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Information in Operation: Probability †

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Abstract: This paper proposes an informational approach to probability based on a non-semantic, non-propositional and non-truth-functional logic of real processes and systems, according to which they interact and evolve—Logic in Reality, LIR. Its fundamental principle is that the contradictory or opposing informational elements of complex real processes move from states that are primarily potential to ones that are predominantly actual, alternately and reciprocally, without going to the abstract, ideal limits of zero or one. LIR provides a thread between the different sciences and constitutes a bridge between the ontological aspects of logic, science and philosophy.

Keywords: actuality; epistemology; information; logic; ontology; philosophy; potentiality; process; reality; science

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1. Introduction

The relation of probability to information and information science emerges in the following questions: (1) is probability theory a logic of science? (2) can any non-probabilistic logic of nature (first-order logic) be used in scientific descriptions, e.g., of the evolution of real processes? These questions refer to both ontological and epistemological issues. It as a companion paper to the one presented at the sub-Conference on the Philosophy of Information, in which I discuss the relation between information and the so-called ontic-epistemic cut in philosophy. In the current paper, the focus is on the relation between probability and my non-standard logical system, Logic in Reality (LIR).

2. Logic in Reality (LIR)

Several major types of logic are used to describe our everyday material and cognitive world: (1) standard linguistic, that is, truth-functional propositional and first-order logics; (2) intuitionist logics based on mathematical constructions rather than linguistic 'truth'; (3) more informal dialectical logics, which attempt to capture some of the features of thought and change.

I have proposed an entirely different non-semantic, non-propositional and non-truth-functional logic as the logic of real processes and systems, according to which they interact and evolve (Logic in Reality, LIR) [1]. My non-linguistic logic of processes is based on the pioneering work of the Franco-Romanian Stéphane Lupasco (Bucharest, 1900–Paris, 1988), up-dated and extended since 2005.

This paper can be viewed as an initial discovery of a logical, physical-ontological interpretation of probability, in the course of which new relations between the three canonical subjects of science, logic and philosophy are described: Logic in Reality enables an extension of non-Boolean conception of logical consequence and complementarity, based on a logic of energy and the non-separability of parts and wholes [2].

3. Computability and Probability

The advent of computational resources has justified and furthered the use of computable models to the exclusion of more realistic ones that are intractable to computation.

This is no more obvious than in discussions of probability, many of which are devoted to pseudo-random events like the throws of dice. Reality comes in only in the deviations, usually negligible to all intents and purposes for fair dice, of the statistical frequency of one face. There are several kinds of more complex concepts of standard probabilities, however, they have in common their reference to standard propositional and truth-functional logic.

The field of information is a microcosm of the features of knowledge and consequently has a central role to play in the philosophical discussion of issues, such as probability, that straddle the domains of logic and science. My general heuristic strategy is to look at information not as defining a domain of statements about reality but as part of dynamic reality itself, a process and a not a 'thing', as Ladyman counsels us in his important book, *Every Thing Must Go* [3]. As the Chinese philosopher of information, Wu Kun, has shown in recent papers in English, information has a unique role in the convergence of science and philosophy. Wu and I have further shown that Logic in Reality provides the best possible logical framework for information in the most general sense used in this paper, placing information, better information processes, at the interface between science, logic and philosophy, with both a constitutive and explanatory role [4].

4. Probability, Information and Truth

Let us assume that there are two major kinds of information: (1) Shannon, objective, or statistical information, without considering truth; and (2) semantic, subjective, or generalized information, for which truth is the criterion of validity. If subjective predictions always accord with facts, the two information accounts are the same. As presented by Chenguang Lu in two articles in a Special Issue of Philosophies, the first approach deals with how information is acquired, a field often referred to as Informatics [5]. The second, different approach of Information Theory deals with information measurement. There is a parallel between the kinds of information and two kinds of probability theory based on logic: (1) on propositional logic and (2) on first-order logic. The key point is that these types of theory are truth-functional. As discussed elsewhere, the LIR theory of information is generalized, in Lu's terms, or objective-subjective, however it is not truth-functional.

References to probability in general terms often correspond to the common understanding of probability as the likelihood of the occurrence of some future event. Stated simply in this way, probability appears as an epistemological concept, one that does not refer to a real physical state. It is an absence, as in the concept of information of Terrence Deacon [6]. Much of the vast literature on probability is essentially devoted to examining the logical and statistical properties of the types of probability as so defined.

5. Jaynesian Probability

Jaynes proposed his theory, literally, as an extension of binary, Aristotelian logic. Such logics, in which the principle of non-contradiction and the excluded middle are central, are of course valid in many simple cases, but Jaynes' perception was that the mathematical rules of probability theory are not merely rules for calculating frequencies of random variables; they are also the unique consistent rules for conducting inference and plausible reasoning of any kind [7]. In Jaynes' probability theory, any probability assessment is necessarily subjective, in the sense that it describes only a state of knowledge and not anything that could be measured in a physical experiment. In relation to Gödel, Jaynes concludes that undecidability is not an inherent property of propositions or events, but only the incompleteness of our own information. From his viewpoint, undecidability merely signifies that a problem calls for inference rather than deduction, and probability theory as extended logic is, accordingly, designed to solve such problems. For Jaynes, probability theory is a tool for detection of contradiction in propositions. Probabilities conditional on contradictory premises do not exist. Exposed to hidden or apparent contradictions, any computer programs being used will crash. This is a problem for the computer programmer, however, if one wants to, one can see it as confirmation of the reality of contradiction, (better, counter-valence or counteraction), having causal influence in the world.

Jaynes stated that inferences are logical connections, which may or may not correspond to causal physical influences. This statement is in contradiction to the fundamental principle of LIR. Any view of causal physical influence requires the re-introduction in logic of contradictory (or counteracting) relations if any sense is to be made of real events, and not only of Jaynes' aseptic robot world.

6. Bayesian Probability

The other major concept of probability relates a given set of data to the chance or likelihood of a hypothesis derived from or conditional on those data being correct, that is making a prediction, which will have been seen to have correctly predicted the data, a posteriori. It relates the direct probability of the hypothesis (being true) to the inverse probability of the data conditional on the hypothesis. From the perspective of Logic in Reality, it should be clear that we are dealing with essentially abstract, epistemological objects and the putative relations between them. The debate is then whether these considerations and the relations between them constitute a part of science and reality in a physical process sense or not. My conclusion is that they do not, and very recent work by Gunji et al. has shown that probability as it emerges from specific and non-Boolean cognitive processes shares some of the complex dynamic properties of all real processes [8].

7. Asymmetry

In his short book, *Asymmetry: The Foundation of Information* (2007) [9], Scott Muller foreshadows the complex relations of this Special Issue, linking information to probability from the standpoints of statistical mechanics, including the Maximum Entropy Principle (MEPP) of Jaynes, physical thermodynamics, quantum theory and symmetry. He correctly, in my view, emphasizes the real property of distinguishability, that an object is one entity and not another, or in one particular state and not another as the foundation for an account of information. Muller succinctly lays out the relationships between symmetry, entropy and information. "Information exists wholly in the physical manifestation and in the relationships of an Information Gathering and Using System (IGUS)." Muller is thus closer to my dynamic view than to the semantic-epistemic one of Jaynes.

There is a fascinating disagreement, worth repeating here, between Jaynes, who claims that "No information denotes symmetry" and Muller's thesis that "Symmetry denotes no information". Muller reconciles the two perspectives in an Algorithmic Information Theory that follows Kolmogorov's well-known definition and incorporates the above considerations into an Asymmetry Principle of Information. This states that information is an objective quantity capable of a relational representation of the system constituted by an IGUS and an object.

Despite the primarily mathematical terms, in which Muller couches his argument, it is a good example of a theory to which a more dynamic one of information reduces. For Muller, symmetry breaking in the "causal process" is a form of the resolution of the possible (JEB: better potential) into the actual. Interestingly, and completely in line with my view on the importance of stating them, Muller gives a position formulated by Rosen that is apparently diametrically opposed to his own: "The symmetry group of the (a) cause is a subgroup of the symmetry group of the effect". Muller captures the interactive existence of the two types of local causal processes, information generating and information destroying. Clearly (the 2nd Law) the universe is becoming globally "more informed. Potentiality is resolved into actuality." However, what Muller and everyone else I am aware of fail to comment on is that if both types of local causal process are in progress at the same time, they may involve the same physical substrate, moving in the two directions at once, with actuality, always in part of course, also changing to potentiality following what I believe are the fundamental, skewed sinusoidal dynamics of complex processes.

Muller uses his notion of information to differentiate between various notions of probability. I can agree with Muller that subjective accounts of probability are concerned with changing probability assignments as epistemological entities. The frequency or frequentist interpretation is that probability has meaning only with reference to the results or outcomes of experiments. Like the frequency interpretations, propensity interpretations regard probabilities as objective properties of entities in the real world. Probability is thought of as a physical propensity, or disposition, or tendency of a given type of physical situation to yield an outcome of a certain kind, or to yield a long run relative frequency of such an outcome. Following von Mises, Muller rejects a purely subjective interpretation of probability; "Probability is an objective, physical property of a dynamic mass system". It might be clearer to say that von Mises notion is both abstract and objective in inhering in a group of events or observations, however, the LIR view clarifies the move apparently closer toward reality in the dispositional accounts of probability. While also maintaining the ontological existence of probability as an "in the world property", such accounts state that probability attaches (how?) to individual events, related to their individual propensity to come into existence. Popper supported a dispositional nature for probabilities, however Popper, according to Muller, formulates his account in a way that is incompatible with determinism. As in similar cases, the Principle of Dynamic Opposition removes the aporia by defining properties and propensities as processes, in dynamic states of actuality and potentiality.

8. Probability and Non-Boolean Complementarity

To repeat, my logic is a logic of, and in reality that is a non-propositional and non-truth-functional logic of real processes, grounded in physics. This logic establishes a dialectic relation between, among other things, uncertainty and its positive counterpart—certainty. I have explored the non-Boolean characteristics of LIR as I look for more new ontological concepts of probability.

The operation of Boolean logic in classical systems is reflected in the two major methodological principles defined by Bohr as complementarity and correspondence. The complementarity of oppositions, when they are actualized from the potential field, means that both opposite concepts can work and interact in the course of realization determining the dynamics of the whole system. The duality of oppositions appears as a complementary realization of potentiality. It forms a new potentiality and possesses the energy as a measure of difference (opposition) that can be converted into work.

Niestegge proposed a non-Boolean extension of the classical probability model that reproduces typical quantum phenomena [10]. His model is more general and more abstract, yet easier to interpret than the quantum-mechanical Hilbert space formalism and exhibits a particular phenomenon (state-independent conditional probabilities) that may provide new opportunities for an understanding of non- quantum information.

Let me re-emphasize that my system is primarily about the non-Boolean yet non-quantum cognitive phenomena that exist at the macroscopic level of reality. It mirrors the Lupasco conception of a universe of objects and processes without a background space or time, like that of Rovelli. The aporia of time is a consequence of the recursive, self-referential character of our existence. Bohr himself seems to have come to something like this ontological interpretation of complementarity in his later work.

I thus suggest that any epistemic concept of complementarity should be replaced by an ontological concept of complex interaction. The concept of conjugate variables, familiar in mathematics, describes the non-Kolmogorovian quasi-sinusoidal movement from primarily actual to primarily potential that characterizes existence. The logic of real interactive processes defines Non-Separability, as their central categorical feature., and is compatible with the indicated extension In place of the standard notions of separate categories of parts and wholes, I see systemically non-separable parts and wholes, each sharing some of the others properties.

9. Conclusions

My approach to probability and information can be applied to non-Boolean phenomena in the macroscopic world. It illustrates the essential point of Logic in Reality that its probabilities have an *objective* character that is defined by informational operators. I thus move from standard numerical measures of probability toward a more dynamic concept of the changing probable informational states of processes, more or less actual or potential. Further development of this concept depends on its debate, which I hope will follow.

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