International Science Council
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PUBLIC PERCEPTIONS AND UNDERSTANDINGS OF SCIENCE:

FROM INTERNATIONAL CONTEXTS TO INSTITUTIONAL RESPONSES

ISC Occasional paper
October 2021

International Science Council Occasional Paper, October 2021

This paper was commissioned by the International Science Council (ISC) as a contribution to its programme on the Public Value of Science, within which the public understanding of science is a critical theme.

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CONTENTS

EXECUTIVE SUMMARY

This paper aims to stimulate discussion for science academies and unions by exploring the structure and characteristics of engagement with science in the global public sphere, with public perceptions as the unit of analysis. The paper aims to reflect a global perspective, including both developed and developing countries. We outline key ideas and recent trends emerging from studies of science communication, including the links between communication and public perceptions. We briefly examine perceptions of science in relation to the COVID-19 pandemic and climate change. We conclude with the identification of potential areas for further research, and implications for research institutions.

The analysis identifies some areas for ongoing deliberation:

- Research institutions should normatively support science through the changing context of social media, echo chambers, and the dynamic interaction between perceptions and information. In addition to the challenges of this 'decentralised' communication, much scientific inquiry increasingly interrogates public values. It is crucial then that institutions and research programmes should continue to cultivate the capabilities required to make sense of the vast landscape of online discourses, in order clearly identify areas of concern, opportunity, and intervention.

- Public perceptions of science are increasingly entangled with issues of social justice – justice in terms of the distribution of wealth, opportunities, and privileges within a society and the structural relationships around communities more broadly. We also increasingly see that history and narratives of identity shape the experience of science. The research community needs to reflect on its collective mandate and the function of the global science system, and whether social justice can or should form part of norms for strategic and communications agendas.

- Transcending the operating principle for many research institutions that the public lacks scientific knowledge, and we should remedy this by providing more, and correct, information, is an ongoing challenge in science. The research community needs to decouple its mission for education from the reproduction of structures or practices that continue to exclude or marginalise groups of citizenry. This points to the importance of growing support for citizen engagement and public participation in ways that value local knowledge and allow scientists to learn from the public.

- In an information environment that provides increasing space for anti-science narratives, the research community must cultivate narratives – and practices - that strengthen the value of science by reinforcing the social contract between science and society.

- The research community needs to interrogate the ways institutions and programmes can demonstrate their positions as honest brokers of scientific information, and representatives of scientific consensus, to bolster public confidence in science. This is challenging in a context where the opening of science allows for more engagement with anti-science agendas and so requires innovative ways to safeguard trust and identify those seeking to abuse goodwill.

- Public perceptions of science are a function of both diverse realities and identity. While science literacy does have an impact on attitudes towards science, social, political and economic variables have considerable effect. Conditions of scientific and technological development, religion, education, standard of living, and political orientation all have significant, but complex, impacts on public perceptions of science, including trust in science, and perceptions of controversies such as the COVID-19 pandemic and climate

change. In this regard, perceptions of science can be understood as cultural constructs. Scientific institutions would benefit from continued reflection, debate, and research on the complexities of the many 'cultures of science' across the world. The diversity of science cultures around the world defies the use of simple taxonomies, models, and correlations. Different contexts require different models for understanding perceptions of science. Close working relationships with national and regional science bodies are therefore required in order to design and implement effective communication and engagement models and strategies.

- A lack of institutional support and incentives constrain scientists' communication and engagement activities. Frameworks and programmes should consider ways of working with its constituent partners to reduce these barriers.

- Research institutions can play an important role in influencing public perceptions, and public policy, during the COVID-19 pandemic. Understanding the structural relationships between public perceptions of COVID-19, pandemic-related health behaviours, socio-economic variables, and science communication, should underpin the communication and engagement strategies of these institutions. A key strategic aim should be to counter anti-scientific, populist, and conspiracy theory narratives in the public sphere. However, this requires institutional design for trust. So, strategies should not only be reactive – they must extend beyond countering narratives, establish new frames for understanding phenomena, and build relationships which acknowledge their position and the position of local communities.

- The research community plays an important role in in developing actionable pathways to address and mitigate the cascading risk of climate change. Continuing to communicate scientific consensus about climate change should form one part of the broader mission strategy to counter anti-science narratives that undermine public perceptions and behaviour with regards to climate change. The increasing role of scientists in climate advocacy should be encouraged, recognising this could mean engaging with 'adversarial influencers' with vested interests.

- Finally, the research community should reflect on its own 'culture of science'. How does it position itself amidst institutions of power and concepts of legitimacy? Given its international constituency, what possibilities can be imagined for forging an international position on the role of science in society? Science is a considerable force for globalization itself. What do current standards imply about science as a Global Public Good and as a civic responsibility? How would this community forge a consensus statement about the meaning, value, impact, and authority of science and its many facets in the current geopolitical context? Such deliberations underpin strategic and tactical questions for the ISC and the science academies and unions that constitute its membership.

1. THE PUBLIC SPHERE OF SCIENCE

Against the backdrop of what is increasingly described as a climate emergency[1] and a pandemic, the institutions of science have been thrown into the spotlight. We find ourselves – not for the first time – living at a juncture in history in which the institutions of science are challenged to engage with the public and the institutions of power in order to save the planet and its population. Many other important debates, which had headlined public attention prior to the pandemic, remain significant: artificial intelligence, automation, social media, biodiversity, vaccination, and genetic modification, amongst others, each raise discourses that continue to unfold in the conversations of the public, in the media, and in the corridors of policy-makers. In an era of information overload, how do research institutions, in both natural and social sciences, make sense of their role within these debates, and within these social structures? How do we differentiate between the signal and the noise?

We can start by identifying the more easily accessible signals. A helpful illustration is the US context where in January 2021, US President Joe Biden announced that the White House Office of Science and Technology Policy would, for the first time, be a Cabinet-level agency[2], and that Alondra Nelson – a black female sociologist of science – would take up the position of Deputy Director for Science in Society[3]. These changes appear to signal an epistemological, cultural, political, and ideological shift from anti-science populism towards pro-science consensus in Washington DC; they signalled that American science policy could embrace gender and racial diversity; and they signalled that science policy can and should be informed both by natural scientists and by social scientists with expertise in science as a social and political system. It is important to acknowledge however that the United States has a relatively high level of COVID vaccine resistance, fluctuating between 30% and just under 50% nationally over a 10-month period from 2020 – 2021[4].

The vaccine rate in the US reflects a duality in the public discourse; a substantial minority who have a different perspective on the nature and purpose of the global scientific consensus and even the social justice agenda calling for diversity in scientific practice. The combination of surveys and policy appointments indicates that the responses to science are deeply rooted in cultural and political debates, subject to shifts in ascendancy and profoundly connected to social phenomenon. Science, and the sense-making around it, exists in a post-consensus world.

The nexus of policy, science and public discourse is highly dynamic - changes in the ways that political authorities signal their positions to the public occur all over the world, every day, whether in major geopolitical powers or a small developing country, in ongoing dialectics between the institutions, cultures, and authorities of science and their countervailing movements – those forces described as anti-science, and interest groups for whom scientific institutions and cultures present an obstacle.

Science, and the sense-making around it, exists in a post-consensus world.

Moreover, debates about science are, within some publics, framed by changes in consciousness of and demand for social justice and accountability[5]. This requires the surfacing of and engagement with debates about social justice issues, such as the links between racism and

1 ISC does not use the term 'emergency' but this raises an important question, referenced elsewhere about how the organisation understands it's work in relation to advocacy, activism and social change framing. For instance, what is the ISC position on the Nobel laurate statement on climate change https://www.nationalacademies.org/news/2021/04/nobel-prize-laureates-and-other-experts-issue-urgent-call-for-action-after-our-planet-our-future-summit?
2 https://www.washingtonpost.com/science/2021/01/15/biden-lander-ostp/
3 https://www.nature.com/articles/d41586-021-00159-z
4 https://www.cnbc.com/2021/02/10/biden-covid-vaccine-anti-vaxxers-us.html
5 https://sitn.hms.harvard.edu/special-edition-science-policy-and-social-justice/

clinical trials[6], racial disparities in the COVID-19 pandemic[7], and racial discrimination in AI-enabled technologies[8]. These challenges present difficult terrain for the science institutions, which have a clear science mandate and may have statues that reference 'freedoms'[9] in the practice and benefits of science but whose outputs and programmes operate through consensus and therefore underplay inequities and contestations of power in practice. This means that science institutions may be regarded as apolitical or wary of championing an explicit social justice mandate. This raises an important set of questions: in what way might science academies or unions identify, frame, debate, and communicate the links between science and social justice?

Typically, many science communication programmes are designed around the notion of a 'public sphere of science', underpinned by the conceptual framework developed by Jurgen Habermas to understand the relationships between public perceptions, communication, and policy formation within a framework of institutional actors and their relationships. Institutional actors include the public, the media, and policy-makers, as well as other stakeholder institutions: interest groups, firms, civil society, education, and research institutions, amongst others. The three dimensions of the public sphere are related through multiple causal channels – for example, the media (both 'centralised' and 'decentralised'[10]) influence public conversations and perceptions, public perceptions influence policy formation, the policy environment regulates the media, and the news value of media outputs depends on public perceptions.

Habermas's notion of the public sphere has itself been subject to critique and has limitations for making sense of public perceptions[11]. This critique has included challenges to the assumptions that the public sphere upholds social democracy and holds the abuse of power to account. Moreover, the notion of the public sphere emerged from historical analysis of bourgeois socio-political spaces and requires adaptation to take account of contemporary communication modalities such as social media. Nonetheless, the notion of the public sphere has been adopted by sociologists of science as a heuristic for understanding public and policy support for, or resistance to, aspects of science and technology[12]. The institutions of science are in turn fragmented along lines of, inter alia, disciplines, technological orientations, national interests, commercial interests, and ideology. The International Science Council (ISC), as a global institutional intermediary body, plays an important convening role in this public sphere. The organization has set itself the strategic aim of increasing awareness of science as a global public good amongst publics, policy-makers and decision-makers. This is a challenging task: the institutions of science are increasingly confronted with the dissemination of misleading and biased information[13], which undermine the social contract between science and society, and undermine the work of science institutions[14]. The pace of digitalization means that the political and media environments are increasingly fragmented, polarized, dynamic, and characterized by information overload as the line between audience and producer blurs[15]. This is further compounded by a lack of reflexivity for many scientific institutions about their approach to science communication and, indeed, their expectations of public engagement with science.

This paper aims to stimulate discussion amongst research institutions by exploring the structure and characteristics of science in the global public sphere, with public perceptions as the unit of analysis. We examine how public perceptions and understandings of science differ around the world, and how they have been changing, and provide some possible explanations to account for these differences. The paper has a global perspective, including both developed and developing countries. We outline key ideas and recent trends emerging from studies of science communication, including the links between communication and public perceptions. We briefly examine perceptions of science in relation to the COVID-19 pandemic and climate change. We conclude with the identification of potential areas for further research, and implications for institutions like the ISC and its constituency.

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6 https://sitn.hms.harvard.edu/flash/2020/racism-and-exploitation-in-phase-i-clinical-trials/
7 https://sitn.hms.harvard.edu/flash/2020/racial-disparities-in-covid-19/
8 https://sitn.hms.harvard.edu/flash/2020/racial-discrimination-in-face-recognition-technology/
9 https://council.science/what-we-do/freedoms-and-responsibilities-of-scientists/
10 https://fee.org/articles/how-the-centralized-media-lost-its-power-over-the-people/
11 Ingram, 2016
12 Bauer, 2002
13 Scheufele and Krause, 2019
14 Iyengar and Massey, 2019
15 Andrejevic, 2013

2. PUBLIC PERCEPTIONS OF SCIENCE

Public perceptions are a composite, consisting of a wide array of knowledge, attitudes, dispositions, and mental models. Perceptions of science include the full spectrum of knowledge about the scientific process and institutions, knowledge about particular scientific concepts, science literacy, and social aspects of science. They include attitudes towards science in general, attitudes towards scientific domains (such as biotechnology, astronomy, or physics), attitudes towards scientific controversies, and even attitudes towards the authority of science to make epistemological claims. These knowledge and attitudinal perceptions are mediated by a wide range of social structures, most notably the media, cultural contexts, and social stratification. For example, at the individual level, science knowledge and attitudes towards science are strongly influenced by which sources of information about science are used, by the prevailing cultural framing of science, and by political orientation.

Figure 1: Literacy to perception

2.1 INSTITUTIONAL INTENTIONS AND COMMUNICATION MODELS

Efforts to understand public perceptions of science have a rich intellectual history[16]. Early efforts to measure and understand public perceptions of science focussed on science literacy, working on the assumption that greater knowledge about science would lead to more positive attitudes towards science, more constructive public uptake of scientific advice, and the facilitation of appropriate science policy. This approach was later identified as the ‘deficit model’, in which the public were seen to have a knowledge deficit, and the primary aim of science engagement and communication was to narrow that deficit.

The deficit model has since been challenged, both conceptually and empirically. Conceptually, it has been argued that public knowledge should not be normatively judged in this manner; instead, citizen knowledge should be valued, citizen engagement should be participative, and knowledge flows between science and the public should be bi-directional. Empirically, decades of research have yet to reveal any overarching or linear description of the relationship between knowledge about science and attitudes towards science, and has instead uncovered a wide array of variables that manifest in different ways in different contexts.[17] The internal consistency of attitudes towards science is poor, and the links between attitudes towards science in general and attitudes towards specific areas of scientific research are weak[18]: ’Responses to general attitude items do not allow the accurate inference of responses to questions about particular areas of scientific research. They predict attitudes towards useful and basic research most effectively but have little relation to attitudes towards other issues’[19]. Understanding public perceptions of science is therefore as much a qualitative sociological exercise as it is a quantitative social-psy-

16 Bauer, Allum and Miller, 2007; Miller, 2004
17 Bauer, Allum and Miller, 2007
18 Evans and Durant, 1995

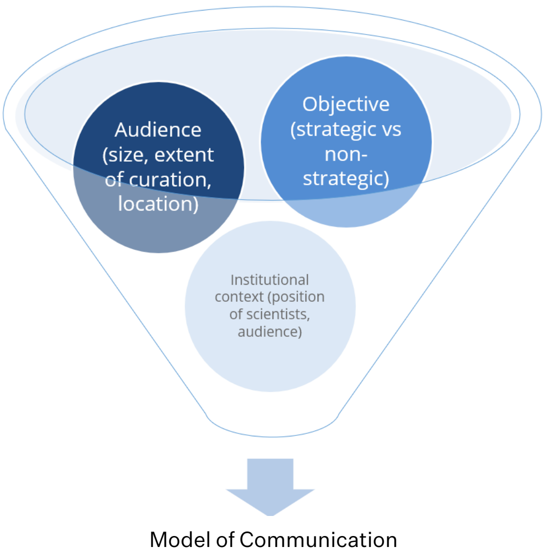
chology exercise – this balance is reflected in the section below exploring global trends from both perspectives.

Decades of research have yet to reveal any overarching or linear description of the relationship between knowledge about science and attitudes towards science

The significance of the process of socialisation in science has led to the emergence of other models of communication applied to science. Specifically, the 'dialogue model', which focuses on consultation, valuing the agency of the audience, and recognising other forms of knowledge to be negotiated with. There is also the 'participatory model', which focuses on the co-production of knowledge and creation of space for publics to set agendas and make institutionally significant decisions. Critiques of the deficit model have become common, and there is much written in the context of responsible science about the value of a deeper more transformative engagement with the public. Nonetheless, it is not helpful to overstate the extent to which the deficit model has been abandoned.

First, focusing on a specific archetypical model for the communication of science devalues the complex reality of institutional practice and the breath of the contexts in which the communication of science applies. The objectives for the communication of science vary, the institutional context varies, and the conceptualisation of audience varies. The diagram below sets out three variables that determine the model of communication. While there is often a normative driver, not all science communication is strategic, for example science journalism, or when scientists give evidence in a court of law. In both these cases there are clear objectives and conventions, but not necessarily the application of strategy.

Figure 2: Drivers of Science Communication Models



Public engagement with science covers a range of modes and does not denote any specific model of communication

19 Evans and Durant, 1995 p64

Distinguishing the mode of communication from the model of communication is important. The model is the framing of the relationship between activity, channel and audience(s) whereas mode is more about the channel and conventions of presenting content. For instance, science journalism can reflect a deficit model (where for instance we announce a breakthrough in cancer research) or it can reflect a participatory model (where a community radio station hosts a debate on plans for urban health and well-being). In this regard, the notion of public engagement with science covers a range of modes (effectively any communication with an audience located outside of the science community), similarly it does not denote any specific model of communication.

The second concern with overstating the abandonment of the deficit model is that it can lead to a focus on the less politically salient elements of any communication model. For dialogue or participation to be transformative, the models need to reflect intention, to demonstrate a commitment to re-distribute the power in the encounter and to move beyond engagement as an extension of capitalist expansion. In short, the communication of science should be about more than growing audience figures. Approaching efforts to engage unfamiliar audiences in a science or research institution with moral assumptions about the relative inferiority of the audience group, is not challenging power structures at large, it is reproducing the status quo and 'othering'. The focus then should not be on which model is being deployed, but about the elaboration of institutional context supporting engagement. Specifically, the frame of analysis for science communication should interrogate the intentions and the assumptions, which shape how trust is facilitated.

2.2 TRUST AND PUBLIC ENGAGEMENT OF SCIENCE

In the public sphere of science, anti-science populism has become increasingly significant, prompting efforts to conceptualize the relationship between populist politics and science. Science-related populism can be conceived of as 'a morally charged antagonism between an (allegedly) virtuous ordinary people and an (allegedly) unvirtuous academic elite, and that this antagonism is due to the elite illegitimately claiming and the people legitimately demanding both science-related decision-making sovereignty and truth-speaking sovereignty"[20]. Within populist narratives, conspiracy theories are a common trope. In the public sphere, conspiracy theorists battle with scientists for epistemic authority, and contest the modes of production of knowledge. Conspiracy theorists challenge the epistemic authority of science using narratives that undermine perceptions of science, focussing on 'the alleged dogmatism of modern science, the intimate relation of scientific knowledge production with vested interests, and the exclusion of lay knowledge by scientific experts forming a global power elite.[21]

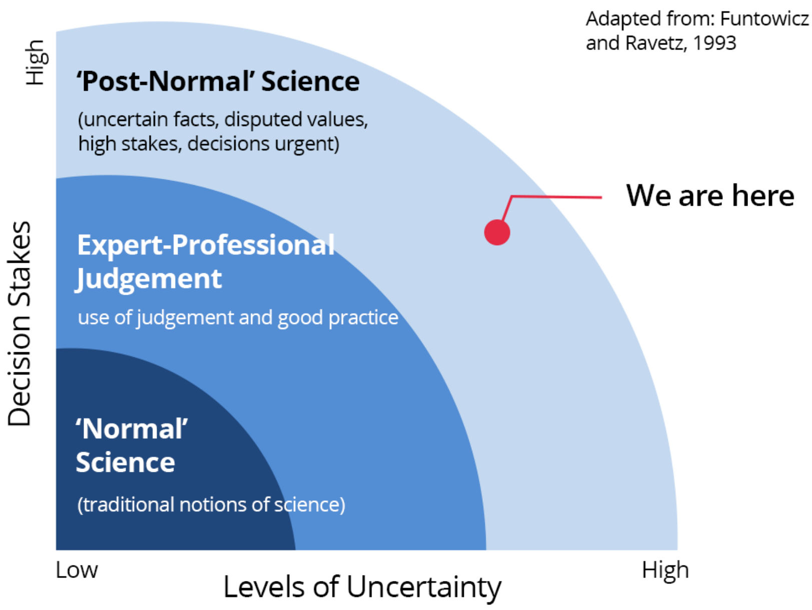
When populist actors and narratives undermine the authority of scientific institutions, they cause deep epistemological rifts. Refuting the authority of science as a source of valid knowledge runs against the principles of rationality and evidence as the basis of a consensus approach towards understanding reality. The destabilisation of knowledge is here driven by two historical phenomena.

The first is the emergence of what some commentators refer to as Post-Normal Science[22]. Post-Normal Science distinguishes itself from 'normal science' because its practice engages with a disputed set of factors (such as social values, political narratives, and economic order) and science is not meant to resolve all of these issues in its inquiry. A particularly resonant example is the scientific research around reducing carbon emissions. A significant feature of this post-normal framing is that uncertainty creates space for value disagreements and for 'adversarial influencers' to advance narratives which support their vested interests or worldviews[23]. Of course, not all research falls into this category but the research that does is having a significant impact on policy and public discourse, and this is the point of the 'post-normal' framing.

20 Mede and Schäfer, 2020, p473
21 Harambam and Aupers, 2015, p466
22 http://www.andreasaltelli.eu/file/repository/Editorials2.pdf
23 Lewandowsky et al, 2020

Trust is an institutional design problem in the post-normal science world. Trust arises from the interaction with policy, science, and publics, but many research programmes have a conceptual blind spot around the construction of this feature[24]. The assumption is that the researcher's expertise inherently warrants trust. This gives rise to a perverse paradox as on one hand, researchers indulge an authority afforded to scientific enquiry as a social institution, while assuming that in effect, science is ahistorical and apolitical. Science and the community practicing it have a social position and this affects the way their work is regarded, which in turn affects the extent to which that work is 'applied'. Engaging with that social positioning and the intentions around it, is the mechanics through which trust is manifested.

Figure 3: Post-Normal Science in Context



Destabilisation is also driven by digital transformation. In a world of information overload, it becomes more challenging to designate truth and trust. The traditional knowledge brokering, and gatekeeping functions of printing presses and broadcasters are long gone. Social media campaigns can with relative ease manipulate public opinion, often with regards to scientific matters, particularly when this may serve a political or commercial agenda. Geopolitics plays a critical role – geopolitical powers have the resources, capabilities, and incentives to wage 'information warfare' that undermines the institutions of science and the credibility of scientific consensus.

The question of trust in science is therefore critical – as has been recognized in the scientific institutions like the ISC – and in media discourses. Science cannot operate without society's trust[25]. A distinction must here be made between personal trust and institutional trust. Confidence is arguably a more appropriate term than trust when referring to public attitudes to institutions, including science[26] – confidence in institutions is a multidimensional concept which encompasses trust, but more broadly refers to citizens' perceptions that institutions serve public interests. Institutions of science commonly perceive themselves as 'honest brokers'[27], more likely to be sources of credible and objective information. This still stands amongst certain groups, but it is worth reflecting on why credibility is a contested value.

24 Sarewitz and Rayner, 2021
25 Weingart, 2018
26 Hardin, 2006
27 Pielke, 2007

3. MENTAL MODELS AND COGNITIVE BIAS

An analytically distinct approach towards understanding public perceptions of science has emerged from the study of cognitive behavioural change. The focus of this literature is on understanding the mental models used to make sense of the world, and how these are manifested in social settings. A particular focus is on cognitive bias - ways in which mental models have the potential to render inaccurate perceptions despite the availability of accurate information. An extensive literature has emerged from the domain of legal scholarship, interrogating the means by which legal objectivity can be enhanced by being mindful of cognitive mechanisms such as confirmation bias, selective information processing, belief perseverance, and the avoidance of cognitive dissonance[28]. These principles have also been applied to the scientific domain, for example by better understanding the anti-vaccination movement[29].

The empirical research that underpins the study of cognitive bias demonstrates that human beliefs are not only imperfect, but also resistant to change. Humans develop theories to better understand the realities they face, but these theories, once formed, are resistant to challenge or change, even when confronted with evidence that undermines the veracity of the theory[30]. When navigating the information landscape, people seek out and value information that confirms their existing theories and give relatively little consideration to information that disconfirms their incumbent theories. Another mechanism that causes cognitive bias is the desire to avoid cognitive dissonance. Inconsistency between one's external behaviour and internal beliefs creates an uncomfortable cognitive dissonance. To mitigate the dissonance, people will adjust their beliefs in a direction consistent with their behaviour and their existing self-perceptions.

Science institutions must grapple with the notion that ignorance may be both rational and highly motivated

Efforts to communicate science, and to shift public perceptions of science, must take such mechanisms into account. It is not enough to disseminate valid scientific information, or to assume that such information will change public perceptions in a rational manner, or in a manner that changes perceptions from counter-scientific to scientific. We need to consider existing belief systems, the ways in which they inform information selection and interpretation, and the dynamic balance between people's actions and their belief systems. The challenge is for science institutions and scientists to determine the extent of their role in this process.

Nonetheless, the deficit model persists – in which 'scientific ignorance' is seen as a result of a deficit of correct information. This mental model is consistent with scientific culture itself, which values evidence, learning, the production of new knowledge, and rational analysis. But it is not consistent with the mental models or behaviours of the public.

Science institutions must grapple with the notion that ignorance may be both rational and highly motivated: "Knowledge is just as often a liability as a source of power. Ignorance protects us from painful truths, insulates us from responsibility for our actions, and sustains the relationships that we depend upon for meaning and belonging. To understand and address societal ignorance, we must come to terms with such benefits... It is distressing to reflect upon one's flaws, a desperate situation, or a dark future, and we like to think of ourselves as good people in control of our lives whose advantages were justly earned. When knowledge drives us towards uncomfortable truths or conflicts with our moral self-image, we therefore often opt for ignorance".[31]

28 Burke, 2006
29 Burke, 2006
30 Lord, Ross, and Lepper, 1979; Snyder and Swann, 1978
31 https://blogs.lse.ac.uk/impactofsocialsciences/2021/01/13/to-communicate-scientific-research-we-need-to-confront-motivated-ignorance/

Reading this in conjunction with the evidence provided by surveys of public perceptions of science, it becomes clear that to understand how research and evidence are resisted by certain groups, we need to reflect on how ignorance is deeply embedded in our identities and in our social connections[32]. Scientific beliefs function as signals of group identity. To abandon such beliefs in the light of new evidence may mean losing one's position within a community. In some cases, where there is a history of using science to oppress or dehumanise groups, this distrust can also be understood as ignorance, but the community would see the consequence of misplaced trust as unacceptably high. This can push the public towards incorrect but socially adaptive beliefs – and acquisition of knowledge can constitute a threat to this adaptation. Such phenomena are described as 'strategic ignorance'. They can be observed in a range of contexts, from multinational companies to vulnerable indigenous communities, and are an increasingly accepted feature of global governance.[33]

The domains of climate change and vaccination provide good case studies of motivated ignorance in action. The scientific consensus on anthropogenic climate change is overwhelming, yet public denial and notional acceptance without commitment is sufficiently commonplace to prove an obstacle to key policy goals. Vaccines have saved millions of lives, yet the 'anti-vaxxer' culture persists. To understand why this is the case, we must acknowledge that positions that deny climate change or the benefits of vaccines are not based on neutral hypotheses: they are signals of group allegiance bound up with attitudes of distrust towards elite institutions, including those of science.

An important lesson for the science community is that its efforts to communicate and sustainably shift the perceptions of the public should not rely only on the correction of knowledge deficits. This pertains even in the contexts of epidemics. It is imperative that communication and engagement consider the interests and incentives that make knowledge costly or otherwise challenging for individuals.

32 https://blogs.lse.ac.uk/impactofsocialsciences/2021/01/13/to-communicate-scientific-research-we-need-to-confront-motivated-ignorance/
33 McGoey and Mallard. 2018

4. GLOBAL SURVEYS, LOCAL CULTURES

Public perceptions of science have been measured through a variety of national and trans-national surveys, utilising a wide range of methodologies and theoretical frameworks[34]. A key distinction here is between qualitative and quantitative ways of making sense of public perceptions of science. Qualitative methodologies focus on theorising connections between perceptions, culture, demographics, media usage, and other local contextual factors. Quantitative approaches have a greater focus on broad high-level deductions based on large-scale, mostly national, data sets. Both approaches are necessary, render different insights, and in some ways form a dialectic in which qualitative approaches challenge the conclusions of quantitative research, and vice versa.

As a consequence of the diverse methodologies used in surveys of public perceptions at national level, both the empirical and analytical approaches towards public perceptions of science are oriented towards the nation state as the primary unit of measure. However, public perceptions are not primarily defined by national boundaries, but rather by a range of other variables, including demographics, culture, identity, and political orientation. Both quantitative and qualitative research have honed in on the notion of localized 'science cultures' as a heuristic for making sense of the markedly different ways in which science is perceived in different contexts[35]. Looking across all these sources of data and analysis, a comprehensive quantitative analysis can be found in a recent publication of American Academy of Arts and Sciences (AAAS)[36]. The report presents a detailed account of variations in public perceptions of science around the world, as well as proposed causalities driving these variations, both at the national level and at the individual level. The AAAS analysis draws on a wide range of national and trans-national survey data sets, the most significant of which is the 2010–2014 World Values Survey[37]. The World Values Survey covers fifty-four countries and eighty-one thousand survey respondents and includes a range of questions testing public perceptions of science, including both science knowledge and attitudes towards science.

Comparisons of science literacy across the world reveal distinct patterns in different countries, each of which tell a local story. The task of making sense of these context specific stories is a large and daunting one – each knowledge construct, each culture, each context, is characterized by a unique fingerprint of public perceptions. Preconceptions about the roles of economic development, education, and culture can be challenged by such analysis. In the World Vaues Survey data, less than half of Americans reported belief in human evolution – less than in India (56%) or China (66%). While 91% of Canadians signalled an understanding of plate tectonics, only 40% of Russians did so. Most Canadians and South Koreans reported a belief that the universe started in a big bang, while in the USA, India, and Russia this was a minority view. The majority of respondents in the USA and Canada signalled a basic understanding of the difference between viruses and bacteria, compared to very low levels in Russia (18%), Malaysia (16%) and China (28%). While the purpose of this discussion paper is not to provide a comprehensive analysis of why science literacy has such complex, and sometimes unexpected, variation, a clear case can be made for localized research and analysis in this area.

Attitudes towards science are also characterized by complex and localized variation. Attitudes include beliefs about the promise of science and technology to improve society ('scientific optimism') and reservations about the impact of science and technology on traditional values and the speed of change ('scientific reservations'). These composite indicators provide insights into how science, broadly speaking, is perceived. The two indicators are independent: it is possible to hold strong attitudes of reservation and promise at the same time.

As with patterns of science literacy, some results can be surprising. The countries with the highest level of scientific optimism are Uzbekistan, Qatar, Rwanda, Kazakhstan, and Azerbaijan. In each of these countries, local history, culture, education, and communication

34 National Science Board, 2010; OECD, 2015; Rerimassie et al, 2015; Miller, Pardo and Niwa, 1997; Allum et al, 2008; Reyes, 2015
35 Pullman et al, 2019
36 Nisbet and Nisbet, 2019
37 Inglehart et al, 2014

Figure 4: Scientific literacy international comparison

(Figures reflect percentage of sample with correct answers)	United States 2014	Canada 2013	China 2010	EU 2005	India 2004	Japan 2011	Malaysia 2014	Russia 2003	South Korea 2004
The centre of the Earth is very hot. (True)	84	93	56	86	57	84	75	—	87
The continents have been moving their location for millions of years and will continue to move. (True)	82	91	50	87	32	89	62	40	87
Does the Earth go around the Sun, or does the Sun go around the Earth? (Earth around Sun)	76	87	—	66	70	—	85	—	86
All radioactivity is man-made. (False)	72	72	48	59	—	64	20	35	48
Electrons are smaller than atoms. (True)	51	58	27	46	30	28	35	44	46
Lasers work by focusing sound waves. (False)	50	53	23	47	—	26	30	24	31
The universe began with a huge explosion. (True)	42	68	—	—	34	—	—	35	67
It is the father's gene that decides whether the baby is a boy or a girl. (True)	59	—	58	64	38	26	45	22	59
Antibiotics kill viruses as well as bacteria. (False)	55	53	28	46	39	28	16	18	30
Human beings, as we know them today, developed from earlier species of animals. (True)	49	74	66	70	56	78	—	44	64
N	2,130	2,004	68,416	26,403	30,255	812–984	2,653	2,207	1,000

Source: National Academies of Sciences, Engineering, and Medicine, Science Literacy: Concepts, Contexts, and Consequences (Washington, D.C.: National Academies Press, 2016); and National Science Board, "Chapter 7. Science and Technology: Public Attitudes and Understanding," in Science & Engineering Indicators 2018 (Washington, D.C.: National Science Foundation, 2018)

https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-technology-public-attitudes-and-understanding/highlights.

have contributed to such perceptions. For example, the Rwandan public sector has taken on a strongly pro-technology narrative, which may have induced scientific optimism[38]. The countries with the highest levels of scientific reservations are South Africa, Ecuador, Mexico, Chile, and Colombia. One common characteristic of these countries is extraordinarily high economic and social inequality – perhaps linked to reservations about science as governed by and benefitting elites. In Africa, science could also be associated with colonialism[39], generating critical calls to decolonize African science by centring local and indigenous knowledge[40], particularly within the university context[41].

Another line of analysis is the examination of differences between levels of promise and reservation. China and Germany have comparatively high levels of optimism, and comparatively low reservations, signalling overall positive attitudes towards science. India and South Africa show the opposite – an overall negative attitude towards science. South Korea is close to the median on both scores, signally a more evenly balanced set of attitudes.

38 Nisbet and Nisbet, 2019
39 Guenther and Weingart, 2018
40 van Jaarsveldt, de Vries, and Kroukamp, 2019
41 Ndlovu-Gatsheni, 2017

These complex patterns of knowledge and attitudes raise the question of the connection between the two. However, while scientific literacy undoubtedly has an impact on attitudes towards science, they are not the primary driver – social, political, and economic variables have greater explanatory power[42]. In the AAAS 2019 report on global perceptions of science, the analysis of World Values Survey data through a one-way Analysis of Variance (ANOVA) model[43] shows that, after controlling for human, economic, and democratic development, publics in countries with greater scientific and technological development, as measured in terms of scientific publications, patents, and citations, tended to be more optimistic about science and technology. One potential explanation of this relationship is that of a virtuous cycle of optimism driving technological outcomes, which in turn strengthen optimistic attitudes. However,

Figure 5: Attitudes of scientific promise and scientific reservation international comparison:

Scientific Optimism			Scientific Reservations		
Country	Mean Score	Standard Deviation	Country	Mean Score	Standard Deviation
Uzbekistan*#	8.8	1.5	South Africa	6.5	1.7
Qatar*	8.6	1.6	Ecuador	6.4	1.7
Rwanda	8.4	1.0	Mexico	6.3	2.1
Kazakhstan*#	8.3	1.7	Chile	6.1	1.8
Azerbaijan*#	8.3	1.7	Colombia	6.0	1.8
Egypt*	8.2	1.5	Thailand	6.0	1.8
Pakistan*	8.0	1.8	Trinidad and Toba-go	5.9	1.9
Belarus#	8.0	1.7	Nigeria	5.9	1.7
Yemen*	8.0	1.8	Pakistan*	5.9	2.3
Kuwait*	7.9	1.8	Armenia*#	5.9	1.6
Estonia#	7.9	1.5	Ghana	5.8	1.5
Ukraine#	7.9	1.7	Turkey*	5.8	2.2
Poland#	7.9	1.9	India	5.8	1.7
Kyrgyzstan*#	7.8	1.8	Philippines	5.8	2.1
Georgia*#	7.8	1.7	Argentina	5.7	1.9
Armenia*#	7.8	1.9	Uruguay	5.7	2.0
Turkey*	7.8	1.6	Jordan*	5.6	1.9
Russia#	7.8	1.8	Romania#	5.6	2.2
China	7.7	1.6	Peru	5.6	1.6
Malaysia*	7.7	1.6	Kuwait*	5.6	2.4
Sweden	7.6	1.7	Singapore	5.4	1.6
Germany	7.6	1.7	Russia#	5.4	2.0
Australia	7.5	1.9	Ukraine#	5.3	2.0
Ghana	7.4	1.6	Lebanon*	5.3	1.8
South Korea	7.4	1.7	South Korea	5.3	1.6
Singapore	7.4	1.5	Cyprus	5.2	1.9
Romania#	7.4	2.0	Zimbabwe	5.1	1.9
Nigeria	7.3	1.5	Egypt*	5.1	1.9
Jordan*	7.3	1.9	Georgia*#	5.1	1.7
Tunisia*	7.3	1.9	Algeria*	5.1	1.8
Morocco*	7.3	1.9	Morocco*	5.0	1.5
Netherlands	7.3	1.5	United States	5.0	2.1
Cyprus	7.3	1.8	Estonia#	5.0	2.1

42 Nisbet and Nisbet, 2019 p
43 Nisbet and Nisbet, 2019 p27

Mexico	7.3	2.1	Malaysia*	5.0	1.7
India	7.3	1.8	Belarus#	5.0	1.8
South Africa	7.2	1.6	Spain	5.0	1.6
Slovenia#	7.2	1.8	China	4.9	1.6
Zimbabwe	7.2	1.8	Kyrgyzstan*#	4.9	2.2
United States	7.2	1.7	Azerbaijan*#	4.8	2.2
Algeria*	7.2	2.1	Kazakhstan*#	4.8	2.1
Trinidad and To-bago	7.1	1.9	Tunisia*	4.8	1.8
Ecuador	7.1	1.8	Brazil	4.7	1.9
Uruguay	7.1	1.8	New Zealand	4.7	2.0
Japan	7.0	1.5	Poland#	4.7	2.0
Argentina	7.0	1.7	Uzbekistan*#	4.7	1.9
New Zealand	7.0	1.7	Slovenia#	4.6	1.8
Philippines	6.9	2.1	Germany	4.6	1.8
Brazil	6.9	2.0	Japan	4.5	1.6
Spain	6.9	1.7	Qatar*	4.4	2.1
Thailand	6.8	1.7	Yemen*	4.2	1.7
Chile	6.8	1.8	Australia	4.1	2.1
Peru	6.7	1.9	Sweden	4.1	1.8
Colombia	6.7	2.0	Rwanda	4.1	1.0
Lebanon*	6.5	2.0	Netherlands	4.0	1.8

* Indicates Muslim-majority country; # indicates former Soviet Republic or Eastern Bloc country. Source: Data from Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

this explanation is speculative since statistical correlation does not provide a sound basis for inferring causality. As in other areas of enquiry regarding public perceptions, such limitations highlight the important role of qualitative research for understanding causality.

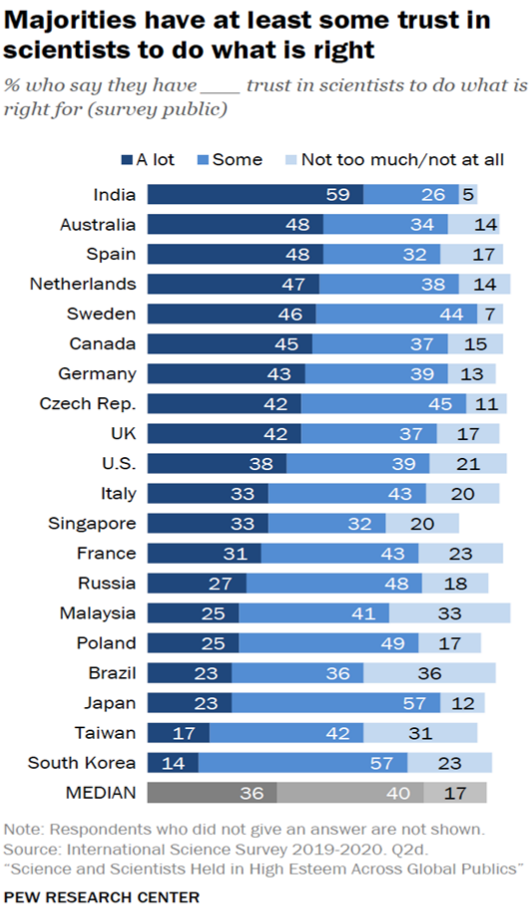
Orientation towards secular or religious values also plays a role. Populations in countries with more traditional values generally scored lower on scientific optimism and higher on reservations. Countries with publics oriented towards classical liberal values of democracy, free enterprise, free inquiry, and freedom of information expressed higher levels of scientific optimism and fewer reservations. These publics were more likely to seek and use information via digital media, more likely to express economic satisfaction, and had higher levels of confidence in universities, business, and civil society groups[44].

The AAAS report also presents intra-national analysis of World Values Survey data. Within rich countries, the least educated groups expressed higher levels of scientific reservations than the least educated living in poorer countries[45]. The authors speculate that less privileged groups living in rich countries fear that innovations will disrupt their jobs or otherwise threaten their communities. Highly religious groups living in rich countries expressed stronger reservations than their counterparts living in poor countries. One potential explanation is that a high material standard of living made religious publics in rich countries more sensitive to the normative trade-offs of science compared to their counterparts living in poor countries, where surviving poverty is a more immediate concern.

Indicators of public trust in science, like most perceptions of science, vary widely (see Figure 5). One of the few clearly demonstrable drivers of differences in perception is that of political orientation – with those on the more progressive political left being more trusting of scientists than those on the conservative political right (see Figure 6).

44 Nisbet and Nisbet, 2019
45 Nisbet and Nisbet, p4

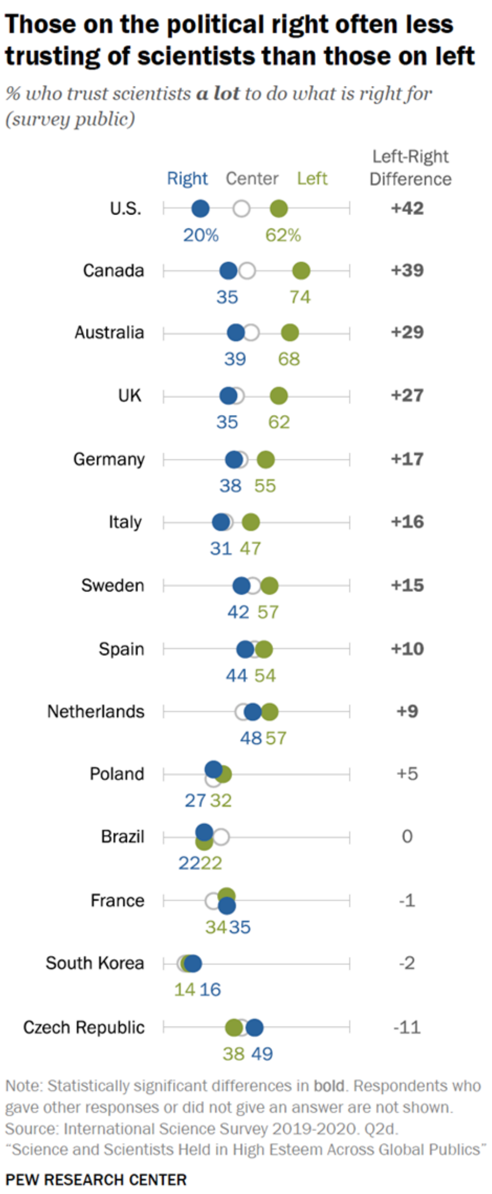
Figure 5: Attitudes of scientific promise and scientific reservation international comparison:



Source for Figure 5: https://www.pewresearch.org/science/2020/09/29/science-and-scientists-held-in-high-esteem-across-global-publics/

Source for Figure 6: https://www.pewresearch.org/science/2020/09/29/science-and-scientists-held-in-high-esteem-across-global-publics

Figure 6: Political orientation and trust in science 2019/20



The challenges of international comparative analysis are compounded when attempts are made to undertake dynamic or longitudinal analysis. The causes of changes in perceptions of science are most easily understood at the local level. Developing overarching theories at the national and international levels is extremely difficult. Efforts to undertake longitudinal analysis acknowledge these limitations, while identifying trends and theorising their causes. Longitudinal analysis of World Values Survey data from 1981 to 2014 across six countries (Chile, India, Japan, South Africa, Spain, Sweden, and the USA) has found an overall aggregate global positive trend towards greater scientific optimism and reduced reservation about science, but at the same time a high degree of national variation from this trend and distinct patterns of change in different countries[46]. However, Van Roten (2014) identifies several methodological challenges to undertaking longitudinal analysis of World Values Survey data. The use of well-established questions across multiple waves of the survey prevents the inclusion of questions testing specific hypotheses about contemporary issues, and there are concerns about the consistency and quality of data emerging from developing countries.

46 Van Roten, 2018

Making sense of these changes to public perceptions, particularly the attribution of causality, requires local and contextual insight. Here, international comparative qualitative analysis is a productive counterpart to quantitative studies, for example, the work of the Mapping the Cultural Authority of Science (MACAS) consortium[47]. Contextualized qualitative analysis can destabilize our understanding of public perceptions of science by arguing that the great diversity of science cultures around the world defy easy correlations, models, and taxonomies. A critical lesson from the MACAS project is that 'a single model of 'science attitudes' as a teleological end point of science culture is increasingly unrealistic if it ever was realistic. 'One shoe does not fit all', and different contexts require different models with different parameters, both in time and space'[48], and that science cultures do not fit neatly into categories of socio-economic development.

For example, in South Africa, science news has previously been focussed on issues related to AIDS and the Square Kilometre Array telescope as locally important debates. These debates took place in a context where the epistemic authority of science was publicly challenged, since a significant proportion of the population considered the institutions of science as seats of privilege and colonialism[49]. Efforts to influence public perceptions in South Africa would need to take these factors into account. In contrast, in Nigeria, religious and scientific authority contested over the issues of polio vaccination and Ebola[50].

In South Korea, positive perceptions of science are based on its practical contributions, rather than its epistemic authority[51]. In Taiwan, cultures of modernity find themselves interwoven with cultures of traditional 'superstition' in a manner that complements adherence to scientific facts but deviates from strict interpretations of scientific knowledge[52]. In India, the most commonly used model of science culture is Nehru's concept of 'scientific temper' as a key to understand the authority of science – a framework that validates the methods and institutions of science as an established part of Indian culture. Establishing this authority has been part of Indian nation building in the anti-colonial struggles of the 19th and 20th century[53]. Drawing on this model, statistical analysis has revealed that inequality, and particularly unequal education outcomes, are key determining factors in the 'cultural distance to science' – the gap between popular culture and the culture of science.

ISC's strategic approach cannot rest on a single overarching understanding of science culture

Longitudinal studies have revealed distinct dynamics in Latin America. In Brazil, analysis of data spanning the period 1987-2015 showed increased interest in science and attention to science. Persistent social stratification led to ongoing differences in perception among the privileged and the marginalized. Low levels of science literacy were correlated with higher expectations from science, while higher levels of science literacy led to a more critical approach[54].

Looking across the qualitative and quantitative analyses, it becomes clear that the ISC's strategic approach towards public perceptions of science cannot rest on a single overarching understanding of science culture, nor on a single global tactical response. While the organization must without doubt take on a position in relation to public perceptions (for example, to foster public trust in the process of science, and public confidence in the institutions of science), the way trust and confidence are culturally framed in different parts of the world differ widely, and the manner in which perceptions can be influenced in different contexts differs widely too. This suggests that a close working relationship with national and regional science bodies will be required in order to design and implement a global communication and perceptions strategy. Local intelligence, local research, and local engagement would be needed in each context in order to adequately understand local perceptions and inform localized communication and engagement strategies.

47 http://www.macas-project.com/
48 Bauer, Pansegrau, and Shukla, 2018, p380
49 Guenther and Weingart, 2018
50 Falade, 2018
51 Kim, 2018
52 Li and Tsai, 2018
53 Raza, 2018
54 Castelfranchi, 2018

5. COMMUNICATION, ENGAGEMENT, AND PERCEPTIONS

Media representations influence public perceptions of science and can tilt perceptions towards attitudes of promise or reservation[55]. Science news is part of the communication landscape, and certainly impacts on public perceptions[56]. However, the dynamics which shape the socialisation of science communication are more fully manifested in the social media, which have in turn fundamentally transformed science communication[57]. Science communication research has shown that social media can play a powerful role in fostering public trust in science[58].

Scientists are increasingly turning to social media to communicate with the wider public, motivated by the need to demonstrate impact and public engagement. On Twitter, scientists interact most intensively with their peers, but evidence suggests that scientists communicate strategically beyond the scientific community, primarily by adjusting their communication style to their audience[59]. Scientists use more neutral language when communicating with other scientists, but are more emotive when communicating with journalists, civil society, and politicians[60]. When communicating with politicians, scientists express higher levels of certainty[61]. However, communication practices differ significantly across disciplines. For example, compared to natural scientists, economists tweet less, mention fewer people, have fewer Twitter conversations with members of the public, use more jargon, and tend to favour traditional written media; on the other hand, natural scientists use a more informal style and engage wider audiences through multimedia contents[62].

Understanding the motivations of scientists is also important

A defining characteristic of social media is its interactive nature – science communication is not only about sending messages, but about receiving messages and responding. User comments can impact on the perceived trustworthiness and credibility of scientists' messages – particularly comments attacking researchers' motivations, which undermine the perceived integrity of scientists and scientific institutions[63]. Social media also create 'echo chambers' of confirmation bias – a phenomenon which also exists in the scientific community[64].

Science communication is often also political communication, particularly when it concerns politically contentious topics[65]. When science operates in the political arena, building trust in scientific institutions is arguably the most significant science communication challenge and imperative[66]. Increased trust in science can draw on the power of scientific consensus. Communicating high levels of consensus around scientific issues increases overall public perceptions of scientific certainty and is in turn associated with greater agreement and policy support. However, this effect is moderated by individuals' overall trust in science, and those with a low level of trust in science fail to perceive scientific consensus as indicative of greater scientific certainty[67]. There is additional value in conceiving of science communication as political communication. This allows the communicator to think of audiences as groups with shared – but specifically located – interests and identities. As we have seen in the global polling above, understanding public perceptions requires careful and historically sensitive disaggregation.

Building trust and confidence requires meaningful public engagement. This in turn requires moving beyond the deficit model, towards ways of engaging with the public that are participative, that value local knowledge, and that allow scientists to learn from the public. The scientific community sometimes struggles to integrate the communication of risk or uncertainty

55 Nisbet et al, 2002
56 Su et al, 2015
57 Brossard, 2013; Davies and Hara, 2017
58 Huber et al, 2019; Anderson et al, 2012
59 Walter, Lörcher, and Brüggemann, 2019
60 Walter, Lörcher, and Brüggemann, 2019
61 Walter, Lörcher, and Brüggemann, 2019
62 Della Giusta et al, 2021
63 Gierth and Bromme, 2020
64 Cote and Darling, 2018
65 Scheufele, 2014
66 Brewer and Ley, 2013; Weingart and Guenther, 2016
67 Chinn, Lane, and Hart, 2018

into their models because of the default framing of science communication as the exercise of 'imparting' knowledge, expertise, and certainty. However, the deficit model is persistent, and continues to characterise science communication. This can be overcome through appropriate training. However, graduate science education programmes generally lack formal training in public communication[68]. Efforts to improve science communication should include 1) training scientists in communication methods grounded in social science research, and 2) using approaches that engage community members about scientific issues.

Understanding the motivations of scientists is also important. While traditionally public engagement and communication have not been seen as core functions of scientists, this has changed over the last few decades. For scientists who are comfortable with communication and engagement, these practices might be beneficial for their careers – for example by becoming established as a well-respected voice that fights against misinformation in the climate change or COVID-19 arenas.

A study of South African scientists' communication behaviour[69] found that their field of research, career stage, age, gender, personality and population group, and attitudes towards communication platforms and the public all influence the way in which they communicate. However, overall, a lack of institutional support, incentives and recognition were identified as the main barriers which limit scientists' communication and engagement efforts. In many science institutions, incentives exist for the publication of journal articles and books, and for the supervision of postgraduate students, but not for public communication and engagement. This raises a question for science bodies regarding the incentives that science institutions create for communication and engagement, and whether these can be strengthened to enhance the local and global quality and scope of science communication.

The question of motivating scientists to constructively communicate and engage with policy-makers (in addition to the public) is strategically critical. Evidence suggests that self-perceived competence in navigating the science/policy interface is associated with a wider range of engagement, while past negative experiences act as a barrier[70]. Training programs linking scientists to policy have the potential to significantly strengthen scientific capacity to negotiate at the policy interface.

68 Simis et al, 2016
69 Joubert, 2018
70 Singh et al, 2014

6. CLIMATE CHANGE

Climate change is a critical issue of our time, and one in which the institutions of science have the potential to have a major impact on the future of humanity and our planet. As is the case for public perceptions of science, perceptions of climate change can best be understood in their cultural context.

In a broad meta-analysis of the correlates of belief in climate change[71], covering 25 surveys, 171 studies and 56 countries, many of the demographic variables that were expected to have a significant effect on perceptions of climate change (such as education, gender, subjective knowledge, and experience of extreme weather events) were not found to be the primary determinants of perceptions. Instead, cultural aspects predominated: perceptions were primarily determined by values, ideologies, worldviews, and political orientation. This underscores the insights gained from other studies of perceptions of science: that they must be thought of as cultural constructs. Similar insights were gained from a study of perceptions of climate change across 47 countries[72].

Empirical studies support common-sense notions of the relationships between climate science, politics, and perceptions. In the USA, a deep divide between the views of liberals and conservatives is widened by the effects of partisan media. Trust in scientists mediates the effect of news media use on perceptions of global warming - conservative media use decreases trust in scientists which, in turn, decreases the perception that global warming is happening. By contrast, use of non-conservative media increases trust in scientists, which, in turn, increases certainty that global warming is happening[73].

Globally, geopolitics plays a role in the media framing of climate change. For example, media coverage of COP21 was significantly influenced by the values of geopolitical powers in the international policy area: 'American media upheld the underlying norms that have long underpinned the existing Western-led order, while Chinese media coverage manifested a rising power in need of world recognition'[74].

Cultural cognition in combination with news media choices play a major role in contributing to opinion polarization on climate change and other politicized science topics. Individuals possessing strongly held cultural worldviews choose news outlets where they expect to find culturally congruent arguments about climate change, and selectively process the arguments they encounter[75]. Media analysis of Twitter posts demonstrates distinct framings in liberal and conservative states and nations, as well as the more common use of misleading and scientifically inaccurate framings by conservative publics[76]. At the same time, climate activists are cultivating new strategies for framing notions of climate change and climate justice in the public sphere[77], in the hope of influencing public perceptions and policy outcomes.

Against this backdrop of polarization and politicisation, the gravity of the climate change emergency has increasingly spurred climate scientists into playing advocacy and activism roles. For example, in the USA, the Trump administration's anti-science stance galvanized increased advocacy and activism amongst scientists[78]. This trend is somewhat of a departure from legacy concepts of the social role of science as a dispassionate observer, rather than a political and cultural actor. However, times are changing: a 2017 survey of American climate scientists found that that the large majority believed that it was their social responsibility to provide scientific input to both policy-makers and the public, and there was almost unanimous support for the implementation of evidence-based climate change mitigation and adaptation strategies[79]. A national survey of climate scientists found that their increased advocacy activity has generally been undertaken without significant risk to their credibility or to the credibility of their institutions[80].

71 Hornsey et al, 2016
72 Kvaløy, Finseraas, and Listhaug, 2012
73 Hmielowski et al, 2014
74 Pan, Opgenhaffen, and Van Gorp, 2019
75 Newman, Nisbet, and Nisbet, 2018
76 Jang and Hart, 2015
77 https://framingclimatejustice.org/headlines/
78 Marris, 2016
79 Getson et al, 2020
80 Kotcher, 2017

This raises questions: given the trend towards increasing amounts of research communication (including public engagement) at the level of research programmes, how will scientific institutions support more effective advocacy by individual scientists? What will be the future direction of norm setting institutions like the ISC with respect to science-based advocacy?

7. COVID-19

The COVID-19 pandemic is one of the defining science conversations of our time:

> Public health experts, virologists, epidemiologists, immunologists, infectious diseases experts, and increasingly also social psychologists and political scientists, have been challenged to advocate with confidence for social measures with wide effects even while their knowledge of the virus and the means to control or eliminate it is provisional. Either explicitly or implicitly they have been saying to their national and international audiences: This is the evidence we have. This is why we advise as we do. Trust Us. Political leaders, representing their societies, have claimed to be "following the science", even as it became clearer that the science is diverse and contested.[81]

A study undertaken for the London School of Economics and Political Science, and the UK Economic and Social Research Council[82] compared historical data, from 1970 to 2019, on the impact of epidemics on trust in science, including a Wellcome Trust survey of more than 70,000 individuals in 160 countries. One of the main findings was that individuals who experience epidemics at first hand retain confidence in the positive potential of science as an endeavour. They continue to believe in the importance of disease-related scientific research, but they are less confident about the trustworthiness and motivations of the individuals involved in scientific endeavours. Epidemic exposure reduces trust in scientists but does not undermine confidence in science[83].

Against the backdrop of this historical analysis, we can ask what the distinctive patterns of knowledge, attitudes, and socio-economic status are within the current pandemic. A variety of data points and studies from developed countries suggest that, on aggregate, the pandemic has brought about an increased level of trust in science[84]. Survey data from the Pew Research Centre[85] indicate that the British public value the expertise of scientists to a greater extent than before the pandemic. Survey data from the Wellcome Trust[86] indicate that, in the UK, the public has become more interested in hearing directly from scientists than they were before the pandemic. Data from 3M[87] indicate decreased scepticism about science during the pandemic. In Germany, trust in science has remained substantially higher during the pandemic than before[88]. In the USA and Canada, scepticism about science has decreased during the pandemic[89].

However, these aggregate changes in developed countries do not tell the full story. There are substantial differences both within developed countries, and within developing countries. In the context of the USA as a paradigmatic space of extreme socio-economic inequality, perceptions and behaviour are evidently mediated by socio-economic status. Health literacy gaps (tied to poverty) are correlated with lower levels of understanding of the implications of the pandemic[90]. Economic suffering, borne more heavily by the less privileged socio-economic strata, is correlated with increased refusal to comply with health guidelines[91]. The linkages between inequality, health literacy, health outcomes, political orientation, and public policy have created a highly charged COVID-19 science/policy nexus.

81 Askvall, 2021, p1
82 Aksoy, Eichengreen, and Saka, 2020
83 https://blogs.lse.ac.uk/impactofsocialsciences/2021/03/12/has-the-pandemic-changed-public-attitudes-about-science/
84 https://www.nature.com/articles/d41586-021-00542-w
85 https://www.pewresearch.org/global/wp-content/uploads/sites/2/2020/08/PG_2020.08.27_Global-Coronavirus_FINAL.pdf
86 https://wellcome.org/what-we-do/our-work/wellcome-monitor
87 https://multimedia.3m.com/mws/media/1898512O/3m-sosi-2020-pandemic-pulse-global-report-pdf.pdf
88 https://www.wissenschaft-im-dialog.de/en/our-projects/science-barometer/science-barometer-2020
89 https://multimedia.3m.com/mws/media/1898512O/3m-sosi-2020-pandemic-pulse-global-report-pdf.pdf
90 Singu et al, 2020
91 Rozentsvit, 2020

At this nexus, public attitudes towards science, and towards the science of COVID-19 in particular, play a critical role. On the one hand, an understanding of the basic scientific facts about COVID is important for shaping constructive public behaviour. On the other, counter-scientific and populist movements[92] are undermining both trust in science and the efficacy of scientifically backed interventions[93].

Many policy arenas are science-led in their response to the pandemic, and much of the global progress that has been made in terms of transmission prevention, treatment, and vaccination can be attributed to the institutions of science and their engagement with policy-makers and the public. However, this is not always the case. In the USA, the Trump administration's undermining of the advice of health authorities, and the Querdenker movement in Germany, are just two examples of a broader phenomenon of movements that have connections to the far right and defy pandemic regulations related to social distancing and wearing masks in public. Populist leaders have harnessed public fears and anxieties to their political benefit by challenging scientific expertise. The Brazilian president initially dismissed the pandemic as 'hysteria', claimed infection rates were inflated, ignored social distancing guidelines when meeting with supporters, and halted the public release of national COVID-19 statistics[94]. The Nicaraguan president and vice president called for a mass parade[95], a marathon, and food festival[96]. The Philippine president labelled those concerned about the coronavirus as 'fools'[97], and publicly made physical contact with supporters. Sri Lanka's health minister endorsed a herbal syrup manufactured by a shaman[98]. The Tanzanian prime minister, and the Madagascan president, both promoted an unproven herbal tonic[99], while the governor of Nairobi promoted increased consumption of cognac[100].

The rapid global spread of COVID-19 has been accompanied by what the World Health Organization has described as an 'infodemic'[101, 102]. Globally, public demand for information in the midst of uncertainty has created opportunities for the dissemination of myths, fake news, and conspiracy theories. For example, the varying public and political responses to narratives of the virus originating in a lab has been matched by contesting political agendas on the national and international stage. In some cases, the disinformation is harmless, but in many cases, it is life threatening, prompting the questions: how many people have died because of COVID-19 disinformation? How can disinformation best be countered? What should be the role of science in responding to these campaigns?

Varying responses to narratives of the virus originating in a lab has been matched by contesting political agendas on national and international stages

One important element is to engage and communicate more, both at the level of individual scientists, and at the level of scientific institutions operationalising considered communication strategies. By publicly countering misinformation about COVID-19, scientists positively influence public behaviour, and prevent policy-makers from introducing ineffective or harmful policies. Such actions ultimately save lives. A major focus should be on the countering of false medical claims about transmission, treatment, and vaccination. Institutional communication strategies will need to consider a wide range of strategic and operational factors, including

92 Mede and Schäfer, 2020
92 https://www.ifpri.org/blog/trust-science-and-government-plays-crucial-role-covid-19-response
94 https://www.nytimes.com/2020/04/01/world/americas/brazil-bolsonaro-coronavirus.html; https://www.theguardian.com/world/2020/jun/07/brazil-stops-releasing-covid-19-death-toll-and-wipes-data-from-official-site
95 https://www.atlanticcouncil.org/blogs/new-atlanticist/nicaraguas-response-to-covid-19-endangers-not-only-its-own-people-but-also-its-neighbors/
96 https://foreignpolicy.com/2020/04/17/ortega-virus-murillo-nicaragua-is-stumbling-into-coronavirus-disaster/
97 https://www.cfr.org/blog/coronavirus-and-rodrigo-dutertes-response
98 https://www.bbc.com/news/world-asia-55780425
99 https://www.voanews.com/covid-19-pandemic/madagascars-covid-19-cure-raises-pride-health-concerns-and-political-risks
100 https://www.cnn.com/2020/04/17/africa/kenya-governor-alcohol-and-coronavirus/index.html
101 https://www.who.int/news/item/23-09-2020-managing-the-covid-19-infodemic-promoting-healthy-behaviours-and-mitigating-the-harm-from-misinformation-and-disinformation
102 https://www.icfj.org/news/un-icfj-research-examines-covid-19-disinformation
103 https://www.forbes.com/sites/leahrosenbaum/2020/04/09/infowars-founder-alex-jones-must-stop-selling-fake-coronavirus-silver-cures-fda-says/?sh=3cc29d59541a

profiles of public perceptions and how these might affect the consumption of messages, public sources of information, the communication of scientific consensus or contestation, and ways to avoid the pitfalls of deficit models in the context of a real-time pandemic.

Strategy will also require insight into why disinformation is propagated. One element is financial profit. In many cases, disinformation is associated with treatments for COVID that have no scientific foundation, but which make a commercial profit – for example, the sale of colloidal silver in the US[103], and the sale of herbal remedies in Madagascar and Sri Lanka. Another important profit motive is advertising revenue associated with viral content. In a world where clicks can easily be converted into cash, demand for information is often untethered from the quality of that information.

Disinformation can also be politically motivated, such as the reports that virus originated in Wuhan Institute of Virology in China, or was a bioweapon created deliberately by one of the geopolitical powers. Actors in the USA, Russia, and China have all generated COVID narrative myths for political purposes. Such narratives present a challenge for scientists, as countering them requires a response that ranges beyond scientific matters. It may be the case that scientists have greater impact when countering myths that are not obviously political in nature. In the geopolitical disinformation arena, it may be more effective for scientists to partner with journalists, fact-checkers, and civil society when cultivating political strategies.

8. IMPLICATIONS FOR INSTITUTIONAL NORMS

Conceptualizing the role of the science institutions in relation to public perceptions and the public sphere requires that we think about scientific research in a cultural context, as an actor within the ongoing ‘culture wars’, in which values and norms are contested through both episodic and ongoing ideological confrontation[104]. It is not possible for scientific institutions to be neutral actors in this space since any position that is taken will be an ideological one. Strategy development will therefore require that institutions clearly define their own science culture, norms, values, epistemic authority, consensus points, narratives, and positions.

It is not possible for scientific institutions to be neutral actors in this space

Defining a ‘culture of science’ is a challenge since the use of any single model of science culture cannot be applied globally. Nonetheless, the function of scientific consensus-building does result in striking similarities across institutions. This reveals that research practice - including the necessary consortia-building – is a notable example of globalization. Institutions such as the ISC may therefore move towards a consensus position that finds broad agreement across the world’s major scientific institutions. In some areas this may be relatively easy – for example support for the scientific method and process as a valid source of knowledge. Other areas may be more challenging, particularly where the interests of national science institutions are at odds.

Potential points of departure for this process may be frameworks already developed by multilateral institutions, for example the UNESCO Recommendation on Science and Scientific Researchers[105]. This framework spells out consensus positions adopted by the UN structure

104 Hartman, 2015
105 https://unesdoc.unesco.org/ark:/48223/pf0000260889_eng#page=116*
106 The UNESCO recommendations make reference to the following ICSU statements: Statement on the Fundamental Character of Science; Charter for Scientists; On the dangers arising from unbalanced applications of the powers given by science (ICSU Committee on Science and its Social Relations (CSSR), transmitted to all members of ICSU at the request of the ICSU General Assembly at its 5th session, 1949); Resolution on free circulation of scientists (adopted by the ICSU General Assembly at its 14th session, Helsinki, 16-21 September 1972); Statute 5 entitled “Principle of Universality (Freedom and Responsibility) of Science” (2011); Sharing Scientific Data, with a Focus on Developing Countries (November 2011); Freedom, Responsibility and Universality of Science (2014).

in relation to, inter alia, the role of science in policy-making, science and skills development, rights and responsibilities in research, and framework conditions to support successful science. Moreover, the UNESCO framework has taken into account several positions of the ISC (then the ISCU)[106].

One area where the global community of science academies and unions need to find new common ground is in the effort to counter anti-science populist narratives, including those related to COVID-19 and climate change, amongst others. However, in this effort, it is critical that these institutions not retreat into reactive positions, in which the focus is on developing counter-narratives. A proactive position, in which the scientific community also focuses on deep reflection towards defining its own narratives about science and scientific issues, may be more significant in the longer term.

A particularly important lesson is that science cultures around the world are distinctly local. In developing strategies and tactics to communicate and engage with the public, it will therefore be necessary to work closely with partner institutions that have a greater presence in national and local public spheres. Partner institutions can foster greater engagement between science and local communities. Arguably, marginalized communities should receive increased attention, given that they have been historically excluded, are central to any social justice agenda, and stand to benefit from increased scientific knowledge. It will also remain important to undertake and synthesise ongoing localized qualitative and quantitative research into public perceptions of science.

Reflecting on the structure and characteristics of engagement with science in the context of the current global public sphere there are three dimensions that need particular consideration in articulating a proactive position for science. Specifically, this concerns the transformative quality of the engagement, the way that the public is conceived (particularly the disaggregation of audiences) and the ways in which institutions plan and design their programmes to manifest trust.

8.1 TRANSFORMATIVE ENGAGEMENT

Institutions will need to practice reflexivity around their public engagement by finding space to debate questions about who they are engaging, and whether the engagement is reproducing existing power disparities or creating opportunities for change. One practical way this can be done is through establishing programmes that support communities to lead public engagement. This will involve challenging the notion of expertise, by valuing more prominently the contribution that 'laypersons' make to the design of public engagement activities and structures. (An increasingly common example is initiatives for communities to play a key role in the architecture and curation of science centres.) Not all science communication needs to be strategic, but it does need to be intentional, which is to say institutions need to be clear about their normative agenda.

Challenging received ideas about knowledge systems requires innovative ways to 'negotiate' with other knowledge systems. This might involve extending the practice of transdisciplinarity to support community involvement in research as experts, not just subjects. It would also suggest documenting and building case studies where outreach work integrates with community belief systems. In effect this entails recognising that such belief systems (outside of the positivist framework) are an inescapable part of the human condition.

The study of science communication needs to be mindful of cultivating and preserving global perspectives in its pedagogy. This is part of an overarching need to understand the positionality of scientific research in social, cultural, and political models.

8.2 DISAGGREGATING AUDIENCES

It is useful to recognize that issues, even if they are transnational in origin or require international collective action, are felt in local and national spheres. There is value in science communication 'mediating' between a global scientific consensus and local structures.

Public engagement should be conceived as less for 'education' and more for social cohesion. Specifically, there should be an increased focus on accessibility and inclusion, in order to connect with and respond to social tensions. This might mean recognising that science communication is about delivering tools for making meaning, or addressing local concerns, rather than broadcasting messages. It also suggests differentiating the different levels of access and privilege 'local' groups have, and how that power is exercised. A strategic decision might be made to focus on those who are most vulnerable or underserved or to engage the powerful with a carefully supported agenda for change.

In decentralised media models typical of social media, audiences may also be producers of content. This provides an opportunity as some of the most successful science communicators in this new media landscape are 'mediators', a role which is less about presenting the science and more about interactively making meaning for specific groups.

8.3 DESIGNING FOR TRUST

The starting position here is to acknowledge and promote legislation for the public's right to be protected against being misinformed. Such a framework would benefit from the development of a set of trustworthiness measures (or markers in relationships, content and process) which audiences, policy-makers and science communicators could look to. It would also require the scientific community to develop mechanisms that identify 'bad-faith influencers' and separate them from open and constructive critique .

Science communicators also need to make a conscious effort to shift the frame about how the scientific endeavour works, for example moving away from the 'hero scientist' narrative which is subject to capture and counter-narrative. For instance, developing a story about scientific practice which makes clear all research requires global knowledge networks, collaborators and broad scientific consensus since the 19th century, challenges ideas about some research being more susceptible to co-option or manipulation. The hero narrative can also make it difficult for scientists to communicate uncertainty or failure. This failing can then be exploited to undermine their credibility.

Further research is needed on how to manage adversarial influencers. This would suggest supporting pilot initiatives that might inoculate the public against such campaigners. It would also be helpful to identify and incentivise institutions that are attempting to respond progressively (through programmatic approaches and training) to this 'post-normal' context for scientific research, supporting them with funding and prestige platforming.

The analysis identifies some areas for ongoing deliberation by the ISC:

- The ISC needs to support science through the changing context of social media and ensure this is reflected in its views of the manifestation of the public sphere and engagement with public goods.
- The ISC will have to consider how it supports researchers to engage the public and negotiate positions of social justice, in view of the impact that structural relationships, power and social positions have on public perceptions of science.
- Researchers need accessible models, frameworks and case studies to transcend received ideas about science communication and public engagement which indiscriminately de-value other knowledge systems and means of communication. ISC needs to consider how it profiles the importance of formal science communication training for science graduates.

- The ISC must cultivate narratives that strengthen the legitimacy of science and reinforce the social contract between science and society.
- The ISC must leverage its strategic strength of being perceived as an honest broker of scientific information, and communicate scientific consensus to bolster public scientific knowledge and confidence in science. This means drawing on science communication as a mode of political communication.
- The ISC would benefit from continued reflection, debate, and research on the complexities of the many ‘cultures of science’ across the world. The diversity of science cultures around the world defies the use of simple taxonomies, models, and correlations. Different contexts require different models for understanding perceptions of science. Close working relationships with national and regional science bodies are therefore required in order to design and implement effective communication and engagement strategies.
- A lack of institutional support and incentives constrain scientists’ communication and engagement activities. The ISC should consider ways of working with its constituent partners to reduce these barriers. This needs also to consider the operational importance of research programmes and consortia in the careers of scientists and the public engagement strategies for research, relative to individual institutions.
- The ISC plays an important role in influencing public perceptions, and public policy, during the COVID-19 pandemic. Understanding the structural relationships between public perceptions of COVID-19, pandemic-related health behaviours, socio-economic variables, and science communication, could underpin the ISC’s communication and engagement strategies. However, the ISC’s strategies must not only be reactive – they must extend beyond countering narratives, and encompass the development and propagation of the ISC’s own narratives about science, scientific controversies, and what these mean for the public.
- Finally, the ISC should reflect on its own ‘culture of science’. Given its international constituency and mandate, what possibilities can be imagined for forging an international position on the role of science in society? Can the ISC put forward a consensus statement about the meaning, value, impact, and authority of science and its many facets?

8.4 IN CONCLUSION

All of these strategic and tactical issues require the research community to reflect on its own culture, to debate the meaning of a ‘culture of science’ that can hold the centre at the global level, and to engage with coalition partners. At a time when the world is depending on the institutions of science to help solve its most pressing problems, such self-reflection and international co-ordination are strategic necessities.

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