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About Popper-Carnap controversy

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Resumen: El artículo muestra un nuevo camino sobre la controversia entre Popper y Carnap acerca de la interpretación probabilística y su uso en la solución al problema de la inducción. En su trabajo tardío acerca de la lógica probabilística e inductiva, Carnap se acercó a la posición bayesiana marcando un importante cambio respecto de su trabajo anterior. Si nos adentramos en los orígenes de estos cambios en el sistema de Carnap, la controversia entre los dos filósofos llega a un sin sentido y no hay ni siquiera puntos en común entre sus intereses.

Abstract: *The paper gives a new light on the controversy between Popper and Carnap on the interpretation of probability and its use to solve the problem of induction. In his later work on probability and inductive logic, Carnap came nearer to the bayesian positions stressing an important shift from his earlier work. If we take into account these changes in Carnap's system, the controversy between the two philosophers becomes meaningless and there is not even any overlapping between their interests.*

PALABRAS CLAVE: CONTROVERSIA, INDUCCIÓN, LÓGICA INDUCTIVA, LÓGICA PROBABILÍSTICA, TEORÍAS COMPROBABLES

1. INTRODUCTION

The controversy between Karl R. Popper and Rudolf Carnap began around 1940, when the latter tried to give an adequate account of induction by the

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construction of a quantitative theory of confirmation based on a concept of inductive probability.[1] The name of this theory, «inductive logic», was chosen because Carnap identified inductive probability with partial implication. Shortly after, Popper, among many other philosophers, discussed Carnap's theory, introducing severe criticisms on it. Since then, Carnap revisited his theory many times and proposed different modified versions of his initial system.

In his later work on probability and inductive logic,[2] Carnap intended to go beyond the criticisms of Popper and the other philosophers. Then he operated some fundamental changes. Accordingly, the aim and the task of inductive logic were clearly changed from Carnap's initial system. On the light of these modifications, a reinterpretation of Carnap's program becomes necessary. The aim of this paper is precisely to discuss and propose an answer to the question of whether it is reasonable to view Popper's viewpoint as Carnap's opponent.

The concept of probability is in the center of the discussion between Carnap and Popper. In section 2, we will introduce the different interpretations of probability proposed by the two philosophers. On the other hand, section 3 is devoted to the Popper's position on the problem of induction to confront Carnap's program, which will be explained in section 4. We will conclude the paper by presenting some recent developments of Carnap's program of inductive logic, in order to give a new light on the Popper-Carnap controversy.

2. THE INTERPRETATION OF PROBABILITY

Carnap, like many other philosophers, was aware of the fact that the process of tackling philosophical problems has to start with the clarification (or analysis) of

[1] In 1940, Carnap embarked on the vast program of developing an inductive logic based on the concept of probability. Carnap acknowledged the influence of John M. Keynes and also Reichenbach, Waismann and Wittgenstein (*see* Carnap's autobiography in Schilpp). Carnap's work on probability and inductive logic culminated with his extensive *The Logical Foundations of Probability* (1950).

[2] Especially Carnap's posthumous work (1971, 1980). In the International *Congress: Logic, Methodology and Philosophy of Science*, organized by Ernest Nagel, Patrick Suppes and Alfred Tarski at Stanford University in 1960 (published in 1962), Carnap introduced a new system based on the notion of rational degree of belief stressing an important shift (e.g., *see* Vickers, 1988). Carnap worked on this new system until his death in September 1970.

the involved concepts. Carnap explicitly recognized that clarification is an indispensable step in solving problems. For this purpose, he introduced the concept of *explication*.

In Carnap's terminology an explication has two elements. It starts with the *explicandum*, which is the pre-scientific, vague, and perhaps ambiguous concept to be explicated. Ultimately, the *explicandum* is replaced by the *explicatum*, which is a systematic or scientific concept. The *explicatum* must be as precise as possible and as simple as possible. In addition, it must be useful in the sense that it gives rise to the formulation of theories and the solution of problems (Carnap, 1950, §3).

2.1. Carnap's interpretation

One of the best applications of the procedure of explication is the concept of *probability*. In Carnap's belief, there are fundamentally two different concepts of probability (or two different explicanda).[3] One is epistemic and the other is objective (statistical); the first concept is related to our knowledge of the world, the other to the world independently of our knowledge. Carnap distinguished between them by calling the first *logical probability* and the second *statistical probability*. He remarked that it is just an unfortunate mistake that the word *probability* is used in such widely different senses. According to Carnap, the source of the enormous confusion about the probability is due to the fact that philosophers and scientists do not clearly make the distinction between the two concepts of probability. Instead of *logical probability*, Carnap sometimes used the term *inductive probability* because in his conception this is the kind of probability that is meant whenever we make an inductive inference.[4]

Unlike Popper (and other philosophers like Keynes), Carnap did not claim a monopoly of truth for only one concept of probability. He argued that there are two primitive or pre-systematic concepts of probability. He called them *probability*$_1$ and *probability*$_2$. Probability$_1$ is a relation between conclusion and evidence, which was initially described or explicated, as a degree of confirmation or a

[3] This position was defended by Carnap from his first publication about the subject (1945). It is one of the most important features of Carnap's philosophy of probability and was defended in all his works on the subject.

[4] By inductive inference, Carnap means "non demonstrative" inference, that is an inference such that the conclusion does not follow a logical necessity when the truth of premises is granted.

degree of evidential support.[5] Judgments of probability$_1$ are analytically true or false: their truth-value depends only on the rules of the language in which they are formulated. The logical concept of probability is especially useful in metascientific statements, which are statements about science. In this case, statements are not synthetic (empirical), but analytic ones.

Carnap did not reject the frequency (or statistical) concept. He regarded it as important for science. In Carnap's opinion, the logical concept of probability is a second concept of an entirely different nature, though it is equally important. Statistical probability is a scientific, empirical concept. Statements about statistical probability are *synthetic* statements, statements that cannot be decided by logic but which rest on empirical investigations. Probability$_2$ is a relation of relative frequency between properties, classes, or kinds of events. Judgments of probability$_2$ are factual and empirical. Carnap acknowledged the utility of probability$_2$ for many purposes.

Carnap (1950) argued that it is possible to reconcile the major opposing traditions by insisting that science utilizes *both* interpretations. The statistical hypotheses of physics, biology, etcetera, may be interpreted as statements about relative frequencies, while all scientific hypotheses are said to have an inductive probability relation with their respective bodies of evidence.

2.2. Popper's interpretation

Popper argued that there is only one concept of probability which is an objective one. He had always defended an objective interpretation of probability. Popper takes as the most interesting and useful concept of probability one that is related to relative frequencies, and not one which is defined in terms of limiting frequencies. Probability is a concept characterizing the behavior of certain entities or kinds of entities under certain conditions. It is an abstract property, which can be described as a kind of potentiality or *would-be*, that may be (but need not to be) expressed by mass behavior. Thus, when we ascribe the probability of 1/2 to a head in the case of a tossing coin, we do not mean to say that the coin has been thrown many times, or that it will be thrown at all. We mean that the coin has, under the usual circumstances, a certain *propensity*[6]

[5] We will see (section 4) that Carnap shifted from this definition of probability$_1$ to the rational degree of belief.

[6] Or a tendency, a disposition or dispositional tendency.

to land with the head uppermost. It has this propensity from the moment of its manufacture, whether or not it is thrown. Furthermore, if it has this propensity to land with a head up about a half of the time, it has it regardless of the outcome of any series of tosses. A probability statement about a tossing coin asserts a propensity or disposition of the coin to display certain stable frequencies on repeated trials (Popper, 1959b).

The word *propensity* suggests some kind of dispositional account, and this marks a difference from the frequency view. Popper first defended a frequency interpretation of probability as was presented by Otto von Mises and Hans Reichenbach. Then, he developed a different interpretation which, while objective and empirical, applies (primarily) to individual events (rather than) and not only to sequences of events.

The question of the possibility of introducing the probability for the single event (or singular probability, as Popper called it),[7] playing an important role in quantum mechanics, is the origin of the propensity theory. Assuming his frequency theory of probability, von Mises had denied that such probabilities could be validly introduced. For example, the probability of the death of John Doe is a single event. Von Mises proposed to introduce the probability of death before the age of 71 in a sequence of say 70-year-old American men. It is simply the limiting frequency of those in the sequence who die before the age of 71. The answer of von Mises is that there is no sense to speak about the probability of death of an individual. Von Mises denied the possibility of any objective singular probability. He insisted that since a probability has only a relative value to an infinite sequence, the empirical concept of probability simply *does not apply* to individual events.

In the propensity context there is not a necessity to describe a particular event by assigning it to a reference class, but in terms of the conditions used to describe it. Popper argued that since probabilities —characterized as dispositional properties of some experiment— appear to depend only on the experiment, this allows us to interpret the probability of a single event as a property of the single event itself.

To sum up, Carnap and Popper had different interpretations of probability. Although both philosophers agreed about the fact that we clearly need a theory of objective probability and that science positively demands one. Popper and

[7] Single-case probabilities are probabilities which can be ascribed to a given events occurring at a particular spatio-temporal location.

Carnap were concerned about two different *explicanda*. Carnap would identify Popper's propensity (as he did with von Mises' frequency) with some concepts of probability, namely probability$_2$ which he did not reject. Once this is clarified, one important source of dispute between Popper and Carnap can be eliminated. Each of them had a different *explicandum* in mind.

3. POPPER AND THE PROBLEM OF INDUCTION

We assume that the reader has some familiarity with Popper's ideas and we shall just mention its major relevant points to our discussion.

The problem of induction can be formulated in modern terms as follows: Are there inferences which, at the same time, preserve the truth and extrapolate beyond the existing data? In other words, is the induction *ampliative*?

For David Hume as for Popper, *ampliative* induction can never be a rational procedure. In other words, there is not a positive solution of the problem of induction. Popper was the first one who recognized that we must simply stop seeking for a solution to the problem of induction since theories are never conclusively verifiable. According to Popper, since a theory and its predictions are not deductible from our data, there is no justification for believing them.

Popper strongly objected to the probabilistic approach of confirmation developed by Carnap (which will be developed in the next section). He maintained that scientists do not aim for highly probable (or highly confirmed) hypotheses. On the contrary, they look for powerful hypotheses which say great deal and which are, therefore, very *improbable*. Popper preferred to base the selection of hypotheses from among those that have been proposed, but not yet refuted on a principle of *falsifiability*. We should accept that hypothesis which will be most quickly eliminated by tests if it is false (the most falsifiable hypothesis, the hypothesis with the greatest content). Popper claimed that, given a choice, we should select the least probable hypothesis, on the grounds that it is the one easiest to test, and easiest to refute if it is in error. Popper (1959a) introduced and defended the view that the acceptability of a scientific hypothesis is directly proportional to its logical improbability. He assumed that his view was exactly the opposite of Carnap's.

On Popper's account theories with great *falsifiability* are submitted to test. We try hard to falsify them. In so far as we fail, they are *corroborated* (1959a, chap. X). The increasing corroboration means the survival through severe tests.

Popper intended to define the concept of corroboration exclusively in deductive terms and refuses to identify corroboration with posterior probability. This refusal is based on his denial that we choose the most probable hypothesis, and his assertion that we accept the hypothesis that has the greatest content and that has resisted to the most severe tests and the most serious attempts to refute it. Popper's concept of corroboration is the first step toward defining a concept of deductive confirmation (Stegmüller, 1973: 503). It is crucial to distinguish corroboration, which allows rationally the selection of a preferred hypothesis, and confirmation, which is based on the idea that a confirmed hypothesis increases its probability.

Popper's position is widely debated. One criticism of this position is that such methodology is not and would not be followed by scientists, because in the practice of science, it is rational to accept hypotheses that are probable. On the other hand, the thesis according to which the rational preferable hypotheses are the best corroborated seems to be incompatible with the rejection of induction. If we do not use the induction, we cannot understand why the resistance of a hypothesis to most severe tests in the past would give any reason to accept it in the future.[8]

Now it is time to introduce the Carnapian position about the problem of induction.

4. CARNAP'S PROGRAM

By "Carnap's program" we mean what Carnap has published about inductive logic, based on the probability concept. This program may be divided into two extensive systematic systems.

In his earlier works,[9] Carnap was interested in the explication of probability$_1$ by the concept of degree of confirmation. Then the latter is an *explicatum* of the first. This is to say that the concept of degree of confirmation has the same meaning and function as probability$_1$, but does not carry its ambiguities and obscurities. The degree of confirmation (or evidential support) is a measure of the support given by a body of evidence (the data) to a hypothesis. Inductive logic

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[8] Popper continued to be an opponent to any probabilistic approach to induction. With one his faithful follower David Miller (1983 and 1987), they propose a logical argument proving the impossibility of any probabilistic inductive logic. This argument was the origin of a huge literature.

[9] Carnap (1950 and 1952).

is understood as the theory of justification of hypotheses (or theories) by observational data. This interpretation may be called the *confirmation-explication*.

Since that time, Carnap moved from the explication of inductive probability as a degree of evidential support to its explication as a *rational* degree of belief (or *fair* betting quotient). Here, the relation between the hypothesis *H* and the evidence *E* is the degree where an agent is rationally entitled to believe in *H* on the basis of *E*. This viewpoint may be called the *belief-explication.*[10]

4.1. Confirmation-explication

Carnap's original conviction was that it is possible to construct a quantitative theory of confirmation based on a concept of inductive probability (probability$_1$). The latter is considered as a logical relation somewhat similar to the logical implication. Indeed, Carnap thought that probability may be regarded as a partial implication. Inductive logic is like deductive logic in being concerned only with the statements involved, not with the contingent truth of these statements. By a logical analysis of a stated hypothesis *H* and stated evidence *E*, Carnap concluded that *H* is not logically implied but is so to speak, partially implied by a certain degree.

How did Carnap proceed? He began by supposing a standard type of artificial language (where the predicates are primitive in structure and finite in number), with a finite number of monadic, first order predicates (like "is female") and a finite number of individual constants.[11] Then an *atomic sentence* is defined as an assignment of an individual constant to a predicate (like "Carla is female").

The clue of his construction is the concept of state description, that is a statement that describes a state of the world as much detailed as possible in that language (a statement expressing a possible state of the world relative to this language). A state-description is defined as a conjunction of sentences containing every atomic sentence or its negation, but not both, and no other sentences. Then, Carnap assigned numbers to the state description in such a way that the numbers assigned to all possible state descriptions add up to one. This assignment constitutes the definition of a measure function (or *a priori* probability) for the state descriptions.

The degree of confirmation of a hypothesis *H* given the evidence *E* is then defined as the conditional probability of *H* on *E*:

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[10] Carnap (1963 and 1971).

[11] Carnap considered this kind of formal language because the logical and semantic properties and relations of *H* and *E* can be made perfectly explicit.

$$c\,(H, E) = \frac{m\,(H \wedge E)}{m\,(E)}$$

This is to say, we define the degree of confirmation of the hypothesis *H* on the evidence *E* to be the *ratio* of the *a priori* probability of the conjunction of *E* and *H* to the *a priori* probability of *E* alone. The degree of confirmation of *H* on *E* is just the conditional probability of *H*, given *E*. This definition reduces the determination of the degree of confirmation to the choice of a measure function for state-descriptions.

Carnap structured the confirmation function through three sets of axioms. The first set of axioms is related to strict coherence and arises from a desire to develop *c* so that it will be conform to the probability calculus. The second set of axioms concerns invariance properties for *c* and is motivated by the desires where there are not *a priori* distinguished predicates or individuals and, where the relation between propositions *H* and *E* depends only on the subset of predicates and individuals they refer. The third set of axioms is concerned with ensuring the ability to learn from experience; they prescribe the behavior of *c* in certain instances of inductive inference.

This system has been criticized by several philosophers, especially by Popper. Two main shortcomings have been pointed out (and not the only ones)[12] and have been widely discussed:

(1) All universal laws have zero-confirmation on any finite evidence;
(2) Carnap could not single out one particular *c*-function as *the* function representing inductive reasoning.

According to Carnap's theory of confirmation, universal laws have zero-probability that gives an infinite number of individuals, which is that universal laws turn out to be non-confirmable. Many authors regarded this as unacceptable especially in a theory that proposes to justify inductive procedures. We intuitively

[12] E. g. Popper has argued that no adequate explicatum of the notion of confirmation is possible and that probability must not be identified with confirmation because a degree of confirmation cannot satisfy certain axioms of probability calculus (Popper, 1959b; 1963) (*see* Michalos, 1971, chap. III for detailed discussion).

consider that laws are well confirmed (supported) by appropriate experimental reports and that their degrees of confirmation increase with new relevant instances. In the face of the counter-intuitive fact, Carnap adopted what he called "the instance confirmation of the law". Roughly speaking, the instance confirmation of a law is the degree of confirmation that the next individual to be observed will confirm this law. Popper denounced the *ad hoc* character of this new concept.[13] Carnap argued[14] that when we refer to the degree of confirmation of a law as high, we really mean that its instance confirmation is actually high. Albeit that laws being of no importance in the formulation of practical problems, we are not inclined to accept Carnap's defense. Carnap had a special conception of the science. He explained that the universal laws are not needed in science and that we can dispense with them and are introduced only to abbreviate the scientific discourse.[15]

Concerning the second difficulty of Carnap's system, the first belief of Carnap was to provide a single inductive method that can be used as the correct rule in all situations of life. Carnap proposed, for a given formalized language, an inductive method, termed $c*$, as the most appropriate choice: it is the solution of the formal problem of inductive logic since it is considered as the adequate *explicatum* of logical probability.[16] Carnap presented $c*$ as *the* method of inductive logic. Severe criticisms have been addressed to $c*$ and even condemned it. Carnap himself stopped defending it. Then, Carnap (1952) shifted from this (unique) method to an extensive class of inductive methods, the so-called *continuum of inductive methods*. The members of this *continuum* are characterized by only one free parameter called λ Any member of the λ-*continuum* can possibly be regarded as *the* appropriate inductive method.

These difficulties led Carnap to abandon the confirmation-explication. As we will see in the next section, the belief-explication seems to solve some problems.

[13] *Cfr*., Popper, 1963: 221.

[14] *Cfr*., Carnap, 1950: 571.

[15] *Cfr*., Carnap, 1950: 575.

[16] *Cfr*., Carnap, 1950: 563.

4.2. Belief-explication

By “inductive logic” Carnap meant a theory of logical probability providing rules for inductive thinking. The nature of inductive logic can be made clear by showing how it can be used in determining rational decisions.[17] This is the position he defended in his later works. Carnap developed a system of inductive logic useful for the purpose of making rational decisions. Then inductive logic is considered to be the foundation of the rational decision-making under uncertainty. Carnap’s second conception (belief-explication) of inductive probability presents a kinship with the Bayesian approach.

Carnap (1963) developed the concept of probability$_1$ in the following way. Consider a person *X* at a certain time *t*. It is possible to know the degree of belief that *X* has in a proposition *H* at time *t*. Cr_X is the credence function of *X* (or *X*’s system of belief). $Cr_X(H,t)$ is the function lying between *0* and *1* and represents the degree of belief which *X* has in the proposition *H* at time *t*. Following Frank Ramsey, $Cr_X(H,t)$ is equal to the highest betting quotient with which *X* is willing to bet on *H* at *t*, for small stakes. Carnap distinguished between an *actual* credence function which is a theoretical property of an individual and a *rational* credence function, which is taken to be the credence function of a perfectly rational being. Now if *X* exhibits some degree of rationality,[18] his degree of belief in a proposition *H* will not depend merely on the time *t*, but on his total observational knowledge at the time *t*. The function which yields the degree of belief is that *X* would have in *H*, where *E* is the total body of knowledge, is a *credibility function Cred(H,E)*. For Carnap, a credibility function is independent from factual information and from which the credence functions are derived; it is simply a generalized conditional credence function on the total evidence. The transition from credence to credibility is an important step in Carnap’s system. This transition needs the acceptance of some idealizations. Thus, Carnap suggested replacing the rational human being by a robot which has among other things an infallible memory and forms his beliefs only by deduction and experience and never by emotions.

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[17] *Cfr.*, Carnap, 1971.

[18] A perfectly rational being is the one who has not a book made against him, therefore his credence function at a given time must be coherent (*i.e.* conform with the rules of the probability calculus).

We now take one more step, and consider rational credibility functions. Carnap's took the logical probability function to be a rational credibility function, but he did not assume that there can be only one such function. He imposed further conditions (regularity, invariance, relevance...). The belief-explication makes inductive logic compatible with the Bayesian theory. But a serious Bayesian will not follow Carnap in imposing any more conditions on the credence function than the ones imposed by the probability calculus (the coherence).

The belief-explication is closely related to utility theory and the foundations of decision-making under uncertainty. Carnap often said that the purpose of inductive logic is to "help people to make decisions in a rational way", and emphasized the application of inductive logic to practical decision problems. These statements should perhaps not be understood literally. Carnap's work has mainly foundational interest. It is an analysis of the foundations of probabilistic reasoning.

In his later work, Carnap preferred the belief-explication and emphasized the application of inductive logic to decision problems. In this context the problem of assigning probabilities to universal generalizations does not automatically arise. In practical decision problems it is normally not necessary to consider the probabilities of universal generalizations. The latter which attract the attention of Popper and the most philosophers of science are completely beyond the scope of Carnap's theory. The belief-explication takes away Carnap's theory from the classical philosophical problems of inductive inference.

5. CONCLUSION

Popper has been perhaps the most prominent and persistent opponent of Carnap's probabilistic inductivism. His opposition has been closely related to the Carnap's earlier works on inductive logic.

The confirmation-explication as a relation between propositions is primarily relevant to the situation in which we are interested in whether (and to what degree) some general hypotheses or theories are logically confirmed (or supported) by the observations. It is related to the problem of explicating how general theories or hypotheses are justified by empirical evidence. Carnap's early work was concerned only with *a priori* judgments of the extent to which a particular statement of evidence would confirm (or support) a particular hypothesis at issue. The belief-explication, on the other hand, is closely related to decision problems and to the foundation of decision-making under uncertainty. In his last works, Carnap preferred this explication and emphasized the application of inductive logic to decision problems. Carnap was only concerned with the probabilistic aspect of normative decision theory.

There is a difference in the aims of logicians like Carnap and methodologists like Popper. The Popper-Carnap controversy is based on an important misunderstanding. While Popper was only interested in the theoretical evaluation of unverifiable theories, Carnap's concern was the foundations of rational decision making under uncertainty. If we consider Carnap's later work (where he preferred the belief-explication), we remark there is not any overlapping of Carnap's and Popper's domains of research. We should cease to consider Popper as Carnap's opponent.

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