Technoscience, policy and the new media. Nexus or vortex?

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A B S T R A C T

Science, technology and policy are today entangled in concurrent crises, rapid transformations and conflicts, which are alimented by an ever-accelerating media system. Existing attempts to capture separate elements of crisis miss their structural coupling, and are hence ineffective. The crisis has elements of inevitability linked to our addiction to technology and communication. Using elementary concepts from social system theory, and reconnecting them to a long intellectual tradition of critique of technoscience, we argue that the relation between science and technoscience is where the analysis should start. Science's epistemic authority is simultaneously challenged and brought to bear of topics where it deeply interacts with technology and society, as we show by taking the vaccine controversy as a test case.

*"I am, like most other critics, armed
less with solutions than with problems"*
Neil Postman (Postman, 1992).

1. Introduction

Nexus or vortex?

The concept of a critical interface between science, technology and policy was formulated by Giandomenico Majone in 1989 (Majone, 1989) in the context of use of arguments in the policy process. At the present moment this interface appears to have eaten up into the surrounding space, filling it up. All that takes place today in our societies and is significant to our human condition has to do simultaneously with science, technology and policy. Many of authors – from Jaron Lanier to Yuval Harari, from Elijah Millgram to Michael P. Lynch to mention just a few, would appear to concur to this vision and to the sense of urgency it conveys, variously detecting threats to democratic representation, dangers from platform or surveillance capitalism, yet new runaway technologies, or crisis in the governance of the science system. Our attempt is to show how all these elements are tightly coupled, in a nexus to which the media system impulses an unprecedented acceleration – hence the vortex in the title. We shall look at some important drivers of the present state of affairs, such as our addiction to technology and to communication. Then we shall briefly discuss to what extent all this is a new world, versus an old world in new clothes. Finally, we shall use social system theory to better characterize the relation between technoscience, policy and the new media, taking the vaccine controversy as a worked example.

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2. Technology and communication as human destiny

The broken dream of a baby boomer. Communication as our destiny. Technology, capital and media

For social system theory and in particular for German sociologist Niklas Luhmann, our present society is functionally differentiated in systems such as law, science, the economy, the media, and politics. This differentiation is what distinguishes our modernity from the previous stratified social structure, whereby each individual had a role assigned at birth. In a functionally differentiated society individuals inhabit and function in a plurality of systems: "Nobody can live in only one of these [functionally differentiated] systems". Here different generalized symbolic media, such as money (for the economy), power (for politics) and truth (for science) allow the simplification of the complexity of our lives, while simultaneously expediting transactions and communications (Moeller, 2006). Love as passion is itself, for Luhmann, a generalized symbolic medium of communication permitting enhanced levels of intimacy and communication (Luhmann, 1998). If science is mediatized (Scheufele, 2014), commoditized (Mirowski, 2011) and politicized (Pielke, 2007) – even in its manifestation of internal crisis (Saltelli, 2018, 2019), this would be interpreted in social system theory as the structural coupling between different systems, the capacity of these systems to 'irritate' and 'resonate with' one another, and finally the capacity of one system to grow at the expenses of others. The communication between systems takes place in a situation of 'double contingency', where each system makes sense of the other only in relation to its own code and programme, and forms an image of the other again as a function of its own code. There is no neutral ground where the two system can communicate.

Social system theory describes the cultural evolution of human society as progressing toward more and richer differentiation and symbolic media of communication. Aristotle saw man as a 'social animal', while in our times Yuval Harari sees Homo Sapiens as a chimpanzee with the added capacity to communicate and share common 'stories', which allows the formation of groups of increased numerosity and internal differentiation (Harari, 2015). Luhmann's theory of a functionally differentiated society engaged in ever more sophisticated generalized symbolic media of communication extends and radicalizes this vision.

Where does this lead us in relation to the problems of media and technoscience? An example will help. A few years ago, a technical magazine devoted its cover to the image of a baby boomer protesting; "You promised me Mars colonies. Instead, I got Facebook" (Coverpage, 2012). At a superficial reading, one might imagine that the present trajectory is just an accident of technology; in a parallel universe, perhaps, the human race is already on Mars without Facebook. What if this trajectory had a reason? For the fathers of the ecological movement humans are compulsive adopters of technology, and this is already a good indication of our fate, since we can more easily adopt a system like Facebook than we can adopt a piece of the space program. But what if we are - by result of our evolution, compulsive adopters of more and better strategies, forms and media of communication as per social system theory? (Moeller, 2006). If we accept Harari's thesis that humans are communicating chimpanzees (Harari, 2015), then we can interpret the role of social media as making humans' shared stories simultaneously more shared and more fragmented. While the synergetic coupling of technology with capital was already noted by Lewis Mumford (Mumford, 1934) in the thirties, the present coupling in the form of platform (Lanier, 2006) or surveillance (Zuboff, 2019) capitalism gives the story a new twist, an acceleration, whereby technology, capital and media become entangled, and contribute to the common core of the different crises of technoscience and political representation.

3. Old or new?

Are we witnessing something new or just old problems in new clothes? Harold Innis'take. Convergence science is here. Trust in Science and trust in social order

At the present junction the ever-communicating humans – addicted to technology and exposed to an increased mediatisation of all spheres of life, find themselves in the so-called post-truth era – an unfortunate expression as it assumes a 'truth-era' which somehow went missing. It is easy to say that this is an old story in a new format, but is this the case? For example, the Twitter hashtag #jewsdid911 is practiced by a community attributing the 9/11 terroristic attack to a Jewish conspiracy. One could say that there is nothing new here, offering as precedent the forgery of the Protocols of the Elders of Zion, or the many theories used to justify pogroms. The difference is that the present technology makes the hashtag universal: it can be read in every part of the planet, is instantly updatable with new content, and – if desired – automated (Harari, 2018), to the extent that automatic algorithms can be, – and actually are, generated to engage humans around the subject in order to stoke hatred and division (Lanier, 2018). Is this just a new format or a new world?

For Harold Adams Innis a society's communication media and the manner its culture develops are entangled (Innis, 1991). Typically, media which travel well in time and less well in space (clay or stones) underpin different cultures than media which travel well in space and less well in time (papyruses).

We can perhaps assume that the use of a medium of communication over a long period will to some extent determine the character of knowledge to be communicated and suggest that its pervasive influence will eventually create a civilization in which life and flexibility will become exceedingly difficult to maintain and that the advantages of a new medium will become such as to lead to the emergence of a new civilization.

(Innis, 1991). Innis would probably see in our new media dominated present the making of a new world. Of course, a rich cohort of scholars would subscribe to the New World paradigm. For Luhmann (King & Schütz, 1994):

The society that we observe today is no longer that of Marx, Weber or Durkheim. And even more so, it is not that of the Enlightenment or the French revolution. More than ever before, the past has lost its binding force and this is also true in regard to the value criteria which

once formed the basis for the search for rationality.

Likewise for the other great German sociologist Ulrich Beck (Beck, 1992) with his reflexive modernity marking a separation to a new phase.

What role does science play in the new configuration? The chains of transmission between science and technology on the one hand, and policy and society on the other have multiplied; mathematical models, artificial intelligence, nano and bio technologies do impact everyday life and behaviours via channels such as algorithms for the social media and the financial system, possibility of human enhancements, genetically modified food, pesticides, robotics, autonomous vehicles, geoengineering, new weapon systems and many others. The 'convergence science' based on the 'nano-bio-info-cogno' (where 'cogno' stands for cognitive sciences) paradigm is hailed by the National Science Foundation as opening the doors to the solution of "vexing research problems, in particular, complex problems focusing on societal needs" (The National Science Foundation, 2016).

While permeating our collective lives, science is at the same time a source of legitimacy for the modern state. "Solutions to the problem of knowledge are solutions to the problem of social order [...] Trust in Science and trust in the prevailing social order are linked" for Shapin and Schaffer (Shapin & Schaffer, 2011).

Trust in the form of 'system trust', is a fundamental ingredient of social system theory:

> *The reduction of complexity [made possible by generalized media of communication as money, power and truth] assumes trust on the part of those who are expecting such reduction and of those who are supposed to accept it once it is accomplished. [System trust thus permits] the bank to lend more money than it possess, the state to issue more commands than it can enforce using the police, that more information is divulged in professional advice than could be backed up empirically or logically.*

(Luhmann, 2017). For Jerome Ravetz (Ravetz, 1971) science is made possible by an 'essential fiduciary status': trust in science is necessary for the general society to continue to support it, materially and with recruits; and mutual trust within science is necessary for its systems of quality assurance to function. In relation to the subject of the present work it can be noted that Jerome R. Ravetz has interpreted change in our relation with technoscience as the result of the maturing of structural contradictions (Ravetz, 2011). As per science's own crisis of quality control Ravetz has offered an original reading in terms of the social nature of the scientific activity, whereby the quality control arrangements in place when science was little become inadequate when science is big, or mega (Ravetz, 1971, 2011). The inadequacy manifests itself in a mismatch between ideals and incentives in research practices, the impossibility to catch up with bad science, and a systematic misdiagnosis of the present crisis (Ravetz, 1971; Saltelli & Funtowicz, 2017).

4. Technoscience and policy

The end of a grand narrative?

The relation of science and technology has a long history and tradition. Jean-François Lyotard and Bruno Latour used the term techno-science to indicate that the arrow of causality doesn't simply flow from science to technology (Latour, 1987), but that these systems coevolve. Likewise for the relation between technoscience and the economy – capitalism to be precise, in the thought of Lewis Mumford, one of the fathers of the ecological movement (Mumford, 1934). Technoscience as engine of growth, generally equated with progress, was central to the post-modern critique, whereby the main narrative of science as a vehicle for personal maturing (*Bildung*) and emancipation (Lyotard, 1979) would have by now run its course.

This tradition of critique becomes all the more cogent today. Science – whose so called reproducibility crisis is only a small piece of the puzzle (Saltelli & Funtowicz, 2017) - is at the core of important trajectories which are shaking our collective life (Harari, 2018; Lanier, 2006). In this reading, science's crisis cannot be separated from the crisis of trust in expertise, from our apparent inability to control technology, and from the insurgence of demagogic or authoritarian movements within mature democracies.

To analyse this, we focus on the couplings between technoscience, politics, economy and society at large as made possible by the new media.

5. Technoscience, science and technology

Technoscience as a separate functional system

First of all, it is necessary to be clear about the differences between science, technoscience and technology. To do so, we will look at them not as epistemologists, nor as philosophers of science, let alone as moralists, but as sociologists, precisely as system-oriented sociologists. As mentioned above, social systems theory has highlighted the functionally differentiated character of modern society. It contends that the functional systems have all their communications shaped by a binary code: true/untrue for the scientific system; payment/non-payment for the economy; government/opposition for policy; information (i.e. new)/non information (i.e. old) for mass media; legal/illegal for law, etc.

The binary code is what allows systems to distinguish themselves from their environment and to connect recursively their communications in an autopoietic manner. Modern society is a heterarchy, not a hierarchy. There is no overarching system and no system – not even the State – can speak in the name of another one. Indeed, only science can communicate about the world in terms of truthfulness/falsity, Law in terms of lawfulness/illegality, and so on. However, in order to select the right side of the distinction, they make use of programs, such as for science, theories and methods, which, contrary to the code, can change and evolve. As long as science will remain science, its binary code will not change, contrary to its theories and methods. So, we have now a sociological definition of science as that social functional system which has the monopole of distinguishing (even if provisionally) between true

and false statements about the world (nature, the individual and society).

What about technoscience? There has been a lot of attempts to get by a convincing definition of technoscience (Raynaud, 2015). We propose the following: technoscience is the system of communication using the same theories and methods of science (its programs) but which is driven by the binary code "work/doesn't work". We follow on this (Luhmann, 1990). While science is concerned with statements about the actual (even if past or future), technoscience is concerned with the virtual, what could exist and how to make it exist. Because it uses the same language than science, one could say that technoscience behaves like the cuckoo who lay its eggs in others' bird nests. Finally, as for technologies, they are eco-systems (or networks) of techniques linked by relations of complementarity and co-operation.

6. Structural couplings between functional systems

Crises 'in' versus crises 'of' a system

The execution of functional programs necessitates resources supplied by the social environment. Therefore, every functional system is dependent on the others. The political system needs (growing) financial resources for satisfying (ever growing) demands from the other systems. The economy needs laws to ensure that contracts are being honoured or that sanctions are applied; all systems need competent individuals able to execute their programs and they expect the education system to provide them. And all need the mass media because "Whatever we know about our society, or indeed about the world we live in, we know through the mass media" (Luhmann, 1996). These kinds of linkages between systems are called "structural couplings". It is through these structural couplings that systems can transfer their internal crisis to others systems, or conversely, become destabilised by crisis affecting the others societal systems. The problem of crisis of functional differentiation can be analysed in term of loose versus tight couplings

Medialization or politicization designates the fact that the couplings between science and the media or the politics have gotten too tight, seemingly blurring the distinction between the different subsystems. However,

> "*It has become fashionable to speak of a 'blurring of the boundaries' or of 'hybridisation'. This is misleading as it incorrectly suggests that the functional differentiation between science and politics disappears. The novel aspect of the use of scientific expertise is the close coupling of science and politics. This coupling is dynamic in the sense that it is driven from both sides to become ever closer.*"

(Weingart, 1999). Structural coupling obtains at the level of structures, not at the code level. This is why Luhmann, following biologists Humberto Maturana and Francisco Varela, insists that structural couplings are orthogonal to autopoiesis, because autopoiesis refers to the property of systems of making/reproducing themselves using strictly only their communication code (e.g. law can only act and communicate in terms of law; simultaneously only law can say what is lawful / unlawful), while the structural couplings take place at the outer level of programs and interaction with the social environment.

It may be useful to distinguish between a crisis "in" a societal system" and a crisis "of" a societal system. An internal crisis is characterized by a discrepancy between the system's binary code and its programme, the latter being less and less up to the binary coding requirements. For science, an internal crisis would mean that its methods and theories have become incapable to discriminate between true and false statements or that what was beforehand accepted as true or false has become indeterminate. The end of the crisis goes generally by what Thomas Kuhn has called a paradigm change (Kuhn, 1962). It is to be noted that in the internal crisis, there is no questioning of the validity of the code itself. On the contrary, it is the system itself which is in crisis when its binary code and its constitutive symbols are questioned to the point of being gradually replaced by others symbols and codes, as, for instance, when the code new/old (mass media), property/non property (economy) or power/non-power (politics) gains prominence at the expense of the code true/false in scientific communications. Major subversions of this nature are generally associated to a growing loss in trust in the symbols and signs of value of the system in crisis, a phenomenon equivalent to the processes of inflation and deflation in the economy. As shown by A. Béjin (Béjin, 1976), all societal systems are backed up by a fiduciary basis, pledges and guarantors that ensure that they remain trustworthy. A crisis consists of a discredit of the signs of values, an erosion of the fiduciary basis and a regression to the pledges, which amounts to a loss of internal complexity, a drastic simplification. In economics, for instance, it is a regression to gold (or land) as refuge value. In the scientific field, it is the reproducibility of experiments and calculations that underpins the trust placed in the signs of truth. The core of certainty of fundamental evidence supports this trust, which is also supported by scientific institutions as they exercise a control function (symbolic violence) on the validity of statements within their competence. A crisis in reproducibility is therefore likely to threaten the whole system, notably because it demonstrates the inability of the guarantors to protect the basis of trust. Likewise, (Weingart, 1999) speaks of the "inflationary use of scientific expertise". This begs the question of what constitutes the regression to the pledge in science … should one say neo-positivism?

It can be argued that the problems encountered by what we have called "the nexus" are not new (Fuchs & Westervelt, 1996) and that they are with us from long ago without having impeded significantly the functioning of society. But today, there is something totally new: it is the pressure exerted by the social media on the three systems: the media, politics and science. The argument, in two words, is the following: the three "classical" systems are "irritated" by the enormous flow of communication coming from the social media and they are, for the moment, unable to make sense of it with their own codes and programs. The case of vaccination will illustrate this: Internet and the social networks have become media of a global social communicational conflict "vaccination/anti-vaccination", which is freeriding as a parasite of the global and national health systems.

7. The vaccine confidence gap

Vaccines in the vortex

15 APRIL 2019, GENEVA - Measles cases have continued to climb into 2019. Preliminary global data shows that reported cases rose by 300 percent in the first three months of 2019, compared to the same period in 2018. This follows consecutive increases over the past two years.

While this data is provisional and not yet complete, it indicates a clear trend. …

Measles is one of the world's most contagious diseases, with the potential to be extremely severe. In 2017, the most recent year for which estimates are available, it caused close to 110 000 deaths…

The disease is almost entirely preventable through two doses of a safe and effective vaccine. For several years, however, global coverage with the first dose of measles vaccine has stalled at 85 percent. This is still short of the 95 percent needed to prevent outbreaks, and leaves many people, in many communities, at risk. Second dose coverage, while increasing, stands at 67 percent.

This alarming quote is from a recent note of the World Health Organization (World Health Organization, 2019).

The steady decline in vaccination coverage (from 95 % in 1997 to 80 % in 2004) started around 1998 and is the outcome of perverse couplings between the systems of health, politics, media, science, the economy, where even religion is involved.

For the readers unfamiliar with the case, we recall that in 1998 the very important and highly rated medical journal "The Lancet" published an article authored by Andrew Wakefield and thirteen others researchers arguing that the triple vaccine against measles, mumps and rubella (MMR) could be associated to the development of autism in vaccinated children. Though the "evidence" provided was coming from only eight children amongst twelve examined, the article "inflamed an already existing debate on the role of childhood vaccination in the UK and contributed to a substantial decline in vaccination uptake in the UK in the early 2000. The impact was still being felt in 2012 and 2013" (Stöckl & Smajdor, 2017 p.239).

Simultaneously, concerns with the role that Thiomersal (also known as Thimerosal), a compound containing ethylmercury, could play in autism were rising in the US and triggered an anti-vaccination movement that is also still active today.

The MMR controversy is particularly interesting because it started from a scientific paper followed by a press conference held soon after its publication so that the media had been alerted very early. This started a debate that continued long after the information had been proved to be false and the article retracted – albeit tardively, from "The Lancet" in 2010. According to a journalist (Brian Deer, of the Sunday Times) Wakefield would have been paid 400,000 pounds by lawyers seeking to prove that the vaccine was unsafe (Kasik, 2012).

The problem of acceptance by the population of government's vaccination schedules offers an exceptionally revealing view of what we mean here by the "nexus". Almost all the functional systems have a stake in the way vaccines and vaccination campaigns are perceived and accepted or not by the public.

First of all, of course, the health system both at the international level with the WHO and at the national one with the different national health services and administrations, whose communications on the benefits of vaccination "irritate" governments and the political system in general. Since vaccination is effective only if a significant proportion of the population is covered, it is considered necessary to overcome the possible free riding behaviour of some by rending vaccination mandatory, for instance for all babies between 9 and 12 months. Vaccinations schedules are therefore "collectively binding decisions". The economy is also structurally coupled to the health system. Vaccines are a big business. As noted in The Lancet:

In the past decade, the global vaccine industry has mushroomed in terms of the number of companies involved and products in development. From 1995 to 2008, the number of vaccine companies that sought to create or manufacture vaccines doubled to 136, as did the number of prophylactic vaccine products in development to 354. The list of WHO prequalified vaccines now has 202 products from different manufacturers targeted against 20 infectious agents, and the US Food and Drug Administration (FDA) list of vaccines available for immunization in the USA consists of 72 products.

(Larson, Cooper, Eskola, Katz, & Ratzan, 2011). According to (Global Market Insights, 2019b) the vaccines market is estimated to rise from the present (2018) value of $38 billion to over $70 billion by 2025.

Among the major companies involved in the global vaccines industry are "*Merck & Co., Abbott, AstraZeneca, Bristol-Myers Squibb, Astellas Pharma, Sanofi Pasteur, Johnson & Johnson, GlaxoSmithKline, Pfizer, Emergent BioSolutions, Novartis, Novavax and CSL*" (Global Market Insights, 2019a). These companies associated with academic laboratories are the main actors in the technoscientific activity of vaccine creation or development.

The law system is also involved. As Anna Kirkland explains: "Vaccines injuries display the inevitability of the meeting between science, politics, and the law, giving us a case to explore how well our democracy manages this tense and productive collaboration" (Kirkland, 2016). In the USA, a "vaccine court" has been established, "a useful institution for handling the recognition of vaccine injuries given that we regard them as posing simultaneously scientific, political, ethical, and legal problems." (Kirkland, 2016).

As we have seen, the "classical" media have played and still play an important role in nurturing a debate that is or should be considered as closed by the scientists and the health system administrators. This has in part to do with the "norm of balance" for journalists. This norm stipulates that "… journalists present all sides of an issue (including all relevant information and stakeholder perspectives) in an objective manner" (Clarke, 2008).

It is doubtful that this standard of balance really corresponds to objective information when it comes to equating the overwhelming majority of scientists and a few isolated researchers. This reminds of the famous recipe for the meat pie fifty-fifty horse and lark: mix the flesh of one horse with that of one lark.

This unfortunate recipe has been deployed in full in the Vaccine-autism issue (Clarke, 2008); in a sample of 279 articles in the UK and USA press between 1998 and 2006, where the words "vaccine" and "autism" appeared, 31 % presented both pro and anti-link (between vaccination and autism) positions, 27 % didn't discuss the link issue at all, 18 % presented only anti-link information and 24

% only pro-link arguments. Moreover the British press devoted considerable attention to pro-link studies and claims, especially during periods of increased coverage in 2001–2002 and 2004 – a time when the scientific consensus on an autism-vaccine link strengthened, rather that weakened. This is not so surprising viewed from a Luhmannian perspective. The autopoiesis of the mass media system is driven by the information/non-information binary code, which amounts to the new (buzz)/old (not buzz) distinction. Information has been characterized by Gregory Bateson as "a difference that makes a difference" (Bateson, 1972) and an isolated voice that preaches the opposite of what thousands of unanimous voices preach is a difference that makes a difference from an informational point of view. In general, observes Luhmann (Luhmann, 1996 p.28), the mass media privilege the dissensus over the consensus, local relevance over global one and individual events rather than general trends and processes:

> *Conflicts are preferred. As topics, conflicts have the benefit of alluding to a self-induced uncertainty. They put off the liberating information about winners and losers by way of reference to a future. This generates tension and, on the side of understanding the communication, guesswork.*

Therefore, even an honestly balanced coverage ends up favouring minority point of view.

> *Media attempts to balance coverage by provision of equal opportunity to all viewpoints exacerbates the challenges to public confidence in vaccines by allowing outlier views and small extremist opinions the same media space as views validated through a rigorous process of peer review by the scientific community.*

(Larson et al., 2011). Of course, the new media have also played (and continue to play) a significant role in the emergence and growth of anti-vaccination communities. The algorithm at the core of Facebook, for instance, is a powerful self-referential engine where the "likes" and "dislikes" (or "share" or "re-tweet") constitute positive and negative feedbacks communications that contribute to the constitution of homogeneous, uniform communities of discourses. No wonder that an article published in the "Vaccine" journal call the internet the "postmodern pandora's box" (Kata, 2010), following a formulation of (Mayer & Till, 1996).

The last, but not the least, the religious system is far from absent from the vaccine battlefield. The refusal of vaccines schedules is often, in Africa especially, but in the USA as well (Belluz, 2019), based on religious creeds or precepts. One victim of the polarized discussion on vaccines is a reasoned account of the trues misdeed of the pharma industry, (Goldacre, 2012; Rang, 2013) and a call to the scientific community to "*do a better job understanding why so many people are susceptible to false claims about vaccines, including conspiracy theories centered on alleged greed*" (Dreger, 2016). This is the climate of 'vaccine exceptionalism' whereby any doubter is an anti-vaxxer, - not to say a "*dangerous idiot*"- and which, by denying the legitimacy of doubts about any aspect of Pharma behaviour, may in fact contribute to the present problem (Dreger, 2015). Finally, as with other divisive issues such as gun control, the perverse role of intentional pollution of the vaccine discussion with a disinformation campaign operated by Russians trolls – far from being a science fiction script, is an acknowledged phenomenon (Broniatowski et al., 2018).

8. Lessons from the vaccination case

A Luhmannian analysis: the perception of vaccines from danger to risk

The vaccination controversy has all the characteristics of an autopoietic social system where communications connect to each other on the opposition or contradictory mode (no-no); in other words to what Luhmann analyses as social conflict (Luhmann, 1995; Taekke, 2017).

The government, the biological technoscience and the health system - what (Kirkland, 2016) calls the 'immunization social order' – on one side argue that vaccines are safe, that parents must trust them and vaccinate their children. On the other side, some parents answer "No. We don't trust you. Vaccines can cause autism. Science has given evidences of the link". To which the 'immunization social order' replies: "No. Science (now) has shown that it is not the case". The problem is "What science should be trusted?", the one which finds a link or the one that contends there is no link? People suspect that the existence of the link is established by "genuine" science and that it is technoscience that negates it because of its (too) close connections (couplings) with the immunization social order.

The parasitism of science by technoscience and the blurring of the distinction between "knowing" interests and "doing "interests has changed the conditions under which one can grant confidence or trust to what the media and society in general characterize as scientific. There was a time when confidence in science could be safely assumed. This time is not totally over but the fact that science has been subsumed by technoscience has changed the way the question is now addressed. Now, the question is to trust or distrust it. What distinguishes confidence from trust is the fact the first attitude is passive and irreflexive while the latter is reflexive and active. We "decide" to trust or to distrust. On the contrary, we "are" confident or not (Luhmann, 1988 pp.94–107).

The image of science in the public was that of a purely disinterested, cognitive activity steered only by the norms and values described by Robert K. Merton (Merton, 1973). The importance of technoscience and its exposition in the medias has changed this. The health system' s image has also changed, and for the same reasons. Here also, we have gone from a confident attitude to a "trust or distrust one".

There is nothing irrational in parents being cautious about jabbing their child with products from technoscience and pharmaceutical companies even if – or especially if – it means disobeying the government. First of all, they know intuitively that:

> *The decisive distinction that determines the form "technology" is now that between controllable and uncontrollable states of affairs. To put it in extremely abstract terms, it is a question of the successful reduction of complexity. Whatever else might happen, technology supplies the intended results. However, we also know, [...] that complexity itself can be captured in no reduction, can be represented in no model. Even*

if it works, we must also expect something to be left over. "Successful" reduction thus amounts to harmless ignoring.

(Luhmann, 1997, p.317). The problem is that even if at a population level, vaccination schedules - ignoring some complexity, can be relatively harmless and fulfil utilitarian ethical precepts, it can be harmful at the individual one. Indeed, vaccines can cause injuries and this is precisely why a special court has been settled in the US to deal legally with these cases.

Parents face nowadays the issue of vaccination of their children not anymore as a danger but as a risk. The distinction between danger and risk has been introduced by Luhmann in his essay on risk (Luhmann, 1993 p. 147), (Taekke, 2017). In brief, danger is the possible harm one can endure irrespective of one's own decisions or behaviours, such as with natural disasters or harmful consequences of others' decisions. Risk concerns the possible harmful consequences of one's own decisions and behaviours. When people were confident in science and medicine, the possible damages resulting from medical errors, or a vaccination with complications, were seen as dangers they had to consider, or as possible but inevitable accidents. But now that there is no more confidence, but trust or distrust, the vaccination of their children has become a risk. Parents must decide if they trust the immunization social order or not. It is up to them to take which risk for their child. If they hesitate or want to find social support for a decision not to trust, they can look into the social networks and join communities of "distrusters" or listen to more balanced voices– those who do not absolve Pharma but still behave responsibly in relation to vaccination, often depending on the cultural status of the parent. In this overheated setting the industry's strategy of producing ever newer vaccines and mixes of vaccines contributes to aliment suspicion and controversy (Larson et al., 2011).

Indeed, the relationship between politics and the bio-technology of vaccines follow the general path described by Luhmann in these terms:

> "Since from the structural point of view technology is a simplification necessary for successful operation, and since it must for this reason disregard actual, to say nothing of possible, causalities, politics has in this field to expect permanent, constantly repeated perturbations. Seek and ye shall find! To this extent there is a structural affinity between technology and politics in the sense of a mutual reproduction context - in which politics cannot avoid approving technology and thus providing itself with a source of perturbation."

(Luhmann, 1993), p.147.

9. The temptation of techno-science

Science: an innocence lost or a new awareness?

It is indeed very tempting to make use of scientific methods, techniques and theories to raise and answer work/doesn't work questions instead of true/untrue ones. In other words, as Karl Marx asserts in his 11th thesis on Feuerbach, to try to change the world rather than to interpret it. Admittedly, for most scientists nowadays it is not just a temptation but a *sine que non*.

It is almost impossible to find subsidies for true/untrue questions research, especially in disciplines such as chemistry, economics, sociology, biology and so forth. In economics, for instance, almost all articles and books presented as "science" are actually "techno-science", devoted to making markets function, profits accumulate and growth be assured, be it at the macro or at the micro (the business enterprise) levels. An important part of what is published under sociology consists in criticizing the world society for not being faithful to the values it claims to embody; the remaining addresses "social problems", trying to discover (or uncover) what could be efficient against poverty, injustice, unemployment, criminality, etc., which is pure techno-science even if rather powerlessness.

There is nothing wrong with trying to be pragmatically helpful, provided the two aims and the two endeavours are clearly distinguished and that techno-science is clearly presented for what it is. In the social, political and economic domain, it means also acknowledging that "changing the world" or even "solving social problems" is not science's first function, let alone privilege, but politicians and citizens's task, with the help of scientists if they can, and under the authority of the "demos". This is the credo of "Post-Normal" and Deweyan inspired experts. However, one can satisfy oneself with trying only to understand somewhat better the world in which we are thrown,

In discussing "Paradoxes in science and law" (King & Schütz, 1994) note how science's autopoiesis contains – as for all other systems, elements of paradox and improbability.

> … since modernity, [science] has tended to assume the function of determining 'truth' for society. The code, which governs its internal operations and by which science constructs the external environment, is that of 'true/false' or 'true/not true'. Science, therefore, distinguishes itself from its environment by the specificity and uniqueness of its identity, yet since any communication is subjected by science to science's coding (or selectivity), how can science be sure that its claim to be capable of distinguishing truth from falsehood is in fact 'true'? The claim rests entirely on science's construction of an environment in which it itself appears as capable of making such judgments of truth and falsehood.

The authors go on to note how for science, as is the case of law, a loss of epistemic authority is obtained when a system is perceived to deviate from its own code in favour of that – say, of the economy or media. Science can attempt an escape from the strictures of the binary distinction truth/false into that of scientifically proved/scientifically unproved, or into attempts to distinguish what is 'science' from what is 'non science', as suggested by Karl Popper (Popper, 1959). (King & Schütz, 1994) warn the positivistic scientist eager to have science having an impact in human affair to literally forget about whether Luhmann is right or wrong – we would say forgetting Luhmann altogether. Yet thse authors subscribe to, and praise, Luhmann's "ambitious modesty" whereby explanation and prognosis are replaced by a modest-and-yet-ambitious effort of description. We shall be contented to have remained

within these remits in the present work.

Acknowledgments

References

Bateson, G. (1972). *Steps to an ecology of mind.* Chicago University Press.

Beck, P. U. (1992). *Risk society: Towards a new modernity.* CA): Sage Publications.

Béjin, A. (1976). Crises des valeurs, crises des mesures. *Communications, 25*(1), 39–72.

Belluz, J. (2019). *Religion and vaccine refusal are linked. We have to talk about it.* June, Retrieved fromVoxhttps://www.vox.com/2019/6/19/18681930/religion-vaccine-refusal.

Broniatowski, D. A., Jamison, A. M., Qi, S., AlKulaib, L., Chen, T., Benton, A., ... Dredze, M. (2018). Weaponized health communication: Twitter bots and russian trolls amplify the vaccine debate. *American Journal of Public Health, 108*(10), 1378–1384.

Clarke, C. E. (2008). A question of balance. *Science Communication, 30*(1), 77–107.

Coverpage (2012). *You promised me Mars colonies; I got instead Facebook.* Retrieved fromhttp://files.technologyreview.com/magazine-archive/2012/MIT-Technology-Review-2012-11-sample.pdf.

Dreger, A. (2015). *What if not all parents who question vaccines are foolish and anti-science?* June 4, Retrieved fromThe New Statesmanhttps://www.newstatesman.com/2015/05/heretic-academy.

Dreger, A. (2016). *Beyond vaccine exceptionalism | Alice Domurat Dreger.* Retrieved August 24, 2019, fromhttps://alicedreger.com/vax.

Fuchs, S., & Westervelt, S. D. (1996). Fraud and trust in science. *Perspectives in Biology and Medicine, 39*(2), 248–269.

Global Market Insights (2019a). *Vaccines market growth statistics 2019-2025.* Retrieved August 24, 2019, fromhttps://www.gminsights.com/industry-analysis/vaccines-market?utm_source=globenewswire.com&utm_medium=referral&utm_campaign=Paid_globenewswire.

Global Market Insights (2019b). *Vaccines market worth over $70bn by 2025.* Retrieved August 24, 2019, fromhttps://www.globenewswire.com/news-release/2019/03/07/1749613/0/en/Vaccines-Market-worth-over-70bn-by-2025-Global-Market-Insights-Inc.html.

Goldacre, B. (2012). *Bad pharma : How drug companies mislead doctors and harm patients.* Fourth Estate.

Harari, Y. N. (2015). *Sapiens: A brief history of humankind.* Harper.

Harari, Y. N. (2018). *21 lessons for the 21st century.* Spiegel & Grau.

Innis, H. A. (1991). *The bias of communication.* University of Toronto Press.

Kasik, O. (2012). *MMR vaccination controversy, a media analysis report*Retrieved fromhttps://vtechworks.lib.vt.edu/bitstream/handle/10919/79932/MMR-Vaccination-Controvery_MediaAnalysis-1.pdf.

Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. *Vaccine, 28*(7), 1709–1716. https://doi.org/10.1016/j.vaccine.2009.12.022.

King, M., & Schütz, A. (1994). The ambitious modesty of Niklas Luhmann. *Journal of Law and Society, 21*(3), 261–287.

Kirkland, A. (Anna R. (2016). *Vaccine court: The law and politics of injury.* New York University Press.

Kuhn, T. (1962). *The structure of scientific revolutions.* University of Chicago Press.

Lanier, J. (2006). *Who owns the future?* Penguin Books.

Lanier, J. (2018). *Ten arguments for deleting your social media accounts right now.* Henry Holt and Co.

Larson, H. J., Cooper, L. Z., Eskola, J., Katz, S. L., & Ratzan, S. (2011). Addressing the vaccine confidence gap. *Lancet (London, England), 378*(9790), 526–535.

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society.* Harvard University Press.

Luhmann, N. (1988). Familiarity, confidence, trust: Problems and alternatives. In D. Gambetta (Ed.). *Trust: Making and breaking cooperative relations*. Basil Blackwell.

Luhmann, N. (1990). Technology, environment and social risk: A systems perspective. *Industrial Crisis Quarterly, 4*(3), 223–231.

Luhmann, N. (1993). *Risk. A sociological theory.* Aldine.

Luhmann, N. (1995). *Social system.* Stanford University Press.

Luhmann, N. (1996). *The reality of the mass media.* Cambridge University Press.

Luhmann, N. (1997). *Theory of society, Volume 1.* Stanford University Press.

Luhmann, N. (1998). *Love as passion: The codification of intimacy.* Stanford University Press.

Luhmann, N. (2017). *Trust and power.* Polity Press.

Lyotard, J.-F. (1979). *La condition postmoderne: rapport sur le savoir.* Éditions de Minuit.

Majone, G. (1989). *Evidence, argument, and persuasion in the policy process.* Yale University Press.

Mayer, M., & Till, J. E. (1996). The Internet: A modern Pandora's Box? *Quality of Life Research, 5*(6), 568–571.

Merton, R. (1973). *The sociology of science: Theoretical and empirical investigations.* University of Chicago Press.

Mirowski, P. (2011). *Science-mart, privatizing American science.* Harvard University Press.

Moeller, H. G. (2006). *Luhmann explained.* Open Court Publishing Company.

Mumford, L. (1934). *Techniques and civilization* (1955 edition). Routledge Kegan Paul LTD.

Pielke, R. A., Jr (2007). *The honest broker.* Cambridge University Press.

Popper, K. R. (1959). *The logic of scientific discovery.* Routledge Classics.

Postman, N. (1992). *Technopoly, the surrender of culture to technology.* Vintage Books, Random House.

Rang, H. (2013). Bad Pharma: How drug companies mislead doctors and harm patients. *British Journal of Clinical Pharmacology, 75*(5), 1377–1379.

Ravetz, J. R. (1971). *Scientific knowledge and its social problems.* Oxford University Press.

Ravetz, J. R. (2011). Postnormal Science and the maturing of the structural contradictions of modern European science. *Futures, 43*(2), 142–148.

Raynaud, D. (2015). Note historique sur le mot "technoscience". *Carnets Zilsel*(April 4), Retrieved from https://zilsel.hypotheses.org/1875.

Saltelli, A. (2018). Why science's crisis should not become a political battling ground. *Futures, 104*, 85–90.

Saltelli, A. (2019). Save Science from itself, Moedas, C., Vernos, I., Kuster, S., Nowotny, H., Saltelli, A., Mungiu-Pippidi, A., Wouter Vasbinder, A., Brooks, D.R., Cunningham, P., 2019. Views from a Continent in Flux. Nature 569: 481–84. Nature, 569, 483.

Saltelli, A., & Funtowicz, S. (2017). What is science's crisis really about? *Futures, 91*, 5–11.

Scheufele, D. A. (2014). Science communication as political communication. *Proceedings of the National Academy of Sciences of the United States of America, 111 Suppl* (Supplement 4), 13585–13592.

Shapin, S., & Schaffer, S. (2011). *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life.* Princeton University Press.

Stöckl, A., & Smajdor, A. (2017). The MMR debate in the United Kingdom: Vaccine scares, statesmanship and the media. In C. Holmberg, S. Blume, & P. Greenoug (Eds.). *The politics of vaccination. A global history*Manchester University Press (pp. 239–259).

Taekke, J. (2017). Crisis communication and social media. A systems- and medium-theoretical perspective. *Systems Research and Behavioral Science, 34*(2), 182–194.

The National Science Foundation (2016). *Convergence research at NSF.* Retrieved March 3, 2019, fromhttps://www.nsf.gov/od/oia/convergence/index.jsp.

Weingart, P. (1999). Scientific expertise and political accountability: Paradoxes of science in politics. *Science & Public Policy, 26*(3), 151–161.

World Health Organization (2019). *New measles surveillance data for 2019.* Retrieved August 24, 2019, fromhttps://www.who.int/immunization/newsroom/measles-data-2019/en/.

Zuboff, S. (2019). *The age of surveillance capitalism: The fight for a human future at the new frontier of power.* PublicAffairs.