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Luck and probability: A philosophical and epistemological study of the shift from intuitive explanation to scientific measurement

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Abstract

This study examines the epistemological and methodological distinction between luck and probability and explains how human reasoning has moved from intuitive interpretations of unexpected events toward formal measurement and evidence-based analysis. It argues that luck should not be treated as an independent causal force. In most ordinary uses, the term reflects incomplete knowledge, limited access to relevant information, or an inability to reconstruct the causal chain that produced an outcome. Probability, by contrast, provides a disciplined mathematical framework for representing uncertainty under explicitly stated assumptions. The study adopts a descriptive-analytical method and traces the two concepts across ancient and modern philosophy, cognitive psychology, economics, politics, and decision theory. It also introduces elementary probability relations to clarify the transition from narrative attribution to measurable uncertainty. The analysis shows that luck and probability are not simply opposites. Luck functions mainly as a psychological and cultural label for surprising outcomes, whereas probability converts uncertainty into quantities that can be examined, revised, and incorporated into decisions. The study concludes that probabilistic thinking does not eliminate uncertainty, contingency, or surprise; rather, it improves the quality of explanation by linking judgments to data, models, assumptions, and transparent rules of inference.

Keywords: Luck, probability, uncertainty, probabilistic thinking, philosophy of science, decision theory, cognitive psychology

1. Introduction

The idea of luck occupies a prominent place in human thought because it offers an immediate explanation for events that appear sudden, unusual, or difficult to understand. When an unexpected success occurs, people may describe the outcome as good luck. When an unforeseen loss occurs, they may attribute it to bad luck. Such language is psychologically convenient because it gives a name to surprise. However, it does not necessarily identify the causes, conditions, or mechanisms that produced the result.

Probability emerged as a more systematic way to reason about uncertain events. It does not remove surprise, guarantee certainty, or predict every individual outcome. Instead, it represents uncertainty in a form that can be estimated, compared, tested, and revised. This capacity explains why probability has become fundamental to mathematics, statistics, economics, medicine, artificial intelligence, public policy, and decision theory.

The research problem arises from the frequent confusion between luck and probability in everyday discourse and, occasionally, in informal explanations of social and economic events. People often use the language of luck when they lack sufficient information, when causal structures are complex, or when an outcome differs sharply from expectation. A probabilistic analysis can examine the same event by identifying the relevant conditions, defining the possible outcomes, estimating their likelihoods, and evaluating the uncertainty attached to those estimates. The central research question is therefore: How did human thought move from explaining uncertain events through luck to analyzing them through probability?

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The importance of this question extends beyond conceptual clarification. The distinction affects how individuals and institutions interpret success, failure, risk, and responsibility. A person who attributes every favorable outcome to luck may ignore the role of preparation, information, and repeated effort. A person who attributes every unfavorable outcome to bad luck may fail to identify avoidable errors. Probabilistic thinking does not deny contingency. It asks a more demanding set of questions: What outcomes were possible? What information was available? Which assumptions were used? How likely was the observed event before it occurred? These questions transform a spontaneous judgment into an analyzable claim.

2. Research Methodology and Objectives

This study adopts a descriptive-analytical methodology. It first defines luck and probability as distinct modes of interpreting uncertain events. It then examines their development in philosophical thought, cognitive psychology, economics, politics, and decision theory. The study is conceptual rather than empirical. Its purpose is not to estimate a new statistical model but to clarify the epistemic transition from impression-based explanation to formal reasoning under uncertainty.

The study has four principal objectives. First, it identifies the conceptual and methodological differences between luck and probability. Second, it explains the philosophical background of chance, causation, and uncertainty. Third, it analyzes how cognitive biases can encourage individuals to interpret outcomes through luck. Fourth, it demonstrates how probability supports risk analysis, political forecasting, and rational choice.

The study proceeds from the hypothesis that luck is primarily a mental and cultural interpretation of unexpected events, whereas probability is a scientific framework for measuring uncertainty. This hypothesis does not imply that probability reveals every hidden cause. A probability statement remains conditional on the model, data, assumptions, and information available to the analyst. The essential difference is that a probability claim can be stated explicitly and evaluated, while a claim based only on luck is usually difficult to test or revise.

3. Conceptual Framework: Luck and Probability

3.1 The Concept of Luck

Luck is an interpretive concept associated with unexpected outcomes. It usually appears when an individual cannot identify the complete set of causes that led to an event or when the observed result differs substantially from what was anticipated. Luck therefore has a strong psychological and cultural dimension. It describes how an event is experienced rather than establishing a measurable causal law.

In everyday life, a person may be called lucky after receiving an unanticipated opportunity or avoiding a serious loss. Another person may be described as unlucky after experiencing an adverse event despite reasonable preparation. Scientific analysis approaches these cases differently. It examines the prior conditions, available choices, environmental constraints, timing, information quality, and random variation. This shift does not invalidate ordinary language. It places the language of luck within its proper explanatory limits.

Luck may also function as a retrospective label. Once an outcome is known, people reconstruct the event in a way that makes it appear either fortunate or unfortunate. This

retrospective interpretation can conceal the range of possible outcomes that existed before the event. An outcome that appears extraordinary after it occurs may have been one of many plausible outcomes in advance. For this reason, a rigorous analysis should distinguish between surprise after observation and probability before observation.

3.2 The Concept of Probability

Probability is a mathematical framework for representing uncertainty over a set of possible outcomes. Let Ω denote the sample space and let A be an event. A probability measure P satisfies the fundamental conditions

$$0 \leq P(A) \leq 1, P(\Omega) = 1.$$

If $A_1, A_2, \dots$ are mutually exclusive events, then

$$P\left(\bigcup_{i=1}^{\infty} A_i\right) = \sum_{i=1}^{\infty} P(A_i).$$

These relations distinguish probability from a purely verbal attribution. A probability value is meaningful only after the event, sample space, information set, and modeling assumptions have been defined. Probability therefore does not describe an event in isolation. It describes the event relative to a specified framework.

Conditional probability is especially important because judgments change when new information becomes available. For events A and B , with $P(B) > 0$,

$$P(A | B) = \frac{P(A \cap B)}{P(B)}.$$

This expression formalizes a basic feature of rational inquiry: evidence should modify belief. An event may seem unlikely under one information set and become plausible under another. When people describe such a change as luck, they may simply be overlooking information that changes the relevant conditional probability.

Bayesian reasoning makes this revision process explicit. If $H_1, \dots, H_k$ are competing hypotheses and E is observed evidence, then

$$P(H_i | E) = \frac{P(E | H_i)P(H_i)}{\sum_{j=1}^k P(E | H_j)P(H_j)}.$$

The equation does not eliminate judgment because prior probabilities and likelihood models must still be specified. It does, however, require the analyst to show how evidence changes the relative credibility of alternative explanations. This transparency is one of the central epistemic advantages of probability.

3.3 An Initial Comparison between Luck and Probability

Table 1 summarizes the principal differences between the two concepts. The comparison should not be read as a claim that probability is infallible or that the language of luck is meaningless. Probability can be poorly modeled, based on biased data, or interpreted with unjustified confidence. The distinction concerns the form of reasoning: probability requires explicit assumptions and permits revision, whereas luck commonly remains an unstructured attribution.

Table 1: Conceptual comparison between luck and probability

Dimension	Luck	Probability
Nature	Psychological, cultural, and impression-based interpretation	Mathematical and methodological representation of uncertainty
Source of judgment	Personal perception and ordinary language	Data, assumptions, formal rules, and models
Testability	Usually weak unless translated into measurable claims	Relatively high when the model and evidence are specified
Epistemic role	Fills an explanatory gap when information is incomplete	Quantifies uncertainty and compares possible outcomes
Response to new evidence	Often remains unchanged as a narrative label	Can be updated through conditional or Bayesian reasoning
Dependence on assumptions	Frequently implicit	Must be stated and examined
Applied example	"The project succeeded because of luck"	"The probability of success increased under specified conditions"

A useful distinction follows from this comparison. Luck is frequently attached to a realized outcome, whereas probability concerns a distribution of possible outcomes before or independently of realization. Every particular sequence of six fair coin tosses has probability $1/64$, yet people often regard a sequence of six heads as more remarkable than a mixed sequence. The difference lies not in the probability of the exact sequence but in the pattern that observers notice and the meaning they assign to it. This example shows why intuition alone can misread randomness.

4. Philosophical Roots of Luck and the Emergence of Probabilistic Thought

Questions about chance and necessity have occupied philosophy since antiquity. Aristotle distinguished events that occur necessarily from those that occur accidentally. In his account, chance did not imply the absence of causes. It referred to the unintended intersection of causal processes (Aristotle, 1996) ^[1]. This interpretation is important because it treats chance as a feature of causal complexity rather than as an autonomous force acting outside nature.

Stoic thought placed events within a comprehensive cosmic order. From this perspective, what appears accidental to an individual may belong to a larger order that exceeds individual knowledge. Marcus Aurelius repeatedly connected human judgment with the limits of perspective and emphasized the need to distinguish events from the interpretations imposed upon them (Aurelius, 2002) ^[2]. Although Stoicism did not formulate modern probability theory, it contributed to the philosophical question of whether uncertainty lies in the world, in human knowledge, or in both. In Arab-Islamic intellectual history, discussions of fate, causation, and human action developed within theological, philosophical, and historical frameworks. Ibn Khaldun's social analysis is especially relevant because it explains political and civilizational outcomes through interacting economic, social, institutional, and psychological causes rather than through isolated anecdotes (Ibn Khaldun, 1967) ^[6]. This approach supports the broader epistemic movement from attributing events to fortune toward reconstructing the conditions that make them possible.

Modern probabilistic thought developed decisively in early modern Europe through attempts to solve problems involving games of chance, uncertain gains, and incomplete information. Hacking (2006) ^[4] explains that this development involved more than the invention of mathematical techniques. It created a new intellectual category in which uncertainty could be treated as an object of rational calculation. Events previously described through fortune, fate, or unpredictability became susceptible to numerical comparison.

The philosophical implications of this transition were substantial. Hume's analysis of induction showed that expectations about the future are not derived from logical

necessity but from experience and habitual inference (Hume, 2007) ^[5]. Later theories of probability attempted to formalize the strength of such expectations. Venn (1866) ^[14] emphasized frequency and long-run regularity, while de Finetti (1974) ^[3] developed a subjectivist interpretation centered on coherent degrees of belief. These approaches differ philosophically, but both replace an unexplained appeal to luck with a disciplined account of uncertainty.

The transition can therefore be described as a change in the structure of the question. The intuitive question asks, "Why was this person lucky?" The probabilistic question asks, "Which outcomes were possible, which conditions were present, and how should the likelihood of the observed outcome be assessed?" The second question does not necessarily provide a complete causal explanation, but it produces a claim that can be examined and challenged.

5. Luck in Modern Thought and Cognitive Psychology

Modern thought increasingly interprets luck as the perceived result of interacting social, psychological, environmental, and informational factors. The same event may be described as lucky by one observer and predictable by another who possesses more information. This variation suggests that judgments of luck depend partly on perspective. What appears random at one level of analysis may reveal structure at another.

Cognitive psychology explains why the language of luck remains attractive even in societies that rely extensively on statistics. Human judgment does not process every possible outcome with equal care. People use mental shortcuts to make rapid decisions, especially under uncertainty. These shortcuts are often efficient, but they can also produce systematic errors in judgment (Kahneman, 2011) ^[7].

Several tendencies strengthen belief in luck. People may remember striking successes more readily than ordinary failures. They may search for evidence that confirms a prior belief about being lucky or unlucky. They may infer causal meaning from short random sequences or assume that a recent run of outcomes must soon reverse. They may also judge a decision only by its final result, ignoring whether the decision was reasonable given the information available at the time. These tendencies blur the distinction between the quality of a decision and the favorability of its outcome.

This distinction is essential. A sound decision can produce a poor result because the world remains uncertain. A careless decision can produce a favorable result by chance. Evaluating decisions solely through outcomes encourages retrospective narratives of luck. A more rational evaluation examines the information set, the alternatives considered, the estimated probabilities, and the decision rule used before the result became known.

Probabilistic literacy therefore reduces dependence on luck as a complete explanation. It teaches individuals to distinguish a

rare event from an impossible event, a favorable outcome from a good decision, and a pattern from a random fluctuation. It also encourages calibrated confidence. A probability estimate of 0.70 is not a promise. It implies that error remains possible and should be incorporated into planning.

6. Applications of Luck and Probability in Economics, Politics, and Decision Theory

6.1 Economics and Risk Analysis

The interaction between luck and probability is especially visible in economics. Financial markets respond to information, expectations, policy decisions, technological change, investor behavior, and unforeseen shocks. An investor may describe an unexpected profit as good luck or a sudden loss as bad luck. Economic analysis instead asks whether the position was exposed to identifiable risks, whether the expected return justified those risks, and whether the observed outcome falls within the range anticipated by the model.

Probability is central to risk analysis because financial decisions concern distributions of possible returns rather than guaranteed values. Historical data and statistical models can estimate expected return, dispersion, tail risk, and the probability of loss. These estimates are never complete descriptions of the future. Markets can change, structural breaks can occur, and models can fail. Nevertheless, a quantified risk assessment is more informative than a retrospective declaration of luck because it makes the assumptions visible.

Mandelbrot and Hudson (2004) ^[10] emphasize that financial variation may be more irregular and extreme than simple models suggest. Their critique illustrates an important point: probabilistic reasoning must include model criticism. The scientific alternative to luck is not blind faith in a formula. It is a continuing process of estimation, testing, revision, and recognition of model limitations.

6.2 Politics and Forecasting

Political forecasting also depends on probability. Election outcomes, coalition formation, public opinion, and policy responses are affected by numerous interacting variables. Polls and forecasting models can summarize current evidence, but they cannot transform political uncertainty into certainty. A forecast of 65% for a candidate means that defeat remains possible. When the less probable outcome occurs, it does not prove that the forecast was useless. The relevant question is whether the model was well calibrated across repeated cases and whether its assumptions were reasonable.

Public discussion often confuses a probable outcome with a guaranteed outcome. This confusion causes people to describe an unexpected result as political luck. A scientific assessment instead examines sampling error, turnout uncertainty, late changes in opinion, model specification, coalition behavior, media effects, and economic conditions. These factors may explain why the outcome differed from the central forecast without requiring the assumption of a mysterious force.

Political analysis must also recognize that probability estimates can influence behavior. Forecasts may affect turnout, campaign strategy, fundraising, and coalition negotiations. Therefore, probabilities in social systems are not always passive measurements. They may become part of the environment they describe. This reflexive feature makes transparency and cautious interpretation especially important.

6.3 Decision Theory

Decision theory combines probability, value, and risk. It provides a formal framework for choosing among alternatives when outcomes are uncertain. Let a denote an action, s_j a possible state of the world, $P(s_j | I)$ its probability given information I , and $U(a, s_j)$ the utility produced by action a under state s_j . The expected utility of an action is

$$EU(a | I) = \sum_{j=1}^m P(s_j | I) U(a, s_j).$$

A rational decision rule selects an action that maximizes expected utility,

$$a_{\text{opt}} = \arg \max_{a \in \mathcal{A}} EU(a | I).$$

This framework, associated with modern utility theory, does not require that individuals care only about money. Utility can represent welfare, safety, time, institutional objectives, or other valued consequences (Von Neumann & Morgenstern, 1944) ^[15]. The framework also separates decision quality from outcome quality. A decision can be rational when it uses the best available probabilities and values, even if an unfavorable state later occurs.

Simon (1947) ^[13] showed that real decision makers operate under bounded rationality. They face limited time, incomplete information, and finite cognitive capacity. Consequently, actual decisions may rely on simplified models and satisfactory rather than optimal solutions. This limitation does not return analysis to luck. It strengthens the need to state what information was available and which uncertainties were ignored.

The practical transition from luck to calculated risk therefore changes the question. Instead of asking, “Will I be lucky?” the decision maker asks, “What outcomes are possible? What probability should be assigned to each outcome? What is the value or cost of each outcome? Which action performs best under the current information?” These questions provide a reproducible basis for judgment.

7. Critique of the Concept of Luck and Reconstruction of Probability

The concept of luck has been criticized because it rarely provides a measurable or testable explanation. To say that an event happened because of luck usually does not identify a mechanism, specify relevant conditions, or generate a prediction. The explanation is often retrospective: it is applied after the outcome is known and may therefore conceal the uncertainty that existed beforehand.

This limitation does not make the word useless. Luck has social and psychological functions. It expresses surprise, acknowledges the role of circumstances beyond individual control, and can reduce excessive personal blame. It may also communicate moral insight. Two people can make similar efforts yet receive very different opportunities because institutions, timing, geography, health, and social networks are unequally distributed. In such contexts, the language of luck can draw attention to contingency and unequal exposure to opportunity.

The scientific problem begins when luck is treated as a sufficient causal explanation. Scientific inquiry requires concepts that can be operationalized, connected to evidence, and exposed to possible refutation (Popper, 1959) ^[12]. Probability meets these requirements more effectively

because it specifies degrees of uncertainty and allows competing models to be compared. However, probability must not be idealized. A numerical value can create an illusion of precision when the underlying data are weak or the model is misspecified.

Probability should therefore be reconstructed as an epistemic discipline rather than a machine for producing certainty. Its strength lies in four practices: defining the relevant event, stating assumptions, updating judgments when evidence changes, and reporting uncertainty honestly. A probability estimate becomes scientifically valuable through these practices, not merely because it is expressed as a number.

8. General Discussion

The analysis shows that luck and probability address the same broad domain—uncertain and unexpected events—but operate at different explanatory levels. Luck describes the human experience of contingency. Probability organizes uncertainty within a formal structure. The two concepts are therefore related but not interchangeable.

The shift from luck to probability should not be presented as a simple historical replacement in which a primitive concept disappears and a superior concept takes its place. Ordinary language continues to need words for surprise, fortune, misfortune, and events outside personal control. The epistemic advance occurs when practical or scientific decisions require more than description. At that point, probability offers a framework for comparing alternatives and evaluating evidence.

This distinction has important educational implications. Students often learn probability as a collection of formulas without understanding its role in reasoning. A stronger approach begins with uncertain situations and asks students to define the sample space, identify assumptions, distinguish independence from dependence, and explain how evidence changes probabilities. Such teaching develops judgment rather than mechanical calculation.

The distinction also matters for public communication. People may interpret a low-probability event as evidence that a model failed, even though low probability does not mean impossibility. Conversely, they may interpret a high-probability event as certain and disregard residual risk. Clear communication should therefore report both the estimate and the conditions under which it was obtained.

For researchers and decision makers, the most practical lesson is to resist both extremes. The first extreme explains every unexpected result as luck and stops inquiry. The second treats every numerical model as objective truth. A mature approach recognizes contingency, seeks measurable structure, tests assumptions, and revises conclusions when evidence changes. Probabilistic thinking is valuable precisely because it makes uncertainty visible rather than hiding it.

9. Conclusion

1. Luck functions primarily as a psychological, cultural, and retrospective interpretation of unexpected events. It does not usually constitute an independent scientific explanation unless it is translated into identifiable causes, conditions, or measurable uncertainty.
2. Probability provides a formal framework for representing uncertainty through explicit events, assumptions, data, and rules of inference. Its scientific value lies in its transparency and capacity for revision.
3. The relationship between luck and probability is best understood as an epistemic transition from spontaneous

attribution to structured analysis, not as a complete elimination of ordinary concepts of fortune and contingency.

4. Cognitive biases can strengthen belief in luck by encouraging selective memory, pattern detection in random variation, retrospective judgment, and confusion between decision quality and outcome quality.
5. Probability has major practical importance in economics, politics, and decision theory because it supports risk assessment, forecasting, evidence updating, and comparison among uncertain alternatives.
6. The distinction between luck and probability promotes critical awareness. It encourages individuals and institutions to ask what information was available, which assumptions were used, how uncertainty was measured, and whether conclusions should change when new evidence appears.

10. Research Recommendations

1. Educational institutions should strengthen the teaching of probabilistic reasoning at school and university levels. Instruction should connect formulas with real decisions, uncertainty, and model assumptions.
2. Researchers should avoid using luck as a final explanation. Unexpected findings should lead to an examination of data quality, causal conditions, sampling variation, and model adequacy.
3. Future empirical studies should measure how beliefs about luck influence economic, educational, health, and social decisions across different cultural and institutional settings.
4. Training programs for decision makers should include probability, risk communication, calibration, expected utility, and the interpretation of low-probability high-impact events.
5. Interdisciplinary research should connect philosophy, psychology, statistics, economics, and political science to develop a more complete account of how people understand and manage uncertainty.

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