particularly natural scientists, working on controversial matters such as climate change, nuclear energy, fracking, or genetic modification, need to acknowledge that the logic of their reasoning and veracity of their conclusions mostly carry no, or very little, inherent executive authority vis-à-vis society at large. To capitalise on epistemic trust, they need to become better versed in engaging with the public from the beginning, in communicating with different societal groups and within the scientific community, thereby enhancing the affective and emotional persuasiveness of their research, while not compromising basic scientific

16 Cf. Carnap, R. (1967), *The Logical Structure of the World: Pseudoproblems in Philosophy*, Berkeley: University of California Press.

17 Jasanoff, S. (2005), *Designs on Nature: Science and Democracy in Europe and the United States*, Princeton, NJ: Princeton University Press, p. 249.

18 See Skinner, Q. (1996), *Reason and Rhetoric in the Philosophy of Hobbes*, Cambridge: Cambridge University Press.

norms. This is an extremely important but difficult and time-consuming challenge, particularly in political and societal environments that are too often hostile to rationally informed modes of persuasion and prefer tendentious and interest-driven judgements over critical assessment. In any case, one should not confuse scepticism, critique or even hostility with irrationality. Both exist, of course, but they are separate phenomena and should be carefully distinguished.

A new Philosophy of Science?

A renewed Philosophy of Science is needed today to bridge the gap between the intuitive 'trust in science' and the need of a normative theory that provides a detailed analysis of what it means to 'trust' in science. Traditionally, Philosophy of Science dealt with the foundations of scientific concepts, the relation between science and truth, the demarcation between 'science' and 'pseudo-science', the methodological problems of verification/falsification, the use of models, and the varieties of scientific inferences (deduction, induction, abduction, etc.). In addition to these classical issues, a normative Philosophy of Science today addresses the issue of trust and the place of science in society. Why do people trust or distrust science? How do they trust? Do they trust the authority of scientists? Do they rely on their reputations? How is science constructed collectively? What are the reliable inferences that may be drawn collectively?

The philosophical sub-field of social epistemology is particularly promising in this perspective, and has tackled the questions of the collective dimension of knowledge and its social responsibilities as well as provided epistemologically sound definitions of what it means to trust in science, within the scientific community,[19] and between scientists and citizens.[20] Further efforts should be made in this direction to provide an encompassing normative framework of trust in science.

Risks of Scientific Publishing

The recent evolution of the modes of production and transmission of science are also influencing trust in science, not only from the perspective of the general audience, but from the scientific community's standpoint. Today, the way in which scientific knowledge is produced and transmitted has been dramatically affected by a series of recent transformations, such as the management of peer-reviewed journals as a business enterprise on one hand and the 'bureaucratic' style in managing the system of research funding by the various funding agencies, public and private.

The scholarly publication cycle has been driven by the scientific paper as its fundamental unit of publication. The scientific paper is a format of scientific communication that allows the development of an incremental mode of scientific production, each paper adding a piece to the overall picture. This mode of production of science undoubtedly has been one of the most enabling inventions of modernity and therefore has remained very stable over many centuries. By making reports of single experiments or minor technological advances possible and accessible for many, peer reviewed papers published in scientific journals shaped science. "Scientists from that point forward became like social insects: They

19 See, for example, Hardwig, J. (1991), The Role of Trust in Knowledge, *The Journal of Philosophy*, 88: 693-708.

20 See, for example, Goldman, A. (1999), *Knowledge in a Social World*, Oxford: Oxford University Press.

Box 2: Techno-societal transformations affecting scientific production and publishing

- Changes in the dynamics of literature-based research caused by the revolution in information and communications technology.
- Changes in the interconnectedness of the scientific literature, due to the collaborative mode of knowledge production typical of 'Big Science'.
- Biases and perturbations in the network of publications created by the introduction of new indexes and other bibliometric measures, such as citation indexes and impact factors.
- New forms of control and accountability introduced by governments and funding agencies on the production of scientific knowledge and, most notably, the introduction of an audit and evaluation culture in national academic systems.
- Evolving business models for the publishing industry.
- Changing academic career tracks influenced by stronger commercialisation of academia and competition for impact.

made their progress steadily, as a buzzing mass."[21]

Today, more than 50 million peer-reviewed scholarly articles have been published all over the world.[22] The way in which this immense and rapidly expanding corpus of knowledge is produced and transmitted has been transformed dramatically in the last decades by a series of techno-societal changes. The most important ones are listed in box 2.

The effect is that science today increasingly resembles an entrepreneurial business rather than a contemplative, disinterested activity.[23] Accordingly, scientific research is no longer exclusively governed by a set of differing norms to those that distinguish it from the productive activities of society. These effects can be traced back to the clash between the spontaneously generated norms of the academic system and the norms generated by the adoption of new modes of mass production of knowledge. The new dynamics of knowledge production enter an idiosyncratic system that borrows features from the market but has profound differences and specificities that are deeply entrenched within the academic culture. Altogether, these changes also contribute to a shift in the perception of scientific research by society.

The broader changes brought about by this clash can be summarised as follows:

- The increasing transformation of researchers into entrepreneurs and the extension of managerial vocabulary and practices to the realm of research.
- The use of indicators and rankings combined

21 Somers, J. (2018) The Scientific Paper is Obsolete, *The Atlan-tic*, online source: https://www.theatlantic.com/science/archive/2018/04/the-scientific-paper-is-obsolete/556676/ (accessed 5/12/2018)

22 Cf. Jinha, A. E. (2010), Article 50 millions. An Estimate of the Numbers of Scholarly Articles in Existence, *Learned Publishing*, 23: 258–263.

23 Cf. Shapin, S. (2009), *The Scientific Life: A Moral History of a Late Modern Vocation*, Chicago: University of Chicago Press.

with an apparent decrease in the importance of peer review and new models of research resource distribution.

» Stronger and broader individual competition as well as competition between academic institutions in part spurred by the university ranking system.

» The creation of new control institutions and mechanisms.

The new system of scientific evaluation ties all these elements together. The outcome is a series of intended and unintended effects on the production and dissemination of scientific knowledge that profoundly impacts public trust in science. Intended consequences range from practices of self-citation to multi-authorship attribution, strategies to earn visibility in the citation system, strategic choices of publishing in any peer-reviewed journal to raise the citation figures,[24] and 'salami slicing' of scientific papers.[25] Unintended consequences include biases in the Science Citation Index (SCI) and its Impact Factor (IF), biases in the ranking systems, anchoring effects (relying too heavily on an initial piece of information), and heterogeneity in the practices of authorship among the various disciplines.

Overall, we face a big transformation in the publishing of scientific knowledge, which, at its worst, can be gamed by its users or biased by its structural features to their own benefit. For example, unnecessarily large numbers of cross-citations to other articles from within the same journal in order to raise the impact factor of said journal may not be an illegal practice, like, for example, plagiarism is. They resemble more the practices of boosting your website's search engine optimisation or trying to improve your online reputation.[26] Yet, they disrupt some of the fundamental norms of science, like disinterest, and create an unnatural measure of 'excellence' that is detached from the judgement of peers.

Open access literature, defined as "[d]igital, online, free of charge, and free of most copyright and licensing restrictions",[27] bears both hopes and illusions regarding the problems outlined. Currently, we witness the shift from a 'public' to an 'open' system of science: 'publication', that is, the idea of making the results of science 'public' through the introduction of a special format of publication for science with its own rules (the peer-reviewed journals) is shifting towards the 'open' model of science, in which publicity of research is not only a way of 'constructing objectivity through public debate', but also of overcoming the obstacles to the diffusion of knowledge created by the concentration of scientific publications in a few big private groups."

Deceptions and problems are closely related to the evolution of and wider access to the Internet within the last 15 years: new potential dangers concerning the exploitation of personal data and the rise of a parallel market of fake and 'predatory' journals. These necessitate a rethinking of the aims of making scientific results widely accessible. Are openness and accessibility basic values of science? And, if so, what norms and practices should we resort to in order to provide the widest access to science?

Especially in times of Big Data science, scientific papers often depend on chains of computer programmes that generate, clean up and plot data, and run statistical models on data. Scientific methods evolve with the speed of hard- and

24 Cf. Hyland, K. (2011). The Presentation of Self in Scholarly Life: Identity and Marginalization in Academic Homepages, E*nglish for Specific Purposes 30 (4)*: 286-297.

25 Cf. Norman, I. and Griffiths, P. (2008), Duplicate Publication and 'Salami Slicing': Ethical Issues and Practical Solutions, *Int J Nurs Stud, 45*: 1257–60.

26 Cf. Caon, M. (2017), Gaming the Impact Factor: Where Who Cites What, Whom and When, A*ustralian Physical & Engineering Sciences in Medicine, 40(2)*: 273-76.

27 Suber, P. (2012), *Open Access*, Boston: MIT Press, p. 4.

software development; the skill most in demand among physicists, biologists, chemists, geologists, even anthropologists and research psychologists, is the ability to operate programming languages and 'data science' packages. This creates a need for new competences in science, in so-called Data Management, which, in turn, will deeply transform how science is traditionally conceived and perceived by the public. A better communication strategy explaining how data are shared and re-used by scientists is thus needed to ensure trust in science.

More generally, new practices of sharing results and communicating how research is generated are needed in order to give a better grasp of 'what scientists do' and what their publications aim to achieve. Videos, public events, debates, occasions of interdisciplinary exchange can be in many contexts more effective to communicate science and raise one's own recognition even within the community of researchers than a mere accumulation of publications in peer-reviewed journals. However, these new practices of communicating science also come with their own risks and are discussed in more detail in a subsequent discussion paper.

Ethics as a Shaping Asset

The role of ethics in scientific research is often regarded as setting limits that may sometimes be perceived as a hindrance to innovation. Ethicists are supposed to be doubters and, at worst, doctrinaires. Their guiding questions are perceived as limiting questions such as: what is an acceptable way of doing research, taking into account ethical obligations towards, for example, the research subjects? Are we allowed to do everything we can do? Where do we set limits to innovation and technological change? However, the core concern of ethics is different: it is about shaping science for the good of individuals and society. Ethics must be viewed as the broad normative human enterprise of evaluating what is right and wrong according to universal principles that go beyond the subjective experience.

The inclusion and more institutionalised attention to ethics in the conduct of science is still relatively recent. Consequently, its complex role in any governance framework of science is still developing. It mainly started with the implementation of commissions and committees addressing ethical aspects, e.g. of research on human subjects, of gene technology or biobanks. Numerous reports and governance policies have been written and set up since then, including in the biomedical sector, the energy sector, and with regard to environmental issues. National Ethics Committees have been established all around the world. They mainly deal with biomedical research, health and life sciences, but some of them also address issues of animal research, environment, energy and so on.

At the end of the 1980s, ethical, legal and social aspects – so called ELSA – became the subject of research programmes themselves. These studies were initially added to those projects dealing with the human genome in the realm of the Human Genome Project in the United States. Since then it has become increasingly common to set up ELSA programmes in large scale research programmes, not only in genomics but also in other scientific areas such as nanotechnology and systems medicine. In Europe, the notion of ELSA research has been reshaped into the concept of Responsible Research and Innovation (RRI) in European research funding programmes.

Still, ethics is and should be something more. Rather than setting limits and being a separate companion of science as in ELSA programmes, ethics needs to be framed as an inherent part of science from the beginning and throughout the whole scientific process. To provide an example, this is currently not the case for procedures regarding the European Commission's grant schemes. Experts responsible for the ethical evaluation receive the project proposals once they have already been approved by a scientific committee. This process of ex-post ethics assessment sequentially following the scientific assessment should be revised, and both should be treated together.

As a truly inherent part of science, ethics would be involved in posing the right questions, in asking the questions correctly (prioritisation of topics, the study design, fostering a participatory approach by engaging the public, like in the many experiences of 'citizen science'), in the way of gaining data and the way of reasoning; in interpreting insights and data in order to produce knowledge by contextualising and by scrutinising assumed concepts; in reporting and publishing; in prioritising the questions asked and the projects pursued with due concern for their social and ethical implications; and, last but not least, in shaping the way of applying new knowledge and technologies as well as in exercising oversight. That is what ethics can do within science.

At the same time, by engaging with it this way, ethics does something important for science. Ethics ensures that scientists are aware of the relation between science and values. It can foster the credibility of scientists. It cannot guarantee truth, but it can ensure that research is carried out in good faith and thus fosters a truth-oriented attitude and, in the end, creates trustworthiness. Eventually, ethics contributes to the social contract between science and society. It should not only come after or work in parallel. Rather, it should be an integral part of the endeavour from the beginning and throughout the entire scientific process starting with the research question and grant design, all the way to the publication and application of the research results. Box 3 highlights

Box 3: Embedding ethics in the full research cycle in four steps

1. Framing the research question

Framing the research question means to decide which kind of answer and what kind of evidence one is trying to get. For good reasons, there is a strong right to freedom of research. Researchers do not have to justify ethically or otherwise what they are looking for as long as they do not violate fundamental rights. Nevertheless, science is not an isolated area with only a one-directional duty of society to support science and let scientists do what they want. Rather, there is also a responsibility placed on organised science, no less than other key institutions of the modern world, to consider social welfare, the public good and public perceptions. If one takes pharmaceutical research as an example, the ethical input required is to choose the outcomes that are most relevant to the patients' welfare rather than to the profits of the pharmaceutical company. This means that from the very beginning of a clinical study defining the research question and, thus, the focus of the outcomes should be on patients' needs.

2. Choosing and designing methods, e.g. for collecting data or for reasoning

The research question leads to the study design and to the selection of methods and instruments. The social interrelation between science and society is highly relevant, e.g. for identifying or developing adequate questionnaires or for choosing appropriate inclusion and exclusion criteria in clinical or social research studies.

3. Interpreting data and insights in order to produce knowledge which also entails contextualisation and scrutinising involved concepts like autonomy, culture or human nature

Once intermediate or definite research outcomes are available, researchers should take into account their given context and especially reflect on their potential implications, including possible unintended consequences when reporting about their research. This implies an obligation to provide adequate opportunities for those concerned to deal with these consequences. Science cannot opt out and simply leave it to society and politics to think about the impact. Rather, it must be involved in shaping that debate and foster it.

4. Designing frameworks for translation and application of scientific results, and exercising oversight and continuous technological assessment

The important contributions of ethics to designing legal and policy frameworks, for translating innovation, as well as exercising oversight is broadly acknowledged. These frameworks should be drafted by multi-cultural and multi-disciplinary groups of researchers and should contribute to maintaining a lively debate on the ethical principles that inspire and guide research.

four steps to make ethical considerations an integral part of the research cycle.

Developing an ethical culture and ecosystem of research means at least two different things: on the one hand, researchers must share internal ethical principles on scientific practices, that is, ethical norms about how science is produced. The previous sections of this paper address questions about scientific practices that are relevant to rethinking the ethical norms of research that must be at the core of science as an activity. On the other hand, scientists, from the outset of their projects, must show awareness of the ethical and societal dimensions of their research, and attempt to contribute with their work to the construction of a more ethical society. Science is not 'neutral': its advancements shape not only our vision of the world, but also, and increasingly so, how we live in this world. A critical awareness of how science impacts our societies and their values, how it resonates with them, is thus essential to produce 'good' science and enhance trust in the potentially enormous benefits of science for society.

Finally, there are four functions that ethics as a shaping asset might and should have throughout the scientific process:

» Ethical thinking can legitimise the scientific endeavour not only by balancing chances and risks but also by making transparent the reciprocal value between science and society. It therefore strengthens the social contract between science and society.

» Ethical thinking contributes to conceptualising research, for instance with regard to the prioritisation of topics, the study design, fostering a participatory approach by engaging the public and individuals concerned, translation into and with society, and making science transparent in its relation to socially relevant values.

» Ethical thinking plays a significant role in clarifying relevant goals, and in evaluating methods and results, when morally relevant goods like health, well-being or security and justice are concerned.

» Finally, ethics represents the moral value part in developing norms for the whole scientific process and its implications.

Concluding Reflections

The aim of this paper has been to analyse some possible causes of loss of trust in science that derive from internal dynamics of scientific research practices and suggest remedies that address the need of new norms within the scientific community and in the interaction between science and society. The three main areas of concern analysed here are: (1) the role of the humanities and of a human-centred, cross-disciplinary way of thinking in reshaping the norms of science; (2) the role of new dynamics of scientific publishing in communicating results within the community and evaluating the impact of research; and (3) the role that ethics should play in research practices and in orienting science as an enterprise geared toward the construction of a better world.

Regarding the need for a cross-disciplinary reshaping of the norms of science, this paper underpins the necessity of continually building up trust and respect among different domains of research and different scientific disciplines. Inter-, multi-, and transdisciplinary research might be one of the ways to build up 'trustworthy knowledge' aimed at the individual and society at large. It might also help us bridge the gap between knowledge and action, and build up links between the past, the present, and the future. The question of how to foster and develop it remains an open one.

Pertaining to new scientific publishing and communication practices, this paper emphasises the importance of closely monitoring the role played by bibliometrics and other recent transformations in the scientific modes of production in fostering or endangering the trustworthiness of research and experts. In this context, there is a need for better communication about how data are shared and re-used by scientists.

Concerning the role of ethics in research and science, this paper affirms the importance of integrating ethical aspects of scientific research at all levels of research by injecting an ethical perspective from the onset and fostering an ethical literacy within the scientific community that goes beyond the mere mechanical application of some ethical 'check lists' and ethical guidance and contributes to the ethical development of scientists and citizens.

In short, scientists need to work their way out of their hermetic boxes, self-critically engage in ensuring high levels of research integrity in themselves and among peers, as well as flexibly and openly be aware of different disciplinary, cultural and social contexts. They must find a way to complement reason with rhetoric when communicating science, thereby taking affective features in the establishment of trust more seriously, without softening well established standards of research integrity. Further reflection on values, beliefs, emotions, cultural and local traditions is needed.

We should ask ourselves the question whether and how structures and processes for internal integrity mitigate external trust. When the communication of scientific results is not embedded in, or somehow fails to consider social and cultural norms, or when it leads to an oversimplification of the scientific process, the public may be inclined to respond in kind by disregarding the complexity of performing scientific research, and subsequently question the expertise and trustworthiness of those who conduct it.

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