# Science, Scientism, and the Disunity of Science: Popular Science during the COVID-19 Pandemic

*Nicolò Gaj and Giuseppe Lo Dico*

*Catholic University of the Sacred Heart, Milan*

*Abstract*

Unsurprisingly, science has been conferred growing expectations in the context of the COVID-19 pandemic. Accordingly, the issue of dissemination and popularization of scientific outcomes has come to the fore. The article describes the main features of the so-called dominant view in popular science, which is claimed to be implicitly connected to scientism, a stance identifying science as the most (if not the only) reliable source of legitimate knowledge. Scientism's implicit philosophical roots are argued to lie in naturalism and a trivialized neopositivist concept of science, which underscores the supposed unity of the scientific enterprise. However, in the context of the pandemic, science's disunity is more than ever visible. It is herein asserted that the untimely glimpse into science's inner workings, clashing with the dominant view in popular science, promotes a distorted image of science and hinders people's trust in science. Finally, this article provides wide-ranging recommendations in order to tackle scientism and promote a balanced outlook on science in the fodder consumed by the masses.

*Keywords*: Scientism, COVID-19 Pandemic, Disunity and Unity of Science, Popularization.

## 1. Introduction

Science is often at the center of media coverage and public debate. In the last year and a half, it has received greater attention than usual due to the global health crisis provoked by the COVID-19 outbreak. Rightly or not, people and politicians alike now expect scientific knowledge to somehow guide them as they face an unprecedented health crisis in their lifetime. Indeed, there is ample evidence that knowledge, attitudes, and practices about the virus play a major role in fostering adherence to positive behaviors and control measures (Zhong et al. 2020; Hager et al. 2020).

*Argumenta* 7, 1 (2021): 179-194
ISSN 2465-2334


DOI 10.14275/2465-2334/202113.gaj

The spotlight shone on science brought the issue of dissemination and popularization of scientific outcomes to the fore. These issues bring complex challenges to be tackled, especially in an extraordinary context as the one humanity continues to face twenty months on.

To begin with, the global emergency created an overabundance of information called 'infodemic' (Cinelli et al. 2020), in which it is difficult for people to find trustworthy sources of knowledge to make informed decisions (Porat et al. 2020). In fact, this overexposure to information often heightens people's distress (Holmes et al. 2020) and is positively associated with mental health problems (Porat et al. 2020).

On the practical side, it must be acknowledged that the spreading of scientific knowledge among the public hardly ensures people's adherence to correct behavior: communication does not always achieve its intended outcome. Dagnall and colleagues (2020: 2) pointed out that non-adherence to COVID-19 measures sometimes represents deliberate disregard due to reduced social identity via the creation of an 'us' and 'them.' Social identity can be defined as the sense of self connected to the perceived belonging to a social group: those groups which underestimate, minimize or reject specific information or control measures would inform coherent behaviors in those who self-identify in them. For example, Green and colleagues (2020: 4) noted that, in the early phase of the crisis, the divergent cues sent by U.S. Congressional Democrats and Republicans corresponded with a partisan divide, "with self-identified Democrats reporting significantly more behavioral change than independents and Republicans".

Therefore, it is rather clear that the task of disseminating scientific information is anything but straightforward. On the one hand, dissemination cannot be but a mainstay in institutional recovery plans aimed at facing the pandemic, in that it is a key means to promote paramount attitudes to address the crisis, such as a sense of trust in institutions, a sense of autonomy in decision-making, solidarity, a clear awareness of the limits of what is known and what is not and a sense of social cohesion (Dagnall et al. 2020; Falcone et al. 2020; Porat et al. 2020). On the other hand, scientists and those who popularize science face the problem of meeting the challenge of effectively conveying available scientific outcomes, confronting science's peculiar dynamics and methodological plurality.

The first part of this article deals with the description of the main features of the so-called dominant view in popular science. It is herein claimed that this view is implicitly connected to scientism, an attitude identifying science as the only reliable source of legitimate knowledge. Scientism's philosophical roots are argued to lie at naturalism and at a trivialized neopositivist conception of science. Accordingly, the dominant view is inclined to disregard science's inherent pluralism and cultivates an idealized image of pure and coherent science.

However, in the context of the current pandemic, science's disunity is visible more than ever, both within science (i.e., horizontal disagreement) and in its interface with the public (i.e., vertical misalignment). It is herein argued that the clash between the dominant view and the untimely inside look at science's inner workings promote a distorted image of science.

In the conclusive part, some wide-ranging recommendations are provided, in order to tackle scientism and to promote a fairer attitude toward the role of science in facing the pandemic.

## 2. The Dominant View in Popular Science

The general aim of popular science is to communicate scientific theories or results to an audience composed of non-specialists. It is worth noting that the term 'non-specialists' does not only refer to a general public or to the so-called non-scientists, rather, the term refers to a large degree of expertise and aims to stress that scientists in a certain field—sometimes even in the same general field—can approach other areas of science as amateurs (Perrault 2013: xiii). This illustrates how thorny is to popularize scientific theories and results. Those who do so (not necessarily scientists but often specialized journalists) must be not only specialists in a specific topic, they must also be able to communicate about it simply but not trivially.

Although the history of popular science is quite recent, starting around the 1600s (Perrault 2013: 37-47), it has undergone changes, especially due to the development of new media and the relationship between scientists and journalists (Dudo 2015: 761-63 and 766). Owing to these changes, at least since the early 1990s, sociologists and communication scientists "have begun to recognize *the fluidity and continuous nature of science communication* rather than its segregate, compartmental division between specialist and popular domains" (Bucchi 2017: 891). In recent times, public audiences appear more engaged in science communication than before (Bucchi 2013: 905). Nonetheless, this engagement "still seems to be lacking among most research institutions in Europe". It can even be argued that much of today's popular science continues to adhere to the so-called dominant view rather than to a model based on public engagement. Hilgartner (Hilgartner 1990: 519; See also Grundmann and Cavaillé 2000: 356) defines this view as a model of communicating science that is based upon an "idealized notion of pure, genuine scientific knowledge against which popularized knowledge is contrasted". The dominant view is depicted as a two-stage model: it begins with scientists developing a genuine, uncontaminated and objective knowledge, a knowledge that represents "the epistemic 'gold standard'" (520); and it ends with popularizers disseminating simplified accounts to the public. At play here is the assumption of the existence of a neat and vast divide between science and 'the rest of the world' (see also Dudo 2015: 764). This means that the rest of the world requires a translation for comprehending scientific knowledge. According to Myers (2003: 266), five claims characterize the dominant view:

1. Scientists and the institutions they pertain to are the authorities on every aspect that constitutes science.
2. Public audiences are assumed to be ignorant on topics with which scientists deal.
3. Scientific knowledge is postulated to go only from science to society, not *vice versa*.[1]
4. Scientific knowledge consists of information contained in a certain number of written statements.
5. When such written information is translated from science to society and public audiences, it must be simplified.

Perhaps the most important issue at stake is the concept of simplification. Clearly popular science must provide simplified accounts to people who do not have any expertise in the field considered. The controversial point is the degree

[1] This is because scientific knowledge is conceived as pure and thus cannot be contaminated by society or other forms of knowledge.

to which this simplification ought to occur. If it is *a priori* assumed that there is a vast gulf between specialists and lay readers, that is to say, "a situation characterized by a hierarchical divide between science and nonscience with technical experts holding the only epistemically valid coin in the realms" (Broks 2006: 46), then this can heavily influence the process of simplification itself. In fact, the aim of this process is to provide simplified accounts of the topics considered, that is, accounts without technicalities. Now, according to the dominant view, because lay readers cannot grasp such technicalities, they have no means to critically discuss the fundamental tenets of the simplified accounts. In other words, for the dominant view such accounts represent the simplified exposition of complex scientific claims that can be only discussed by the experts of the field because non-specialists do not possess an adequate knowledge for understanding their basic assumptions, in that "their claims have not been subjected to the kind of challenges that claims undergo in scientific discourse" (Myers 2003: 269). In this sense, according to the dominant view, popular science is conceived as a mere public relations activity from scientists to lay readers that does not permit any interference or engagement from those who are not specialists (Perrault 2013: 3-6).

In summary, the dominant view conceives the popularization of science as a top-down process through which scientific authorities dispense simplified knowledge without any participation from the public. A clear example can be found throughout the 1985 Royal Society of London report on the public understanding of science (see also Myers 2003: 266; Wynne 1995: 362). In the summary, it is reported that

> Scientists must learn to communicate with the public, be willing to do so, and indeed consider it their duty to do so. All scientists need, therefore, to learn about the media and their constraints and learn how to explain science simply, without jargon and without being condescending (Royal Society of London, 1985: 6).

Scientists must do their best to communicate with public audiences, who are not expected to intervene, criticize or wade into scientific debate. The dominant view of popular science assumes that science lives a life of its own, with no direct contact with other human and public activities (Grundmann and Cavaillé 2000: 353). It conceives of science as existing in a vacuum (379): science cannot be questioned from the outside, only from the inside.

## 3. Scientism

Throughout the years, sociological and communication science literature has widely discussed the dominant view of popularization and focused on various related issues. Among these, there is the plausibility of the divide between specialists and non-specialists and the idea of scientific knowledge as pure and uncontaminated (Broks 2006); the effects of the power given to scientific authorities over the public and thus the place of science in a democratic society (Perrault 2013); the boundaries between simplification and distortion of the scientific information (Myers 2003); and so on. Sociological and communication science literature generally deals with these topics by discussing detailed historical cases of popular science or focusing on the analysis of surveys or the ways popular science communicates.

Sociological and communication science literature does not appear to be interested in pinning down the philosophical foundations of the dominant view, remaining at a descriptive level useful as a basis for criticism and reflection. However, the assessment of these foundations is not irrelevant because, in their work, popularizers implicitly adopt positions that appear to be scientific, but that are actually philosophical in character. Bunge (2017: 144) argues that thinking there is no connection between science and philosophy is nothing but a myth: it is not plausible to assume "that scientists start from observations, or from hypotheses, and handle them without any philosophical preconceptions". Bunge makes this point by simply offering some examples from the history of science (143-46). This myth refers to the ideal of purity and absence of contamination characterizing the dominant view discussed above. This is a crucial philosophical point because it calls into question the problem of the boundaries of science. As Stenmark argues (2018: 57), the issue is whether any genuine knowledge different from the scientific one actually exists or whether science provides the only reliable manner of obtaining knowledge. If one answers affirmatively, he is a supporter of scientism.

But what is precisely scientism? Very generally, philosophers appear to be divided in those who consider it a thesis or a doctrine (for example, Peels 2017 and 2018; Stenmark 2018) and those who consider it a stance toward science (for example, Bunge 1986 and 2017; Haack 2007; Ladyman 2018). Although this goes far beyond the aims of this paper, it is here considered as a stance, with scientism depicted mainly as an epistemological and methodological point of view (that is, a stance regarding knowledge and the way it is reached) rather than an ontological one (that is, a stance regarding what does and does not exist). This is for two reasons: first, as will be better considered further on, philosophical discussion about scientism occurs mainly at the level of scientific method or the ways through which scientific knowledge is obtained rather than at the level of the questions about the existence of scientific entities; second, apart from some notable exceptions (such as Peels 2017 and 2018 and Stenmark 2018), philosophical literature tends to treat scientism as a stance typical of some supporters of naturalism, no matter here if interpreted at the ontological, epistemological or methodological level. Supporters of scientism tend to be also supporters of naturalism (but not necessarily *vice versa*).

The word scientism is often used in a pejorative sense, not only in philosophical debates but also in public discussions. For example, Haack (2007: 17-18; see also Sorell 1991: 1) depicts scientism as "an exaggerated kind of deference towards science, an excessive readiness to accept as authoritative any claim made by the sciences, and to dismiss every kind of criticism of science or its practitioners as anti-scientific prejudice".[2] Although such a pejorative characterization is not shared by all the critics of scientism (Peels 2018: 30; Stenmark 2018: 59), Haack's definition focuses on a fundamental feature of scientism: the attribution of an authoritative position to science and scientists. As for the dominant view, science provides the most (if not the only) reliable kind of knowledge. It is important to

[2] It is worth noting that Haack (2007: 18) classifies scientism as one of two kinds of confusion we can fall into when we deal with science (and also with popular science, of course). She defines the other 'anti-science', as "an exaggerated kind of suspicion of science, an excessive readiness to see the interests of the powerful at work in every scientific claim, and to accept every kind of criticism of science or its practitioners as undermining its pretensions to tell us how the world is". The problem with each is that they are excessive—scientism in terms of deference, anti-science in terms of suspicion.

stress that here 'science' is fully identified with natural science: reliable knowledge cannot come from sources such as common sense, memory, introspection, intuition, religion or, considering only the area of the academic disciplines, the humanities (Peels 2017: 2; Sorell 1991: 9). This is because scientism assumes that science, unlike the other sources of knowledge, has a way of reaching knowledge that is much more advanced and reliable than that of the others: the scientific method or, more precisely, an idealized version of the scientific method typical of the natural sciences (in particular, physics). As Bunge (1986: 25) clearly states, "the scientific method, rather than any special results of scientific research" is "the very kernel of scientism". For scientism, it is the application of the scientific method that guarantees to obtain the most reliable knowledge. From this claim, it usually follows that, in principle, there are no areas of inquiry that cannot be studied through the methods of natural science. As Ladyman (2018: 113) points out, "everything real can in principle be investigated by scientific methods and no limits should be placed on what science can study". As a consequence, this leads some supporters of scientism to propose that the scientific method be applied to every sort of human question.

Here, the challenging task of scientism is to define both the scientific method and how it can be potentially applied to every object and field of inquiry, not only to scientific realms but also other areas such as the humanities. If we assume that many cases in the history of science demonstrate that various scientific disciplines use several variations of the scientific method (that is, different methods for different objects), then it is meaningless to think about a single scientific method and, as a consequence, scientism. Thus, in order to adequately defend scientism, we must defend something similar to the old neopositivistic ideal of the unity of method for all the sciences or, at least, the ideal that all science has a well-defined and limited set of methods to be applied. In fact, this ideal is anchored to some basic methodological precepts constituting the backbone of the neopositivist project of science's unification and representing the 'hidden bearings' of those supporting scientism. First, the methods characterizing natural sciences stand as the gold standard of all sciences, underscoring the supposed methodological superiority of a certain family of sciences. Second, scientific disciplines are expected to use strictly empirical procedures in order to postulate general and universal principles. Third, notwithstanding technical differences in investigational methods, scientific statements are supposed to be justified in the same way: deriving from them empirical implications that can be checked intersubjectively. This means that for every private fact there should be a public counterpart which is at the basis of intersubjective agreement, and this is the fourth point (Hempel 1942; see also Gaj 2016). However, certainly scientism cannot be simply assimilated to neopositivism *tout court* (see Sorell 1991: 1-23). Indeed, the latter is a (more or less) consistent philosophical movement, while the former is a general stance about the reliability of knowledge. Here we see scientism takes root in a trivialized version of neopositivism, implicitly endorsing the core message of its main thesis about the unity of science.

In summary, scientism manifests an extreme confidence in knowledge obtained by empirical research: the most reliable knowledge can be produced only through scientific methods, understood as the methods used by natural sciences. This leads to the ideal of unified science, whose feasibility is established under the aegis of one method fitting for all the disciplines appropriately named sciences. From this perspective, all meaningful questions (and answers) about the world

must be formulated according to the register of science so understood. Hence, scientism cannot but inherently mingle with naturalism. Indeed, naturalism represents scientism's metaphysical commitment to a world whose features are assumed to be entirely reducible to the categories of the natural sciences.

A key topic related to the core of scientism and the dominant view is the controversial issue of the unity or disunity of the scientific endeavor.

## 4. The Supposed Unity of Science amid the COVID-19 Pandemic

The connection between the dominant view of popular science and the scientistic stance appears to be quite straightforward. In fact, those popularizers who adopt the dominant view basically depict science as an authority bringing a kind of knowledge that cannot be fully understood and criticized by public audiences. It is crucial to stress that many popular science products typically adopt scientism implicitly: it is difficult to find straightforward formulations of it. A risk here is that popularizers can "come up with woefully inadequate characterizations of key concepts and offer very crude arguments for and against positions that they're discussing" (de Ridder 2014: 23). According to this paper, popularizers tend to implicitly endorse an inadequate characterization of the scientific enterprise as something unified in the name of the scientific method. 'Inadequacy' does not mean that popular science characterizes science as immune to errors or uncontroversial in some stages of its progress. Rather, it means that, in spite of their errors and controversies, scientists who attempt to solve a problem share a common method that allows them to find a common solution or result in the long run. Simply put, the application of a shared and common scientific method allows scientists to agree.

Consider two useful and well-documented sources of information about the COVID-19 pandemic, two recent bestsellers: Richard Horton's *The Covid-19 Catastrophe: What's Gone Wrong and How to Stop It Happening Again* (2020) and Debora MacKenzie's *COVID-19: The Pandemic that Never Should Have Happened, and How to Stop the Next One* (2020). Each author characterizes science in scientistic terms. MacKenzie does this quite explicitly, for example in the following (2020: X):

> What is especially sad for a science journalist like me who writes about disease for a living is that this pandemic has not exactly been a surprise. Scientists have been warning for decades, with mounting urgency, that this was going to happen. And journalists like me have been relaying their warnings that a pandemic is coming and that we aren't prepared.

This excerpt is certainly not wrong: it is plainly true that for a long time scientists were warning us of the possibility of a pandemic scenario similar to the present one (see, for example, Perrin and McCabe 2009). Yet these sentences are implicitly scientistic because they suggest that the scientific community in its entirety and without any controversy shares the same position about the present pandemic and perhaps even about the measures we must take to confront it. The paper will later show that this is a simplistic and unsatisfying narrative about the COVID-19 pandemic.

Although less directly than in MacKenzie's book, examples of scientism are not difficult to find in Horton's book. Both books laud scientific work and, in general, the idea of scientists making a joint effort to deal with the pandemic,

without great divisions. Both books provide a historical reconstruction of how scientists discovered SARS-COV-2 and its expressions as a disease and proposed different hypotheses in order to explain it. So, too, both depict the scientific community as a sort of entity using more or less the same methods of research and working in the same direction. This united community seems isolated from 'the rest of the world,' except when things start to go wrong! But what, exactly, goes wrong? The following excerpt from Horton's book puts this question in this manner:

> The global scientific community made an unrivalled contribution to establishing a reliable foundation of knowledge to guide the response to the SARS-CoV-2 pandemic. And yet the management of COVID-19 represented, in many countries, the greatest science policy failure for a generation. What went wrong? (Horton 2020: 41).

On this point, MacKenzie's book is more direct:

> The only real surprise when Covid-19 finally hit was the sheer extent to which most governments simply had not listened to the warnings. We were unable as a planet to muster our considerable scientific understanding of disease in time to soften the blow, never mind preventing it in the first place. And, as I will explain in the coming pages, we could have—at least a lot more than we did. Science didn't actually fail us. The ability of governments to act on it, together, did. Experts had warned about the lack of preparation in addition to the risk of a pandemic itself (MacKenzie 2020: xiii).

Both books place the responsibility for the problems and errors of the management of the pandemic firmly and only on the political sphere: things started to go wrong the moment politicians had to take decisions and create policies. Horton talks about "the gap between the accumulating evidence of scientists and the practice of governments" (Horton 2020: ix). Both he and MacKenzie posit that the scientific side cannot be blamed for anything: scientists were united in their work and proposed the best solutions, but politicians didn't listen to them, for various reasons, ranging from bad intentions to lack of expertise. The image of science is that of an uncontaminated entity corrupted by politicians. The question is whether it is actually all so uncontroversial and clear on the scientific side.

## 5. Science's Display of Disunity

Well before the declaration of Public Health Emergency of International Concern (January 30, 2020, WHO), scientists throughout the world began jointly to study the behavior of the newcomer in the coronavirus family. As in other cases addressing new phenomena, from the very onset of the pandemic a core set of scientists rapidly formed in order to address issues related to COVID-19: on one side, bottom-up-wise, selected scientists emerged from the scientific community and progressively became deeply involved in research on the virus; on the other side, top-down-wise, policymakers were to designate reliable scholars to collaborate in crafting COVID-19-relevant public policies. The upshot of this essentially social process is the constitution of a group of core-scientists (Collins and Evans 2002) debating on issues related to the many scientific challenges posed by COVID-19. At the moment, they form a community of collectively considered

experts who are expected to explore the knowledge frontiers about the virus. Of course, due to the newness of the phenomena under scrutiny, their debates have been characterized by a plurality of voices and, often, disagreement and controversy. For example, key scientists and public-health agencies were late to acknowledge the aerosol transmission of the virus and the consequent benefits of using masks (see Tufekci 2021). Currently, a debate about vaccine safety and transmission from vaccinated individuals continues to take place.

In order to understand how the public could easily understand science's inherent plurality of voices as disunity and fragmentation, it is worth taking into account the dynamics ruling the connections between science and the wider community. Somewhat simplifying their proposal, Collins and Evans (2002) argue that this relation follows approximately this path:

1. Core-scientists debate, confronting different positions about a new subject matter, often via different methods. This involves a high level of uncertainty and diversity of scientific conclusions.
2. As time goes by, scientific disputes normally tend to reach a point where uncertainty and diversity decrease. This entails an inevitable process of simplification and stabilization, by means of which scientific debates are seemingly settled in the eyes of laypeople. "Distance lends enchantment" (ibidem: 246): the more one looks science from a distance, the more unanimous it seems. 'Settled positions' are reached when scientific outcomes are somehow popularized, appropriated in a simplified and coherent manner by the wider scientific community, non-specialists, policymakers and laypeople. This entails a significant reduction of the initial uncertainty characterizing core-scientists' controversies.
3. Despite this outside perception, core-scientists linger long after the wider community believes matters have been settled: science is always open and revisable, at the level of those deeply involved in a specific issue, and is characterized by high levels of uncertainty and plurality of positions and methods of inquiry. High degrees of coherence and certainty characterize popularized versions of science, whereas continuous disputes and plurality inherently characterize any scientific enterprise.

This ideal path does not exactly describe the case for the COVID-19 pandemic. Being a new and demanding challenge, science cannot but fail to rapidly provide relatively stable outcomes for the wider community. As noted above, time is required before core-scientists' conclusions are stabilized as a result of exposure to the wider community. On the contrary, the conflicting dynamics of science have never been as visible to laypeople and the media as they have been during this pandemic, at a time when solid scientific answers are more yearned for than ever. The problem here is not that laypeople and policymakers may not be adequately prepared to understand scientific results, as the dominant view would suggest; rather, they may not be adequately prepared to confidently address science's characteristic plurality of voices in approaching a new phenomenon.

Indeed, the untimely exposure to scientific inner workings may prejudice people's attitudes toward science and bring potential damage to its credibility. While experts may consider disagreements to be part of the scientific process, laypeople may have a different perception. The uncertainty, fluidity and disunity characterizing core-scientists' controversies may violently clash with the expectations of both policymakers and laypeople, who generally hope for unanimous and

definite outcomes from science. Real-life decisions are mostly formulated as binary choices (yes/no, do that/do not do that): so, it is likely that science is considered as a useful tool to the extent it substantially contributes to disentangling such knots (Collins and Evans 2002; Nichols 2017).

In this scenario, science may appear far less united and robust than expected and may be no longer viewed as a source of confidence (Collins and Evans 2002): uncertainty and distrust may spread in the wider community, fostering contentious attitudes toward science (Kosolosky and Van Bouwel 2014). Indeed, even in non-emergencies, laypeople tend to use overly narrow attributions to make sense of scientific disagreements, overlooking the irreducible uncertainty of the world as a relevant source of scientific dispute. Even though education and available cognitive resources play a role, people tend to favor inferences according to which uncertainty stems from either incompetence or bias on the part of the experts (Dieckmann et al. 2017). Such effects might well worsen in a situation where the public is prematurely exposed to early debates among core-scientists and the uncertainty level is high.

So, how does science's disunity manifest in the context of the current pandemic? This article argues that horizontal disagreement (HD) is to be distinguished from vertical misalignment (VM).

HD is defined as the expected discordance among core-scientists when addressing a relatively new topic or problem. Various theoretical and methodological positions compete. The accuracy of scientific outcomes (that is, the preciseness of the answer given to a certain query) is at stake here (Kosolosky and Van Bouwel 2014). In the early phases of investigation of a relatively new phenomenon, core-scientists struggle to reach the most thorough understanding possible. However, it is likely that scientific accuracy is partial and rapidly growing in these phases, possibly conveying the idea that science is unstable and ever-changing. The notion of robustness, or lack thereof, might account for this. Robustness is the idea that hypotheses about entities and processes are better supported if they are detectable, derivable, producible in a variety of independent ways, i.e., via multiple techniques and methods relying on different background assumptions (Eronen 2015; Miller 2013; Stegenga 2009). A scientific conclusion deserves to be defined as robust when many independent threads of evidence progressively converge in an intelligible form and a picture gradually emerges and becomes detectable. Before this threshold, those independent threads of evidence may appear as fragmented, if not opposing, positions within the scientific arena. So, when a line of research lacks robustness due to its immaturity, what is seen is fragmentation. In the present situation, laypeople are often exposed to HD well before science's different voices may converge in a (more or less) coherent picture. This might easily create an appearance of incoherence and disunity. In the context of the present pandemic, some instances of HD have been, and are, clearly visible to the wider community. These include: disputes about whether the origins of COVID-19 were artificial vs. natural (Chaturvedi, Ramalingam, Singh 2020; Andersen, Rambaut, Lipkin, Holmes, Garry 2020); and the mystery of long COVID, a varied syndrome that can have long-term disabling effects, about which very little is known (Sollini et al. 2021).

VM (vertical misalignment) regards the relationship between scientists and the public. As already noted, evident disagreement among scientists may be easily taken as a sign of incompetence or bias influence (Dieckmann et al. 2017), favoring mistrust and disbelief (Collins and Evans 2002; Nichols 2017): "everyone gets

to see the soft flesh of the scientific fruit and the familiar passions and arguments that constitute it" (Collins and Evans 2002: 248). This markedly influences the credibility of visibly ever-changing scientific conclusions. When it comes to the interface between core-scientists and the community at large, VM deals with the notion of adequacy. Adequacy points at what an explainee expects of a scientific answer and, thus, deals with how scientific outputs and the explainee's epistemic interests reciprocally fit. Adequacy concerns the congruity of scientific outcomes with the interests or *desiderata* at play (Kosolosky and Van Bouwel 2014). Borrowing an example from the literature on maps, the need to orient people in a specific environment, e.g., a subway system, requires maps with an *adequate* degree of accuracy, precisely based on the users' epistemic needs. The adequacy of a map depends on its inclusion/exclusion of specific features based on the purpose for which the map is being made (Giere 2006): not all maps (supposedly having different degrees of accuracy) would fit the users' needs. More precisely, VM deals with the relation between an incomplete and still growing accuracy—as a characterizing feature of HD—and adequacy. In fact, adequacy can be achieved to the extent that a certain degree of accuracy has been reached among core-scientists. In the present situation, the ever-growing accuracy and the instability of scientific conclusions characterizing HD make adequacy a hard goal to reach, fostering a state of VM where people may be easily disoriented by science's provisional answers. Of the several instances of VM emerging from the current pandemic, two stand out for their ability to highlight the misalignment between science and the public.

One regards the early use of masks. Late to ascertain the usefulness of wearing masks, even considering that imposing the wearing of masks *per se* poses few downsides (Tufekci 2021), science-wise scientists waited for a high level of accuracy and certain evidence before communicating the effectiveness of this measure. In doing so, the public might have been confused by science's reticence to express a clear opinion in the early phase of the pandemic. Accordingly, relevant recommendations for protecting people from airborne transmission came late and with less credibility than required.

The second case regards different ways to understand and communicate how to measure the contagiousness of the virus. After many months of collecting data, scientists discovered that parameter R0 (an indicator of the average number of secondary infections caused by every infected individual) is an insufficient index for understanding how the virus spreads. Because COVID-19 tends to spread in clusters, the average is not useful for understanding its distribution. On the contrary, parameter *k*, which might be not as familiar as R0, is an adequate measure to account for the behavior of an over-dispersed pathogen such as COVID-19 (Endo, Abbott, Kucharski, and Funk 2020; Hasan et al. 2020; Tufekci 2020). Public exposure to growing scientific accuracy about the behavior of the virus may have puzzled laypeople and had a late and suboptimal influence on the design of appropriate safety measures and on people's compliance.

These are but two examples in which science's provisional outcomes disoriented the public, not providing univocal information and unwittingly disseminating the image of a disunited science.

Both HD and VM convey an image of science as an inherently pluralistic, disunited, ever-progressing endeavor. Indeed, this is exactly science's nature, something quite different—and perhaps even more intriguing and sophisticated—than that proposed by scientism. The clash between the dominant view and the

view conveyed by the untimely exposure to science's early controversies may drastically hinder a mature consideration of its virtues and limits.

In the concluding section, the article will suggest some recommendations to promote a balanced image of science, against scientism and its popularized counterpart, the dominant view. This aims to educate the public to science's inherent pluralistic and provisional status, which must be understood as a desirable trademark feature, rather than a sign of unreliability.

## 6. Concluding Remarks

The main aim of scientism is to promote an image of science as pure and able to provide solutions to every problem through the application of a well-established and recognized method or set of methods. This is plainly wrong: the COVID-19 pandemic continues to show that science is far from perfect, full of controversies and difficulties, with a plurality of methods and points of view. Further, science does not stand apart from the world: indeed, far from existing in a vacuum, science is in a continuous exchange with the public and everyday life—and the present pandemic is perhaps the most dramatic proof of this fact. For these reasons, the article argues that one of the preliminary tasks of popularization must be to demonstrate and explain how science is pluralistic and integrated in social discourse. It must provide people the means to debunk the various myths regarding science and to form a critical opinion about it.

At the operative level, this might mean various different things. To begin with, consider a central methodological procedure commonly used in science: the rejection of the null hypothesis, the way through which knowledge is produced and is gained credibility in academia. Usually, scientists are interested in testing the experimental hypothesis (i.e., the prediction that the manipulation of the independent variable will have some effect on the dependent variable) by rejecting the opposite null hypothesis, namely, that the prediction is wrong and that there is no relationship between variables. The experimental hypothesis can be accepted only if it excludes that the results obtained accordingly occurred by chance (see Field 2005). Although this is a common scientific procedure, laypeople may misunderstand it. First, scientific outcomes may be rhetorically presented as the exclusion of the possibility that one variable has a relationship with another variable, until the relationship is not proven by the (definitive)[3] rejection of the null hypothesis. This would convey the idea that some conclusions are not (this far) 'scientifically proven', even if they are highly probable on the basis of current knowledge. As Tufekci reported,

> On January 14, 2020, the WHO stated that there was 'no clear evidence of human-to-human transmission.' It should have said, 'There is increasing likelihood that human-to-human transmission is taking place, but we haven't yet proven this' (Tufekci 2021).

[3] Here, the adjective 'definitive' is not to be literally understood. Rather, it refers to values which are statistically significant. Normally, a 95 percent probability that the relationship between the variables is genuine vs. a 5 percent probability that the relationship occurs by chance, is considered a sufficient value to argue that scientists face a real effect or that there exists a true relationship between variables (Field 2005).

Accordingly, scientific conclusions may appear as more uncertain that they actually are, if only available information is carefully taken into consideration. Still following Tufekci,

> Later that spring, WHO officials stated that there was 'currently no evidence that people who have recovered from COVID-19 and have antibodies are protected from a second infection,' producing many articles laden with panic and despair. Instead, it should have said: 'We expect the immune system to function against this virus, and to provide some immunity for some period of time, but it is still hard to know specifics because it is so early' (Tufekci 2021).

Popularizers must be aware of these methodological features when they design their dissemination strategies. Indeed, they should raise awareness on science's specific workings, in order to contain scientism and strengthen people's trust in science. Accordingly, they must provide basic epistemological notions to their readers in order to explain how science works (Dieckmann et al. 2017: 335). In particular, science's characteristic disunity, its probabilistic nature and the inherent limitations of scientific knowledge should be made known to laypeople: in familiarizing the public, popularizers ought to convey a clear image of the scientific enterprise as uncertain and provisional (Porat et al. 2020: 9), yet valuable. Moreover, popularizers should always keep in mind the needs of the various audiences and contexts for which the information is intended, in that these factors considerably influence the understanding of information and the adhering to safe behaviors (Bucchi 2017: 890; Kosolosky & Van Bouwel 2014; Porat et al. 2020: 8). Lastly, popularizers should nurture the skill of communicating honestly what is known and what is not, conscientiously indicating the aims and general strategy pursued by scientific research (Porat et al. 2020: 10).[4]

These are only few recommendations for improving popular science. They deserve to be further developed by the joint efforts of scientists, philosophers and popularizers. The main contribution of this article to the topic of popular science is to suggest not to confound science with scientism: scientism offers a distorted image, if not a caricature, of what science really is. Science is disunited, not united—and we should not be afraid of it.

## References

Andersen, K.G., Rambaut, A., Lipkin, W.I., Holmes, E.C., Garry, R.F. 2020, "The proximal Origin of SARS-CoV-2", *Nature Medicine*, 26, 450-52.

Broks, P. 2006, *Understanding Popular Science*, New York: Open University Press.

Bucchi, M. 2013, "Style in Science Communication", *Public Understanding of Science*, 22, 8, 904-15.

[4] As a reviewer stressed, popularizers often exhibit a kind of "epistemic irresponsibility" (Magnani 2017: 161-97. See also Park 2020) by spreading an image of science as a form of static knowledge, that is, something contrary to the so-called knowledge in motion. By underestimating the epistemic and philosophical topics underlying the scientific enterprise, they tend to describe scientific research as not multidisciplinary, interdisciplinary and transdisciplinary (Magnani 2017: 161) and thus unable to foster "good human abductive creative reasoning" (Magnani 2017: 167). Very briefly, popularizers promote an image of science as fake or, at the very best, uninteresting.

Bucchi, M. 2017, "Editorial. Credibility, Expertise and the Challenges of Science Communication 2.0", *Public Understanding of Science*, 26, 8, 890-93.

Bunge, M. 1986, "In Defense of Realism and Scientism", *Annals of Theoretical Psychology*, 4, 23-26.

Bunge, M. 2017, *Doing Science in the Light of Philosophy*, Singapore: World Scientific Publishing.

Chaturvedi, P., Ramalingam, N., and Singh, A. 2020, "Is COVID-19 Man-Made?", *Cancer Research Statistics and Treatment*, 3, 284-86.

Cinelli, M., Quattrociocchi, W., Galeazzi, A., Valensise, C.M., Brugnoli, E., Schmidt, A.L., Zola, P., Zollo, F., Scala, A. 2020, "The COVID-19 Social Media Infodemic", *Scientific Reports*, 10, 165-98.

Collins, H.M., Evans, R. 2002, "The Third Wave of Science Studies: Studies of Expertise and Experience", *Social Studies of Science*, 32, 2, 235-96.

Dagnall, N., Drinkwater, K.G., Denovan, A., Walsh, R.S. 2020, "Bridging the Gap between UK Government Strategic Narratives and Public Opinion/Behavior: Lessons from COVID-19", *Frontiers in Communication*, 5, 1-8.

de Ridder, J. 2014, "Science and Scientism in Popular Science Writing", *Social Epistemology Review and Reply Collective*, 3, 129, 23-39.

Dieckmann, N.F., Johnson, B.B., Gregory, R., Mayorga, M., Han, P.K., and Slovic, P. 2017, "Public Perceptions of Expert Disagreement: Bias and Incompetence or a Complex and Random World?", *Public Understanding of Science*, 26, 39, 325-38.

Dudo, A. 2015, "Scientists, the Media, and the Public Communication of Science", *Sociological Compass*, 9, 9, 761-75.

Editorial 2020, "Meeting the Challenge of Long COVID", *Nature Medicine*, 26, 1803.

Endo, A., Centre for the Mathematical Modelling of Infectious Diseases COVID-19 Working Group, Abbott, S., Kucharski, A.J., and Funk, C. 2020, "Estimating the Overdispersion in COVID-19 Transmission Using Outbreak Sizes outside China", *Wellcome Open Research*, 5, 67 [version 3; peer review: 2 approved].

Eronen, M.I. 2015, "Robustness and Reality", *Synthese*, 192, 3961-77.

Falcone, R., Colì, E., Felletti, S., Sapienza, A., Castelfranchi, C., and Paglieri, F. 2020, "All We Need Is Trust: COVID-19 Outbreak Reconfigured Trust in Italian Public Institutions", *Frontiers in Psychology*, 11, 1-17.

Field, A. 2015, *Discovering Statistics Using SPSS*, 2nd Edition, London, Thousand Oaks and New Delhi: Sage.

Gaj, N. 2016, *Unity and Fragmentation in Psychology: The Philosophical and Methodological Roots of the Discipline*, London and New York: Routledge.

Giere, R.N. 2006, *Scientific Perspectivism*, Chicago and London: The University of Chicago Press.

Green, J., Edgerton, J., Naftel, D., Shoub, K., Cranmer S.J. 2020, "Elusive Consensus: Polarization in Elite Communication on the COVID-19 Pandemic", *Science Advance* 6, 1-5.

Grundmann, R., Cavaillé, J.P. 2000, "Simplicity in Science and its Publics", *Science as Culture* 9, 353-89.

Haack, S. 2009, *Evidence and Inquiry. A Pragmatist Reconstruction of Epistemology*, 2nd Edition, Amherst: Prometheus Books.

Hager, E., Odetokun, I.A., Bolarinwa, O., Zainab, A., Okechukwu, O., Al-Mustapha, A.I. 2020, "Knowledge, Attitude, and Perceptions towards the 2019 Coronavirus Pandemic: A Bi-National Survey in Africa", *PLOS ONE*, 1-13.

Hasan, A., Susanto, H., Kasim, M.F. et al. 2020, "Superspreading in Early Transmissions of COVID-19 in Indonesia", *Scientific Report* 10, 223-86.

Hempel, C.G. 1942, "The Function of General Laws in History", *Journal of Philosophy*, 39, 35-48.

Hilgartner, S. 1990, "The Dominant View of Popularization: Conceptual Problems, Political Uses", *Social Studies of Science*, 20, 519-39.

Holmes, E.A., O'Connor, R.C., Perry, V.H., Tracey, I., Wessely, S., Arseneault, L., Ballard, C., Christensen, H., Silver Cohen, R., Everall, I., Ford, T., John, A., Kabir, T., King, K., Madan, I., Michie, S., Przybylski, A.K., Shafran, R., Sweeney, A., Worthman, C.M., Yardley, L., Cowan, K., Cope, C., Hotopf, M., Bullmore, E. 2020, "Multidisciplinary Research Priorities for the COVID-19 Pandemic: A Call for Action for Mental Health Science", *Lancet Psychiatry*, 7, 547-60.

Horton, R. 2020, *The COVID-19 Catastrophe: What's Gone Wrong and How to Stop It Happening Again*, Cambridge: Polity Press.

Kosolosky, L., Van Bouwel, J. 2014, "Explicating Ways of Consensus-Making: Distinguishing the Academic, the Interface and Meta-Consensus", in Martini, C. and Boumans, M. (eds.), *Experts and Consensus in Social Sciences*, Dordrecht: Springer, 71-92.

Ladyman, J. 2018, "Scientism with a Humane Face", in de Ridder J., Peels, R., and van Woudenberg, R. (eds.), *Scientism: Prospects and Problems*, Oxford: Oxford University Press, 106-26.

Mackenzie, D. 2020, *COVID-19. The Pandemic that Never Should Have Happened and How to Stop the Next One*, Paris: Hachette Books.

Magnani, L. 2017, *The Abductive Structure of Scientific Creativity: An Essay on the Ecology of Cognition*, New York: Springer.

Miller, B. 2013, "When is Consensus Knowledge Based? Distinguishing Shared Knowledge from Mere Agreement", *Synthese*, 190, 1293-1316.

Myers, G. 2003, "Discourse Studies of Scientific Popularization: Questioning the Boundaries", *Discourse Studies*, 5, 2, 265-79.

Nichols, T. 2017, *The Death of Expertise: The Campaign against Established Knowledge and Why it Matters*, New York, NY: Oxford University Press.

Park, W. 2020, Review of Magnani 2017, *Transaction of the Charles S. Pierce Society*, 56, 3, 456-65.

Peels, R. 2017, "Ten Reasons to Embrace Scientism", *Studies in History and Philosophy of Science*, Part A 63, 11-21.

Peels, R. 2018, "A Conceptual Map of Scientism", in de Ridder J., Peels, R., and van Woudenberg, R., (eds.), *Scientism: Prospects and Problems*, Oxford: Oxford University Press, 28-56.

Perrault, S. 2013, *Communicating Popular Science: From Deficit to Democracy*, London: Palgrave Macmillan.

Porat, T., Nyrup, R., Calvo, R.A., Paudyal, P., Ford, E. 2020, "Public Health and Risk Communication during COVID-19: Enhancing Psychological Needs to Promote Sustainable Behavior Change", *Frontiers in Public Health*, 8, 1-15.

Royal Society of London (report of) 1985, *The Public Understanding of Science*, London: The Royal Society.

Sollini, M., Morbelli, S., Ciccarelli, M., Cecconi, M., Aghemo, A., Morelli, P., Chiola, S., Gelardi, F., and Chiti, A. 2021, "Long COVID Hallmarks on [18F]FDG-PET/CT: A Case-Control Study", *European Journal of Nuclear Medicine and Molecular Imaging*, 48, 10, 3187-97.

Sorell, T. 1991, *Scientism: Philosophy and the Infatuation with Science*, London: Routledge.

Stegenga, J. 2009, "Robustness, Discordance, and Relevance", *Philosophy of Science*, 76, 5, 650-61.

Stenmark, M. 2018, "Scientism and Its Rivals", in de Ridder J., Peels, R., and van Woudenberg, R. (eds.), *Scientism: Prospects and Problems*, Oxford: Oxford University Press, 57-82.

Tufekci, Z. 2020, "This Overlooked Variable is the Key to the Pandemic: It's not R", *The Atlantic*, https://www.theatlantic.com/health/archive/2020/09/k-overlooked-variable-driving-pandemic/616548/.

Tufekci, Z. 2021, "5 Pandemic Mistakes We Keep Repeating: We Can Learn from Our Failures", *The Atlantic*, https://www.theatlantic.com/ideas/archive/2021/02/how-public-health-messaging-backfired/618147/.

Wynne, B. 1995, "Public Understanding of Science", in Jasanoff S., G.E. Markle, J.C. Petersen, and Pinch, T. (eds.), *Handbook of Science and Technology Studies,* Thousand Oaks: Sage, 361-88.

Zhong, B.L., Luo, W., Li, H.M., Zhang, Q.Q., Liu, X.G., Li, W.T, and Li, Y. 2020, "Knowledge, Attitudes, and Practices towards COVID-19 among Chinese Residents during the Rapid Rise Period of the COVID-19 Outbreak: A Quick Online Cross-Sectional Survey", *International Journal of Biological Sciences*, 16, 1745-52.

Online References

https://www.who.int/news-room/spotlight/a-year-without-precedent-who-s-covid-19-response (retrieved February 23, 2021).