

Prediction Biases: An Integrative Review

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Abstract

Research in psychology and related fields has documented a myriad of prediction biases, such as the underprediction of hedonic adaptation and the overprediction of other people's concern for fairness. These prediction biases are ostensibly independent, each with its own cause. We argue, however, that many of these seemingly disparate biases are specific instances of a general bias—situation insensitivity: People are insensitive to variations in the situational variable that underlies the target variable (the variable to be predicted). Consequently, when encountering a condition in which the situational variable is at one of its ends such that the value of the target variable is low, people overpredict the value; conversely, when encountering a condition in which the situational variable is at its other end such that the value of the target variable is high, people underpredict it. Most prior research documenting prediction biases has focused on only one end of the situational variable and therefore has shown either only an overprediction bias or only an underprediction bias. We argue that at the other end of the situational variable, the originally documented bias can disappear or even reverse. Our framework not only explains known biases but also predicts new biases.

Keywords

prediction bias, forecasting errors, overgeneralization, regression, relevance insensitivity

Accurate predictions are the foundation of good decisions. Yet people's predictions often deviate from reality. Research in psychology and related fields has documented a variety of prediction biases (also called forecasting errors), in which people mispredict a target variable, such as how well they will perform on a task, how much personal control they have, how much other people are willing to take risks, and how much other people care about fairness. Some of these biases are overpredictions (overestimating the value of a target variable), and others are underpredictions (underestimating the value of a target variable). Most research has treated these biases as unrelated to each other. But could these ostensibly independent biases—for example, the underprediction of hedonic adaptation and overprediction of other people's concern for fairness—possibly be driven by the same cause?

In this article, we offer a unifying framework that attributes these seemingly disparate biases to a general underlying bias: situation insensitivity. In the following sections, we first present our framework and then illustrate its power to both explain known biases and predict new biases.

Situation Insensitivity

We posit that many prediction biases arise because people are insensitive to variations in situational variables (SVs) and, hence, insensitive to variations in the corresponding target variables (TVs). Figure 1 depicts our theory.

We theorize that people generally make accurate estimations of the TV when the actual value of the SV is around its central tendency, $\bar{sv}$, but that people are not sensitive to variations in the SV; they rely on $\bar{sv}$ to estimate the TV even when the SV is not actually around $\bar{sv}$. Consequently, when the SV is near sv_1 , so the corresponding TV is low (tv_1), people overestimate tv_1 , thus exhibiting an overprediction bias; when the SV is

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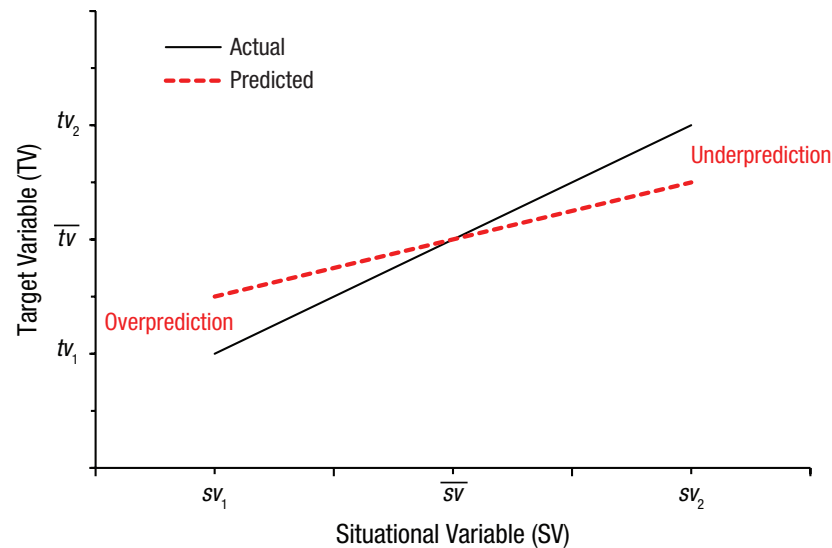


Fig. 1. A depiction of the situation-insensitivity theory. The y-axis represents the target variable (TV)—the variable to be predicted; the x-axis represents a situational variable (SV)—a factor that monotonically influences the TV; sv_1 and sv_2 are two ends of the SV, and $\bar{sv}$ is the central tendency of the SV values that people usually encounter in their learning history; tv_1 , tv_2 , and $\bar{tv}$ are the corresponding TV values. When the SV nears its sv_1 end, the TV value will be lower than average, and people will overestimate the TV value; when the SV nears its sv_2 end, the TV value will be higher than average, and people will underestimate the TV value.

near sv_2 , so the corresponding TV is high (tv_2), people underestimate tv_2 , thus displaying an underprediction bias.

For example, consider the misprediction of performance (i.e., biases in confidence judgments). People overpredict their performance on difficult tasks (i.e., overconfidence; Fischhoff et al., 1977) but underpredict their performance on easy tasks (i.e., underconfidence; Lichtenstein & Fischhoff, 1977). In this case, the TV is performance, and the SV is task difficulty. The TV is a function of the SV; performance is low (tv_1) when the tasks are difficult (sv_1) and high (tv_2) when the tasks are easy (sv_2). According to our theory, people mispredict their performance because they are insensitive to variations in task difficulty (the SV). The average difficulty of the tasks that people encounter in life ($\bar{sv}$) falls between sv_1 and sv_2 . When they encounter tasks that are more difficult than usual (sv_1), such that the actual performance is low (tv_1), people overestimate their performance, thus exhibiting overconfidence; when they encounter tasks that are easy (sv_2), such that the actual performance is high (tv_2), people underestimate their performance, thus exhibiting underconfidence.

We are not the first to make this argument regarding the misprediction of performance; other researchers made similar arguments long ago (Lichtenstein & Fischhoff, 1977; Moore & Healy, 2008). Our tenet is that

this insensitivity-based argument is not limited to the misprediction of performance—rather, it applies to many mispredictions. This broader perspective is our situation-insensitivity theory. It builds on prior work on regressive response (Erev et al., 1994; Fiedler & Prager, 2018; Fiedler & Unkelbach, 2014), noise in response (Hilbert, 2012), and, especially, relevance insensitivity (Hsee et al., 2019). According to Hsee et al. (2019), many classic judgmental biases—including the sunk-cost fallacy, the anchoring bias, and base-rate neglect—stem from decision makers' insensitivity to the relevance (i.e., diagnosticity) of the given information for the given task; decision makers exhibit a bias in one direction when the relevance of the information is low and a reverse bias when the relevance is high. The situation-insensitivity theory we propose here is an extension of Hsee et al.'s relevance-insensitivity model.

A key insight of our theory is that one may observe both an overprediction bias and an underprediction bias of the TV by examining predictions at different ends of the underlying SV. Many studies that document prediction biases focus on only one end of the SV spectrum (e.g., the sv_1 end), thus giving the wrong impression that the documented prediction bias occurs in only one direction (e.g., always overprediction). Our framework suggests that at the other end of the SV, the previously identified biases may disappear or even reverse.

Integrating Existing Biases

In this section, we review various other classic prediction biases and show how they fit our situation-insensitivity theory (see Fig. 2).

Personal control

In her seminal work, Langer (1975) documented an intriguing illusion-of-control phenomenon: People overpredict the degree to which they have control over the outcome of an uncertain event. More than three decades later, Gino et al. (2011) found that people overpredict personal control only when the outcome is determined purely by luck. If the outcome depends purely on skill, people underpredict their personal control (Gino et al., 2011).

According to our theory, these seemingly opposite biases occur because people are insensitive to variations in the SV underlying the TV. Here, the TV is personal control, and the SV is the extent to which the outcome depends on luck versus skill. When the outcome depends solely on luck (sv_1), people have no control (tv_1), and therefore they overestimate their control, thus exhibiting the illusion-of-control bias originally documented by Langer (1975). When the outcome depends fully on skill (sv_2), people have ample control (tv_2), and therefore they underestimate their ability to control, exhibiting the reverse bias that Gino et al. (2011) identified.

Other people's propensity to take risks

In the domain of risk preferences, Hsee and Weber (1997) found that people overpredict other people's tendency to take risks. The authors considered their effect so general that they dubbed it a "fundamental prediction error." However, in subsequent research, Faro and Rottenstreich (2006) found the bias not so general after all—it is limited to situations in which the risky options involve high-probability gains or low-probability losses. If the risky options involve low-probability gains or high-probability losses, people underpredict other people's propensity to take risks (Faro & Rottenstreich, 2006).

Again, according to our theory, these apparently opposite biases arise because predictors are insensitive to variations in the SV underlying the TV. Here, the TV is other people's propensity to take risks, and the SV is a combination of the probability (high vs. low) and valence (gain vs. loss) of the prospects. According to prospect theory (Kahneman & Tversky, 1979), people (i.e., predictees) are risk averse (tv_1) in situations involving high-probability gains or low-probability losses (sv_1)

and risk seeking (tv_2) in situations involving low-probability gains or high-probability losses (sv_2). According to our theory, predictors will overpredict the predictees' risk-taking tendency in sv_1 situations and underpredict their risk-taking tendency in sv_2 situations. Indeed, the overprediction bias is what Hsee and Weber (1997) found, and the underprediction bias is what Faro and Rottenstreich (2006) found.

Temporal regression

Another classic prediction bias is the nonregressive forecast: People underpredict the extent to which extreme values will regress toward the mean over time (Harrison & Bazerman, 1995; Kahneman & Tversky, 1973). However, Hsee et al. (2019) found that this bias is also situation-specific: People underpredict temporal regression when the outcome of an event depends on luck and overpredict temporal regression when the outcome depends on stable skills. For example, in a study reported by Hsee et al., participants learned that a player of a purely luck-based or a purely skill-based game scored low on Day 1, and participants then predicted the player's performance on Day 2. Participants underpredicted regression toward the mean on Day 2 when the game was purely luck based but overpredicted regression when the game was purely skill based.

In this example, the TV is temporal regression, and the SV is the extent to which the outcome of the event depends on luck or skill. According to our theory, both the underprediction and the overprediction of temporal regression arise because people are insensitive to variations in the SV. When the outcome depends on luck (sv_2), such that the actual temporal regression is high (tv_2), people underestimate temporal regression; when the outcome depends on skill (sv_1), such that the actual temporal regression is low (tv_1), people overestimate temporal regression, exhibiting the reverse bias.

Summary

To summarize, in each of these cases, the original research demonstrated a prediction bias, which was presumed to be general, but subsequent research found the bias to be situation-specific. The biases arise (at least in part) because people are insensitive to variations in the underlying SV and, therefore, to variations in the corresponding TV.

Predicting New Biases

Our theory not only explains existing findings but also predicts new biases. In this section, we review areas in which the existing literature has identified a bias at only

Target Variable (TV)	Situational Variable (SV)	Values of SV	Corresponding Values of TV	Direction of Prediction Bias	Bias's Name
Performance	Task Difficulty	Difficult (sv_1)	Low (tv_1)	Over	Overconfidence (Fischhoff et al., 1977)
		Easy (sv_2)	High (tv_2)	Under	Hard-Easy Effect (Lichtenstein & Fischhoff, 1977)
Personal Control	Nature of the Outcome's Determinant	Luck (sv_1)	Low (tv_1)	Over	Illusion of Control (Langer, 1975)
		Skill (sv_2)	High (tv_2)	Under	Imperfect Estimates of Control (Gino et al., 2011)
Other People's Propensity to Take Risks	Probability and Valence	High-Probability Gains or Low-Probability Losses (sv_1)	Low (tv_1)	Over	Fundamental Prediction Error (Hsee & Weber, 1997)
		Low-Probability Gains or High-Probability Losses (sv_2)	High (tv_2)	Under	Regressive Misprediction (Faro & Rottenstreich, 2006)
Temporal Regression	Nature of the Outcome's Determinant	Luck (sv_2)	High (tv_2)	Under	Nonregressive Forecast (Harrison & Bazerman, 1995; Kahneman & Tversky, 1979)
		Skill (sv_1)	Low (tv_1)	Over	Overprediction of Regression (Hsee et al., 2019)
Likelihood of Reversal	Nature of the Drawing Procedure and Resource Size	With Replacement or With Ample Resources (sv_1)	Low (tv_1)	Over	Gambler's Fallacy (Tversky & Kahneman, 1971)
		Without Replacement and With Limited Resources (sv_2)	High (tv_2)	Potentially Under	To Be Tested
Other People's Concern for Fairness	Magnitude of Consequences	Low Stakes and No Long-Term Consequences (sv_1)	Low (tv_1)	Over	Allocator's Illusion (Cooney et al., 2016)
		High Stakes or Long-Term Consequences (sv_2)	High (tv_2)	Potentially Under	To Be Tested
Satiation	Interval Between Adjacent Consumption Episodes and Complexity of Stimuli	Long Intervals or Complex Stimuli (sv_1)	Low (tv_1)	Over	Overprediction of Satiation (Kahneman & Snell, 1992; O'Brien, 2019; Ratner et al., 1999; Read & Loewenstein, 1995)
		No Intervals or Simple Stimuli (sv_2)	High (tv_2)	Potentially Under	To Be Tested; Galak et al. (2011) and O'Brien (2019) Found No Bias
Hedonic Adaptation	Permanence, Certainty, and Inherent Evaluability	Permanent, Certain, or Inherently Nonevaluable Change (sv_2)	High (tv_2)	Under	Durability Bias (Gilbert et al., 1998; Wilson et al., 2000)
		Temporary, Uncertain, or Inherently Evaluable Change (sv_1)	Low (tv_1)	Potentially Over	To Be Tested

Fig. 2. Summary of known biases and hypothesized new biases.

one end of an SV, and we use our situation-insensitivity theory to hypothesize a potential reverse bias at the other end of the SV (see Fig. 2).

Likelihood of reversal

A well-known bias in the judgment and decision-making literature is the gambler's fallacy. Imagine that you randomly draw balls with replacement from an urn that contains eight balls, of which half are red and half are blue. If the first three balls you draw are red, what is the likelihood that the fourth ball you draw will be blue instead? The correct answer is 50%, but if you are like most people, you will tend to overestimate the probability, mistakenly believing that because the first three balls were red, a blue ball must be "due" next time. This is an example of the gambler's fallacy—overestimating the likelihood that the next observation will be the opposite to the previous observations (i.e., the likelihood of reversal; Tversky & Kahneman, 1971).

In this example, the TV is the likelihood of reversal (e.g., the likelihood that the next ball will be different from, rather than the same as, the balls already drawn). According to our theory, people overpredict the likelihood of reversal because they are insensitive to variations in SVs that affect the likelihood of reversal. One such SV is whether the balls are drawn with or without replacement. Specifically, our theory predicts that when the balls are drawn with replacement (sv_1), such that the actual likelihood of reversal is low (in this case, tv_1 is 50%), people will overestimate the likelihood of reversal, exhibiting the typical gambler's fallacy. By contrast, if the balls are drawn without replacement (sv_2), such that the actual likelihood of reversal is high (in this case, tv_2 is 80%), people will underpredict the likelihood of reversal, exhibiting the reverse of the gambler's fallacy.

Another SV in the ball-drawing case is the total number of balls in the urn. Suppose that you draw *without* replacement from an urn that contains equal numbers of red and blue balls, that the first three balls you draw are red, and that your task is to estimate the likelihood of reversal (i.e., the likelihood that the next ball will be blue). Consider two alternative scenarios for the SV. In one (sv_1), the urn contains 800 balls; in the other (sv_2), it contains only eight. When the urn contains 800 balls (sv_1), having drawn three red balls has little impact on the likelihood of reversal for the next ball, and the actual tv_1 equals 49.8%; in this case, we expect that you would likely overestimate the likelihood of reversal, again exhibiting the classic gambler's fallacy. By contrast, when the urn contains only eight balls (sv_2), the actual tv_2 equals 80%, and, as noted earlier, we expect that you would exhibit the opposite of the gambler's fallacy.

In short, we propose that predictors are sensitive to neither the nature of the random process (drawing with replacement or without) nor the resource size (number of balls in the urn): They will commit the gambler's fallacy if they draw with replacement or there are many balls in the urn, and they will exhibit the opposite of the gambler's fallacy if they draw without replacement and there are only a small number of balls in the urn.

Other people's concern for fairness

Virtually everyone cares about fairness, a fundamental value in society. But do people accurately predict how much other people care about fairness? Cooney et al. (2016) found that allocators (i.e., people who allocate resources for others) overpredict how much recipients care about fairness.

Again, we argue that this bias is situation-specific and that the more general bias is that allocators are insensitive to variations in SVs that determine the TV (how much recipients actually care about fairness). In this case, a key SV is the magnitude of the consequences of an allocation. According to our theory, if an allocation involves only low-stakes outcomes and has no long-term consequences (sv_1), such that recipients' concern for fairness is low (tv_1), allocators will overestimate recipients' concern for fairness; this is what Cooney et al. (2016) reported. However, our theory also suggests that if an allocation involves high-stakes or long-term consequences (sv_2), such that recipients' concern for fairness is high (tv_2), allocators will likely underestimate recipients' concern for fairness, the opposite of the reported bias.

Satiation

Prior research has shown that people overpredict satiation, namely, the extent to which they will be fed up with a consumption item after they have consumed it multiple times (O'Brien, 2019; Ratner et al., 1999; Read & Loewenstein, 1995). For example, people overpredict the extent to which they will become tired of a piece of music if they listen to it once per day for seven consecutive days (Kahneman & Snell, 1992).

In this case, the TV is the degree of satiation. According to our theory, people overpredict satiation because they are insensitive to SVs that influence satiation. Two such SVs are the interval between adjacent consumption episodes and the complexity of the stimulus. If the interval between consumption episodes is long or the stimulus is complex (sv_1), actual satiation will be low (tv_1), and people will overpredict satiation (Kahneman & Snell, 1992; O'Brien, 2019; Read & Loewenstein, 1995). This is the classic finding.

On the other hand, if there are no intervals between consumption episodes (i.e., consumption is continuous) or the stimulus is simple (sv_2), the actual satiation will likely be high (tv_2), and we predict that the previously documented overprediction effect will disappear or even reverse. Indeed, some studies (Galak et al., 2011; O'Brien, 2019) have shown such attenuation effects. Although no previous research has found a reverse bias (i.e., underpredicting satiation), we suspect that it may occur if the SVs are extreme. Suppose that you love buffalo chicken wings, and you are hungry now. Consider two alternative scenarios. In one, you eat 10 buffalo chicken wings, one per day for the next 10 days. In the other scenario, you eat 10 buffalo chicken, one every 3 min over the next 30 min. Note that satiation in the first case will likely be low because the interval is long (1 day), and satiation in the second case will be high because there is virtually no interval between consumption episodes. On the basis of our theory, we hypothesize that you will underpredict your enjoyment of the 10th chicken wing in the first case (i.e., overpredict satiation) but overpredict your enjoyment of the 10th chicken wing in the second case (i.e., underpredict satiation).

Hedonic adaptation

People hedonically adapt to most changes. Existing research has shown that people generally underpredict hedonic adaptation (Wilson et al., 2000); for example, faculty up for tenure underpredict how fast life will return to normal if they are denied tenure (Gilbert et al., 1998).

However, we doubt that people always underpredict adaptation. Rather, we argue that people are insensitive to variations in the SVs that determine the rate of adaptation (TV). Such SVs include whether a change is permanent or temporary, certain or uncertain, or inherently evaluable or nonevaluable. Generally speaking, people adapt more slowly to uncertain and temporary changes than to certain and permanent changes (Frederick & Loewenstein, 1999; Smith et al., 2009; Wilson et al., 2005; Yang et al., 2017). Furthermore, people adapt more slowly to inherently evaluable changes (changes that affect their basic psychobiological needs) than to inherently nonevaluable changes (Tennant & Hsee, 2017).

Thus, according to our theory, the classic finding that people underpredict hedonic adaptation will hold only in conditions in which the change is permanent, certain, or inherently nonevaluable (sv_2); in such cases, the actual rate of adaptation is high (tv_2). When a change is temporary, uncertain, or inherently evaluable (sv_1), the actual rate of adaption will be low (tv_1), and people may overestimate adaptation, exhibiting the opposite of the previously identified bias.

Conclusion

We have proposed a unifying framework that integrates ostensibly unrelated prediction biases and suggests hypotheses regarding new prediction biases. The biases we have discussed are only some examples, and are far from exhaustive.

It is important to note that prediction biases may not necessarily occur in both directions. We suspect that whether an underprediction bias has a corresponding overprediction bias, and vice versa, depends on where $\overline{sv}$ (the central tendency of the SV values that people encounter in their learning history) lies on the SV dimension (i.e., where the crossover point is in Fig. 1). If $\overline{sv}$ falls somewhere in the middle between the two ends, sv_1 and sv_2 (as illustrated in Fig. 1), then both an overprediction bias and an underprediction bias will be observed, one at or near each end. If $\overline{sv}$ is near or at one end of the SV, then people will not exhibit a bias at this end and will exhibit a bias only near or at the other end. However, regardless of where $\overline{sv}$ falls and whether there are biases at both ends, the bias observed at one end of the SV will at least disappear at the other end.

Most extant research on prediction biases has focused on only one end of an SV and therefore has shown either only an overprediction bias or only an underprediction bias. In this sense, the biases documented in many reports reflect the researchers' own biases in stimulus selection. As Fiedler (2011) noted, biased stimulus selection is a serious but largely overlooked problem in psychological science, in which "fortunate stimulus selection is respected like an asset or skill rather than treated as a problem" (p. 164). This review draws attention to this problem and offers a systematic stimulus-selection approach that can help uncover potential prediction biases in opposite directions.

Recommended Reading

- Faro, D., & Rottenstreich, Y. (2006). (See References). Reports on findings that people underpredict others' tendency to take risks when those others' propensity to take risks is high.
- Fiedler, K. (2011). (See References). Examines the stimulus-selection bias and other sampling biases that can lead to inflated effects.
- Gino, F., Sharek, Z., & Moore, D. A. (2011). (See References). Shows that people underpredict personal control when personal control is high.
- Hsee, C. K., Yang, Y., & Li, X. (2019). (See References). Demonstrates that people overpredict temporal regression when temporal regression is weak.

Transparency

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