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The Ascent of Instrumentalism in the Natural Sciences and its Consequences

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Abstract

We discuss instrumentalism as a component of the social changes that accompanied the second industrial revolution, following particularly the case of Germany. These changes constituted a departure from the Enlightenment tradition of natural philosophers towards a new approach to knowledge. We claim that instrumentalism cannot be separated from the disciplining of science that produced the sciences and further specialism, nor can it be separated from the intervention of the State, in representation of society, that conceived science as an economic resource, invested in it, in its teaching and use, making scientific knowledge an instrument of massive use, massively developed. But science as "economy of thought" (a view developed by Mach and others) has collateral casualties; ranking first among them is: free reasoning. The changes in education implemented in Prussia and the personalities displayed by the leaders of the new ethos of science produced (as expected) social conditions in which the development of critical reason was impeded. Only instrumental reason developed, thus producing technoscience, a constant development of new techniques (instruments) and a decline in the human constitution of the intellectual elite. The distance between the professional graduated from the universities and logic machines decreased by the improvement of the second and the decline in autonomous, self-controlled reasoning of the former.

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1 Introduction

In philosophy of science, *instrumentalism* is a form of *utilitarianism* stating the view that theories are merely instruments for predicting observable phenomena or systematising observation reports[2]. Hence, the truth value of a scientific theory lies solely in the possibility of applying the theory in order to fulfil some predetermined goal. It connects with *pragmatism*, a line of thought advocated by William James and John Dewey[3,4]. For any given belief James asks "what concrete difference will its being true make in anyone's actual life?" [41] Here the goal would be to operate some concrete difference in our actual lives. In turn, Dewey asserts that "Reasonableness or rationality is, according to the position here taken, as well as in its ordinary usage, an affair of the relation of means and consequences." [17, vol. 12 p. 17] He continues: "It is reasonable to search for and select the means that will, with the maximum probability, yield the consequences which are intended". If theories are just means, and one looks for the "best" theory, it still may be that best is not good enough.

Despite coming close to the target, these accounts fail to capture the broader picture of instrumentalism. Our view, which we call *rational empiricism* and develops the heritage of the Enlightenment and more recently of Peirce and Whewell is that instrumentalism has an earlier origin in the natural sciences that can be traced to about 1870 (around half a century before e.g., Dewey) and it imprints

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[2]Anjan Chakravartty (2011), 'Scientific Realism' 4.1, Stanford Encyclopedia of Philosophy(consulted 2025-12-23).

[3]Dewey is credited with having coined the term instrumentalism in 1916, his ideas going back to 1903:

> In the logical version of pragmatism termed instrumentalism, action or practice does indeed play a fundamental rôle. But it concerns not the nature of consequences but the nature of knowing. To use a term which is now more fashionable (and surely to some extent in consequence of pragmatism) than it was earlier, instrumentalism means a behaviorist theory of thinking and knowing. [16, p. 331]

[4]James and Dewey refer to Peirce, who was considered the father of pragmatism, but Peirce could not sustain their theses and renamed his own standpoint as *pragmaticism*, to distance his ideas from theirs.

science ever since, thus leading the development of education (instruction), technology and economy. Even the criticism of Horkheimer [38, p. 64] fails to recognise the instrumentalist orientations in e.g., quantum mechanics and relativity, although he recognises that "...reason has become an instrument." (ibid, p. 21). Rather than an academic classification of discourse, we regard instrumentalism as the predominant force in the shaping of contemporary society. We share the view of Konrad Lorenz as reported in [1, p. 54] namely that technoscience (normal science) produces tools ready to use by anybody, even those who cannot understand how they work. In that sense, *understanding*[5] is not always an intended predetermined goal.

We will review and identify instrumentalist content in science through the work of Hertz, Mach, Einstein and Dirac (among others) and advance into its consequences for science and for society as a whole. In particular, we will discuss in which way the current forms of Artificial Intelligence based on models that nobody knows exactly how —or why— they work [67, 34] represents a developed form of instrumentalism.

2 Instrumentalism in science

2.1 The origins: Hertz

Instrumentalist ideas can be traced back to the final decades of the XIX century with Hertz. Famous for his experiments on electromagnetic waves, Hertz was a disciple of Helmholtz, a scientist whose importance in the shaping of science in Germany cannot be overestimated (see below). To place ourselves in the historical context, we note that Hertz claims that by 1879 the electromagnetic laws that "enjoyed universal recognition" led to Maxwell's equations [36, p. 6]. In fact, Hertz was satisfied with having access to a working set of dynamical equations, regardless of the contents underlying the mathematical symbols. In his words,

> "I have not always felt quite certain of having grasped the physical significance of his [Maxwell's] statements. [36, p. 20]. [...] To the question: 'What is Maxwell's theory?' I know of no shorter or more definite answer than the following:– Maxwell's theory is Maxwell's system of equations. Every theory which leads to the same system of equations, and therefore comprises the same possible phenomena, I would consider as being a form or special case of Maxwell's theory;[...]" [36, p. 21]

[5] Clearly this word has different meanings for instrumentalists, pragmaticists and others.

Hertz claimed that theories have to be provided with what he called *interpretation*, an element that runs alongside the mathematics and helps in constructing experiments related to theory, while at the same time theory can be detached from its construction. In this way several nonequivalent interpretations can be attached to a theory. Hertz' deep epistemological change has been highlighted by D'Agostino:

> "...by separating the mathematical structure of a theory from its modes of representation he [Hertz] has profoundly challenged the conception of a physical theory as an indivisible unity of the two – a conception accepted by Maxwell and other nineteenth-century mathematical physicists." [15, 22].

In practice, Hertz retained the form of Maxwell's equations but he felt free to detach them from the constructive work undertaken by Maxwell. This is a far reaching break with the Enlightenment tradition. Let us stop here for a moment to briefly review this tradition.

Contradictory theories that share the same observational record should not be distinguished according to Hertz. This can be compared with Maxwell's standpoint, where the agreement of theories based on contradictory premises (one with ether, the other without) was regarded as an issue of concern that required further research:

> That theories apparently so fundamentally opposed should have so large a field of truth common to both is a fact the philosophical importance of which we cannot fully appreciate till we have reached a scientific altitude from which the true relation between hypotheses so different can be seen. [49, p. 228]

2.2 The Enlightenment tradition

With the present day insight we may say that the Enlightenment tradition had taken a radically different path as compared to Hertz. Indeed, since Galileo and Newton we regard scientific theories as an interplay between the sensible world that generates stimuli to our senses and the world of ideas, where we try to organise those stimuli. The outcome of this interplay are the foundational concepts of the theory (we arrive at them at the *end* of our inquiries rather that as a starting point) and their interrelations in the form of natural laws guided by reason. The consequences of these laws are investigated with the use of mathematical logic and the most we can hope for is to fail in our efforts of refuting the theory (by means of an observation that conflicts with rational predictions).

The keyword is reason. Non refuted theories are our current beliefs [55] and refutations are regarded as opportunities to exercise the "marvellous self-correcting property of reason" [55, CP 5.579] attempting to enlarge the theory (beyond the scope of the refutation) in a way that it becomes more consilient [66, p. XXXIX, aphorism XIV], meaning that it explains a larger class of facts. This process has been described by Peirce as *abduction* or *retroduction* [55].

In this context, *understanding* refers to a search for unity, where theories are constructed attempting to eliminate arbitrary assumptions (or at least being independent of eventual inevitable arbitrary choices)[62] and they gradually encompass a broader body of phenomena in a consistent way.

Hertz, on the contrary, advocates what is now common place, namely that agreement with (the equations governing) observations is the only goal that a theory can hope for. In short: If it works, it is correct. Needless to say, this is an unacceptable weakening of the term understanding, since mutually incompatible theories may provide the same predictions. Verification is never enough. Further, understanding –in the Enlightenment form– focuses in eliminating arbitrary or unobservable ingredients. For example, resorting to the photon and the quantisation of the electromagnetic field to explain spectroscopic chemical observations is both unnecessary and of undecidable reality. [63, p. 198]

The detachment of concepts from the context in which they were created is a recurrent issue in instrumentalist theories and it constitutes one of the fundamental differences with the Enlightenment tradition. For example, a survey of the different meanings of "velocity" in different versions of electromagnetic theory can be found in [3, Vol. 5, p. 314]. The issue here is that concepts (in this case relative velocity between two circuits, thus defined originally by Maxwell and amenable to measurement in any situation) are introduced in a theory to fulfil a function; they have a meaning. Eventually, the concept enters some equation through a symbol (say v). If later the same symbol v in the same equation(s) is reinterpreted as something different, it is mandatory to check whether the new meaning conflicts with the original one. For e.g., Lorentz, the same symbol v enters the same equation as in Maxwell (a case of the so-called Lorentz force) but it has a different meaning: it is the velocity of a target particle with respect to the ether, something that is not clearly defined and cannot be measured. In order to perform observations, Lorentz' theory required to hide under the rug the problem of measuring velocities relative to the ether.

2.3 The second industrial revolution

Instrumentalism enters the scene in natural sciences at a moment in history where the developments of electromagnetic theory boosted the so-called second industrial revolution. It was a period of important transformations in society, some of them reaching until present days. We will focus here in some of the consequences for the natural sciences.

The quest for technological development and its perceived social benefits in terms of welfare and economic growth gave momentum to **specialisation**. The philosophy of Enlightenment focused on the unity of knowledge. However, to connect new observations with previous knowledge slowed the pace of technological applications and the sciences shifted focus towards the result side. It gradually led to the appearance of *experts*, namely scientists with considerable acquaintance in some narrow branch of science and comparable ignorance of other branches. The sciences were more and more reorganised into **guilds of specialists**, which developed control elites managing the relations with the state (which by then was the main economic supporter of academy in Europe). The relationship of scientists with the state opened up for political influences. Indeed, **political persecution** of scientists in German universities is recorded since at least 1837 where the *Göttinger Sieben* were fired for protesting against the King of Hannover.

The organisation of experimental science changed deeply as well. The process can be followed in Germany. By the beginning of the XIX century laboratories were private, often located at the residence of the researcher. Otherwise, they were laboratories with teaching purposes, like the one used by Ohm. With Humboldt's university, laboratories became integrated to the University (and supported by the state through the University). Such was the case of the laboratory used by Weber at Göttingen. Yet, research was conducted individually, perhaps with the aid of a young researcher as it was the case of Riemann in Weber's laboratory. In the next stage, University laboratories grew larger and better funded by the state. The example of the Physics laboratory directed by Helmholtz at Berlin U. is paradigmatic. The laboratory was well funded and considerable power was held by the director. Several students pursued their careers at the lab under the general supervision of Helmholtz. Even visiting scholars were allocated time for the use of the facilities as it was the case of Rowland. The laboratory exerted influence not only at Berlin U. but beyond it, and the work in the laboratory was organised by a hierarchy of researchers [68]. In the late XIX century, state-run institutions dedicated to research emerged. Again, we see the figure of Helmholtz associated to Siemens in front of this new stage creating the *Physikalisch-Technische Reichsanstalt* [9, 10].

The influence of "power brokers" within each guild increased along with the number of teachers and students. This influence was directed both towards the state, suggesting lines of research, and within the universities, being part of committees for teaching appointments and the like. Helmholtz lobbied in 1879 for the institution of a prize on electromagnetic theory by the Prussian Academy of Science (Berlin) and encouraged his disciple Hertz to run for it [4, p. 49]. It is a clear example of how political influence leads to funding, support for a disciple and eventually academic merits. The German imperial state, under the rule of Bismarck operated a change in the culture of science spreading beyond Germany. In particular, German physics dominated the scene through various decades. Helmholtz' better and worse sides were reproduced throughout the social body of science.

Similarly, the **organisation of teaching** was reshaped in favour of technoscience. Mach, along with other thinkers of his time, advocated for a faster and goal oriented instruction in order to accelerate the formation of experts.

As compared with the Enlightenment period, the quality control of research shifted from a somewhat monastic attitude of self control and harmony with the universe, towards **peer control**, enacted by the specialist guild, following the "trends" or interests of the elites.

2.3.1 Specialisation

The instrumentalist demands of technoscience epistemology opens up for specialisation. Again, Mach is explicit in this respect:

> The division of labor, the restriction of individual inquirers to limited provinces, the investigation of those provinces as a life-work, are the fundamental conditions of a fruitful development of science. Only by such specialization and restriction of work can the economical instruments of thought requisite for the mastery of a special field be perfected [48, p. 609].

We notice how Mach envisions one of the cornerstones of technoscience and its relation with contemporary economic development. Further, science as an asset to be transmitted in order to develop economic wealth is necessarily based in language. For Mach, "Language, the instrument of this communication, is itself an economical contrivance. Experiences are analyzed, or broken up, into simpler and more familiar experiences, and then symbolized at some sacrifice of precision." [48, p. 578]. Not only precision is sacrificed, as acknowledged. The process of simplification breaks the connections present in the real world and hides the assumptions made in the process of idealisation. It ignores the process that constructed the token of knowledge. The end result are concepts without conceptualisation, mere opinions that cannot be distinguished from pure products of imagination, which indeed, have replaced observation and classroom experience, sacrificed in the altar of the economy of thought.

The restriction of research to "limited provinces" was already an established practice, it had been identified around 1830 in *After Hegel* [5], where the idea of the sciences being "autonomous" repeatedly appears:

> Rather than attempting to provide a basis for the sciences, philosophy should recognise "the fact of science,", i.e., the fact that the sciences

> are autonomous, that they have proven their own success, and that there is no point in worrying about scepticism regarding them. [5, p. 20]

Whewell coined the term "Scientist" and "Physicist" to distinguish the new social character from the old experimental philosopher [72]. Specialisation and compartmentalisation are imposed to Nature (who does not know about them) and confines the efforts of scientists to the specific areas. Gradually, "speciation" takes place. Research issues that do not clearly belong in one or the other compartment are left to the promises of interdisciplinary research, which rarely are enacted.

Such imposed restrictions prevent researchers to develop their own human potential and critical spirit, as identified by Humboldt:

> THE true end of Man, or that which is prescribed by the eternal and immutable dictates of reason, and not suggested by vague and transient desires, is the highest and most harmonious development of his powers to a complete and consistent whole. Freedom is the grand and indispensable condition which the possibility of such a development presupposes; but there is besides another essential,—intimately connected with freedom, it is true,—a variety of situations. Even the most free and self-reliant of men is thwarted and hindered in his development by uniformity of position. [39, p. 53]

Experimental philosophers were coming into (almost) extinction and the new social actor, the professional scientist, was replacing them in the development of science.

As long as the truth-value of a theory lies in its agreement with observations, it is not a demand for theories to be consistent with each other. Each theory may have its own way to asses its truth-value, despite possible clashes with other related theories. Accelerated charged particles radiate in classical electrodynamics but do not radiate as part of e.g., an atom. Moreover, entities without anchorage in the sensible world could be a part of the theory, such as the derivation of a velocity from Dirac's equation [63, p. 194] (which has no connection with the mechanical velocity that it was supposed to represent) or the formalism of matrix mechanics as Born admitted in his Nobel lecture: "What the real significance of this formalism might be was, however, by no means clear" [63, p. 176]. Indeed, the textbook versions of quantum mechanics, electrodynamics and mechanics display several conflicting points.

Helmholtz identified at least two dangers with specialisation, namely isolation and overvaluation, while depicting the behaviour of scientists and students of his time:

> First, then, I would say that union of the different Faculties is necessary to maintain a healthy equilibrium among the intellectual energies of students. Each study tries certain of our intellectual faculties more than the rest, and strengthens them accordingly by constant exercise. But any sort of one-sided development is attended with danger; it disqualifies us for using those faculties that are less exercised, and so renders us less capable of a general view; above all it leads us to overvalue ourselves. Anyone who has found himself much more successful than others in some one department of intellectual labour, is apt to forget that there are many other things which they can do better than he can: a mistake—I would have every student remember—which is the worst enemy of all intellectual activity. How many men of ability have forgotten to practise that criticism of themselves which is so essential to the student, and so hard to exercise, or have been completely crippled in their progress, because they have thought dry, laborious drudgery beneath them, and have devoted all their energies to the quest of brilliant theories and wonder-working discoveries! [35, p. 10-11]

Helmholtz writes as a person who has witnessed these behaviours. For him, specialisation is given as a fact or a necessity and its consequences have to be dealt with. Apparently, he does not conceive an alternative. This very transition away from the unity of science and towards specialisation that Helmholtz was experiencing and influencing will be analysed a few decades later by Ortega y Gasset, who asserts that the heritage of Enlightenment faded away in a few generations and "the majority of scientists help the general advance of science while shut up in the narrow cell of their laboratory, like the bee in the cell of its hive, or the turnspit in its wheel" [The Barbarism of 'Specialisation', 54, p. 111]. Ortega's description is vivid, passionate and sharply critical.

> Specialisation commences precisely at a period which gives to civilised man the title "encyclopaedic." The XIXth Century starts on its course under the direction of beings who lived "encyclopaedically," though their production has already some tinge of specialism. In the following generation, the balance is upset and specialism begins to dislodge integral culture from the individual scientist. When by 1890 a third generation assumes intellectual command in Europe we meet with a type of scientist unparalleled in history. He is one who, out of all that has to be known in order to be a man of judgment, is only acquainted with one science, and even of that one only knows the small corner in which he is an active investigator. He even proclaims it as a virtue that he takes no cognisance of what lies outside the narrow

> territory specially cultivated by himself, and gives the name of "dilettantism" to any curiosity for the general scheme of knowledge. [The Barbarism of 'Specialisation', 54, p. 110]
>
> [...] But this creates an extraordinarily strange type of man. The investigator who has discovered a new fact of Nature must necessarily experience a feeling of power and self-assurance. With a certain apparent justice he will look upon himself as 'a man who knows'. And in fact there is in him a portion of something which, added to many other portions not existing in him, does really constitute knowledge. This is the true inner nature of the specialist, who in the first years of this [XX] century has reached the wildest stage of exaggeration. The specialist "knows" very well his own, tiny corner of the universe; he is radically ignorant of all the rest.
>
> Here we have a precise example of this strange new man, whom I have attempted to define, from both of his two opposite aspects. I have said that he was a human product unparalleled in history. The specialist serves as a striking concrete example of the species, making clear to us the radical nature of the novelty. For, previously, men could be divided simply into the learned and the ignorant, those more or less the one, and those more or less the other. But your specialist cannot be brought in under either of these two categories. He is not learned, for he is formally ignorant of all that does not enter into his specialty; but neither is he ignorant, because he is "a scientist", and "knows" very well his own tiny portion of the universe. We shall have to say that he is a learned ignoramus, which is a very serious matter, as it implies that he is a person who is ignorant, not in the fashion of the ignorant man, but with all the petulance of one who is learned in his own special line. [The Barbarism of 'Specialisation', 54, p. 111-112]

2.3.2 Teaching: The economy of thought and didactic transpositions

We will exemplify this phenomenon mainly with quotes by Mach, a philosopher that is still mentioned in elementary physics textbooks, in spite of his misunderstandings. Mach's work constitutes an important and coherent example of a line of thought that was widespread in those times. In his own words,

> In recent times the view in question [science as economy of thought] has been repeatedly though diversely expressed, first by myself in my lecture *Ueber die Erhaltung der Arbeit* (1872), then by Clifford in his *Lectures and Essays* (1872), by Kirchhoff in his *Mechanics* (1874),

> and by Avenarius (1876). To an oral utterance of the political economist A. Herrmann I have already made reference in my *Erhaltung der Arbeit* (p. 55, note 5);[...] [48, p. 592]

The main goal of technoscience is to develop improved technology within the accepted current status of knowledge, as efficiently as possible. In the present times, *efficiency* cannot be detached from economic profit. In this sense, technoscience demands the production of skilful and expert professionals. To this end, Mach advocates for reshaping current knowledge in order to optimise knowledge transfer. Concepts need not be transferred as they were originally developed, as long as the transmitted (and possibly simplified) concept has the same observational value. In Mach's words,

> When we wish to bring to the knowledge of a person any phenomena or processes of nature, we have the choice of two methods: we may allow the person to observe matters for himself, when instruction comes to an end; or, we may describe to him the phenomena in some way, so as to save him the trouble of personally making anew each experiment.[48, p. 6]
>
> It is the object of science to replace, or *save*, experiences by the reproduction and anticipation of facts in thought. Memory is handier than experience and often answers the same purpose. This economical office of science, which fills its whole life, is apparent at first glance; and with its full recognition all mysticism in science disappears.
>
> Science is communicated by instruction, in order man may profit by the experience of another and be spared the trouble of accumulating it for himself and thus, to spare posterity, the experiences of whole generations are stored up in libraries. [48, p. 577]
>
> Knowledge which is historically first, is not necessarily the foundation of all that is subsequently gained. As more and more facts are discovered and classified, entirely new ideas of general scope can be formed. We have no means of knowing, as yet, which of the physical phenomena goes *deepest*, whether the mechanical phenomena are perhaps not the most superficial of all, or whether all do not go *equally deep*. Even in mechanics we no longer regard the oldest law, the law of the lever, as the foundation of all the other principles.[48, pp. 596–597]

This discourse exemplifies the habit of *didactic transposition*, namely when the organisation and content of concepts is reshaped to optimise instruction. It hides several dangers, the most important being that it responds to the idea that knowledge is received from the outside, rather than produced by ourselves. This shift in the construction of knowledge dehumanises the students, who cease to be autonomous beings that decide what is true and what is not by the power of their own reasoning. Instead, the students lend their brains to run forms of thinking provided by the instructors, being thus treated not as autonomous beings with own aims but rather as biological machines being programmed to fulfil a function in society.

Another danger is that altering the order in the presentation of concepts may hide misunderstandings on the side of the teacher. We have pinpointed elsewhere some of Mach's own misunderstandings [63, p. 38-45] of Newtonian mechanics that have propagated to standard textbooks. Indeed, Mach does not understand Newton's concept of mass, thus ending with two concepts of mass rather that just one. If didactic transpositions can be done at all, it is because the goal is to convince students to use a given set of imported ideas. Transposition requires a new process of conceptualisation when constructing the concepts.

It is apparent that the key motivation in Mach is "instruction", namely to transmit knowledge "as it is", in a manner as efficient as possible. In Mach's words, "My conception of economy of thought[6] was developed out of my experience as a teacher, out of the work of practical instruction" [48, p. 591]. This attitude may be tolerable when we are in the situation of training ourselves into a proven and recognised technique, but it is clearly inappropriate to develop our capability to address tasks that require critical and synthetic judgement.

Despite Mach's or Hertz' convictions, concepts do not exist independently of the context in which they where constructed. Rather than starting points, concepts are arrival points summarising the ideas we want to develop. Separating concepts from their content –an absurdity within the epistemology inherited from Enlightenment– turns science into a game of words void of content. This attitude has far reaching consequences in our time. The methodology of generative AI (Artificial Intelligence) is based upon relations between meaningless symbols and therefore it depends on (and supports) the instrumentalist approach. The warnings made by Peirce in 1887 about logical machines [7, 55, C.P 2.56] still apply, for example: "They do not appear to think, at all, in any psychical sense; and even if we should discover that they do so, it would be a fact altogether without bearing upon the logical correctness of their operations, which we should still have to assure ourselves of in the same way we do now" and indeed this is one of the main current problems as reported in [34]. Present day experience with

[6]Mach's ideas about the economy of thought appeared first (1872) in the pamphlet (his wording) "*Die Gestalten der Flüssigkeit*" (The forms of fluids) and in a more detailed form by 1882 in his thesis "*Die ökonomische Natur der physikalischen Forschung*" (The economic nature of physical research).

AI suggests that whenever the user is capable of independent thinking and only uses AI tools to pick up hints, they could be of help. Those unable to exercise independent thinking (for example because they are ignorant about the subject matter) run serious risk of being misled. AI operates only at the level of symbols, it generates likely discourse on the base of previous discourses used for training. Actually, such form of thinking would satisfy the requirements put by Carnap [11] who reduces thinking to logical propositions and language, a line of thought related to that of the young (first) Wittgenstein [70], sharply criticised by the mature (second) Wittgenstein [69].

2.3.3 Political persecution

Apart from the example above about the Göttingen Sieben, the reorganisation of the universities opened up for the politicisation of the academic environment, where competing power-brokers attempt to become hegemonic in their zone of influence. Such attitude was described by Bourdieu [6] and it may be recognised in the present days. The politician of science strives to impose the idea that *their science* is the best and deserves best funding. Further, it contributes in positioning their disciples socially in the guild, thus broadening their influence. In the period which we discuss, Helmholtz, Hertz, Clausius and others all the way to H. A. Lorentz were supporters of the ether (the conjectured undetectable site of electromagnetic action) and attempted to discredit in different ways alternative standpoints, in particular the ether-free alternative of the Göttingen school (Gauss, Riemann, Weber, L. Lorenz, etc.). In 1881 Helmholtz promoted to rename the unit of current *Ampère* rather than (as was customary by then) *Weber*. [2, p. 51].

2.3.4 The inner and the outer view of science.

The reason why science interests us appears to have always been dual. For the men of science the motivation had been a direct relation with Nature. For the rest of the society, the main interest has been to draw benefits from such knowledge. In the XVII century, Galileo Galilei represents the inner view of science, the view of those that develop science, while Francis Bacon represents the outer view, the view of those that expect to benefit from science. While the inner view predominated, Science was akin to experimental or natural philosophy, belonged to Kant's second faculty [43] and was eventually supported by patrons just like the arts. When society, through the state, decided to develop sciences, the second view took command. Science moved from the second faculty to Kant's first faculty.

For Kant and many others, ethics was in unity with reason, they could not be conceived separately. When Science moved to the first faculty, scientists separated it from ethics. Ethics operates on what we do with knowledge and the sciences focused on generating knowledge regardless of ethical issues.

With this deep change science became a profession, the doings and products of the professionals had to be controlled and what perhaps is more important, the new ethos of science attracted different personalities. The personality previously attracted into science is well represented by W. Humboldt (who can be considered a founder of language studies). Humboldt writes:

> The axiom that nothing on earth is so important as the highest power, and most varied cultivation of the individual, and that, therefore, the primary law of true morality is, educate yourself, and only the second, influence others by what you are; these axioms are so firmly impressed upon my mind that nothing can change them. [65]

Later, C. Peirce describes in the spirit of Enlightenment how true science can only be developed by those with a passionate thirst for reason and learning:

> If we endeavor to form our conceptions upon history and life, we remark three classes of men. The first consists of those for whom the chief thing is the qualities of feelings. These men create art. The second consists of the practical men, who carry on the business of the world. They respect nothing but power, and respect power only so far as it [is] exercized. The third class consists of men to whom nothing seems great but reason. If force interests them, it is not in its exertion, but in that it has a reason and a law. For men of the first class, nature is a picture; for men of the second class, it is an opportunity; for men of the third class, it is a cosmos, so admirable, that to penetrate to its ways seems to them the only thing that makes life worth living. These are the men whom we see possessed by a passion to learn, just as other men have a passion to teach and to disseminate their influence. If they do not give themselves over completely to their passion to learn, it is because they exercise self-control. Those are the natural scientific men; and they are the only men that have any real success in scientific research. [55, CP. 1.43]

Let us contrast this standpoint with Helmholtz' considerations about the (social) relations with academic peers:

> How many such men have become bitter misanthropes, and put an end to a melancholy existence, because they have failed to obtain among their fellows that recognition which must be won by labour and results, but which is ever withheld from mere self-conscious genius! And the more isolated a man is, the more liable is he to this danger; while, on the other hand, nothing is more inspiriting than to feel yourself

> forced to strain every nerve to win the admiration of men whom you, in your turn, must admire. [35, p. 11]

For the Enlightenment, to be in harmony with the Cosmos is more important than social recognition or admiration, it is the inner relation whats counts. For Helmholtz social relation is what counts. A majority of scientists appear to adhere today, over one hundred years after Helmholtz, to the outer view. [7]

[7] Baruch Spinoza makes clear in [64, pp. 2-3] that "Riches, Fame, and the Pleasures of Sense" are the principles orienting the life of the common men and discuss how they interfere and prevent the development of reason. The social recognition that Helmholtz praises is precisely what Spinoza calls "fame". We quote Spinoza:

> [5] (1) In the case of fame the mind is still more absorbed, for fame is conceived as always good for its own sake, and as the ultimate end to which all actions are directed. (2) Further, the attainment of riches and fame is not followed as in the case of sensual pleasures by repentance, but, the more we acquire, the greater is our delight, and, consequently, the more are we incited to increase both the one and the other; on the other hand, if our hopes happen to be frustrated we are plunged into the deepest sadness. (3) Fame has the further drawback that it compels its votaries to order their lives according to the opinions of their fellow men, shunning what they usually shun, and seeking what they usually seek.

This latter is the principle of action of the mass men, or the mediocre men in José Ingenieros [40], who writes:

> To vary is to become somebody, differentiate oneself is to have character, a plume, big or small: finally, a Crest, indicating that we don't simply live as a reflection of others. The capital function of the mediocre man is the imitative patience. The one of the superior man is creative imagination. The mediocre aspires to blend with those who surround him; the original tends to differentiate from them. While one thinks with society's head, the other aspires to think with his own. Therein lies the distrust that surrounds the original characters: nothing seems more dangerous than a man that attempts to think with his own head. [40]

The scientist is then a paradoxical character: they need to be somewhat original to be appreciated as men of science, they cannot be absolutely mediocre, but they cannot be original in extreme either, much less propose radically different points of views, because they aspire to the recognition of their colleagues and to achieve it they must align with the guild. The result of the tension is beautifully summarised by Bourdieu

> [...] there is invention according to a previously invented art of inventing, which, by solving all the problems likely to be raised within the limits of the established problematic, through the application of proven methods (or by working to save established principles from heretical challenges [...]) tends to occlude the fact that it only solves the problems it can raise and only raises the problems it can solve; on the other side, there is heretical invention, which, by challenging the very principles of the old scientific order, creates a radical dichotomy, with no chance of compromise, between two mutually exclusive systems.[6]

2.3.5 Instrumentalism and the outer view.

Agreement with observations has always been a fundamental criteria for acceptance of new knowledge. At the same time, achieving external goals is the determining criteria for acceptable technologies, in one word: success. Success makes the social acceptance or rejection of a technique and it has always been so. The technique is a tool in terms of the present discussion, something that assists us in achieving our goals more efficiently. In contrast, how the idea that led to the new tool occurred to us is not relevant in principle, but mere anecdote. A science oriented and supported in view of the technical possibilities that it opens (technoscience) unavoidably will tend to enhance the relevance of useful results (such as predictions) and disfavour the grounding of the new ideas in observations and previous understanding. Actually, if a tool works in a good number of cases but not in a restricted set of exceptional cases, the solution to the technical problem is to develop specialised tools that overcome the exceptional difficulties of those cases (a procedure called *patching* below). Thus, technology calls for specialisation by itself. The philosophical view would have considered that the "exceptions" actually refuted the theory and a new theory would have been thought, making us overcome our blindness. Thus, the Enlightenment attitude towards science promotes critical thinking where technoscience promotes specialisation.

2.3.6 The state's need to control the scientist's activities and the guild of specialists

Today, under late capitalism, the premise that the one that supports economically an activity acquires by this fact the right to exercise control (or at least monitor the activity) appears as natural. Thus, the professionalisation of the scientific activity demands some sort of quality control of its outcome.

In Medieval times craftsmen gathered in guilds that ensured production standards (they exerted "quality control"), achieved political influence and put entry requirements to newcomers. In our times scientists gather in groups of practitioners of constantly specialising research fields constituted by reciprocally recognised scientists (peers). In such form they achieve the same goals that medieval guilds on behalf of the bourgeois's science [53].

The "quality control" of scientific results has been gradually shaped into today's peer review practice. Each super-specialised journal has its own set of reviewers, who control that a proposed publication fits the interests of the group, satisfying also some demands on originality. Both originality and correctness are shaped after the subjectivity of the guild. A manuscript in e.g., population dynamics containing elementary mathematics may be deemed original by experts in population dynamics while applied mathematicians may regard it as elementary or standard, i.e., *not* original. Specialisation allows for the coexistence of opposing criteria. Indeed, most scientists do not recognise this issue as a problem, but rather as the normal state of affairs, being specialisation so deeply rooted into our consciences.

2.4 Instrumentalism in the early XX century physics

The first decades of the XX century witnessed the upraise of Relativity and Quantum Mechanics. Many of their creators attempted to explain or develop the epistemological background sustaining their theoretical effort, thus providing fresh examples of the instrumentalist epistemology. Indeed, these results in physics stimulated the activity in epistemology. Philosophers such as Carnap, Popper, Reichenbach, Russell and even Horkheimer (among others) "knew" beforehand that Relativity and Quantum Mechanics were the highest peaks in human science and elevated some of their authors (especially Einstein) to exemplary figures whose results could not be questioned. A social mandate.

2.4.1 Einstein and Relativity

Early in the XX Century the conflict between the interpretation of Maxwell's equations and the hypothesis regarding the ether was evident. The ether was not a good hypothesis from the instrumentalist point of view, a problem that threatened not only the belief in the ether but more radically, it threatened instrumentalism in itself since the ether was its first product and it had been opposed by Gauss, Riemann and others that sustained the old rational empiricism of the experimental philosophers. Declining the existence of the ether and moving back to the latest safe point in the development of Electromagnetism amounted to recognise that the instrumentalist epistemology inculcated especially in the German universities was not making the expected mark. Einstein saved instrumentalism in 1905. In two separated works he proposed a new form of thinking about light conforming, as much as possible, with the ancient saying "matter cannot act where it is not". The material ether was then left behind and the alternative of a quasi-material entity –the photon– carrying electrical action was introduced in [24]. In addition, if the new (imagined) entity was to be in agreement with the action described by Maxwell's equations, and the material ether was to be removed, the solution at hand was to replace the ether by empty space [25] and the relational space-time used to construct electromagnetism by Minkowski's space so that Maxwell's equations equivariance with respect to Lorentz' transformations was justified, based upon the imagined photon. The construction was supported with the introduction of two postulates [23]: constancy of the (body-like) speed of light with respect to different "inertial frames" and the principle of relativity, taken from Poincaré, whose epistemic origin could not be ascertained neither by Poincaré nor by Einstein or for the matter by any other until present times. The new interpretation of Electromagnetism required some additional corrections, such as adherence to the instrumentalist view detaching the theory from its construction and once more reinterpreting its symbols at will. Special Relativity (SR) gradually gained acceptance and its critics have been subsequently ignored or vehemently fought throughout the years. There is essentially one textbook presentation of SR, with rods and clocks, dictated by this acceptance.

Einstein's instrumentalist view is manifest:

> There is no inductive method which could lead to the fundamental concepts of physics. Failure to understand this fact constituted the basic philosophical error of so many investigators of the nineteenth century. It was probably the reason why the molecular theory, and Maxwell's theory were able to establish themselves only at a relatively late date. Logical thinking is necessarily deductive; it is based upon hypothetical concepts and axioms. How can we hope to choose the latter in such a manner as to justify us in expecting success as a consequence? [26, p. 365].
>
> Physics constitutes a logical system of thought which is in a state of evolution, and whose basis cannot be obtained through distillation by any inductive method from the experiences lived through, but which can only be attained by free invention. The justification (truth content) of the system rests in the proof of usefulness of the resulting theorems on the basis of sense experiences, where the relations of the latter to the former can only be comprehended intuitively. [26, p. 381]

As with Hertz, this point of view precludes deeper criticism of the foundations of the theory. For example, it is never discussed why light, or electromagnetic waves in general, should have a "velocity" in the first place; it appears to be an accepted habit. The whole scaffolding of SR collapses with the belief in this velocity. However, L. Lorenz' electromagnetic waves rest on delayed action at a distance and do not require a "velocity of light". Moreover, all of classical electrodynamics can be formulated within Lorenz' framework, thus explaining the "relativistic" Doppler effect without SR (i.e., in a manner that is compatible with the rest of electrodynamics and with mechanics) or transformations among inertial frames, using Lorentz' boosts in a novel manner.

These issues and other inconsistencies and conflicts with SR are extensively discussed in [63, sections 2.4.1, 3.2]

2.4.2 Bohr, Dirac and Quantum Mechanics

Quantum mechanics (QM) was developed in order to organise microscopic phenomena, mostly of electromagnetic nature. The experimentally observed quantisation was imposed on a planetary model of the hydrogen atom by Bohr. Further, the formalism of matrix mechanics by Heisenberg and Schrödinger's wave mechanics took over. The theory provided means to agree with e.g., spectroscopic results, described as transitions (detected as electromagnetic waves) between stationary "states" (manners of existence) of atoms. [44, p. 80] reports in the scientific biography of Paul Dirac that he (Dirac)

> "...shared the positivist and instrumentalist attitude of the Copenhagen-Göttingen camp, including its belief that quantum mechanics is devoid of ontological content. He thought that the value of quantum mechanics lay solely in supplying a consistent mathematical scheme that would allow physicists to calculate measurable quantities. This, he claimed, is what physics is about; apart from this, the discipline has no meaning."

Several *interpretations* of QM appeared, being the most popular among physicists the statistical interpretation by Max Born, also called the *Copenhagen interpretation* [8]. Apart from the declared lack of meaning beyond agreement with experiments, this interpretation is marred by a number of "patches" to hide or circumvent contradictions. For instance, *Schrödinger's cat* was raised to become a central issue, while Schrödinger meant to ridicule [60] the statistical interpretation. Further, dynamics is ruled by the Schrödinger equation for the wave function, unless we perform a measurement on the system, after which its wave function collapses to a stationary state. The collapse is not prescribed by Schrödinger equation and it is assumed to take place instantaneously. Also, the efforts by Dirac [20] to interpret negative energy states simply ignores the practical difficulties. The idea of an infinite aggregation of electrons does not survive scrutiny. Such aggregation would have associated an infinite mass and infinite charge which nevertheless would not produce any observable effects. The hypothesis is there to "patch" the issue of negative energies, but at the same time it destroys the connection with mechanics and electromagnetism. Surprisingly enough, Dirac [21] set out to improve on Klein-Gordon's equation, being one of the motives that it allowed for solutions of negative energies.

[8] In a survey by Nature [33] the Copenhagen interpretation had 36% support, against 17% for the closest "competitor".

3 The development of true science

> But I repeat that I am astonished at the ease with which when speaking of technicism it is forgotten that its vital centre is pure science, and that the conditions for its continuance involve the same conditions that render possible pure scientific activity. **Has any thought been given to the number of things that must remain active in men's souls in order that there may still continue to be "men of science" in real truth? Is it seriously thought that as long as there are dollars there will be science?** This notion in which so many find rest is only a further proof of primitivism. As if there were not numberless ingredients, of most disparate nature, to be brought together and shaken up in order to obtain the cocktail of physico-chemical science! Under even the most perfunctory examination of this subject, the evident fact bursts into view that over the whole extent of space and time, physico-chemistry has succeeded in establishing itself completely only in the small quadrilateral enclosed by London, Berlin, Vienna, and Paris, and that only in the XIXth Century. This proves that **experimental science is one of the most unlikely products of history**. Seers, priests, warriors and shepherds have abounded in all times and places. But **this fauna of experimental man apparently requires for its production a combination of circumstances more exceptional than those that engender the unicorn**. Such a bare, sober fact should make us reflect a little on the super volatile, evaporative character of scientific inspiration. **Blissful the man who believes that, were Europe to disappear, the North Americans could *continue* science**! It would be of great value to treat the matter thoroughly and to specify in detail what are the historical presuppositions, vital to experimental science and, consequently, to technical accomplishment. But let no one hope that, even when this point was made clear, the mass-man would understand. The mass-man has no attention to spare for reasoning, he learns only in his own flesh. [54, p. 84–85](emphasis added).

Ortega y Gasset (OyG) concerns presented by 1930 can now be evaluated in historical terms. Europe almost disappeared during WW II (1939-1945). Scientists were involved on both sides of the battlefield and their contributions were of great and decisive importance. Think of the radar, V1 and V2 bombs, cryptography –based on a just born computer science–, the race for the atomic bomb, chemical and biological warfare. Hundreds of scientists fled to the United States of America (US), those of the winner side mostly before or during the war, those of the losing side after the war. The centre of gravity of science moved to the US. New institutions were created, such as the NSF (1950)[9] under H. Truman's presidency after a the study by V. Bush [8]: "Science, the endless frontier", a visionary work in the political spirit of F. Bacon. Funding of science escalated swiftly. For example, particle accelerators, once table top devices, reached an economic limit before 1960 [10]. New technology allowed to build a linear accelerator of $3219\,m$ between 1962 and 1966 [11]. The extent of fields opened by the old science and the first generation of technoscience may have been beyond what OyG could imagine. The large accelerators produced particles which according to the underlying theories (SR-Electromagnetism and QM) would be moving with respect to the laboratory at speeds close to that of light. However, these two theories were in a deep conflict[28, 27]. While a self-critical experimental philosopher would have considered this conflict as a clear indication that the shortcuts used to produce both theories were incompatible and this would have prompted them in turn to rework matters without separating in theory what was unity in Nature, physicists tried to imagine a new layer of objects. Quantum electrodynamics (QED) and Relativistic quantum mechanics were born. The new creatures required to leave aside a new level of reason. Actually, unless mathematics was converted in a new conventional tool representing conventional manipulation rules of symbols uprooting consistency from mathematics, the task was impossible [52]. Feynman [32] and Dirac [44, pp.184-185,], the initiators of QED, yielded to evidence. Yet, the mass-men harvesting in the paradigm could not follow. As expected by OyG, later generations of technoscience would get in deep trouble. Instrumentalism required to make of mathematics an instrument devoid of meaning and logical consistence, a mere set of prescribed manipulation rules.

Not only was OyG correct in this matter, Nisbet [53] observes the fall of the academic dogma. *Knowledge is good in itself* was left behind, knowledge was encouraged only as an instrument of socio-economic development. Laboratories adapting to the new policy flourished while those bound to the academic dogma followed an extinction process. In later years, after the collapse of the Soviet Union, the same social operation was applied in countries so different as France, Brazil and Argentina (just to mention a few) under the command of the World Bank [37].

It appears to us that OyG was right on target. However, he did not address how the mass-men become irrational. Let us provide some insight into this matter.

[9] History of the NSF, consulted 2025-12-12.
[10] History of particle accelerators, consulted 2025-12-12.
[11] Stanford Linear Acceleration Center, consulted 2025-12-12.

4 Programming the human machine

Let us examine the educational process that results in new scientists. In the first place, it recruits students with different inclinations. A majority of them, as informal studies reveal, do not have a sharply defined scientific interest. Those that have a hard time deciding between biology, chemistry, physics and mathematics abound. The same students consider philosophy among their interests as well. Not to mention computer sciences and their myriad of specialisations. Whatever their inclinations, none of them appear to be enticed by "trial and error", the ancient method of technology and according to Popper (and others) the essence of science [12].

During the first stage of instruction, already at the University, they learn about ideas in science, grounding this process in their previous beliefs. The example of physics, that we know best, implies that space and time are used in terms of the intuitions carried along by the students. No attempt is made to produce a critical revision of these ideas, the relational character of them, the consequences of our basic views or the subjectivity of a non relational space and time. Actually, time is portrayed as a spatial coordinate, a definite image provided by plots. The difficult process that entails the relation between what is observed and the mathematical symbols (or whatever is the representation adopted) is left as "an exercise" to the student that will distillate it in academic (i.e., extremely singular) contexts by imitation and repetition. No time is spent to elaborate on this transcendental step which is also left in an opaque zone outside consciousness. Observations and experimentation are largely absent (because of Mach's economy of thought). Thus physics, to a great extent, develops in terms of imagined experiments. Students must incorporate the received lesson, show their acquaintance with the given ideas and show that they can use them in a training environment. The fixation of beliefs proceeds, in practice, by the method of authority discussed by Peirce [55, CP 5.358], clearly inferior to the method of science. The authority of professors and books force students to drop their doubts accepting paradoxes like Schrodinger's cat or the various paradoxes of Relativity. Take for example the concept of the light quanta, the photon. The idea was introduced by Einstein [24] to explain the photoelectric effect and became later an inspiration for quantum mechanics. The concept is introduced at the undergraduate level in the physics curricula and most if not all physicists consider they understand it. However, Albert Einstein wrote to his friend Michele Besso on December 12th. 1951:

[12] The instrumentalist dogma in Popper reads: Reason works by trial and error. We invent our myths and our theories and we try them out: we try to see how far they take us. And we improve our theories if we can. The better theory is the one that has the greater explanatory power: that explains more; that explains with greater precision; and that allows us to make better predictions. [58, p. 259]

> A total of fifty years of conscious speculation have not brought me any closer to answering the question “What are light quanta?” It is true that nowadays any rascal thinks he knows the answer, but he is mistaken.[29, Letter 177, p. 398]

The photon raises doubts for his creator some 45 years after its invention, yet those that have been taught about it entertain no doubts. Actually, the photon is a result of the instrumentalist approach. It is a mental instrument that helps to predict relations that are later corroborated. The problem is that there is no need to introduce the photon in order to match observations, at least for the photoelectric and Compton effects. The results follow from electromagnetism when carefully used. [63, Section 5.D., p. 198]

Once graduated, students are incorporated to the culture of science in the little cell where they are expected to produce their initial work. The process called “enculturation” [59] is described as “acquisition of conceptual blind spots and epistemological prejudices”. These blind spots and prejudices allow our students to avoid conflict with the guild that monitors their field of study, i.e., the authority is transferred from books and professors to the guild, but the method of fixation of beliefs (or cessation of doubt) continues to be what is enforced by the authority. The *majority of age* of the student, in the terms used by Kant [42], never arrives. Those that attempt to follow their own ideas will see their social progress relented. Those that consider to challenge the beliefs of the paradigm soon understand that their academic life could reach a rapid end if such inclination is followed. Even those that after a successful career dare to challenge the basic beliefs of the guild will run into a social confrontation that menaces their professional or academic life. Such are the stories told by Dingle [18, 19], Essen [30, 31], Woit [71], Smolin [61] and Phipps [57, 56], testimonies of the few that survived the social attacks when they challenged the beliefs of the physicist’s community. Even Schrödinger [60] underwent such social problems.

These social circumstances display how the repression of independent and (true) critical thinking works without the need of killing nowadays “Giordano Bruno(s)” and how only the exercise of instrumental reason is permitted.

Several warnings that apply to these processes come to our mind.

> Protection, therefore, against the tyranny of the magistrate is not enough: there needs protection also against the tyranny of the prevailing opinion and feeling; against the tendency of society to impose, by other means than civil penalties, its own ideas and practices as rules of conduct on those who dissent from them; to fetter the development, and, if possible, prevent the formation, of any individuality not in harmony with its ways, and compel all characters to fashion themselves upon the model of its own. [51, pp. 10–11]

The students that successfully adapt to the process of formation as scientists actually do not perceive the limits put by society on them. This is achieved by allowing freedom to be exercised between the socially determined limits that mass-men know well it is nonsense to trespass. In this way, repression is exercised only over the small, statistically insignificant, populations of people with “extreme ideas”, ideas not approved by the collective authority that guards the interest of the scientific elite. [13].

W. von Humboldt had his saying as well:

> The man who frequently submits the conduct of his actions to foreign guidance and control, becomes gradually disposed to a willing sacrifice of the little spontaneity that remains to him. He fancies himself released from an anxiety which he sees transferred to other hands, and seems to himself to do enough when he looks for their leading, and follows the course to which it directs him. Thus, his notions of right and wrong, of praise and blame, become confounded. The idea of the first inspires him no longer; and the painful consciousness of the last assails him less frequently and violently, since he can more easily ascribe his shortcomings to his peculiar position, and leave them to the responsibility of those who have shaped it for him. [39]

In short, we see how instrumentalism and the “economy of thought” prevent the development of critical reason, free thinking and other forms deviant from instrumental reason. The students that approached science with a wide range of interests end up with formations into fields narrower than disciplines and with the definite impression that, for example, philosophy has no relevance for biology (or any other discipline) and that, if a second discipline is to be perused, the right thing to do is to follow the path designed for those that had never received education at the university. The system of “majors and minors” of the US does not change this perception. Instead of perceiving one science with different particular realisations determined by the collection of problems of interest, knowledge becomes extended and additive, rather than profound.

It is this view the constitutive element of the often heard statement that “One obvious consequence of this vast extension of the limits of science is, that every student is forced to choose a narrower and narrower field for his own studies, and can only keep up an imperfect acquaintance even with allied fields of research.” [35, p. 4] Certainly, the full catalogue of science cannot be covered in this form, but nothing prevents human beings to be in an internal disposition that allows them to work at the level of people trained in the corresponding discipline in a short time (relative to those required by professional training).

[13]The idea is taken from N. Chomsky [12] who applies it in a more general context.

Professional training in science is thus biased towards the formation of experts, specialised in a narrow field of science shaped under the control of the guild (peers). To the extent critical reason is resigned or limited, the professional acts as a biological computer, designed within the socially accepted science of each guild. This programme favours the advance of new instruments as much as it obstacles independent thought outside this frame. The free exercise of reasoning is replaced by the "freedom" of choosing among the available options and reason is limited to its instrumental version.

Any critical view is perceived by the community of the paradigm not only as a rational debate but also as a social challenge. While we cannot establish whether the "winner" of a debate was guided in the argumentation by reason or by convenience (e.g., to preserve the social prestige enjoyed by the paradigm), we can be certain that the opponent that yields to reason is the one showing true rationality. The duality of the paradigm

> The term 'paradigm' enters the preceding pages early, and its manner of entry is intrinsically circular. A paradigm is what the members of a scientific community share, and, conversely, a scientific community consists of men who share a paradigm. [Postscript of 1969, 45]

makes of every scientific criticism a social challenge. For the mass-men, the inner satisfaction of being utterly loyal to reason weights next to nothing in front of the social satisfaction produced by the appraisal of the community of pairs. In the ensuing conflict of interests, the common interest of the paradigm weights far more than the interest of humanity (reason).

The sort of knowledge that is favoured by the instrumentalist approach is the creation of *tools* [14] adapted to fulfil a given specialised purpose. Society at large uses such devices every day (think of mobile phones). Indeed, everyday reality is shaped by such tools, so that we can hardly conceive a life without them.

Mach's "economy of thought" is actually a process that converts knowledge in "instrumental knowledge", knowledge that can be productively used even by those that only understand the rules of its use. In OyG words:

> What happens is that, enclosed within the narrow limits of his visual held, he [the scientist] does actually succeed in discovering new facts and advancing the progress of the science which he hardly knows, and incidentally the encyclopedia of thought of which he is conscientiously ignorant. How has such a thing been possible, how is it still possible? For it is necessary to insist upon this extraordinary but undeniable fact: experimental science has progressed thanks, in great

[14] In [1] Konrad Lorenz describes a knowledge token of modern society as a "tool [...]. It is something that even the most idiotic person can use" (our translation).

> part, to the work of men astoundingly mediocre, and even less than mediocre. That is to say, modern science, the root and symbol of our actual civilisation, finds a place for the intellectually commonplace man and allows him to work therein with success. The reason of this lies in what is at the same time the great advantage and the gravest peril of the new science, and of the civilisation directed and represented by it, namely, mechanisation. A fair amount of the things that have to be done in physics or in biology is mechanical work of the mind which can be done by anyone, or almost anyone. For the purpose of innumerable investigations it is possible to divide science into small sections, to enclose oneself in one of these, and to leave out of consideration all the rest. The solidity and exactitude of the methods allow of this temporary but quite real disarticulation of knowledge. The work is done under one of these methods as with a machine, and in order to obtain quite abundant results it is not even necessary to have rigorous notions of their meaning and foundations.[54, pp. 110–111]

The process in which instrumentalism emerges is a process of industrialisation of science. Knowledge itself becomes instrumental and massively produced. When knowledge becomes instrumental, it lends itself to be used by people that lack the capabilities to build it, that do not need to know where and why it works. Instrumental knowledge becomes a tool, and as any other tool it is ready to be used by anyone.

4.1 Validation, iterated instrumentalism and patching

Perhaps an example is appropriated here. A professional in medicine, as part of the health authority of a large city (in what follows “the official”), responsibly fears for a possible epidemic of dengue. They know that there are vectors of dengue in the city (*Aedes aegypti* to be more precise) and they decide to prepare for a possible stress on the health system in case of an epidemic outbreak. Their first task is to get an estimate of the possible size and distributions in time of cases that require hospitalisation. After some research they end up with some papers by a prestigious scientist in prestigious journals that explain how their authors believe the question can be answered. Moreover, the authors generously made the coding available for public use (upon request). With this tool at disposition the research moves into gathering the necessary local information to feed the code. This is, research now proceeds within the limits indicated by published science. Nobody told the official that *Aedes aegypti* might not be a determination precise enough in terms of the sensitivity of the code. Actually, the producer of the code never thought about it. It is a scaring possibility that does not favour "selling the product", hence ignored by the community of the paradigm. The same can be said about DENV (dengue virus), actually, the variability of the virus is well known but rather inconvenient for the paradigm. For example, the "extrinsic incubation time" required for a mosquito infected with DENV to become infectious is a key element in the prediction of dengue in temperate climates, the case the health official intends to predict. Our official, following our prestigious scientist, uses as estimator a number he pulls out from the literature. It is almost impossible for them to know that such number has no meaning, that the distribution of measured times is not peaked around a number but rather extremely flat and much less that it is not determined by the species but rather by the relation of the species with its habitat (which includes prevention measures taken by the authorities).

The model the official is using has been "**validated**" in other regions.[15] Our doctor knows nothing about critical epistemology (it is not their field of expertise, clearly) they take the word "validation" by its "propaganda value" and think that they can trust the model. After processing the data with the model they are relieved to know that DENV epidemics are not possible in this city and no preventive measures are needed. This finding certainly explains why there are no records of such epidemics in the city.

However, the next summer a (fortunately) minor epidemic outbreak takes place. Our official revises the calculations and concludes that they have overestimated the length of the intrinsic incubation time, which was not appropriated for the exceptionally hot summer they had (about a 20% excess in time estimation). Actually, the model assumed the life span of the adult mosquitoes to be shorter than the incubation period, which was the reason why the model prevented (in silica) DENV to circulate. It does not occur to our official that the life span of the modelled mosquito was short by a factor of two or three, and that mosquitoes do not have a programmed death after n days as the model assumes; all this is hidden under the validation. If the mosquito represented in the code had been incorrect –they think– the matter would have popped out during the validation attempts. Our official is using the instrumentalist approach. However, what happened was "compensation of errors" during the testing phase. Such compensation worked for the validation data which was similar to the data used in the construction of the model, but it does not work in general. It is the same type of knowledge (uncritical experience) that made European people to believe that "all swans are white".

[15] Validation is a popular process in predictive sciences. A model is constructed using some data and observations. The model is next used to "predict" results in some other situation that has been observed and the predicted kind of data has been collected. If there is a match (always a subjective thing) between the data produced by the model and the data obtained from the event, according to some metric and statistical criteria, the model is considered **validated**. A validated model is consequently trusted following the instrumentalist spirit.

This story is real. We are not providing the references to protect the identity of the official and the scientists involved. If not protected they could become scapegoats for a crime committed by our civilisation. Neither the official nor the scientist involved are fools and much less dishonest, actually we are inclined to believe they are earnestly honest and good human beings, but they are victims of a system with a faulty epistemology that they are not allowed to control and they have been impeded to achieve the necessary critical abilities, for after all, as professionals, they are confined to their hive.

How would a professional of philosophy or medicine know about this actual problem when they do not understand mathematics, statistics, computer science, mathematical modelling, general biological concepts, and the particular biology that matters to the example? How would any one confined to a hive know about the universe? By the year 400 BC, Chuang Tzu discussed the problem [Autumn floods, 13], this is not new.

Current **Iterated instrumentalism** is a process that no longer exploits science, it produces new instruments using older instruments. The instruments are used without consideration of how appropriate they are. After all, correctness is only to be determined by the results. At the end, if the results are well aligned with our interests they can be considered correct. If the results are in clear contradiction with observations, the tools have to be patched. **Patching** is a process of specialisation that produces adequate tools for special (low occurrence probability) situations. Patching saves the standard tool, it prevents refutation. A successful patching process eliminates the evidence that refutes the theory or at least, introduces hypotheses that are harder to refute. This doing preserves the capital of the paradigm. For example, if you are a scientist that with effort and sacrifice (especially of your critical reason) have acquired some shares of the General Relativity paradigm, when the paradigm confronts problems, you might be willing to accept the existence of an hypothetical entity which is hard, if not impossible, to access experimentally (call it pink matter). The new patched theory, owned by the same community, preserves the value of your shares. If the patched theory begins to be inadequate after some years, it can be further patched introducing “pink energy”, a new patch that attempts to preserve the gains in “irrefutability” made with pink matter by rendering its failures “invisible”. If the patching process succeeds in moving contradictions to a place beyond experimental reach, instrumentalism allows the community to claim that the hypothesised entities are real. The social value of their shares will then increase: the theory made new “predictions”. (Any relation of this fable with reality is not casual.)

5 Artificial intelligence (AI), the ultimate instrument

For Ortega y Gasset (see above) it was transparent that instrumental science or technoscience rests on scientific development. If science stops developing, so would technoscience soon after stop as well. Certainly, "soon" is an imprecise measure, depending on how future projects could be spawned from present knowledge. We may be prepared to admit that technological development based on electrodynamics and quantum mechanics[16] proceeds today at a lower pace than that derived from biology, biochemistry and medical advances.

The raw material of technoscience are the experts, which to a large extent are "programmed" to enact the standpoint of the guild and extend it within the allowed boundaries. It is no longer a surprise that a machine designed ad-hoc for the same purpose could successfully replace the expert.

This situation constitutes a dramatic difference with the status quo discussed by Ortega y Gasset (1930) since with AI technology takes over the whole process. In AI there is no underlying science to be exploited. Instead, it deals with a technique to generate discourse by reproducing possible, and probable texts, learned by imitation (which is also an important part of the training of expert professionals). Moreover, AI systems can use external tools in a similar way as many humans do, namely without knowing how, nor why they work. AI discourse is selected by comparing tokens, which reinforces uniformity. Tokens with low occurrence in the training set are less likely to be selected to generate new discourse.

Since their methodology is geared towards token matching, ultimately based on a training set, there is no evidence that AI systems can distinguish truth from falsity (this is obvious if "truth" is incompatible with the training set, in which case there is no token to pick). On the contrary, AI systems are known to *hallucinate* (namely generate text that looks plausible but it is severed from reality, such as correctly formulated false quotes or nonexistent references). AI developers hope to improve the methodology in order to avoid this and other problems. However, thought guided by reason differs in many planes from the generation of discourse by likelihood. Human reasoning rests in observations as a first source of truth, it is aware of the fallibility of both thoughts and observations, it is in addition self-aware and it displays the double requirement of coherence and unity with both other areas of knowledge and the observations. Generated discourse relies in token matching within a (very large) training set so its control mechanism is likelihood rather than truth.

Patching IA models is relevant also here. In the end, patching operates by further specialising the tool to situations with low occurrence probability such as the already mentioned hallucinations. After enough patching we expect to "elim-

[16]Ortega y Gasset wrote his book around 1930, when physics had a sort of leading role in science.

inate errors" which in this case means that the errors will be so subtle that most of us will fail to recognise they are there. The mass will then claim that those that perceive errors in AI technology are actually AI haters and society will sentence them to silence.

We have seen in the course a few years how AI systems were able to create videos of false facts. Those videos were easy to recognise as fakes using our abilities constructed and selected over thousands of years of adaptation to Nature. Knowing how fake videos were recognised, new generations of the technology improved to patch the algorithms producing precisely such clues. Today fake videos cannot be distinguished from real ones by humans with their built-in knowledge and sensors. Most people apparently do not understand that to use a brain prepared to consider the real and to make inferences using incomplete sensorial information is not apt for properly considering virtual reality, which is incomplete by construction. The photograph, the film, the sound record never had any reality other that being a photograph, a film, or a sound record. Our (vulgar) inference to the best explanation (IBE)[47, 50] made the rest. Simply stated, IBE in this subject matter fails, it can no longer be trusted.

6 Final discussion

Dewey presents a view of instrumentalism (see footnote 3) where knowledge is produced in the same terms than behaviour in behaviourist theories. If we take his words at face value, we tend to increase the frequency of those actions (thoughts) that lead to satisfaction (positive reinforcement) while those thoughts that lead to undesired results become less likely to be repeated. What constitutes success for an intellectual activity, however, opens a diversity of options that depend deeply upon the subject. For a large number of people, money is an almost universal reinforcement, this is the sense in which scientists are perceived as disinterested people [6] since they do not respond to stimuli that are common place in other human activities. It is easy to identify two families of stimuli for the workers of science: as Helmholtz hints us, peer recognition is one and it constitutes an external stimulus. The other stimulus is linked to reason, it is an internal stimulus that can be described as an inner demand for coherence. It demands the unity of ourselves and the unity of the universe to be a central requirement of any knowledge and relation to the world. The task of reason is to show (or construct) this unity of the world. This demand is primary, it emerges when we decide that there is Ego and not-Ego (the environment) and the totality we call universe. We have tried to use consistently the expression experimental philosopher for those who respond to stimuli of the second kind and scientist for those responding to the first kind. The experimental philosophers need freedom if they are going to develop their reason to its highest possible level. They are like those species that almost certainly die in captivity. In contrast, the scientist can be domesticated to serve the general interest of society, their dependence on social stimuli makes it possible.

This domestication, operated during the second industrial revolution, led to the social selection of the scientist and the almost extinction of the experimental philosopher. Since reason can be regarded as a result of millennial evolution it cannot be extinguished so easily but the development to the highest levels can be impeded by restricting freedom as in domestication. The industry developed for milking the scientific cattle inhibited the development of critical reason that went into a de facto extinction, its genetics is still present and in rare cases such as that of Piaget it emerges up to recognisable levels.

In the more general sense in which instrumentalism has been used considering science an instrument to achieve other goals (usually material ones) we have tracked the idea to F. Bacon and its definite prevalence with regard to the industrial revolution. The evolution of Germany into a modern capitalist society offers a credible account on how this social transformation happened. Certainly, instrumentalism was only one of several pieces of that transformation and cannot be understood without making reference to the complete social operation.

We have argued that the restriction of science to instrumental science had several aspects of reason as collateral victims. The massive reproduction of a science conceived as an instrument and valued as such, impeded the development of critical and synthetic reason needed to preserve the unity of science and reason. Science became an extensive catalogue impossible to be learned, each science became independent of the others and all of them were proclaimed independent of reason. The philosopher, the master in reasoning as Galileo said, became obsolete.

The professional of science, the scientific, produced at the universities was confined to increasingly narrow fields making impossible the development of their capabilities to the maximum possible level compatible with their inborn possibilities. This social process generated an era of material progress while the human character declined in compensation. Reason leads to ethics (practical reason in Kant) and knowledge entails love as Humboldt explains, but ethics and love of Nature may slow the accumulation of capital and the development of economic forces. The new science supported in a mutilated reason, instrumental reason, became a perfect tool to achieve the goals of the powers that be.

Modern society is characterised by the use of tools for which we have different levels of understanding. Problems that in earlier times in history were handled through handcraft, where every step in the process was under complete control, have gradually replaced handcraft with tools having different levels of instrumentalist iteration. Society has also accepted this compartmentalisation to the extent that hardly anybody can fully understand the most sophisticated tools. The previous knowledge leading to the tool remains enclosed in it and gradually disappears from society, since we just need to know how to press a button. Even this button may be produced by a tool that does not know how it works. We become less intelligent, in the sense that we are less prepared to face the challenges of the world without tools of any level of iteration.

In the process of reproduction of instrumentalism, new instruments are constructed using old instruments. In such form, and in the absence of "*liberty stricto sensus*"[17], the possibilities of doing are increased at the expense of the possibilities of knowing/understanding. Instrumental reason can then be seen as a reason that has been deprived of its liberty (*stricto sensu*). After years of education, the professional of science has internalised [46] the controls that prevent the full development of critical thinking. The problem with critical thinking is that it cannot be confined to a subject matter. Once we learn about the existence of hives that limit our thinking activity we will explore the forms that those hives take in other aspects of human life such as society and politics. Thus, the mutilation of reason into instrumental reason is an effective form of social control as well.

When science becomes of interest for society (at the beginning represented by the State) it has to be taught in the form that the State (society) indicates. As Kant writes it: "... For the government does not teach, but it commands those who, in accepting its offices have contracted to teach what it wants (whether this be true or not)... " [43]. The scientist must rent his intellectual power to use and expand the received scientific doctrines. Once a science is mature (in Kuhn's terms) or a paradigm is hegemonic (in Gramsci's terms) any critical perspective is viewed as a regression. Hence, the social structure of science determines that science is always advancing, since no doubt regarding the doctrine is allowed. The scientist is dehumanised and they get close to a computing machine that lends its computing power to the tasks and forms mandated by the programmer. There is then a convergence between the advanced computing machines of our time and the professional which can be though of as biological computers or robots. Actually, AI can be regarded as the perfect instrument (and instrumentalist). It has no consciousness and no form to tell the difference between true and false, its dial is graduated between likely and unlikely. Neither AI, nor us know why it works, it has been developed by the ancient method of technology: trial and error;

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> [Speaking of liberty] The accent would not be placed on the free decision (to do otherwise), or on the non-determination of the will (to have been able to desire (will) otherwise), but on a causal power to create something new, something not expected given the previous state of things, i. e., to produce some ontological novelty in the world. Related to our proposal regarding free will, a positive notion of freedom. [14]

leaving no room for meaning. Its evaluation is only subject to external controls, namely its success.

The arc of civilisation that goes from the second industrial revolution and reaches our times presents a monotonic decline of our humanity and an equally monotonic rise of techniques. From the highs of Science and the lows of technology it travels towards the low of science and the highs of technology. It can also be viewed as the constant decline of reason and liberty (*stricto sensu*) and the social ascent of the *idiot*s, etymologically understood[18] as the people centred in their own (private) interest as opposite to the common (public) interest.

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[18]The roots of "idiot" come from Ancient Greek ἰδιώτης (idiṓtēs), from ἴδιος (ídios, "one's own, pertaining to oneself, private") (Wiktionary consulted 2025-12-21), literally "private person". The idiṓtēs of the Ancient Greek is only concerned with their private business and does not participate in public (common) affairs. From this etymological start point the semantic derive makes "layman, person lacking professional skill", since those participating in public affairs usually had some special skills. And the derive continues when passing from Ancient Greek to Latin, and later to Old French, next to Middle English with a current meaning of "a stupid person or someone who is behaving in a stupid way" (Cambridge dictionary consulted 2025-12-21) which is certainly not what we mean.

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