CAUSALITY IN PHILOSOPHY OF SCIENCE: FROM HUME TO TODAY

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ABSTRACT

This study investigates one of the basic concepts of science: Causality. It presents an historical perspective of the concept from Hume to today. Our exploration of the terms cause, effect and causality begins with Hume and with contributions of Kant. As a second part, the place of causality in the philosophy of science is examined. The discussion of the concept together with the concepts of determinism, probability, functional relation and uncertainty principle have been taken into account from the standpoint of modern science.

1. Introduction

A single object or fact on its own isn't regarded as something important by science. What science is concerned with is the relationship between multiple objects or facts. Not all the relationships between facts are of the same kind. These relationships may be observational, theoretical, invariable, universal or statistical. The present study investigates one of the relationships with which science is concerned, namely causality. One of the major aims of science is to predict future events by examining our knowledge of past events. What makes such predictions possible is to understand causal relations between observed regular events. Science considers that some facts give rise to others since all process and change are dependent on some cause. "Each fact is connected to some other single or multiple facts for which they are responsible." (Yıldırım, 1979, p.119)

In this paper the discussion begins with the definition of the concept of causality together with the concepts of cause and effect. The discussion leads to the analysis of the contributions of Hume and Kant to causality. The research will end with the exploration of the place of causality in the philosophy of science and recent approaches towards this concept. This last section will include the discussion of Whewell's idea of cause, Mill's Principle of Universal Causation, Reichenbach's causality, induction and probability in his work *The Rise of Scientific Philosophy,* Laplace's causal determinism in his work Theorie Analiytique des Probabilities, Suppes's causality and probability in his work Probabilistic Theory of Causation and Heisenberg's indeterminism.

2. What is causality?

Objects and facts are related to one another by causality. A process of change that takes place in the universe in some time shows a physical necessity. In the process of change a quality disappears and another quality comes into existence. The source of these is causes. There is a cause for every quality that is produced at the end of every event or change. But to confess that there is any one cause behind every event doesn't help us to explain the universe correctly. Many events have certain types of causes that are in correlation with them. (Denkel, 1994) According to Krikorian causality is formed in non-anthropomorphic, uniform and determinist correlations among groups of physical entities in space-time continuum. (1934) When this definition is analyzed we come up with three characteristics of causal relation. The first characteristic of causal relation is being non-anthropomorphic. Causal relation is the name given to the order of a certain type of events, "not a name for an activity of an agency behind events." (ibid. p. 319) When referring to causal correlations, desire, wish and purpose are not mentioned.

Another characteristic of causal relations is uniformity. Causal relations are explanations of uniformity or unchanging peculiarities between facts. Uniformities of causal relations are not about the universe as a whole, but are about special processes under certain limited conditions. There is no causal relation between an infinite whole and its parts. A causal relation can only exist between one part and another part of a whole. The third characteristic is determinism. Causal relations are deterministic in that cause and effect involve connected relation. In causality, there is the determination of a result by the existence of another factor. There are two additional points in Krikorian's definition which are about causal entities. Causal entities are not purely logical, they have a spatio-temporal habitat. Causal entities can be measured due to the fact that they are physical quantities.

There are two traditional views of causality: empiricist view and rationalist view. According to the empiricists in a judgment like "X is the cause of Y", "an observed factual relation between X and Y" is depicted. What is pointed here is: "Y always follows X" or "X and Y always goes together". Empiricists believe that causality can not be used in any other further meaning. According to the rationalists, while on one hand one aspect of causal relations is observation, on the other hand another aspect of causality is necessary connection. Rationalists claim that in causality, there is one relation that has metaphysical quality and that is beyond observation. What is indicated here is "X and Y necessarily goes together" Empiricists reject the necessary relation for it is metaphysical and can neither be proved nor disproved. For Hume and his empiricist followers, causal relation can be explained with "always going together" and there is no use of chasing a concept like necessary relation which is impossible to observe.

3. Hume and Causality

Hume claims that the order of the universe arises from "similar causes result with similar effects all around the universe." (Denkel, 1994, p.63) In Hume's *A Treatise on Human Nature* the concept of causality and cause-effect relation have been discussed in the section "Knowledge and Probability". In this section it is not the mathematical probability Hume is interested in. What Hume is concerned with is the doubtful knowledge presented by the empirical data gathered from non-demonstrative results. This includes our knowledge of future and knowledge of unobserved parts of present and past. In fact this involves everything else except direct observation, logic and mathematics. The analysis of this type of skeptical knowledge leads Hume to certain skeptical conclusions.

Hume starts with the distinction of seven types of philosophical relations: Resemblance, identity, relations of time and place, proportion in quantity or number, degrees in any quality, contrariety and causation. (Book I, Part III, Section 1) Hume divides these seven relations into two classes: Those that depend on the ideas and those that may be changed without any change in the ideas. The relations in the first class are resemblance, contrariety, degrees in quality and proportions in quantity or number. Relations of time and place, identity and causation are in the second class. The relations in the first class give certain knowledge while our knowledge of others are doubtful. Knowledge of algebra and mathematics are kinds of knowledge the certainty of which we will never doubt despite a long chain of reasoning. Among Hume's seven relationships identity, relations of time and place and causation are the ones that do not depend solely on ideas. In the first two of these relations human mind can not go further than what exists in senses. It is only causation that enables us to infer certain events and things from other events and things. " 'Tis only causation which produces such a connexion, as to give us assurance from the existence or action; nor can the other two relations be ever made use of in reasoning, except so far as they either affect or are affected by it." (Book I, Part III, Section II)

The problem that arises from Hume's argument is that there is nothing as impression of a causal relation. We can perceive that A is not B or that A is on/under/ on the left of B only by observation. However, we can not perceive that A is the cause of B solely by observation. In the past causal relation has been related to its basis in logic which was a mistake according to Hume. Both in Cartesian and Scholastic philosophy cause effect relation was considered as a necessity as in logical relations. The first real challenge to this view came from Hume and thus modern philosophy of causation started with Hume. Hume's subject is the subject of pure knowledge. The change in the theory of causation is to replace ontological problem with the problem of knowledge. If world is to be considered as a theological language, how humans can understand this language can not be questioned. Hume starts with the claim that the power of one subject to produce the other can not be discovered from the object's ideas and observes that cause effect relation can not be can not be known by reasoning or reflection but only by experience. "...whatever begins to exist, must have a cause of existence." (Book I, Part III, Section III) Hume asserts that this argument doesn't have an intuitive certainty as the propositions in logic. "There is no object, which implies the existence of any other if we consider these objects in themselves and never look beyond the ideas which we form of them." (Book I, Part III, Section VI)

Hume supports that what gives the knowledge of cause and effect is experience but it is not the experience of individual events A and B having a causal relation. The experience meant here is the experience of constant conjunctions connecting A type of events to B type of events. In the case of two objects' continuously connecting, we, in fact, infer one event from the other. That is perception one event produces an expectation of another. "Perhaps 'twill appear in the end, that the necessary connexion depends on the inference, instead of the inference's depending on the necessary connexion." (Book I, Part III, Section VI). The rise of A causes the expectation of B and encourages us to believe that there is a necessary connection between A and B. When making causal judgments human understanding goes beyond sense experiences because these judgments are about facts outside our experiences.

As soon as human understanding observes an event, it moves to the idea of another thing that precedes or follows it because it presumes events in a cause-effect relation. Hume questions what motive leads human understanding to this and concludes that there are two characteristics experienced in the events having cause-effect relation. Denkel asserts that these two characteristics are the contiguity of cause and effect in space and the succession of cause and effect in time. Hume also mentions that there is a necessary connection between cause and effect. When people experience the cause event, they expect the effect to necessarily appear. But this necessity is not a rational one.

Inference is not determined rationally because in such a case we should assume that there is uniformity in nature. The idea that there is a reason for every fact arises neither from intuition nor from proof. Hume questions the source of this idea and states that it exists in a subjective tendency. Alquie (1990) claims that repetition encourages us to move from one term to the other, expect one when the other is given. This will bring about habit. But habit does not exist in objects, instead it is a principle of human nature. In other words mind is determined by habit. It is important to give an example to present Hume's skeptical position. When I see an apple, I expect to get a certain taste if I eat it. But Hume claims that there is no justification for me to get such a taste. The principle of habit can explain such an expectation but can not justify it. Hume has an objection to reduce causal relation to a constant relation and maintains that such an experience can not justify the expectation of similar future events. For instance, when I see an apple, my past experiences causes the expectation that it won't taste like a beef. But no rational justification can be found for this expectation.

4. Kant and Causality

It was Hume's criticism of the concept of causality that awakened Kant from his "dogmatic slumbers". The main aim of Kant's most important work, *Critique of Pure Reason*, is to prove that all our knowledge, despite the fact that it doesn't surpass experience, is in a sense apriori and can not be induced from experience. Our apriori knowledge is not only logical but is more than which could exist in logic or be inferred from logic. Kant makes two distinctions: Analytic or synthetic propositions and apriori or empirical propositions. Analytic propositions are the ones in which the predicate is a part of the subject. Such propositions follow the law of contradiction. A proposition like "A beautiful woman is a woman" is analytic and to assert that a beautiful woman is not a woman is self contradictory. Synthetic propositions are the ones that are not analytic. All the propositions that are known only through experience are synthetic. We can not discover the truths like "January was a cold month" only by an analysis of concepts. But Kant didn't accept that all propositions that are known solely through experience. This guided Kant to make a second distinction.

The second distinction is that of apriori and empirical propositions. An empirical proposition can be known by the help of the sense experience of ourselves or of someone else whose testimony we accept. Facts concerning history and geography are of this kind. On the other hand apriori proposition is the one that has a basis other than experience though can be inferred from experience as well. A child learning algebra can learn though experience that two marbles when added two other marbles make four. But when general proposition is grasped there won't be any need to experience the proposition "2+2=4". (Russell, 1946) Hume proved that the law of causation is not analytic. Kant admitted the idea that it is synthetic but still supported the idea that it is known apriori. Kant understood Hume's message: The connection that we make between objects is not given by the objects themselves, but is established by the subject and is therefore an act of the subject. But Kant based what Hume had considered as a natural instinct on the necessity of science and explained it with the constancy of laws of physics. Kant accepted the judgment that each fact has a cause as the apriori supposition of all sciences.

5. Causation in the Philosophy of Science

5.1 Whewell and the Idea of Causation

Whewell claims that there are two opposing elements in all knowledge: Ideas and perceptions. Whewell wanted to find a middle way between pure rationalism and strict empiricism. According to Whewell to obtain knowledge can be possible by paying attention to both ideas and senses. The ideas which Whewell calls basic ideas are obtained by the mind itself and can be provided by our observations of the world. Ideas are not the result of experience but are the result of the specific structure and activity of mind. In sum, Whewell asserts that mind is an active participant in our efforts to understand the world, but is not a passive receiver of sense data. Ideas of space, time, cause and resemblance constitute a structure for sense experience. For instance the idea of space makes us to perceive the shape, gravity, and state of the objects. In every science, there is a basic idea needed to arrange the facts in that specific science. For example the idea of cause is a basic idea in the science of mechanics. Whewell adds that each basic idea includes certain concepts and there are special modifications of these concepts which are used under certain circumstances. The concept of power can be given as an example.

The concept of power is a modification of the idea of cause and is used for certain circumstances of movement. (Snyder, 2008) We experience succession of causes and events which are connected to each other. We learn the laws of this connection through experience to the limit that they present themselves to us. But while doing this, we depend on succession of appearances that we are aware by our senses and thus support the idea of cause in our minds. This idea is not a result of experience. Its source exists somewhere in mind and is presented to our experience by the active part of human nature. What is meant by cause is a quality, power and influence with which the states of things produce other states that follow. Thus the movements of bodies come true by the help of idea of cause which we call power. In cases when bodies fall down this power is called gravity. In these situations the concepts of power and gravity take their meanings from the idea of cause which they include. As seen here the idea of cause doesn't arise from experience. We can make necessary and universal claims including this idea, however, knowledge that is a result of experience is true as far as experience presents it and can never have evidence in itself that shows its necessity.

The idea of cause included by and based on this doctrine couldn't have come to our minds from the field of experience. No sense or skill regarding external observation can find the power or quality that we call cause. Cause is what connects one event to the other, but no sense or perception can state this relation that we observe between events. We see that one event follows the other but we see nothing showing us that one event should follow the other. One ball strikes the other and makes the other move. But with what compulsion this takes place is one question and where the necessity is another that should be answered. If we mention that mind can see the thing that makes this state inevitable we must clearly reveal what that thing is. But in reality there is no such reality that can be discovered. It sounds absurd to claim that the ball may not move and such a statement will strictly be objected by emphasizing that it is against the laws of movement. But the laws of movement are results of experience and thus their necessity can not be proven. Yet there is no necessity showing that the laws of movement are just like how we know them. (Whewell, 1840)

5.2 Mill and Universal Law of Causation

Mill claims that explanation of an individual fact is given by drawing attention to its cause. Explanation of a law of nature is possible by mentioning the other law or laws that provide the rise of that law. Here Mill might be considered as having a deductionist view but Mill's deduction is distinctive. According to Mill in each syllogism that is accepted as an argument to prove the conclusion there is a petition principii. Mill regards a deductive inference as being circular in a sense and in fact is founded on a non deductive inference. Law of nature and causal laws are reliable for empiricists. Mill explains a law of nature as a generalization showing invariable realization of a fact under certain circumstances and the opposite in the absence of those circumstances. Such uniformities are of either simultaneous or successive facts and laws of causation are of the second type. The law of causation shows that the invariability of succession comes from our observation between a fact in nature and another fact preceding it. An individual law of causation is a special and invariable succession of two types of facts.

According to Mill's theory explanations need laws. Laws are uniformities and uniformities are patterns of events. Besides Mill adds that a law is explained by other laws that are inferred from it. Mill's causation is deterministic. For Mill everything that happens has a cause and every cause is deterministic. When a cause occurs, a certain type of effect invariably follows it. Mill thinks that explanation is a deductive argument which is a statement of a fact whose conclusion is explained. Mill also puts forward that there is a law about laws. This law declares that for every type of event there are laws to be discovered explaining that type of event. According to this law every event has another event that is regularly connected to it by a law. As science develops we generalize this law which is for all laws including all kinds of events. This is the Universal Law of Causation. This law guarantees that if we search for it carefully, there is a law that can be discovered for all types of events in the world.

5.3 Causation and Probability for Reichenbach

One of the logical empiricists of our age, Hans Reichenbach, being affected by Kantian apriorism and Einstein's emphasis on relativity in space and time directed his works to scientific philosophy and empiricist epistemology. Criticism and justification of scientific method became the basis of his philosophical works. In his work, *The Rise of Scientific Philosophy*, Reichenbach makes important points about the concept of causation. When the proposition that "electric current turns the magnetic indicator" is analyzed, we arrive at the conclusion that electric current always occurs together with magnetic indicator. The word "always" is important due to the fact that it differentiates causal relation from an accidental relation. What distinguishes causal relation from an accidental relation is repetition. The repetition in causal relation is without any exception. But does every repetition without exception display a causal relation?

For instance can we assert that there is a causal relation between day and night because of the fact that one follows the other repeatedly without exception? Modern empiricists have found an answer to solve this problem. "Every relation that can not be considered as a special state of a higher level relation should be accepted as a causal relation." (Yıldırım, 1979, p.122) We don't accept the relation between day and night as a causal one because it is a special state of a higher level relation between the earth rotating around itself and the sun, the source of light. Reichenbach discusses whether causality is a basic and universal principle or not and whether it's valid only in macroscopic level and not applicable to subatomic level. The answer was given by the analysis of phenomena of subatomic level in Planck's quantum mechanics. According to quantum mechanics individual atomic phenomena can not be explained by causality. Thus necessarily the laws of probability replaced the laws of causation. The laws of probability are generalizations with exceptions.

In his doctoral thesis The Concept of Probability in the Mathematical Representation of Reality, Reichenbach had foreseen 21st century's discussions of probability between micro and macro systems. Reichenbach puts forward an argument adding principle of transcendental probability to Kant's principle of transcendental causation. As Reichenbach interpreted Kant, principle of transcendental causation claims that every event has a cause that determines it on account of a universal law. This principle is transcendental because it can not be proven empirically, but is a prerequisite for the probability of empirical knowledge. Reichenbach's assertion is the existence of an equal principle of probability. This principle can not be proven empirically but exists as a prerequisite of empirical knowledge. (Glymour and Eberhardt, 2008)

According to Reichenbach, propositions of probability are synthetic propositions that are about empirical world and that can not be proven to be true. Reichenbach explains that his mission is to show that a proposition of probability together with sufficient causal principles is a necessary transcendental principle for empirical knowledge.

Reichenbach expands his analysis to the error probabilities in the measurements in physics. For all measurements in physics may be subject to errors, knowledge of the laws of nature is only possible if errors occur on a probability distribution and this is a synthetic proposition which can not be proven empirically. Thus empirical knowledge requires the union of an apriori probability principle of individual events with general laws.

5.4 Causal Determinism

Causal determinism is the idea emphasizing that due to the laws of nature each event requires other events or situations preceding it. In the 18th century this view has been subjected to explanatory and mathematical analysis. On one hand, determinism is connected to the explanatory demand of physical sciences and on the other, our ideas about free acts of human beings. The roots of determinism can be found in the idea that everything can be explained due to a principle or everything that exists has a sufficient reason to exist and to be as it is. In other words the basis of determinism is in Leibniz's Principle of Sufficient Reason. But after the theories of physics had been put forward, the concept grew away from this basis. In order determinism to be true, laws of nature are required. (Hoefer, 2008) In his work, *Theorie Analytique des Probabilities*, Laplace supports determinism by mentioning that by looking at the past of universe its future can be predicted. The inadequacy of Newton mechanics in explaining phenomena in both macro and micro levels has weakened the trust in classic physics. At this point two important systems of thought have appeared: Theory of Relativity and Quantum Theory.

5.5 Functional Relation

In modern science we encounter efforts to find causal relations rather than approaches to the concept of causality. Some scientists suggest the use of a new term, functional relation, instead of causal relation. Functional relation can be considered as a mathematical statement of the concept of "always going together".

It is not right to tell that functional relation corresponds with causal relation. In causal relation besides always going together there are two additional characteristics. The first characteristic is the dimension of time. Effect follows the cause in time or they occur simultaneously. The second characteristic is that it is not possible to turn the relation back. The relation in which X is the cause and Y is the effect is not the same as the relation in which Y is the cause and X is the effect. (Yıldırım, 1979)

5.6 Causality and Probability

The development in physics led the scientists to different views relating to causal relation. The idea of strictly determinist causal relations were quitted and replaced by relations which are determined by possibility in a degree. (Moyal, 1949) The fact that causes are not invariably followed by their effects has been a great difficulty. For instance, that smoking is a cause of lung cancer is a common belief.

However, it has been seen that not all smokers suffer from lung cancer. The main idea behind the probability theories of causality is that causes increase the probability of effects. An effect may occur without a cause or the effect may not occur in the presence of a cause. Therefore smoking is a cause of lung cancer because smokers are more apt to lung cancer than non-smokers.

Suppes mentions that in modern physics and social sciences causality can not be considered as deterministic. On the other hand, he emphasizes that in Newton mechanics as in classical physics the concept of causality can be replaced by functional relation because deterministic relations can be stated as a mathematical equation. The relations in modern physics and social sciences are neither deterministic nor certain and complete. Modern science applies theory of probability instead of causality for it suits better to the quality of relations in those sciences. Suppes explains the concept of causality in his work, A Probabilistic Theory of Causality which was published in 1970. According to him, if the occurrence of a fact like Y follows the occurrence of a fact like X with a high probability and if there is no third fact responsible for the probabilistic relation between X and Y, then X is called the cause of Y.

5.7. The Principle of Uncertainty against Determinism

Quantum mechanics is accepted as a basic and universal theory of physics that is candidate for description of physical world. The conceptual frame drawn by this theory is quite dissimilar to that of classical physics. In fact moving from classical physics to quantum mechanics is a revolution for our understanding and comprehending of the world. The main difference between these two is that classical mechanics anticipates that exact simultaneous values can be applied to all physical quantities. (Hilgevoord and Uffink, 2008)

> In the classical theories of physics, statistical considerations are introduced in order to deal with large aggregates of elementary particles, but it is not thought that there are any essential theoretical limitations to the fineness of possible observations on the individual elementary particles. In quantum theory on the other hand, we have at the basis Heisenberg's principle of uncertainty, which by a close analysis of methods of observation shows that there are essential theoretical lower limits to the accuracy with which we can measure the dynamical variables (e.g. position and momentum) connected with the individual elementary particles. More precisely, the uncertainty principle formulates the disturbance of states by observations, by affirming that (a) it is impossible to measure simultaneously "complementary" or "non-commuting" variables, such as the position *q* and momentum *p* of a particle, and (b) that the more precisely we measure q, the less precisely can we predict *p*. (Moyal, 1949, p.315)

The classical causality in macro level had been meaningless in micro level. For instance the moving of electrons form one trajectory to the other couldn't be predetermined and accounted for. How only a certain percentage of particles of great number will act could be mentioned. This is not about the classical determinism in causality but shows a relation of probability. (Yıldırım, 1979) In 1927, Heisenberg put forward the principle of uncertainty which devastated deteminism. "The uncertainty principle (for position and momentum) states that one canot assign exact simultaneous values to the position and momentum of a physical system." He mentions that in order to predict the place of a particle in the future, its starting conditions should be known and this isn't possible in micro level. The more precisely the position of the particle is determined, the less precisely its momentum is determined. (Hilgevoord and Uffink, 2008)

The difficulty mentioned here is that measurement and can not disprove the classical principle of causality. Classical determinism relates the designation of an object at a moment to its faultless measurement of its starting conditions. In cases when we cannot determine its starting conditions, the inadequacy of our measurement method or tools of measurement will be in question. But it is wrong to explain the uncertainty principle with an impossibility of measurement because this principle is relevant to the interaction between the process of measurement and the object measured. (Yıldırım, 1979)

6. Conclusion

It has been frequently epmhasized in this study that one of the basic aims of science is to predict future events by lookiing at the past ones. We have also mentioned that such predictions are tried to be made by setting out from the observed regularities and appealing to causal relations. These relations are later named as laws of nature and by means of these laws the predictions have been possible. This study was carried out beacuse causal relation is an important concept in the basic structure of science. The study has discussed the concept of causation from a historical perspective. Starting with Hume and Kant's contributions, the relationship between cause and effect has been presented. The research has continued with the concept of causation in modern science. Related to the the causality, the concepts of determinism, probability, functional relation and uncertainty principle have also been taken into account.

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