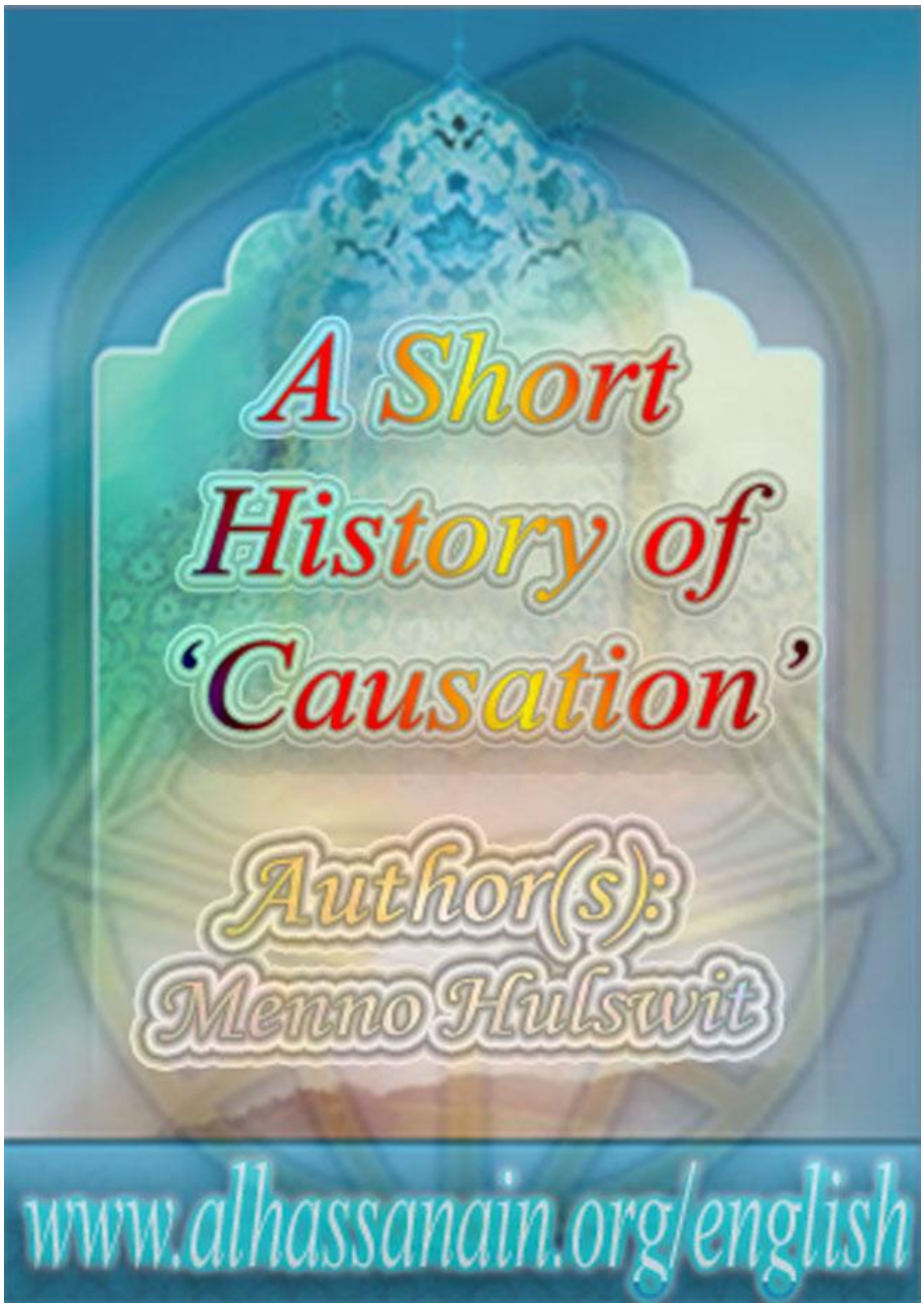

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A Short History of ‘Causation’

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ABSTRACT

Philosophical theories are always answers to questions raised within certain historical contexts, which involve the common presuppositions of an era. A thorough insight into a particular philosophical problem therefore requires a historical perspective. Thus, in order to better understand the contemporary approaches to the complex issue of causation, and the problems they raise, it is necessary to have a clear insight into the historical evolution of the concept of cause.

In this article, I will show that the development of the history of the concept of cause reveals a remarkable discrepancy between the constancy in the use of terminology and the gradual shift in the meaning of the terms used. This development - which has largely remained unnoticed - requires analysis, if only because most contemporary discussions on the subject, which almost invariably stand in the tradition of Hume, seem to have been victimized by it. For, contrary to what is generally supposed, causation is not a univocal conception (which either can or cannot be further analyzed). It is an ambiguous conception, with at least two (or three) different meanings, each of which requires a critical analysis on its own. Hume's celebrated criticism concerns only one of these senses of cause, which is notably just a derivative sense.

The objective of this article is to discuss some important historical moments in the evolution of the concept of cause, and, more specifically, to discuss the conceptual tensions that are inherent to this historical development. I will focus my attention upon the conception of cause in, successively, Ancient Greek Philosophy (Aristotle and the Stoics), the Middle Ages (Aquinas), and the Modern period (Descartes, Hobbes, Leibniz, Locke, Newton, Hume, Kant, and Mill).

1. CAUSATION IN ANCIENT GREECE

Though the concept of causation has emerged in Pre-Socratic philosophy, it was probably Plato who first stated the principle of causality: "everything that becomes or changes must do so owing to some cause; for nothing can come to be without a cause" (Timaeus 28a). But Plato emphasized the causal importance of formal causes. Nothing can be unless there be a changeless pattern of formal causes of which the individual sensible phenomenon is a mere appearance. However, since Aristotle was the first philosopher to give an extensive account of causes, I will start my discussion with his theory.

1.1. Aristotle: four types of explanation

The most important passages where Aristotle discussed his theory of ‘causation’ are to be found in his Posterior Analytics, his Physics, and his Metaphysics. The context always concerns both a certain being and the conditions of knowledge of that being. Thus, Aristotle said, for example, in his Posterior Analytics (I.2, 71b9-12) that knowing a thing involves knowing its aitiai.

Aristotle stated that, in reference to any singular entity, the question ‘What is this?’ could be answered in four different ways, each of which corresponded to what he called a ‘cause’ in the sense of ‘something without which the thing would not be’ (aitia). Thus, given a marble statue, the question ‘What is this?’ could correctly be answered in one of the following ways: ‘This is marble’, ‘This is what was made by Phydias’, ‘This is something to be put in the temple of Apollo’ and ‘This is Apollo.’ These answers are the answers to four different questions, respectively: ‘What is this made of’, ‘Who is this made by?’ ‘What is this made for?’ and ‘What is it that makes this what it is and not something else?’ The answers have come to be known as, again respectively, the material cause, the efficient cause, the final cause and the formal cause. Though a complete answer to the original question would encompass those four different answers, and therefore the four different causes, Aristotle argued that the most important and decisive cause was the formal cause (Physics II.3,194b23-195a3).

Only the efficient aitia has features we now associate with the idea of causation. Aristotle conceived efficient causes as 'things responsible' in the sense that an efficient cause is a thing that by its activity brings about an effect in another thing. Thus, the efficient cause was defined by reference to some substance performing a change: it is the "primary source of the change" (Metaph. V.4, 1014b18-20). That which is produced is either some new substance, such as ashes from wood, or simply a change in some property of a given substance.

Efficient causation involves a form being transmitted from the efficient cause to the effect. Thus, for example, the efficient cause of the statue is the form in the mind of the sculptor (Metaph. VII.7, 1032a11-1032b23). The form of the statue (effect), which is the same qua form in his mind, comes about from him by means of the motion he originates (Generation of Animals I, 21-22).

It is a matter of dispute whether Aristotle also defended the modern idea that efficient causes necessitate their effects. There is evidence that he associated explanation by efficient cause not simply with what happens always and necessarily, but with what happens for the most part. Indeed, given a certain man, he must have a father, but given a man, there is nothing that determines him to be a father. In other words, Aristotle defended the view that, given a certain effect, there must be some factors that brought about that effect. But he nowhere inferred from this that given certain conditions, some effect necessarily follows.[2]

However, it would appear that there is another kind of necessity involved in the efficient cause. Efficient causation presupposes that in some way a form is transmitted, and it is precisely this form which is some kind of boundary

condition; it determines that a particular substance can behave in such-and-such a way, but not in another way; the form of man, for example, does not determine what a particular man will do, but it determines that he cannot, for example, fly as a bird.

1.2. The Stoics: causation, exceptionless regularity, and necessity

The Stoic cosmos is an organism imbued with divine reason (logos), and its entire development is providentially ordained by fate. The Stoics were the first philosophers to systematically maintain the idea that every event is necessitated by certain causal conditions. This so-called principle of causality has come to dominate our whole western outlook up to the present time.

Thus, one of the main innovations of the Stoics was that the idea of cause is linked both to an exceptionless regularity and to necessity. The Stoics strictly held to the view that each event has a cause. They rejected the idea that there could be any uncaused events, because that would undermine their basic belief in the coherence of the universe (e.g. Cicero, De Fato, 43). They held, moreover, that each particular event necessitates its effect. According to Alexander, for example, it is necessary that the same effect will recur in the same circumstances, and it is not possible that it be otherwise. Given the same cause and circumstances surrounding the cause (periestekota), the same effect could not fail to occur (many Stoics expected that in future times, an exact repetition of circumstances was going to occur) (Sorabji 1980, 64-9).

The Stoic principle of universal causation - which entails that 'chance' and 'possibility' only refer to our ignorance of the causal connections between events (Long 1996, 164) - is very well expressed in the following passage by an unknown Stoic author:

Prior events are causes of those following them, and in this manner all things are bound together with one another, and thus nothing happens in the world such that something else is not entirely a consequence of it and attached to it as cause. [...] From everything that happens something else follows depending on it by necessity as cause. (Quoted in Long 1996, 164)

Though this passage could very well have been written by a contemporary philosopher, there is an important difference with the modern conception of cause: contrary to the modern conception, the necessity involved in the causal relation does not pertain to types of events, but only to the relation between particular causes and particular effects (Sorabji 1980, 64-69).

2. CAUSATION IN THE MIDDLE AGES

In the thirteenth century, most Christian philosophers tried to reconcile Aristotle's philosophy with the Christian idea that God created the world out of nothing. As a consequence, Aristotle's ‘unmoved mover’ was transformed into a ‘creating cause of existence’ (Gilson 1962). More generally, the Liber de Causis - a Neo-Platonic Arabic work of the ninth century, translated into Latin in the twelfth century - had a decisive influence on the concept of cause. In accordance with the view exposed in that book, most thirteenth century philosophers,[3] contrary to Aristotle, distinguished two quite different sorts of efficient cause: causa prima and causa secunda. The first type of efficient cause is the originative source of being. The second type of efficient cause is to be found only in created things, and refers to the origin of the beginning of motion or change. The First Cause works in all secondary causes, which may be considered as instrumental causes subservient to the first.

This conception of the primary efficient cause involves a radical switch in respect of the Aristotelian notion of efficient causality. Whereas in Aristotle, efficient causation was the origin of a change or a motion by means of the transmission of form, in medieval philosophy, primary efficient causality concerns the creation of both matter and form.

In this article, however, I will restrict myself primarily to the concept of secondary efficient causality, and in this section, to the view of Thomas Aquinas (1224/5-74), who may be regarded as one of the most influential representatives of later medieval philosophy.

2.1. Thomas Aquinas

In the Summa Theologiae (Ia 2,3), Aquinas formulated five ways of arguing for the existence of God. His fifth way concludes from the observation of finality within natural bodies that there must be some intelligent being, God, by which all natural things are ordered to their end. Like Aristotle, Aquinas distinguished between internal and external final cause. Whereas all natural things have internal final causes themselves, created by God, the ultimate external goal is God himself. For, while the primary goal of created things is self-realization, this striving toward self-realization coincides with the striving toward the ultimate goal, which is God. In the formation of the world, but also in all created causality, final causality comes first and works in and through the efficient causes. The efficient causes are subordinate to the final causes inasmuch as they are means to ends (SCG II: 42.5).

The (secondary) efficient cause is that which induces some form in natural things. Thus, fire may communicate its form (fire) to something else, and the form of the house that exists in the builder's mind, may cause a real house. Particular agents necessarily require pre-existing matter from which to produce their effects by bestowing a form upon it (SCG II: 16.7).

In natural things, the necessity is derived from the form of the things. Thus, given the efficient cause, "the natural thing necessarily tends to its end in accordance with the power of its form." This necessity is absolute inasmuch as the way toward the end state is completely determined by the form and the other causal circumstances ("every agent which acts by natural necessity is determined to one effect"). It is interesting to see that, with Aristotle, Aquinas mentioned 'gravity' as an example of final or formal causality (SCG II: 30.15), and not as an instance of efficient causality, as has been commonly supposed since the rejection of final causation in the modern period.

Whereas Aquinas held that all inanimate things behave according to natural necessity, he made a distinction between two kinds of efficient cause, which, in modern terminology, might be called 'loose causes' and 'tight causes.' Whereas tight causes necessitate their effects independently of any other causal circumstances, loose causes require that other conditions be fulfilled (cf Collingwood [1938] 1991, 153).

Thus, in some cases (‘tight causes’) necessary connection is associated with the efficient cause as such; "the sun's motion, for example, necessarily gives rise to changes in terrestrial bodies" (SCG II: 29.18) and is therefore absolute necessity. In other cases (‘loose causes’) it is relative to both the agent and the patient; "if fire is hot, it necessarily has the power of heating, yet it need not heat, for something extrinsic may prevent it" (SCG II: 30.12).

However, given both the agent and the patient, the necessity is just as absolute as in those cases in which the efficient cause itself is a sufficient cause. Aquinas therefore concluded that all inanimate things are characterized by natural necessity: "For, as nature is, so is its action; hence, given the existence of the cause, the effect must necessarily follow" (SCG II: 35.4). Whereas man is endowed with free will, "inanimate things, plants, and brute animals" behave according to natural necessity (SCG II: 47.3), which is responsible for the uniform behavior of natural things: “... the power of every

agent which acts by natural necessity is determined to one effect; that is why all natural things happen in the same way, unless there be an obstacle; while voluntary things do not" (SCG II: 23.2).

By saying that "all natural things happen in the same way," Aquinas meant that things belonging to the same type act similarly in similar causal circumstances. By thus relating efficient causality to natural necessity, and natural necessity to law-like behavior, Aquinas would have a major impact on the development of the modern conception of causality.[4]

3. CAUSATION IN MODERN PHILOSOPHY

In the seventeenth century a movement of thought arose that has come to be known as modern science. This evolution involved a radical change in the development of the concept of cause. Explanations by formal causation and final causation were rejected; the only valid explanations were explanations by efficient causation. Moreover, the concept of efficient causation itself had radically changed. More specifically, in the seventeenth century the idea took root that (a) all causation refers exclusively to locomotion, (b) that causation entails determinism, and (c) that efficient causes were just the inactive nodes in the chain of events, rather than the active originators of a change. These changes have had a lasting influence on the evolution of our conception of cause, and indeed our entire Western outlook.

The history of the development of this outlook is extraordinarily complex, and was influenced by a web of both theological and scientific beliefs. However, the idea that causation involves determinism does not have a scientific origin, but a theological one. In spite of differences in detail, the arguments for determinism in the writings of Descartes, Hobbes, Spinoza and Leibniz, are very similar. In no case did the conclusion that all things are determined receive its justification from a concern with empirical fact. The idea was that all things are causally determined because, and only because, determinism is entailed in the idea of God's omnipotence and omniscience. If God knows everything and can do everything, whatever is must be. For the same reason, it is misleading to say that any finite agent is a genuine cause, that is to say, an active initiator of a change. Only God can be the cause of anything.

This straightforward determinism had important consequences for the development of the diverse conceptions of causation in the seventeenth century. In this section I will first discuss the rationalist conceptions of causation of Descartes, Hobbes, Spinoza, and Leibniz - some of the most important seventeenth century metaphysicians. Next, I will discuss the views of the empiricist approaches of Locke, Newton, Hume, Kant and Mill.

3.1. THE METAPHYSICAL SYSTEMS FROM DESCARTES TILL LEIBNIZZ

3.1.1. Descartes: dismissal of substantial forms

The ‘founding father of modern philosophy,’ who said to break with the tradition by starting completely anew, did not doubt the principle of causation. However, his interpretation of efficient causes as mechanical causes was an important new development. His mechanistic worldview involved that the principles of nature were identical to the principles of mechanics.

It seems appropriate to say that the primary aim of Descartes’ natural philosophy was the dismissal of the scholastic doctrine of active qualities and substantial forms as causal factors in natural processes, and their replacement by purely mechanical principles of explanation. The idea of substantial forms and active qualities as causal factors has no basis whatever in our experience of things:

Let another, if he likes, imagine in this piece of wood the Form of fire, the Quality of heat, and the Action which burns it as things altogether diverse; for my part I, who fear I shall go astray if I suppose there to be more in it than I see must needs be there, am content to conceive in it the movement of its parts. (Descartes, quoted in Miles 1988, 100)

By thus raising a few simple questions about the example of a piece of wood being burned, Descartes laid open what is perhaps the most important problem with any theory of causation based upon a substance ontology: how can a substantial form be transmitted from a cause to its effect?

The rejection of the fourfold causality of Aristotle and the Scholastics by Descartes (and Galilei and Bacon) had a profound influence on subsequent thinkers. Whereas he endorsed matter, and in this particular sense may be said to have subscribed to material causality, he rejected the idea of substantial forms or formal causality. And though he did not deny the existence of final causes - which he identified as God's intentions - he denied the usefulness of such a search. In order to explain nature, we need only examine the efficient causes of things (Descartes [1644] 1983, I: 28). Thus, in effect, there was only one type of cause for Descartes: the efficient cause.

However, Descartes endorsed two very different concepts of efficient causality. There are particular causes and there is one general cause. Descartes attributed to God the status of a general cause, which insures the constancy of quantity of motion in the universe ([1644] 1983, II: 36). Interestingly, the particular causes are not the motions of the individual parts of matter, but the general principles or laws of nature ([1644] 1983, II: 37). In the beginning, God created matter and motion, and he conserves exactly the same quantity of motion for all time. God is the efficient cause of any change of motion in an otherwise inert matter. And He does so according to the laws of nature, which became secondary causes. Thus, Descartes attributed some efficient causality to the laws of motion, which determine all particular effects. By doing so they provide causal, mechanical explanations. The only 'active initiator of change' that remained was the cause of all causes: God.

Descartes’ theory entailed a radical change in the concept of cause: by thus identifying efficient causes with deterministic laws, causes were no longer conceived as particulars, but as types. Moreover, they were no longer

identified as the 'active initiators of a change,' but, instead, as some inactive instruments of God.[5] This change had a tremendous impact upon the scientific view of the world.

3.1.2. Hobbes: causation and motion

Like Descartes, the English philosopher Thomas Hobbes (1588-1679) presupposed causal determinism, rejected formal and final causation, and thought that causation was only relevant to motion. He explained all phenomena, even psychological and sociological ones, in terms of causal relations between moving bodies.

However, not the bodies but the accidents of bodies are the causal elements. Hobbes defined a(n) (efficient) cause as "the aggregate of accidents in the agent or agents, requisite for the production of the effect" (Hobbes [1655] 1839, 9.4). And he defined an effect as "that accident, which is generated in the patient" ([1655] 1839, 9.1). But, given that the accidents themselves are motions of parts of the body that is changed, causation consists, ultimately, in motion ([1655] 1839, 9.3; 9.9). Thus, the causal relata are not particular bodies or substances, but their motions; causation is a relation between the motions of different bodies. Nothing would happen if nothing moved, and the only things that move are bodies. Moreover, all causation occurs by contact, that is to say, it consists in motion of contiguous bodies ([1655] 1839, 9.7). There is no action at a distance.

Consistent in his attempt to resolve all phenomena to motion, Hobbes rejected the concept of formal or final causes, which are nothing but 'disguised' efficient causes ([1655] 1839, 10.4). Yet, Hobbes maintained a distinction between efficient cause and material cause. Whereas the material cause is just the receptor of the agent's activity, "the aggregate of accidents in the patient," the efficient cause is the aggregate of properties in the agent required for the production of the effect. The material and efficient causes are both part of the entire cause ([1655] 1839, 9.4). Necessity or necessary connection is not associated with the efficient cause as such, but with the entire cause, which entails both the agent and the patient. Entire causes are complex conditions (of both agents and patients) that are necessary and sufficient for the occurrence of the effect ([1655] 1839, 9.3).

Consequently, in Hobbes's universe, everything happens by necessity: "all the effects that have been, or shall be produced, have their necessity in things antecedent" ([1655] 1839, 9.5). Moreover, given the cause, "it cannot be conceived but that the effect will follow" ([1655] 1839, 9.7; italics mine). This description of cause (involving necessity) corresponds with what Taube thought to be the definition of necessity that was current in the seventeenth century, namely: "that the opposite of which is inconceivable" (Taube 1936, 102). A connection is necessary inasmuch as it is inconceivable, or contradictory, that the connection should not obtain. However, this supposed necessity is not based on any matter of fact relation. Hobbes (and most of his seventeenth century colleagues) secured necessary connection by postulating God in the causal relations of finite things. To hold that an entity acts in a manner not determined by God was inconceivable.

3.1.3. Spinoza: causation is logical necessitation

Spinoza (1632-77) was perhaps the most straightforward defender of the view that necessitation means implication. Causes logically necessitate their effects, and, conversely, they are themselves logically necessitated by their effects.

Spinoza made a distinction between 'free causes' and 'necessary causes.' Whereas free causes act from the necessity of their own nature (and are therefore the initiators of a change) necessary causes are necessitated by other causes (and are therefore just inactive nodes in a chain) (Spinoza [1677] 1949, Def. 7). God is the only free cause, by which is meant that, though He simply had to create what He did, He was not forced to do this by some external cause. He alone exists and acts from the necessity of his own nature. Only God is a genuine cause: "God's intellect is the sole cause of things, both of their essence and of their existence" ([1677] 1949, Prop. 17). The other 'causes' are just the nodes of a chain, completely compelled by previous links.

But, irrespective of the kind of cause, be it God or just some secondary cause, the relationship between cause and effect is one that involves necessity: “From a given determinate cause an effect necessarily follows; and, on the other hand, if no determinate cause be given it is impossible that an effect can follow” ([1677] 1949, Axiom 3). Given the reciprocity of the necessary relation between cause and effect, and given that "the order and connection of ideas is the same as the order and connection of things" ([1677] 1949, part II, Prop. 17), the necessity involved in the causal relationship must be understood as logical necessity. Causes logically necessitate their effects, and, conversely, effects logically necessitate their causes.

Moreover, the causal order is also understood in terms of the mechanical model. Spinoza radically rejected final causation as an anthropomorphic fiction. Ideas of purpose are derived from our tendency to act with an end in view. From this habit we incline to look at the universe as though it too had a purpose. But it is utterly wrong to look at ourselves and at the universe in this way. "This opinion alone would have been sufficient to keep the human race in darkness to all eternity if mathematics, which does not deal with ends but with the essences and properties of forms, had not placed before us another rule of truth" ([1677] 1949, 74). The truth is that everything just happens from the necessity of God's eternal nature, which simply is. By rejecting final causation and by considering all events as modifications of the eternal substance, Spinoza reduced the causal order to the mechanical order, and the mechanical order to the timeless order of mathematics. By doing so, he came to understand causation as some sort of logical necessitation.

3.1.4. Leibniz: sufficient reason and the denial of intra-substantial causality

The principle of sufficient reason is one of the foundations of the great metaphysical system of Gottfried Wilhelm Leibniz (1646-1716). It refers both to the logical ground and to the real cause of things: "there is nothing without a reason, or no effect without a cause" ([ca. 1680-84] 1969, 268).

Leibniz's very peculiar view of causality has its origin in his rejection of the reduction of metaphysical change to locomotion (Descartes, Hobbes, Spinoza). This rejection in turn was the consequence of a fundamental critique of the Cartesian concept of matter as extended substance: "I do not think that substance is constituted by extension alone, since the concept of extension is incomplete. Nor do I think that extension can be conceived in itself, but I consider it an analyzable and relative concept" (Leibniz [1699] 1969, 516). Thus, instead of being an ultimate, unanalyzable quality, extension is an analyzable relation.

However, Leibniz's view of extension as a relation entails that the final constituents of bodies are not extensive. If they were, they would themselves be relations. Thus, Leibniz concluded that the ultimate existents must be non-extensive monads. The material bodies have monads as their constituents. The characteristic features of matter - extension, solidity, inertia, etcetera - are derived from the relations between the constituent monads. Thus matter is just a derivative entity, constituted by the relations between the primary existents (cf Leclerc 1986, 87).

Leibniz's analysis of matter had significant consequences for the concept of motion. Because motion is a modification of the extensive relations, it too is of secondary importance when compared to the action of the monad, which is always perception: "This is the only thing - namely, perceptions and their changes - that can be found in a simple substance. It is in this alone that the internal actions of simple substances can consist" (Leibniz [1714] 1969, 644).

Given this critique of matter as extended substance and of the reduction of change to locomotion, Leibniz necessarily had to develop a different concept of causality. In the first place, he rejected the idea that the ultimate constituents of reality (the monads) have a causal relation to each other. Instead, he proposed that the history of each individual monad consists of one causal chain.

Each individual substance has a concept from which everything follows that will ever be true about it: "The complete or perfect concept of an individual substance involves all its predicates, past, present, and future" ([ca. 1680-84] 1969, 268). The completeness of the individual concepts entails that there is a mutual causal independence of created substances. The correspondence of individual substances is explained by the doctrine of pre-established harmony: God has programmed the world in such a way that each monad develops in synchrony with all other monads. Just like a good clockmaker who constructs a number of clocks that keep perfect time, God pre-established the harmony of the universe at the beginning of things ([ca. 1680-84] 1969, 268-9).

Thus, all individual created substances are different expressions of the same "universal cause." However, though God caused their existence, their

successive states are (normally) produced by their own natures. Every state of every monad is completely determined by its nature or substantial form, which is an internal, active causal principle. Thus every simple substance is "spontaneous," that is to say, "the one and only source of its modifications" ([1712] 1973, 175). The doctrine of the spontaneity of substance ensured for Leibniz that created individual substances were centers of activity, a feature he took to be a necessary condition of genuine individuality.

The internal forces of monads, which were identified with the substantial forms, Leibniz conceived as appetites. The appetites or substantial forms are teleological principles, which lead the monad from one perception to another in a pre-established way. This aspect of teleological causation, however, does not preclude efficient causality. On the contrary, efficient causality and final causality are complementary. Each efficient cause happens in accordance with a general rule or final cause, which is preordained by God [1712] 1973, 174). Thus, final causation and efficient causation are not different types of causation, each of which would act in different situations. But in each act of causation there is an efficient and a final component.

Leibniz's doctrines of final causality and of the spontaneity of simple substances fully agree with his brand of determinism: each monad behaves in accordance with its original purpose, that is to say, with its nature or substantial form, which it received from the beginning through God's creation. Leibniz's determinism - which is based on his principle of sufficient reason - entails that the necessity involved in the relation between cause and effect is as strong as logical necessity. A complete knowledge of the causes would yield the premises from which by reasoning alone the effects could be concluded.

3.2. CRITICAL PHILOSOPHY FROM LOCKE TILL MILL

3.2.1. Locke: causation and power

After the metaphysical systems in which Descartes, Hobbes, Spinoza and Leibniz tried to give an insight into the structure of reality, John Locke (1632-1704) merely hoped to discover what kind of things God has fitted us to know, and how we should use our intellect and understanding. Living in the century that witnessed the birth of modern natural science, Locke wished to defend its empiricist ontology against the weight of the philosophical tradition, which was rationalist in temper.

Basic to Locke's approach to the concept of causation was the idea of power. He held the Aristotelian belief that causes are substantial powers put to work:

Power being the source from whence all Action proceeds, the Substances wherein these Powers are, when they exert this Power into Act, are called Causes; and the Substances which thereupon are produced […] are called Effects. (Locke [1690] 1975, II, xxii, 11)

Thus, a cause is a particular substance putting its power to work. Apparently, Locke conceived causes and effects as particulars. In his entire discussion of power there is no reference to either uniformity or necessary connection. 'Power' and 'necessary connection' are kept separate in Locke's thought, for although we do perceive powerful or changing objects and thus have the ideas of power and cause, we do not perceive any necessary connections between ideas ([1690] 1975, IV, iii, 1).[6] By linking causation to power, but not to necessity, Locke clearly upheld what is nowadays called a singularist approach to causation.[7] This view conflicts with the modern received view of causation (ever since Hume), according to which causation involves uniformity or necessary connection according to law.

In the next section I will show that Isaac Newton defended a view that, though similar qua basic insights, was even more radical than Locke's. Whereas it was Locke's view that the idea of causation does not involve the idea of necessary connection according to law, Newton took the far more radical step of separating causation from law-like behavior.

3.2.2. Newton: rejection of the principle of causality

In his masterpiece, Philosophiae Naturalis Principia Mathematica, Newton (1642-1727) set forth the mathematical laws of physics and "the system of the world." The world system consists of material bodies (masses composed of "solid, massy, hard, impenetrable, moveable particles") at rest or in motion and interacting according to his three famous laws of motion, which are stated in implicitly causal terms:

(1) Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon.

(2) The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed.[8]

(3) To every Action there is always opposed an equal Reaction; or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts. (Newton [1687] 1968, I: 19-20)

The meaning of his implicit reference to causation in expressions such as "motive forces impressed upon" a body, which "compel" the body to move differently than if they had been absent, and the relationship between the concept of cause, these compelling motive forces, and the laws of motion, can only be understood by studying the Scholium.

In his Scholium (on absolute space and time), Newton made a distinction between "true motion" and "relative motion." Whereas true motion refers to some absolute standard (for example: a sailing ship in relation to the immovable earth), relative motion is motion in respect of some relative standard (for example: a man walking on a sailing ship). It is in his attempt to explain the difference between true motion and relative motion that Newton showed what he meant by 'cause':

The causes by which true and relative motions are distinguished, one from the other, are the forces impressed upon bodies to generate motion. True motion is neither generated nor altered, but by some force impressed upon the body moved; but relative motion may be generated or altered without any force impressed upon the body. For it is sufficient only to impress some force on other bodes with which the former is compared, that by their giving way, that relation may be changed, in which the relative rest or motion of this body did consist. Again, true motion suffers always some change from any force impressed upon the moving body... (Newton [1687] 1968, I: 14; italics mine)

Thus, Newton meant by cause precisely the above mentioned (in the first two laws of motion) "motive force impressed upon" a body, which "compels" it to move differently. Put more precisely: causes are forces or constraints that compel moving bodies to behave differently than they would have done without them. Thus ‘caused’ means constrained or compelled. Newton used the expression "free" motion to refer to unconstrained motions. Thus, every body that continues in its state of rest, or of uniform behavior in a straight line, is uncaused or free.

Thus Collingwood rightly concluded that "in Newton there is no law of universal causation; he not only does not assert that every event must have a cause, he explicitly denies it." Any movement that happens according to the

first law of motion is an uncaused event. Thus if a body moves freely from A to B to C, the event which is the movement from A to B, is in no way the cause of the event which is the movement from B to C; it is not caused at all. The first law of motion is in fact a law of free or causeless motion (Collingwood [1938] 1991, 159; italics mine).

Thus, Newton may be said to radically reject the principle of universal causation, and to defend a fundamental distinction between causation and law-like behavior. For, there are two classes of events in Newton's universe: (a) those that happen according to a law, and (b) those that are the effects of causes. Causation and law-like behavior (or necessary connection according to law) are mutually exclusive notions.

In the next section, we shall see that Hume neglected (or misrepresented) both Locke's and Newton's basic insights. He simply assumed that the concept of cause involves the concept of necessity, which he identified with the concept of power.

3.2.3. David Hume: Causation and Regularity

Hume (1711-76) started from the observation that we think that our concept of causation involves the concept of necessity: events or states of objects follow their causes with some kind of necessity. More specifically, he held that the causal relation is characterized by three factors: (1) contiguity (in space and time) of cause and effect, (2) priority in time of cause to effect, and (3) a necessary connection between cause and effect. He considered the third factor to be by far the most important, because it is the criterion by which we seem to distinguish causal from non-causal relations (Hume [1739] 1978, 77).

The problem is that given the concept of causal necessity, there seems to be no way of rationally justifying it. To Hume such justification could be given only if causal necessity could be shown to be as stringent as logical necessity. But this is impossible. Hence, the necessity that we read into causal relationships is illusory; the illusion is born from our expectations, which are due to habit.

In accord with the empiricist principle that ideas are derived from impressions, Hume explained that in order to clarify and justify our idea of causation, we must find the impression that has given rise to it. The idea of necessity cannot be derived from our experience of individual cases of causation. For, in a single instance of causation, we can never discover any necessary connection or power. Instead, the idea of necessity arises from our experience of a great many similar instances. The constant conjunction produces an association of ideas - so if we see a flame, by sheer habit an idea of heat will come to mind. But the constant conjunction also produces a feeling of necessary connection in the mind. Thus, there are two roots of our idea of necessity: constant conjunction of the objects, and the feeling of necessary connection in the mind. The habitual transition from impression to idea feels like a necessitation, as if the mind were compelled to go from one to the other. The necessary connection is not discovered in the world but is projected onto the world by our minds ([1739] 1978, 266).

Most contemporary philosophers believe that Hume refuted the views of the rationalists before him (Descartes, Hobbes Spinoza, and Leibniz), who all held that there is an element of genuine a priori reasoning in causal inference. According to Hume, however, causal relations are not logically necessary, and hence they cannot be known a priori. To say that causation is not a logically necessary relation is to say that even if A caused B, it is not logically impossible to suppose that, given A, B might not have occurred. So far as reason and logic are concerned, given a particular event, anything may happen next. This is precisely the reason why causal relations cannot be known a priori; in order to determine whether or not a causal relation holds between A and B we must rely on our experience of similar relations. "There are no objects," wrote Hume, "which by the mere survey, without consulting experience, we can determine to be the causes of any other; and no objects, which we can certainly determine in the same manner not to be the causes" (Hume [1748] 1975, 75).

Today, Hume’s idea that regularity or constant conjunction is a necessary condition for causation is generally accepted.[9] If HIV is the cause of aids,

then HIV and aids are constantly conjoined. This view seems to agree with our common sense view. We expect similar causes to have similar effects. But Hume held that regularity is also a sufficient condition for causation. This view was easily shown to be false by Thomas Reid (1710-96): there are many examples of constant conjunctions, such as day following night, that are not causal relations (Reid [1846] 1967, 627).

3.2.4. Kant: causation as an a priori conception

Hume's discussion of causation played an important role in the development of Kant's critical philosophy. Kant (1724-1804), much impressed by the obvious success and constant advance of scientific knowledge, Newtonian physics in particular, could not accept Hume's conclusion that neither causation nor induction can be rationally justified, and that, consequently, we cannot rationally justify scientific knowledge. His basic epistemological strategy was to ground the principle of causality in the structure of reason. Given the epistemologically disastrous consequences of Hume's critique, Kant attempted to justify causality by declaring it an a priori conception.

In the Transcendental Analytic of the Critique of Pure Reason (1781/87), Kant first tried to establish that certain pure concepts or categories, including substance and causality, are universally valid with respect to possible experience, and then argued for a set of synthetic a priori principles involving each of his twelve categories. Among the most important of these are the principles (the "Analogies of Experience") that every change has a cause, and that all changes in the phenomenal world are alterations in the properties of enduring substances.

In a preliminary section to the Transcendental Analytic, Kant had raised the problem of the transcendental deduction of the concept of cause. According to him, the concept of cause "signifies a special kind of synthesis, whereby upon something, A, there is posited something quite different, B, according to a rule." However, Kant added, "it is not manifest a priori why appearances should contain anything of his kind [...]; and it is therefore a priori doubtful whether such a concept be not perhaps altogether empty, and have no object anywhere among appearances" (A 90/b 123). He concluded that there were only two possible solutions to this problem: either must the concept of cause be completely abandoned as a mere chimera, or it must be grounded completely a priori in the understanding:

If we thought to escape these toilsome enquiries by saying that experience continually presents examples of such regularity among experiences and so affords abundant opportunity of abstracting the concept of cause, and at the same time of verifying the objective validity of such a concept, we should be overlooking the fact that the concept of cause can never arise in this manner. It must either be grounded completely a priori in the understanding, or must be entirely given up as a mere phantom of the brain. For this concept makes strict demand that something, A, should be such that something else, B, follows from it necessarily and in accordance with an absolutely universal rule. Appearances do indeed present cases from which a rule can be obtained according to which something usually happens, but they never prove the sequence to be necessary. To the synthesis of cause and effect there belongs a dignity which cannot be empirically expressed, namely, that the effect not only succeeds upon the cause, but that it is posited through it and arises out of it. This strict universality of the rule is never a characteristic of empirical rules; they can acquire through induction only comparative universality, that is, extensive applicability. If we were to treat pure concepts of understanding

as merely empirical products, we should be making a complete change in [the manner of] their employment. (Kant [1781/87] 1963, A 91-2/B 123-4)

In this passage, Kant expresses a distinctly anti-Humean conception of the causal relation. First, Kant explicitly endorses the kind of necessity that Hume had rejected: effects do not just follow their causes as a matter of fact, but follow them necessarily. Moreover, contrary to Hume, the universality involved in the causal relation is not based upon induction, and is therefore not empirical; for, experience can never provide strict universality ([1787] 1963, B 3-4). Whereas "the concept of cause implies a rule according to which one state follows another necessarily" ([1783], 1950, 315), experience can only show us that one state of things commonly follows another, and therefore neither affords strict universality nor necessity.

Thus, an event A is the cause of an event B if, and only if, there is a universal law of the form: events of type A are necessarily followed by events of type B. And, because neither the necessity nor the strict universality involved in the causal relation can be established empirically, they must be grounded a priori. The judgment that A caused B must be grounded in the a priori conditions of objective judgment of possible experience.

In his ‘Second Analogy of Experience,’ Kant's concern is with the principle that "all alterations take place in conformity with the law of the connection of cause and effect" ([1787] 1963, B 232). Thus, the Second Analogy is the principle that every event has a (sufficient) cause. Whereas Hume had roused Kant from his 'dogmatic slumber' by contending that this principle can never be established by human reason, Kant, on the contrary, maintained that the principle of causality can be shown to be a necessary condition of experience. He explicitly rejected Hume's view that we first perceive temporal succession between events, and then regard one as cause and the other as effect. The opposite is true: in order to establish an objective order in time, we need cause-effect relationships.

This may seem to contradict all that has hitherto been taught in regard to the procedure of our understanding. The accepted view is that only through the perception and comparison of events repeatedly following in a uniform manner upon preceding appearances are we enabled to discover a rule according to which certain events follow always upon certain appearances, and that this is the way in which we are first led to construct for ourselves the concept of cause. Now the concept, if thus formed, would be merely empirical, and the rule which it supplies, that everything which happens has a cause, would be as contingent as the experience upon which it is based. Since the universality and necessity of the rule would not be grounded a priori, but only on induction, they would be merely fictitious and without genuinely universal validity. (Kant [1781/87] 1963, A196; B 241)

Thus, Kant claimed to have shown that concepts such as ‘cause’ (and ‘substance,’ and ‘community’), and the principles drawn from them (for example, that each event "presupposes something upon which it follows according to a rule") "stand a priori before all experience and have their undoubted objective rightness, though admittedly only in respect of experience" ([1783] 1950, 311). The principle of causality is an a priori conception, grounded in the structure of reason. It involves that (a) every

event has a cause; (b) the cause of every event is a prior event; (c) the effect follows from the cause necessarily, and (d) in accordance with an absolutely universal rule; (e) this is known to us not from experience but a priori.

In the next section we will see that, contrary to Kant's a priorism, John Stuart Mill (1806-73) defended a radical empiricism, thus following in the steps of Locke, Newton, and Hume.

3.2.5. John Stuart Mill: causes and causal circumstances

Mill (1806-73) defined cause as “the antecedent, or the concurrence of antecedents, on which [a given phenomenon] is invariably and unconditionally consequent” (Mill 1874, 245). Thus, whereas it was Hume's view that two changes A and B are respectively the cause and the effect of each other if A was immediately followed by B and if things similar to A are always immediately followed by things similar to B, Mill added the restriction that the two must be unconditionally conjoined. Mill hereby reintroduced the idea of necessity, which was not only repudiated by Hume, but also by Mill himself at the beginning of his essay about the “Law of Causation.” Here he spoke about the "supposed necessity" between physical facts, of which he said: "No such necessity exists for the purposes of the present inquiry, nor will any such doctrine be found in the following pages" (1874, 236).

It was Mill's view that what we usually call the cause of an object or an event is only a partial cause. In ordinary discourse we tend to call the cause the factor to which we wish to call attention, although it is not the only factor. We select one condition out of a whole set of conditions which are together sufficient, and call it the cause. What we call the cause is: (a) the last condition to be fulfilled before the effect takes place, or (b) the condition whose role in the affair is "superficially the most conspicuous" (1874, 238-39). Thus, we say that striking the match caused it to burn, because it was "the one condition which last came into existence" (proximate event). And we refer to the gene as the cause of the cancer, because it is the most conspicuous of all the conditions involved.

According to Mill, this common sense idea of 'cause' is misleading because there are many more conditions involved that are equally necessary for the effect to occur. Therefore, "philosophically speaking," we have no right to select one of them and give it the name of 'cause.' Accordingly, Mill defined the cause of an event as that set of conditions upon which the event (that is, an event of this type) invariably occurs:

The cause, then, philosophically speaking, is the sum total of all the conditions, positive and negative taken together, the whole of the contingencies of every description, which being realized, the consequent invariably follows. (Mill 1874, 241)

The "real cause" of an occurrence is that set of conditions which, when they are all met, is invariably followed by the type described as effect. However, the cause does only involve those conditions that are needed for the effect to occur; it does not involve "the addition of any superfluous circumstance" (1874, 245). Whereas the whole set of conditions is sufficient for the occurrence of the effect, each of the conditions alone is necessary, but no one of them alone is sufficient. Thus, the cause of combustion consists of three conditions: a) oxygen, b) inflammable material, and c) a temperature requirement. If all these conditions are met, combustion will occur.

However, Mill stressed that the cause (sufficient condition) is not just that set of conditions on the occurrence of which the effect invariably occurs. It occurs invariably and unconditionally. Given the whole constellation of causal circumstances, the effect will occur, whatever the other conditions may be:

If there be any meaning which confessedly belongs to the term necessity, it is unconditionalness. That which is necessary, that which must be, means that which will be, whatever supposition we may make in regard to all other things. The succession of day and night evidently is not necessary in this sense. It is conditional on the occurrence of other antecedents. That which will be followed by a given consequent when, and only when, some third circumstance also exists, is not the cause, even though no case should ever have occurred in which the phenomenon took place without it. (Mill 1874, 245)

This demand that the cause be unconditional was intended to eliminate non-causal regularities, like day following night. Day is not the cause of night, because the occurrence of night is not dependent upon the prior occurrence of day, but on all kinds of circumstances, such as the existence of the sun, the earth rotating on its axis, and the absence of obscuring material between sun and earth.

Thus, Mill tacitly reintroduced the idea of a necessary relation between causes and effects. For to say that A and B are "unconditionally" conjoined is to say that they are not only conjoined under all actual circumstances, but also under all imaginable or possible circumstances. By so doing, Mill had abandoned the basic point of empirical analysis, according to which causation must be analyzed in terms of what actually does happen, not in terms of what could possibly happen.[10]

4. CONCLUSION: IMPORTANT CHANGES IN THE MEANING OF CAUSE

In this concluding review of the results of this article, I will point out the conceptual tensions that are inherent to the historical development of the concept of cause. More specifically, I will show that two decisive milestones mark the history of causality: the Aristotelian (-scholastic) Conception (I), and the Scientific Conception (II). It will be shown that these two conceptions of cause are mutually incompatible.

(I) Aristotle conceived efficient causes as 'things responsible' in the sense that an efficient cause is a thing, which by its activity brings about an effect in another thing. Thus, the efficient cause was defined by reference to some substance performing a change: it is the "primary source of the change." That which is produced is either some new substance, such as ashes from wood, or simply a change in some property of a given substance. Furthermore, the general context of this meaning of efficient cause is teleological, for each efficient cause acts for the sake of an end. Hard work, for example, is the efficient cause of fitness, which is the end. Thus, according to the Aristotelian conception, causes are conceived as the active originators of a change that is brought about for the sake of some end.

(II) Probably the most radical change in the meaning of cause happened during the seventeenth century, in which there emerged a strong tendency to understand causal relations as instances of deterministic laws. Causes were no longer seen as the active initiators of a change, but as inactive nodes in a law-like implication chain.

This change of perspective had its antecedents in Stoicism and medieval philosophy. The Stoics were the first to associate causation with exceptionless regularity and necessity. But, contrary to the scientific conception of cause, the necessity involved in the causal relation pertained to particular events; it was thought to be necessary that the same particular effect would recur in the same particular circumstances, and that it was not possible that it would be otherwise. Aquinas went further than the Stoics by relating efficient causality to natural necessity and to law-like behavior; things belonging to the same type act similarly in similar causal circumstances. The dismissal of explanations by final and formal causation by Descartes, Francis Bacon and Galilei brought about the rejection of the Aristotelian-scholastic doctrine of active qualities and substantial forms as causal factors in natural processes. The Aristotelian idea that a substantial form be transmitted from a cause to its effect had no basis whatever in our experience of things.

However, paradoxical as it may seem, it was precisely this concept of formal cause that came to play an important role in the development of the new conception of efficient cause, according to which efficient causes were simply instances of general laws, which in turn were general, mathematical principles. But, to a large extent, the concept of law of nature was the inheritor of the concept of formal cause: both concepts were meant to explain the stability of the world. The main difference is that, whereas the formal cause was thought to explain the stability of the world by explaining the structure of things, the laws of nature were thought to explain the stability of the world by explaining the relations between things.

An important characteristic of the modern conception of cause was that causation and determinism became virtually equivalent. The crux of the debate between the rationalists and the empiricists pertained to the nature of this determination.

(IIa) In the rationalist conception of cause, the relationship between cause and effect is a logical relation. Necessitation involves implication. Thus, a complete knowledge of the causes is tantamount to knowing the premises from which by reasoning alone the effects can be deduced. Though Descartes, Hobbes, Spinoza, and Leibniz roughly shared this view, they could not avoid some basic ambiguities.

Thus, Descartes, while regarding the laws of nature themselves (instead of their instances) as efficient causes, also held the view that the relation of a cause to its effect is the relation of ground to consequent: a logical relation. On the other hand, he regarded minds as free and as particular causes, in the sense of active initiators of a change. [11]

Hobbes's position was equally ambiguous. For, while he defended IIa (given the cause, "it cannot be conceived but that the effect will follow"), he regarded the concepts of cause and power as complementary notions (Hobbes 1655, 9.3), an idea that is characteristic of the Aristotelian conception of cause (I).

Similarly, Spinoza, perhaps the most straightforward defender of the view that necessitation involves implication, held that God is a free cause in the sense of being a real initiator of change, but that the necessary causes are necessitated by other causes and are therefore just inactive nodes in a chain, each of them logically necessitating its effects and logically necessitated by its effects.

Even Leibniz, who held the most original view of causation by rejecting the idea that the ultimate constituents of reality (the monads) have a causal relation to each other, and thus limiting causation to the links of the historical-logical chain constituting each individual substance, could not avoid one major ambiguity. For, whereas, in his view, the necessity involved in the causal relation is as strong as logical necessity (IIa), the innermost significance of causality is that of the active initiation of change (I). For, every monad is "spontaneous," that is to say, its substantial form is the only source of its modifications. Monads are real "centers of activity." Remarkably, Leibniz' originality resulted partly from his 'reactionary' defense of both formal and final causation. Each monad behaves in accordance with its nature or substantial form, which is its original purpose, given by God. Efficient causes are therefore means to ends (I).

Thus, it may be argued that the rationalist philosophers all held some hybrid conception of cause, involving a combination of cause IIa (the identification of causes with grounds) and cause I (the originators of a change).

(IIb) To David Hume, commonly held to be the main representative of the empiricist approach to causation, our idea of causal necessity is due partly to our observation of the constant conjunction of certain objects, and partly to the feeling of their necessary connection in the mind. The habitual impression of conjunction feels like a necessitation, as if the mind were compelled to go

from one to the other. The necessary connection is not discovered in the world but is projected onto the world by our minds.

However, Hume's view was far from being shared by all empiricist philosophers. Indeed, by suggesting that his fellow empiricists held the belief that necessity is synonymous with power, he seriously misrepresented their views. For, both Locke and Newton explicitly denied that the ideas of causation or power involved the idea of necessary connection according to law. According to Newton, these two notions are even mutually exclusive because complete uniformity or necessary connection would entail a denial of causal efficacy. For Locke, as for Newton, causality is related to the Aristotelian belief that causes are substantial powers that are put to work. Therefore, Hume's famous criticism only concerns the rationalist scientific conception of cause (IIa), which, from an historical perspective, is merely a derivative sense of 'cause.'

Kant's concept of cause, by which he tried reconcile the rationalist and empiricist views, is a hybrid of IIa and IIb. Because causal relations involve laws (II), Kant in effect says that an event A is the cause of an event B if, and only if, there is a universal law of the form: events of type A are necessarily followed by events of type B. But, while defending the rationalist idea that causality is an a priori conception, which involves strict universality and necessity (IIa), he also holds the empiricist view that causes precede their effects, which from the perspective of IIa (according to which, causes are contemporaneous with their effects) is utterly impossible.

Mill too conceived causal relations in terms of law-like generalizations (II). His analysis is about kinds of causes and kinds of effects. The "real cause" of an event is that set of conditions which, when they are all met, is invariably and unconditionally followed by the type described as the effect.

All in all, the complex evolution of the concept of cause from the seventeenth century on is marked by the interplay between, at least, two radically different conceptions of cause: the Aristotelian-scholastic conception, according to which causes are the active initiators of a change, and the scientific conception, according to which causes are the inactive nodes in a law-like implication chain.

Our common use of causal terms is entirely oblivious of this ambiguity. But, more deplorably, most discussions by modern philosophers have failed to see this basic duality, because the premises of those discussions are usually infected by it. For instance, the common assumption that causation is inherently linked to law-like behavior is far from obvious.

In short, my analysis of the historical development of the concept of cause shows that each analysis of causation must start from the recognition that causal propositions are ambiguous, and that (at least) two mutually exclusive meanings are to be distinguished. According to I, 'A is the cause of B' means 'A is the initiator of a change in B'; according to II, 'A is the cause of B' means 'Given the occurrence of B, A must necessarily have occurred.'

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NOTES

1. This is an abridged version of the first chapter of my From Cause to Causation. A Peircean Perspective. Dordrecht, Kluwer Publishers, 2002.

[2]. See for example, Physics II.9; Analytica Posterior II.11, 95a3-5. For a thorough discussion, see Sorabji, 1980, 51-56.

[3]. See Dunphy, 1966, and Lauer, 1974.

[4]. Other important characteristics of the efficient cause are, according to Aquinas: (a) secondary efficient causes either precede their effects or are simultaneous with them (SCG II 38.9); (b) the secondary causes are modeled after the primary cause inasmuch as "the agent is distinct from the patient and superior to it" (SCG II 45.4); (c) there is a proportional correspondence of effects to their causes: "we attribute actual effects to actual causes, potential effects to potential causes, and, similarly, particular effects to particular causes and universal effects to universal causes, as Aristotle teaches in Physics II" (SCG II 21.4).

[5]. It must be noted that, according to Descartes, human beings are in some sense the efficient causes of their actions. Descartes tried to reconcile his idea that "it is certain that all things are pre-ordained by God" (Princ. I: 40) with the "self-evident" idea of freedom of the will (Princ. I: 39). Descartes' solution was that the mind could not change the quantity of motion but that it could change the direction of motion.

[6]. Also Locke ([1690] 1975, IV, iii, 12, 14, 16. Cf Taube 1936, 20; Wallace 1974, 29.

7. According to the singularist view, the correct definition of causality must be framed in terms of one single case of causal sequence. Thus, laws are not relevant to causation qua causation. Important representatives are C.J. Ducasse and G.E.M. Anscombe.

[8]. Here, the impressed force equals mass times the rate of change of velocity, i.e. acceleration. Hence the formula, F = ma.

9. A notable exception is the singularist approach to causation. See note 7.

[10]. Eventually, despite his alleged empiricism, Mill appears to be some kind of a Laplacean determinist, according to whom the whole future course of nature is completely determined by antecedent causes: "The state of the whole universe at any instant we believe to be the consequence of its state at the previous moment; insomuch that one who knew all the agents which exist at the present moment, their collocation in space, and all their properties, in other words, the laws of their agency, could predict the whole subsequent history of the universe ..." (Mill 1874, 250). It is obvious that such a conclusion about the future course of the universe cannot be based on empirical data alone.

[11]. See note 5.

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