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Psychological narratives in decision theory: what they are and what they are good for

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ABSTRACT

Decision theory is a branch of economics concerned with how individuals make choices under conditions of uncertainty. The mathematical models developed in this field are generally accompanied by 'psychological narratives,' i.e. accounts of the psychological factors and processes that determine an individual's choices under uncertainty. This paper makes three contributions. First, it reviews the psychological narratives associated with nine influential models developed since the late 1970s to supersede expected utility theory. Second, it examines the epistemological status of these narratives, arguing that they draw from folk psychology and are best understood as as-if constructs. Third, it explores two main epistemic functions of psychological narratives: they serve as rhetorical devices that enhance a model's perceived validity; more importantly, and despite their fictional nature, they provide explanations for choice-behavior phenomena. Recognizing this latter function requires abandoning the assumption that truth is a necessary condition for explanation.

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1. Introduction

Broadly speaking, decision theory is the part of economics that studies how individuals make choices among alternative options. These options may be of different types: presently available bundles of goods, mortgage contracts involving a series of predetermined future payments, or prospects that entail uncertainty. In the latter case, the outcome of a decision depends on whether a particular event occurs. For instance, the outcome of the decision to buy a lottery ticket depends on whether the ticket is drawn, while the outcome of the decision to undergo surgery depends on whether the operation is successful. When economists refer to decision theory without further qualification, they typically mean the branch of economics concerned with how individuals make choices under uncertainty. It is in this specific sense that the term 'decision theory' is used in this paper.

The models of decision theory have a mathematical character and are often highly formalized. They typically feature a function that identifies the decision an individual makes or should make, a set of axioms that define the properties of the individual's preferences between uncertain options, and theorems connecting these axioms to the function proposed by the model. However, these mathematical models are generally accompanied by 'psychological narratives.' These are accounts of the psychological factors and processes that, according to the model, determine an individual's choices under uncertainty – leading her, for instance, to buy a lottery ticket rather than forgo it or to opt for pharmacological therapy over surgery.

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In discussing the psychological narratives of decision theory, it is useful to distinguish two layers. The first layer of a narrative concerns the single psychological determinants of the individual's behavior in situations of uncertainty, such as the desire to gain money or the fear of losing money; the aversion, or attraction, to uncertainty; the beliefs about the likelihood of events; or concerns about the potential disappointment if a decision turns out to be mistaken. Intuitions about these psychological determinants are formalized using technical concepts and tools such as utility functions, preference relations, probability measures, and decision weights. The second layer concerns the way in which the single psychological determinants are combined into a decision mechanism. Typically, this happens via mathematical operations, such as multiplication, summation, maximization, or integration.

For example, consider the canonical model in decision theory, Expected Utility theory (EU). According to the psychological narrative associated with EU (or, more exactly, with one version of this theory; see sections 4.1 and 4.2), two main factors drive economic behavior under uncertainty: the intensity of the individual's desires for outcomes and her beliefs about the likelihood of those outcomes. In EU, these are expressed by a utility function $u(x)$ and a probability function $p(x)$, which are then combined via multiplication and summation. Specifically, in the psychological narrative of EU, the individual weighs the desirability $u(x_i)$ of each of the N possible outcomes by multiplying it by its probability $p(x_i)$, and chooses the option for which the expected utility $\sum_{i=1}^{N} u(x_i)p(x_i)$ is highest. In our initial examples, according to EU, the individual will buy the lottery ticket or undergo surgery if the expected utility of doing so exceeds that of all alternative choices.

This paper makes three main contributions. First, it reviews the psychological narratives that have accompanied some prominent decision models developed since the late 1970s to supersede EU, presenting the material in an accessible manner and as a case study for subsequent methodological considerations. Second, it investigates the epistemological status of these narratives, arguing that the psychological factors and mechanisms they describe do not correspond to actual mental entities and processes and should therefore be understood as as-if constructs. Third, the paper explores the epistemic functions of psychological narratives, contending that, despite their fictional nature, they provide explanations for choice-behavior phenomena. Recognizing this function requires abandoning the assumption that truth is a necessary condition for explanation.

A more detailed illustration of these contributions, along with their relationship to the existing literature, is provided by the next two subsections.

1.1. Outline

EU became the dominant economic model of decision-making under uncertainty in the early 1950s. Although some alternative models were proposed during the 1950s and 1960s (e.g. Allais, 1953; Ellsberg, 1961), it was not only until the late 1970s that the accumulation of robust experimental evidence against EU prompted decision theorists to advance a range of models intended to supersede it. Since then, the development of these post-EU models has remained a major trend in economic analysis (for a history of EU, see Moscati, 2023).

The literature distinguishes between two main types of decision models: those for decision-making in situations of *risk*, where objective probabilities can be assigned to each possible event and are assumed to be known by the decision maker, and models for decision-making under *ambiguity*, where objective probabilities are unavailable or unknown.[1]

In the lottery example, if the decision maker knows that the objective probability that the purchased ticket is drawn is 1 in 10, 000, then her decision of whether to buy a lottery ticket is a decision under risk. In contrast, in the surgery case, especially when medical data on similar operations are scarce, the choice of whether to undergo surgery is a decision under ambiguity.

Sections 2 and 4 review the psychological narratives about the single psychological factors and the decision mechanisms that combine these factors in nine post-EU decision models – six for risk and three for ambiguity. The risk models are prospect theory (Kahneman & Tversky, 1979), rank-dependent utility theory (Quiggin, 1982), regret theory (Loomes & Sugden, 1982; Sugden, 1993), disappointment theory (Loomes & Sugden, 1986), cumulative prospect theory (Tversky & Kahneman, 1992; Wakker & Tversky, 1993), and salience theory (Bordalo et al., 2012). The ambiguity models are Choquet expected utility theory (Schmeidler, 1989), the maxmin expected utility theory (Gilboa & Schmeidler, 1989), and the smooth model of ambiguity (Klibanoff et al., 2005).

While this review may at times seem tedious, it is necessary to present the material considered in the subsequent methodological discussion. The analysis of these decision models will be simplified, aiming for accessibility even to readers unfamiliar with decision theory.[2] The selection of the nine models is primarily based on their significance and impact in the literature.

Sections 3 and 5 investigate the epistemological status of the psychological narratives attached to post-EU decision models by addressing the following questions: Do these narratives draw from scientific psychology, or do they mainly draw from introspection and folk psychology – that is, the conceptualization of mental states based on commonsensical, prescientific notions? Should these narratives be understood realistically as representing actual psychological factors and mechanisms that operate in the decision maker's mind? Or are they best understood as as-if stories in the sense of Friedman's (1953) methodological views?

I will argue that psychological narratives in decision theory primarily draw on introspection and folk psychology rather than on scientific psychology; that the psychological factors and mechanisms they describe – such as the ranking of alternatives through complete and transitive preferences, or the calculation of expressions like $\sum_{i=1}^{N} u(x_i)p(x_i)$ – are cognitively too demanding to be performed by actual decision makers; and that, therefore, these factors and mechanisms are best understood as as-if constructs.

This claim gives rise to an apparent paradox: If psychological narratives in decision theory are best understood as as-if stories, why are they so ubiquitous? Why do decision theorists not simply put forward a mathematical decision model, deduce its empirically observable implications, and test its descriptive validity without bothering to offer a psychological narrative supporting the model? In other words, what epistemic functions do as-if psychological narratives perform in decision-theoretic modeling?

Sections 6 and 7 argue that the paradox is, in fact, only apparent. Its resolution lies in recognizing that, despite their potentially fictional nature, psychological narratives serve two primary epistemic functions in decision theory. First, in a situation where neither experimental studies nor normative considerations have narrowed down the set of proposed post-EU models, psychological narratives act as rhetorical devices that enhance the perceived validity of a model. Second, they provide explanations for choice-behavior phenomena. Recognizing this latter function requires reconsidering the traditional notion of scientific explanation, which holds that only true accounts explain. Drawing on recent work in the philosophy of science, I emphasize the plurality of epistemic functions that scientific explanations can serve and argue that many of these functions can be fulfilled even by explanations that are not true.

Sections 8 concludes.

1.2. Related literature

In discussing psychological narratives in decision theory, this paper contributes to the recent methodological and historical literature, developed by Morgan and other scholars, that explores the epistemic functions of narratives in scientific research broadly, and economics in particular (see e.g. Juille & Jullien, 2017; Morgan, 2012, 2017; Morgan et al., 2022; Morgan & Stapleford, 2023; Morgan & Wise, 2017). This literature, however, has not examined the status and functions of the psychological

narratives featured in post-EU decision models. My claim that decision-theoretic narratives provide explanations for choice-behavior phenomena aligns closely with Morgan's (2017, p. 86) thesis that narratives in science 'work … as a form explanation.' The contribution of this paper is to investigate more precisely how psychological narratives fulfill their explanatory functions in decision theory, despite being fictional in nature.

Mehta (2013) and Lecouteux (2023) provide critical examinations of psychological narratives regarding the limited cognitive capacities of individuals, often found in behavioral economics. Mehta and Lecouteux address the policy implications of these behavioral narratives, while my focus here lies on the epistemological status and epistemic functions of decision-theoretic narratives.

In an article titled 'What are axiomatizations good for?', Gilboa et al. (2019) discuss the functions of a main component of contemporary decision theory, namely, the so-called 'representation theorems' that connect axioms on the decision maker's preferences to the mathematical function expressing the decision rule proposed by the model. This paper complements Gilboa et al.'s work by discussing the functions of another main component of decision theory: the psychological narratives accompanying decision models.

Focusing on the notions used in EU, Mongin (2011) highlights the difference between the conceptualization of mental states based on folk psychology and the corresponding theoretical constructs of decision theory. Here, Mongin's discussion is extended to include the notions used in post-EU decision models.

This paper belongs to a broader research project of mine that aims at understanding the nature of decision-theoretic models. In Moscati (2023, 2024a), I have already put forth some of the claims about the as-if character of decision models and the nature of scientific explanations presented here. However, those works do not examine the diverse array of psychological narratives employed in contemporary decision theory, nor analyze their functions in depth.

The apparent paradox concerning the role of psychological narratives mentioned above (if these narratives are best understood as as-if stories, why do decision theorists bother to offer them?) relates to what Reiss (2012) calls the 'explanation paradox.' This paradox consists of three mutually inconsistent statements that, according to Reiss, are widely accepted: (1) economic models are false; (2) economic models are nevertheless explanatory; and (3) only true accounts explain. In section 7, I propose resolving the paradox by abandoning the assumption that truth is a necessary condition for explanation, that is, by rejecting statement (3).

In economics, the term narrative is most commonly associated with Shiller's (2019) research on 'narrative economics,' which investigates how popular and possibly nonfactual narratives spread among economic actors, influence their behavior, and generate macroeconomic phenomena such as business cycles. There are at least two key distinctions between Shiller's narratives and the psychological narratives discussed here. The first concerns their 'producers' and 'consumers': Shiller's narratives are produced and consumed by economic actors in the course of their economic activities, whereas the psychological narratives associated with decision models are formulated and potentially embraced by decision theorists as they develop, apply, or teach these models. The second distinction lies in the focus of our inquiries. Shiller concentrates on the economic effects of the narratives he examines, that is, on how they impact individuals' economic behaviors regarding spending, saving, and similar activities. In contrast, this paper explores the epistemic effects of psychological narratives, specifically, how they influence the way decision theorists interpret a decision model or assess its validity.

In psychology, Tuckett and his co-authors (see, e.g. Johnson et al., 2023; Tuckett & Nikolic, 2017) have developed 'conviction narrative theory,' a psychological framework that examines how individuals construct and use narratives to convince themselves and potentially others that their choices in complex situations are the right ones. As with Schiller's narrative economics, there are at least two important distinctions between Tuckett's conviction narratives and the psychological narratives discussed here. Once again, their producers and consumers differ: Tuckett's narratives are constructed and adopted by individuals in their everyday lives to guide practical decisions (e.g. whether to

divorce), whereas the narratives examined here are formulated and utilized by decision theorists for scientific purposes. Additionally, we approach the role of narratives from different perspectives. Tuckett's work is rooted in psychology: he and his coauthors seek to understand how conviction narratives help individuals make decisions. In contrast, my analysis falls within the philosophy of science: I am concerned with the epistemological status and epistemic functions of psychological narratives in decision theory.

2. Narratives about single psychological factors

This section reviews the wide range of narratives about the single psychological factors featured in the nine post-EU decision models for risk or ambiguity considered in the paper. The review focuses on a dozen narratives concerning single psychological factors and is structured around five main themes: narratives about utility, narratives about preferences, narratives about probability weighting in situations of risk, narratives about beliefs in situations of ambiguity, and narratives about attitudes toward ambiguity.

2.1. Utility

2.1.1. Desires, satisfaction, utility

Since the marginal revolution of the late nineteenth century, the fundamental psychological narrative in much economic theory is that individuals desire things and act to obtain them. Desires can stem from various motivations: biological needs, physical or intellectual pleasures, moral commitments, or religious prescriptions. When individuals obtain what they desire, they experience satisfaction from consuming, using, or possessing those items (see, e.g. Jevons, 1871; Marshall, 1890).

The intensity of desire or satisfaction that an individual derives from an object x is expressed by the number that a real-valued function $u(x)$, called a utility function, associates with x. It is often assumed that the additional satisfaction an individual obtains from an additional unit of a commodity diminishes as the individual consumes or possesses a larger quantity of it. This is called the principle of diminishing marginal utility, and it implies that the utility function $u(x)$ is concave.

In post-EU decision models, the utility function $u(x)$ is frequently modified to incorporate various psychological factors that were not considered in earlier models.

2.1.2. Reference dependence

In advancing prospect theory (1979), and later cumulative prospect theory (1992), Kahneman and Tversky argued that basic principles of perception and judgment indicate that individuals typically perceive outcomes as gains or losses relative to a reference point, rather than as final states, as assumed in EU.

Focusing on monetary outcomes, let r denote the decision maker's reference point and x the actual monetary payoff. Reference-dependent outcomes are then defined as $x - r$, and the utility function becomes $u(x - r)$. When x exceeds r, the individual experiences a gain; conversely, when x is less than r, she experiences a loss. The reference point r is not fixed: it can be the individual's initial wealth, a payoff that she aspires to obtain, the average payoff obtained by her peers, or another relevant benchmark.

2.1.3. Loss aversion

Kahneman and Tversky also argued that the discomfort individuals experience from losing a sum of money is greater than the pleasure they derive from gaining the same amount. For example, the pain associated with a loss of \$100 is more severe, in absolute value, than the joy associated with a gain of \$100: $|u(-\$100)| > |u(+\$100)|$. This psychological phenomenon is known as loss aversion.

2.1.4. Regret and disappointment

The theories of regret and disappointment developed by Loomes and Sugden (1982, 1986) share the psychological consideration that the utility an individual derives from an outcome depends not only on the outcome itself but also on the pain or pleasure she experiences when comparing it with an alternative outcome she could have obtained under different circumstances.

In regret theory, the individual compares the utility $u(x)$, experienced if she chooses course of action A and event E occurs, with the utility $u(y)$ she would have experienced in the same event E had she chosen course of action B. In disappointment theory, the individual compares the utility $u(x)$, experienced if she chooses course of action A and event E occurs, with the average intrinsic utility associated with that action.

More formally, in both theories, the overall utility an individual derives from outcome x results from two distinct factors: (1) the basic or intrinsic utility $u(x)$ of the outcome; and (2) the utility $\theta(u(x) - u^*)$, which hinges on how $u(x)$ compares with u^*, the utility she could have obtained under different circumstances. Thus, the overall utility of outcome x is given by $u(x) + \theta(u(x) - u^*)$.

2.2. Preferences

A second psychological narrative – only partially complementary to the one based on utility – emerged in decision theory with Pareto (1906/2014) and centers on the notion of preference.

According to this narrative, individuals do not directly assign utility numbers to options and choose the one with the highest number. Instead, they simply compare options based on their preferences and select the one they prefer most. In this approach, preference is the primary psychological concept, while utility becomes an ancillary mathematical tool without a clear psychological interpretation: it merely serves as a numerical index that represents an individual's preference ranking by assigning higher numbers to more preferred options (for an historical account, see Moscati, 2018).

Pareto and the so-called 'ordinalists' who adopted his approach in the 1930s were comfortable with the commonsensical and somewhat vague notion of preference. However, in the 1940s, von Neumann and Morgenstern (1944) formalized this intuitive concept and transformed it into a precise technical construct. They defined 'preference' as a binary relation, that is, a relation between any two entities. This relation is denoted by the symbol $\succeq$, where $x \succeq y$ indicates that the individual either prefers x to y or is indifferent between them. A utility function u represents an individual's preference ranking $\succeq$ if and only if $x \succeq y$ implies $u(x) \geq u(y)$.

For preferences to be representable by a utility function in this sense, they must satisfy certain properties that are defined by axioms. Among these properties, completeness and transitivity play a central role. Completeness requires that individuals are aware of all available alternatives and that, when faced with any two options x and y, they are never undecided: they either prefer x to y, or y to x, or are indifferent between them. Transitivity states that if an individual prefers x to y and y to z, then she should also prefer x to z. Together, completeness and transitivity ensure that individuals can rank all options from the least to the most preferred and choose the most preferred one.

Although the notions of utility and preference are closely interconnected, it is useful to treat them as distinct. As discussed is sections 4, 5, and 7.2, in fact, utility and preferences underpin two different narratives about the psychological mechanisms that produce decisions.

2.3. Decision weights in situations of risk

2.3.1. Decision weights vs. distorted probabilities

In situations of risk, each possible uncertain outcome x_i is associated with an objective probability $p(x_i)$, and the decision maker is supposed to know the full probability distribution $p(x)$. In EU, the decision maker's beliefs about the likelihood of outcomes coincide with their objective probabilities $p(x_i)$, and she weighs the utility $u(x_i)$ of each outcome by multiplying it by its probability $p(x_i)$.

In contrast, several post-EU models for risk – including prospect theory, rank-dependent utility theory, cumulative prospect theory, and salience theory – posit that individuals weigh the utility $u(x_i)$ of each outcome by multiplying it by a factor $w[p(x_i)]$, called a 'decision weight.' Decision weights may, and typically do, differ from objective probabilities. For instance, in the lottery example, an individual may weigh the utility of winning a $\$1,000,000$ prize by multiplying it by 0.01, even if she knows that the objective probability of winning is 0.0001 rather than 0.01.

There are two interpretations of decision weights. According to an early view proposed by the experimental psychologists who explored the issue in the 1940s and 1950s (see, e.g. Edwards, 1953; Preston & Baratta, 1948), decision weights are subjective distortions of objective probabilities. On this interpretation, they are difficult to justify normatively: an individual who knows that the objective probability of winning the $\$1,000,000$ prize is 0.0001 but assess it as 0.01 seems to be deceiving herself through wishful thinking.

In the post-EU literature, however, the interpretation is typically different. As argued by Kahneman and Tversky (1979, p. 280) decision weights measure 'the impact of events on the desirability of a prospect.' From this standpoint, the individual who attaches a decision weight of 0.01 to the $\$1,000,000$ prize is not distorting objective probabilities or deceiving herself. Rather, that decision weight reflects the strong psychological impact of the prize's desirability, which leads her to evaluate the prize with a weighting factor of 0.01 instead of 0.0001.

2.3.2. Prospect theory

In prospect theory, Kahneman and Tversky (1979) posited that individuals weigh the probabilities $p(x)$ of single outcomes x, so that decision weights take the 'simple' form $w[p(x)]$. Specifically, Kahneman and Tversky suggested that individuals tend to overweigh unlikely extreme outcomes (such as winning a lottery prize) and underweigh likely outcomes. This implies that for low probabilities $w(p) > p$, while for high probabilities $w(p) < p$, resulting in an S-shaped weighting function.

2.3.3. Rank-dependent utility theory and cumulative prospect theory

According to rank-dependent utility (Quiggin, 1982) and cumulative prospect theory (Tversky & Kahneman, 1992), individuals do not weigh single probabilities but rather 'cumulative probabilities.' Introducing this concept requires reordering and ranking the outcomes of a risky prospect – typically a lottery with monetary payoffs – from the least desirable (denoted x_1) to the most desirable (denoted x_N).[3] Correspondingly, p_1 is the probability of the least desirable outcome x_1, p_2 is the probability of the second-least desirable outcome x_2, p_i is the probability of the outcome of rank i in the ordered series of outcomes, and p_N is the probability of the most desirable outcome x_N.

This reordering of outcomes and their probabilities enables defining cumulative probabilities as $p_i + \ldots + p_N$. This is the probability of obtaining either outcome x_i or an outcome better than x_i, or, equivalently, an outcome at least as good as x_i.

In the psychological narrative associated with rank-dependent utility theory and cumulative prospect theory, individuals are assumed to weigh the cumulative probability of obtaining an outcome that is at least as good as x_i. Thus, probability weighting takes the form $w(p_i + \ldots + p_N)$. The term 'rank-dependent' is used for models employing this form of probability weighting because the cumulative probability $p_i + \ldots + p_N$ attached to each outcome x_i depends on its rank in the ordered series of outcomes.

As argued by Quiggin (1982, pp. 325–326), rank-dependent probability weighting has two main advantages over probability weighting applied to single probabilities. At the descriptive level, it allows for the possibility that individuals assign different weights to outcomes with the same probability but different ranks (e.g. the best outcome and an intermediate outcome both having a probability of 0.01). At the normative level, it rules out an unwelcome possibility permitted by single-probability weighting, namely that individuals might prefer stochastically dominated options, that is, options that consistently yield less than other available alternatives (on this point, see also Fishburn, 1978).

2.3.4. Salience theory

According to salience theory (Bordalo et al., 2012), individuals overweigh outcomes that attract their attention, i.e. those that are salient, while they underweigh outcomes that are nonsalient. In the simplest version of the theory, the individual faces two lotteries, A and B, each yielding N monetary payoffs. The payoff x that lottery A yields if event E occurs is salient if it differs significantly in percentage terms from the payoff y that lottery B yields in the same event E. More formally, the salience index $\sigma(x, y)$ for payoff x is defined as $\sigma(x, y) = \frac{|x-y|}{|x|+|y|}$. The individual is then supposed to rank and reorder the N payoffs based on their salience index σ. The most salient payoff x_1 has rank k_1, the least salient payoff x_N has rank k_N, and generic payoff x_i has rank k_i.

Like prospect theory, salience theory applies decision weights to single outcomes and their probabilities rather than to cumulative probabilities. However, unlike prospect theory, the decision weight attached to outcome x_i depends not only on its objective probability $p(x_i)$ but also on its salience rank k_i and a parameter δ that measures the individual's sensitivity to salience. Specifically, the decision weight attached to outcome x_i is given by $p(x_i)\delta^{k_i}$.

2.4. Beliefs in situations of ambiguity

In situations of ambiguity, the objective probabilities of events are unavailable or unknown to the individual, who is instead assumed to hold subjective beliefs about the likelihood of the N possible events E_i. In EU, the decision maker's subjective beliefs are represented by a single function $\pi(E)$ that satisfies all properties of standard probability functions, notably additivity. Additivity states that the probability of two disjoint events is equal to the sum of their individual probabilities, and implies that the sum of all possible events equals one.

Post-EU decision models for ambiguity account for the fact that in many situations it is not possible to represent the individual's beliefs by a single probability function $\pi(E)$. These models are typically accompanied by one of two psychological narratives regarding the individual's beliefs under ambiguity.

2.4.1. Multiple probability distributions

In the first narrative, found in maxmin expected utility theory (Gilboa & Schmeidler, 1989) and the smooth model (Klibanoff et al., 2005), the decision maker is assumed to consider a set of possible probability distributions $\pi_1, \ldots, \pi_Z$ over the events, rather than a single probability distribution π. These distributions are those that she cannot rule out based on the available information.

For example, consider a patient deciding whether to undergo surgery after consulting two different doctors. According to doctor 1, the surgery succeeds (event E_1) 9 times out of 10 and fails (event E_2) 1 time out of 10. According to doctor 2, the surgery succeeds only 5 times out of 10. In this case, the patient may consider two possible probability distributions, π_1 and π_2, where $\pi_1(E_1) = 0.9$ and $\pi_2(E_1) = 0.5$.

In some versions of the narrative, such as that accompanying the smooth model, the individual holds second-order beliefs $\mu(\pi_i)$ about which possible distributions are more likely. In our medical example, if the patient trusts doctor 1 more than doctor 2, this belief may be expressed by saying that she attaches second-order probabilities $\mu(\pi_1) = 0.6$ and $\mu(\pi_2) = 0.4$ to the overall evaluations π_1 and π_2 made by the two doctors.

2.4.2. Capacities

In the second psychological narrative, which accompanies Choquet expected utility theory (Schmeidler, 1989), individuals' beliefs are expressed by a single probability measure $c(E)$, which, however, does not satisfy the additivity property. These measures, introduced by the French mathematician Gustave Choquet in the 1950s, are called nonadditive probabilities or capacities. According to the capacity-based narrative, the patient may believe that the surgery succeeds 8 times out of 10 and fails 1 time out of 10. In this case, $c(E_1) = 0.8$, $c(E_2) = 0.1$, and $c(E_1) + c(E_2) = 0.9$, violating additivity.

More specifically, in Choquet expected utility theory, capacities apply to unions of events such as $E_i \cup \ldots \cup E_N$. Similar to rank-dependent utility theory, the outcomes x_i and the events E_i under which they are obtained can be reordered from the least desirable (x_1 under E_1) to the most desirable (x_N under E_N). Accordingly, $E_i \cup \ldots \cup E_N$ represents the event in which the individual obtains an outcome at least as good as x_i, and the capacity $c(E_i \cup \ldots \cup E_N)$ expresses the individual's belief that she will obtain an outcome at least as good as x_i.

2.5. Attitudes toward ambiguity

Ellsberg (1961) observed that most individuals prefer choosing between risky options rather than ambiguous ones, in a way that cannot be accounted for by EU. He attributed these preferences to a distinct psychological factor not incorporated in EU, namely the individual's attitude toward ambiguity.

In the model Ellsberg proposed, this attitude is indirectly captured by a parameter ρ, which measures the individual's degree of confidence in her beliefs about the ambiguous events she faces. ρ ranges between zero and one, with higher values indicating greater confidence and, consequently, less concern for ambiguity (for more on Ellsberg's model, see Moscati, 2024b). Although Ellsberg's model did not catch up in decision theory, his insight that attitude toward ambiguity is a specific psychological factor influencing decision-making remains important in post-EU ambiguity models.

In maxmin expected-utility theory (Gilboa & Schmeidler, 1989), individuals are explicitly assumed to be ambiguity averse, and this attitude is formalized through one of the preference axioms underlying the model, namely the 'uncertainty aversion axiom'. The smooth model (Klibanoff et al., 2005) features a function ϕ, whose curvature reflects the individual's attitude toward ambiguity: a concave ϕ expresses ambiguity aversion, while a convex ϕ expresses attraction to ambiguity.

3. Discussion of single psychological factors

3.1. Many plausible narratives, many decision models

The most notable insight from the review in section 2 is the multitude of psychological factors invoked in the narratives associated with post-EU models.[4] Moreover, many of these narratives seem, at least initially, plausible: it appears plausible that people care more about possible losses than gains, are concerned about potential regrets and disappointments, evaluate outcomes using weights that may differ from objectives probabilities, attach greater importance to salient outcomes, consider – when information is lacking – a range of possible probability distributions rather than a single one, hold beliefs that may not satisfy the additive properties of probability, and exhibit aversion toward ambiguity.

However, over the past forty-five years, introducing novel psychological factors 'by plausibility' has led to a proliferation of post-EU decision models. The challenge posed by this proliferation is that neither experimental tests of their descriptive validity nor arguments about their normative validity have succeeded in narrowing the set of plausible models.[5]

3.2. The ineffectiveness of experimental model selection

Numerous experimental studies have been conducted to test and compare the descriptive validity of post-EU models.[6] However, the psychological factors featured in these models – or, more precisely, the decision-theoretic concepts designed to capture them (e.g. reference points, regret and disappoint functions, decision weights, parameters expressing attitudes toward ambiguity) – are difficult to identify through experimental data. As a result, these concepts operate as flexible variables within the models, often allowing for opportunistic adjustments to ensure compatibility with various experimental findings.

Furthermore, concerns about experimental design – including factors such as the size of incentives, the information presented to subjects, and the statistical significance of results – frequently cast doubt on the reliability of findings, weakening their role in supporting or refuting a given decision model. To be sure, some of these issues are common across experimental economics, but they appear particularly pronounced in research on post-EU models.[7]

In Popperian terms, the empirical falsification or validation of competing models has proved particularly challenging in post-EU decision theory, failing to establish a consensus on which post-EU models are most reliable.[8]

3.3. Many decision models, many rationality concepts

Normative arguments about the rationality of the psychological drives underlying post-EU models have likewise failed to narrow the field. In fact, the introduction of novel psychological factors on the basis of their plausibility has led not only to a proliferation of models but also to a corresponding multiplication of rationality concepts.

Specifically, the narratives about psychological factors are often used to argue that a proposed post-EU model is not only descriptively valid but also normatively justifiable. For example, individuals who care more about possible losses than gains, or who are concerned with potential regrets and disappointments, have been seen as rational or, at least not irrational (see Loomes & Sugden, 1982, p. 820; Loomes & Sugden, 1986, p. 280). Likewise, it has been argued that individuals who, in ambiguous situations, contemplate a range of possible probability distributions, hold beliefs that do not satisfy the additive properties of probability, and dislike – or even like – ambiguity, are not irrational (see Gilboa & Schmeidler, 1989, pp. 142–143; Klibanoff et al., 2005, pp. 1850–1851; Schmeidler, 1989, pp. 571–572). If such attitudes are normatively justifiable even if they lead to choice behaviors violating EU, then – so the argument goes – it is the concept of rationality embedded in EU and its axioms that should be revised in favor of a more liberal notion, one that accommodates these behaviors (see, e.g. Gilboa et al., 2009, pp. 285–289; Gilboa et al., 2012, pp. 18–20).

My point here is not to criticize what Hume might have called an unjustified leap from *is* to *ought*, but rather to emphasize that this shift has not helped narrow the set of creditable post-EU models. The liberal concept of rationality embedded in any given model, and typically characterized by a particular set of axioms, seems compelling when the model and its axioms are considered in isolation. Yet, once the broader landscape of competing models and axiomatic systems is considered, it becomes clear that there is a risk of ending up with as many concepts of rationality as there are post-Expected Utility decision models.

3.4. Introspection, folk psychology, and scientific psychology

I submit that most ideas proposed by decision theorists about the psychological determinants of decision-making stem not from scientific psychology, but from a mixture of introspection and folk psychology – that is, commonsense, prescientific notions of the mind.

References to findings in scientific psychology are in fact rare in the decision-theoretic literature, even for post-EU decision models that are often presented by their advocates as more psychologically grounded than EU. Moreover, even when such references are present (as in Kahneman & Tversky, 1979 or Bordalo et al., 2012), the plausibility of the model does not seem to hinge on them. To wit, we do not find the idea that people overweigh salient outcomes persuasive because Bordalo and coauthors (2012, p. 1254) cite the *Principles of Neural Science* by Kandel et al. (1991) but rather because we intuitively and introspectively find the idea of salience compelling.

One reason why findings from scientific psychology play such a limited role in decision theory is likely that many decision theorists are trained as applied mathematicians or mathematical economists, rather than as psychologists.[9] Another likely reason is that psychology itself lacks a unified and

shared theory about decision-making processes. As in economics, there are many alternative theories of decision-making in psychology. Furthermore, decision models in psychology often refer to psychological factors, such as personality traits, emotional states, or cognitive abilities, that are very different from those currently used in economics (see, e.g. Almlund et al., 2011; Mata et al., 2018). Therefore, appealing to one of the k available psychological theories to support the n-th economic model of decision-making arguably does not significantly enhance its persuasiveness.

3.5. From psychological intuitions to technical constructs

The plausibility of the narratives associated with decision models begins to diminish when psychological intuitions are transformed into technical constructs. Although it seems plausible that an individual desires the different possible outcomes of a prospect with varying intensities, it is less plausible that she can assign these intensities numerical values, as required by the utility function. While it is plausible that an individual has preferences between different objects, it is less plausible that she is aware of all options available to her and that she is never undecided between them, as completeness requires (more on this point in section 5.3). Although it is plausible that an individual overweighs salient outcomes, it is less plausible that she can calculate the salience index σ of each outcome and reorder all outcomes based on it. The examples can continue.

The overarching issue here is whether the scientific constructs of decision theory reflect actual psychological factors or are best understood as fictional constructs that may lack any direct reference in the decision maker's mind. In section 5, after considering the narratives about the psychological mechanisms featured in the nine models under consideration, I will argue that the latter perspective is more appropriate.

4. Narratives about psychological mechanisms

The psychological narratives of decision theory encompass not only the individual determinants of economic behavior but also how these factors are combined into mechanisms to produce decisions. These mechanisms can be broadly categorized into two main types: multiply-and-add mechanisms featuring a utility function and mechanisms based on preferences. As we will discuss, a single decision theory is often associated with both psychological mechanisms.[10]

4.1. Multiply-and-add mechanisms

The quintessential multiply-and-add mechanism is featured in the version of EU originally proposed by Bernoulli (1738/1954) and outlined in section 1. In Bernoulli's EU, the decision maker follows these steps: (1) assesses the utility $u(x_i)$ of the N potential outcomes; (2) multiplies each utility by its probability $p(x_i)$, calculating the N values $u(x_1)p(x_1), \ldots, u(x_N)p(x_N)$; (3) computes the expected utility $\sum_{i=1}^{N} u(x_i)p(x_i)$ of the risky prospect; (4) repeats steps 1–3 for all prospects in her choice set; (5) selects the prospect associated with the highest expected utility $\sum_{i=1}^{N} u(x_i)p(x_i)$.

All nine models considered in this paper, developed to overcome EU, feature multiply-and-add mechanisms akin to those used in EU. We first review the models for risk and then those for ambiguity.

4.1.1. Risk models

In prospect theory, when evaluating lotteries involving both potential gains and losses, individuals are assumed to weigh the reference-dependent utility $u(x_i - r)$ of each outcome by multiplying it by its corresponding decision weight $w(p_i)$. They then select the lottery with the highest weighted sum $\sum_{i=1}^{N} u(x_i - r)w(p_i)$.[11]

In rank-dependent utility theory, individuals weigh the utility $u(x_i)$ of each outcome using rank-dependent decision weights based on cumulative probabilities. Specifically, for each lottery, they

compute $\sum_{i=1}^{N} u(x_i)[w(p_i + \ldots + p_N) - w(p_{i+1} + \ldots + p_N)]$, and select the lottery that maximizes this value.[12]

A similar formula is used in cumulative prospect theory, with two key modifications: the utility function $u(x)$ is replaced by the reference-dependent utility function $u(x - r)$, and the weighting function $w(p)$ is split into two distinct functions: $w^+(p)$ for gains and $w^-(p)$ for losses.

In disappointment theory and regret theory, individuals weigh the overall utility $u(x_i) + \theta(u(x_i) - u^*)$ of each outcome by its probability $p(x_i)$ and select the risky prospect with the highest weighted sum $\sum_{i=1}^{N} [u(x_i) + \theta(u(x_i) - u^*)]p(x_i)$.

In salience theory, individuals weigh the utility $u(x_i)$ of each outcome by multiplying it by the decision weight $p(x_i)\delta^{k_i}$ and select the prospect with the highest weighted sum $\sum_{i=1}^{N} u(x_i)p(x_i)\delta^{k_i}$.

4.1.2. Ambiguity models

The formula of Choquet EU theory closely resembles that of rank-dependent utility theory, with capacities $c(E_i \cup \ldots \cup E_N)$ replacing decision weights $w(p_i + \ldots + p_N)$. Specifically, in Choquet expected utility theory, individuals select the course of action that maximizes the function $\sum_{i=1}^{N} u(x_i)[c(E_i \cup \ldots \cup E_N) - c(E_{i+1} \cup \ldots \cup E_N)]$.[13]

In maxmin EU theory, the individual considers a set of possible probability distributions $\pi_1, \ldots, \pi_Z$ over the events. She first calculates the expected utility $\sum_{i=1}^{N} u(x_i)\pi_j(E_i)$ of each course of action under each possible probability distribution π_j. For each course of action, the lowest value of $\sum_{i=1}^{N} u(x_i)\pi_j(E_i)$ represents the worst-case scenario expected utility, i.e. the minimum level of expected utility the individual would obtain if she chose that action. The individual then focuses on worst-case scenarios and selects the course of action that maximizes this minimal expected utility. This corresponds to the action maximizing the function $\min_{j=1,\ldots,Z} \sum_{i=1}^{N} u(x_i)\pi_j(E_i)$.

In the smooth model, the individual holds second-order beliefs, denoted as $\mu(\pi_j)$, about the likelihood of the probability distributions that she considers possible. First, she calculates the expected utility of the course of action under the assumption that the true probability distribution is π_j, that is, she calculates $\sum_{i=1}^{N} u(x_i)\pi_j(E_i)$. Second, this expected utility is transformed by a function ϕ, whose curvature reflects the individual's attitude toward ambiguity. Third, the individual weighs the transformed expected utility $\phi\left(\sum_{i=1}^{N} u(x_i)\pi_j(E_i)\right)$ by multiplying it by the second-order probability $\mu(\pi_j)$, which represents her belief that the true probability distribution is in fact π_j. Finally, she selects the action that maximizes the weighted sum $\sum_{j=1}^{Z} \left[\phi\left(\sum_{i=1}^{N} u(x_i)\pi_j(E_i)\right)\right]\mu(\pi_j)$.

4.2. Preference-based mechanisms

In the version of EU for risk developed by von Neumann and Morgenstern (1944) and later refined by others, the primitive element is not a utility function $u(x)$ but rather a preference relation $\succcurlyeq$ defined over the set of available risky prospects. Similarly, in Savage's (1954) EU for ambiguity, the primitive element is a preference relation $\succcurlyeq$ defined over the set of possible courses of actions.

In both EU models, the preference relation is assumed to satisfy a set of axioms, including completeness and transitivity (see section 2.2), and some form of independence.[14] According to the psychological narrative associated with von Neumann and Morgenstern's and Savage's models, decision-making does not require performing complex multiplications and summations such as $\sum_{i=1}^{N} u(x_i)p(x_i)$. Instead, individuals are assumed to rank all available prospects or courses of action from the least to the most preferred and choose the most preferred one. No calculation on the part of the decision maker is required.

A representation theorem then establishes that if the individual's preferences satisfy completeness, transitivity, independence, and other appropriate axioms, she will choose the prospect that maximizes a functional form like $\sum_{i=1}^{N} u(x_i)p(x_i)$.

With the exception of salience theory, all other post-EU decision models discussed thus far have a preference-based version. Accordingly, these models support a psychological narrative in which individuals do not engage in complex calculations but simply select their most preferred option.

Typically, post-EU models still assume that the decision maker's preferences are complete and transitive. However, some properties of EU preferences, most notably independence, are weakened.[15]

5. Discussion of psychological mechanisms

5.1. Multiply-and-add mechanisms

Interpreting the multiply-and-add decision mechanism featured in EU as corresponding to an actual psychological process occurring in the decision maker's mind seems farfetched. In fact, it is highly questionable whether a decision maker actually engages in, let alone correctly performs, the N multiplications $u(x_1)p(x_1)$, ..., $u(x_N)p(x_N)$, and subsequently sums the resulting numerical values to calculate $\sum_{i=1}^{N} u(x_i)p(x_i)$.

This evaluation is based not only on introspection but also on psychological research on numerical skills and cognition (see, e.g. Campbell, 1997; Nuerk et al., 2015; Zbrodoff & Logan 2005). This research indicates that normal individuals encounter significant difficulties when dealing with addition and multiplication tasks that are much simpler than those involved in the calculation of $\sum_{i=1}^{N} u(x_i)p(x_i)$.

As we have seen in section 4, all nine post-EU models examined in this paper incorporate mechanisms that require calculations as complex as $\sum_{i=1}^{N} u(x_i)p(x_i)$ or even more intricate, such as $\sum_{i=1}^{N} u(x_i)[w(p_i + \ldots + p_N) - w(p_{i+1} + \ldots + p_N)]$ or $\sum_{j=1}^{Z}\left[\phi\left(\sum_{i=1}^{N} u(x_i)\pi_j(E_i)\right)\right]\mu(\pi_j)$. Therefore, interpreting the multiply-and-add decision mechanisms featured in these modes as mirroring actual mental processes is, akin to the case of the EU mechanism, farfetched.

An alternative interpretation of these multiply-and-add mechanisms is that they do not correspond to processes occurring in the decision maker's mind but are instead theoretical constructs existing in the decision theorist's mind. Through these constructs, the theorist attempts to explain, describe, or predict the decision maker's choice behavior. This is the essence of the as-if interpretation of decision models, originally proposed by Friedman and Savage (1948) to shield EU from criticism of unrealism and subsequently extended by Friedman (1953) to other economic models.[16]

More broadly, in the as-if interpretation, decision models seek to account for the observable choices individuals make without claiming to capture the underlying psychological mechanisms that generate them. While an underlying choice-generating mechanism, such as utility maximization, is associated with the model, the decision theorist remains agnostic about whether this mechanism actually operates in the decision maker's mind. She may even consider, or explicitly acknowledge, that the mechanism and its components are merely fictional constructs. Nonetheless, the decision theorist explains, describes, or predicts the decision maker's choices as if they were generated by the posited psychological mechanism. As long as the as-if model can account for the decision maker's choice behavior, the model is deemed scientifically valid.

I contend that since the multiply-and-add mechanisms featured in EU and post-EU models cannot be interpreted as corresponding to actual decision processes, they are best understood as as-if mechanisms, in the sense just illustrated.

5.2. The red herring of the unconscious

One might argue that the multiply-and-add mechanisms found in EU and post-EU models are psychologically real but operate in the unconscious part of the decision maker's mind. This claim,

however, implicitly assumes that the unconscious mind is more mathematically skilled than the conscious mind and can perform operations that are too complex for conscious reasoning. Yet, there is no evidence for this in the psychological literature.[17]

As I have argued more extensively in Moscati (2024a), asserting that the multiply-and-add mechanisms found in EU and post-EU models are unconscious is merely a more convoluted and less transparent way of stating that they should be regarded as as-if mechanisms. Rather than positing that complex calculations such as $\sum_{j=1}^{Z}\left[\phi\left(\sum_{i=1}^{N} u(x_i)\pi_j(E_i)\right)\right]\mu(\pi_j)$ occur in an unconscious part of the decision maker's mind, I contend that it is more appropriate to acknowledge that they take place in the conscious mind of the decision theorist.

5.3. Preference-based mechanisms

As previously mentioned, with the exception of salience theory, all other post-EU models under consideration include versions featuring a preference-based decision mechanism, which appears cognitively far less demanding than the multiply-and-add mechanism. In the psychological narrative illustrating this mechanism, individuals simply rank all uncertain options from the least to the most preferred and choose the most preferred option.

While most decision theorists acknowledge that the utility function and the multiply-and-add mechanisms based on it lack a real psychological counterpart in the decision maker's mind, they maintain that decision makers do hold preferences in their mind and make decisions based on them.

However, this view conflates the intuitive, folk-psychological notion of preferences with the technical, decision-theoretic concept of preferences. In the post-EU models under review, the preferences that individuals are presumed to hold are not the loose preferences of common sense or folk psychology but rather the preferences of decision theory. These preferences are binary relations that are complete, transitive, and typically satisfy additional properties, such as some weaker version of independence.

I contend that decision makers do not hold binary, complete, and transitive preferences in their minds. Like the utility function and the multiply-and-add mechanisms based on it, these preferences are theoretical constructs that decision theorists use to make sense of the decision maker's choice behavior.

I have presented more extensive arguments supporting this claim in Moscati (2023), but the key point is that the preferences of actual decision makers often fail to be complete and transitive. While actual preferences may also violate other properties required by EU and post-EU decision models, completeness and/or transitivity are required by all such models. Therefore, for the purposes of my argument, focusing on these two properties suffices.

Completeness may be violated because decision makers are often unaware of all available options (see, e.g. Gilboa et al., 2021). Even when they are aware of all options, they may not know which they prefer and remain undecided (Aumann, 1962; Gilboa et al., 2012). Transitivity may be violated when options involve multiple dimensions. For example, intransitive preference patterns are common when the two basic dimensions of lotteries – monetary payoffs and their probabilities – are inversely correlated (Tversky, 1969).

Since the preferences of actual decision makers are often incomplete and intransitive, decision mechanisms based on complete and transitive preferences – just like multiply-and-add mechanisms – should not be seen as corresponding to actual psychological processes but as as-if mechanisms.

5.4. From paradox to epistemic functions

The claim that the psychological narratives associated with decision models do not represent actual psychological mechanisms but are best understood as as-if stories, gives rise to a paradox: if this is the case, why are these narratives so ubiquitous in decision theory? Why do decision theorists not simply advance a mathematical decision model, either in terms of utility functions or preferences

relations, deduce its empirically observable implications, and test its descriptive validity without bothering to offer a psychological narrative supporting the model? [18] In other words, what epistemic functions do as-if psychological narratives perform in decision-theoretic modeling?

In the next two sections, I will argue that they perform two primary functions. First, they serve as rhetorical devices that enhance the perceived validity of a model. Second, and more importantly, they provide explanations for choice-behavior phenomena, despite their fictional nature.

6. Psychological narratives as rhetorical devices

In their article on the functions of axiomatizations in decision theory, Gilboa et al. (2019, p. 345) argue that axiomatizations serve as 'powerful rhetorical devices.' They do not use the term 'rhetoric' pejoratively, denoting 'tricks that are designed to win an argument,' but rather in a positive sense, referring to 'tools of reasoning that a person would be truly convinced by.' In a similar, positive vein, I suggest that a first epistemic function of psychological narratives is to serve as rhetorical devices that enhance the perceived validity of a decision model.

As noted in sections 3.2 and 3.3, experimental studies have failed to discriminate among the multitude of proposed post-EU models, and normative arguments about the rationality of the psychological drives underlying these models have likewise proven ineffective in narrowing the group of contenders. Given this state of affairs in the field, a psychological narrative that portrays the psychological factors featured in a given model as descriptively plausible and, possibly, normatively justifiable, can enhance the acceptance of the model.

A proviso to this claim, however, is necessary. The rhetorical power of psychological narratives crucially depends on keeping folk-psychological concepts and decision-theoretic constructs distinct.

Consider, for example, salience theory. At the level of folk-psychology and casual introspection, the idea that individuals attach greater importance to salient outcomes appears intuitively plausible, and this plausibility strengthens the perceived validity of the theory. However, as discussed in section 3.5, this 'credibility effect' diminishes when the folk-psychological notion of salience is formalized as a decision-theoretic construct, such as the salience index $\sigma(x, y) = \frac{|x-y|}{|x|+|y|}$. It nearly vanishes when the theory posits that individuals compute the salience index for each outcome, reorder outcomes accordingly, weigh each outcome by $p(x_i)\delta^{k_i}$, and calculate the expression $\sum_{i=1}^{N} u(x_i)p(x_i)\delta^{k_i}$.

Similar considerations hold for regret theory. The idea that the utility an individual derives from an outcome also depends on her consideration of 'what might have been' resonates with casual introspection and folk psychology, and thereby enhances the theory's intuitive appeal. Yet, this rhetorical force weakens significantly once this notion is formalized into a mathematical function such as $\theta(u(x_i) - u^*)$, and it is assumed that individuals calculate expressions like $\sum_{i=1}^{N} [u(x_i) + \theta(u(x_i) - u^*)]p(x_i)$.

Analogous observations apply to each of the other seven models discussed in this study.

7. Psychological narratives as explanations

The second, and more significant, function of psychological narratives in decision theory is to provide explanations, that is, answers to how and why questions, regarding the behavior of decision makers under conditions of uncertainty.

7.1. Nine shades of explanation

Consider an individual who chooses uncertain option *A* over uncertain option *B*. Various, possibly complementary, psychological narratives discussed in this paper provide explanations for this choice. The individual chooses *A*:

(1) because she intensely desires one of its potential outcomes, denoted as *x*;
(2) because she is concerned about the potential loss she could incur by choosing *B*;
(3) because she fears the regret she might feel is she does not take the risk of choosing *A*;
(4) because she believes, possibly mistakenly, that obtaining *x* is very likely;
(5) because, although she correctly assesses the probability of obtaining *x*, she assigns such importance to *x* that she gives it a weight greater than its probability;
(6) because *x* is salient and has attracted her attention;
(7) because, in the worst-case scenario, *A* guarantees a better outcome than *B*;
(8) because she dislikes ambiguity, and *B* is ambiguous while *A* is not; or, conversely, because she likes ambiguity, and *A* is ambiguous while *B* is not;
(9) simply because she prefers *A* over *B*.

Most philosophers of science agree that explanation, possibly alongside description and prediction, is a major epistemic goal of scientists (see Woodward & Ross, 2021 for a recent review of the philosophy of scientific explanation). Decision theorists are also interested in explaining the behaviors of decision makers and not only in describing or predicting them correctly. The primary reason for the ubiquity and significance of psychological narratives in decision theory, I submit, lies in their capacity to offer potential explanations like the ones listed above.

7.2. Utility-based vs. preference-based narratives

There is, however, a difference between the explanations offered by narratives 1–8 and the explanation provided by narrative 9 in the list above. Narratives 1–8 explain behavior by mobilizing desires, decision weights, beliefs, attitudes toward losses or ambiguity, and other psychological factors and mechanisms discussed in sections 2 and 4. For brevity, I will group these diverse psychological elements under the umbrella term 'utility,' and refer to such accounts as utility-based explanatory narratives.

By contrast, narrative 9 offers a preference-based explanation, which simply states that the individual chooses option *A* over option *B* because she prefers *A* to *B*. Admittedly, this kind of narrative does not explain much.

When the choice options are simple, such as between dishes at a restaurant, a minimal, preference-based explanatory narrative like 'The individual chooses dish *A* over dish *B* because she likes *A* more than *B*' may be satisfactory. However, when the choice options are more complex, such as between lotteries with multiple risky payoffs, or courses of actions involving ambiguous scenarios, a preference-based explanation tends to beg the question. Returning to our earlier medical example, if we ask, 'Why does the patient opt for surgery over pharmacological therapy?', an answer like 'Because she prefers to do so' sounds uninformative, even baffling.

As noted in section 2.2, since the works of Pareto and von Neumann – Morgenstern, the notion of preference has replaced that of utility as the primary concept in decision theory, and this shift occurred for a series of solid theoretical and methodological reasons (for discussion, see Moscati, 2018). Nonetheless, the richer, explanatory narratives involving utility, beliefs, and related concepts have never disappeared from decision theory, and even decision-theoretic models formally grounded in preference axioms continue to be accompanied by such narratives. The resilience of utility-based narratives in decision theory, I contend, stems precisely from the fact that they offer explanations, whereas preference-based narratives do not.[19]

7.3. Abandoning truthfulness, resolving the paradox

The claim that psychological narratives in decision theory, particularly utility-based narratives, provide explanations may appear contradictory at first. On the one hand, in fact, I have argued

that these narratives are best understood as as-if stories, positing psychological factors and mechanisms that may not correspond, and typically do not correspond, to actual entities or processes in the decision maker's mind. On the other hand, I now assert that psychological narratives explain behavior. But how can seemingly false as-if narratives genuinely explain? Isn't truth a necessary condition for proper explanation, thereby rendering 'false explanations' a contradiction in terms? As mentioned in section 1.2, this is the issue that Reiss (2012) calls the 'explanation paradox.'

I propose to resolve the paradox by rejecting the idea that truth is a necessary condition for explanation. Several philosophers of science (Bechtel & Abrahamsen, 2005; Bokulich, 2018; Colombo et al., 2015; Rowbottom, 2019) have called attention to the plurality of cognitive functions that scientific explanations can serve – such as allowing scientists to coherently organize their thinking about phenomena, facilitating counterfactual reasoning about causes, indicating how to influence or control certain states of affairs, and suggesting how to modify theories unable to rationalize phenomena – and suggested that scientific explanations can fulfill most of these functions even if they are not true.

Indeed, scientific theories now considered false, such as Aristotelian physics, Ptolemaic astronomy, the phlogiston theory, or the caloric theory of heat, did provide explanations for the phenomena they addressed, precisely by serving these cognitive functions. Modern decision theories explain in a similar way: they enable decision theorists to organize their thinking about choice-behavior phenomena coherently, to reason counterfactually about how changes in some component of the posited decision mechanism could modify choice behavior, to indicate strategies for influencing individuals' choice behavior, and to suggest modifications to models that fail to make sense of observed choice patterns. The psychological narratives accompanying a decision model play a crucial role in this explanatory endeavor, which accounts for their ubiquity and significance in decision theory.

7.4. Looking for new names

A critic may insist that false explanations do not exist and that what Aristotle, Ptolemy, ancient phlogiston theorists, and modern decision theorists offer are not explanations but 'something else' devoid of scientific value (see Alexandrova & Northcott, 2013 for a view along these lines). As Rowbottom (2019) suggests, the problem with this stance is that, by adhering to a narrow, truth-based notion of explanation, the critic can account for little of what has happened, and continues to happen, in science, whether in physics, astronomy, chemistry, or economics. Perhaps it is more productive to let the critic retain the heavily charged term 'explanation' and search for an alternative label to capture the explanatory practices scientists actually engage in.

Indeed, terms such as 'narrative explanations' and 'how-possibly explanations,' recently used by historians and philosophers of economics like Morgan (2017), Verreault-Julien, and Grüne-Yanoff (Grüne-Yanoff & Verreault-Julien, 2021; Verreault-Julien, 2019; Verreault-Julien & Grüne-Yanoff, 2025), can be interpreted as reflecting, at the terminological level, the need to broaden the truth-based notion of explanation in order to better account for the actual practices of economists. This conceptual shift is still in its early stages, and I hope that the present paper, by analyzing the explanatory practices of decision theorists, can contribute to its development.

8. Summary and conclusion

In this paper, I first reviewed the psychological narratives that accompany nine prominent post-EU models for decision-making under risk or ambiguity. I then examined the epistemological status of these narratives and argued that the psychological factors and mechanisms they describe do not correspond to actual mental entities and processes. Rather, they are best understood as as-if narratives, in the sense proposed by Friedman (1953). Finally, I explored two main epistemic functions of these narratives within decision theory. First, in the absence of experimental evidence or normative criteria to narrow the field of post-EU models, psychological narratives act as rhetorical devices that

enhance a model's perceived plausibility and appeal. Second, they provide explanations for choice-behavior phenomena. Recognizing this explanatory function requires abandoning the assumption that truth is a necessary condition for explanation.

Acknowledging these two functions of psychological narratives in post-EU decision theory does not amount to licensing freestanding storytelling within the discipline. On the contrary, such acknowledgment should help us to overcome a psychologically realistic, but ultimately naïve, interpretation of these narratives, and lead us to recognize that the psychological drives and mechanisms they posit are far less straightforward and plausible than they may initially appear. This awareness, in turn, could serve as a caution against the unchecked proliferation of decision models that has characterized the field in recent decades.

Notes

1. Terminology in the decision-theoretic literature is not uniform. Following Knight's (1921) original classification, what is referred to here as ambiguity is often called uncertainty. However, in line with current practice (see, e.g., Gilboa, 2025), this paper reserves the term uncertainty for the general case, with risk and ambiguity as its specific subcategories.
2. For more technical reviews, including additional models not covered here, see Etner et al. (2012); Gilboa (2009, 2025); Gilboa and Marinacci (2013); Machina and Siniscalchi (2014); Schoemaker (1982); Starmer (2000); Sugden (2004).
3. The convention for denoting outcomes varies across the literature. I follow the notation used by Starmer (2000), Sugden (2004) and others, in which lower numbers correspond to less desirable outcomes. Wakker (2010) and other authors adopt the opposite convention, associating higher numbers with less desirable outcomes. I find this latter approach less intuitive, as lower numbers are typically associated with lower, not higher, values.
4. Additional psychological factors may be included in the cluster if other decision models are considered. These encompass, among others, aversion to utility dispersion (Allais, 1953; Hagen, 1991), random elements in decision-making (Gul & Pesendorfer, 2006), evaluation of the similarity across decision situations (Gilboa & Schmeidler, 2001), the influence of intertemporal preferences on risk preferences (Chakraborty et al., 2020), and aversion to the complexity of risky prospects (Bernheim & Sprenger, 2020; Oprea, 2024).
5. For a critical discussion on the proliferation of models in behavioral economics, including some of the post-EU models considered here, see also Fudenberg (2006).
6. For reviews, see Camerer (1995); Starmer (2000); Hey (2014).
7. A striking example of the difficulty in reaching agreement within post-EU research over the interpretation of experimental evidence is the recent debate between Bernheim and Sprenger (2023) and Wakker (2023a). The dispute centers on the validity of the experimental design and findings of Bernheim and Sprenger (2020), who investigated whether individuals weigh single probabilities, as posited by prospect theory, or cumulative probabilities, as in cumulative prospect theory.
8. On the lack of consensus in contemporary decision theory, see also Gilboa and Marinacci (2013) and Gilboa (2025).
9. I thank one of the anonymous referees for pointing out this aspect.
10. A third type of decision mechanisms, featured in models adopting the heuristic-based approach introduced by Simon (1955), relies on the application of a series of "rules of thumb" by decision makers. Due to space constraints and the minor role heuristic models have played in post-EU decision-theoretic literature, I do not discuss them here. Nevertheless, in Moscati (2024a), I examined the decision mechanisms featured in the priority heuristic model (Brandstätter et al., 2006) and other heuristic models, contending that they too are best understood as as-if mechanisms.
11. For lotteries yielding only gains or only losses, the mechanism and the corresponding mathematical formula differ slightly (see Wakker, 2023b for a detailed discussion). However, this alternative formulation still follows a multiply-and-add-utilities format and therefore can, for the purposes of this paper, be treated as equivalent to the one presented in the main text.
12. In this formula, $p_{i+1} + \ldots + p_N$ represents the probability of obtaining an outcome strictly better than x_i. By convention, it is assumed that, for $i = N$, $w(p_{i+1} + \ldots + p_N) = 0$. An alternative, but mathematically equivalent, formulation of the rank-dependent-utility functional is $u(x_1) + \sum_{i=2}^{N} [u(x_i) - u(x_{i-1})]w(p_i + \ldots + p_N)$. This expression also follows a multiply-and-add-utilities format and can, for the purposes of this paper, be assimilated to the one presented in the main text.
13. In this formula, $E_{i+1} \cup \ldots \cup E_N$ represents the event in which the individual obtains an outcome strictly better than x_i. By convention, it is assumed that, for $i = N$, $c(E_{i+1} \cup \ldots \cup E_N) = 0$.

14. Independence essentially requires that the preference ranking between two uncertain options is not influenced by the parts they have in common, but only by the parts that distinguish them.
15. Regret theory and salience theory, however, permit intransitive choice patterns.
16. For a discussion of Friedman's 1953 essay and the extensive debate it generated, see Mäki (2009).
17. For an introductory discussion, see Dehaene (2011).
18. In fact, some economists and philosophers of economics advocate for a behaviorist, i.e., anti-psychologistic, account of economic theory in general and decision theory in particular (see e.g. Binmore, 2009; Gul & Pesendorfer, 2008; Ross, 2014). However, other economists and philosophers of economics, including myself, have criticized the behaviorist account of decision theory as invalid not only at the descriptive level (among other things, because behaviorism cannot make sense of the counterfactual type of reasoning crucial in decision and game theory) but also at the normative level (for behaviorism relies on outdated epistemological presuppositions; see e.g. Dietrich & List, 2016; Guala, 2019; Hausman, 2008; Moscati, 2021, 2024a). Extensive critical discussions of behaviorism already exist, so I will not address it here.
19. This point is rarely acknowledged by decision theorists; a recent exception is Gilboa (2025, 20), who recognizes the important role played by the utility-based explanatory narrative accompanying the maxmin expected EU in the model's success.

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