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Between Techno-Science and Post-Truth: The Need for the Creation of the Figure of the Science Critic in the Public Communication of Science

Is scientific culture served by the one-sided glorification of "facts" and presenting objectivity as the absolute norm?

Pierre Thuillier

Introduction

The COVID-19 pandemic that we have just experienced brought to light a number of characteristics about the dominant modes of science communication. More specifically, it has become clear that the flow of information about science is often completely decontextualised, and that it serves commercial, industrial, national, and even geopolitical interests, rather than contributing to an understanding of what is happening, the possibilities for finding solutions on a global scale in a situation like the pandemic, or stopping it completely. What we have instead is a dense fog. The unbridled race to be the first to patent a vaccine led research laboratories to disseminate information without verification, such as the duration of the virus on different surfaces, and this without knowledge of whether it was capable of continuing to infect, and thus triggering a wave of fear. Similarly, one of the vaccines was disqualified because of its side effects, albeit based on data of very low probability, and because of the technology used (not RNA but an "old" one). A great deal of other information was disseminated during this time, much of it out of context, that contributed little to increasing understanding and a lot to increasing fear (Carrillo-Trueba, 2021).

This state of affairs finds its origins in the techno-scientific character of the contemporary economy, which has caused social and environmental changes on a scale that may well be irreversible. Science and technology have been subjected to what Pestre (2003) characterised with great clarity as "the regime of production and validation of knowledge", thus being essentially transformed into inputs for the production of goods, industrial processes, services, and becoming just another commodity used for short-term, profitable, instrumental projects. This impression is exacerbated by the predominance of private investment and the reduction of public investment to the extent that the interests and objectives of companies impose themselves on the orientation of research in universities and other public institutions (Pestre, 2003). In other words, science has been privatised. As Bauer points out, it has gone from being "a public good" to "a private good" (2008, p. 2).

The effects of this new regime of knowledge production and validation on science communication are manifold. The most obvious is its increasing commercialisation, the mediatisation of science com-

munication (Väliverronen, 2021), and its transformation into what Bauer (2008, p. 5) calls "the public relations of science". The primacy of marketing over everything else has led to the introduction of marketing-specific forms of science communication, which regularly appear in public debates (such as the GMO controversy). These marketing-specific approaches include the following: absolute but deliberate decontextualisation in the form of the concealment of methods and sources, which allows the biased interpretation and presentation of information in order to support economic interests; the elaboration of scenarios based on dubious information; the minimisation or maximisation of risks according to the purpose pursued; the use of images, diagrams, graphs, and other visual elements assuming their veracity; the distortion of trends and statistics; the systematic denial and disqualification of researchers who criticise such products, even forcing publications to withdraw their articles and accusing them of fraud and methodological flaws, the intention of the companies being to silence critical voices at any cost. At the same time, companies run promotional campaigns by hiring and paying ad hoc science communicators, subsidising scientific publications, granting advertising to various mass media, financing congresses and other academic events, and even funding fraudulent research to support their views (Bauer, 2008, partially addresses this last point).

This process of commercialisation has had an impact on the ongoing crisis of science communication, in part due to the prevailing persistence in pursuing the deficit model and its vision (Hilgartner, 1990), and also the customary habit of labelling as ignorance any public reaction other than the desired one. It is a case of continuing to try to naturalise risk as something inherent to technological development, without taking into account the fact that the public is becoming less and less aware of the benefits of many technologies, and more and more aware of the risks and fears they generate. Similarly, the promotion of new models of science communication (dialogical, participatory) tends to be a sham, perpetuating the rules of the deficit model, rather than taking into account different audiences and social actors. In short, as Brian Wynne forcefully states, this is nothing less than total myopia in the face of the current situation:

> Scientific institutional actors and the policy officials they advise seem unable to recognise these basic points, as the epistemic culture of instrumentalism and control which defines modern scientific knowledge has been allowed to pervade and latterly to define science-policy institutional culture (2006, p. 220).

The combination of these two phenomena in the current political situation – which itself is characterised by the rise of right-wing populist parties and movements that exploit certain scientific issues such as climate change – has led, in a cascading effect, to a specific mode of scientific communication. The main characteristic of this mode is the intensification of marketing methods in all areas of society, to the extent that the reliability of information does not matter: anything goes as long as it serves a certain purpose. Thus, we have the spread of fake news and the advent of the post-truth era.

The current scenario is strongly polarised: on the one hand, there are the defenders of a neutral and untainted truth, above all social interests (political, economic, etc.), and on the other, there are those who distort, invent, and deny theories and facts for the sake of causes placed above all others (life in the case of abortion; the Great America in the case of global warming). However, as Wynne (2022) points out, this polarisation lends an aura of sanctity to the production and validation of scientific knowledge in the "age of truth" (before the post-truth era). But did truth above suspicion ever really exist before? As mentioned above, it did not. In a sense, the commercialisation of science paved the road to the post-truth era. Either way, it is undeniable that the climate of polarisation has become a boggy marsh. How do we get out of it?

This chapter proposes the need to create the figure of the science critic, which would allow a systematic approach to science in its context and in society – just as the art critic does with art – contextualising scientific results, clarifying research processes, explaining the stakes, and the political, economic, ideological, and other interests at play, and, last but not least, serving as a stepping stone between science communicators and science studies and science communication research where there is still a yawning gap. This may be the only way out of this dichotomy, and indeed out of the crisis that public science communication has been in for some time.

To this end, we will first characterise the dominant way in which science communication is carried out today and, through a typology of the figures of communicators present in the arena, we will describe the most common ways of working in this field. We then go on to show the relevance of the figure of the science critic (with some references to the main features of the art critic, the inspiration for this proposal) and finally to outline the way in which the science critic should proceed. The conclusion highlights the need and urgency of the presence of a science critic in the current situation.

The dominant mode of science communication

After decades of studies (from Kuhn, 1962; Habermas, 1968; Rose & Rose, 1970, to specialised publications, academic programmes, and numerous congresses today), it has been established in the academic world (Social Studies of Science and Technology, Science Communication Studies, etc.) that science is a social activity, and therefore its organisations and even its theories are embedded in the political, economic, ideological, philosophical, and other spheres of society. However, not much of this social embeddedness is reflected in what is read, heard, or seen about science in the media, and in the daily work of science communication. Broadly speaking, this is due to the following reasons:

a) Science news is mostly decontextualised because there is a tendency to isolate the results of its processes – the famous black boxes – and it is framed by a vision where science is intrinsically beneficial and all new knowledge represents progress (Carrillo-Trueba, 1997; Van Gorp & van der Goot, 2012, p. 137).

b) Scientific activity is presented as a provider of material well-being due to the technological development it produces in a disinterested manner, with its own dynamic, driven only by the desire for knowledge (as stated by Popper in 1935), detached from society, and thus generating universal knowledge that can be reproduced anywhere in the world (Pestre, 2006).

c) Science is presented as an activity carried out by morally pure people (Shapin, 2008) who are dedicated to expanding the frontiers of human knowledge, who fight from the heights the obscurantism,

ignorance, irrationality, misinformation – or fake news as we call it today (Dawkins, 2006).

d) Knowledge is communicated to the "ignorant public" as it has been described in numerous studies, a public with a knowledge deficit (Miller, 2001), to whom scientists and science communicators communicate in a unidirectional way, using a range of different means and techniques (Burns et al., 2003; Kappel & Holmen, 2019).

e) There is a huge gap separating science communicators from researchers – even researchers of science communication (Bucchi & Trench, 2021). The pandemic we have recently suffered has clearly shown how wide this gap still is (Carrillo-Trueba, 2021).

In short, the present-day vision of science not only has blind spots, but also ends up constructing a very poor image of scientific activity, science – always presented as something homogeneous, without cracks or fissures – and sometimes even of the world itself (Thuillier, 1983, 1988b). Thus, science becomes ungraspable because it is always presented in a fragmented, decontextualised way, without sense, lacking in meaning (Carrillo-Trueba, 1997). The intrinsic heterogeneity or plurality of science is eliminated as are the paradigms that support different positions, metaphors, and their relationship to the larger culture (Keller, 2002). The different ways of doing science and the nuances with which cultures imbue them, that is, the whole complexity of science production and validation, are set aside.

Of course, this situation is neither absolute nor constant. It varies from country to country, and even from region to region. In places where science and technology are more developed, their impact is greater, and there tends to be more reflection and public debate on scientific issues and their implications. (The exception may be countries such as China, where, despite scientific and technological development, there is no debate because of state control of the media). Elsewhere, not only are these debates less common, but they can even be considered sacrilegious if they are critical, as in Mexico ("science in our country is so weak and then they come and criticise it") where the exercise of scientific communication is mainly unidirectional, and the criticism of science, the questioning of its orientation, is considered to be a "luxury" of countries where it has already been established (Kreimer, 2015).

Many of these debates are part of what has become known as "scientific controversies" and, as is well known, they go well beyond the strictly scientific framework (Brossard, 2009).

However, similar to the situation we live in today (between truth and post-truth), the polarisation that emerges from these debates overshadows many important aspects of the understanding of the matter at hand, simply for the sake of defending one's own positions and winning the debate or a lawsuit if it comes to that. And these debates are frequently distorted by the Manichean way in which they are presented: one side is right and the other is wrong, one side defends pure science and the other mere ideology, one side is driven by corporate interests and the other does science for the common good. In the process, both sides gain allies and form seemingly well-defined factions (Latour, 1987; Brossard, 2009). The final outcome is disconcerting, as the winner becomes either the champion of SCIENCE or yet another villain who stood in the way of an undeniable truth.

Furthermore, a deeper look would reveal that opposite positions arise from the same situation, that is, there is symmetry in the causes that produce both effects (Bloor, 1976). The case of James Watson and his racist remarks in 2007 is a case in point. There was little reflection on them and the Nobel Laureate was simply declared senile. Closer analysis, however, revealed that Watson had made similar comments on other occasions, namely that biological determinism has many common features with molecular biology, and that genetics have been given a primacy in the understanding of human nature. In other words, it wasn't merely a detour from the right path (Carrillo-Trueba, 2009). The same lack of symmetry can be found in debates about scientific fraud. Whenever a case occurs, it is quickly categorised as an anomaly, but as Broad and Wade have argued, it is a more common practice than usually thought: "The roots of fraud lie in the barrel, not in the bad apples that occasionally come to public attention" (1982, p. 108). Even when such controversies erupt, it is still not common practice to integrate discussions and reflections on science as a social phenomenon into the daily practice of science communication.

Finally, in light of what has been outlined above, we can state that what several authors have called the crisis of science communication lies

largely in the dominant mode of science communication, which some authors have even described as a failure (Wynne, 1992b; Bauer, 2009; Miller, 2001).

Figures in the field of science communication

As is widely recognised, science communication is a field that is not fully defined (cf. for example, Bucchi & Trench, 2021, p. 3) and is delimited by various criteria. It is defined either by its mission (PAS, PUS, SL, SC, according to the terms defined by Burns et al. (2003), called paradigms by Bauer et al., (2007)), by the objectives it pursues (nine according to Thomas & Durant (1987), eight according to Kappel & Holmen (2019)), by the modes of communication used (unidirectional or dialogic, called paradigms by Kappel & Holmen (2019)), or by the models it follows (Deficit, Contextual, Lay Expertise, Public Engagement, from the perspective of Brossard & Lewenstein (2010)). These definitions overlap, moreover, by the innumerable means and activities, techniques and tools used to reach the equally numerous audiences: science centres and museums, television, film, radio, print, theatre, science clubs, the web, and a long etcetera (Burns et al., 2003). In practice in this field, the combination of such elements generates a complex topography. In other words, in everyday work, the typologies overlap, the boundaries between paradigms, objectives and models become blurred, and the means and activities multiply.

On the basis of the above and in order to characterise what the figure of the science critic should be, we will first present an outline of the typology (in the process of elaboration) of the figures that perform in the field of science communication. This typology was elaborated based on the concept of the "frame", taken from the cognitive sciences, which is now widely integrated in the study of communication (Lakoff, 2014; Van Gorp, 2007; Scheufele, 1999). The concept of frame refers to the ideas, values, and intentions that guide and delimit the work of science communication that an individual carries out. Throughout history, it can be seen that the appearance of these figures (and these modes of communicating science) takes place in specific periods, and in a certain way they correspond to the periods that Pestre (2003) defined in his characterisation of "the regimes of knowledge production".

It should be noted that these figures are ideal types, designed for heuristic purposes (good for thinking, as is said in anthropology) rather than as finished classifications of the universe that science communicators currently comprise. In all cases, however, it is possible to find science communicators who correspond to these types and with whom one usually interacts, discusses, and collaborates on various projects.[1] The value of this typology is that it highlights contrasting positions, perspectives, intentions, and interests, and thus the characteristics that a science critic should have. And it could well form the foundation for the development of a classification of science communicators, or of the modes of communicating science through empirical research.

For the time being, ten are listed here (with a touch of humour to honour the memory of the recently departed Bruno Latour).[2]

The Illuminist

The Illuminist[3] is a figure who is convinced that the progress of humanity can only be achieved by spreading scientific knowledge, its results, its truth, and that science is a beacon that will eradicate the darkness that still haunts mankind (superstition, beliefs of all kinds, including religious ones, traditions that hinder progress). This is why, like Don Quixote, she constantly fights against everything that is not scientifically proven, against pseudo-sciences (such as homeopathy), which she considers irrational, anachronistic, and destined to disappear. For the Illuminist, everything that comes from science is inherently good.

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1 Steven Yearley (2021) discusses the figure of the environmentalist as science communicator in the context of the current climate change debate in a similar way to what is proposed here. Such a figure would play the part of "the activist" in the typology presented here.

2 Humour does not detract from the respect I have for the community of science communicators to which I belong. These are my colleagues, with whom I collaborate, share, discuss, and even debate vigorously, and who send articles to the journal of public science communication of which I have been the editor for more than three decades. Not without some embarrassment – for an editor keeps secrets like a doctor – I confess that this typology takes my work as an important reference. The journal called *Ciencias* is published by the Faculty of Science of the National Autonomous University of Mexico (print and digital versions are available: https://www.revistacienciasunam.com/es/.)

3 In these descriptions, the feminine gender pronoun is used in some paragraphs and the masculine in others to avoid the duplication of she/he; it does not correspond to a specific gender for a particular figure, there is both in all categories.

The Scientist

The Scientist is attached to the great syntheses of thought, which makes him a typical figure of the nineteenth century. With the development of science, many philosophical systems based on scientific knowledge appeared (materialism, monism, positivism, etc.) that influenced the thinking of the time. The Scientist is a prolific writer, usually covering long periods and vast areas, easily the whole of mankind. He has perpetuated himself by the weight he has acquired in the constitution of the popular image of human history (from Ernst Haeckel to Jared Diamond), and of what is called "human nature" (from Herbert Spencer to Richard Dawkins). Usually, in his works, the social and economic system is naturalised by means of biological and social determinism. He elevates scientific knowledge, its way of knowing, as the only and indisputable basis for understanding the world, its past and future, its direction and transformation.

The Educator

The Educator promotes the scientific method, which makes science unique and superior to all other forms of knowledge and has been established as the main characteristic of science, as a fundamental element of education. She is a tireless promoter of experimentation, whether in physics, chemistry, or biology, or even applied to agronomy and electric power generation. She is convinced that this is the only way to establish scientific thinking, which is indispensable for solving all social problems, from food to climate change.

The Civiliser

The Civiliser is an enthusiastic promoter of the material progress of society based on the technological advances generated by science, both in the city and in the countryside, in developed and underdeveloped countries – where, he asserts, it is even more necessary for civilisation and development to become a reality. He is convinced that technology, hand in hand with science, is the engine that drives the world.

The Functionary

The involvement of the state in the management of scientific and technological development, and in the promotion of research itself, has

given rise to new types of science communicators, including the figure of the Functionary who is responsible for the dissemination of information by government institutions and their agencies (including universities and research centres), as well as by international bodies (FAO, UN, etc.). Her theme is the solution to the problems affecting the various sectors of society, regions, continents, or the entire planet, for which research and technological development are crucial – (is there any other way to solve them? indigenous peoples are invited to the forums to give a little colour…) – on the basis of which she draws up local or planetary plans in international coordination.

The Marketer

More associated with the private sector, the figure of the Marketer appears with increasing regularity in controversies concerning products and technologies that in some way affect one or more social sectors. He is the defender of knowledge linked to capital, alienated by patents, of corporate investment in technological development aimed, he claims, at solving social problems (GMOs for food production, energy supply by wind farms), and crucially, of the right to profit from it. The neutrality of science and the benefits of technology are his banners, private contributions in the face of public cuts are his shield, and marketing is his sword.

The Entertainer

Convinced that science is a good thing in itself, and that the most important thing is to bring its marvellous achievements to as many people as possible, the character of the Entertainer devotes herself entirely to using her enthusiasm to spread the taste for science and science for its own sake. Visits to science centres and museums, fairs, workshops, theatrical performances, the cinema: all is used to accomplish this. Entertainment is a means of absorbing science, far from any uncomfortable social issues.

The Plotter

Perhaps because of the secrecy of laboratory work and its imaginary resemblance to alchemists and sorcerers, there has always been the idea that scientists are forging something inside that we do not know

about outside. With the involvement of the state in the creation of large projects such as the Manhattan Project this fear has only grown. Today the figure of the Plotter has become very present and active on social networks and in the media, as we saw during the COVID-19 pandemic and with the issue of climate change. He takes scientific information, decontextualises it, reinterprets it, distorts it for his own purposes, and presents it as the truth, arguing that what is officially circulating is not accurate because it is manipulated: a conspiracy in short. He is a science communicator who uses everything to forward values and interests that he puts above all else, elaborating complex frames, as Lakoff (2014) has pointed out on many occasions and bordering on what Bauer calls "bullshitting" (2008, p. 6).

The New Age Figure

The disillusionment caused by the use of the Hiroshima bomb, the Vietnam War, the growing reductionism of scientific theories, the increasing instrumentalisation of technology, and the dehumanisation that all of this implies, have given rise to a way of approaching science that is embodied in the New Age Figure, characterised by the search for holism, theories with a spiritual aspect (quantum mechanics, deep ecology), alternative technologies, natural medicine, certain proposals of neuroscience, in short in any scientific production that approaches an Eastern or ancestral philosophy and helps to preserve this forgotten part of the human being. (A well-known example is Fritjof Capra, 1975.)

The Activist

The Activist is a central figure in debates on issues relating to science and technology (GMOs, nuclear energy, labelling of industrially produced foods, pollution, etc.). The Activist's scope for action tends to be limited, as she is completely committed to a specific issue and usually for a specific period of time (e.g. the passing of a law), although there are collectives such as Greenpeace that are constantly present on a range of different issues. She mobilises a wealth of scientific information and forges alliances with researchers and groups involved in or affected by the issues in question, and therefore has considerable influence on the development of those issues and on public opinion. Her peculiarity lies in the fact that she is perhaps the only figure that always

addresses the political, economic, and social dimensions of scientific and technological activity, albeit in a somewhat Manichean way.

The science critic

Like the critic of art, literature, film, or theatre, the main task of the science critic is to contextualise. In other words, the science critic should analyse the social and historical situation of scientific knowledge production, the relationships between theories, schools of thought, philosophical and political currents, the different styles of research (even of a national character), the use of metaphors, cultural influences, forms of scientific imagination, and much more. This is because science is inseparable from culture and shares many characteristics with the ways culture and art represents the world (Godin & Gingras, 2000; Goodman, 1978; Van Gorp, 2007). The analysis of the science critic should consist of four steps: 1) deconstruction; 2) addressing science in society (opening up relevant issues, generating dialogue, and reflection); 3) giving meaning to the production and validation of knowledge, and; 4) contributing to the formation of a scientific culture.

Given the dominant vision in society of what science is, the production and validation of scientific knowledge, and technological development which is generally reproduced in science communication (Hilgartner, 1990), the first task of the science critic should be its deconstruction. That is to move from SCIENCE to the sciences, which means their social insertion, the way they participate in the creation of the social (Pestre, 2003; Latour, 2005), as well as dismantling its image of neutrality and immanence – the image of the researcher as a saint and laboratory martyr – and its assumed Popperian dynamics and absolute objectivity. In a pluricultural world and in democratic societies, it is also necessary to take into account the claim of science's universal character as the only valid form of knowledge in contrast to other cultures, and the homogeneity with which it is usually presented.

To many science communicators, this may seem like a radical, relativistic position that ultimately diminishes science and its mission. However, it is based on decades of very serious and rigorous research, derived from the STS (Science, Technology, and Society) perspective, which is the source of many concepts, tools, and forms of analysis, and offers

ways of entering this universe in a subtle and detailed way in order to understand it. The daily work of science is therefore fundamental to science communication as it allows us to recover the complexity that characterises scientific activity in society and to humanise the scientist, perceiving him as just another citizen, subject to prejudices and ideas that inevitably influence his work, albeit not necessarily in a negative way. This could be a good starting point for addressing "science in society".

Given that form and content are closely linked in communication, science critics should lean toward the dialogic mode, generating topics of common social interest, encouraging reflection on them, and opening up conversation around them (following the proposals of Bauer, 2008, and Bucchi & Trench, 2021). In order to do this, they must be committed to providing certain information, concepts, theories, processes, and may sometimes resorts to the diffusionist mode, but always in relation to context, the plurality of elements, and reflection on different positions. The scheme proposed by Bucchi and Trench (2021, p. 8) can be seen as an account of the continuum that exists between one mode and the other (the diffusionist at one end and the dialogic in the middle), taking into account, at the other end, the participatory mode of communities and individuals whereby they intervene in the issues that concern them, but also in the design of research policies – something that is very necessary today and an activity into which the science critic can also venture – and, of course, the policies of public science communication.

By privileging the dialogical mode, we take up the critique of the way in which certain governmental and private entities have used it to mitigate the loss of trust in science and technology, as well as in their institutions (Wynne, 2006; Gregory, 2016; Burns et al., 2003; Miller, 2001; Bucchi & Trench, 2021).

Even if we were to accept the definition proposed by Bucchi & Trench that "science communication is the social conversation around science" (2021, p. 6), once the most appropriate mode of communication for the work of the science critic has been defined, the question that inevitably follows is the content and the way the communication is put together in order to make sense. This is the most laborious part of our daily work.

Perhaps our priority should be to avoid the decontextualisation prevalent in the way new research results and technologies are presented in most science communication. As the mathematician Rene Thom put it: "What limits what is true is not what is false, but what is insignificant" (1991, p. 132), i.e. the proliferation of news that has no meaning for the public and is therefore insignificant, and the excess of information characteristic of this era that ends up trivialising research work. Contextualisation does not mean simply adopting the so-called contextual model (Brossard & Lewenstein, 2010), but rather recovering the image of the world that the sciences produce in a fragmented way, due to the prevailing hyper-specialisation in the production of knowledge (as in the industrial chain stemming from Taylorism (Carrillo-Trueba, 1997). It is necessary to integrate the contributions of each discipline to the subject in question: the different views, the way they are spun to avoid reductionism and recover levels of organisation, non-linear processes, the emergence of properties, using these and other concepts from the philosophy of science that are heuristic in the elaboration of an integrating vision.

Contextualising science also means bringing together traditionally distant areas, such as the social sciences and the humanities, with the so-called hard sciences. Given that scientific issues of social relevance are hybrids (Latour, 1999) – i.e. combining economic, political, historical, social, ethical, philosophical, and even ontological aspects – it is necessary to integrate the contributions of these disciplines in order to understand science in society, to make more sense of the different elements that make up the issue being addressed, to contextualise it, and make it as meaningful as possible for the target audience. In short, the work of the science critic is formative rather than informative; it is heuristic because knowledge is generated in relation with the public.

In this sense, the context of the public is fundamental. This context includes the public's perception of scientific knowledge and, above all, of technological innovations, their social impact, their risks, what they imply in terms of the culture in which they function, the values they might presupposse (Van Gorp, 2007; Scheufele, 1999), and how they are perceived in the world. For example, the cultivation of genetically modified maize in Mexico is seen not only as a health risk but also as a threat to a

food that has enormous cultural, symbolic, and even cosmological value in certain regions. It is also important to realise how much science has tended to target those already in the know, and now to extend communication to audiences that are not, which requires knowledge of their context and well-defined strategies (Nisbet & Scheufele, 2009, p. 1776).

The cultural context is even more important in pluricultural countries that are made up cultures completely different from western culture, that maintain their own ways of living, thinking and knowing, including the languages that are the reservoir for all of the above. Here the dialogue is of an intercultural nature and implies being located in the ontological sphere, since what exists, what is possible, and what is causal is based on different premises that are as valid as others in their respective contexts.[4] Of course, even in developed countries that do not consider themselves to be pluricultural, it is possible to find populations that, by virtue of their way of life, maintain characteristics different from the dominant values, including their own forms of knowledge. This was true in the well-known case of the sheep farmers from the Lake District of Cumbria in the north of England (Wynne, 1992b).

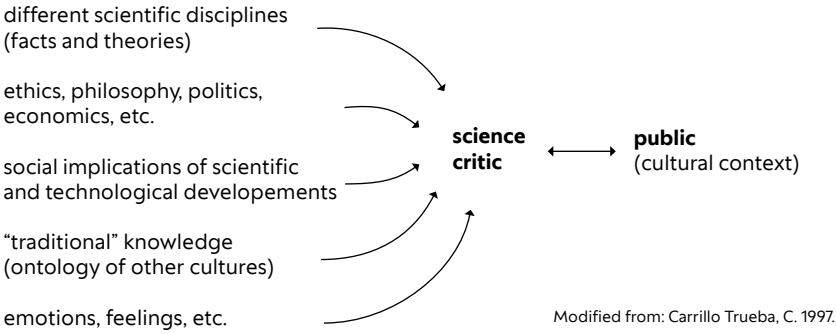
Finally, there is an aspect that has long been marginalised by the prevailing rationalism in science and its communication, and which is only now being taken into account thanks to neuroscientists such as Damasio: namely, emotions. It is necessary to mobilise emotions both in the work of deconstruction and in that of giving meaning, both in the way of establishing dialogue and gathering relevant information, always using the possibilities offered by the medium used. It is well-known that without emotion there is no knowledge (Damasio, 1994).

Integrating all these elements into the work of the science critic (Figure 1) means making frames explicit, dismantling them, and constructing new ones, because frames play such a fundamental role in communication (Scheufele, 1999; Van Gorp, 2007; Nisbet & Scheufele, 2009). However, this requires time and hard work, since the dismantling of the dominant frames means their replacement by new ones, and such adoption is never immediate because it requires a deep change (Lakoff, 2014). As explained by Gregory Bateson (1972), the frame is not exter-

4 This concept was developed in my book *Pluriverso: un ensayo sobre el conocimiento indígena contemporáneo* (2006).

nal, like that of a photograph, but it is imbricated with what it delimits. This means that the frame in some way provides the science being communicated with attributes. It gives the science meaning because it is constituted by ideas and values as well of ways of seeing and relating to the world that are shared by a social sector. (Van Gorp and van der Goot wrote an interesting work on this subject, 2012.)

The science critic:
the work of integration



Modified from: Carrillo Trueba, C. 1997.

It follows from this discussion that the practice of science criticism presupposes certain qualities, also identified by various researchers. One is "reflexivity" (Bloor, 1976; Bourdieu, 2001, 2003), which means that science critics must begin by being critical of their own work, positions, ethics, and values, and the knowledge they mobilise. This is a central aspect of the science critics' work since the relationship of trust they seek to establish with the audience depends on this reflexivity. Science critics must also avoid pontificating, making speeches and general statements that are empty of content (Gregory, 2016). This implies a degree of scepticism, which is crucial in the communication of science, especially taking into account the claims of science often made under the banner of absolute truth (Bauer, 2008, p. 13). However, as Wynne points out, it demands that ethical and other dilemmas must not be avoided, and indeed making clear the values that drive a debate in order to foster trust (2006, p. 220). In other words, the limits of science

and technology must be openly admitted without undermining them, but as an inherent quality in the way the hybrid nature of the issues at stake are constituted.

Of course, science critics may want to take a stand on a particular issue, but then it must be done openly and clearly. Before doing so, however, they must problematise, give voice to the different positions and actors, weigh up the arguments at stake, and the different perceptions and frames as the aim is to provide the necessary elements for understanding and taking a position on the specific issue. By taking a position in this way, science critics participate in the formation of opinion by showing the plurality of perspectives and thus also contribute to the democracy of a society.

As mentioned above, science critics should not only focus on the issues of the moment, but also delve into the intricacies of the production of knowledge, that is, uncover the black boxes behind the processes, the paths followed, life in the laboratory, styles of research, the scientific imagination, aesthetics, language, and metaphors used: in other words, the creation of science in its crucible. This is a vast field that has been fruitfully cultivated by historians of science and that is attracting renewed interest from the perspective described in this section. There are many cases that illustrate and allow a better understanding of science in society, but they must be presented from a point of view that enters an almost intimate sphere. Such perspectives are currently very rare in science communication.

In the long term, the work of science critics should contribute to the formation of a scientific culture in society. This is understood here not as a synonym of Scientific Literacy or Public Understanding of Science (Burns et al., 2003), but from a more anthropological perspective, that is, as a collective dimension embedded in the dominant culture of a society, with its particularities in the different collectives and communities that coexist within it. It should also be understood from an individual perspective, which takes into account the inevitable differences between individuals, often only of degree, but also quantitative and qualitative differences when they are expressed by groups with distinct cultural traits that distinguish them from other groups.

Since each society is endowed with institutions that contribute in different ways to the maintenance of its culture, the different types of science communicators who operate within these institutions play a crucial role in shaping the scientific culture of a society. The way in which collectives relate to scientific knowledge and technological innovation depends on the cultural context. The fact that in India there are Ayurvedic (traditional medicine) hospitals created by the state is not surprising, since both society and doctors share the same cultural background regarding the causes of disease and the way to cure them. It is interesting how science is inserted into this context, into the relationship between patients and doctors, and how clinical research is carried out in this context, and articulated by and in other scientific institutions.

The three models presented by Godin and Gringras (2000) to explain the relationship between science and technology and culture are suggestive. Namely, they are not two separate entities, nor does one inform the other. In fact, science and technology are immersed in a specific culture and therefore acquire the attributes, modes, and characteristics of that culture. They are also embedded in and intertwined with other forms of knowledge.

It is in this social and cultural reality that science critics will participate in the formation and transformation of the scientific and technological culture of collectives, individuals, and society as a whole. A critique of the rules that guide the work of other science communicators, of the institutions and actors they represent, and the alliance among them, the complementarity that may exist in certain situations, the dialogue that science critics maintain: all of this shapes the actions and communication of science in society.[5]

5 It should be noted that this proposal is inspired by the work of several science communicators who share some of the characteristics described here: Stephen Jay Gould, Evelyn Fox Keller, Steven Rose, James Gleick, Richard Lewontin, Christophe Bonneuil and, in particular, Pierre Thuillier, from whom I took the idea of creating the figure of the science critic which, although he did not develop – life did not give him the time – showed the way forward with his ceaseless and passionate work.

Conclusion

Studies on the public communication of science show that this is still a field in the process of being defined and constructed, and thus still immersed in debates and ongoing reflections. To the contrary, those engaged in the practice of science communication tend to maintain fixed modes, purposes, ideas and styles, to the point that they can be grouped according to the rules they follow and what guides their practice (the ten figures outlined here), without departing too much, as a whole, from what has been called the "dominant mode" of doing science communication (Hilgartner, 1990). However, the current situation in the production, validation, and communication of scientific knowledge has changed so dramatically that an increasing number of communication scholars are pointing to the need for substantial changes in the way we work in this field.

Indeed, as mentioned above, the highly techno-scientific character of the economy in recent decades has led to the increasing commercialisation of scientific activity. The objective of obtaining patents in research projects is an example of this. The existence of university theses the content of which cannot be published because they have been financed by companies – "under embargo" as it is termed – and whose defence is not open to the public, is proof of the level of privatisation that scientific production has reached in the public sphere (Pestre, 2003, p. 108). This has had unfortunate consequences on areas and disciplines that are focused on understanding certain phenomena, theoretical and conceptual development, and even in the mythical curiosity of the scientist. As Bauer (2008) points out, the very ethos of the scientist has changed from the search for truth that characterises them in the social imaginary, to the search for patents, the creation of companies and marketing; from the university laboratory to the start-up, from the distracted-scientist-genius to the businessman-watching-the-stock-market.

This new regime of knowledge production and validation on science communication has many effects. The most obvious is its increasing commercialisation of science communication, its transformation into promotion rather than communication for understanding the world and shaping a scientific culture in society. Certainly, as Väliverronen

(2021) explains, this process is immersed in the growing mediatisation of the whole society (greater in certain parts of the planet and certain social sectors), driven by changes in the media due to the penetration of social networks, and finally by the hand of "market forces" which now extends to all of society (Väliverronen, 2021, p. 133). The result is first the complete mediatisation of politics – developed and exploited by right-wing movements – and then of all other social spheres from education and health to war, climate change, and science.

It is difficult to discern whether the main cause is social networks, right-wing political movements, the strength of large corporations, or some other factor. As Väliverronen (2021) explains, the empire of marketing in the production and communication of science, even in the training of science communicators at universities, is the result of the combination of all these factors.

What is clear is that this mediatisation has prompted an accelerated urge in the field of science communication to master and make the most of social media. This in turn has generated numerous studies on these phenomena. Once again, the lack of dialogue between science communicators and academics is evident here, as several well-known researchers in this field have been sounding the alarm, and some, such as Miller, for quite a long time:

> If we are entering a new age for public understanding of science, it is important that citizens get used to scientists arguing about controversial facts, theories, and issues. Only in this way will more people get a clearer idea of the potential and limitations of the new wonders science is proclaiming (2001, p. 119).

And more recently, in relation to the forms of communication under discussion (unilateral, dialogical, and participatory), Gregory points in the same direction:

> We should be careful about concentrating intellectual and other resources exclusively in apparently socially-orientated dialogues about new technologies, given that they neglect the content of science, serve economic interests rather than responding to public concerns, and let scientists off the hook of their social responsibilities. New technologies are exciting and can be useful, but they are

> rarely necessary or urgent – except for the investors, who benefit from the work we all do to socialise their ambitions (2016).

Clearly, we cannot proceed without questioning the modes that have characterised science communication over time and which are embodied in certain figures who become obligatory interlocutors in the design of a new way of conceiving of this activity. Thus, the new figure, the science critic, will have to engage in dialogue and debate with them, revealing to them the contributions of science communication to society. It will be a regular and ongoing task. The treatment of science in society must be constant and not limited to moments of controversy and heightened public debate. As Bauer emphasises:

> Public vigilance and debate are urgently required. How will the public sustain a critical conversation when scientific information is leaning heavily towards advertising, strategic public relations, and propaganda in the service of private interests? Where can we find the vestiges of a sceptical public to sustain the vigilance needed to the call the bluff on fraud and high-tech snake oil? The source of quackery is no longer outside science: it is high-octane itself (2008, pp. 8–9).

The creation of the figure of the science critic is fundamental in overcoming this situation, in constructing a social and contextualised perspective of the production and validation of scientific knowledge and of the communication of science itself by bringing the reflections and debates from the field of research closer to practice through dialogue with the other figures with whom we coexist in this field. It is perhaps the only way out of the swamp between techno-science and post-truth where we find ourselves, the necessary lever to get out and move in another direction, towards the construction of a true scientific culture. As Bauer concludes, this is fundamental for a democratic society: "The community of science communicators might recognise here its new mission: to empower public opinion to recognise the exaggerated claims of private knowledge marketing" (2008, p. 14).

The dilemma between defending science above society (or possessing a truth of inviolable purity) and embracing the post-truth era is a false dilemma (Wynne, 2022). In fact, it is not even a new dilemma. It hap-

pened to Stephen Jay Gould more than twenty years ago, when his criticism of the prevailing neo-Darwinism in evolutionary theory was taken up by creationists who fought to ban its teaching in American educational systems (Gould, 1981). However, it has now taken on larger dimensions as was seen in the case of Bruno Latour's criticism of certain aspects of climate change theories used by climate change deniers, and also during the COVID-19 pandemic. It is a dilemma that is not only false, but perverse, because it places us in a situation that is so uncomfortable it can be paralysing: by criticising the current dominant regime of knowledge production, are we providing ammunition to the negationists? Are we ourselves fuelling the post-truth era? When Bauer (2008) states that a more sceptical public is needed to counter the growing commercialisation of science, is he empowering the climate sceptics who use conspiratorial arguments and fake news? The answer is an emphatic no.

The following question raised by Pierre Thuillier several decades ago is still relevant today: "Is scientific culture served by the one-sided glorification of 'facts' and the presentation of objectivity as an absolute norm?" The answer is even more evident today: not only is scientific culture not glorified, it is affected and even diminished, as we have seen in several of the current debates. By not addressing science in society, we have left the myriad aspects of knowledge production and validation in the hands of others (private knowledge marketing and post-truth standard bearers). Regaining this ground is an urgent task. The proposal to create the figure of the science critic to communicate science to society has this as its primary aim.

Acknowledgements

To Pablo Kreimer, with whom I have discussed the relevance of the figure of the science critic on many occasions, for his careful reading of the manuscript and his comments. To the reviewers for their suggestions, which helped to improve this text, and to the editors for their patience and kindness.

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