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Probabilistic kingdom – problem of objectivity in contemporary science[1]

***Abstract**: Within the world of modern scientific theories, probability theory is one of the basic tools with which hypotheses are constructed. Scientists using probability theory often rely on its objective interpretation. In practice, this means that probability assertions should be independent of the beliefs of the individual. Accordingly, the following question arises: what do the contents of scientific assertions based on an objective interpretation of probability theory refer to? To answer that question, the author analyzes objective probability in the context of the scientific debate on determinism, addressing two types of arguments. On the one hand, a position will be examined according to which the only viable plane allowing for objective probability is indeterministic. Subsequently, the discussion will focus on arguments to the contrary, which presume coexistence of objective probability and determinism. The aim of this paper is to answer the question concerning the meaning of a sentence referring to the objective interpretation of probability, and aim to resolve whether it is in the context of either deterministic or indeterministic plane that one can speak of objective probability. As a result, the following thesis will be advanced: both the acceptance of a deterministic and an indeterministic plane as possible areas where objective probability can occur is extremely problematic. Depending on the chosen area, different types of problems arise, whose common denominator is misunderstood objectification. Consequently, the postulated objectivity of probability (and pertinent assumptions) can be reduced to the epistemic variant.*

***Keywords:** philosophical interpretations of probability, the objectivity of probability, probabilism, scientific realism, determinism*

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Introduction

Currently, it is difficult to imagine a branch of science which does not use the theory of probability. In certain scientific disciplines, this tool performs a fundamental explanatory role, for instance in modern economics, physics, biology, computer science, or social studies. One calculates the probability of financial gain, the occurrence of genetic mutation, the appearance of the alpha particle, the average lifespan of a resident of Kraków. In each case assertions are formulated which are probabilistic in nature. This raises the elementary question: what are scientists actually saying? Do these assertions reflect their degree of belief in a particular thesis? Or is this an objective description of the world? What does objectivity mean in this context?

In this paper, the key to answering these questions is to embed an objective probability within the scientific debate on determinism.

Accordingly, this paper is structured as follows. In the **first** part (1), the distinction between epistemic and objective interpretation of probability is explained. In the **second** part (2), the distinction between the so-called probabilistic assertions and explanations based on probability is shown. The **third** part of the paper (3) examines the coexistence of objective probability on a deterministic plane. The **final** (4) part of the paper contains conclusions.

1.

Within mathematics, probability is defined as a function in a defined measurement space. This approach allows for different characteristics (interpretations) of the term 'probability.' The main difference between individual variants (interpretations) is based on assigning different meaning to a mathematically primal term that is probability. For example, in light of the so-called logical interpretation,[2] one can speak of a semantic relationship between certain types of events. Conversely, frequency interpretation[3] indicates that the probability of a type A event can be defined as the limit of the relative frequency of occurrences of such events in the infinite reference class B. An extensive discussion of the different philosophical interpretations of probability can be found in works by T. Childers,[4] A. Eagle,[5] and D. Gilles,[6] among others.

[2] See R. Carnap, *Logical Foundations of Probability*, The University of Chicago Press 1950.

[3] Cf. R. von Mises, *Probability, Statistics and Truth*, 2nd English edition. George Allen & Unwin, Dover reprint 1957.

[4] T. Childers, *Philosophy and Probability*, Oxford University Press 2013.

[5] A. Eagle, *Philosophy of Probability: Contemporary Readings*, Routledge 2010.

[6] D. Gillies, *Philosophical Theories of Probability*, Routledge 2000.

However, from the standpoint of this paper, the most important is a more general, so-called pre-theoretical division.[7] It includes the distinction between **epistemic** and **objective** probabilities. In this context, different interpretations of probability are classified into these very categories.

Epistemic probability is defined as a measure of our uncertainty regarding the possibility of the occurrence (or lack thereof) of a given event. It is a characteristic of our beliefs about the chance occurrence of uncertain events.

> Epistemological interpretations of probability take probability to be concerned with the knowledge or belief of human beings. On this approach probability measures degree of knowledge, degree of rational belief, degree of belief, or something of this sort.[8]

The epistemic approach is usually connected to the so-called subjective interpretation of probability.[9] Probability is characterised as the degree of belief of a rational individual. According to this interpretation, the key fact is that the above function of beliefs complies with the axioms of probability. A specific set of conditions is imposed onto the function of beliefs. As a result, epistemic probability is a particularly important tool, which is used in different branches of science.

Objective probability constitutes the second element of the division. In its simplest form, it is characterised as a measure of the possibility of the occurrence of events and therefore as a characteristic of the world's structure. Under this interpretation, one can be more specific and thus talk about different types of planes to which it refers:

(a) real observable features of the world,

(b) real unobservable features of the world,

(c) logical relationship between sentences.

The difference between (a) and (b) is based on different approaches towards the structural characteristics of the world. In the first case (a), we can speak e.g. of the frequency of results for a given experiment (based on empirical observation). In the second case (b) we relate to a specific type of unobservable characteristics that are attributed to the structure of the world. One example may be the tendency of a given structure to realise a certain state of things.

In the third case (c), objectivity takes a different form: it is assumed that logical relations between sentences have objective characteristics. We postulate that they are independent of the degree of belief of a given individual. Individual beliefs are not a factor affecting the degree of probability, but logical objects (their relations) with a subjectively independent status are.

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[7] See ibidem.

[8] Ibidem, p.2.

[9] See: F.P. Ramsey, *Truth and Probability. Foundations of Mathematics and other Essays*, R. B. Braithwaite 1926; B. de Finetti, *Philosophical Lectures on Probability*, Springer Verlag 2008.

2.

With this basic outline of the meaning of 'objective probability,' let us look at probabilistic assertions occurring in science. Here are three examples:

(a) There is a 70% chance that the leader of North Korea, Kim Jong Un, will increase the military budget.

(b) The probability that dinosaurs became extinct 65 million years ago as a result of an asteroid hitting the Earth is 70%.

(c) The probability that an atom of radium will disintegrate in T1 time is 70%.

The above examples are characterised by varying degrees of accuracy and relate to different fields of science, but their common element is a reference to probability. Can all these assertions be treated as equal? According to many philosophers, they cannot. The author of one of the classifications, which requires a distinction between these assertions is J. Schaffer.[10] The latter claims that one should distinguish between the so-called **explanation through probability** and **probabilistic explanation**.

All inaccurate (commonplace) applications of probability are considered to be an **explanation through probability**. These are applications in which, thanks to additional facts, probability could be reduced to a non-probabilistic characteristic. According to Schaffer, these types of statements have only an intuitive, loose relationship with probability; the group would thus comprise assertions (a) and (b) above. In the first case (a), additional information on the conduct of the North Korean leader would be required. In the second case (b), if we went back in time to 65 million years ago we would know the cause of dinosaur extinction. As a result (a) and (b) could be presented in a non-probabilistic form.

The second type of assertions are probabilistic explanations. This category applies to all assertions that cannot be reduced to a non-probabilistic form. According to Schaffer, this criterion is extremely rigorous, therefore most statements (including those occurring in the world of science) would be rejected in the light of that characteristic. Only statements about the processes occurring on the indeterministic plane are permitted (e.g. quantum processes), whereas all other probabilistic assertions (without such a strong reference) should fall into the first group, according to Schaffer. Example assertion (c) can be defined as a probabilistic explanation, as its irreducibility stems from the role probability plays in quantum mechanics.

Should we agree with the above differentiation? On the one hand, it is beyond any doubt that commonplace and scientific understandings of probability should be separated. A similar distinction was proposed by Carnap.[11] It is a division between the so-called *explicandum* and *explicatum*. The first group consists of colloquial

[10] J. Schaffer, *Deterministic Chance?*, "The British Journal for the Philosophy of Science" 58(2)/2007.

[11] R. Carnap, *Logical Foundations*…

terms, as well as those which are in a pre-scientific state. The second of Carnap's groups (*explicatum*), includes more precise terms, such as those employed in science. Importantly, the two groups are not mutually exclusive, though it is important to differentiate between the areas in which a term (in this case probability) is used.

In this case, should we concur with the second part of Schaffer's proposal? Can objective probability be realised only on the indeterministic plane? Many philosophers disagree with such a notion and offer a negative answer to the second question. Before proceeding further to discuss the co-existence of objective probability and determinism, it may be worthwhile to consider the indeterministic plane for a moment. Is this actually a non-controversial plane for this type of probability?

Schaffer refers to quantum processes, but this does not obviate the complexity of interpretation. Also, issues of measure and reference are worth mentioning at this point, as they reveal a problem arising due to the discrepancy between the assumed model and empirical experience (function characteristic). Consequently, we do not have an explicit reference between the probabilistic assertions and an ontological structure.

3.

Let us see then—Schaffer notwithstanding—if co-existence of objective probability and determinism is possible. For a start, one should take a look at how determinism is defined in that respect:

> Determinism – doctrine that every event has a cause. The usual explanation of this is that for every event, there is some antecedent state, related in such a way that it would break a law of nature for this antecedent state to exist yet the event not to happen.[12]

In light of the above definition, the aforesaid coexistence seems to become quite a controversial thesis. How is it possible that probability occurs in a world where everything is connected through causality (cause – effect)? This question was raised by many philosophers:

> Today I can see why so many determinists, [...] believe in a subjectivist interpretation of probability: it is, in a way, the only reasonable possibility which they can accept; for objective physical probabilities are incompatible with determinism [...].[13]

Nevertheless, the possibility that determinism and objective probability coexist has its supporters, the so-called compatibilists. Chief proponents of this view in-

[12] S. Blackburn, *The Oxford Dictionary of Philosophy, Oxford University Press*, Oxford 1994, p. 103.

[13] K.R. Popper, *Qantum Theory and the Schism in Physics, Hutchinson*, London 1982, p. 105.

clude B. Loewer[14] and C. Hoefer,[15] who draw mainly on examples from classical statistical mechanics in their arguments. In this context (as these philosophers contend), classical statistical mechanics is interpreted as a deterministic one on the one hand, while on the other predictions within it are made using probability.

In spite of this dissonance, compatibilists seek to maintain the objectivity of probability, whereby this requirement derives from the characteristics of the empirical sciences. If science is to be objective, it should not be based on subjective beliefs of the individual. According to compatibilists, subjectivation is incompatible with the basic principles of scientific methodology, as well as with pragmatic versatility theory. Probability linked to the various fields of science is an explanatory factor, whereas for compatibilists this is a premise which proves the objectivity of applied probability.

An interesting summary of the evidence cited by the compatibilists is provided by Schaffer. It features three lines of defence that compatibilists adopt:

1. **The paradigm case argument**—in a deterministic world, there are some specific cases relating to randomness, to which fixed, objective probability tends to be attributed.

(P1) There are coin flips in deterministic worlds;
(P2) Coin flips involve a 0.5 objective chance that a heads landing will occur, in the world in question, at the time of flipping: ch <p heads, w, t flip> = 0.5;
(C) There are objective chance values other than 0 or 1 in deterministic worlds.

The incompatibilist should deny (**P2**), and should distinguish between objective chance, and merely epistemic chance. Of course, this is not tantamount to denying that objective information (such as frequency data, and physical information concerning asymmetries in the coin) can impact the chance of landing heads.

2. **The nonreductionist argument**—in a deterministic world there are macro events. The macro space is autonomous (in relation to micro) and has associated rights, thus entailing objective probability, which is not necessarily reducible to micro events (occurring on an indeterministic plane).

(P1) There are macro-events in deterministic worlds;
(P2) The macro-realm has an independent reality with independent laws and chances;
(C) There may be macro-chances in deterministic worlds.

[14] B. Loewer, *Determinism and Chance*, "Studies in History and Philosophy of Modern Physics" 32/(2001).

[15] C. Hoefer, *The Third Way on Objective Probability: A Sceptic's Guide to Objective Chance*, "Mind" 116(463)/2007.

The incompatibilist should still deny (**P2**), however precisely explicated. That is, even having granted some form of 'independent reality' to the macro-realm, the incompatibilist should still deny the independence of macro-chances.

3. **The CSM argument** invokes classical statistical mechanics, positing that it does not exclude occurrence random events in a deterministic world. Objective probability plays an explanatory role there (e.g. in thermodynamics).

(P1) CSM postulates nondegenerate chances in a deterministic world;
(P2) Such chances play a role in explanations;
(C) Such chances must be objective chances.

The incompatibilist should deny that **(C)** follows. She should distinguish between probabilistic explanation, in which objective chances play an explanatory role, and probability of explanation, which is merely an ignorance measure over various nonchancy explanatory paths.

At their foundation, these arguments are based on a different understanding of objective probability. Therefore, according to Schaffer, four types of objective probabilities should be distinguished:

1. Deterministic micro-posterior chance.
2. Deterministic macro-posterior chance.
3. Deterministic micro-initial chance.
4. Deterministic macro-initial chance.

This division is based on two main criteria. The first one concerns the distinction with respect to the plane of physical processes: micro (e.g. The disintegration of a radium atom in x time) - types (a) and (c) and macro (e.g. a coin toss) – types (b) and (d).

The second is based on a temporal classification. The featured variants are: initial – types (c) and (d), posterior – types (a) and (b). The first relates to the initial moment of the universe (a reference to entropy), while the second to a specific time before the occurrence of a given event.

A summary of the dependencies between compatibilistic arguments (1–3) and a certain variation of deterministic chance (a-d) is shown in the following table.

As may be seen, selected types of arguments refer to specific interpretations of objective probability. Of course, incompatibilists—who oppose such a view—seek to refute the above thesis. The probability occurring in these types of assertions should be characterised as a subjective degree of individual belief, or epistemic probability in other words. Counterarguments are primarily focused on demonstrating the contradictions of arguments 1–3. However, it may be quite interesting to take a slightly different route and to see why the existence of objective probability should even be postulated.

Tab. 1. Summary of arguments in favour of compatibilism with different types of chance

	Deterministic micro-posteriori chance	Deterministic macro-posteriori chance	Deterministic micro-initial chance	Deterministic macro-initial chance
The paradigm case argument	–	+	–	–
The non reductionist argument	–	+	–	+
The CSM argument	–	–	–	+

Source: collated by author.

4.

It is worth noting that both compatibilists and incompatibilists talk of three types of premises whilst arguing in favour of an objective probability (thereby negating the epistemic variant):

(p1) usability in science,
(p2) informative objectivity,
(p3) reference to reality.

It is fairly apparent that the use of a reference to epistemic interpretation does not mean a limitation of its usefulness (p1). This is evidenced by numerous examples adduced within decision theory or demography and economics, among other things. In a more detailed reference, it would suffice to analyse the tools used within the so-called subjective Bayesianism (used in certain areas of quantum mechanics). Another objection is that epistemic understanding of probability may be associated with objective information (p2). Much as in the previous case, one can refer to the Bayesian principle of conditioning. The last element on the list—an ontological reference—is equally problematic in both types of probability classification. Objective understanding of probability does not have any significant advantage here. On a indeterministic plane (in quantum mechanics) there is a whole range of problems associated with reference (p3). Moreover, the same postulate of ontological reference may be incorrect.

> The abandonment of superstitious beliefs about the existence of the Phlogiston, the Cosmic Ether, Absolute Space and Time, ... or Fairies and Witches was an 9 essential step along the road to scientific thinking. Probability, too, if regarded as something

> endowed with some kind of objective existence, is no less a misleading misconception, an illusory attempt to exteriorize or materialize our true probabilistic beliefs.[16]

The question now arises, whether the assumption of objectivity is not an abstract requirement. If it does not guarantee any advantage over the competing approach, it may be that in the context of scientific expectations objectivity of probability is simply an artificial creation. Hence, the general conclusion is close to de Finetti's intuition:

> De Finetti's treatise on the theory of probability begins with the provocative statement "probability does not exist", meaning that probability does not exist in an objective sense. Rather, probability exists only subjectively within the minds of individuals.[17]

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[16] B. de Finetti, *Philosophical Lectures*…, p. X.

[17] R.F. Nau, *De Finetti was Right: Probability Does Not Exist*, "Theory and Decision" 51/2002, p. 89.