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On Probability and Induction

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Abstract

The present paper attempts to show that probability and induction are connected ideas that help us understand uncertainty. Probability measures how likely something is to happen, ranging from impossible to certain. Induction involves using specific examples to make general conclusions, but we are not always sure if they are true, making our conclusions probable rather than definite. Induction uses specific observations to make broader generalizations, and probability helps measure our uncertainty. Logicians like Kneale, Jevons, and Mill have discussed how probability and induction are related. Some argue that probability stems from induction, while others claim that induction relies on probability. Ultimately, probability is based on induction, which gives it a basis in real-world data. Induction shapes probability, and probability helps guide induction by revealing our level of uncertainty. This interplay is crucial for science and everyday thinking, helping us understand uncertainty and the limits of our knowledge. This is where the paper's relevance actually lies.

Keywords

Induction, probability, uncertainty.

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Introduction:

The term probability is closely associated with inductive logic or induction in that the conclusion of an inductive inference is always probable, not certain. This raises questions about the nature of probability and induction. Probability refers to the uncertainty or doubt associated with an outcome, measuring the likelihood of an event with values ranging from 0 (impossible) to 1 (certain). Induction, on the other hand, is a reasoning process that establishes general truths based on specific or particular instances, as induction is an inference from 'particular to general'. It involves drawing a general conclusion from particular observations, where the conclusion exceeds the premises in scope. However, the premises don't guarantee the truth of the conclusion; they merely provide support. Even with true premises, the conclusion remains probable, not certain. This probability stems from the *leap* from specific observations to a broader generalization. Thus, induction involves moving from some instances of a fact to a general conclusion about all such instances, introducing an element of uncertainty that makes the conclusion probable rather than definitive. The connection between probability and induction is rooted in how we move from specific observations to broader generalizations, highlighting the inherent uncertainty of inductive reasoning, thereby making the conclusion probable and uncertain.

Objectives: The paper's main objectives are outlined below:

(i) To explain the relationship between probability and induction

(ii) To show how probability forms the backbone of induction and how probability is based on induction

(iii) To explain how probability and induction intersect in scientific and everyday thinking.

Methodology: This paper employs a conceptual-analytical approach, reviewing literature on probability and induction to examine their relationship. It explains how probability supports and is informed by induction and highlights their intersection in science and everyday life, drawing on philosophical insights, logical analysis, and illustrative examples.

Discussion and findings:

The term 'probability' has a dual nature, with its everyday meaning differing from its scientific interpretation. In common usage, probability implies that an event is more likely to occur than not, whereas rare events are often described as possible rather than probable. This distinction between possibility and probability is more pronounced in everyday language, where something is considered possible if it

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doesn't involve self-contradiction - a golden mountain, for instance, is possible but not probable in the popular sense. However, scientifically, probability encompasses a broader spectrum, applying to events that are neither impossible nor certain. An event is considered probable in the scientific sense if it falls within this range, including what might be deemed merely possible in everyday language. This scientific interpretation views probability as a matter of degree, existing on a continuum from impossibility to certainty, with varying levels of likelihood in between. Consequently, events considered possible in the ordinary sense are also encompassed within the scientific definition of probability, highlighting the subtle distinction between the two perspectives on probability.

Probability is often quantified as a fraction, where 1 represents certainty and 0 represents impossibility. This fractional representation allows us to express the likelihood of an event occurring, with the denominator indicating the total number of possible outcomes and the numerator representing the number of outcomes that align with the event in question. For instance, in a game of dice, the probability of rolling a six can be calculated by dividing the number of times a six is thrown (numerator) by the total number of throws (denominator). As the number of throws increases, the probability of rolling six approaches 1/6, indicating that it is likely to occur once in every six throws. This illustrates how probability provides a numerical measure of the likelihood of an event, bridging the gap between certainty and impossibility.

Probability can also be expressed as a proportion, where the likelihood of an event is represented by a ratio. For example, the probability of rolling a six is 1/6, which translates to 1 favorable outcome for every 5 unfavorable ones, or a 1:5 chance in favour, and a 5:1 chance against. This concept applies to situations where an event is bound to occur a certain number of times within a limited set, but we are unsure about a specific instance. We acknowledge underlying laws governing the event, making it inevitable, yet our limited understanding of causes and laws forces us to estimate probability rather than predict certainty. Imperfect knowledge leads to probability estimates, whereas perfect knowledge would yield certainty.

The foundation of probability, or the grounds of probability, is viewed differently by various logicians. Some, like Jevons, advocate for a purely subjective approach, where probability is shaped by individual beliefs about an event's occurrence or specific outcome. In contrast, others propose an objective stance, suggesting probability is derived from empirical experience. This highlights a divide in understanding probability's underlying principles, with subjectivists focusing on personal belief quantification and objectivists emphasizing experiential data, illustrating the ongoing debate on whether probability is rooted in personal perspective or observable facts. This dichotomy influences how probability is perceived and applied in different contexts, reflecting fundamental differences in interpreting uncertainty and making predictions based on available information and knowledge.

Carveth Read disagrees with the subjective approach, saying the idea that probability is only based on personal opinions or beliefs isn't a strong viewpoint. He highlights the following reasons why it's not entirely reliable.

Firstly, belief is hard to quantify because it is a mental state that doesn't easily translate into numerical values. For example, if letters are mixed in a bag with one 'x', and we draw them one by one, it's unclear if our confidence in drawing 'x' next actually grows as fewer letters remain, showing the challenge in measuring belief accurately.

Secondly, our beliefs don't always match reality. They are influenced by emotions, biases, and past experiences, so two people can have the same experience but interpret it differently. For example, one person might think they have seen a ghost, while another explains it as a trick of the light. This subjectivity makes it tough to use belief as a basis for calculating probability.

Thirdly, for probability to be relevant to inductive logic, it needs to tie in with the experiences that inform our inductions. Induction relies on beliefs backed by facts, not just any belief. So, the idea that probability is purely subjective is incorrect, not just wrong.

Therefore, it can be said that probability in induction has a dual nature, encompassing both subjective and objective aspects. On the subjective side, it is a mental state of belief or confidence in an outcome; on the objective side, it is rooted in empirical evidence and experience. This dual nature means that when we deem an event probable, we are referencing the evidence for and against it – that is the objective part – and expressing our belief that it is more likely to happen than not, reflecting the subjective element. The balance of evidence informs our belief, making probability a blend of fact-based assessment and personal judgment.

It is important to note here that the term 'induction' has become part of educated discourse, originating as a translation of Aristotle's '*epagoge'*, which means 'leading to' or 'bringing upon'. In Aristotle's works, *epagoge* refers to "the establishment of universal propositions, i.e., propositions expressible in the form 'All á is â', by considering particular cases which fall under them."[1] Induction involves deriving universal principles from particular observations. According to Joyce, it is "the legitimate derivation of universal laws from individual cases."[2] Similarly, Fowler describes it as "the legitimate inference to the general from the

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particular."[3] This shows that an inductive inference draws broader conclusions than its premises, based on observed facts. It involves a *leap* from particular instances to general conclusions, like concluding all men are mortal from Ram and Karim's mortality. The conclusion that all men are mortal isn't a certainty, making it a probabilistic inference from particular to general. In his *The Logic of Scientific Discovery*, Karl Popper says, "It is usual to call an inference 'inductive' if it passes from singular statements... to universal statements, such as hypotheses or theories"[4] highlighting the transition from specific observations to broader theories.

It is important to note that in inductive inferences, the conclusion goes beyond the premises. The premises don't guarantee the conclusion's truth, allowing for true premises and a false conclusion. The premises don't provide definitive proof, making the conclusion probable only, never certain. Thus, inductive conclusions are uncertain and based on likelihood rather than absolute truth.

Moreover, inductive reasoning operates differently from deductive reasoning, so labels like valid or invalid don't really apply. It is more about the strength of the argument, which hinges on how well the premises support the conclusion. If the premises strongly support the conclusion, it is a good inductive argument. The premises might make the conclusion highly likely, or just somewhat plausible – that is what determines the argument's merit. This means inductive reasoning deals with probabilities, not certainties. The conclusion is never guaranteed; it is just more or less likely based on the premises. That is what makes inductive reasoning distinct – it is all about likelihoods, not certainties.

Now the question arises: what is the problem of induction? Induction aims to establish the truth of a universal statement by observing specific instances. It involves making a general claim about all cases based on a few similar examples. This process, known as an '*inductive leap*', takes us from some observed instances to all instances, including unobserved ones, and from known information to unknown territory. However, this leap is problematic because observing a few instances doesn't guarantee that the same pattern holds true for all instances. For instance, observing some black crows leads us to generalize that all crows are black, but we can't possibly observe every crow to confirm this. Observation only tells us about the specific crows that we have seen, not all crows. The truth of specific cases doesn't necessarily lead to the truth of a general statement, so the question remains: how do we justify making these inductive leaps? How do we move from specific observations to broad generalizations, from known to unknown, and from observed to unobserved? This is the problem of induction, highlighting the uncertainty or probability inherent in making general claims based on limited observations.

We know that Induction, a cornerstone of human reasoning, involves drawing broad conclusions from specific observations, but it is inherently uncertain, relying on probability rather than certainty. The problem of induction, first raised by David Hume, questions how we justify making leaps from specific instances to general claims. It reveals that probability plays a central role, gauging the likelihood of a general statement's truth based on observed instances. Observing patterns in a few cases leads us to assign probabilities to hypotheses, like inferring all swans are white after seeing many white swans. Therefore, no one can deny the close relationship between probability and induction or inductive science. In his book *Probability and Induction*, William Kneale says, "The sciences are called inductive, and their conclusions, unlike those of pure mathematics, are said to have only high probability, since they are not self-evident and cannot be demonstrated by conclusive reasoning."[5]

It is interesting to note that some inductive results, like generalizations in elementary chemistry, are so well-established that using 'probably' seems unnecessary. Yet, we can imagine experiences that might compel us to revise them. The inductive sciences are crucial for practice and for shaping our worldview, making their methods a significant part of any discussion on probability.

William Kneale highlights another key reason to focus on induction. According to Kneale, many useful probability statements are established through inductive reasoning. For example, saying it is improbable Jones will act dishonestly given his 20 years of faithful service relies on a rule derived from experience – most people with similar records haven't turned dishonest. This rule, general in form, is itself an inductive inference from observed cases. Since inductive results are probabilistic, stating a probability rule derived from induction should, strictly speaking, be a second-order probability statement – a probability about a probability. This raises serious issues, as our account of induction must cover how probability rules are derived from experience.

Accordingly, a deep connection exists between probability and induction. Probability forms the backbone of induction, offering a way to assess the likelihood of broad claims based on specific observations. Induction, meanwhile, depends on probability to validate its findings. Their interplay is clear in that probability guides induction by measuring uncertainty, induction produces probability statements about hypotheses, and inductively derived probability rules spark questions about second-order probabilities. This complex link hinges on probability's pivotal role in inductive reasoning, intertwining the two concepts in scientific and everyday thinking.

However, the question that needs to be addressed is: Is probability based on induction or is induction based on probability? Logicians typically argue that

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probability is rooted in induction. In contrast, Jevons posits that induction is grounded in probability. Jevons claims that inductive conclusions are probable rather than definitive or certain. Let's examine this perspective as given below.

Jevons emphasizes that Nature's vastness and complexity make it impossible to establish causal connections with absolute certainty. He grounds induction in Nature's uniformity, claiming its conclusions hold true only if this uniformity persists. According to Jevons, "Inductive inference might attain to certainty, if our knowledge of the agents existing throughout the universe were complete, and if we are at the same time certain, that the same power which created the universe will allow it to proceed without arbitrary change. There is always a possibility of causes being in existence without our knowledge, and these may at any moment produce an unexpected effect."[6] Given these limitations, Jevons concludes that inductive inferences are merely probable, indicating that induction is rooted in probability.

In response, it is acknowledged that natural phenomena's complexity does make determining causal connections challenging, but it is an overstatement to claim absolute certainty is unattainable. Jevons' objection stems from an ambiguous interpretation of "certainty". Theoretically, nothing in the universe is absolutely certain, but that is not the kind of certainty science aims for. Fowler says, "Many of our inductive inferences have all the certainty of which human knowledge is capable. There is no special uncertainty attaching to the truths arrived at by induction. They are, indeed, like all other truths, relative to the present constitution of Nature and the present constitution of the human mind, but this is a limitation to which all our knowledge alike is subject, and which it is vain for us to attempt to transcend."[7] Given this, Jevons' view seems unnecessarily pedantic, as many inductive inferences achieve the certainty human knowledge can attain, making his stance overly restrictive.

Conclusion:

From the above discussion, it can be said that the correct view is that probability is rooted in induction, which provides the objective basis for probability. We derive the materials for probable conclusions from experience, relying on induction from observed data. As Mill says, "We trust solely to induction from a sufficiently prolonged basis of actual observation"[8] in all probable inferences. Mill further illustrates this with an example: if observations over many years show a pattern of four dry days followed by three wet days in a particular place, it is inductively certain that this pattern will persist, demonstrating induction's role in shaping probability.

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