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Three Theories of Choice and Their Psychology of Losses

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Abstract
Loss aversion has long been regarded as a fundamental psychological regularity, yet evidence has accumulated to challenge this conclusion. We review three theories of how people make decisions under risk and, as a consequence, value potential losses: expected-utility theory, prospect theory, and risk-sensitivity theory. These theories, which stem from different behavioral disciplines, differ in how they conceptualize value and thus differ in their assumptions about the degree to which value is dependent on state and context; ultimately, they differ in the extent to which they see loss aversion as a stable individual trait or as a response to particular circumstances. We highlight points of confusion that have at least partly fueled the debate on the reality of loss aversion and discuss four sources of conflicting views: confusion of loss aversion with risk aversion, conceptualization of loss aversion as a trait or as state dependent, conceptualization of loss aversion as context dependent or independent, and the attention–aversion gap—the observation that people invest more attentional resources when evaluating losses than when evaluating gains, even when their choices do not reveal loss aversion.

Keywords
loss aversion, loss attention, attention-aversion gap, risky choice, decisions under risk

Loss aversion—the tendency to weight losses more heavily than equivalent gains—has been described as "one of the basic phenomena of choice under both risk and uncertainty" (Tversky & Kahneman, 1992, p. 298). The idea that, in decisions, "losses loom larger than gains" (Kahneman & Tversky, 1979, p. 288) has had a profound impact in psychology, economics, and finance and has influenced fields such as political science and law. It has been suggested that loss aversion can explain a variety of empirical phenomena, including the endowment effect (Kahneman et al., 1990; Thaler, 1980), the disposition effect (Weber & Camerer, 1998), the counterintuitive effect of point-rewards systems in sports (Riedl et al., 2015), and underinvestment in the stock market (Benartzi & Thaler, 1995).

But whereas some see loss aversion as "one of the most fundamental and well-documented biases" (Rozin & Royzman, 2001, p. 306) or simply "a fact of life" (Benartzi & Thaler, 1995, p. 86), others consider its effects to be much more limited. Ert and Erev (2013) identified a set of situations in which loss aversion is unlikely to emerge, such as when feedback is given on decisions and when the status quo is safe. Walasek and Stewart (2015, 2019) went further. They showed that loss aversion partially depends on the ranges of the possible outcomes. For example, loss aversion emerged when gains ranged between $0 and $40 and losses between $0 and $20, but disappeared when gains and losses were in the same range. The effect, though small, was robust. Thus, Walasek and Stewart argued that decisions that appear to reflect loss aversion could be caused by asymmetry in the potential gains and losses.

Systematic reviews have also questioned the idea of widespread loss aversion. Yechiam and Hochman (2013) reviewed articles that examined loss aversion using symmetric gambles (i.e., offering an equal chance of winning or losing an amount of money or points) and found that only four of 24 studies reported evidence for loss-averse choices. With evidence accumulating against loss

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aversion, Yechiam (2018) revisited early studies of loss aversion (Fishburn & Kochenberger, 1979; Galanter & Pliner, 1974) that Kahneman and Tversky (1979) had referenced to substantiate the notion of loss aversion in their first exposition of prospect theory (PT). Yechiam concluded that these early results had been "over-interpreted" (p. 1327) by Kahneman and Tversky. Gal and Rucker (2018) attributed the widespread belief in loss aversion to its intuitive appeal, arguing that loss aversion tends to be inappropriately generalized to everyday situations. Gal (2018) concluded that loss aversion is a fallacy—in the minds not of decision makers but of researchers.

How has research led to such starkly opposing views on loss aversion? To answer this question, we consider three views of how people make decisions under risk and, as a consequence, value potential losses. These views all relate to risky choice but stem from three separate behavioral disciplines: psychology, economics, and behavioral ecology. To illustrate our argument, we introduce three fictional brothers, each of whom has inherited €1,000. The brothers differ in how they value money. Ed is concerned with the long term; he cares about his total wealth. Paul lives in the present; he cares about how his wealth changes. And Rick is concerned with having enough to survive. Each brother's behavior illustrates a distinct theoretical approach to decisions under risk: expected-utility theory (EUT), PT, and risk-sensitivity theory (RST), respectively. We discuss how these theories conceptualize value and how they each model people's attitude to losses. In so doing, we highlight key similarities and differences among the theories and cast light on points of confusion that have at least partly fueled the ongoing debate on loss aversion.

EUT: The Normative Account

Ed cares about his total wealth. His preferences are described by EUT (von Neumann & Morgenstern, 1953), which is the normative account for decisions under risk and the overarching framework of economic rational-choice theories. Ed sees a gain or a loss of €100 in the context of his final state of wealth: If he already has €1,000, Ed thinks of a gain or a loss of €100 as giving him a total of €1,100 or €900, respectively. He does not ignore the fact that, even if he loses €100, he still has €900 in the bank. Ed's view is focused on the long term: Money acquired even several years back affects his future financial decisions, and money gained or lost today will influence his decisions in a month.

We use monetary gambles to illustrate how Ed's valuation of money drives his decisions. A gamble G is a proposition that a given random event causes outcome x to happen with probability p. A coin toss that pays €10 for heads and €0 for tails is an example of a monetary gamble. Gambles permit us to construct abstract choice sets that illustrate the similarities and differences of the three theories examined here. So how does Ed choose among monetary gambles? He chooses the gamble G with the highest expected utility, given by the equation

$$EU(G) = \sum p_i u(x_i), \qquad (1)$$

where p_i is the probability of each possible outcome x_i, and $u(x_i)$ is a positive but decelerating function of the monetary amount x_i. Figure 1a plots a standard utility function $x^{0.5}$ (Glöckner & Pachur, 2012; Harrison & Rutström, 2009), which embodies Ed's preferences. It converts monetary amounts to subjective values or utilities. Consider a gamble that offers equal chances of winning or losing €100. For Ed, the utility of €1,000 is 31.6 (i.e., $1{,}000^{0.5}$). Gaining €100 increases the utility to 33.2 ($1{,}100^{0.5}$)—that is, by 1.54 units. Losing €100 decreases the utility to 30 ($900^{0.5}$)—that is, by 1.62 units. Thus, because a gain of €100 increases utility by 1.54 units whereas an equivalent loss decreases it by 1.62 units, losses are more unpleasant than gains are pleasant. In EUT, losses loom larger than gains of equal magnitude.

As Figures 1a and 1b show, $x^{0.5}$ is concave; x increases at a decelerating rate. It can also be said to reflect diminishing marginal utility on x. This shape implies that value in EUT is *state dependent*, in that gaining €100 has a different impact on utility depending on Ed's current *state* of wealth—that is, his current position on the utility curve.

The concave shape implies that Ed is risk averse, because $EU(G) < U(EV(G))$: The expected utility of the gamble, $0.5 \times 1{,}100^{0.5} + 0.5 + 900^{0.5}$, is smaller than the utility of the expected value of the gamble, $(0.5 \times 1{,}100 + 0.5 + 900)^{0.5}$, or $1{,}000^{0.5}$. In this example, playing the gamble has an expected utility of 31.58, whereas the utility of not playing (and keeping the €1,000) is 31.62. The concavity of the utility function, which guarantees risk aversion, also guarantees that a decrease in x has a larger impact on u than does an increase of the same amount. Figure 1b—which expands the gray section of Figure 1a, exaggerating the curvature to show the properties of a concave utility function—shows that a gain of €100 moves utility from $U(1{,}000)$ to $U(1{,}100)$, whereas a loss of the same amount reduces utility substantially more, from $U(1{,}000)$ to $U(900)$. The dotted line shows the expected value of any gamble comprising the possible outcomes 900 and 1,100. The fact that the dotted line is below the utility curve for any value between €900 and €1,100 indicates risk aversion. Thus, in EUT,

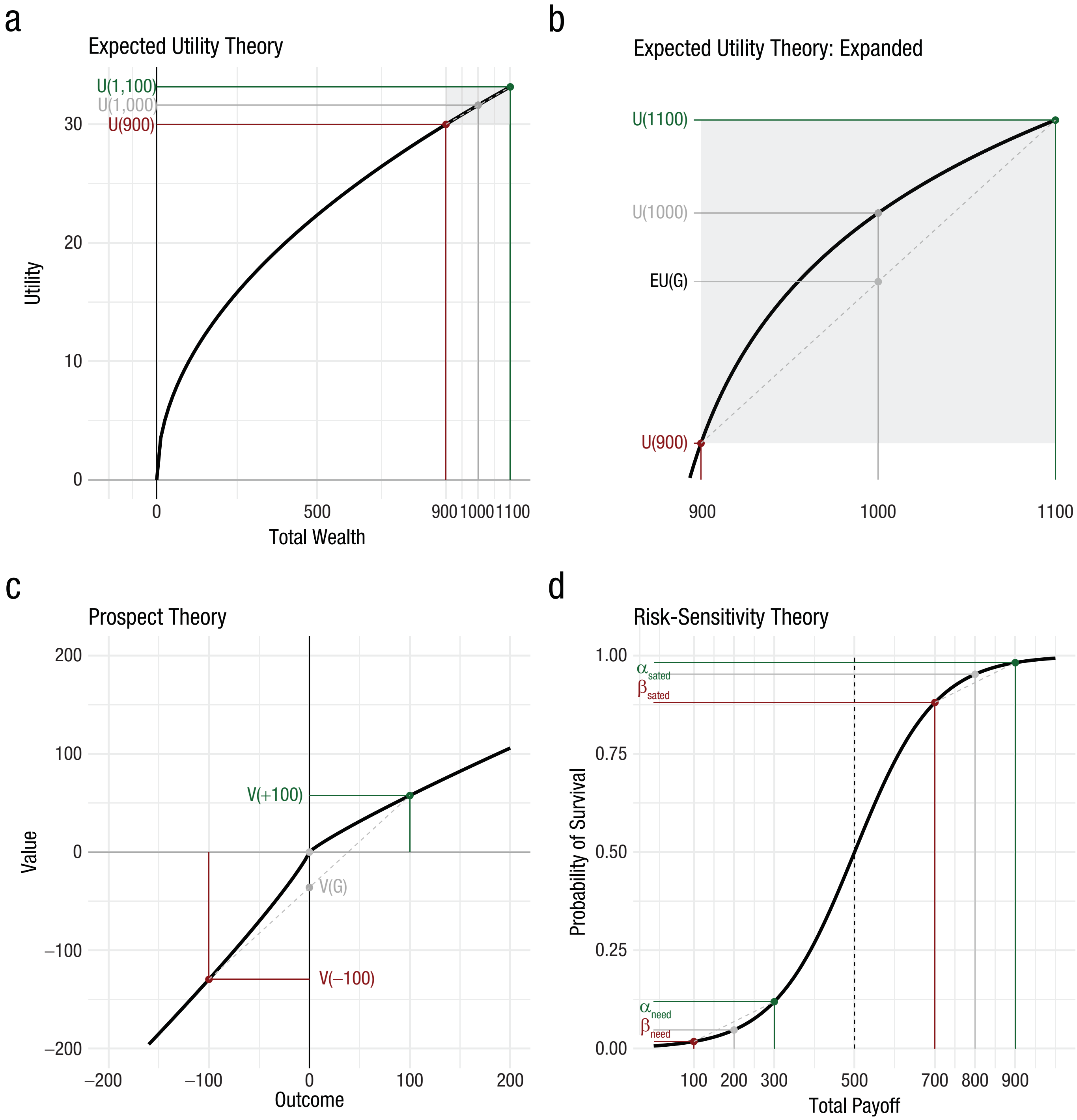

Fig. 1. Loss sensitivity as modeled by three theories of decisions under risk and uncertainty. The graph in (a) depicts a concave utility function in EUT. The graph in (b) expands the gray section of (a), exaggerating the curvature to show the properties of a concave utility function. Concavity implies that a change from €1,000 to €1,100 has a smaller impact on utility than does a change from €1,000 to €900 ($\alpha < \beta$). The graph in (c) depicts the value function in PT. The gray dot at the origin denotes the reference point. The graph shows that a gain of €100 has an impact on value that is higher than the impact of an equivalent loss ($\alpha > \beta$). The dashed line indicates that the value of a symmetric gamble that offers €100 or −€100 is lower than the reference point. The graph in (d) shows a fitness function from RST. The dotted line indicates the critical level for survival (arbitrary in this example). The gray dots denote two states: The dot to the left of the critical level curve indicates the current state of wealth of a person in need; the dot to the right shows the current state of wealth of a sated person. When an organism is sated, a gain and a loss of €100 reflect loss sensitivity, as $\alpha_{sated} < \beta_{sated}$. However, when the organism is in need—below the critical threshold—a gain of €100 has a larger impact on the probability of survival than does a loss of €100 ($\alpha_{sated} > \beta_{sated}$).

a concave utility function—that is, risk aversion—entails that losses loom larger than gains.[1] And because it is assumed that Ed's concave utility function is stable and his valuation of money is therefore always risk averse, the fact that losses loom larger than gains can be considered tantamount to an individual trait.

The second observation about EUT's conceptualization of losses is that the asymmetry in utility between gains and losses depends on Ed's wealth—his position on the curve. When Ed has €1,000, a loss of €100 decreases utility by 1.62 units, whereas an equivalent gain increases it by 1.54 units. In this state, the impact of losses on utility is 1.05 times that of gains. However, if Ed had just €100, a loss of €100 would decrease utility by 10 units, whereas an equivalent gain would increase it by 4.1. The impact of a loss on utility would thus be 2.4 times that of gains. This example illustrates that the asymmetry in utility between gains and losses decreases with wealth in a concave utility function. Therefore, although the regularity that losses loom larger than gains within EUT can be considered tantamount to an individual trait (insofar as a person's risk preference is considered trait-like and stable; see Frey et al., 2017, 2021), the psychological intensity regarding which losses loom larger depends on the individual state of wealth.

Most people are risk averse (e.g., Holt & Laury, 2002). EUT transforms money into utility using a concave utility function. This function implies risk aversion; it also implies that a loss has a stronger impact on utility than does a gain of the same magnitude, and that this asymmetry decreases with wealth. Thus, for the many risk-averse individuals captured by EUT, losses do loom larger than gains. However, not everyone cares about total wealth, and not everyone's choices follow the axioms and predictions of EUT.

PT: The Descriptive Account

Paul is not like Ed. He does not think of the money he already has nor does he worry about the long term. He is concerned with how his wealth changes in the here and now. His preferences are described by PT (Kahneman & Tversky, 1979). Paul generally evaluates options according to how they affect his current wealth, but circumstances such as a strong expectation can cause his reference point to change. For instance, if Paul expects a bonus of €100, but receives just €10, he might perceive it not as a gain of €10, but as a loss of €90. Social context may also provide reference points: If Paul's €100 bonus is less than what his colleagues receive, he may perceive it as a loss. Because reference points can be affected by context in myriad ways, and because value derives from changes from a given reference point, value in PT is context dependent. For now, we assume that Paul's reference point is his current wealth, consistent with the assumption made in Tversky and Kahneman's (1992) parametrization of PT. Their goal in developing PT was "to assemble the minimal set of modifications of expected utility theory that would provide a descriptive account of . . . choices between simple monetary gambles" (Kahneman & Tversky, 2000, p. x). What does this mean for how Paul evaluates gambles and prospective losses relative to gains?

According to PT, Paul chooses as if he computes the value of each gamble he encounters, then selects the alternative with the higher value. The value of a gamble G results from the equation

$$V(G) = \sum \pi(p_i) v(x_i), \tag{2}$$

where π is a weighting function of the outcome probabilities p_i, and v is a function of the outcome x_i of the form

$$v(x) = \begin{cases} x^{\alpha} \; if \; x \leq 0, \\ -\lambda(-x)^{\beta} \; if \; x < 0 \end{cases}, \tag{3}$$

where $\alpha \in [0,1]$ and $\beta \in [0,1]$ affect the curvature of $v(x)$ for gains and losses, respectively, and $\lambda \in [0, \infty]$ specifies the degree of loss aversion. Higher values indicate higher loss aversion. Although probability weighting affects the propensity to take risks, what is critical for the analysis of losses versus gains is the shape and properties of the value function $v(x_i)$, as plotted in Figure 1c.

PT's value function has three properties. First, it passes through the origin, which denotes the person's reference point. All outcomes are evaluated as deviations from the origin, no matter the person's state of wealth. In contrast to EUT, value in PT is defined in terms of changes in wealth, not in terms of states of wealth. Thus, when current wealth is taken as a reference point, value in PT is (wealth) state independent: The value Paul places on a €100 bill is independent of whether he already has €1,000, unlike the value Ed places on the same bill.[2]

Second, the value function is concave in the domain of gains, like the utility function described in EUT. Thus, this function implies risk aversion for gambles where all outcomes are possible gains. In the domain of losses, however, the function is convex, reflecting risk-seeking behavior when people choose among potential losses. The convex section of the value function implies risk-seeking behavior because $V(G) > V(EV[G])$.

Third and most critically, the value function is asymmetric around the origin and is assumed to be steeper for losses than for gains. This asymmetry implies loss aversion. Figure 1c shows that a change in value of a gain of €100 is smaller than that of a loss of the same amount: According to the parametrization of PT in Tversky and Kahneman (1992), a gain of €100 increases value by 58 units, whereas a loss of €100 decreases value by 129 units.[3] Thus, losses loom larger—about 2.25 times larger—than do gains.

Whether Paul has €1,000 in the bank is irrelevant. In making decisions, he is positioned at the origin—again, assuming that current wealth is the reference point. Therefore, offered a gamble with equal chances of winning or losing €100, Paul will decide not to play. The higher psychological impact of the loss makes the gamble worse than the status quo. The asymmetry between losses and gains is so pronounced that even if the gamble offered a gain of €200 and a loss of €100 with equal probabilities, Paul would still reject it—again, according to the 1992 parametrization. And because Paul always uses the same value function to evaluate changes, no matter how much wealth he owns—he does not "move" along the function in the same way Ed does—loss aversion is tantamount to an individual trait, relatively constant across time and circumstances.[4]

It was there all along

Although nearly synonymous with PT, the phenomenon of losses looming larger than gains had been observed centuries before Kahneman and Tversky christened it loss aversion (see reviews by Baumeister et al., 2001; Rozin & Royzman, 2001; Yechiam, 2018). It featured as early as 1738, in Daniel Bernoulli's (1738/1954) "Exposition of a New Theory of Risk," the first description of EUT. Figure 2 shows the concave utility function proposed in Bernoulli's landmark article. Individuals derive utility *A* from wealth *B*. Upon receiving *BP* additional wealth, individuals get a boost in utility *AN*. They lose an equivalent utility *An* upon losing *Bp* in wealth. As Figure 2 shows, *Bp* is just a fraction of *BP*.

In Bernoulli's (1738/1954) words,

> This follows from the concavity of curve sBS to BR. For in making the stake, Bp, equal to the expected gain, BP, it is clear that the disutility po which results from a loss will always exceed the expected gain in utility, PO. (p. 29)

Why did Kahneman and Tversky (1979) propose that loss aversion is distinct from risk aversion?

Kahneman and Tversky (1979) proposed PT to capture both the behavior already captured by EUT and a set

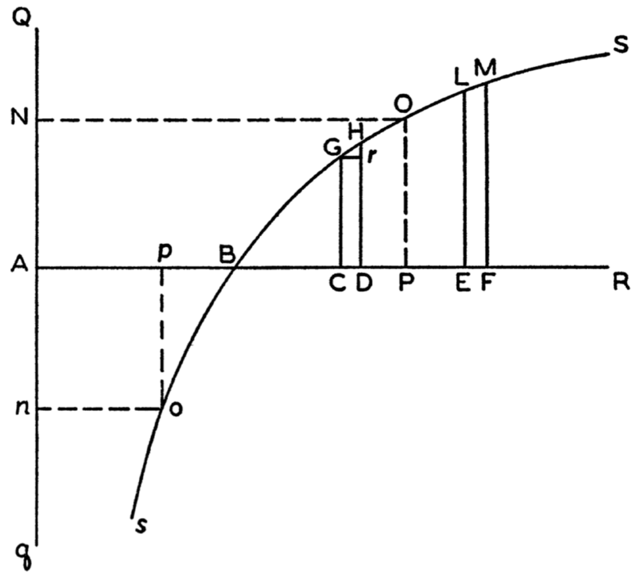

Fig. 2. Utility function proposed by Bernoulli (1738/1954). Here, the increase in utility *AN* equals the decrease in utility *An*, but the associated monetary losses (*Bp*) and gains (*BP*) are such that *Bp* < *BP*.

of behaviors that violate the predictions of EUT. For this reason, PT has been dubbed a repair program (Gigerenzer, 2008; Güth, 2008); others have seen it as a descriptive rather than a normative theory. One robust behavioral tendency captured by EUT was that people tend to reject gambles in favor of a sure amount equivalent to the gamble's expected value. PT thus had to capture the observation that people tend to be risk averse for gambles that offer the possibility of winning some money or going away empty-handed. In PT, this is accomplished by assuming a concave utility function for the domain of gains. So far, nothing new.

However, Kahneman and Tversky observed several deviations from the predictions of EUT. Some of these observations implied nonlinear weighing of probabilities. These we do not address here. But others related to the valuation of outcomes—and thus to PT's value function. Consider the Problems 3 and 3′ posed by Kahneman and Tversky (1979): In Problem 3, participants (N = 95) were given a choice between an 80% chance of gaining 4,000 and a guaranteed gain of 3,000; 80% of participants preferred the guaranteed outcome. In Problem 3′, participants (N = 95) were given a choice between an 80% chance of losing 4,000 and a guaranteed loss of 3,000; 92% of participants preferred the risky loss. The positive and negative prospects are of equivalent magnitudes, but Kahneman and Tversky (1979) observed that although 80% of participants preferred the safe gain (3,000) to the risky gain, they adopted a different risk attitude in the loss domain, where they preferred the risky loss to the safe loss (−3,000)—a pattern of choice called the reflection effect. Although people tend to prefer sure over risky gains, they tend to avoid sure losses while risking an even bigger loss. This reflection effect cannot be accommodated by EUT. PT accommodates it by assuming a value function that is concave for gains and convex for losses, and symmetric around the origin. However, this value function does not accommodate a perhaps more critical empirical regularity.

Consider the following gambling problem: Tversky and Kahneman (1992) asked participants to imagine tossing a coin; if the coin came up heads, they would lose 25, but if the coin came up tails, they would gain x. They asked the participants to give a value for x at which they would be indifferent between having nothing and tossing the coin. They observed that the magnitude of the possible win had to be more than twice that of the possible loss to make the gamble attractive. This implies that people will reject gambles that offer equal chances of winning or losing a given amount. This observation is partly accommodated by EUT, because losses reduce total wealth, and the concavity of EUT's utility function implies risk aversion and thus rejection of symmetric gambles. In other words, in EUT, a loss of 25 has a larger impact on utility than does a gain of 25.[5]

The modeling of this behavior in PT is different, however. Gains and losses are assumed to be evaluated using different sections of the value function: gains in the concave region and losses in the convex region. Recall that a function that is concave for gains and convex for losses is necessary to capture the reflection effect. Therefore, people's tendency to reject symmetric gambles entails that the value function is steeper for losses than for gains. Indeed, examining PT's value function across the loss and gain domains, the kink around the origin makes the value function behave as though it were concave. In fact, in Figure 1c, all points along the dashed gray line connecting the red and green dots fall below the value function, indicating that the value at the reference point (0, 0) is higher than $V(G)$, the value of a symmetric gamble offering equal chances of €100 and –€100. This functional concavity holds for any pair of values in which one is a gain and the other a loss. With this shape, Tversky and Kahneman (1992) could simultaneously capture the observations that people tend to (a) avoid risks among gains, (b) seek risks among losses, and (c) reject symmetric gambles.

Not states but changes in states

The idea that valuation and decisions are driven by final states of wealth—as in EUT—is reasonable from a prescriptive perspective but "wrong" from a descriptive perspective (Kahneman, 2003, p. 1455). The fact that value is defined in terms of changes in PT but in terms of states in EUT has profound implications. Imagine that Ed_{EUT} and Paul_{PT} each find a €100 bill on the floor at lunchtime and lose it by dinnertime. They both experience more suffering from losing the bill than joy at finding it. But EUT implies that moments later, Ed will feel just the same as he did before lunch—after all, his wealth state after losing the bill is identical to his state before finding it. In EUT, it is this state that determines Ed's total utility and well-being. It is less certain how Paul will feel moments later, once the feeling of loss has settled and he finds himself in a new wealth state. This will depend on how long the pain of losing the bill outlives the pleasure of finding it. In conceptual terms, because value in EUT is defined in terms of states of wealth, EUT can be used to predict how people feel about their wealth at all times, given that people are always in one state or another. The same does not apply to PT. Because value in PT is defined in terms of changes in wealth, PT is mute about how people feel about their wealth. It can only enable predictions in the face of the prospect of change (hence the name "prospect" theory). The moment a new state comes into being, PT renders no prediction. EUT is thus conceptually broader than PT: EUT makes predictions about how people feel about their wealth at all times—because they are always in some state of wealth—whereas PT is concerned only with the specific moment in which people consider a prospect with potential gains or losses.

This observation reveals another conceptual difference: The time frame of EUT is more general than that of PT. In EUT, all previous outcomes affect the valuation of the current possible outcomes, and the outcome of the current choice will affect future valuations and subsequent decisions. In PT, past outcomes are not considered, and future outcomes will be unaffected by the current choice. Thus, EUT's focus on states implies a wider time window, whereas PT is concerned with a narrower time window: the moment of change.

To conclude, shifting the carrier of value from total wealth (EUT) to change in wealth (PT) made it possible for Kahneman and Tversky (1979) to decouple risk attitudes from loss attitudes—two concepts that are inseparable in EUT. Although the idea that losses loom larger than gains had existed in EUT since the early 18th century, as a property of Bernoulli's utility function, Kahneman and Tversky's separation of loss aversion from risk attitudes was a novel contribution to the modeling of decisions under risk.

RST: Where Survival is Paramount

Rick needs €500 to survive safely. He therefore evaluates options relative to this survival threshold. When his current wealth falls below €500, Rick must take risks to survive. Rick's valuation of money, and his resulting risky behavior, is captured by RST (Mallpress et al., 2015; McDermott et al., 2008; Stephens, 1981). RST aims to capture how organisms forage. Its behavioral predictions have been supported empirically across the animal kingdom (Caraco et al., 1980).

In RST, options are valued not in terms of their intrinsic value or utility, but in terms of how much they affect the organism's probability of survival. McDermott et al. (2008) proposed a survival function that captures some properties of PT. In their model, an organism must achieve a minimum level of energy by the end of the day to survive the night, much as Rick needs to stay above a €500 threshold. Figure 1d illustrates the function that maps an organism's probability of survival as a function of the expected payoff, and its distance to the survival threshold. This survival function illustrates how Rick values money; it is comparable with the value function in PT and the utility function in EUT.[6] McDermott et al. proposed that when an organism is in a state of need, below the survival threshold (e.g., when Rick's wealth is below €500; the dotted line in Figure 1d), it makes decisions in the domain of losses, but when it is sated (e.g., when Rick has more than €500), it makes decisions in the domain of gains. This function implies risk seeking for an organism in need and risk aversion for an organism that is sated. This behavioral pattern, which is not captured by EUT, matches the reflection effect postulated by PT.

However, because this function is symmetric around the critical threshold of energy, and because it assumes final (energy) states as EUT does, it cannot capture loss aversion—at least, not as conceptualized in PT (Houston et al., 2014). If organisms move along the survival curve—as EUT assumes for wealth—risk aversion and loss aversion are inseparable in RST, as they are in EUT. In other words, if RST assumes that final states drive value, and so risk attitudes and loss attitudes cannot be disentangled.

Therefore, increases in wealth would be evaluated as gains, and decreases as losses, no matter where on the survival curve the organism stands; changes along the survival function would determine whether an organism earns or loses energy—just as EUT values money. If Rick is in a state of need, with, say €200 in his pocket, a gain of €100 translates into an α_{need} increase in the probability of survival, and a loss of €100 translates into a β_{need} decrease in the probability of survival. Given that $\alpha_{need} > \beta_{need}$, because of the convexity of the survival function when in need, Rick cannot afford to be risk averse. He must risk a loss for a chance to pass the €500 threshold. In contrast, when Rick's wealth is above €500, say €800, the opposite occurs. When an organism is sated, losses loom larger than gains. Under this interpretation of McDermott et al.'s (2008) survival function, loss aversion and risk aversion are one and the same thing, as in EUT. Moreover, unlike in PT, the tendency of losses to loom larger than gains cannot be interpreted as an individual trait because that tendency differs across energy or wealth states.

RST also makes unique predictions. To illustrate, someone needing €10,000 for urgent medical treatment is likely to prefer a 10% chance of receiving €10,000 to the certainty of receiving €2,000, even though the expected value of the safe option is twice that of the risky option. Neither PT—with current wealth as its standard reference point—nor EUT would predict a preference for the risky option in this situation.[7]

To conclude, in RST, in contrast to PT, loss aversion is inseparable from risk aversion. Losses loom larger than gains as an adaptive response; a sated organism will not take risks. Things change profoundly if the organism's metabolic state drops below a minimum threshold. It then has no choice but to suspend its aversion to losses to seek gains. In RST, loss aversion is a dynamic and state-dependent phenomenon (in terms of the organism's metabolic, not wealth, state).[8]

Sources of Conflicting Views on Loss Aversion

The debate on the nature and scope of loss aversion has been triggered by both conceptual concerns and empirical findings. Our analysis of three theories of risky choice sheds light on some of the conceptual issues (summarized in Table 1). Let us briefly discuss four important distinctions that can help to explain conflicting views in the debate on loss aversion.

The distinction between loss aversion and risk aversion

Confusion can arise if one does not distinguish loss aversion as conceptualized in PT from the more general concept that losses loom larger than gains, as embodied in EUT. The idea that losses have more psychological impact than do gains has been around since the early 1700s. It is implied by any concave utility function that embodies risk aversion. The crucial point in the current debate is that it is difficult to disentangle loss aversion from risk aversion by observing people's behavior outside the laboratory. People's avoidance of potential losses can be driven by loss aversion, as assumed in PT, or by risk aversion, as assumed in EUT. Researchers therefore test for and measure loss aversion in highly controlled settings, in which people make decisions

Table 1. Summary of Characteristics of Expected-Utility Theory, Prospect Theory, and Risk-Sensitivity Theory

Characteristic	Expected-utility theory	Prospect theory	Risk-sensitivity theory
Value is a function of	Final state of wealth	Change from a reference point	Final state of energy or wealth
Conceptual scope	Predicts feelings about wealth and resulting choices	Predicts choices	Predicts feelings about wealth and resulting choices
Time frame	Broad	Immediate	Intermediate and cyclical
State dependence	Dependent	Independent	Partially dependent because of resetting cycles
Context dependence	Independent	Dependent, as reference points are affected by context	Independent
Loss aversion and risk aversion are distinct	No	Yes	No
View of loss aversion	Trait, but its degree is contingent on wealth state	Trait	Contingent on need state

between gambles—on that basis, all parameters in PT can be estimated. Only by assessing lambda (λ), the loss aversion parameter, can researchers show whether loss aversion, in addition to or instead of risk aversion, is manifest in people's choices. Thus, if researchers estimating PT parameters fail to find evidence of loss aversion (e.g., Lejarraga et al., 2019), it speaks against Kahneman and Tversky's conceptualization of loss aversion but is still consistent with the broadly accepted idea that losses loom larger than gains (i.e., risk aversion). In short, people commonly dislike losses and they dislike them more than they like the equivalent gains. This intuitive idea is not disproven when estimates of the PT parameter $\lambda = 1$, because the regularity that losses loom larger than gains is not reducible to loss aversion as conceptualized in PT.

The distinction between trait-dependent and state-dependent loss aversion

Another source of confusion is that researchers' views may differ regarding whether loss aversion is a stable individual trait or a response to a particular state or circumstance. PT conceptualizes loss aversion as a trait-like construct. Likewise, EUT, assuming that losses loom larger than gains in terms of concave utility function, assumes this psychological regularity to be trait-like to the extent that an individual's risk preference is stable. In RST, however, losses loom larger than gains only under certain states. Thus, failure to observe $\lambda > 1$ is inconsistent with the conceptualization of loss aversion assumed in PT but is not at odds with the trait-dependent view in EUT or the state-dependent view in RST.

The distinction between trait-dependent and context-dependent loss aversion

In PT, loss aversion can be interpreted as a trait-like construct, but the theory's key idea of valuation relative to a reference point opens up the possibility that context guides loss-averse choice. For example, a decision maker could consider a change in a product's price to be a gain or a loss depending on the past prices they recall, such as the most recent or the cheapest price. Relatedly, Walasek and Stewart (2015, 2019) proposed another mechanism for how context influences loss aversion. According to their decisions-by-sampling account, the valuation of an outcome depends on its ranking among possible gains or losses. That is, the range and skew of potential gains and losses determines the position of a given outcome in an overall ranking, thus influencing its valuation. The effect is small and does not fully explain loss-averse choices, but it is robust (Walasek & Stewart, 2019). Ranking and context dependency (as embodied in PT's central idea of reference points) suggest that another source of confusion is the possibility that loss aversion is simultaneously trait-like and context dependent. Context dependency can attenuate or even eliminate loss aversion.

The distinction between attention and choice: the attention–aversion gap

Finally, another possible source of confusion relates to the impact of losses on people's physiology and on their behaviors other than choice. Growing evidence shows that losses have a special psychological status:

Fig. 3. Loss aversion as a function of attention to loss versus gain information (i.e., including both outcome and probability boxes). Each dot represents a participant's loss aversion parameter λ relative to the ratio of box opening times in loss problems to those in gain problems. From "The Attention–Aversion Gap: How Allocation of Attention Relates to Loss Aversion," by T. Lejarraga, M. Schulte-Mecklenbeck, T. Pachur, and R. Hertwig, 2019, *Evolution and Human Behaviour*, *40*, p. 463. Copyright 2019 by Elsevier. Reprinted with permission.

People treat losses differently than gains, even if their choices do not reflect loss aversion as measured in PT. For example, relative to gains, losses trigger asymmetric responses of the autonomic nervous system (Sokol-Hessner et al., 2009; Yechiam et al., 2015), heart rate (Hochman & Yechiam, 2011), hormonal response (Burke et al., 2018; Margittai et al., 2018), neural response (Canessa et al., 2013; Sokol-Hessner et al., 2013; Tom et al., 2007), and measures of attention such as search within options (Lejarraga et al., 2012), search across options (Lejarraga & Hertwig, 2017; Yechiam et al., 2015), and visual search (Lejarraga et al., 2019; Pachur et al., 2018; Yechiam & Hochman, 2013). This asymmetry in attention is robust. It is present when people make loss-averse choices and when their choices do not reflect loss aversion at all (Lejarraga et al., 2019). Figure 3 illustrates 166 participants who chose between gambles; their loss aversion was estimated and their attention patterns were recorded using MouselabWEB (for details see Lejarraga et al., 2019). Most participants (94%) spent more time viewing losses than gains, but only 71 (40%) were loss averse in their choices. This attention–aversion gap is another source of confusion. Evidence against loss aversion in choice behavior does not mean that losses do not have privileged status psychologically. They clearly trigger a stronger response on a wide range of behavioral, physiological, and cognitive dimensions.

Discussion

For centuries, scholars have thought that losses have a larger psychological impact than do gains of equivalent magnitude. The idea was captured in the first formal theory of decisions under risk, EUT (Bernoulli, 1738/1954), according to which decision makers evaluate the options they face in terms of the implied final states of wealth. Kahneman and Tversky's (1979) PT, in contrast, assumes that decision makers evaluate options in terms of the changes they imply relative to a meaningful psychological reference point, usually current wealth. It also assumes that people's risk attitudes differ depending on whether the choice involves potential gains or losses. Decision makers are assumed to avoid risks to secure gains but to seek risks when pursuing the goal of avoiding losses. To model the phenomenon that losses loom larger than gains and to capture their new empirical observations about human choice, Kahneman and Tversky proposed a value function that is steeper for losses than for gains. Although the function is convex for losses, implying risk-seeking behavior, and concave for gains, implying risk aversion, it is functionally concave around the reference point. This permitted the theory to capture risk aversion in symmetric gambles. As we have shown, the phenomenon of losses looming larger than gains does not differentiate between PT and EUT. Establishing the distinction between risk aversion and loss aversion does.

Several evolutionary theorists and psychologists (Aktipis & Kurzban, 2005; McDermott et al., 2008; Mishra et al., 2017) argued that loss aversion serves an adaptive function: Losses, if large enough, can threaten the livelihood of an organism; no such critical threshold exists in the domain of gains. A gain can increase the probability of survival and reproduction and usually does not kill. Therefore, it is reasonable to assume that natural selection has shaped organisms to be more alert and vigilant toward losses than gains. RST, the main theoretical framework of foraging behavior in behavioral ecology, implies that losses loom larger than gains depending on an organism's metabolic state: When in need, an organism must accept the risk of losses to achieve a minimum energy level necessary for survival; once it has secured a momentarily high level of energy, it can and should afford to be loss averse (Lejarraga et al., 2019).

In conclusion, we suggest that in the debate about loss aversion in human choice it is important to carefully distinguish between the theoretical interpretations of loss aversion in psychology, economics, and behavioral ecology and to keep their historical roots in mind. Evidence inconsistent with one interpretation need not also refute another. Finally, the phenomenon of losses looming larger than gains appear to trigger a general vigilance to the threat of a loss. This vigilance represents a necessary but insufficient condition for loss aversion in choice.

Transparency

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Notes

1. The opposite of loss aversion holds when the utility function is convex, thus describing risk seeking.
2. Although state independence is the common treatment of PT as used, for example, by Tversky and Kahneman (1992) to estimate PT parameters, the authors left room for the possibility that changes are affected by wealth state: "the emphasis on changes as the carriers of value should not be taken to imply that the value of a particular change is independent of initial position" (Kahneman & Tversky, 1979, p. 277).
3. PT could also imply loss aversion when $\lambda = 1$ and $\alpha < \beta$.
4. This observation should not be confused with the fact that different reference points can move decisions from the gain domain to the loss domain and vice versa, thus shifting risk-seeking choice to risk-averse choice. Even if the context can change behavior, the value function that is assumed to underlie all decisions will be asymmetric and imply loss aversion.
5. As noted by Yechiam (2018), loss aversion was the only phenomenon for which Kahneman and Tversky (1979) did not show experimental evidence. They assumed loss aversion was a stylized fact from previous literature. Yechiam questioned the strength of that early evidence. In their 1992 article, however, Tversky and Kahneman did provide experimental evidence for loss aversion.
6. McDermott et al.'s (2008) model assumes that organisms make a one-off choice between alternatives, which makes it comparable with EUT and PT. Houston et al. (2014) showed that McDermott et al.'s survival function does not hold when organisms can exploit the food sources throughout the day or when they can dynamically change food sources. We use McDermott et al.'s survival function as a graphical illustration of the more general phenomenon captured by risk-sensitive foraging models: risk-seeking behavior when the organism is in need and risk-averse behavior when it is sated (Stephens, 1981).
7. Admittedly, Kahneman and Tversky (1979) considered the possibility that people's circumstances could affect their preferences, particularly loss aversion:

> Any discussion of the utility function for money must leave room for the effect of special circumstances on preferences. For example, . . . an individual's aversion

to losses may increase sharply near the loss that would compel him to sell his house and move to a less desirable neighborhood. Hence, the derived value (utility) function of an individual does not always reflect "pure" attitudes to money, since it could be affected by additional consequences associated with specific amounts. (pp. 278–279)

8. Houston and McNamara (1999) examined the implications of an organism that can store energy or wealth: The time frame is longer and the cyclicality implied in the current exposition of RST is broken.

References

Aktipis, C. A., & Kurzban, R. O. (2005). Is homo economicus extinct? Vernon Smith, Daniel Kahneman and the evolutionary perspective. In R. Koppl (Ed.), *Evolutionary psychology and economic theory* (pp. 135–153). Emerald Group Publishing.

Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology*, *5*, 323–370. https://doi.org/10.1037/1089-2680.5.4.323

Benartzi, S., & Thaler, R. H. (1995). Myopic loss aversion and the equity premium puzzle. *The Quarterly Journal of Economics*, *110*, 73–92. https://doi.org/10.2307/2118511

Bernoulli, D. (1954). Exposition of a new theory on the measurement of risk (L. Sommer, Trans.). *Econometrica*, *22*(1), 22–36. https://doi.org/10.2307/1909829 (Original work published 1738)

Burke, C. J., Soutschek, A., Weber, S., Beharelle, A. R., Fehr, E., Haker, H., & Tobler, P. N. (2018). Dopamine receptor-specific contributions to the computation of value. *Neuropsychopharmacology*, *43*, 1415–1424. https://doi.org/10.1038/npp.2017.302

Canessa, N., Crespi, C., Motterlini, M., Baud-Bovy, G., Chierchia, G., Pantaleo, G., & Cappa, S. F. (2013). The functional and structural neural basis of individual differences in loss aversion. *The Journal of Neuroscience*, *33*, 14307–14317. https://doi.org/10.1523/JNEUROSCI.0497-13.2013

Caraco, T., Martindale, S., & Whittam, T. S. (1980). An empirical demonstration of risk-sensitive foraging preferences. *Animal Behaviour*, *28*, 820–830. https://doi.org/10.1016/S0003-3472(80)80142-4

Ert, E., & Erev, I. (2013). On the descriptive value of loss aversion in decisions under risk: Six clarifications. *Judgment and Decision Making*, *8*, 214–235. https://doi.org/10.2139/ssrn.1012022

Fishburn, P. C., & Kochenberger, G. A. (1979). Two-piece von Neumann–Morgenstern utility functions. *Decision Sciences*, *10*, 503–518. https://doi.org/10.1111/j.1540-5915.1979.tb00043.x

Frey, R., Pedroni, A., Mata Rieskamp, J., & Hertwig, R. (2017). Risk preference shares the psychometric structure of major psychological traits. *Science Advances*, *3*, Article e1701381. https://doi.org/10.1126/sciadv.1701381

Frey, R., Richter, D., Schupp, J., Hertwig, R., & Mata, R. (2021). Identifying robust correlates of risk preference: A systematic approach using specification curve analysis. *Journal of Personality and Social Psychology*, *120*(2), 538–557. https://doi.org/10.1037/pspp0000287

Gal, D. (2018, July 31). Why the most important idea in behavioral decision-making is a fallacy. *Scientific American*. https://blogs.scientificamerican.com/observations/why-the-most-important-idea-in-behavioral-decision-making-is-a-fallacy/

Gal, D., & Rucker, D. D. (2018). The loss of loss aversion: Will it loom larger than its gain? *Journal of Consumer Psychology*, *28*, 497–516. https://doi.org/10.1002/jcpy.1047

Galanter, E., & Pliner, P. (1974). Cross-modality matching of money against other continua. In H. R. Moskowitz, B. Scharf, & J. C. Stevens (Eds.), *Sensation and measurement* (pp. 65–76). D. Reidel.

Gigerenzer, G. (2008). *Rationality for mortals: How people cope with uncertainty*. Oxford University Press.

Glöckner, A., & Pachur, T. (2012). Cognitive models of risky choice: Parameter stability and predictive accuracy of prospect theory. *Cognition*, *123*, 21–32. https://doi.org/10.1016/j.cognition.2011.12.002

Güth, W. (2008). (Non)behavioral economics: A programmatic assessment. *Zeitschrift für Psychologie*, *216*, 244–253. https://doi.org/10.1027/0044-3409.216.4.244

Harrison, G. W., & Rutström, E. E. (2009). Expected utility theory and prospect theory: One wedding and a decent funeral. *Experimental Economics*, *12*, 133–158. https://doi.org/10.1007/s10683-008-9203-7

Hochman, G., & Yechiam, E. (2011). Loss aversion in the eye and in the heart: The autonomic nervous system's responses to losses. *Journal of Behavioral Decision Making*, *24*, 140–156. https://doi.org/10.1002/bdm.692

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, *92*, 1644–1655. https://doi.org/10.1257/000282802762024700

Houston, A. I., Fawcett, T. W., Mallpress, D. E. W., & McNamara, J. M. (2014). Clarifying the relationship between prospect theory and risk-sensitive foraging theory. *Evolution and Human Behavior*, *35*, 502–507. https://doi.org/10.1016/j.evolhumbehav.2014.06.010

Houston, A. I., & McNamara, J. M. (1999). *Models of adaptive behaviour: An approach based on state*. Cambridge University Press.

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review*, *93*, 1449–1475. https://doi.org/10.1257/000282803322655392

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1990). Experimental tests of the endowment effect and the Coase theorem. *Journal of Political Economy*, *98*, 1325–1348. https://doi.org/10.1086/261737

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*, 263–292. https://doi.org/10.2307/1914185

Kahneman, D., & Tversky, A. (Eds.). (2000). *Choices, values, and frames*. Russell Sage Foundation.

Lejarraga, T., & Hertwig, R. (2017). How the threat of losses makes people explore more than the promise of gains. *Psychonomic Bulletin & Review*, *24*, 708–720. https://doi.org/10.3758/s13423-016-1158-7

Lejarraga, T., Hertwig, R., & Gonzalez, C. (2012). How choice ecology influences search in decisions from experience. *Cognition*, *124*, 334–342. https://doi.org/10.1016/j.cognition.2012.06.002

Lejarraga, T., Schulte-Mecklenbeck, M., Pachur, T., & Hertwig, R. (2019). The attention–aversion gap: How allocation of attention relates to loss aversion. *Evolution and Human Behavior*, *40*, 457–469. https://doi.org/10.1016/j.evolhumbehav.2019.05.008

Mallpress, D. E. W., Fawcett, T. W., Houston, A. I., & McNamara, J. M. (2015). Risk attitudes in a changing environment: An evolutionary model of the fourfold pattern of risk preferences. *Psychological Review*, *122*, 364–375. https://doi.org/10.1037/a0038970

Margittai, Z., Nave, G., Van Wingerden, M., Schnitzler, A., Schwabe, L., & Kalenscher, T. (2018). Combined effects of glucocorticoid and noradrenergic activity on loss aversion. *Neuropsychopharmacology*, *43*, 334–341. https://doi.org/10.1038/npp.2017.75

McDermott, R., Fowler, J. H., & Smirnov, O. (2008). On the evolutionary origin of prospect theory preferences. *The Journal of Politics*, *70*, 335–350. https://doi.org/10.1017/S0022381608080341

Mishra, S., Barclay, P., & Sparks, A. (2017). The relative state model: Integrating need-based and ability-based pathways to risk-taking. *Personality and Social Psychology Review*, *21*, 176–198. https://doi.org/10.1177/1088868316644094

Pachur, T., Schulte-Mecklenbeck, M., Murphy, R. O., & Hertwig, R. (2018). Prospect theory reflects selective allocation of attention. *Journal of Experimental Psychology: General*, *147*, 147–169. https://doi.org/10.1037/xge0000406

Riedl, D., Heuer, A., & Strauss, B. (2015). Why the three-point rule failed to sufficiently reduce the number of draws in soccer: An application of prospect theory. *Journal of Sport and Exercise Psychology*, *37*, 316–326. https://doi.org/10.1123/jsep.2015-0018

Rozin, P., & Royzman, E. B. (2001). Negativity bias, negativity dominance, and contagion. *Personality and Social Psychology Review*, *5*, 296–320. https://doi.org/10.1207/S15327957PSPR0504_2

Sokol-Hessner, P., Camerer, C. F., & Phelps, E. A. (2013). Emotion regulation reduces loss aversion and decreases amygdala responses to losses. *Social Cognitive and Affective Neuroscience*, *8*, 341–350. https://doi.org/10.1093/scan/nss002

Sokol-Hessner, P., Hsu, M., Curley, N. G., Delgado, M. R., Camerer, C. F., & Phelps, E. A. (2009). Thinking like a trader selectively reduces individuals' loss aversion. *Proceedings of the National Academy of Sciences, USA*, *106*, 5035–5040. https://doi.org/10.1073/pnas.0806761106

Stephens, D. W. (1981). The logic of risk-sensitive foraging preferences. *Animal Behavior*, *29*, 628–629. https://doi.org/10.1016/S0003-3472(81)80128-5

Thaler, R. (1980). Toward a positive theory of consumer choice. *Journal of Economic Behavior & Organization*, *1*, 39–60.

Tom, S. M., Fox, C. R., Trepel, C., & Poldrack, R. A. (2007). The neural basis of loss aversion in decision-making under risk. *Science*, *315*, 515–518. https://doi.org/10.1126/science.1134239

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, *5*, 297–323. https://doi.org/10.1007/BF00122574

von Neumann, J., & Morgenstern, O. (1953). *Theory of games and economic behavior* (3rd ed.). Princeton University Press.

Walasek, L., & Stewart, N. (2015). How to make loss aversion disappear and reverse: Tests of the decision by sampling origin of loss aversion. *Journal of Experimental Psychology: General*, *144*, 7–11. https://doi.org/10.1037/xge0000039

Walasek, L., & Stewart, N. (2019). Context-dependent sensitivity to losses: Range and skew manipulations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*, 957–968. https://doi.org/10.1037/xlm0000629

Weber, M., & Camerer, C. F. (1998). The disposition effect in securities trading: An experimental analysis. *Journal of Economic Behavior & Organization*, *33*, 167–184. https://doi.org/10.1016/S0167-2681(97)00089-9

Yechiam, E. (2018). Acceptable losses: The debatable origins of loss aversion. *Psychological Research*, *83*, 1327–1339. https://doi.org/10.1007/s00426-018-1013-8

Yechiam, E., & Hochman, G. (2013). Losses as modulators of attention: Review and analysis of the unique effects of losses over gains. *Psychological Bulletin*, *139*, 497–518. https://doi.org/10.1037/a0029383

Yechiam, E., Retzer, M., Telpaz, A., & Hochman, G. (2015). Losses as ecological guides: Minor losses lead to maximization and not to avoidance. *Cognition*, *139*, 10–17. https://doi.org/10.1016/j.cognition.2015.03.001

Yechiam, E., Zahavi, G., & Arditi, E. (2015). Loss restlessness and gain calmness: Durable effects of losses and gains on choice switching. *Psychonomic Bulletin & Review*, *22*, 1096–1103. https://doi.org/10.3758/s13423-014-0749-4