Fundamentals of the Classification of Sciences

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Abstract: This paper seeks to contribute to understanding the fundamentals of an extensively used classification of modern sciences. It opens by setting out the differences between modern sciences and philosophy and then goes on to refute a common misunderstanding in the classification of sciences: that there is such a thing as a system of sciences sharing a common set of principles. In their stead, it puts forward a currently accepted classification of the modern sciences. Recognizing that this classification is hardly original, the paper attempts to shed light on the related fundamentals.

Keywords: classification of sciences; system of sciences; hierarchy of sciences; formal sciences; human sciences; natural sciences; historical sciences.

Introduction

In this paper, I will use Gustavo Bueno's philosophy as my theoretical framework, particularly his philosophy of science as stated in the "theory of categorial closure" (Bueno 2013)[1]. Aware that Bueno's philosophy is hardly known to English-language readers, I will briefly introduce certain tenets of his philosophy that deal with the fundamentals of the classification of sciences. According to Bueno's philosophy:

1. Philosophy is not a science. Sciences are first-order disciplines directly constructed with objects and material operations performed with objects; philosophy, however, is a second-order knowledge that requires the prior existence of first-order knowledge such as techniques, sciences, technologies and ethical and political knowledge, to name but a few. The third section will make further comment in this regard.

2. Although a given science can be understood, in certain ways, as a complex system of theorems, no "system of sciences" exists, since a set of systems is not necessarily a system, just as a group of political states is not a state and a set of circles is not a circle. The second section will touch briefly on this.

The classification of modern sciences advocated herein implies the following:

1. A distinction between sciences and techniques/technologies.

2. A distinction between the so-called "formal sciences" (logic and mathematics) and "non-formal sciences" (all other sciences).

3. A split in the non-formal sciences between, on the one hand, human and ethological sciences and, on the other, non-human/non-ethological sciences, often referred to as the "natural sciences".

4. Lastly, I will defend the idea that, within the human sciences, historical sciences exhibit specific epistemological features.

The third section of this paper discusses this classification's fundamentals. Aware that this classification is extensively used, I contend that Bueno's theory of categorial closure may still contribute to further understanding. The issues relating to the first two sections will be discussed only briefly, since a more in-depth approach would fan out into problems that cannot be pursued further here. Readers familiar Gustavo Bueno's philosophy may skip directly to the third section.

1. The difference between modern sciences and philosophy

Physics, chemistry, biology, mathematics, psychology, linguistics and other modern sciences are first-order knowledge about certain regions of the world. Each of these sciences has its own field of phenomena, and its particular objects, instruments and operations. Other first-order knowledge includes techniques, technologies, arts and prudence-based disciplines such as ethics, politics, and jurisprudence.

Academic philosophy, though, is second-order knowledge that implies the prior existence of first-order disciplines. The philosophical ideas of causality, truth, beauty, good and identity must take into account a wide variety of first-order knowledge. For instance, the idea of causality runs throughout physics, biology, psychology, history, techniques, politics, jurisprudence, etc. Philosophical ideas are frequently mixed with practical knowledge: the practice of techniques, politics or jurisprudence are accompanied by a multitude of ideas (beauty, prudence, good, justice, and many others), but this does not prevent the dissociation of their practical moment (as first-order knowledge) from their ideological, "philosophical" moment, which implies a certain degree of "theorization" of that practice (Bueno 2010 115-125).

Consequently, classifying the modern sciences is an entirely different task than classifying the philosophical disciplines. In the former, the classes are "formal sciences", "natural sciences", "human sciences", "nomothetic versus idiographic sciences", etc., whereas the latter classification leads to disciplines such as ontology, epistemology, ethics, politics, aesthetics, etc.

Starting with the first *Elements* of scientific geometry (written by Theudius of Magnesia, Eudoxus of Cnidus

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and Hippocrates of Chios, at the time of Plato and Aristotle) and up to the full constitution of scientific mechanics (at the time of Newton's *Principia*), certain philosophies and strict sciences coexisted indistinctly within a single, joint science-philosophy block. Platonic, Aristotelian and Thomist systems of philosophy uninterruptedly included the contents of geometry, kinematic astronomy and logic.

The emergence of the modern natural sciences (physics, chemistry, biology, geology and thermodynamics) in the 17th, 18th and 19th centuries showed that philosophy is not a science in the strict modern sense. Still, as late as 1651, Thomas Hobbes sketched out a classification of knowledge in which sciences such as astronomy and geometry shared their place with philosophical disciplines such as ethics and political philosophy (Hobbes 1651, chap. 9). The watershed came with Kant's *Critique of Pure Reason*, which drew the line between modern science (contemporary Newtonian mechanics) and philosophy (Kant, 1781 and 1787). Encouraged by the advances of modern sciences, Auguste Comte, in *Cours de philosophie positive,* developed the law of three stages, which forecast the disappearance of philosophy as an archaic form of knowledge and the substitution thereof by the emergent positive sciences, including his own social physics (Comte 1830-42). Along with certain renowned logical empiricists in the 20th century, Comte held that the origin of all sciences was philosophy. Subsequently, once sciences reached maturity, they emancipated themselves and abandoned their old and exhausted mother, which was then seen as a metaphysical vestige. Positivists conceive of the sciences mainly as theories, as maps or representations of certain regions of the world, and maintain that scientific theories come from prior philosophical metaphysical theories.

Other materialist-driven philosophies understand the sciences less as maps of the world and more as interventions on certain areas of reality (Hacking 1983). This understanding is usually associated with the idea that scientific material fields come from prior practical knowledge, an idea defended by many leading historians and philosophers such as Gordon Childe, Benjamin Farrington, Boris Hessen, Ortega and Ludovico Geymonat (Childe 1942; Farrington 1944 and 1949; Hessen 1931; Ortega 1933; Geymonat 1972). Assumptions acting in this paper hold that sciences, understood as first-order knowledge, do not emerge from philosophy, but rather from a wide variety of prior techniques. Accordingly, the origins of geometry can be traced to the techniques of architects, urbanists, and land surveyors (the *harpedonaptai* or "rope stretchers") and those of chemistry in the techniques of pharmacologists, spirits producers, herbalists, metallurgists, dyers and alchemists. In this interpretation, Newton's mechanics does not arise from Aristotle's physics, but rather pushes against it. Modern physics is a radically different, non-philosophical, empirical-mathematical way of taking into account practical, technical problems concerning the motions of bodies and the forces acting on them, both on the Earth and in the skies: bodies rolling on inclined planes or falling from towers, projectiles launched from weapons, planets orbiting the Sun, pulleys and levers, among many others. This theory on the origin of sciences implies that each science has its own material field arising from certain precursory techniques. As such, sciences and the relationships between them cannot be classified based on a deduction from their phylogeny (as would be the case if all the sciences were "sisters" engendered from the same "mother philosophy" or "branches" sprouting from the same "philosophical trunk").

2. No "system of sciences" exists

The idea of system implies the existence of a whole with different parts and the existence of a principle (or set of principles) coordinating these parts; in the case of practical applied systems, the goals pursued act as the coordinators of the system's parts. Two examples may serve to briefly illustrate these two varieties of systems. The first is the periodic table of chemical elements, which is a non-teleological system in which the parts are the elements with their subparts (electrons, protons, configurations), and the principles of classical chemistry (the periodic law, Dalton's law, Proust's law, etc.) act as the coordinators of those elements through their subparts. The second is any given machine, such as an aircraft, which is a teleological, practical, technological system with thousands of parts and subparts coordinated by the overarching goal of the machine, i.e. transporting loads by air. The same can be said about techniques and technologies that pursue practical goals, as occurs in politics and legal doctrine (Alvargonzález 2019).

As mentioned, before the first scientific revolution, when philosophy and science were not yet distinguished one from the other, the system of knowledge was guided by certain philosophical principles (Bueno 1991). During the Middle Ages, those principles were mainly of a theological and metaphysical nature. Take for instance the famous *'Ihsâ al 'ulûm* (*Enumeration of the Sciences*) by al-Fârâbî, in which he presented a system of sciences whose highest knowledge and keystone was theology (al-Fârâbî 1953 [1310]).

After modern sciences coalesced, defenses of the idea of a system of sciences were still made based on non-religious premises. A system of sciences would suppose the existence of several sciences, understood as the parts of the system themselves coordinated by the same principles. Notable among those advocating this view is Gabriel Tarde in *The Laws of Imitation* in which he articulated a system of sciences ruled by a single principle of universal repetition, since the sciences were defined as the study of repetitive processes. In his view, the various forms of repetition gave rise to three different types of sciences: mechanical repetition, present in wave transmission, is characteristic of physical sciences; hereditary repetition, as it appears in the reproduction of living entities, is typical of biological sciences; social sciences, for their part, focus of the study of imitative repetition (Tarde 1890-5, chap.1).

Certain Marxists philosophers have also affirmed the existence of a system of sciences. Boniface M. Kedrov conflated strict sciences, techniques and philosophy in a single system guided by a "principle of subordination", which implied that "philosophical sciences", "social sciences" and "psychology" are subordinate to the natural sciences (Kedrov 1961).

The pluralism acting in Bueno's theory of categorial closure dictates that every science has its own material principles governing in the immanence of its own particular field alone. Although certain sciences may share methodological procedures, there is no single set of principles common to all sciences and, consequently, no one single system of sciences exists. The general principle of repetition proposed by Tarde does not take into account particular components which are present in most sciences: *e* or π in mathematics, the physical constants *c* and *g*, the idiographic character of the Sun, Moon, planets, Milky Way and geological fossils and the unrepeatability of historical events. Kedrov's systems of sciences, with its melting pot of heterogeneous disciplines, looks to present the arguable, philosophical principles of Marxism as if they were universal scientific truths.

A given science, such as classical mechanics, can be characterized as a system in which the bases are the scientific theorems and the principles (Newton's famous three principles) coordinate all the theorems of the field through their subparts. The system's parts are often at the same time systems themselves: in an aircraft, there are several different systems (electrical, hydraulic, avionic), each with its own parts and purpose. In the sciences, scientific theorems are also systems, as illustrated by the aforementioned example of the periodic system of chemical elements. The solar system may also serve as another illustration: Kepler's laws are the coordinators of the system whose bases are the Sun, the planets, the satellites and the comets, each with their own constitutive characteristics (Alvargonzález 2019).

However, just as a group of political states is not automatically a state and a set of circles is never a circle, a set of systems is not always necessarily a system. Such is the case with modern sciences: although each science is a system of theorems coordinated by certain principles, numerous sciences as a whole do not give rise to a unified system since they do not share common material principles. A system of sciences would presuppose the existence of several sciences (understood as the system's parts) that are coordinated by the same material principles; this does not happen, though. Jordi Cat has summarized the numerous metaphysical and methodological unity of science projects together with the most relevant criticism lodged against them (Cat 2017). The materialism acting in this paper defends the ontological and methodological pluralism advocated by certain philosophers in the Stanford School (Dupré 1993, Galison and Stump 1996, Cartwright 1999).

3. Fundamentals of a classification of sciences based on their internal structure

Bueno's idea of sciences as categorial closures recognizes both the multiplicity of sciences and their mutual irreducibility. However, this plurality does not lead to chaos or preclude a classification grounded on their internal structure as it affects their scientificity. Specifically, I will defend the following:

1. The difference between the sciences, on one hand, and techniques and technologies, on the other.
2. The specificity of the so-called formal sciences and the difference from the rest of the sciences.
3. In terms of the non-formal sciences, the pertinence of the distinction between the human and ethological sciences, on the one hand, and the rest of the sciences (often designated as the "natural sciences"), on the other.
4. The specificity of history and archaeology.

This classification of sciences is by no means original; however, the fundamentals on which it rests remain, in certain chief points, obscure. My argument centers on this classification as grounded on the internal structure of the various scientific fields and on their specific degree of scientificity.

3.1. Fundamentals of the difference between the sciences and techniques and technologies

Aristotle's *Metaphysics* first classified the disciplines into two kinds, speculative (or theoretical) and practical; this was subsequently defended by Augustine in *The City of God* (2012 [ca 415]), Hugh of Saint Victor in *Didascalicon* (1991 [1172]) and Dominicus Gundissalinus in *De divisione philosophiae* (1974 [1150-60]), among many others. The distinction draws on the difference between what ought to be understood and what ought to be done. At a time when philosophy and science had not yet been distinguished, it served to discriminate between two kinds of philosophical disciplines: on the one hand, those dealing with practical, applied problems such as politics and law and, on the other, those focusing on more speculative issues such as theology and mathematics. At present, though, the existence of myriad sciences, techniques and technologies demands that this classification be reconsidered.

The difference between the sciences and techniques and technologies can no longer be understood by distinguishing between theoretical and practical disciplines. Sciences, techniques and technologies are all institutions of a practical nature, since they entail the intervention in and transformation of certain parts of the world. This practical, operational, intervening character is common to all sciences, be they formal, empirical, natural or human, and is also shared by techniques and technologies. As already stated in section 1 above, at their origin, each science exhibits a continuity with an aggregate of forerunner techniques to such a point that certain devices and things of a technical, practical origin still themselves remain in the field of the sciences, albeit in a compounded and transformed state: rulers, compasses, triangles, scales, distillation coils, levers, pulleys, clocks, flasks, monoculars and many others. This proximity between sciences and techniques is an essential principle of Bueno's materialism. Techniques always include certain "theoretical" postulates, even if those theories are mythical, magical or religious. For their part, the technologies present in electronics, nuclear energy, aerospace engineering and medicine require the internal use of strict sciences such as mathematics, physics, chemistry and biology. Even further, sciences, techniques and technologies give rise to disciplines that can be taught and learned in an appropriate institution, and so stand on equal footing from a social point of view.

Notwithstanding this close relationship, sciences, techniques and technologies do show certain distinctive features. Techniques exist long before the sciences, are independent of them and can develop substantially without the need for scientific knowledge. The classical Chinese civilization serves as an illustration of an entire millenary culture developing a large number of significant technical innovations in the absence of any science in the strict modern sense (Needham 1954). In western civilization, nautical techniques enabled the discovery of America and the architectural techniques used to build the great Gothic cathedrals were developed before the first scientific revolution. Techniques imply the "violent" (in the Aristotelian sense) transformation of the world so as to achieve certain practical goals, to either make things (products, machines, buildings, etc.), in line with Aristotle's' *poiesis,* or to rule over the ethical and political *praxis* moderated by the *phronēsis*.

Sciences, though, have no such immediate practical aims: a geometrical theorem or astronomical discovery may lack of any immediate application, even though they represent scientific achievements or universal truths. The distinctive function of sciences lies in that they neither represent reality nor solve particular practical problems; rather, certain regions of reality are only accessible thanks to certain sciences, such as microphysics, astrophysics, genetics, biological evolution and n-dimensional non-Euclidean geometric structures, among many others (Bueno 1995). Although these regions of the world would not come to be constituted as such if the sciences did not exist, the ontological significance of those scientific categories does not depend on the absence or presence of useful applications, since scientific truths and theorems transcend any goal-oriented context.

Technologies and techniques alike share an organization around certain particular practical objectives but, unlike techniques, technologies necessarily include the internal use of scientific theorems and, consequently, they may be seen as applications of certain scientific discoveries. As a counterpart of the dependence of technology on science, the sciences themselves, once they reach a certain degree of complexity, become dependent on the use of a wide array of technological devices. At any rate, recognizing this undeniable interplay between sciences and technologies and their mutual inseparability accords with defending their essential dissociation and differentiation, in the same way as the inseparability of an animal's various systems (the nervous system, the circulatory system, the digestive system, etc.) accords with their disassociation in anatomical terms.

To summarize, sciences, techniques and technologies are activities of a practical, surgical nature since they imply operations on and transformations of certain bodies. Techniques and technologies must be directly geared towards certain practical goals; sciences need not. The internal organization of a given science does not depend on fulfilling a particular practical purpose (as happens in techniques and technologies), but on its theorems, and on its specific principles, which coordinate those theorems and make its categorial closure possible. Scientific principles and theorems are universal apodictic truths.

While the preceding paragraphs may seem to have drawn distance from the central topic, distinguishing the sciences from techniques and technologies is instrumental to pinning down the fundamentals of a classification of sciences. As stated above, techniques and technologies can be classified based on their practical goals: medical technologies can be clearly distinguished from aerospace technologies by their different goals. Nevertheless, that practical criterion is not used when taking sciences into account since their advancement does not depend on achieving a single, particular goal. Nevertheless, sciences are also practical activities implying the intervention in, transformation and constitution of chief parts of the world and mark the way to reaching universal truths, as stated in their theorems and principles. This lays the groundwork for locating certain criteria for the classification of sciences by following the way in which they operate with different kind of bodies and by analyzing the way in which they come to their universal theorems and principles. I will contend that these criteria are internal to the sciences since they are taken from the internal structure of their fields and from the degree of scientificity they have achieved.

3.2 Fundamentals of the distinction between formal and non-formal sciences

From his transcendental idealist standpoint, Kant conceived of mathematics as an *a priori* discipline that studied the pure forms of intuition, while D'Alembert, Mill and Spencer, among other positivists, understood mathematics as a discipline subordinate to the natural sciences. Wilhelm M. Wundt disagrees with them all in *System der Philosophie*: against Kant, he is suspect of the existence of *a priori* forms and, against the positivists, he argues that certain human sciences, such as economics, psychology and sociology, make use of mathematical methods and, consequently, mathematics is also a constituent of certain human sciences (Wundt 1889b, V). Moving from those theories, Wundt contends that mathematics is neither a natural science nor a human science since it is completely uninterested in empirical reality. In his view, mathematical objects and their properties are purely ideal, for they take into account certain formal properties of the objects, abstracting the related content and focusing exclusively on the forms obtained. Accordingly, he claims that pure mathematics has nothing to do with empirical reality and gives rise to a new realm called the "formal sciences", which stand in opposition to the "experimental" or "real" sciences.

In my view, Wundt has the merit of becoming cognizant of the fact that formal sciences shared certain distinctive features with and should be distinguished from the rest of the sciences, but he failed in determining their actual differences. He also failed to choose the appropriate words to refer to the two kinds of sciences, since, as I will argue, the labels "formal" and "real" induce confusion when applied thereto.

From the tenets of a materialist philosophy of science, the idea of a science that studies "pure forms" or "purely ideal objects", a science beyond "empirical reality", is contradictory. If mathematics and logic are strict sciences (and I contend they are), they should have a material field of objects, and those objects should be materially operated on, transformed and interrelated as in any other science. Matterless pure forms (angels or pure spirits) do not exist and, consequently, cannot shape the field of any science. At any rate, the syntagma "formal sciences" has such widespread use among academics and lay people alike and the risks of coining new terms are so high that I will still use that designation, since I am not looking to coin new words but rather discuss the fundamentals of the classification.

Following the tenet of the inexistence of pure forms, where then does the sui generis status of the formal sciences lie? Bueno's categorial closure theory states that formal sciences also have a field of objects, which are themselves the typographic materials operated on by logicians and mathematicians. Those typographic, mathematical and logical objects (numbers, variables, curves, polyhedra, etc.) are self-referential since, from a mathematical (or logical) standpoint, their potential references to outside do not matter. Consequently, taking cues from Bueno's philosophy of the formal sciences, the criterion to differentiate formal from non-formal sciences can be briefly formulated as follows. In the formal sciences, scientists operate with typographic objects (signs) that are self-referential. In the rest of sciences, though, scientists operate with objects other than signs, and signs are mostly allegorical since they refer to objects on the outside (Bueno 1979).

Euclid's *Elements of Geometry* is commonly recognized as the first strict science, as the first "modern science" *avant la lettre*. As a formal science, geometry is a science of typographic, self-referential objects made with rulers and compasses. From the operations with those self-referential objects, geometers built a vast array of universal scientific truths and theorems, which they coordinated into a system by means of a set of principles and postulates, giving rise to the first known categorial closure of a strict science. Formal sciences are currently viewed as the paradigm of strict scientificity and their demonstrations and theorems are frequently presented as the clearest examples of universal scientific truths.

To conclude this section, I will briefly comment on the labels selected by Wundt to refer to the mathematical sciences. As I have already mentioned, the adjectives "real" and "formal" for the noun "sciences" used by Wundt may induce confusion. Firstly, the word "form" is ordinarily put in opposition to "matter", following Aristotle's hylomorphist tradition. As stated, the inexistence of pure forms separate from matter is a pillar of ontological materialism and, consequently, formal sciences cannot study pure forms that do not exist. Furthermore, the non-formal sciences also study many forms as they are embodied into the real world (orbits, trajectories and shapes, among others). Secondly, the contradistinction between formal and real or empirical sciences strongly suggest that formal sciences are neither real nor empirical, which is clearly misleading. Formal sciences are as real as any other science, and they have an empirical character since they imply operations with self-referential signs, which are a specific kind of object existing in the real world. As it stands, the distinction between formal and non-formal sciences is, in certain aspects, superficial: both are real, empirical sciences and the fact that the fields of the formal sciences contain self-referential objects does not affect their degree of scientificity.

3.3. Fundamentals of the distinction between human and non-human sciences

The constitution of sociology, psychology, linguistics, cultural anthropology, economics and history as positive sciences in the 19th century brought in tow an important discussion about the place of these new sciences in relation to the natural sciences. The idea of science as a mere representation of reality neatly cohered with the nature-culture ontological dualism that was born of idealist German philosophy and had broad influence. As a result, leading philosophers understood that each of these two comprehensive ontological spheres, nature and culture, need to be studied by a specific group of sciences: the natural sciences and the cultural sciences (also called the moral sciences, social sciences, human sciences, etc). This ontological foundation of these two classes of sciences proved compatible with the idea that the human sciences, due to their specific object of study (humankind, culture, society, etc.), make use of certain, particular methodologies. With Weber and Droysen as forebears, Dilthey and Simmel defended the famous distinction between the mechanical procedure of "explanation" (*Erlären*) used by the natural sciences, and the empathic "comprehension" (*Verstehen*) typical of human sciences (Dilthey 1883; Simmel 1920).

Space constraints prevent me from discussing these theories with due care. For the present purposes, suffice it to say that the sciences, as they exist at present, pose substantial difficulties to the nature/culture divide. Are the contents of formal sciences natural or cultural? Are animal cultures cultural or natural? To what extent are natural sciences themselves a chief component of our cultures? Furthermore, the foundation on which this ontological dichotomy rests is far from clear. As regards the existence of two different methodologies (explanation and comprehension) corresponding to the two different kinds of sciences, the main problem may be stated as follows: is that methodological dualism compatible with the unity of the idea of science and the unity of the idea of scientific universal truth? Does the expression "scientific truth" mean the same thing when referring to the "explanation" built into a formal or natural science and to the "comprehension" of a historical event?

Bueno's theory of science contends that classifying non-formal sciences into two different groups (human-ethological sciences and "natural" sciences) is meaningful since it affects the structure of their respective operational fields, but cannot be grounded on an ontological dichotomy. As stated above, the field of a non-formal science includes objects other than signs, as well as signs referring allegorically to those objects. Scientists operate and trans-form those objects and try to find the unchanging aspects of those transformations, which give rise to scientific principles and theorems. Whenever this regularity proves itself to be independent of scientists' will, these principles and theorems can be deemed objective and universally valid. Common to all sciences, this procedure modulates differently depending on the nature of the operated terms of the fields. In the so-called "natural" sciences, the operated terms leading to scientific truths are objects that are either inert or, if not, then the related operations are not taken into account. Conversely, in the human and ethological sciences, certain subjects' operations must always be present in the field, and these operations must be taken into consideration when stating the scientific theorems. Consequently, in the field of human and ethological sciences there are two levels of operations:

1. As in any other science, the scientists' operations with the field's terms.
2. The thematic subjects' operations, i.e. the operations of the subjects studied by that science: speakers, natives, economic agents, historical subjects, animals, etc. These subjects' operations are taken as the terms of the science's study, as the terms of the related scientific field. Human sciences try to explain their operations by connecting them with the field's other terms: artifacts, institutions, etc.

Based on this characterization, the ethological sciences fall on the side of the human sciences since animals may be considered operating subjects, and their operations, as far as they are analogous to humans' in certain aspects, can be terms of a science's field. Here again, there are two operational planes: that of the operating animal and that of the ethologist or psychologist who operates on the operations of the animal.

At this juncture, it is worth remembering that, according to Bueno's theory of scientific truth, the theorems of the strict sciences imply the elimination of the subject. Bueno contends that, in the constitution of scientific truths, the operations of different subjects are neutralized among themselves so that certain relationships between terms can be stated, independently of the subject. This is the case of the observations of many astronomers over the centuries that led to Kepler's laws: The three famous laws establish certain relationships between the terms of the solar system that are deemed independent of the subjects.

Gustavo Bueno argued that certain deficiencies in the human and ethological sciences are but a consequence of the existence of their dual operational plane: the plane of scientists' operations, and the plane of operations of the thematic subjects, be they animal or human. As a result, of this dual operational plane, the fields of human and ethological sciences find themselves structurally tensed between two poles. On the one hand, according to Bueno's theory of scientific truth, there is the requirement to eliminate subjects' operations from the field of the science so that universal, objective scientific truth can be built. On the other hand is the fact that, in the human and ethological sciences, the operations of human subjects (or their non-human animal analogues) must always be present. As operations are more completely eliminated, the more objective, the more scientific the discipline will become; however, its status as "human" science will fall into jeopardy (assuming, with Bueno, that the human sciences must contain the operations of the thematic subjects). Conversely, if these operations remain in the field, the science then retains a human-ethological character but, consequently, the scientificity of that discipline will be endangered since scientific objectivity implies a neutralization of subjective operations. According to Bueno, this chronic precariousness of the human and ethological sciences is but a consequence of the structural tension between the elimination and maintenance of the thematic subject's operations (Bueno 1978 and 2013). These circumstances do not affect the natural sciences and, accordingly, the classification of non-formal sciences into two groups (natural and human-ethological) can be deemed to be internal to the structure of science itself.

The proposed criterion facilitates an understanding of the proximity between human and ethological sciences. Scientists, the gnoseological subjects, are always humans, since animals do not engage in science. The thematic subject, the subject whose operations are studied by a given science, can be either human (as in linguistics, economics and history) or animal (as in ethology and animal psychology).

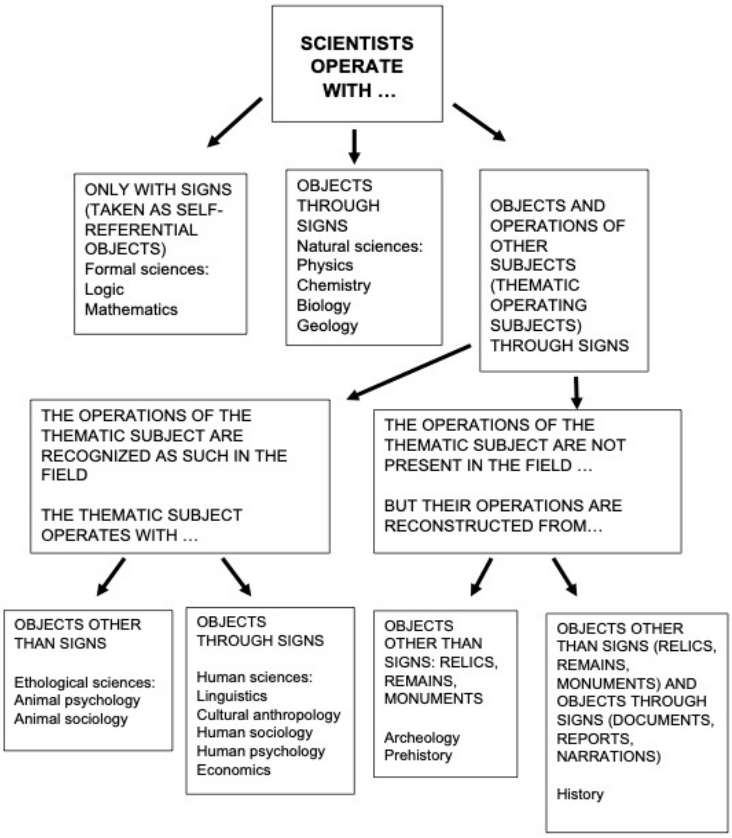
3.4. Fundamentals of the specificity of human historical sciences

Drawing on the foregoing criterion, in the fields of human sciences the operations of certain subjects (thematic subjects) are recognized as such, and scientific theorems are expected to accommodate those operations within an explanatory context. As stated, this is the case of human sciences such as linguistics, psychology, ethology, sociology, economics and cultural anthropology, to cite but the most relevant. In them, scientists (the gnoseological subjects) interact with speakers, economic agents, natives and animals, among others (the thematic subjects). Historical sciences, though, pose a very specific problem, since past historical subjects have died and their operations are not directly present in the field of the science. Nevertheless, historians must suppose the existence of their past operations by deducing them from the field's object-terms (documents and unwritten remains); otherwise, such remains could not be differentiated from the surrounding objects of non-operational etiology. Hence, historians take relics, remains, monuments, documents, narrations and reports and populate them with the ghosts of their coeval subjects. Consequently, the operations of the thematic subjects (the historical agents), although not in the field directly, are inferred from certain objects. In archeology and prehistory, these objects do not include written vestiges, as they do in history.

The specificity of idiographic history as a scientific discipline has been frequently asserted. In *Scienza Nuova*, Giambattista Vico applied the *verum factum* principle ("the true is the made"), arguing that only the products of human actions can be properly understood and our understanding of the inert world will always be partial: only God, who designed and created the world, has a complete understanding of it (Vico 1725, Element I). In line with Vico, Wilhelm Windelband put forward his distinction between nomothetic and idiographic sciences: natural sciences are nomothetic since they state universal laws (*nomos*), while history is idiographic since it focuses on the study of particular (*idios*) events. Scientific laws establish functions linking variables, while history studies the reasons why certain actors behaved in a given way (Windelband 1894, Rickert 1926). Robin G. Collingwood, in *The Idea of History*, argued that history focuses on human agents, on human affairs insofar as humans are rational beings, and argued that historians look for the motives that render those actions intelligible (Collingwood 1946). In my view, history, archaeology and prehistory share a common feature, as mentioned: their thematic subjects are dead and the related past operations must be inferred from certain specific objects (relics and narrations). Nevertheless, historical sciences share with the other human and ethological sciences the primary structure of the two operational levels described: the scientists' operations on the field and the thematic subjects' operations in the field. At any rate, the idiographic history, understood as the reconstruction of past, singular events, does not lead to the construction of a system of theorems coordinated by principles. A nomothetic, systematic history would imply the comparison between different isolated events: the parallel, independent evolution of ancient Egyptian and pre-Columbian American empires may serve as an illustration.

Concluding remarks

To conclude, at the cost of some slight repetition, I will summarize the fundamentals of the classification of sciences herein defended with the aid of a diagram (see Table 1).



Assumptions acting in this paper require that sciences always imply the intervention and transformation of the surrounding world and, consequently, they always imply the existence of scientists performing a wide array of operations on a field of objects. When scientists operate exclusively with object-signs understood as self-referential, the resulting sciences are formal sciences: mathematics and logic. Euclidean geometry serves as a paradigm of these sciences.

In the non-formal sciences (natural or human-ethological), scientists operate with objects other than signs and the object-signs are used allegorically to refer to something else outside them. Non-formal sciences, for their part, have two different varieties depending on the operational structure of their respective fields:

1. In the natural sciences, scientists operate on objects that either are inert or, if such objects do carry out operations, they are not taken into account. Physics and chemistry are paradigmatic illustrations of natural sciences since physical objects (planets, bodies, etc.) and chemicals (compounds, elements, etc.) do not perform operations.

2. In the human and ethological sciences, though, scientists operate on a field where other subjects' operations (human or animals) are present. Accordingly, those fields have two operational levels: that of the gnoseological subjects (the scientists) and that of the thematic subjects (animals, natives, speakers, etc.). Ethology, psychology and cultural anthropology are examples of these sciences. Sciences studying animal behavior may be differentiated from those studying human operations, since human operations are always accompanied by the use of a very specific language of words.

Historical sciences share this dual operational structure with the other human-ethological sciences, but the former present the particularity that, because the thematic subjects are dead, their operations are not directly in the field and must be deduced from the field's object-relics. When these objects comprise texts from the human language of words (narrations, reports, documents) we speak of history *strictu senso*, while in absence of texts we speak of prehistory and archeology.

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Note

[1] Brendan Burke and Lino Camprubí translated the Spanish-language word "*categorial*" as the English-language word "categorical" (in Bueno 2013). The English-language word "categorical" (and its Spanish counterpart) takes on a very specific meaning associated with Kantian idealism in such expressions as "categorical imperative" and "categorical syllogism". As this use is foreign to Bueno's materialism, I prefer the adjective "categorial". In Bueno's philosophy, the closure of a given science is "categorial" since it gives rise to a specific ontological category, but it is not "categorical" in the Kantian sense.