Available online at www.sciencedirect.com
ScienceDirect
Organizational Behavior and Human Decision Processes 105 (2008) 67–81
ORGANIZATIONAL BEHAVIOR AND HUMAN DECISION PROCESSES
www.elsevier.com/locate/obhdp

Reference point adaptation: Tests in the domain of security trading ☆

Hal R. Arkes [a,*], David Hirshleifer [b,1], Danling Jiang [c], Sonya Lim [d]

[a] *Department of Psychology, The Ohio State University, 240N Lazenby Hall, 1827 Neil Avenue, Columbus, OH 43210-1222, USA*
[b] *Fisher College of Business, The Ohio State University, USA*
[c] *The College of Business, Florida State University, USA*
[d] *The Kellstadt Graduate School of Business, DePaul University, USA*

Received 5 May 2006
Available online 24 October 2007
Accepted by Robyn Dawes

Abstract

According to prospect theory [Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk, *Econometrica, 47*, 263–292], gains and losses are measured from a reference point. We attempted to ascertain to what extent the reference point shifts following gains or losses. In questionnaire studies, we asked subjects what stock price today will generate the same utility as a previous change in a stock price. From participants' responses, we calculated the magnitude of reference point adaptation, which was significantly greater following a gain than following a loss of equivalent size. We also found the asymmetric adaptation of gains and losses persisted when a stock was included within a portfolio rather than being considered individually. In studies using financial incentives within the BDM procedure [Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science, 9*(3), 226–232], we again noted faster adaptation of the reference point to gains than losses. We related our findings to several aspects of asset pricing and investor behavior.

Keywords: Prospect theory; Reference point; Asset pricing; Security trading

Introduction

The reference point plays a prominent role in prospect theory (Kahneman & Tversky, 1979). In this theory outcomes are measured against a reference point for the evaluation of utility or "value". An important question is how this reference point is updated through time as a function of the outcomes of past decisions. In this paper, we test the adaptation of reference points in response to payoff outcomes in experimental settings in the domain of security trading.

By "adaptation of the reference point", we mean a shift in the reference point in the direction of a realized outcome. To illustrate the importance of reference point adaptation, consider a prospect-theory investor who purchases a stock at $30 per share, observes it drop to

☆ The major part of this work was conducted when Danling Jiang was at The Ohio State University. We appreciate the helpful comments from three anonymous reviewers, the participants in the Finance 923 seminar at The Ohio State University, the audience members at the Society for Judgment and Decision Making annual conference in Toronto, Canada in November of 2005, and at the Behavioral Decision Research Management conference in Santa Monica, CA in June of 2006. We thank Stephen Broomell, Aaron Getzinger, and Emily Houlis for their excellent research assistance and Melissa Marks, Dan Oglevee, Bill Rives, and Paul Weinstock for their coordination in recruiting subjects. We are grateful for the financial support from the Program in Decision, Risk, and Management Science at the National Science Foundation (NSF 0339178 and 0339052). All errors remain our own. The order of the authors is alphabetical.
* Corresponding author. Fax: +1 614 688 3984.
E-mail address: Arkes.1@osu.edu (H.R. Arkes).
[1] Present address: The Paul Merage School of Business, The University of California—Irvine, USA.

0749-5978/$ - see front matter © 2007 Elsevier Inc. All rights reserved.
doi:10.1016/j.obhdp.2007.04.005

$20, and expects that the stock price will either go up or down by $5 with equal probability. If her reference point remains at the purchase price $30, she is likely to hold on to the stock because people are generally risk-seeking in the loss domain. In contrast, if her reference point has adapted to the new price of $20, she is likely to sell the stock at $20 since, owing to common loss-aversion, a zero-expected-value gamble is usually not attractive. On the upside, if the stock were to rise from $30 to $40, the extent of upward migration of the reference point would also affect the propensity to sell the stock. These simple examples illustrate that reference point adaptation affects risk-taking decisions.

Thaler (1980, 1985) introduced the concept of mental accounting, which has important implications for prospect theory. Mental accounting consists of the ways in which people mentally categorize financial transactions in order to monitor where their money is going, to assess the performance of their investments, and to plan future investment decisions. We hypothesize that adaptation of the reference point is integrally related to the way people mentally account for prior gains and losses. If investors fully adapt to the changes in stock prices by closing out their old mental accounts with all of the realized gains/losses, they will evaluate future prospects relative to the current stock price. This implies that prior gains or losses are segregated from the subsequent mental account. However, if investors do not fully adapt to the price change, a part of the prior gain or loss will be included in the mental account containing the future prospect.

Thaler (1999) points out that mental accounting does not have rigid rules like regular accounting. As a result people may be tempted to be "creative" in adjusting their accounting principles in order to feel good about themselves or about their pecuniary outcomes.

Such hedonic considerations may influence how investors update the reference point in response to a price change. We examine two kinds of hedonic considerations.

First, consider again the adaptation of the reference point to a gain versus a loss. Following a gain, migration of the reference point toward the level of the new wealth will mean that a subsequent gain will be enjoyed more than if the reference point had not budged following the first gain. This is due to the fact that the value function is concave in the region of gains; diminishing returns render subsequent gains less valuable than initial ones. Thus a hedonic maximizer might adapt to gains in order to reset the origin of the prospect theory value function close to the new level of wealth; the overall hedonic value will be greater if one updates the reference point after the first gain. On the other hand, the convexity of the value function in the region of losses might cause a value maximizer to resist reference point migration downward following a loss. If the reference point adapts to the first loss, a subsequent loss will be more painful than if the original reference point were to be maintained; the overall hedonic value will be greater if one refrains from updating the reference point after the first gain. For these reasons we hypothesize that reference point adaptation following a gain will be more complete than reference point adaptation following a loss.

The second factor pertains to the fact that closing an account in the "black" generates immediate gratification, but closing an account in the "red" produces immediate misery (Prelec & Loewenstein, 1998). Closing an account resets the reference point and segregates the prior consequences from future ones. Due to the differential *immediate* hedonic consequences, investors will have more incentive to close a prior account after a gain than after a loss. This second factor is in addition to the consequence of closing the account on the hedonic experience of *subsequent* gains and losses. For both reasons, we predict that reference point adaptation will be greater following a gain than following a loss.

The reference point in prospect theory

Kahneman and Tversky (1979) proposed prospect theory as an alternative to the normative theory of expected utility maximization. Three aspects of prospect theory are most relevant to our research. First, people derive utility from gains and losses relative to a reference point, while traditional utility theory assumes that people derive utility from total wealth or consumption. Although the reference point is generally one's current wealth (Kahneman & Tversky, 1979), aspiration levels or norms can also serve this function (Kahneman & Tversky, 1979, p. 286; Heath, Larrick, & Wu, 1999). Second, the value function is concave in the domain of gains and convex in the domain of losses. Tversky and Kahneman (1992) suggested that a power function with an exponent of approximately 0.88 fitted the data they obtained in both the region of gains and the region of losses. Third, in the neighborhood of the reference point, the effect on value of a unit of loss is much larger than that of a unit of gain. Thus a loss has a larger effect than does a gain of equal absolute value. Most research suggests that losses have an effect approximately 2 to 2.5 times that of a gain of the same size (e.g. Tversky & Kahneman, 1992). In all these aspects of prospect theory, the reference point plays an important role.

Kahneman and Tversky (1979) suggest that several factors, such as status quo, social norms, and aspiration levels may determine the reference point. However, Kahneman and Tversky did not specify how the reference point changes over time. Since in reality individuals such as stock investors make multiple decisions over time, it is important to understand how reference points are updated after such investors experience intertemporal outcomes. This topic has received only a modest amount of prior investigation.

Where is the reference point?

One natural reference point in the context of stock investment is the price at which the stock was initially purchased. Spranca, Minsk, and Baron (1991) provide evidence that the starting point enjoys a privileged role. [Shefrin and Statman (1985) and Odean (1998) provide related discussion and evidence.] However a second candidate for the reference point is suggested in recent papers by Koszegi and Rabin (2004) and Yogo (2005), who posit that the reference point is one's expectations about future outcomes, not the original purchase price.

A third possibility is based on the assumption that over time the reference point is likely to migrate from the initial purchase price as a stock's price changes. Investors may eventually update their reference points to the current price or partially update to a price between the initial price and the current price. Chen and Rao (2002) suggest that people's reference points shift after a stimulus is presented, but do so incompletely. However Chen and Rao (2002) only examined situations in which two outcomes occur with one being positive and the other being negative.

Gneezy (2002) inferred reference point adaptation from participants' decisions to sell their stocks when stock prices followed a random walk. He argued that, based on prospect theory, investors are risk averse in the gain domain and thus should sell only when the current stock price is above the reference point. His experimental results suggested that participants are most likely to use the historical peak as the reference point. However, Gneezy's design did not allow him to locate the reference point nor compare the magnitude of adaptation to gains and to losses, which are the emphases and main contributions of our paper.

Clearly, more empirical evidence is needed to learn how investors update their reference points. That is the goal of the present research. We used two approaches to test for reference point adaptation. In the first, subjects answered questions in hypothetical trading scenarios. In the second, we inferred the reference point adaptation from the trading decisions of subjects in a stock trading game, in which their monetary payoffs were directly tied to their trading profits. We will first present the questionnaire studies.

Questionnaire experiments to estimate reference point adaptation in different contexts

In the questionnaires, we asked subjects what stock price today will generate the same utility for them as a previous stock price that changed from the initial purchase price. If the previous stock price is P_1 and the previous reference point is R_0, the difference between P_1 and R_0 should be the same as the difference between the price reported by subjects (P^*) and the new reference point R^*, assuming the shape of the prospect value function remains unchanged.

$$P^* - R^* = P_1 - R_0 \quad \Rightarrow \quad \Delta R = R^* - R_0 = P^* - P_1 \quad (1)$$

Through this equality, we can calculate the reference point adaptation ΔR.

Experiment 1: The basic questions

Methods

Subjects

The participants in Experiments 1, 2, 3, and 5 were students in an introductory undergraduate finance course at The Ohio State University who answered brief questionnaires in a classroom setting. Over 95% of the students in this course were undergraduate business majors. Less than 5% of the students were either non-business undergraduate students or graduate students. The total number of respondents for each problem is denoted by *N*. In all four experiments, we used a between-subject design. The participants in Experiment 4 were undergraduate students in a senior level finance course at Florida State University (all are business majors), and it was a within-subjects design. All students voluntarily filled out the questionnaires to enter a lottery of $20 within each class.

Materials

Problem 1 (winner) [N = 138]. Two months ago, you bought a stock for $30 per share. Last month, you were delighted to learn the stock was trading higher—at $36 per share. This month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as happy with the stock's price this month as you were when you learned the stock had risen from $30 to $36 last month?

Problem 2 (loser) [N = 141]. Two months ago, you bought a stock for $30 per share. Last month, you were disappointed to learn the stock was trading lower—at $24 per share. This month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as sad with the stock's price this month as you were when you learned the stock had dropped from $30 to $24 last month?

Results

For the winner problem, the subjects on average believed that a gain to $40.24 would give them the same pleasure as the last month's price increase to $36:

Table 1
Distribution of the reported prices (P) for Problem 1 (winner) and Problem 2 (loser)

Problem 1 Winner: \$30 → \$36		Problem 2 Loser: \$30 → \$24	
Price	Frequency	Price	Frequency
$P < \$36$	6	$P < \$18$	10
$P = \$36$	20	$P = \$18$	16
$\$36 < P < \$40$	17	$\$18 < P < \$20$	11
$P = \$40$	30	$P = \$20$	38
$\$40 < P < \$42$	2	$\$20 < P < \$24$	20
$P = \$42$	35	$P = \$24$	36
$P > \$42$	28	$\$24 < P < \$30$	8
		$P > \$30$	2
Total	138	Total	141

$V(\$40.24 - R_1) = V(\$36 - R_0)$. Given that the shape of the prospect value function remains unchanged, the new perceived gain $\$40.24 - R^*$ must be equal to the old perceived gain $\$36 - R_0$, as in Eq. (1). Hence, the reference point adaptation $R^* - R_0$ should be \$4.24 ($\$40.24 - R^* = \$36 - R_0 \rightarrow \Delta R = R^* - R_0 = \$40.24 - \$36 = \$4.24$) after the initial \$6 gain.

In contrast, the subjects regarded the loss down to \$21.49 to be as painful as last month's price decrease to \$24. We can infer that the reference point must have adapted downward by \$2.51 (\$21.49 − \$24). Comparing the adaptation of \$4.24 after a gains and \$2.51 after a loss, the difference is \$1.73. Hence, our point estimates indicate that adaptation after gains is greater than adaptation after losses. The statistical comparison between \$4.24 after a gain and \$2.51 after a loss will be presented after this result is combined with the results of the next two studies.

Table 1 contains the distribution of responses by subjects to problems 1 and 2.

Experiment 2: Intervention with selling and repurchasing

Thaler (1985) discussed the consequences of the integration and segregation of multiple outcomes. For example, getting two \$50 parking tickets might have a different psychological impact than a single \$100 dollar ticket. If one fully adapts after the first ticket, then a second ticket is painful. Due to the asymptotic nature of the prospect theory's value function in the loss region, a single ticket costing \$100 would be less agonizing. In this example it is easy to segregate the two \$50 increments by assigning them to different tickets, and it is easy to integrate them by assigning the two components to the same ticket.

We attempted the same sort of strategy in our second set of scenarios. In order to facilitate the segregation of the second gain (or loss) from the first gain (or loss), we wrote the scenario so that following the first outcome the person sold the stock. The person then subsequently bought the stock at the same price at which he or she sold it, and a second gain (or loss) then occurred. Based upon Thaler's (1985) mental accounting theory, we expect the selling event to close the mental account of the first transaction and the repurchasing event to open a new mental account for the new transaction. Accordingly, compared to the prior basic scenarios, we expect the subjects to be more likely to reset their new reference point to the new purchase price and away from the initial purchase price when they sell the stock and later repurchase it at the same price.

Methods

Materials

Problem 3 (winner, with sale and repurchase intervention) [N = 66]. Three months ago, you bought a stock for \$30 per share. Two months ago, you were delighted to learn the stock was trading higher—at \$36 per share. You sold the stock for \$36 per share. Last month, you thought it was still a good idea to invest in the same stock. So you bought it again at \$36 per share. This month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as happy with the stock's price this month as you were when you learned the stock had risen from \$30 to \$36 two months ago?

Problem 4 (loser, with sale and repurchase intervention) [N = 60]. Three months ago, you bought a stock for \$30 per share. Last month, you were disappointed to learn the stock was trading lower—at \$24 per share. You sold the stock for \$24 per share. Last month, you thought it was still a good idea to invest in the same stock. So you bought it again at \$24 per share. This month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as sad with the stock's price this month as you were when you learned the stock had dropped from \$30 to \$24 two months ago?

Results

The average answer given by respondents to Problem 3 was \$41.84, which implies an adaptation of \$5.84. The average answer given by respondents to Problem 4 was \$20.93, which implies an adaptation of \$3.07. We again found that adaptation was greater following gains than following losses. Furthermore we found that the sale/repurchase intervention resulted in an average adaptation of \$4.52, compared to an average adaptation of only \$3.37 without this intervention (see Table 2). Again, we will postpone the statistical analysis of this experiment until we present Experiment 3.

Table 2
Reference point adaptation following gains and losses in the basic groups, the groups with the sale/repurchase intervention, and the groups with portfolios in Experiments 1, 2, and 3

Group	Outcome		
	Gain	Loss	Mean
Basic questions 1 & 2	\$4.24	\$2.51	\$3.37
Sale/repurchase intervention questions 3 & 4	\$5.84	\$3.07	\$4.52
Portfolio questions 5 & 6	\$3.82	\$1.55	\$2.61

Experiment 3: The presence of portfolios

We also considered whether our results would hold in a portfolio rather than a single-stock environment, since both financial theory and popular advice given to investors often emphasizes the importance of evaluating decisions at a portfolio level. When holding a portfolio, an investor may evaluate gains and losses of a portfolio rather than those of each individual stock in her portfolio. If so, it may be the trading outcome of the portfolio rather than the trading outcome of an individual stock that has an impact on the reference point. Accordingly, our results may have rather limited implication for stock markets since most investors usually hold portfolios instead of one stock. Hence, we examined whether people make different decisions on single stocks when they held portfolios. We assumed the investor held a portfolio of two stocks, one with a \$6 gain as in Problem 1 and one with a \$6 loss as in Problem 2.

Methods

Materials

Problem 5 (portfolio-gain) [N = 22]. Two months ago, you bought 200 shares of stock A and 200 shares of stock B, each at a price of \$30 per share. Last month, you were delighted to learn stock A was trading higher—at \$36 per share, and you were disappointed to learn stock B was trading lower—at \$24 per share. This month, you decide to check the stock's price again.

At what price would stock A need to trade today to make you just as happy with stock A's price this month as you were when you learned stock A had risen \$6 from \$30 to \$36 last month?

Problem 6 (portfolio-loss) [N = 25]. This was the same scenario as in Problem 5, but a different question was asked: At what price would stock B need to trade today to make you just as sad with stock B's price this month as you were when you learned stock B had dropped \$6 from \$30 to \$24 last month?

Results

The average answer to Problem 5 was \$39.82, which implies an adaptation of \$3.82. The average answer to Problem 6 was \$22.45, which implies an adaptation of \$1.55. Again, our point estimates indicate that adaptation following a gain exceeded that following a loss. The mean adaptation for each of the six scenarios discussed thus far is displayed in Table 2. We subjected the results of these first six scenarios to a 2 (price movement: winner/loser) $\times$ 3 (group: basic questions 1& 2/sale & repurchase questions 3 & 4/portfolio questions 5 & 6) analysis of variance (ANOVA). The winner/loser main effect was significant [$F(1,446) = 27.42$, $p < .0001$], with the adaptation for gains being far greater than the adaptation for losses (\$4.67 versus \$2.55). Also significant was the group main effect [$F(2,446) = 5.74$, $p < .01$]. Tukey post-tests revealed that the mean adaptation following the sale and repurchase intervention (\$4.52) significantly exceeded the mean adaptation of the basic questions (\$3.37), $q(270) = 3.10$, $p < .05$, and it also significantly exceeded the mean adaptation of the portfolio group, $q(270) = 5.15$, $p < .01$. On the other hand, the portfolio group's mean adaptation (\$2.61) did not differ from that of the basic questions. The interaction did not approach significance ($F < 1$).

In short, we find that investors tend to shift reference points upward after prior gains and downward after prior losses. The size of the adaptation after gains appears to be greater than that after losses. Inserting a sale and repurchase, which we hypothesize closed the prior mental account, fostered significantly higher levels of adaptation following gains and losses.

Finally, we consider an objection to our questionnaire studies, namely, that we *assumed* that the reference point adapts following a gain or loss rather than actually testing for this. Specifically, a reviewer's concern is whether our test applies if the value function can have arbitrary shape and if individuals derive utility from changes rather than levels of wealth. For example, suppose that a stock had increased from \$30 to \$36, and a subject responded that the stock would have to sell for \$42 to provide the same amount of happiness as the original price increase did. Our contention is that in this instance the reference point has adapted by the full \$6. An alternative interpretation is that the reference point has not adapted at all, that utility derives from the change in wealth, and that the utility function is linear over this range.

We do not believe that alternative interpretations of this kind oppose our conclusions. So long as there is full updating of the reference point, it is equivalent to say that (a) individuals derive utility from the level of price with an updated reference point, or (b) the individual derives utility from the change in wealth. In either case, future utility is derived from the deviation between the future price and the earlier price. So in this situation the "change" interpretation is just a rephrasing of the finding, not an alternative to it. Specifically, in terms of levels this is full updating of the reference point, not zero updating.

We prefer the phrasing in terms of levels, because a phrasing in terms of utility of changes lacks generality. Our approach does not *assume* that updating occurs to the latest price (in which case utility might meaningfully be viewed as a function of changes rather than levels). Rather, our test method ascertains whether updating is full or partial.

Also as an empirical matter, our evidence is not consistent with utility being a function of changes and a fixed reference point (i.e., with utility being a function of wealth and full updating). Consider utility as a function of wealth changes, and suppose the utility function is linear, or non-linear with a curvature in both the gain and loss domains less than one, such as 0.88 as suggested by Tversky and Kahneman (1992). Then the marginal utility will be constant or decreasing in the gain domain, which would require that subjects would have reported a price equal to or greater than $42 ($6 gain or greater) when they were asked "At what price would the stock need to trade today to make you just as happy with the stock's price this month as you were when you learned the stock had risen from $30 to $36 last month?" The group means were substantially below $42, and only 20% (28 out of 138) subjects indicated a price greater than $42 following a prior gain (see Table 1). Also subjects should have indicated a further loss greater than $6 subsequent to a prior $6 loss (due to the decreasing marginal disutility when one moves down along the curve). However, only 7% (10 out of 141) of our subjects actually reported such a price. Thus the data do not support a fixed reference point with either constant or decreasing marginal utility as a function of change in wealth.

What is true is that the numerical estimates we obtain do rely on the shape of the prospect theory value function. We believe that it is reasonable, in a test for whether prospect theory reference points update, to take as a premise that prospect theory is correct. However, as further corroboration we ran the following small experiment to ascertain quite directly the value function among a sample of undergraduates. This enabled us to test for linearity using dollar amounts similar to those used in the prior three experiments.

Experiment 4: The value function

We want to ascertain whether our subjects possess a non-linear utility with dual risk attitudes around a reference point and whether they show asymmetric adaptation to prior gains and losses. Therefore, we performed a questionnaire study in Florida State University with two pairs of questions. The first pair includes two questions that test the reflection effect of prospect theory (Kahneman & Tversky, 1979). The purpose is to examine whether an individual is risk averse in the gain domain and risk seeking in the loss domain. The second pair consists of the two questions in Experiment 1, the test of asymmetric adaptation to gains and losses. For brevity, we do not repeat those two questions here.

Methods

Materials

Problem 7 (N = 81)
Option A. Win $40 with probability .8 and win nothing with probability .2.
Option B. Win $30 for sure.
Circle the option that is more attractive to you: A or B.

Problem 8 (N = 81)
Option A. Lose $40 with probability .8 and lose nothing with probability .2.
Option B. Lose $30 for sure.
Circle the option that is more attractive to you: A or B.

Results

In Problem 7, 36 out of 81 (44%) subjects chose the gamble, while 56% subjects chose the sure payoff. However, in Problem 8, 61 out of 81 (75%) of subjects prefer the risky choice. This 31% (75 – 44%) increase in risk-seeking behavior is due to the net effect of 42 subjects who switched to risk seeking and 17 subjects who switched to risk aversion when the prospects changed from the gain domain to the loss domain. Using McNemar's test (Siegel, 1956, p. 63), we find that this pair of switches comprise a statistically significant change ($\chi^2(1) = 9.76$, $p < .01$).

Having verified that 42 subjects exhibited behaviors consistent with prospect theory, we focused on our test of asymmetric adaptation in this group of subjects. We obtained their answers to the same two problems used in Experiment 1: We asked them the stock price level that will make them as happy (sad) as when they learned of a prior $6 gain (loss) in the previous trading period. The average desired stock price after a prior $6 gain was $39.20, and that after a prior $6 loss was $21.81. The corresponding implied reference point adaptation is $3.20 versus $2.19. Again, we observed faster adaptation to prior gains than to prior losses ($p = .055$). Among the 42 subjects, 45% showed faster adaptation to gains, 40% showed symmetric adaptation, and only 14% showed faster adaptation to losses. Thus, the percentage of subjects that adapted to gains faster than losses dominates the percentage that exhibits the opposite tendency. However, there is a substantial number of subjects who adapted to positive and adverse prior outcomes symmetrically.

In sum, our results show that subjects in whom we verified risk aversion in the gain domain and risk seeking in the loss domain also show asymmetric adaptation. This result again supports our premise that subjects possess a prospect theory value function, and they update the reference point toward prior outcomes.

Experiment 5: Controlling for expectations

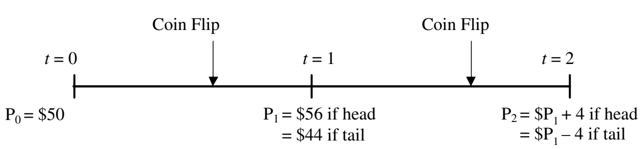
We wanted to minimize the possibility that differences in expectations about future price movements were responsible for the results we have reported thus far. For example, subjects may form expectations about future stock prices based on prior price movements. If they hold a bold momentum view after a prior gain but a cautiously contrarian view after a prior loss, they may wishfully expect a gain after both prior gains and losses. As a result, they may report a price level that is further away from the purchase price of $30 after a prior gain than after a prior loss, but the difference in their indicated prices could be due to expectational biases rather than differences in reference point adaptations. We tried to minimize the use of expectational biases in the prior experiments by explicitly stating in the instructions "... that stock prices are not predictable by any means." In this experiment, we specify exactly what possible future prices are and their associated probabilities to further minimize the possible effect of expectational biases.

Methods

Materials

We asked the following questions:

Problems 9 ($N = 15$) and 10 ($N = 24$):



At $t = 0$, you bought one share of stock A for $50 per share. At $t = 1$, the experimenter flipped the coin: it is a head (tail). Now your stock is worth $56 ($44). You have a chance to sell your shares now through a private transaction to another investor or wait until the second coin flip and sell your share at P_2. So you have two options: Option A: Sell your share to another investor through a private transaction for $X. Option B: Wait until the second period to sell your share at the second period stock price P_2. The experimenter will flip a coin again, and the stock price will be $60 ($48) if it is a "head" or $52 ($40) if it is a "tail". Which stock price $X in Option A will make you exactly indifferent between the two options? Please indicate your minimum selling price $X.

Problems 11 ($N = 26$) and 12 ($N = 16$): These were identical to Problems 9 and 10 except that we inserted the sale and repurchase intervention in precisely the same way that we added them in Problems 3 and 4.

Table 3
Reference point adaptation following gains and losses in the basic groups and the groups with the sale/repurchase intervention in Experiment 5

Group	Outcome	
	Gain	Loss
Basic questions 9 & 10	\$6.34 ($n = 15$)	\$5.49 ($n = 24$)
Sale/repurchase intervention questions 11 & 12	\$6.40 ($n = 26$)	\$5.49 ($n = 16$)

Results

By asking the above questions, we obtained a price that gave the investor the same utility as the gamble of $60 ($48) and $52 ($40) with equal probability. In this manner, we hoped to achieve greater control over participants' expectations about subsequent price movement. We solved their implicit reference point by equating the utility from the gains of selling stock for $X and the expected utility from the gamble. Thus we inferred their reference points at date 1 (R^*) in the following manner:

$$V(X - R^*) = 0.5V(60 - R^*) + 0.5V(52 - R^*), \tag{2}$$

where X is the dollar amount they indicate, and R^* is the implicit reference point. The value function is the cumulative prospect theory value function (Tversky & Kahneman, 1992)

$$V(x) = \begin{cases} x^{\alpha} & x > 0 \\ -2.25(-x)^{\alpha} & x < 0 \end{cases} \tag{3}$$

After solving Eq. (2) for the reference point, we obtained the magnitude of adaptation by taking $R^* - P_0$ when there was a prior gain and $P_0 - R^*$ when there was a prior loss. Using $\alpha = 0.2$, we obtained the mean reference point adaptations displayed in Table 3.[2] The mean adaptation following a gain was $6.38, and the mean adaptation following a loss was $5.49. A 2 (Outcome: gain/loss) × 2 (Group: basic questions/sale – repurchase intervention) ANOVA revealed only a significant main effect for outcome [$F(1, 77) = 14.87$, $p < .0001$].

Discussion

These results lead us to conclude that the more complete adaptation following gains is robust to a rather significant change in methodology. However the faster updating following the sale/repurchase intervention, which was manifested in Problems 3 and 4, was absent with the "coin flip" methodology used in Problems 11 and 12. We will assess the magnitude of the sale/repurchase intervention once more when we extend our

[2] Our basis for choosing $\alpha = 0.2$ will be explained below.

research to experiments involving actual monetary consequences.

In all of the above survey questions, the gains and losses were hypothetical. Some economists suggest that people may exhibit different behavior when they are provided with monetary incentives to make better decisions (see the discussion by Camerer & Hogarth, 1999). It is possible that the subjects when answering hypothetical questions may make different decisions compared to when their decisions influence their real payoffs, and their decisions under monetary incentives may mirror their real life investment decisions more closely. To address this concern, we designed an experiment with real monetary incentives. The details of this experiment are discussed in the next section.

Experiment 6: Stock trading with monetary incentives

This experiment has two purposes. The first is to examine whether the asymmetric adaptation after gains or losses holds when investors' decisions involve monetary incentives. The second is to explore whether the selling and repurchase events used in questions 3, 4, 11, and 12 influence reference point adaptation when incentives are present.

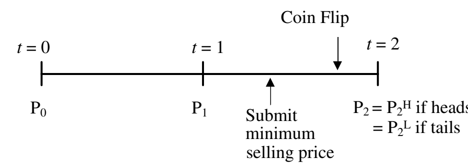
Methods

Subjects

A total of 100 undergraduate students from introductory finance courses at The Ohio State University and DePaul University participated in the experiment. Students were recruited from several introductory finance classes, and the study occurred outside of class time.

Procedures

The basic procedure of the trading experiment mirrored Experiment 5 of the previous section. Each round consisted of three dates and two periods. At the beginning of the trading round, subjects were told that they had purchased a stock at a certain price (P_0) and have held the stock for a week. They were then informed of the current price P_1, which was either higher or lower than their purchase price P_0. Also, they were informed of the two future possible prices of the stock in the next trading period (P_2). Before the realization of the second period price P_2, subjects had a chance to sell the stock to the experimenter by stating their minimum selling price. Following the Becker, DeGroot, and Marschak (1964) procedure (BDM), a buying price was randomly drawn between the two possible future prices P_2^H and P_2^L. If the randomly drawn buying price exceeded or equaled the subject's minimum selling price, the subject sold the stock at the randomly drawn buying price. If the buying price was less than the minimum selling price, the subject held the stock and sold it at the next trading period's price P_2 which was to be determined by a coin flip.



Under the BDM procedure, it is optimal for the subjects to set their minimum selling price equal to their valuation of the gamble. Thus, the BDM procedure reveals through subjects' minimum selling prices their valuations of risky gambles, which in turn helps us infer how their reference point changes after they experience gains or losses. By obtaining the certainty equivalent, we are able to solve for the implied reference point using the prospect value function.

Each subject traded four stocks in addition to a set of stocks which were inserted for the purpose of creating a time delay between the interventions of selling and repurchasing. Among the four stocks, two were winners and two were losers. The winner stocks, which were purchased at \$20, went up to \$26 after the first period. The subjects were informed that the stocks would have to be sold at either \$30 or \$22 with equal probability in the next trading period. The BDM valuation procedure then followed.

The loser stocks were purchased at \$20 and went down to \$14 with a future price of either \$18 or \$10 with equal probability. As with the winner stocks, the BDM procedure then followed.

One winner and one loser stock had the intervention of selling and repurchasing that we used in questions 3 and 4. For those two stocks, we introduced a time delay after the shares were sold but before they were repurchased. During the time delay, the subjects traded other stocks in some sessions and solved anagrams in other sessions. This time delay, which was between 10 and 25 minutes, was designed to help subjects segregate the prior outcomes.

In order to maximize the success of the BDM procedure, we explicitly instructed subjects about the reasoning as to why it is optimal to ask their true valuation of the stock, including illustrative examples showing how asking above or below one's valuation brings suboptimal outcomes (the instructions are in Appendix A). All subjects in each session had a chance to gain experience in the trial periods and were paid according to their trading gains or losses in two randomly selected stocks.

The subjects were promised a \$20 base payment for participation. They were also told that, at the end of the experiment, one of the stocks they have traded will be randomly drawn and its trading profit will count toward their final payoff. This creates a pecuniary incentive for the participants to follow the optimal strategy. Further, since trading profits are not cumulative, their decisions should not be influenced by prior outcomes. The maximum gains or losses were $10. The trading profits were divided by two before joining the $20 participation payment, which made the range of the final payoff from $15 to $25.

In the first few sessions of the experiment, we conducted a brief survey after the games and asked subjects to rate their understanding of the procedure (1, very poor; 2, poor; 3, fair; 4, good; 5, very good; 6, excellent) and whether or not they were convinced about the optimal strategy in stating their minimum prices with BDM mechanism (1, definitely "no"; 2, probably "no"; 3, unsure; 4, probably "yes"; 5, definitely "yes").

Results

We found no significant differences in the reference point adaptation between the two groups of subjects who had different activities (anagrams versus other stock trading exercises) during the time delay. Therefore we collapsed over this factor.

The brief survey was answered by a total of 46 subjects. Subjects gave an average 5.3/6 rating to their understanding of the experimental procedure, and an average rating of 3.8/5 to their acceptance of the optimal strategy under the BDM mechanism. More than 71% of subjects said that they indeed reported their true minimum selling price. For those who claimed that they did not respond in such a manner as to reveal the true indifference price, they generally claimed that they systematically asked either higher prices or lower prices than their true minimum selling price. However, there was no clear pattern of biased reporting toward either higher or lower prices relative to the true minimum selling price.

After obtaining the reported minimum selling price ($P^{\min}$), we inferred their reference points at date 1 (R^*) in the following manner:

$$V(P^{\min} - R^*) = 0.5V(P_2^H - R^*) + 0.5V(P_2^L - R^*) \qquad (4)$$

Though we explicitly instructed the subjects that a reasonable minimum selling price should be between the two possible future prices P_2^H and P_2^L, a few subjects still reported a minimum selling price as either P_2^H or P_2^L. We interpret these behaviors as inconsistent with that described in prospect theory and with general theories of decision making under uncertainty.[3] For these observations there is no solution for the implied reference point, regardless of the conjectured value of α. In addition, a few subjects reported a price that was 10 or 20 cents below P_2^H or above P_2^L. For these observations, we generally find a solution for the implied reference point when we choose a relatively small α, such as 0.2. But we obtain no solution for these observations when α is large, close to the proposed value of 0.88 suggested by Tversky and Kahneman (1992). To increase the range of minimum selling prices that makes Eq. (4) solvable, we used $\alpha = 0.2$. We defined the amount of reference point adaptation as $R^* - P_0$ when there was a prior gain and $P_0 - R^*$ when there was a prior loss. We discarded 9 observations from the loser-sell/repurchase intervention cell due to a procedural error. Five data points were not calculable due to the reasons mentioned above. Thus the 100 participants contributed 386 data points in this completely within-subject design.

Table 4 reports the average reference point adaptation for the four stocks. Our results show that reference points adapt faster to the past gains than losses by $0.59. Also, the selling and repurchasing event increases the size of reference point adaptation in a significant way. After such an intervention is inserted, the reference point adapts faster by $0.39. The direction of the asymmetric adaptation verifies the result from the questionnaire studies. However, the magnitude of the difference in adaptation decreased substantially. (Recall that the difference was $1.73 ($4.24 − $2.51) in the basic question scenarios). Nevertheless, the asymmetry in the adaptation following gains and losses was quite robust in this study with monetary incentives. Without the selling–repurchase intervention, 69.8% of the subjects exhibited larger adaptation to gains than losses. With the selling–repurchase intervention, 73.3% exhibited this asymmetry.

Using a 2 (outcome: winner/loser) × 2 (selling–repurchase intervention: present/absent) ANOVA, we find that the winner/loser effect is significant [$F(1,86) = 6.81$, $p = .01$] and the intervention effect is also significant [$F(1,86) = 15.22$, $p < .01$]. The interaction effect did not approach significance.

We present in Table 5 the results of this study for $\alpha = 0.50$ and $\alpha = 0.88$ in order to demonstrate the robustness of our findings across various magnitudes

Table 4
Reference point adaptation using financial incentives following gains and losses in the basic groups and the groups with the Sale/Repurchase Intervention ($\alpha = .2$)

Group	Outcome		
	Gain	Loss	Mean
Basic questions	$5.75	$5.13	$5.44
Sale/repurchase intervention questions	$6.10	$5.55	$5.83
Mean	$5.93	$5.34	

[3] In the prospect theory value function, utility increases in perceived gains (or decreases in perceived losses). Thus, the expected utility of the gamble cannot be equal to the utility of one possible outcome. Choosing to report a minimum selling price as P_2^H suggests that the subject is extremely risk-seeking and she prefers to take the gamble in any circumstances. In contrast, choosing to report a minimum selling price as P_2^L suggests that the subject is extremely risk-averse and she will accept even a very low payoff.

Table 5
Reference point adaptation using financial incentives following gains and losses in the basic groups and the groups with the sale/repurchase intervention ($\alpha = 0.50$, $\alpha = 0.88$)

Group	Outcome		
	Gain	Loss	Mean
$\alpha = .5$			
Basic questions	\$6.30 ($n = 93$)	\$4.82 ($n = 84$)	\$5.60
Sale/repurchase intervention questions	\$6.67 ($n = 89$)	\$5.12 ($n = 83$)	\$5.92
Mean	\$6.48	\$4.97	
$\alpha = .88$			
Basic questions	\$7.42 ($n = 47$)	\$4.15 ($n = 36$)	\$6.00
Sale/repurchase intervention questions	\$8.06 ($n = 47$)	\$3.90 ($n = 39$)	\$6.17
Mean	\$7.74	\$4.02	

Note. α is the exponent of the prospect theory value function (Eq. (3)). n is the number of data points for which we can calculate the reference point using Eq. (4).

of prospect theory's power function exponent. The results appear to be even stronger, even though we had to delete more observations for which solutions did not exist.[4]

Discussion

The results of this experiment replicated the results presented in Table 2, which contains data obtained from participants who did not have financial incentives. Namely, adaptation was more complete following gains than losses, and the selling/repurchase intervention accelerated adaptation.

While we have documented reference point adaptation in dollar terms, the conclusion is identical if we interpret them in percentage returns. Without the selling/repurchase intervention, the reference point increases by 28.75% (\$5.75/\$20 = 0.2875) after a 30% increase (\$6/\$20 = 0.3) in stock price. Following a 30% decrease in stock price, the reference point decreases by 25.65% (\$5.13/\$20). Since both the winner and loser stock cases start with the same purchase price of \$20, the amount of reference point adaptation in percentage returns is the dollar amount divided by \$20. We have chosen to report all results in dollars rather than in percentage returns.

Since the results of our experiment with financial incentives generally replicated the results of our studies without them, our research generally supports the conclusion of Camerer and Hogarth (1999). Their analysis of 74 experiments led them to conclude that the modal result of financial incentives in experiments is "no effect on mean performance" (p. 7). When financial incentives do influence performance, it is generally on tasks that are responsive to increased effort. We suggest that increased effort will not significantly change the mean indication of how one feels about a gain or loss. Thus we did not find that introduction of financial incentives modified in a qualitative way either the results or the conclusions from the earlier studies we reported.

[4] We lose five observations for winner questions and 10 observations for the loser questions after we switch from $\alpha = 0.2$ to 0.5. The deleted observations with higher value of a do not seem to bias the results in support of the asymmetric adaptation. In fact, we lose more observations from the low adaptation for losers which should increase the overall mean adaptation of the losers, thus mitigating the asymmetry.

General discussion

Using questionnaire and money-incentive experiments, we found that people tend to adapt reference points upward after stock investment gains and downward after losses, and that the size of the adaptation after gains tends to be greater than that after losses. Such asymmetry in adaptation is observed in experiments with and without monetary incentives. It is robust to whether investors hold a single stock or a portfolio, sold and repurchased the stock after the price change, or simply kept the stock.

We hypothesize that the faster adaptation to gains than to losses is related to mental accounting and hedonic maximization. In particular, the asymmetric adaptation can be at least partially explained by the tendency to segregate intertemporal gains and integrate intertemporal losses. Intuitively, after experiencing gains, segregating part of the prior gains from the subsequent mental account increases hedonic utility by placing the remaining prior gains in the steeper region of the gain domain and also using it to cushion the future possible losses. In contrast, after experiencing losses, in order to minimize hedonic disutility, investors are inclined to keep it integrated so that a future potential loss is evaluated in the flatter region in the loss domain and a future possible gain can offset part of the prior loss. We can further illustrate these principles with two simple examples. Our examples mirror the stocks in our experiment with monetary incentives.

Suppose investors purchased a stock at \$20, and later the stock price rose to \$26. In the next period, they have to sell the stock at either \$30 or \$22 with equal probability. We assume that there are two mental accounts: in the old mental account, the reference point is \$20; in the new mental account, the reference point is $\$R^*$. Updating a reference point is equivalent to closing the old mental account at the new reference point, which produces the value of $V(R^* - P_0)$. Then the total value from trading the stock is the sum of the values from both the old and new mental accounts:

$$V = V(R^* - 20) + 0.5V(30 - R^*) + 0.5V(22 - R^*). \quad (5)$$

We argue that in the scenario with prior gains, adaptation is preferred to non-adaptation. To see why, let us compare two cases: in Case 1, the reference point adapts to \$22; in Case 2, it remains at \$20. When the reference point adapts to \$22, the overall value from holding the stock is

$$V_1 = V(22-20) + 0.5V(30-22) + 0.5V(22-22)$$
$$= V(2) + 0.5V(8).$$

In contrast, when the reference point remains at \$20, the overall value is

$$V_2 = V(20-20) + 0.5V(30-20) + 0.5V(22-20)$$
$$= 0.5V(10) + 0.5V(2).$$

It is easy to show that $V_1 > V_2$ since

$$V_1 - V_2 = 0.5[V(2) + V(8) - V(10)] > 0.$$

The value from the segregated two gains is greater than the value from a single lump-sum gain. Accordingly, after gains, adapting the reference point is preferred to no adaptation.

To further illustrate that it is optimal for investors to adapt partially to gains, we calculate the prospect theory value based on Eq. (5) for a range of possible reference points R^* in this scenario. In the prospect theory value function, we set $\lambda = 2.25$ and $\alpha = 0.88$, where λ is the ratio of the impact of the loss to that of a gain.

As can be seen in Fig. 1, the maximum total value would be achieved by setting the new reference point equal to \$22, the lowest possible future price. In other words, it would be optimal to adapt the reference point upward by \$2 after gains, given the objective function. Thus, the prior gain of \$6 (\$26 − \$20) would be segregated into two parts: \$2 (\$22 − \$20) goes to the old mental account and the remaining \$4 goes to the new mental account.

In contrast, suppose investors purchased a stock at \$20, and later the stock price dropped to \$14. In the next period, they have to sell the stock at either \$18 or \$10 with equal probability. Then the total value from trading the stock is

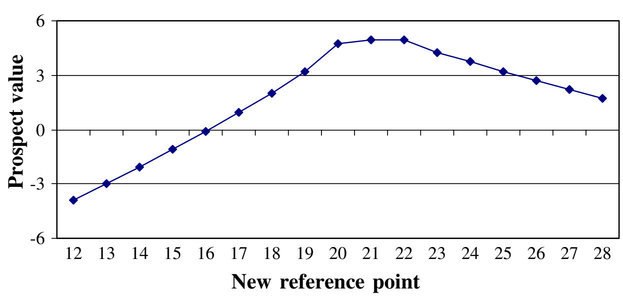


Fig. 1. Total value of a gain from \$20 to \$26 plus a subsequent sale of the stock at either \$30 or \$22 with equal probability as a function of the new reference point.

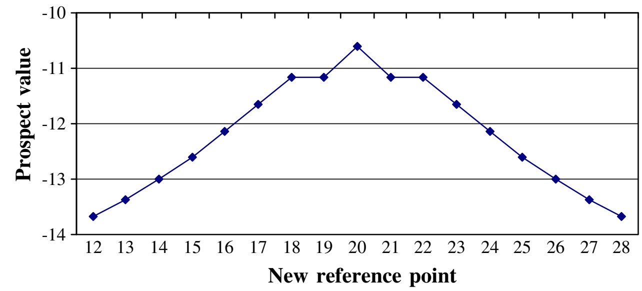


Fig. 2. Total value of a loss from \$20 to \$14 plus a subsequent sale of the stock at either \$18 or \$10 with equal probability as a function of the new reference point.

$$V = V(R^* - 20) + 0.5V(18 - R^*) + 0.5V(10 - R^*). \quad (6)$$

When we compare adaptation (Case 1) versus no adaptation (Case 2) in this case, it is easy to show that $V_1 < V_2$ since

$$V_1 - V_2 = 0.5[V(-2) + V(-8) - V(-10)] < 0.$$

In the loss domain, it is optimal to integrate losses, because integrating losses generates higher value than segregating them by updating the reference point.

Using the same parameter values of the prospect theory value function, we calculate the value based on Eq. (6) for a range of R^*. In Fig. 2, we show that in this case, the maximum total value is achieved by setting the new reference point equal to \$20. In other words, it is optimal not to adapt to a loss by fully integrating the loss into the new mental account.

If the hedonic consideration were the only factor underlying reference point adaptation, these examples suggest that one would never adapt to losses and the adaptation to gains would be small enough to maximize the likelihood that future prospects are in the gain domain. However, a sense of reality may force investors to take into account the current price to some extent. Therefore we concede that the tug of reality may increase the amount of reference point adaptation beyond that predicted in the prior two examples Therefore, we expect that there will be some adaptation in reality to both gains and losses, but with an asymmetry of gains and losses due to hedonic maximization.

Our suggestion that a greater proportion of prior gains than losses are likely to be segregated from the new mental account is consistent with the spirit of the hedonic editing hypothesis proposed by Thaler (1985) which maintains that people mentally account for outcomes to make themselves as happy as possible. The hedonic editing hypothesis suggests that one is better off to segregate gains and integrate losses. Thaler and Johnson (1990) and Linville and Fischer (1991) provide support for the tendency to segregate gains, although the integration of losses was not supported by these studies. In a recent study, Lim (2006) found support for the above principles in her investigation of over

158,000 brokerage accounts during a 71-month period that losses were significantly more likely to be bundled into a single day's trades than were gains.

Also consistent with hedonic editing, Hirst, Joyce, and Schadewald (1994) reasoned that integration of outcomes will be more likely if the gain and loss occurred together in time compared to the situation in which the two outcomes were not simultaneous. They found that subjects prefer to make payments on an item during the time the item is actually used than after its term of use has expired, and also that subjects were willing to incur a cost to ensure that a financial gain and loss were temporally integrated.

Besides exhibiting preferences for bundling of stock trades or the timing of payments, people have been shown to take quite active roles in "hedonic engineering" so as to improve their overall hedonic experience. Wertenbroch (1998) showed that people are willing to pay a premium to buy small quantities of "vices" so as to impose self-control on themselves. For example, people may buy small packages of sinful chocolates whose price per candy is much higher than the price of those in a larger box. However this uneconomical strategy prevents the self-loathing that would occur as soon as one stepped on the scale.

A number of studies of commitment strategies also suggest that people can anticipate their future feelings and behave so as to maximize utility. For example, Ariely and Wertenbroch (2002) showed that self-imposed deadlines are effective in reducing procrastination. As they pointed out, in a world without self-control problems, self-imposed deadlines would seem to be non-normative. However to prevent the substantial disutility that often accompanies failure, people are willing to forgo flexibility and other benefits now in order to achieve a better hedonic experience later.

Similarly, we suggest that people have a tendency to adapt to gains faster than they adapt to losses, because this pair of strategies results in a more favorable overall hedonic experience than symmetric adaptation would engender. We hypothesize that the awareness of the strategy is not essential to its successful execution.

Relation to prior research

Our model and experimental findings provide an integrative framework to help explain prior research studies in a parsimonious manner. These include studies on investment behavior as well as other microeconomic phenomena.

Gneezy (2002) found that subjects' selling behaviors in a stock trading experiment are best explained when the past price peak is assumed as the reference point. The reason why the past price peak may appear to be the reference point can be understood by asymmetric adaptation. Since investors tend to move reference points upward after gains more than downward after losses, after experiencing gains or losses, reference points tend to be closer to the higher of the two prices—the past period price and the current period price. When a reference point moves more quickly upward to a higher price compared to downward toward a lower price, after a number of periods it will eventually approach the past price peak.

The differential rates of adaptation between gains and losses would also have important implications on the inability to "make peace with one's losses", which is typically necessary if one is going to avoid succumbing to the sunk cost effect (Arkes & Blumer, 1985). We have shown that to maximize hedonic utility, people are unable to ignore sunk costs; they are unable to segregate prior losses from the consideration of future prospects. This will result in keeping the prior account open, integrating the current account with the prior one, and remaining in the southwest quadrant of the prospect theory value function where future losses are assuaged by the asymptote of the curve. These factors will contribute to the maladaptive economic behavior known either as the sunk cost effect or escalation of commitment (Staw & Ross, 1987).

In the gain region of the prospect theory value function we propose that updating and segregation of accounts is more likely to occur. This would explain the "hedonic treadmill" proposed by Brickman, Coates, and Janoff-Bulman (1978). People seem not to be satisfied with improvements, which are quickly deemed insufficient. Quick adaptation of an individual's reference point in the direction of the initial improvement renders that improvement inadequate, motivating new efforts. Thus the individual views his current wealth position as being at the new reference point, where the marginal utility from a further gain and the marginal disutility of an incremental loss are at their greatest (see also Scitovsky, 1976).

Finally, starting from a much different theoretical viewpoint than ours, Coombs and Avrunin (1977) were interested in explaining the ubiquity of single-peaked preference functions when the to-be-rated stimuli are comprised of either one (e.g., warmth) or two (e.g., approach and avoidance) dimensions. For example, as a neutral stimulus becomes warmer, it is rated more highly until it becomes hot, at which point a person's hedonic rating of it quickly starts to diminish. Coombs and Avrunin (1977) were not concerned with the movement of reference points. Nevertheless, in describing a single-peaked preference function, they offered the general conclusion that "Good things satiate and bad things escalate" (Coombs & Avrunin, 1977, p. 224). Although it is not clear whether there is any deep connection between their approach and our findings, speculatively one might extrapolate this aphorism to be consistent with one of our findings that reference point adaptation is more complete following a gain—fostering satiation—than following a loss.

Among the various patterns that have been identified concerning individual investor behavior is the disposition effect (Shefrin & Statman, 1985), which has been extensively documented (e.g. Dhar & Zhu, 2006; Genesove & Mayer, 2001; Grinblatt & Keloharju, 2001; Odean, 1998; Weber & Camerer, 1998). The disposition effect is defined as the tendency to hold losers too long and to sell winners too soon. Note that our hypothesis concerning reference point adaptation would lead one to predict that there are positive hedonic consequences of closing mental accounts in the gain region and negative hedonic consequences of closing mental accounts in the loss region, which is consistent with the disposition effect.

Weber and Camerer (1998) investigate the disposition effect in an experimental setting. They identify the disposition effect by assuming the purchase price or the most recent price as the reference points. Weber and Camerer conjecture that the purchase price and previous prices affect the reference point and argue that we need to learn more about how reference points adapt over time and how previous prices are weighted in forming reference points. We argue that the reference point in the current mental account is related to both the purchase price and any subsequent price that investors have experienced to the extent of how much the reference point has updated toward any of those prior outcomes. Depending on which past prices have had a stronger effect on the current reference point with which investors make their liquidation decision, one may find a stronger disposition effect by assuming one reference point rather than another.

In a recent paper, Karlsson, Loewenstein, and Seppi (2005) developed a model where investors select whether to pay attention to their current portfolio value. The authors assumed that paying attention increases the speed of reference point adaptation, and they test the predictions of their model that investors are more likely to pay attention to their portfolios when the market is up than down. Their results indicate that the reference point adapts faster in rising markets than in falling ones, consistent with our findings. However, our results suggest that reference points adapt faster to gains than losses irrespective of whether the aggregate market rises or falls, implying that differences in attention in up or down markets are not the sole cause of asymmetric reference point adaptation.

Several theoretical models of asset pricing (Barberis & Huang, 2001; Barberis, Huang, & Santos, 2001; Grinblatt & Han, 2005) take account of the adaptation of reference points. In these models, reference points migrate symmetrically toward new outcomes. If individual investors adapt their reference point asymmetrically to gains and losses as we hypothesize, this would have far-reaching consequences for these theories of asset pricing.

Conclusions

In prospect theory (Kahneman & Tversky, 1979), the reference point plays a prominent role. Whenever one outcome follows another, the hedonic consequences of the second one depend in part on the adaptation of one's reference point to the first one. Heretofore there has not been a systematic investigation of the magnitude of adaptation of the reference point to a gain or loss. The purpose of our research has been to address this issue.

Our results lead us to conclude that reference point adaptation occurs more completely to gains than to losses. This result was obtained under a variety of circumstances, including questionnaire studies, investigations using financial incentives, and scenarios that included portfolios as well as individual stocks. In addition, we obtained evidence that adaptation occurs more quickly if a stock is sold and then repurchased at the prior selling price. We hypothesize that the more complete adaptation under these circumstances is due to the fact that the sale closes the prior "mental account" (Thaler, 1999), thus segregating it from the subsequent one. With a new mental account thus initiated, the purchaser can more fully adapt to the prior one. Without the sale, the prior mental account is not closed, and a new gain or loss is integrated with the prior one, thus stalling a person's adaptation to the prior one.

We attempted to relate the asymmetric adaptation of gains and losses to several aspects of investor behavior, including the disposition effect (Shefrin & Statman, 1985), the sunk cost effect (Arkes & Blumer, 1985), and the "hedonic treadmill" (Brickman et al., 1978). We have suggested that our results may also inform theories of asset pricing.

We are not, of course, the first to suggest that one adapts quickly to gains. According to George Bernard Shaw, "There are two tragedies in life. One is to lose your heart's desire. The other is to gain it". Although he did not express his view in the following terms, apparently Shaw felt that the gain of one's heart's desire shifts one's reference point sharply upward, making the attainment of the prize eventually seem much less glorious than anticipated.

Appendix A. Instructions to participants

Optimal strategy in stating the minimum selling price

Before the second period, you have a chance to sell your stock by stating your minimum selling price. A buying price will then be randomly drawn from a known range of stock prices (ranging from the lowest to the highest second period price). If the randomly drawn price *exceeds or equals* your minimum selling price, you will sell the stock at the randomly drawn price. If the randomly drawn price is *less than* your minimum selling price, you will hold the stock until the second period, and you will sell your stock at the second period stock price determined by a coin flip.

You form your minimum selling price based on possible future stock prices. Your minimum selling price is equal to the number of dollars that someone would have to pay you to make you just barely willing to sell the stock, instead of holding it until the second period. Therefore, *your minimum selling price is equal to what the stock is worth to you*: You prefer holding the stock if someone offers you a price lower than your minimum selling price, and you prefer selling the stock if someone offers you a price higher than your minimum selling price.

Your best strategy in submitting your minimum selling price is truthfully reporting what the stock is worth to you: It is not your advantage to submit your minimum selling price higher or lower than what the stock is worth to you.

To see why, suppose you are willing to sell the stock at or above $55 because you think the stock is worth $55 to you. If you submitted $53 for your minimum selling price and the randomly drawn buying price was $54, you would be forced to sell your stock at $54, resulting in a one-dollar loss for you ($\$55 - \$54 = -\$1$). That is, you would be forced to sell the stock for $54 even though it is worth $55 to you. Thus, you don't want to ask only $53. In fact, if you ask a minimum selling price lower than $55, there is always a possibility that the randomly drawn buying price is below $55, forcing you to sell your stock at a price lower than your valuation of the stock. So you never want to submit the minimum selling price lower than your true stock valuation.

Now suppose you set your minimum selling price higher than $55, say, $57. If the randomly drawn buying price was $56, you will lose a chance to sell the stock at $56, because the price you asked ($57) is higher than the price being offered ($56). Had you asked a price of $55 instead of $57, you would have sold your stock for $56 and have made a $1 profit ($\$56 - \$55 = \$1$). In fact, if you ask a minimum selling price higher than $55, there is always a possibility that the randomly drawn buying price is between your stock valuation ($55) and what you submit as your minimum selling price, thus preventing a sale. By asking above $55, you throw away possible profits in this situation. Therefore, you don't want to submit a higher price than your true minimum selling price.

These arguments confirm that the optimal strategy is always to set your minimum selling price equal to what the stock is worth to you. The purpose of our game is to study the stock valuations of different people. *Your task in the game is to decide what the stock is worth to you, taking into account what you are told about the future possible prices of the stock.*

References

Ariely, D., & Wertenbroch, K. (2002). Procrastination, deadlines, and performance: Self-control by precommitment. *Psychological Science, 13*, 219–224.

Arkes, H. R., & Blumer, C. (1985). The psychology of sunk cost. *Organizational Behavior and Human Decision Processes, 35*, 124–140.

Barberis, N., & Huang, M. (2001). Mental accounting, loss aversion, and individual stock returns. *Journal of Finance, 56*(4), 1247–1292.

Barberis, N., Huang, M., & Santos, T. (2001). Prospect theory and asset prices. *The Quarterly Journal of Economics, 116*(1), 1–53.

Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science, 9*(3), 226–232.

Brickman, P., Coates, D., & Janoff-Bulman, R. (1978). Lottery winners and accident victims: Is happiness relative? *Journal of Personality and Social Psychology, 36*(8), 917–927.

Camerer, C., & Hogarth, R. M. (1999). The effects of financial incentives in experiments: A review and capital-labor production. *Journal of Risk and Uncertainty, 19*, 7–42.

Chen, H., & Rao, A. (2002). Close encounters of two kinds: False alarms and dashed hopes. *Marketing Science, 21*(2), 178–196.

Coombs, C. H., & Avrunin, G. S. (1977). Single-peaked functions and the theory of preference. *Psychological Review, 84*, 216–230.

Dhar, R., & Zhu, N. (2006). Up close and personal: An individual level analysis of the disposition effect. *Management Science*.

Genesove, D., & Mayer, C. (2001). Loss aversion and seller behavior: Evidence from the housing market. *Quarterly Journal of Economics, 116*, 1233–1260.

Gneezy, U. (2002). Updating the reference point: Experimental evidence. Working paper, which can be obtained from the author at The University of Chicago, Graduate School of Business, 5807 South Woodlawn Avenue, Chicago, IL 60637, USA.

Grinblatt, M., & Han, B. (2005). Prospect theory, mental accounting, and momentum. *Journal of Financial Economics, 78*(2), 311–339.

Grinblatt, M., & Keloharju, M. (2001). What makes investors trade. *Journal of Finance, 56*, 589–616.

Heath, C., Larrick, R. P., & Wu, G. (1999). Goals as reference points. *Cognitive Psychology, 38*, 79–109.

Hirst, D. E., Joyce, E. J., & Schadewald, M. S. (1994). Mental accounting and outcome contiguity in consumer-borrowing decisions. *Organizational Behavior and Human Decision Processes, 58*, 136–152.

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

Karlsson, N., Loewenstein, G., & Seppi, D. (2005). The "Ostrich Effect": Selective attention to information about investments. Working paper, available at <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=772125>.

Koszegi, B., & Rabin, M. (2004). A model of reference-dependent preferences. Working paper, available at <http://emlab.berkeley.edu/users/botond/refdep.pdf>.

Lim, S. (2006). Do investors integrate losses and segregate gains? Mental accounting and investor trading decisions. *Journal of Business, 79*(5), 2539–2573.

Linville, P. W., & Fischer, G. W. (1991). Preferences for separating or combining events. *Journal of Personality and Social Psychology, 60*, 5–23.

Odean, T. (1998). Are investors reluctant to realize their losses? *The Journal of Finance, 53*, 1775–1798.

Prelec, D., & Loewenstein, G. (1998). The red and the black: Mental accounting of savings and debt. *Marketing Science, 17*(1), 4–28.

Scitovsky, T. (1976). *The joyless economy: An inquiry into human satisfaction and consumer dissatisfaction*. Oxford, England: Oxford University Press.

Shefrin, H., & Statman, M. (1985). The disposition to sell winners too early and ride losers too long: Theory and evidence. *The Journal of Finance, 40*, 777–790.

Siegel, S. (1956). *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill.

Spranca, M., Minsk, E., & Baron, J. (1991). Omission and commission in judgment and choice. *Journal of Experimental Social Psychology, 27*, 76–105.

Staw, B. M., & Ross, J. (1987). Behavior in escalation situations: Antecedents, prototypes, and solutions. *Research in Organizational Behavior, 9*, 39–78.

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

Thaler, R. H. (1985). Mental accounting and consumer choice. *Marketing Science, 4*, 199–214.

Thaler, R. H. (1999). Mental accounting matters. *Journal of Behavioral Decision Making, 12*, 183–206.

Thaler, R. H., & Johnson, E. J. (1990). Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice. *Management Science, 36*, 643–660.

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

Weber, M., & Camerer, C. F. (1998). The disposition effect in securities trading: An experimental analysis. *Journal of Economic Behavior & Organization, 33*, 167–184.

Wertenbroch, K. (1998). Consumption self-control by rationing purchase quantities of virtue and vice. *Marketing Science, 17*, 317–337.

Yogo, M. (2005). Asset prices under rising aspirations and reference-dependent preferences. Working paper, available at <http://finance.wharton.upenn.edu/~yogo/papers/unpublished/Habit060105.pdf>.