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Is Science Able to Perform under Pressure?

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Abstract: Science has been an incredibly powerful and revolutionary force. However, it is not clear whether science is suited to performance under pressure; generally, science achieves best in its usual comfort zone of patience, caution, and slowness. But, if science is organized knowledge and acts as a guiding force for making informed decisions, it is important to understand how science and scientists perform as a reliable and valuable institution in a global crisis. This paper provides insights and reflections based on the experience of the COVID-19 pandemic and from an analytical perspective. In particular, we analyze aspects such as speed, transparency, trust, data sharing, scientists in the political arena, and the psychology of scientists—all of which are areas inviting more detailed investigations by future studies conducting systematic empirical studies.

Keywords: science under pressure; economics of science; trust in scientists; psychology of scientists; science during the pandemic

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"If your brain is too busy, you won't hear or see well".
Abraham Maslow (1966, p. 11)

1. Introduction

Historically, science is an incredibly powerful and revolutionary force, dispelling many of the unfounded traditional beliefs with often disastrous consequences; for example, witchcraft, illnesses attributed to sorcery or insanity due to possession by evil spirits, and the practice of human sacrifice [1]. Science is powerful because scientific progress and discovery build up over time in incremental steps [2] and because it follows a clear set of grounded rules in which it operates [3]. Doubt, for example, is a powerful tool that guides science through the process of questioning, refining, and replacing [4]. As Feynman [5] (p. 185) points out, science is "the result of the discovery that it is worthwhile rechecking by new direct experience, and not necessarily trusting the race experience from the past". Thus, science is organized knowledge [6]. Most of the work is performed by "normal scientists" who are "like those tiny marine animals building up a common coral reef" [7] (p. 2), and their diversity contributes to a healthy ecosystem. In this sense, it is "knowledge hard won, in which we have much more confidence than we have in opinion, hearsay and belief" [6] (p. 3).

However, science has also been criticized for its detachment from the person-in-the-street. For example, Dunbar [8] argues that science "has become a form of magic practiced by an élite priesthood whose members have been subjected to a long and arduous apprenticeship in secret arts and rites from which the layman is firmly excluded" (p. 7). Even fields with strong links to the 'outside world' have not been free of such criticism. For the field of economics, for example, Clower [9] (p. 23) stated that "[m]uch of economics is so far removed from anything that remotely resembles the real world that it is often difficult for economists to take their subject seriously". Mark Blaug [10] made important contributions related to the history of economic thought and the methodology of economics, noting that "[m]odern economics is sick; economics has increasingly become an intellectual game played for its own sake and not for its practical consequences" (p. 36). Also, several well-known economists and Nobel Prize recipients in economics have criticized their field for its lack of involvement in real life issues (for a discussion, see [11]). Shiller [12] points out that [u]ltimately, the objective of forecasting is to intervene now to change future outcomes for society's benefit", (p. xv) yet macroeconomic forecasts beyond a few quarters are often unreliable (p. xiv).

In addition, science tends to protect the methods, opinions, and innovations by those with inside access while barring outsiders, resulting in navel-gazing research questions of little import to society or even science as a whole [13]. Others criticize the endless repetition of old ideas in social sciences [14]. A division of labor promotes different ideas, instruments, and conclusions; nobody wants to listen to an orchestra with musicians who only play the bassoon or the oboe. Specialization is a result of prizing the production of knowledge [15], but an increasing overspecialization or insularity makes scientists unintelligible to each other and the public, ensuring nobody can see the whole picture [6]. Nobel laureate George Stigler [15] points out in his *Memoirs of an Unregulated Economist* that "[u]niversities cater to more highly specialized human beings than most other callings in life. If X is a great mathematician, he will be more or less silently endured even though he dresses like a hobo, has the table manners of a chimpanzee, and also achieves new depths of incomprehensibility in teaching. His great strength is highly prized; his many faults are tolerated" (p. 31). He adds, "I should not exaggerate the virtuous single-mindedness of the university's search for scholarly ability. Because of personal characteristics or behavior a maverick type like Thorstein Veblen or Abba Lerner found it much harder to receive the recognition his scientific abilities deserve" (p. 31).

The consilience of different fields and approaches to knowledge [16] aid in the understanding of real and human phenomena, particularly when exploring sudden and surprising shocks, changes, or crises [12]. Wilson [16] sees a reduction in the gaps between branches of science as a way of increasing the diversity and depth of knowledge, classifying the attempting to link sciences with humanities as the "greatest enterprise of the mind" (p. 8). Stigler [15] also acknowledges that Adam Smith "in fact severely condemned the narrowness of vision and thought that he believed would result from excessive specialization" (p. 33), even as he provided us insights of the power of increased division of labor.

The term science (scientia) is derived from the Latin term 'scire', which means to know, and while the pursuit of knowledge and understanding is noble in and of itself, it raises an important question: What do we want from science? Specifically, what is it that we and our societies want science to provide. For science to benefit humankind, it needs to have social function, i.e., some benefit outside of itself. John D. Bernal [17], for example, argued that science should contribute to satisfy the material needs of ordinary human life and that it should be centrally controlled by the state to maximize its utility (benefit). Others, such as John R. Baker, favored the more liberal free-science approach in the spirit of Bacon, who emphasized that "the advancement of knowledge by scientific research has a value as an end in itself" (Baker cited in [18], p. 46). This was echoed in Thomas Henry Huxley's (1887) reception of Darwin's newly published *Origin of Species*: "The known is finite, the unknown infinite; intellectually we stand on an islet in the midst of an illimitable ocean of inexplicability. Our business in every generation is to reclaim a little more land, to add something to the extent and the solidity of our possessions" [19] (p. 557). For none of us are clairvoyant enough to know what science will become useful and shape the future and which will be left on a shelf and forgotten by all but the original author. A perfect example of this was the creation of Boole's [20] *Mathematical Analysis of Logic*. Little did he or anyone else understand that his exercises in mathematical logic, which were completely useless (impractical) at the time, were to become the foundation of all modern computing and technology.

Thus, the question arises over whether such detachment from reality and the subsequent issues it raises may affect how scientists manage the demands for fast, efficient, and flexible knowledge generation in a crisis. If science is organized knowledge, science should also be functional in a crisis, a situation where feeding back into the decision-making process becomes essential. In other words, is science as an institution able to perform under pressure? A global crisis such as the recent COVID-19 pandemic is therefore an interesting situation or case study to analyze and reflect upon; scientists are challenged in a key part of their science, namely their judgment around what to observe and to which phenomena or information should they pay attention [5] (p. 173). Science, one would expect, would be able to provide valuable information and knowledge that can guide policy decisions in times of crisis. Good science must be versatile and adaptable while maintaining caution and skepticism [7]. A pandemic moves scientists away from their usual comfort zone of being primarily patient, cautious, and slow [7]. The "art of not making mistakes" is challenged. On the other hand, it also naturally attracts scientists to important problems, rather than remaining stuck in method-centered endeavors that are technically elegant but potentially less useful to society. We therefore aim to provide insights on the capacity and adaptability of science during the COVID-19 crisis. As we are interested in the immediate scientific response, we will only focus on the first couple of months of the pandemic.

2. Materials and Methods: Lessons from Past and Current Experiences

2.1. The Challenge of Speed during the Initial COVID-19 Crisis

Snowden [21] notes that, historically, "major epidemics caught authorities unprepared, leading to confusion, chaos, and improvisation" (p. 77). The urgency of a crisis and its pressing concerns automatically makes the public and the government impatient to find solutions. From a clinical perspective, for example, conducting trials of novel interventions during pandemic emergencies such as COVID-19 becomes increasingly important for the success in identifying potential vaccines or therapies and controlling the spread of an infectious disease [22].

Lessons from the testing of Ebola treatments indicate that research responses were implemented late, despite rapid protocol approval by ethics committees and the devising of transparent and pragmatic protocols. However, bureaucratic and logistical barriers slowed down the clinical trial phase [23]; for example, difficulties in deploying staff and delays over contracts were identified as key elements for the slowdown. Consequently, it was clear that the world needed to "be 'research ready' for the next outbreak" [23] (p. 30). Lang [23] suggested the assembly of an on-call global task force of around 100–200 clinical-trial staff, available for everyday studies and trained for outbreak research. Contractual agreements between parties with stakes in clinical trials are predictably required, which is something that can be addressed ahead of time using contract templates. Lang [23] also recommended a neutral, independent body that sets research priorities during an epidemic. Lang suggested the World Health Organization (WHO), but criticized the agency for lacking the necessary funds, mandate, and support. Similarly, Keusch et al. [24] suggested international coordination and cooperation for disease outbreaks. In developing countries, the limited local experience with clinical research and poor capacity for timely scientific and ethical review or negotiation of research contracts combined with differing views of trial designs and reactions was said to slow down the process [24]. In addition, volunteers may be fearful, vulnerable, stigmatized, and confused about goals, benefits, and risks of trials. Thus, a relationship of mutual trust between researchers and participants is required; otherwise, misunderstandings and resistance become the norm [24] (p. 2456). The US National Academies of Sciences, Engineering and Medicine [25] evaluated the clinical trials on Ebola in a special report, providing recommendations on how to improve the likelihood that important new information on therapeutics and vaccines are obtained in future epidemics. The key points of the report related to the development of sustainable health systems and research capacities in low-income countries; facilitation of data collection and sharing; facilitation of rapid ethics reviews and legal agreements; ensuring capacity-strengthening efforts that benefit the local population; incorporation of research into national health systems; prioritizing communication of engagement in research, and response and fund training; and research into community and coordinated international efforts [24] (p. 2456). The report also emphasizes the importance of maintaining ethical standards: "The high mortality of Ebola and the uncertainty about how the epidemic would progress produced a sense of urgency to quickly identify effective therapeutics or vaccines. Despite this sense of urgency, research during an epidemic is still subject to the same core scientific and ethical requirements that govern all research on human subjects" (p. 33). In addition, the report also recommended a Coalition of International Stakeholders, including representation from governments, WHO, academia, the private sector, humanitarian response organizations, and the countries and communities at risk [24] (p. 2457). To avoid being a "toothless tiger", the report recommended that such a coalition should secure financial resources to lead the effort and should have the responsibility and resources to convene a fast response. The WHO has developed guidance and tools on how to frame collaborations and exchanges. At the request of member states, it has developed a blueprint for accelerating research and development in epidemics or health emergencies to address situations with no or insufficient preventive and curative solutions (https://www.who.int/teams/blueprint/who-r-and-d-blueprint-for-epidemics, accessed on 1 April 2024).

London and Kimmelman [26] strongly criticize the attitude toward research exceptionalism during the COVID-19 crisis. Indeed, the initial preventive measures taken for the COVID-19 pandemic in many countries bore a significant resemblance to those implemented during the Spanish Flu pandemic a century ago. Furthermore, for China and some other countries, one could argue that a contemporary adaptation of a 19th-century quarantine system was put into practice—akin to the methods Victorian doctors might have employed to manage a tuberculosis outbreak in the pre-antibiotic era. Similarly, the pure concept of lockdowns echoes historical approaches to public health crises. To balance scientific rigor against the danger of speed, they urge following the five conditions of informativeness and social value of research proposed by Zarin et al. [27]: "(1) the study hypothesis must address an important and unresolved scientific, medical, or policy question; (2) the study must be designed to provide meaningful evidence related to this question; (3) the study must be demonstrably feasible (e.g., it must have a realistic plan for recruiting sufficient participants); (4) the study must be conducted and analyzed in a scientifically valid manner; and (5) the study must report methods and results accurately, completely, and promptly. Trials that do not meet all these conditions are very likely to be uninformative" (p. 813). In general, the number of studies on COVID-19 until the partial fading of the panic related the first wave (here, set around 1 May 2022) had quickly reached very high numbers (Table 1) compared to previous pandemics in total (see, e.g., SARS 2002–2003 figures). Unsurprisingly, a large share of published articles on COVID-19 were initially in the fields of medicine, immunology, and microbiology, or biochemistry, genetics, and molecular biology (also see Table A1).

A significant portion of these studies were based on initial data. Indeed, early in the pandemic, extensive data on the spread, hospitalizations, and deaths were made available online. The numbers of hospitalizations and deaths attributed to COVID-19, even though patients might have had multiple other conditions, were taken at face value. More critically, the accuracy of infection data was not necessarily consistently scrutinized in the early phases of research, such as numerous studies analyzing the pandemic's spread. This oversight is concerning given that the official infection figures are heavily influenced by testing strategies. As a result, the actual number of COVID-19 cases was likely significantly higher, potentially several times the number of reported cases. John Ioannidis, on 17 March

2020, was among the first to point out that decisions were being made based on unreliable data [28]. Eichenberger and colleagues [29], referencing initial WHO reports from March 2020, noted that an "estimated 80% of known COVID-19 cases are currently classified as mild" (p. 464), suggesting a focus on immunity certification by identifying all infected individuals. This approach also aimed to address the economic and societal consequences, such as lockdowns.

Table 1. Number of studies exploring different pandemics until 1 May 2020.

Field	Ebola	SARS (2002–2003)	SARS (Since 2002)	COVID-19
Medicine	3747	719	5369	2057
Immunology and Microbiology	1568	38	1840	243
Biochemistry, Genetics, and Molecular Biology	1280	151	2911	202
Social Sciences	562	15	523	100
Pharmacology, Toxicology, and Pharmaceutics	436	66	1399	93
Environmental Science	291	23	772	92
Health Professions	121	6	114	64
Nursing	223	27	176	60
Neuroscience	70	7	152	53
Engineering	148	54	585	40
Computer Science	119	10	277	37
Agricultural and Biological Sciences	688	88	2133	36
Multidisciplinary	431	34	388	35
Psychology	34		72	32
Mathematics	197	21	264	24
Dentistry	2	2	17	21
Business, Management and Accounting	78	40	204	21
Chemistry	189	47	1102	15
Energy	2		46	15
Chemical Engineering	79	20	243	14
Materials Science	68	32	239	13
Physics and Astronomy	78	24	344	13
Economics, Econometrics and Finance	43	7	65	11
Arts and Humanities	107	1	87	9
Decision Sciences	21	3	42	6
Veterinary	128	4	100	5
Earth and Planetary Sciences	30	21	475	1
Undefined	1		15	

Note: Scopus contribution based on a search conducted on 1 May 2020.

2.2. Partnerships between Government Agencies and Scientists

Particularly at the start, a crisis such as a global pandemic demands close interactions between scientists, government agencies, and politicians. However, building and maintaining this relationship has been challenging in the past. Medawar [6], for example, criticizes that "politicians tend to have a low opinion and an unaccountably resentful attitude toward science and scientists" (p. 19). Similarly, scientists are critical when it comes to politicians, with the former accusing the latter of being subject to an action bias (for more details on action bias, see, e.g., Patt and Zeckhauser [30]) [31].

Lack of an honest portrayal of partial knowledge can lead to dilettantism, quackery, and the failure to humbly listen—without presupposing, classifying, or approving or disapproving, or dueling with what has been said—and this can reduce credibility. In his book, titled *Epidemics and Society*, Snowden [21] concludes that "[p]lague regulations also cast a long shadow over political history. They marked a vast extension of state power into spheres of human life that had never before been subject to authority. One reason for the temptation in later periods to resort to plague regulations was precisely that they provided justification for the extension of power, whether invoked against plague or, later, against cholera and other diseases... With the unanswerable argument of a public health emergency, this extension of power was welcomed by the church and by powerful political and medical voices. The campaign against plague marked a moment in the emergence of absolutism, and more generally, it promoted an accretion of the power and legitimation of the modern state" (pp. 81–82). At the start of the COVID-19 crisis, the parliament in Hungary gave Prime Minister Viktor Orbán, for example, the right to rule indefinitely by decree. Dr Balazs Rekassy, a former manager of a state health clinic criticized that Orbán was trying to strengthen his power to create a long-term political advantage (https://www.nytimes.com/2020/04/05/world/europe/victor-orban-coronavirus.html, accessed on 1 April 2024). In a podcast with Sam Harris (*Making Sense*), the historian Yuval Noah Harari expressed his worries about the political situation in Israel (https://samharris.org/podcasts/201-may-1-2020/, accessed on 1 April 2024), stressing that even at the beginning of the crisis, Israel's prime minister used the situation as an excuse to try to shut down the elected parliament and rule de facto with emergency decrees. He received enough pushback to reopen the parliament to maintain a democratic balance. Indeed, the stat power expanded initially, and it took even beyond the advent of vaccines against COVID-19 to reduce government power, partly by courts judging the extensions as unconstitutional.

The politicization of scientific methods can be dangerous. Science is not some magic bullet that can slay the monsters that haunt us, nor can it solve all the world's ills with a wave of its microscopes. It can, however, inform and provide a range of options and solutions to problems, which might be feasible and might predict what the outcomes of them might be. In general science does not directly answer questions of what ethics, morality, fairness, or social acceptability should be—the social sciences sometimes report on what they currently are. The role of science is to advise politicians and, in particular, the public. It is not to rule or decree—that is the role of decision makers (democratically elected or not). Politicians have seen the power that science-backed evidence can have on public opinion, and its ability to sway or win over an argument. Unfortunately, "what politicians want is not evidence-based policy rather but policy-based evidence" [32] (p. 70). If science is abused for political gain and not society's benefit by, for example, cherry picking evidence that supports their beliefs (or pet policy) rather than examining all the evidence to create a functional policy has often been observed; the general public may also lose trust in science as many are not used to scientific terminology or methods applied to make science testable, repeatable, and falsifiable [33]. Feynman [34], for example, argues that we are not living in an unscientific age, "Sometimes when history looks back at this age they will see that it was a most dramatic and remarkable age, the transformation from not knowing much about the world to knowing a great deal more than was known before. But if you mean that this is an age of science in the sense that in art, in literature, and in people's attitudes and understandings, and so forth science plays a large part, I don't think it is a scientific age at all" (p. 63). Richard Dawkins, for example, provides a wonderful discussion on scientific terminology, "Confusion of a different kind is introduced by those who agree to abandon "theory of evolution" but try to replace it by "law of evolution". It is far from clear that evolution is a law in the sense of Newton's Laws or Kepler's Laws or Boyle's Law or Snell's Law. These are mathematical relationships, generalizations about the real world that are found to hold true when measurements are made. Evolution is not a law in that sense (although particular generalizations such as Dollo's Law and Cope's Law have been somewhat dubiously introduced into the corpus of Darwinian theory). Moreover, "Law of Evolution" conjures up unfortunate associations with grandiose overgeneralizations linking biological evolution, cultural evolution, linguistic evolution, economic evolution and evolution of the universe. So please, don't make matters worse by turning evolution into a law" (https://richarddawkins.net/2015/11/is-it-a-theory-is-it-a-law-no-its-a-fact/, accessed on 1 April 2024). The political abuse of science and the lack of scientific training in the political class can result in large-scale policy failures, as evident in the March 2010 eruption of the Eyjafjallajökull volcano in Iceland [32]. As soon as the eruption was detected, an instant no-fly zone was declared across Europe as volcanic ash can melt and destroy jet engines, but no one tested or examined the levels of ash in the atmosphere (which were much lower than any previous examination). Fairly quickly, the industry tested the ash levels and revised the safety threshold for ash in the air, and flights resumed—but not before immense economic damage was done. The government's response to the threat was to impose a blunt and heavy-handed knee-jerk reaction to safety that effectively cost the airline industry an estimated £2.2 billion. "We have been left with the impression that while science is used effectively to aid the response to emergencies, government attitude to scientific advice is that it is something to reach for once in emergency habits, not a key factor for consideration from the start of the planning process", the select committee concluded (quoted in [32], p. 87). This is not dissimilar in nature to the automatic lockdown measures that were seen as a response to COVID-19, particularly during the initial wave. Exceptions of broad lockdowns were rare but clearly not unscientific at the point in time (e.g., the case of Sweden), and particularly with the benefit of hindsight.

Scientists, in general, struggle with politicians' lack of patience and understanding for sound and credible assumptions behind the models and data when supporting policy choices. In a global crisis, in particular, it is challenging to strike a scientific balance between simplicity and concision or between total comprehensiveness and inclusiveness. Political pressure may lead to biases, such as wishful extrapolations driven by untenable assumptions. As Manski [35] (p. 27) stresses, "[w]hen researchers overreach, they not only give away their own credibility, but they diminish public trust in science more generally" (p. 27). Such damage can be particularly severe in a time of crisis. There is some ignorance or even "innocence" of handling human choices in situations that arise so infrequently, which produces planning and dilemma problems. Thus, partnerships between government agencies can be challenged during a crisis due to impractical and condensed time frames on alliances that otherwise require substantial efforts, investments, and adjustments when establishing an effective framework [36]. Social science research struggles with the unobservability of counterfactual outcomes in a crisis, and the lack of time or willingness to conduct systematically randomized field experiments hampers causal insights. Pandemics are extremely challenging to investigate from an empirical point of view due to the complex nature of social interactions. Thus, the risk of unequivocal policy recommendations increases. It is understandable that concerned citizens as well as civil servants, journalists, and politicians have a limited understanding of the prediction methods necessary to assess immediate dangers within a crisis. Derivation of reliable insights during a pandemic requires a never-ending interplay of theoretical abstraction and real data on lived experiences. The denial of doubt, confusion, or the lack of versality may affect the quality (or even the existence) of such an interplay. Although different studies might be coherent internally, studies conducted at the beginning of a crisis are (necessarily) subject to fragile foundations of weak data, which undermine their findings. In addition, crises demand a higher level of certitude and lower tolerance for ambiguity about the consequences of alternative decisions—which is a problem for science as policy predictions are often fragile [35]. Maslow [7] considers the ability to admit ignorance as a defining characteristic of an empirical or scientific attitude (p. 71). Even in normal times, we seldom find policy reports that chronicle, for example, interval predictions of policy outcomes. Manski [37] cites President Lyndon B. Johnson's response to an economist report offering a range for forecast values, "Ranges are for cattle. Give me a number" (p. 8). Ioannidis [31] discusses the implications of an action bias, "adoption of measures in one institution, jurisdiction or country creates pressure for taking similar measures elsewhere under fear of being accused of negligence. Moreover, many countries pass legislation that allocates major resources and funding to the coronavirus response. This is justified, but the exact allocation priorities can become irrational" (p. 2).

On the other hand, a pandemic can also change scientific norms. Many scientists avoid being subjected to imprecise, undefined, or even non-manageable problems. But a crisis may encourage acceptance and embrace of the mentality 'what needs doing, is worth doing even though not very well'. The first effort to research a new problem is often inelegant, imprecise, and crude [7] (p. 14). Such efforts help others understand what needs improving to advance knowledge in the area. In addition, if scholars are able and willing to reveal their experiences of uncertainty and ambiguity, faster feedback can be provided on how to improve knowledge. As Maslow states, "[S]omebody has to be the first one through the mine fields" (p. 14).

3. Results: A Contest over Priorities

Just like any other institution, science is subject to several pathologies driven by the reward system, pathologies that are often a mere expression of human nature. As Merton [38] emphasizes, "[o]ur religion, our moral fabric, our very basis of life are centered around the idea of reward" (p. 321). The contest over priority is a key one, and it was already discussed in great detail by sociologists such as Merton [38]. Major scholars in the history of science have been subject to hostile battles over priorities, revealing the supreme value of originality as a mechanism of advancing science. Newton, for example, fought battles with Robert Hook over priority in optics and celestial mechanics or Leibniz over the invention of calculus [38] (p. 287). Not even brotherly love can prevent such feuds, as evident in the repeatedly bitter attacks between Jacob and Johannes Bernoulli (p. 313). According to Merton, even the sensitive and modest Faraday was wounded by the claims of others to several of his key discoveries (p. 288). In addition, like other professions, science may attract ego-centered people who are hungry for fame (p. 290) or recognition (p. 293) as symbols of having carried out one's job well. Merton quotes Darwin who once emphasized that his "love of natural science . . . has been much aided by the ambition to be esteemed by my fellow naturalists" (p. 293).

It was natural that scientists in all domains were eager and impatient to contribute their efforts to our understanding of and coping with the global pandemic. Concerns with success in scientific work can lead to some negative effects in a time of a crisis such as COVID-19, effects that can deteriorate some academic standards. The competition for journal publication may encourage scientists to announce their results quickly, although, over time, the scrutiny of science will provide some readjustments of what is perceived as relevant: "The large majority of scientists, like the large majority of artists, writers, doctors, bankers and bookkeepers, have little prospect of great and decisive originality. For most of us artisans of research, getting things into print becomes a symbolic equivalent to making a scientific discovery" [38] (p. 316). A focus on later citations is also linked to social determinants [39]. Ioannidis [31], early on, flagged the dangers of exaggerated information and non-evidence-based measures. He provided examples of articles in *The New England Journal of Medicine* and *The Lancet*, indicating that even top journals are not free of sensationalism. He also criticized that "peer review may malfunction when there is little evidence and strong opinions. Opinion-based peer review may even solidify a literature of spurious statements" (p. 1). The *Nature* journal also discussed high-profile retractions in *The Lancet* and *The New England Journal of Medicine*, which raised concerns about data oversight (e.g., work with unvalidated data) [40].

Early on into the pandemic, Ioannidis [28] was critical of how the circulation of exaggerated estimates can even come from otherwise excellent scientists, listing pandemic estimates around cases of fatalities and exponential community spread as examples. He also criticized the adoption of extreme measures with unknown effectiveness, stressing the lack of evidence for the most aggressive measures. He cited a review study that found insufficient evidence on entry port screening and social distancing for past events [41]. He also referred to the potential harms of impulsive actions, such as panic buying of face masks, that result in shortages among medical personnel. In addition, contrary to many economists, he very early pointed out the risks of the misallocation of resources and economic and social distribution. For example, "if only part of resources mobilized to implement extreme measures for COVID-19 had been invested toward enhancing influenza vaccination uptake, tens of thousands of influenza deaths might have been averted" (p. 1). He was also concerned that "some political decisions may be confounded with alternative motives. Lockdowns weaponized by suppressive regimes can create a precedent for easy adoption in the future" (p. 3), a point also raised by other scholars, referring, for example, to the situation in Hungary [29]. Dean et al. [22] suggested the need to "balance the importance of publishing the results of all completed clinical trials against the potential adverse consequences if published results do not provide reliable answers to the questions that the trials were designed to address" (pp. 1366–1367). Later on, the rush of scientists to submit papers to journals and the expedited review or publication process during COVID-19 was criticized to be connected with a higher number of retracted or withdrawn papers, affecting the overall quality of the obtained COVID-19 research (e.g., [42,43]).

3.1. Trust in Scientists

Trust in science can help society as it informs politicians, legitimizing political decisions ([44] in [45]), and allows for individuals to form opinions about important political issues [45]. Evidence indicates that as complexity increases, individuals rely more on trusted representations [46]. Trust in science may help in guaranteeing preparedness and response-ability [47] and can influence compliance with prevention guidelines ([47,48]). Research in science is reliant on a public willingness to participate in research studies and on public funding [49]. Therefore, if society does not have trust in science, it can become problematic. Definitions put forward on trust, such as by Rousseau et al. [50], outline trust to be a psychological state, "comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another" (p. 395), with Gambetta [51] describing trust as "the probability that [someone] will perform an action that is beneficial or at least not detrimental to us is high enough for us to consider engaging in some form of cooperation with [them]" (p. 217). In other words, these definitions indicate that trust can be considered to be reliant on the good will of others, although Mayer et al. [52] have identified trust in others to comprise factors such as expertise, integrity, and benevolence. While trust is important, its effects may also be overestimated [53].

Regardless, the concept of trustworthiness in scientists is a debated topic. In a British sample from a European Commission [54] survey, 52% of participants agreed with the statement "information they hear about science is generally true", with 40% of those participants further stating that they had no reason to doubt the scientists. With reference to the assumed competence of scientists, 66% of participants agreed to the statement "university scientists are qualified to give explanations about the impact of scientific and technological developments on society", while, in contrast, only 35% of participants felt that scientists working for private companies were qualified. An American sample from a more recent survey found that participants trust in scientists more than business leaders and elected officials [55]. Results found 86% of participants to have, at minimum, "a fair amount" of confidence that scientists act in the interest of the public. However, researchers have found that trust in certain topics, such as climate change, indicates a lower trust than that in general science [56]. Pew Research Center [57] studies have found adults to be skeptical toward climate change, with only 50% of participants, in an American sample, agreeing that climate change occurs as a result of human activity. Meanwhile, in another American survey (Nationwide POLE survey) following the 2015 outbreak of the Zika virus, participants were asked if they trust the information coming from agencies, such as the Centers for Disease Control and Prevention, with 73% responding that "they trusted science agencies for information about the Zika virus" [58]. However, trust in science agencies, such as the Centers for Disease Control and Prevention, was also driven by individual ideology. Trust fell dramatically among Republicans, while it was not affected among Democrats (see [59]). Evidence from the COVID-19 pandemic also indicates the importance of careful science communication to maintain public support for science-based policies [60] and that adequate government communication can reduce the interest in conspiracy ideas [61]. Moreover, trust in science is positively correlated with compliance behavior, being even the dominant factor relative to other trust factors, such as trust in the government or trust in others [62]. However, Borgonovi and Pokropek [63] find that higher levels of trust are associated with a lower mobility reduction. They argue that "trust in science may induce a sort of optimistic impotent: when people trust science, they may slow to enact profound and difficult behavioral changes because they believe scientific advances will provide effective solutions" (p. 13). Chan et al. [64] find that societies with low levels of health care confidence initially exhibit stronger self-isolation responses, but, over time, this reaction plateaus more quickly than mobility in high health care confidence societies and declines with a greater magnitude. Thus, less confidence may signal citizens' perception that the health care system is not able to handle an outbreak, which leads to a more rapid individual response. Due to the importance of trust in scientists, an interesting avenue is to check how scholars from different fields, backgrounds, and geographical areas respond to available policy strategies, including immunization strategies and options [65].

3.2. Psychology of Scientists

Pandemics lack the kind of empirical knowledge around decisional processes that scientists and citizens prefer. Emerging hard facts about the actual world are therefore often harder to apply in a systematic and rigorous way using theory or available tools of thought and exploration. For example, media coverage during pandemics is often overreaching, which challenges the demands inherent to the seriousness and informative nature of a policy analysis. Media slant exists and is affected by ownership [66]. Impulsivity or arbitrary whimsicality and emotionality are more likely to emerge in a pandemic, and scientists are not free of such emotions. A conversation provided by Kong and Chan [67] in *Science* offers a window into the emotional turmoil personally faced by scientists during COVID-19. Ben-Haim [68] stresses, "[n]othing is as ancient as the feeling that some things are beyond our control" (p. 27). Being directly subjected to and absorbed with potential risks trigger emotional responses that may affect a scientist's judgement; thus, scientists are no longer passive spectators like a viewer of a movie. Their suggestions can have a direct and rapid impact on their lives and the lives of their beloved ones; thus, ambiguity and uncertainty may trigger feelings or dislike akin to skating on thin ice. One cannot assume that scientists are always cool, sober, or stern despite being usually skilled, competent, professional, knowledgeable, and learned. It is questionable to assume that science is free of human values, "our orthodox conception of science as mechanistic and a human seems to me one local part-manifestation or expression of the larger, more inclusive world view of mechanization and dehumanizing" [7]. Science does not exist in an intellectual vacuum; thus, pressure to be rational, sensible, logical, analytic, and precise may even backfire. It is natural that scientists respond to fear with cognitive impulses that could affect their scientific evaluation. As Maslow [7] points out, "being a full human being is difficult, frightening, and problematic . . . Thus knowledge includes the defenses against itself, the repressions, the sugar-coatings, the inattentions, the forgettings. . . any methodology for getting at this truth must include some form of what psychologists call "analysis of the resistance", a way of dissolving fear of the truth about oneself, thus permitting one to perceive himself head on, naked—a scary thing to do" (p. 17). It is unclear as to how much anxiety and anxiety-free interests are involved during a crisis, but is clear that scientists are subject to a mixture of both. Mastering one's own anxieties around coping with problems is challenging, and humans have the tendency to avoid any anxiety-producing confrontation with problems. It is understandable that feelings of safety become an important cognitive element, a way of coping with the pandemic, and also a method of dealing with both anxiety-avoiding and anxiety-controlling mechanisms. Although scientists love knowledge and seek it, they may also fear it. Justin Wolfers—an economist at the University of Michigan—was quoted by a New York Times article, declaring that "[i]t's useful to adopt the cost–benefit frame, but the moment you do that, the outcomes are so overwhelming that you don't need to fill in the details to know what to do", adding that the only case in which the benefits outweigh the costs is when "the epidemiologists are lying to us about people dying" (https://www.nytimes.com/2020/03/24/business/economy/coronavirus-economy.html, accessed on 1 April 2024). In general, scientists may not be free of an optimal sin problem [69] when trying to find solutions. Standard notions of intelligent choices are based on strict morality, which means that values and actions have to be consistent. However, it is more consistent with our behavior that we do things, or that we need to do things that unfortunately deviate from our values. As March [69] points out, "saints are a luxury to be encouraged only in small numbers" (p. 603). In the following, we will therefore shortly discuss some of the narratives used by scientists at the beginning of the pandemic to deal with the pandemic. Showing some of the narratives may help to understand the beliefs, assumptions, values, thought processes, and psychology of scientists in general. We will focus on economists to understand how their arguments may deviate from what they are usually trained to apply as tools of thought and exploration under normal circumstances.

Scientists, including academics, are also not free of the institutional or career pressures that plague every other person in the working world; scientists are usually highly trained (many with 20+ years of education) and work in a specific environment where skills are not easily transferred to another career [70]. Added to this has been the erosion of the ideals of academic freedom and integrity, where, once, academics and scientists were asked to speak without fear or favor on issues they were expert on—now such freedoms only exist on toothless documents that are no longer supported by the institutions and universities that wrote them. Now, governments threaten to regulate freedoms and the withdraw funding to ward off evidence and comments that do not support the narrative they wish to paint. Internally, there is an ongoing and extreme pressure to 'publish or perish', i.e., those that do not publish regularly and in high-ranked journals... perish. Such a system has the problem of disregarding other scholarly contributions [71] and can lead to boring and irrelevant papers and even to intellectual prostitution [72]. This is a tight rope to walk—to be productive and publish often in high-ranked journals but to not say anything or carry out any research that may be perceived as controversial or unpopular, making sure that you are more successful than your colleagues. Thus, in this sense, when the funding cut happens, you are not the first to feel the axe. In short, scientists, like academics, regularly fear for their jobs.

In an open letter petitioning the Australian Prime Minister and Members of the National Cabinet not to sacrifice health for the economy (https://theconversation.com/open-letter-from-265-australian-economists-dont-sacrifice-health-for-the-economy-136686, accessed on 1 April 2024), signed by 265 Australian economists, it was not surprising that a large number of the signatories were Go8 (https://go8.edu.au/about/the-go8, accessed on 1 April 2024) university scholars, particularly from the University of Melbourne (including the Melbourne Institute, for example, University of Melbourne: 66; Monash University: 28; University of Sydney: 24; University of Queensland: 16, ANU: 15). Among them were recipients of prestigious Australian awards and recognitions as well as overseas scholars from universities such as the University of Oxford, University of Chicago, University of Toronto, or University of Michigan. The short letter criticizes that the trade-off between the public health and economic aspects is a false distinction, stating that one "cannot have a functioning economy unless we first comprehensively address the public health crisis". The letter also stresses that "We recognise the measures taken to date have come at a cost to economic activity and jobs, but believe these are far outweighed by the lives saved and the avoided economic damage due to an unmitigated contagion". The core initiators also argue in a complementary article published in *The Conversation* [73] that "[w]e believe a callous indifference to life is morally objectionable, and that it would be a mistake to expect a premature loosening of restrictions to be beneficial to the economy and jobs, given the rapid rate of contagion" (https://theconversation.com/open-letter-from-265-australian-economists-dont-sacrifice-health-for-the-economy-136686, accessed on 1 April 2024).

Interestingly, both documents showed very little evidence of the normal tools or lines of thought that an economist usually would employ in their work (either articles or textbooks), and both provided very limited economic insights or rationale. From the discipline known as 'dismal science', they chose to make emotional pleas unsupported by the usual plethora of evaluations or economic justifications. The narrative they used [12] relied on minimizing a loss function, but it was unclear whether it also maximized social welfare, while other economists requested a cost–benefit analysis [29]. A New York Times article quoted Walter Scheidel, an economic historian at Stanford who asked "Why is nobody putting some numbers on the economic costs of a monthlong or a yearlong shutdown against the lives saved? The whole discipline is well equipped for it. But there is some reluctance for people to stick their neck out." (https://www.nytimes.com/2020/03/24/business/economy/coronavirus-economy.html, accessed on 1 April 2024). The same New York Times article also quoted Casey Mulligan, a University of Chicago economist who acted as chief economist in Trump's Council of Economic Advisers, with the following: "We put a lot of weight on saving lives. But it's not the only consideration. That's why we don't shut down the economy every flu season. They're ignoring the costs of what they're doing. They also have very little clue how many lives they're saving". Another economist, Kip Viscusi, argued in that article that "[m]aking people poorer has health consequences as well" and that jobless people sometimes commit suicide, with poor people being more likely to die if they become sick, estimating that every loss of USD 100 million in income from the economy causes one additional death.

A few Australian economists, such as Gigi Foster, a professor from the University of New South Wales, openly discussed on national television (ABC) (https://www.abc.net.au/qanda/2020-20-04/12141184, accessed on 1 April 2024) what economists would usually argue about every day, i.e., the trade-offs. Specifically, she discussed the lives that would have been lost or sacrificed because of the lockdown, (see around 12 min after the start of the presentation, accessed on 1 April 2024) not caused by the pandemic but by the actual lockdown; for this, she was heavily criticized (https://au.news.yahoo.com/coronavirus-economist-slammed-horrible-lockdown-idea-013505468.html, accessed on 1 April 2024) by people purporting to be economists. Abul Rizvi, at the Australian National University, even tweeted that "Gigi Foster makes me ashamed to be an economist (https://twitter.com/RizviAbul/status/1252203583954546691, accessed on 1 April 2024)"; even Joshua Gans [74] argued in his book, titled *Economics in the Age of COVID-19*, that "pandemics are not the time where trade-offs at the margin are appropriate", emphasizing the need to "balance the needs of the economy with the needs of public health" by combining epidemiological models with economic analysis (https://economics-in-the-age-of-covid-19.pubpub.org/pub/2yyquj1y/release/4, accessed on 1 April 2024). However, other economists have made comments consistent with economic thought, emphasizing the statistical lives that may be lost in the future because of the decisions we have already made. "These are the people that will die in years to come because the roads they drive on didn't get repaired because of lack of funds because of the pandemic. These are the people that will die without proper health care because the health sector will have less funds as there is less to go around. These are the people that will die because their doctors, policemen, farmers, and everyone else is somewhat less competent because of the lower education due to the panic we now have. They will be the ones dying from diseases that sewage works would have prevented, but those sewage works were delayed. They will be the millions dying in civil wars as this economic meltdown pushes their social systems over the brink" [75] (http://clubtroppo.com.au/2020/03/18/has-the-coronavirus-panic-cost-us-at-least-10-million-lives-already/, accessed on 1 April 2024). Snowden [21] concluded his chapter on SARS and Ebola with the observation that "[a]n economic system that neglects what economists euphemistically call "negative externalities" will ultimately exact a heavy cost in terms of public health. Among these externalities, "the negative effects of certain models of development on the relationship between human beings and their natural and societal environments" (p. 505) are chief. Knowledge can be feared and potentially avoided or distorted. However, a certain level of abstraction is still necessary during a crisis to avoid what Maslow [7] calls "total insanity and if we wish to live in the world" (p. 75), while still having "their footing in the experiential reality with which all knowledge and all science begins" (p. 101).

4. Discussion: The Power of Collective Initiatives

In 1837, William Whewell received the Royal Medal at the Annual Meeting of the Royal Society of London for his contribution to the understanding of ocean tides in a project called "great tide experiment", which relied on almost a million observations collected by thousands of ordinary people living in coastal towns [76]. Volunteers at 650 tidal stations measured tides around the clock at exactly the same points in time for two weeks in June 1835. Collection initiatives such as open-source platforms have gained importance in recent years. For example, the Human Connectome Project compiles neural data and a graphical interface to navigate data, and the Genome Aggregation Database aims to aggregate and harmonize exome and genome sequencing data. Further remarkable collaborations are the Earth Microbiome Project (https://earthmicrobiome.org/, accessed on 1 April 2024), which is systematically attempting to characterize microbial life on the planet and its functional diversity with participation of more than 500 investigators, and the Long Term Ecological Research Network (https://www.ltern.org.au/, accessed on 1 April 2024), which is being carried out across Australia to understand the impacts of disturbances in the Australian ecosystem. The success and sustainability of such initiatives depend on the willingness of researchers to share data, a practice that has been intensively debated in science. A relatively recent survey suggests that the acceptance and willingness to engage in sharing data have increased, but barriers to data sharing persist [77]. A core barrier is, for example, the right to make the data public. Global scientific bodies such as the European Commission, the Global Research Council, or the US Office of Science and Technology are more active in designing policies that increase public access to research [78]. A large number of organizations, societies, publishing houses, and journals have affirmed their commitment to the 2016 Statement on Data Sharing in Public Health Emergencies (https://wellcome.org/press-release/statement-data-sharing-public-health-emergencies, accessed 1 April 2024) that allow the World Health Organization (WHO) to obtain rapid access to findings that may help inform a global response to COVID-19 (https://wellcome.org/press-release/statement-data-sharing-public-health-emergencies, accessed 1 April 2024). The WHO created, for example, Zika Open (https://www.who.int/bulletin/online_first/zika_open/en/, accessed 1 July 2020), a platform that tried to facilitate data sharing.

A crisis such as a pandemic offers the opportunity to pursue a common goal, reducing uncertainty and providing caregivers, health systems, and policy makers with the knowledge to address individual and public health [26]. Various interesting data-sharing initiatives emerged during COVID-19 early on. For example, Nextstrain (https://nextstrain.org/ and https://nextstrain.org/ncov/gisaid/global/6m, accessed on 1 April 2024), an open-source project, tries to harness the scientific and public health potential pathogen genome data, including visualization tools, to aid in the epidemiological understanding and improving of the outbreak response. Dashboards such as Singapore's COVID-19 UpCode SG allowed residents to see known infection cases (https://co.vid19.sg/singapore/, accessed 1 July 2020). The COVID-10 Dashboard by the Center for Systems Science and Engineering (CSSE) at the John Hopkins University is a widely cited source of information (https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6, accessed on 1 April 2024). The trade-off faced by such dashboards is the goal of guaranteeing accurate data representation while taking people's concerns and fears into consideration [79] (https://www.technologyreview.com/2020/03/06/905436/best-worst-coronavirus-dashboards/, accessed on 1 April 2024). A key concern is whether such dashboards violated the privacy of those infected; for example, Singapore's Ministry of Health's official dashboard provides detailed information of each hospitalized case including age, sex, approximate residence, workplace, and places visited [79]. In addition, various scientific "consortia of intelligences" have emerged during the COVID-19 crisis. For example, various international surveys have been conducted or are currently in progress. A good example is the International Survey on Coronavirus (https://covid19-survey.org/, accessed on 1 April 2024) involving an international team of researchers from 12 different institutions collecting data from 113,362 individuals around the world and making the data accessible to the public and researchers (see osf.io/3sn2k/, accessed on 1 April 2024), which led to various publications (see, e.g., [80,81]). Van Bavel and co-authors also organized large-scale collaborations in the area of social sciences that led to various publications ([82–84]).

While there is much to be gained through international collaboration—the sharing of data and ideas—there always lies the potential for unintended group thinking, i.e., so much focus is devoted to a single line of thought that other competing points of view are drowned out. However, group thinking only becomes a problem if the chosen research path is ultimately unsuccessful and all the time and resources are tied up into a single stream. For example, the string theory has tied up physics for decades as being the primary focus of world research, with it being mathematically attractive and untestable, remaining an unproved conjecture. . . now, what if it is wrong? Physics would be set back decades, with millions of dollars of funding and countless hours of research time and thought ending with no other viable alternatives currently being explored. Smolin [85] stresses that the strong focus on the string theory "hurts science, because it chokes off the investigation of alternative directions, some of them very promising" (p. xxii), stressing that science requires "a delicate balance between conformity and variety" (p. xxii). However, this specific thinking problem can extend well beyond the limits of a single field, as we see in the research outputs that were published after the SARS and Ebola outbreaks, with the emergent focus being mostly limited to the medical impacts (accounting for over 75%). What is clearly missing from this work is how pandemics impact the rest of our lives—our economies, businesses, social structures, and societies—in general. Have we been so conditioned that, as scientists, we believe that pandemics are only of value for medical research with the exclusion of the rest of our society? If we consistently undervalue, underfund, and ultimately underpower all other streams of science, when it comes to pandemics, we should not be surprised that solutions and advice only come from limited number of sources—as underpowered science will result in underpowered solutions in emergencies (when we need them most).

5. Concluding Remarks

Science has experienced rapid progress since we swallowed what Eiseley [86] terms a magic pill: the pill of science. Not long after the plague and the Great Fire of London in September 1666, the House of Commons Committee inquired into the causes of those misfortunes and concluded that it must be attributed to Divine displeasure; however, this raised the question of who the source of vexation was. Perhaps unsurprisingly, and possibly conveniently, Hobbes, the author of *Leviathan*, was blamed by the Committee for such displeasure. The Committee decided that Hobbes' works had most displeased the Lord, initiating a decree that no work of his should be published in England [1] (p. 4). Great statesmen of science, such as Francis Bacon, helped to bring about the invention of invention: the experimental method offering that unique soil in which science could flourish [86]. Bertrand Russell [1] reminds us that despite Aristotle's knowledge and insights, it never occurred to him to verify his statement that women have fewer teeth than men by examining his wives' mouth, despite being twice married.

Scientists would agree that policy choices should be driven by research findings or the tools of thought and exploration applied by scientists. Science—as any social institution—is faced with forces that are defensive, conserving, ordering, or stabilizing [7]. In this paper, we discussed insights regarding just how fit science is to deal with a global crisis at the early stage of the COVID-19 pandemic. In such circumstances, the health and functionality of science and academia are revealed, with the crisis providing insights into whether methods need to be revised (or created) and how heuristic frameworks need to be adjusted. COVID-19 is a fascinating case study of how human aspects such as emotions, impulsiveness, spontaneity, or expressiveness become more dominant in a crisis; observing how scientists interact under such conditions provides signs regarding the health of science.

We have discussed the positive but also negative elements observed in the wake of the COVID-19 crisis, and this narrative discussion indicates that science is not free of human values. Among other factors, it is now clear that the pressure for speed may have led to the neglect that it is imperative that data should be approached with meticulous attention. Trust in the government may induce scientists to not critically assess official data, even when there is a significant likelihood that reported figures may diverge substantially from the actual situation. This was notably evident during the early stages of the pandemic when testing was not yet widely available. The fact that science is not free of human values is an insight that is not new to many scholars in the history of science [87]. There are many examples of important scholars with a clear agenda that was not free of values. For example, Karl Pearson tried to completely remove causation from science, seeing it as fetish of modern science and stressing that meaningful thoughts can only be reflected in patterns of observation—and these can be entirely described by correlations [88]. As Pearson's biographer, Porter [89] wrote *Karl Pearson: The Scientific Life in a Statistical Age*, stressing that "Pearson's statistical movement had aspects of a schismatic sect. He demanded the loyalty and commitment of his associates and drove dissenters from the church biometric" (p. 249). But even he could not escape the discussion on spurious correlation that required references to causality [88]. Smolin [90] discussed how David Bohm was attacked by scholars of the Copenhagen view when trying to invent a realist completion of quantum mechanics. Léon Rosenfeld (protégé of Bohr) stated that "there is not truth in your suspicion that we may be talking ourselves into complementarity by a kind of magical incantation. I am inclined to retort that it is just among your Parisian admirers that I notice some disquieting signs of primitive mentality . . .". Even Robert Oppenheimer—Bohm's former mentor at Princeton—called Bohm's attempt "juvenile deviationism" and stated that [i]f we cannot disprove Bohm, then we must agree to ignore him". John Nash then wrote to Oppenheimer, complaining about the dogmatic attitudes he found among Princeton physicists. Even Einstein struggled to understand his cosmological constant that he introduced to save the universe from collapsing or expanding. Georges Henri Joseph Édouard Lemaître estimated the rate at which the universe was expanding, but when Einstein met him at a conference in 1927, he dismissed his work as mathematically sound, but that his grasp of physics was abominable [91].

The insights offered here also raise questions as to whether there needs to be more detailed discussion within various scientific fields regarding the philosophical assumptions of the stereotypical nature of science, which are usually classified as detachment, objectivity, subjectivity, reliability of knowledge, value, and precision [7]. Scientists have their own goals and purposes, and the sooner the scientists admit this, the easier it is to develop new methods for studying human elements in science. It is not only important to understand reproduction, replication, and robustness in scientific rigor but also revelation, namely the need for accountability and transparency, by disclosing and communicating more effectively the reasoning for how scientists develop strategies, derive insights, and draw conclusions [92]. Changing the way we communicate scientific findings by revealing all the confusions and ignoble thoughts would help to collect very valuable information that is often lost [93] (https://communities.springernature.com/posts/changing-the-way-we-communicate-scientific-findings, accessed on 1 April 2024).

General science is also personal science. Many scientific fields are used to place everything in its place, organizing the environment to be predictable, controllable, or safe. However, such a search for control may freeze scientists into static and unchanging patterns. On the other hand, rapid and efficient organization of large-scale surveys with minimal barriers is an indication that scientists and their institutions (at least in some fields) can adjust their common patterns based on changing environmental conditions. In addition, a major crisis naturally gravitates scientists to an important problem rather than approaching science purely with a method-centered motivation, carrying out something technically elegantly that attracts the approval of peers due to its rigor. In addition, the experiential naïveté of how to cope with a new situation may allow scientists and their institutions to identify valuable new heuristics, as prior expectations or demands are absent. In a sense, the opportunity to see things with the fresh eyes of a child may help spark deeply needed reforms of some institutional conditions.

The current article touched on the psychology of science in a global crisis too. Future studies could provide more insights into how we can analyze crises, using findings from the growing literature in the area of psychology of science. This field tries to understand how science develops in individuals [94] or the effect of cognitive aspects on scientific practices [95]. Beyond these analyses, such insights need to be complemented with tools applied in the sociology and economics of science to better understand the incentives and institutional conditions of scientists. Future studies should explore, in more detail, how narrative elements can be investigated empirically.

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Appendix A

Table A1. Field contributions by percentages.

Field	Ebola	SARS (2002–2003)	SARS (Since 2002)	COVID-19
Medicine	34.89%	49.25%	26.91%	62.11%
Immunology and Microbiology	14.60%	2.60%	9.22%	7.34%
Biochemistry, Genetics, and Molecular Biology	11.92%	10.34%	14.59%	6.10%
Social Sciences	5.23%	1.03%	2.62%	3.02%
Pharmacology, Toxicology, and Pharmaceutics	4.06%	4.52%	7.01%	2.81%
Environmental Science	2.71%	1.58%	3.87%	2.78%
Health Professions	1.13%	0.41%	0.57%	1.93%
Nursing	2.08%	1.85%	0.88%	1.81%
Neuroscience	0.65%	0.48%	0.76%	1.60%
Engineering	1.38%	3.70%	2.93%	1.21%
Computer Science	1.11%	0.68%	1.39%	1.12%
Agricultural and Biological Sciences	6.41%	6.03%	10.69%	1.09%
Multidisciplinary	4.01%	2.33%	1.94%	1.06%
Psychology	0.32%	0.00%	0.36%	0.97%
Mathematics	1.83%	1.44%	1.32%	0.72%
Dentistry	0.02%	0.14%	0.09%	0.63%
Business, Management, and Accounting	0.73%	2.74%	1.02%	0.63%
Chemistry	1.76%	3.22%	5.52%	0.45%
Energy	0.02%	0.00%	0.23%	0.45%
Chemical Engineering	0.74%	1.37%	1.22%	0.42%
Materials Science	0.63%	2.19%	1.20%	0.39%
Physics and Astronomy	0.73%	1.64%	1.72%	0.39%
Economics, Econometrics, and Finance	0.40%	0.48%	0.33%	0.33%
Arts and Humanities	1.00%	0.07%	0.44%	0.27%
Decision Sciences	0.20%	0.21%	0.21%	0.18%
Veterinary	1.19%	0.27%	0.50%	0.15%
Earth and Planetary Sciences	0.28%	1.44%	2.38%	0.03%
Undefined				

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