

NOTE ON BEHAVIOURAL FINANCE

Michael Lay wrote this note under the supervision of Stephen Foerster and Amos Nadler solely to provide material for class discussion. The authors do not intend to provide legal, tax, accounting, or other professional advice. Such advice should be obtained from a qualified professional.

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Version: 2017-06-09

Behavioural finance is a sub-field of behavioural economics that specifically attempts to explain financial market-related behaviour. Behavioural economics (and thus behavioural finance) is a relatively new branch of study that formally began in the 1980s and has garnered increasing attention from economists and neuroscientists. This note provides an overview of the fundamental theories and empirical findings in behavioural finance and describes recent breakthroughs that have expanded the breadth of the field. Furthermore, this note outlines strategies that are used to correct irrational financial behaviour.

TRADITIONAL FINANCIAL MODELS VERSUS BEHAVIOURAL FINANCE

Most traditional financial and asset pricing models, such as the capital asset pricing model, are based on two key assumptions: first, markets are frictionless, meaning there is no transaction cost to trade; and second, all investors are rational. Rationality means that when new information is received, investors update their beliefs appropriately and, given their beliefs, investors make choices that are consistent with expected utility maximization, implying that they desire higher expected returns and lower risk. In other words, traditional models assume that the markets adhere to the efficient market hypothesis (EMH), in which market prices fully and immediately reflect all relevant information and hence always equal a true fundamental, or intrinsic, value. Therefore, if the EMH holds, the key practical implication for investors in equities is to buy and hold an index fund, such as one that tracks the S&P 500 index.

Behavioural finance does not follow the same assumptions. Rather, behavioural finance simply observes how investors, financial managers, and markets behave and then draws implications from the observed behaviour (see Exhibit 1). According to behavioural finance, to accurately interpret empirical findings in finance, models should consider market frictions and investors who are not fully rational. Contrary to the assumptions of traditional financial models, investors do not always update their beliefs appropriately and do not always maximize expected utility. Furthermore, market prices do not always equal fundamental value. To understand these irrational phenomena, two core areas have been identified: limits to arbitrage and investor psychology. These are the behavioural finance building blocks.¹

LIMITS TO ARBITRAGE

The EMH assumes that as soon as a price deviates from its fundamental value (i.e., mispricing occurs), rational traders will see an attractive trading opportunity and immediately seize it. This response pushes the price back to its fundamental value, thereby correcting the mispricing, and the rational traders make “risk-free” profits, thereby gaining a “free lunch” (i.e., making gains at no cost). Therefore, “prices are not right” equates to “free lunch.” This situation is an example of arbitrage: an investment strategy that offers riskless profits at no cost. Subsequently, no “risk-free” profits can be made on correctly priced securities (i.e., “prices are right” means “no free lunch”).

Consider the following example: Suppose Pepsi is trading at its fundamental value of \$20 per share. Subsequently, a negative price shock caused by irrational traders pushes the price to \$15 per share. Supporters of the EMH would argue that rational traders would see this arbitrage opportunity and buy the security while shorting² a “substitute” security, such as Coca-Cola. The buying pressure on Pepsi would push its price from \$15 per share back to \$20 per share to match its fundamental value. Therefore, “prices are not right” means “free lunch” for the rational arbitrageurs.

Supporters of behavioural finance would disagree with the assumption that rational traders will correct the mispricing. Mispriced stocks may not return to their correct price due to further irrational behaviour. For instance, if the price of Pepsi falls from its fundamental value of \$20 per share to \$15 per share, the price may continue to decline due to further sell-off from irrational, or “noise,” traders (i.e., those who trade based on random “noise” rather than based on pertinent information). The price-correcting strategy of arbitrageurs is now both risky and costly, and mispricing can remain and even widen, thereby removing the opportunity for a “free lunch” from arbitrage.

The implication in this example is that arbitrage has its limits, and that “no free lunch” can be true in an *inefficient* market since it may be difficult for rational traders to correct the mispricing caused by irrational traders. In other words, “no free lunch” does *not* imply “the prices are right.” The limits to arbitrage are numerous and can be divided into three categories: fundamental risk, noise trader risk, and implementation costs.

Fundamental Risk

When a rational trader buys Pepsi stock at \$15 per share, one risk is that any announcement of bad news related to Pepsi’s fundamental value could push the stock price further down and lead to a loss. Rational traders are aware of this risk, so they may choose to hedge their Pepsi purchase by, at the same time, shorting a substitute security such as Coca-Cola. However, perfect-substitute securities are rare. Pepsi and Coca-Cola sell comparable products, yet the two are still distinct companies. The failure to remove fundamental risk arises from this second observation. Shorting a substitute security may protect the rational trader from the adverse effects of industry-wide bad news, but it still leaves the trader vulnerable to bad news specific to Pepsi; thus, fundamental risk remains.

Noise Trader Risk

Rational traders take a position assuming that the market price will return to its fundamental value. Even if it is true that the market price will eventually equal the fundamental value, the mispricing being exploited by rational traders can worsen in the short run—before the traders are ultimately profitable. For example, if the price of Pepsi has already fallen to \$15 per share from its fundamental value of \$20 per

share, pessimistic noise traders may develop an even more pessimistic outlook, thereby creating a sell-off that drives prices further down. The lowering share price could force rational traders to exit their positions early, due to forced liquidation, such as margin calls³ related to shorting.

The risk of an early, forced liquidation occurring during a temporary worsening of the mispricing causes rational traders to be more cautious from the start, and constricts them to effectively focus on short-run performance. In other words, rational traders are often risk-averse and have short horizons for their positions.

Some rational traders understand that noise traders are inevitable in the market and implement strategies oriented around particular types of noise trading. For example, rational traders may opt to trade in the same direction as noise traders. In this situation, “positive feedback” or “momentum” traders will buy more during a period when a particular security performed well in the previous period. Therefore, noise traders may push the price above the security’s fundamental value, but rather than sell or short the security, rational traders will buy it, expecting that the rise in price will attract additional positive-feedback traders who will push the price up even more. Thus, rational traders can exit at a profit, but only if they correctly anticipate the behaviour of the noise traders. As such, this strategy still holds an inherent risk.

Implementation Costs

The term “implementation costs” refers to the reality that, in actual securities exchanges, there are costs to trade, thereby showing that markets are not frictionless. A non-exhaustive list of these costs includes commissions, bid-ask spreads, price impacts of trading large quantities of a security (and hence of affecting prices), short-sale constraints (such as locating stocks to borrow), margin requirements, legal constraints, and the cost of finding and exploiting arbitrage. Accordingly, accruing all these costs makes price-correcting strategies more expensive.

INVESTOR PSYCHOLOGY

This section describes the second behavioural finance building block: deviations from rationality that might be expected due to cognitive limitations, which can be characterized as irrational behaviour. From the early work of cognitive psychologists and further experimental evidence, it has become clear that (1) how a decision is framed affects how that decision is made; (2) people have systematic cognitive biases that influence their beliefs and their preferences, thereby affecting their decision-making;⁴ and (3) people rely on rules of thumb (i.e., widely used principles) or heuristics when making decisions, ignoring some important aspects related to the decision.

Framing Effects

Preferences are influenced by framing effects, whereby people respond differently depending on how information is presented. Put another way, choices can be presented in such a way that they highlight the positive or negative aspects of the same decision, thereby changing the relative attractiveness (i.e., the preference) of that choice. Some framing effects derive from prospect theory and are related to loss aversion and the disposition effect.

Prospect Theory

Prospect theory is acclaimed for increasing recognition of the field of behavioural economics. It was developed by Daniel Kahneman and Amos Tversky,⁵ two psychologists who are arguably the “initiators” of behavioural economics. At its core, prospect theory is the idea that people weigh losses more heavily than gains. In other words, the pain from a loss of \$10 feels worse than the pleasure, or “utility,” felt from an equivalent gain of \$10.

The graph in Exhibit 2 illustrates the non-linear relationship between gains and losses. The graph is asymmetrical, with the function for loss being steeper. The reference point, where the vertical axis intersects with the horizontal axis, is a key feature segregating gains and losses.

Loss Aversion

Kahneman and Tversky’s study showed that, when there is a choice of receiving either \$10 with a 50 per cent probability (and zero otherwise) or \$5 with 100 per cent probability, the popular choice would be to accept the sure \$5. However, if individuals initially receive \$10 and are given the choice to either lose \$10 with 50 per cent probability (and lose nothing otherwise) or lose \$5 with 100 per cent certainty, most people choose the \$10 loss-or-no-loss option.⁶ Note that, in both situations, the expected dollar amount that individuals could obtain is identical, yet they choose differently. The study showed that most people are risk-averse over gains, and risk-seeking over losses.

One implication of this theory is that losses loom larger than similar-sized gains. This cognitive phenomenon is known as loss aversion. In other words, individuals have a greater sensitivity—estimated at approximately two-and-a-half times as great—to losses than to similar-sized gains. Loss aversion can lead investors to behave in a risk-averse manner and often treat repeated risks in the same manner as one-time risks, thereby acting too conservatively. Further, risk aversion may not be constant, but may change markedly following wins and losses relative to a reference point.

The Disposition Effect

The disposition effect is a direct consequence of loss aversion as predicted by prospect theory. Put simply, investors tend to sell winners too soon due to risk aversion and to hold losers too long due to risk seeking in an effort to avoid realizing losses. For example,⁷ suppose an investor purchased a stock last month for \$50 and it is now selling for \$60. Suppose also that there is a 50-50 chance that in the next month the stock will either decline back to \$50 or increase to \$70. The investor has the choice to sell now and realize a \$10 gain or hold for one more month, given the 50-50 odds of losing the sure \$10 gain or gaining an additional \$10. Prospect theory predicts the investor will choose the former, selling the winner.

Now suppose an investor purchased a stock last month for \$50, and it is now selling for \$40. Suppose also that there is a 50-50 chance that in the next month the stock will either decline to \$30 or recover to \$50. The investor has the choice to sell now and realize what had previously just been a \$10 “paper loss” or hold for one more month given the 50-50 odds of either losing an additional \$10 or “breaking even.” Prospect theory predicts the investor will choose the latter, holding on to the loser in hope that the price will increase and allow the investor to avoid realizing a loss.

Biases

A bias is a preconceived or unreasoned inclination or outlook for or against someone or something. With a specific focus on financial markets, several major biases that affect investor decisions are excessive optimism, overconfidence, confirmation bias, and belief perseverance.

Excessive Optimism

The excessive optimism bias is the overestimation of the frequency of favourable outcomes and the underestimation of the frequency of unfavourable outcomes. Therefore, investors display unrealistically hopeful views of their abilities and prospects.

For example, in mid-1999, some technology stocks (particularly those related to the then-nascent Internet) traded at price-earnings ratios upward of 100 times, whereas the long-run average was only approximately 16 times. To justify the Internet company stock prices as of mid-1999, based on reasonable assumptions related to expected price-earnings ratios and profit margins, investors were pricing anticipated annual revenue growth rates of approximately 80 per cent over five years, even though many of these companies were currently unprofitable.⁸ Such stocks were often referred to as being “priced for perfection,” implying that, to justify their prices, everything had to go right and nothing could go wrong. To put these expectations in perspective, Microsoft, one of the most successful early-stage public companies, grew its revenue in its first five years after its initial public offering at a rate of “only” 50 per cent annually. The resulting investment implication is that decisions being made from subjective and incorrect probabilities are likely to lead to mistakes. One possible solution for an investor is to first critically assess the situation, and then assign realistic probabilities to possible investment outcomes.

Overconfidence

The overconfidence bias is the belief that one has more knowledge and ability than one actually has. This bias leads to being overly convinced that one’s view or judgment is correct. Consequently, overconfident investors trade excessively and earn lower returns, an effect most pronounced in males. The bias of overconfidence can distort corporate investment.⁹ Overconfidence can take three distinct forms: over-precision, over-placement, and overestimation.

In one study, when asked to provide a 98 per cent confidence interval for the level of the Dow Jones Industrial Index in a year, the confidence intervals of participants included the true value only approximately 60 per cent of the time.¹⁰ The study concluded that the estimates were too narrow. This result is a feature known as over-precision, which is the tendency to express unwarranted certainty in the accuracy of one’s beliefs.

The over-placement (i.e., the “above-average effect”) of one’s performance relative to others was shown in another study through a simple two-part survey question: “Are you a good driver? Compared to other drivers you encounter, are you above average, average, or below average?”¹¹ The results showed that more than 80 per cent of those surveyed believed they were above average, which is statistically not possible.

Over-estimation is the tendency to overvalue one’s performance or judgment. This type of overconfidence can stem from two other distinct cognitive errors: the self-attribution bias and the hindsight bias. Self-attribution bias is the tendency of individuals to ascribe any success to their own talents while blaming

failure on bad luck; whereas hindsight bias is the tendency to believe that one predicted an event before it happened, a belief that is stated after the event has already occurred (i.e., the “I-knew-it-all-along” bias). These biases may lead investors to believe that they can predict the future better than they can, thereby over-estimating their actual performance.

Confirmation Bias

Confirmation bias is the tendency to search for, or interpret, information in a way that supports one's preconceived beliefs. Individual who have confirmation bias would interpret ambiguous information as supporting their prior views (i.e., hearing only what they want to hear). In practice, people spend too much time searching for reasons to support their views and not enough time searching for reasons why their current views may be wrong. Furthermore, such people are resistant to changing their prior views, even when presented with compelling counter-evidence.¹² This bias shows how investors may have incorrect belief formations. A potential counter to the confirmation bias is to play the “devil's advocate” before investing, for example, by examining opposing views about a stock's prospects.

Belief Perseverance

Belief perseverance is the tendency of individuals to maintain a belief despite the presence of contradicting evidence, which they treat with excessive skepticism. Although confirmation bias can lead to a skewed belief by acknowledging only that information that is consistent with their views, belief perseverance can lead to the same consequence of a skewed belief by actively rejecting any opposing information. For example, an investor who initially believes in the efficient market hypothesis may continue to believe in it even when substantial opposing evidence emerges. In some situations, when belief perseverance is powerful enough, it can lead to a strong form of confirmation bias, wherein people misinterpret counter-evidence as favourable evidence.¹³

Heuristics

Heuristics are readily accessible mental processes that facilitate the rapid retrieval of information or rapid problem solving (i.e., mental “shortcuts”) and are usually derived from experiences of similar situations or cognitive defaults. Consequently, heuristics are sufficient for immediate goals but do not guarantee optimal or perfect results. As such, they are a flawed, and these rapid decision-making processes can lead to irrational behaviour. Several heuristics that affect investor decisions are representativeness, sample size neglect, anchoring, availability, and affect.

Representativeness

The representativeness heuristic is best illustrated through an example. Consider the following:

“Mary is quiet, studious, and concerned with social issues. While an undergraduate at Berkeley, she majored in English literature and environmental studies.” Given this information, indicate which of the following two cases is most probable:

A. Mary is a librarian.

B. Mary is a librarian and an environmental organization member.

In this study conducted by Kahneman and Tversky,¹⁴ subjects assigned greater probability to B, which is statistically nearly impossible since only a subset of librarians can also be environmental organization members. People put too much emphasis on the high probability that someone who matches the description B is Mary, thereby neglecting the fact that A is the more general case.¹⁵ Subsequently, this situation illustrates how investors should not confuse what may appear to be a “good company” with a “good investment.” Strictly speaking, investors should consider company products and services separately from the firm’s financial fundamentals and current stock valuation.

Sample Size Neglect

Sample size neglect is the tendency of representativeness to cause individuals to neglect the smallness of sample sizes and generalize their claims. This neglect can lead to overreaction. For example, given two sets of coin toss results, 3 heads/3 tails and 500 heads/500 tails, representativeness implies that people believe both sets are equally informative about the fairness of the coin. However, statistically, the larger set is much more informative.

If people do not initially know the data collection process, they will tend to prematurely arrive at conclusions based on too few data points. For example, a person may believe a financial analyst that picks four good stocks is talented because four successes are not representative of a bad or mediocre analyst. Put another way, this belief is based on the idea that even small samples will reflect the properties of the parent population (i.e., the “law of small numbers”).¹⁶ This belief generates the “hot hand fallacy” effect in basketball, whereby people assume that a player who has made a few baskets in a row is more likely to make another one. However, evidence is mixed as to whether such a belief is indeed a fallacy.¹⁷

If people know the data collection process in advance, the law of small numbers leads to the “gambler’s fallacy.” That is, if a fair coin generates five heads in a row, some people will think, “tails are due” (i.e., perceive a need for more tails to balance out the heads), believing that even a short sample should be representative of the fair coin.¹⁸

Sample size neglect has important investment implications. For example, it demonstrates that investors should be wary of assuming that mutual fund managers in the top quartile in the past year have “hot hands” and thus will be in the top quartile in the current year; investors should thus refrain from making decisions based on insufficient data.

Anchoring

Anchoring is the tendency to slowly adjust away from an initial and arbitrary value, underreact to new information, and therefore make an insufficient adjustment (i.e., “anchoring” too much on the initial value). In a study, Kahneman and Tversky¹⁹ asked participants, “What per cent of UN countries are African: higher or lower than [random number between 0 and 100] per cent?” They found that, when the arbitrary comparison value was “10 per cent,” participants subsequently guessed “25 per cent” on average, and when the arbitrary comparison value was “60 per cent,” they subsequently guessed “45 per cent.” The implication is that, when given new information, investors may update insufficiently. Therefore, investors should update their views with the full range of possibilities rather than continuing to base their views on the possibilities that were implied by previous data. In other words, investors should be prepared to update their beliefs about a stock’s prospect based on information that is not anchored in the past.

Availability

When judging the probability of an event, people often search their memories for relevant information; however, not all memories are equally retrievable or “available.” In simple terms, availability is synonymous with “what comes to mind.” Therefore, more recent and more salient events will weigh more heavily and may distort estimates of an event occurring. As such, people tend to overweight current information, thereby failing to consider all relevant information. For example, investors’ attention to investment categories (e.g., stocks, bonds, and real estate) may be affected by the amount of public attention or inattention that is given to the different categories.²⁰ As well, investors tend to consider buying only those stocks that have caught their attention (e.g., stocks that are in the news as a result of experiencing either abnormally high trading volume or an extreme one-day return).²¹

Affect

The affect heuristic is the tendency to rely on instinct or emotional “gut feel” instead of formal analysis. Consequently, an investment that “feels right” may lead to a poor return. The implication for investors is that emotion and path dependence²² affect rational decision-making. Therefore, when possible, to reduce the impact of emotion, one should dedicate sufficient time to decision-making and engage explicit or quantitative analysis or both.

BIOLOGICAL EXPLANATIONS FOR IRRATIONAL INVESTMENT DECISIONS

Behavioural finance is still a relatively new field, and new theories and empirical studies on investor behaviour are constantly being published. A new field, called neurofinance, studies neurobiological factors that give rise to and affect investment behaviours and decisions. This interdisciplinary research combines neuroscience, behavioural endocrinology, and other biological streams to better understand the complex processes that influence financial decision-making. For example, gains and losses are computed in different parts of the brain, thereby providing a neurobiological explanation for the gain-loss asymmetry depicted in prospect theory.²³ Also, hormones (i.e., chemical messengers produced by the brain to change behaviour) have been shown to affect cognition and financial decision-making. For example, the sex hormone testosterone has been shown to impair reflective thinking (which is necessary in complex financial scenarios) and increase both the size of stock market bubbles and the willingness to invest in risky assets.²⁴ Furthermore, chronic exposure to stress hormones makes people less willing to take risks. A study has shown that in times of market volatility, cortisol levels increase, and the stress response is to decrease risk taking in times of prolonged uncertainty.²⁵ Together, convergent evidence suggests that biological factors affect decision-making. Additionally, studies suggest that sunshine, weather, and hours of daylight affect stock returns and investment decisions. Sunshine, which contributes to positive mood, has been found to be positively correlated with daily stock returns and, along with good weather, to promote risk-taking behaviour.²⁶ However, other weather conditions such as rain and snow have been shown to be unrelated to returns. Additionally, the shortness of daylight (particularly during fall and winter) leads to depression or an overall negative mood. As such, when linking the amount of daylight, length of day, and risk aversion, one study provided evidence of a link between seasonal depression and seasonal variation in stock returns.²⁷

CORRECTING IRRATIONALITY

Once irrational behaviour has been identified, many believe there are simple ways by which such behaviour can be corrected. Three general beliefs include the following:

- Through repetition, people learn how to overcome a bias.
- Experts (e.g., professional traders such as those working in investment banking) make fewer errors.
- The offering of more powerful incentives will lead the effects of irrational behaviour to disappear.

However, little evidence supports these beliefs that irrational behaviour can be eliminated. The following points are the counterarguments for these three beliefs:²⁸

- The effect of learning is often muted by errors of application. That is, people may understand biases when they are explained but will then continue to commit those biases in specific applications.
- Experts have been found to exhibit more overconfidence than average investors, particularly when receiving limited feedback about their predictions.²⁹
- Although incentives can sometimes reduce the display of biases, “no replicated study has made rationality violations disappear purely by raising incentives.”³⁰

Despite these findings, techniques do exist to combat irrational investing decisions; some of these were presented earlier. For example, when dealing with framing effects, the disposition effect can be avoided by setting clear investment criteria guidelines as to when a stock is either bought or sold (e.g., based on research). Accept any losses and treat sunk costs as sunk. As well, rephrase thoughts when appropriate (e.g., do not think, “When will the stock price recover?” but rather “What are the prospects?”).

“De-biasing” requires eluding overconfidence by recognizing limitations, avoiding excessive trading, tracking the reason for buys and sells, tracking performance (including the performance of stocks that were sold), diversifying, and thinking long term. Further, overconfidence can be mitigated by recognizing that one is trading against an unknown party, which could be a well-informed professional investor or a proprietary algorithm—both of which are likely to have better data and timing than the average retail trader.

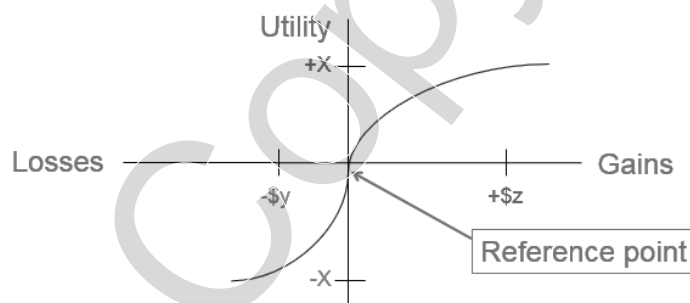
Avoid reliance on simple (and misplaced) heuristics by heeding the following advice. First, recognize that good companies—such as those that make state-of-the-art products and have grown revenue substantially over the past—are not always good investments, particularly at their current stock prices. Second, do not be fooled by randomness—do not infer a pattern or trend where none exists. Third, update your beliefs about stocks based on new information, and be willing to consciously relinquish prior beliefs that lack supporting evidence. Lastly, use systematic and evidence-based processes to avoid “gut feel” decisions, and avoid “hot” investments, such as those investments that have recently doubled in value.

EXHIBIT 1: TRADITIONAL VERSUS BEHAVIOURAL FINANCE MODELS

Traditional Finance Models	Behavioural Finance Models
Assumptions: <ul style="list-style-type: none"> Markets are frictionless. Investors are rational: <ul style="list-style-type: none"> Behaviour is consistent with expected utility maximization. Beliefs are updated correctly when new information is received. Implications: <ul style="list-style-type: none"> There is no opportunity for arbitrage. Market price equals fundamental value. 	Observations: <ul style="list-style-type: none"> Markets are not frictionless. Not all investors are rational. <ul style="list-style-type: none"> Investor psychology: <ul style="list-style-type: none"> Framing effects Biases Heuristics Implications: <ul style="list-style-type: none"> There are limits to arbitrage. Market price does not necessarily equal fundamental value.

Source: Created by the case writer.

EXHIBIT 2: FRAMING EFFECT: PROSPECT THEORY



- Investors feel good (bad) with gains (losses) but not “linear”
- Asymmetry: function is steeper for losses
- Reference point is key: often segregate gains vs losses

Source: Created by the case writer based on Daniel Kahneman and Amos Tversky, “Prospect Theory: An Analysis of Decision under Risk,” *Econometrica* 47, no. 2 (1979), Figure 3. doi:10.2307/1914185.

ENDNOTES

¹ For a detailed discussion and an excellent in-depth introduction to behavioural finance, see Nicholas Barberis and Richard Thaler, "A Survey of Behavioral Finance," in *Handbook of the Economics of Finance*, ed. George M. Constantinides, Milton Harris, and René Stulz (Amsterdam: Elsevier, 2003), 1053–1128.

² *Shorting* refers to borrowing a security that one does not own and selling it in the hope that its price will decline, at which time the investor will buy back the security at a lower price and profit from the drop in price.

³ When an investor shorts a security, a balance, or margin, is required in the investor's account in case the security increases in price. If that happens, the investor may be required to set aside more money; the "margin call" is the notification from the broker to the investor to set that additional sum aside.

⁴ Beliefs are ideas or principles that an individual considers to be true with or without empirical evidence supporting their case. Beliefs are susceptible to biases that can divert choices away from rational decision-making. Preferences are individuals' attitudes toward something, typically reflected in the decision-making process, thereby underlying how people behave. However, preferences are not stable over time. They can be modified subconsciously or through active decision-making.

⁵ Daniel Kahneman and Amos Tversky, "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica* 47, no. 2 (1979): 263–292. doi:10.2307/1914185; Daniel Kahneman and Amos Tversky, "Advances in Prospect Theory: Cumulative Representation of Uncertainty," *Journal of Risk and Uncertainty* 5 (1992): 297–323. doi:10.1007/BF00122574.

⁶ Nicholas Barberis and Richard Thaler, "A Survey of Behavioral Finance," in *Handbook of the Economics of Finance*, ed. George M. Constantinides, Milton Harris, and René Stulz (Amsterdam: Elsevier, 2004), 1069.

⁷ *Ibid.*, 1103.

⁸ For their methodology, see Anthony Perkins and Michael Perkins, *The Internet Bubble: Inside the Overvalued World of High-Tech Stocks—And What You Need to Know to Avoid the Coming Shakeout* (New York: Harper Business, 1999).

⁹ Brad M. Barber and Terence Odean, "Boys Will Be Boys: Gender, Overconfidence, and Common Stock Investment," *Quarterly Journal of Economics* 116, no. 1 (2001): 261–292. doi:10.1162/003355301556400; Ulrike Malmendier and Geoffrey Tate, "CEO Overconfidence and Corporate Investment," *Journal of Finance* 60, no. 6 (2005): 2661–2700. doi:10.1111/j.1540-6261.2005.00813.x.

¹⁰ Marc Alpert and Howard Raiffa, "A Progress Report on the Training of Probability Assessors," in *Judgment under Uncertainty: Heuristics and Biases*, ed. Daniel Kahneman, Paul Slovic, and Amos Tversky (Cambridge, UK: Cambridge University Press, 1982), 294–305.

¹¹ One can infer similar results when "driver" is replaced with "investor"; Ola Svenson, "Are We All Less Risky and More Skillful Than Our Fellow Drivers?," *Acta Psychologica* 47, no. 2 (1981): 143–148. doi:10.1016/0001-6918(81)90005-6.

¹² Matthew Rabin and Joel Schrag, "First Impressions Matter: A Model of Confirmatory Bias," *Quarterly Journal of Economics* 114, no. 1 (1999): 37–82. doi:10.1162/003355399555945.

¹³ Charles Lord, Lee Ross, and Mark Lepper, "Biased Assimilation and Attitude Polarization: the Effects of Prior Theories on Subsequently Considered Evidence," *Journal of Personality and Social Psychology* 37, no. 11 (1979): 2098–2109. doi:10.1037/0022-3514.37.11.2098.

¹⁴ Daniel Kahneman and Amos Tversky, "Judgment under Uncertainty: Heuristics and Biases," *Science* 185, no. 4157 (1974): 1124–1131. doi:10.1126/science.185.4157.1124.

¹⁵ This error is called base rate neglect (and is derived from Bayes' law, which is used in statistics).

¹⁶ Matthew Rabin, "Inference by Believers in the Law of Small Numbers," *Quarterly Journal of Economics* 117, no. 3 (2002): 775–816. doi:10.1162/003355302760193896.

¹⁷ See, for example, Thomas Gilovich, Robert Vallone, and Amos Tversky, "The Hot Hand in Basketball: On the Misperception of Random Sequences," *Cognitive Psychology* 17, no. 3 (1985): 295–314. doi:10.1016/0010-0285(85)90010-6; Joshua Benjamin Miller and Adam Sanjurjo, "Surprised by the Gambler's and Hot Hand Fallacies? A Truth in the Law of Small Numbers," IGER Working Paper, 552, 2016, accessed January 20, 2017, <https://ssrn.com/abstract=2627354> or <http://dx.doi.org/10.2139/ssrn.2627354>.

¹⁸ Barberis and Thaler, *op. cit.*, 1065.

¹⁹ Daniel Kahneman and Amos Tversky, "Judgment under Uncertainty: Heuristics and Biases," *Science* 185, no. 4157 (1974): 1124–1131. doi:10.1126/science.185.4157.1124.

²⁰ Robert J. Shiller, "Human Behavior and the Efficiency of the Financial System," National Bureau of Economic Research Working Paper 6375, National Bureau of Economic Research, Cambridge, MA, 1998, 1.

²¹ Brad M. Barber and Terrance Odean, "All That Glitters: The Effect of Attention and News on the Buying Behavior of Individual and Institutional Investors," *Review of Financial Studies* 21, no. 2 (2008): 785. doi:10.1093/rfs/hhm079.

²² Path dependence is the tendency to continue to use a product or practice based on historical preference or use.

²³ Sabrina M. Tom, Craig R. Fox, Christopher Trepel, and Russell A. Poldrack, "The Neural Basis of Loss Aversion in Decision-Making under Risk," *Science* 315, no. 5811 (2007): 515–518. doi:10.1126/science.1134239.

²⁴ See Amos Nadler, Peiran Jiao, Veronica Alexander, Cameron Johnson, and Paul Zak, "The Bull of Wall Street: Experimental Analysis of Testosterone and Asset Trading," ResearchGate, April 24, 2017, accessed June 7, 2017, www.researchgate.net/publication/316428328_The_Bull_of_Wall_Street_Experimental_Analysis_of_Testosterone_and_Asset_Trading; Carlos Cueva, R. Edward Roberts, Tom Spencer, Nisha Rani, Michelle Tempest, Philippe N. Tobler, Joe Herbert, and Aldo Rustichini, "Cortisol and Testosterone Increase Financial Risk Taking and May Destabilize Markets," *Scientific Reports* 5 no. 11206 (2015): doi:10.1038/srep11206; Gideon Nave, Amos Nadler, Colin Camerer, and David Zava, "Single Dose

Testosterone Administration Impairs Cognitive Reflection in Men," ResearchGate, April 11, 2017, accessed June 7, 2017, www.researchgate.net/publication/316001989_Single_dose_testosterone_administration_impairs_cognitive_reflection_in_men.

²⁵ John M. Coates and Joe Herbert, "Endogenous Steroids and Financial Risk Taking on a London Trading Floor," *Proceedings of the National Academy of Sciences* 105, no. 16 (2008): 6167–6172. doi:10.1073/pnas.0704025105; Narayanan Kandasamy, Ben Hardy, Lionel Page, Markus Schaffner, Johann Graggaber, Andrew S. Powlson, Paul C. Fletcher, Mark Gurnell, and John Coates, "Cortisol Shifts Financial Risk Preferences," *Proceedings of the National Academy of Sciences* 111, no. 9 (2014), 3608–3613. doi:10.1073/pnas.1317908111.

²⁶ See David Hirshleifer and Tyler Shumway, "Good Day Sunshine: Stock Returns and the Weather," *The Journal of Finance* 58, no. 3 (2003): 1009–1032. doi:10.1111/1540-6261.00556; Anna Bassi, Riccardo Colacito, and Paolo Fulghieri, "O Sole Mio: An Experimental Analysis of Weather and Risk Attitudes in Financial Decisions," *The Review of Financial Studies* 26, no. 7 (2013): 1824. doi:10.1093/rfs/hht004.

²⁷ Hirshleifer and Shumway, op. cit.; Mark J. Kamstra, Lisa A. Kramer, and Maurice D. Levi, "Winter Blues: A SAD Stock Market Cycle," *American Economic Review* 93, no. 1 (2003): 324–343, accessed June 6, 2017, www.jstor.org/stable/3132178.

²⁸ Barberis and Thaler, op. cit., 1066.

²⁹ Michael Haigh and John List, "Do Professional Traders Exhibit Myopic Loss Aversion? An Experimental Analysis," *Journal of Finance* 60, no. 1 (2005): 523–534. doi:10.1111/j.1540-6261.2005.00737.x.

³⁰ Colin Camerer and Robin Hogarth, "The Effects of Financial Incentives in Experiments: A Review and Capital-Labor Production Framework," *Journal of Risk and Uncertainty* 19, no. 1 (1999): 7. doi:10.1023/A:1007850605129.