# How do prior Outcomes affect Risk Attitude?*

**Martin Weber**[1] **Heiko Zuchel**[2]

**Universität Mannheim**

This version: February 2003

**Abstract:** Modelling choice in multi-period asset pricing requires assumptions about how prior outcomes affect risk attitude. We present an experimental study of the influence of prior outcomes on risky choice. We document a strong framing effect. By manipulating the presentation format of the decision problem we can induce increased risk taking following a gain, i.e. the house-money effect (Thaler and Johnson 1990) or, alternatively, increased risk taking following a loss, i.e. escalation of commitment (Staw 1976). Maximization of a value function from prospect theory can explain some of our results. Escalation of commitment in our experiment does not appear to be driven by a need to justify or rationalize the initial decision.

---

* We gratefully acknowledge financial support from the Deutsche Forschungsgemeinschaft, through SFB504 and the Graduiertenkolleg at Mannheim, and from the European Commission through the RTN "Understanding Financial Architecture" at Toulouse. We received helpful comments from participants of BDRM 2002 at Chicago, GEW2001 and the Theory Workshop at Mannheim.

[1] Universität Mannheim, Lehrstuhl für ABWL, Finanzwirtschaft, insb. Bankbetriebslehre, D-68131 Mannheim. weber@bank.bwl.uni-mannheim.de and CEPR, London.

[2] Universität Mannheim, Graduiertenkolleg "Allokation auf Finanz- und Gütermärkten", D-68131 Mannheim. zuchel@rumms.uni-mannheim.de.

**JEL code: C91**

# I. Introduction

There is a growing theoretical literature in finance that studies how observed features of asset prices can be linked to departures from conventional assumptions about investors` behavior, i.e. departures from expected utility theory.[3] In this literature, it has become common to use pre-existing evidence from the psychological literature on individual decision making to substantiate the particular departure from expected utility theory (see, for example, Odean (1998b), Barberis, Shleifer and Vishny (1998), or Daniel, Hirshleifer and Subrahmanyam (1998)).[4] In fact, some authors go so far as to demand that "the basic building blocks of new theory must derive empirical and experimental support from our sister social sciences." (De Bondt and Thaler (1995, p. 388)). Prospect theory (Kahneman and Tversky (1979)) has become such a cornerstone for building financial theories which are based on a more appropriate modeling of human decision making.

One problem with the use of pre-existing psychological evidence is that it typically comes from studies that were not designed to specifically investigate investment behavior. Hirshleifer (2001) stresses this problem and points out a possible remedy: "It is often not obvious how to translate pre-existing evidence from psychological experiments into assumptions about investors in real financial settings. Routine experimental testing of the assumptions [...] of asset pricing theories is needed to guide modeling" (p. 43).

Take prospect theory as an example which deviates from expected utility theory by considering a reference point and different risk attitudes for gains and losses.[5] Note that this theory is designed to describe behavior in a one shot decision situation under risk. However, in financial settings, e.g. in a capital market context, it is quite common to consider sequential decision making under risk. Extensions of prospect theory or related research on sequential decision making under risk are needed to model behavior in relevant financial settings. Suppose, for example, that prior gains would increase risk tolerance and, conversely, prior losses would decrease risk tolerance. Barberis, Huang and Santos (2001)

---

[3] Barberis and Thaler (2002) and Hirshleifer (2001) surveys this literature.

[4] There are other ways to justify deviations from the assumption of expected-utility maximization. Some authors simply appeal to plausibility (e.g. Hong and Stein (1999)), while others use well-defined preference theories such as disappointment aversion (Ang, Bekaert and Liu (2000)) or prospect theory (Gomes (2000)). Yet others appeal to observed investor behavior (De Long, Shleifer, Summers and Waldmann (1990), Zuchel and Weber (2001)).

show that such a link can help explain the high premium, excess volatility, and predictability of observed stock returns.[6]

In this paper, we consider the problem of sequential decisions under risk using different financial frames. We ask if behavior in later stages of the sequence is influenced by the outcomes resulting from earlier decisions. Especially we investigate if prior outcomes affect risk attitude? The answer to this questions is directly relevant for researchers modeling asset pricing: any influence of prior gains or losses on current behavior – if present in aggregate – would lead to patterns in equilibrium returns. Our aim is to make sense of the at times conflicting empirical results concerning sequential decision making under risk,[7] and to evaluate recent theories of investor behavior that, based on some experimental results, make strong assumptions on how investors are affected by prior gains and losses.

In our experiment we confront subjects with two versions (two financial frames) of a sequential decision-making problem under risk which are identical from an economic perspective in the sense that the set of attainable probability distributions over outcomes is identical. The two versions differ, however, in the presentation format. In the first version, the portfolio treatment, the decision situation faced by subjects shares many characteristics of a dynamic portfolio choice problem. Subjects are endowed with an initial amount of money that they can invest in two successive periods. Money can either be kept in cash or invested in a risky asset whose price fluctuates randomly. In the second version, the lottery treatment, the decision situation resembles a sequence of two rounds of a lottery (betting game). This version is close to the original prospect theory frame, i.e. considers two rounds of one shot decisions. In each round, subjects receive an amount of money that they can use to purchase lottery tickets that generate a random payoff. For both versions we investigate if the fact that subjects were (or were not) responsible for the initial decision influences subsequent behavior. We do so by either assigning a choice for the first period or by allowing free choice.

We find that there is a strong link between prior outcome and risky choice in the portfolio treatment and a less pronounced link working in the opposite direction in the lottery treatment. In the portfolio treatment, subjects take significantly greater risk following a loss than following a gain. This difference reflects escalation of commitment (Staw 1976), i.e. increased risk-taking following a loss. Conversely, in the lottery treatment there is greater risk taking after a gain than after a loss. This difference reflects the house-money

---

[5] There is also the transformation of probabilities which we do not want to consider here.
[6] Marcus (1989) and Sharpe (1990) make similar points.

effect (Thaler and Johnson 1990), i.e. increased risk taking following a gain. Assigning the initial choice does not make much of a difference for the link between prior outcome and risky choice. If anything, this link is strengthened, if the prior outcome results from an assigned choice.

The next section explains the design and procedure of the experiment. We go on to spell out competing hypotheses, based on existing theory and evidence, in Section III. In Section IV we present our results that we discuss in Section V and relate to existing evidence on the link between prior outcomes and investor behavior in Section VI. Section VII concludes. In the Appendix we provide the instructions and other material used in the experiment.

## II. Design and Procedure

We study the simplest case of sequential decision making: a sequence of decisions in two successive periods. We are interested in whether and how risky choice in the second period is affected by the prior outcome, i.e. the outcome in the first period. To address this question we simply compare risk taking after a gain with risk taking after a loss. To find out which factors influence the link between prior outcome and risky choice, we introduce two additional treatment variables: We vary across subjects the presentation format between a portfolio format and a lottery format. There are two reasons to choose these presentation formats explained below. First, the portfolio treatment resembles closely what investors do in a financial setting, emphasizing the decision making's sequential aspect whereas the lottery treatment models two independent sequential investment opportunities, emphasizing the one shot aspect of each decision. Second, both frames have been used in the literature before, so we can relate our results to those presented in the literature. In addition, we vary whether the decision for period 1 is assigned or whether subjects can choose freely. This allows us to test a more elaborate set of behavioral hypothesis.

### *Portfolio versus Lottery Presentation Format*

In the *portfolio format* the decision situation is presented as a simple dynamic portfolio choice problem: Subjects are endowed with an initial amount of money that they can invest in two successive periods. In each period, money can either be kept in cash or invested in a risky asset whose price fluctuates randomly. Subjects are paid, as real earnings from the

---

[7] We briefly discuss the literature in Section III.

experiment, the final value of their portfolio, i.e. their cash position plus the value of their holdings of the risky asset.

In the first period, subjects were endowed with DM 6.[8] They had to decide how many "units" to buy. We used neutral terms, e.g. we referred to units rather than "shares" or "assets."[9] A unit in period 1 did cost DM 0.60. We constrained subjects' choice of the number of units between zero and ten. Subjects kept any money not used for the purchase of units.

In the second period, subjects could purchase additional units or sell units, or leave their number of units constant. The price of units in the second period, would either be DM 1 (DM 0.60 + DM 0.40) with probability ½ or DM 0.30 (DM 0.60 – DM 0.30) with probability ½.[10] Subjects were fully informed about the objective probabilities of winning and losing, and about the corresponding size of price changes. The actual price change would be determined by the throw of a die. The *only constraint* for their decision was that their total number of units had to remain between zero and ten. This implies that the number of units that could be held (i.e. the opportunities for risk taking) is the same in both periods and independent of whether there was a gain or a loss in the first period.

To derive the redemption value of the units, a second price change was determined at the end of second period. Independent of the price change at the end of period 1, there was a ½ chance of a price increase of DM 0.40 and a ½ chance of a price decrease of DM 0.30. Subjects were again fully informed about the probabilities and magnitudes of price changes. The actual price change would again be determined by the throw of a die.

Subjects were paid the final value of their units plus their cash holdings. As an illustration, consider the case of a subject who goes for maximum risk and always holds ten units. Her probability distribution of payoffs from the experiment would be (DM 14, .25; DM 7, .5; DM 0, .25).

In the *lottery format* the decision situation resembles a sequence of two opportunities to participate in a lottery (betting game). This setup is close to the basic setup used in Gneezy and Potters (1997) and Gneezy, Kapteyn and Potters (2002). Again, we used only neutral terms to describe the decision situation and simply referred to units. In *each of the two* periods, subjects were endowed with DM 3. They had to decide how many units to buy at a price of DM 0.30, i.e. subjects could purchase between zero and ten units in each pe-

---

[8] At the time of the experiment, DM 1 exchanged for about US$0.50.
[9] See the appendix for the full instructions to the experiment.
[10] The price changes where defined so that probabilities were most simple, that they had a positive expected value and that both presentation formats were economically identical.

riod. Units would either pay out DM 0.70 with probability ½ or nothing with probability ½. Subjects were again fully informed about the probability distribution. Subjects could not bet money accumulated in the first period. The money earned in the experiment is equal to the sum of the endowments in both periods minus the cost of purchases of units plus the payoffs from units.

Figure 1 makes transparent that the lottery treatment is equivalent to the portfolio treatment in the sense that the set of attainable payoff distributions is the same under both treatments. In both treatments, one unit implies the possibility of a gain of DM 0.40 with probability .5 and the possibility of a loss of DM 0.30 with probability .5. In the portfolio treatment the gain comes in the form of a price increase and the loss in the form of a price decrease. In the lottery treatment, the gain comes in the form of a positive payoff from one unit minus the cost of purchase of the unit. The loss is simply the cost of purchase in the case of a zero payoff from the unit.

**Figure 1: Portfolio and lottery presentation format imply the same payoff opportunities**

| | Portfolio format | Lottery format |
|---|---|---|
| **Endowment** | Subjects **receive DM 6** at the beginning of period 1 | Subjects **receive DM 6** in two payments of DM 3 in each period |
| **Opportunity set** | **0 to 10 units** in all decisions | **0 to 10 units** in all decisions |
| **Payoff profile** | A unit generates either a **gain of DM 0.40** (price increase), or a **loss of DM 0.30** (price decrease) in each period. Gain and loss are equally likely. | A unit generates either a **gain of DM 0.40** (payoff DM 0.70 minus cost of DM 0.30), or a **loss of DM 0.30** (cost of purchase). Gain and loss are equally likely. |

When formulating the two treatments we made sure that the formulation of the instructions and decision sheets for both treatments were similar (see Appendix).

A crucial feature of the design for both formats is that the actual outcome in the first period was determined only at the end of the experiment, i.e. after subjects had made all their decisions. This means that when making their (binding) decisions for the second period, subjects did not know the actual outcome in the first period. So they had to make two contingent decisions for the second period: One for the case of a gain in the first period and one for the case of a loss. This way, we vary the treatment variable "prior outcome" within subject: For any subject who purchased units in the first period, we observe behavior in the case of a prior gain *and* in the case of a prior loss.[11] Within-subject comparisons have also been used by Thaler and Johnson (1990) to investigate the effect of prior outcomes on risky choice. This within-subject design is a direct application of Selten's (1967) well know strategy method. This method, commonly used in game theory experiments, asks subjects to give their answers to all possible moves of their opponents, i.e. to give their complete strategy.

The simple setup allows us to test for a link between prior outcomes on risky choice. Do subjects behave differently in the second period in the case of a gain in the first period and in the case of a loss in the first period? Our variable of interest is the number of units held. More units mean greater risk taking. If prior outcomes affect risky choice we would expect the number of units held to differ between the case of a gain in the first period and the case of a loss.

[11] We alternated across subjects the order in which we asked for behavior after a gain and after a loss.

### *Free versus Assigned Initial Choice*

With respect to the number of units held in period 1 we investigate two conditions. In the free-choice treatments, subjects choose their number of units in period 1 as described above. In the assigned-choice treatments we eliminate the choice in period 1. Rather than having the subjects decide, the number of units in the first period was given; subjects decided only about the number of units to be held in the second period after a gain and after a loss. The assigned choices were 6 units in the portfolio treatment and 7 units in the lottery treatment. These numbers correspond roughly to the average first-period holdings in the free-choice treatments. Note that, unlike the change in the presentation format from portfolio to lottery format, eliminating free choice in the first period changes an economic aspect of the decision situation: Without free choice in the first period that subjects have less freedom.

We introduced the assigned-choice treatments for two reasons. First, as we will explain in more detail later on, cognitive-dissonance theory suggests that decision makers have a tendency to stick to their initial (first-period) choice when making subsequent decisions. This tendency is eliminated when there is no initial free choice. Second, a given initial choice eliminates variation in the magnitude of the gain or loss in the first period. Hence, unlike in the free-choice treatments, the magnitude of the prior outcome (from the perspective of the second period) is the same for all subjects.

### *Subjective Reaction to Losses*

We included a second part in the experiment, which was common to all treatments. Here we asked subjects about their "subjective reactions to losses." These question are essentially a translation from Thaler and Johnson (1990).

1. (a) You lose DM 20
   (b) You lose DM 20 after having gained DM 60

   The loss of DM 20 hurts more in: (a), (b), or (no preference)

2. (a) You lose DM 20
   (b) You lose DM 20 after having lost DM 60

   The loss of DM 20 hurts more in: (a), (b), or (no preference)

We use the Thaler-Johnson questions to see if we can replicate their results and to see if statements about subjective reaction to losses are related to actual risk-taking behavior in the experiment.

In addition, we asked subjects for some personal information such as age, gender, etc.. The last question was an open question on what subjects thought when making their decisions under risk.

### *Procedure*

The experiment was conducted at Mannheim University. The subjects were 133 male and female undergraduate students mostly with a major in economics or business administration with an average age of 23. The experiment is a pen and paper experiment, conducted in the classroom. We recruited subjects by announcing at the end of various economics or business administration classes the opportunity to participate voluntarily in a paid experiment on decisions under risk. One session of the experiment took about 20 to 30 minutes. The average number of subjects per session was 17. There was a large variation between sessions with 3 subjects in the smallest session and 47 in the biggest.

## III. Competing Hypotheses

The effect of prior outcomes on subsequent choice has been the subject of several empirical studies. Even the most cursory glance at these studies reveals that results are often conflicting. E.g. prior losses have at times been found to increase risk-taking and at times to decrease risk-taking. Based on their research on the influence of prior outcomes, Thaler and Johnson (1990) state that "[p]erhaps the most important conclusion to be reached from this research is that making generalizations about risk-taking preferences is difficult" (p. 660). We discuss some of the empirical studies in the following subsections. This discussion is organized around the theoretical predictions, based on expected-utility theory, prospect theory, and the self-justification hypothesis derived from cognitive dissonance theory. Just like the empirical evidence, theory provides no clear-cut predictions. As we discuss briefly, expected-utility maximization or prospect theory are consistent with very different kinds of behavior. It is important to stress that we do not attempt to test these different theories. Rather we ascertain which factors induce which of the different kinds of behavior that have been found in the empirical literature.

### *Expected-Utility Theory*

Under expected-utility maximization, prior gains and losses can affect risky choice because any prior outcome changes current wealth which in turn determines risk aversion. Increased risk taking following a gain is consistent with expected-utility maximization if the utility function exhibits decreasing absolute risk aversion. Increased risk taking following a loss is consistent with expected-utility maximization if risk aversion is an increasing function of wealth. If risk aversion is constant there is no effect of prior outcomes on risky choice.

So without restrictions on the shape of the utility function, expected-utility maximization is consistent with all kinds of behavior within a single treatment; sharper predictions of behavior in a single treatment are possible only if we impose additional restrictions. Suppose that we impose the restriction that the utility functions of subjects be "reasonable" in the sense that they represent reasonable preferences over large-scale gambles. Suppose also that the utility function is differentiable. As the amounts in the experiment are small relative to subjects' lifetime wealth, these restrictions imply that subjects should go for maximum risk in any decision in the experiment, a point that is made forcefully in Rabin (2000). This result is just an application of the local-risk-neutrality property of expected-utility maximization with a differentiable utility function (Arrow 1971). Local risk-neutrality implies that subjects always take maximum risk in "small" gambles, such as the ones in our experiment.

*Hypothesis:* Local Risk-Neutrality
*Subjects go for maximum risk (10 units) in every decision.*

Even without restrictions on the shape of the utility function, there is a sharp prediction concerning behavior across different treatments. Expected utility depends only on the probability distribution of outcomes and is consequently independent of the presentation format of the decision problem. In our experiment, we vary across subjects the presentation format of the decision problem (lottery/free-choice and the portfolio/free-choice treatments) while keeping the probabilities and magnitudes of possible outcomes fixed. Expected-utility maximization implies that behavior should not differ between different presentation formats.

*Hypothesis:* Invariance of Changes in Risk Attitude across Presentation Formats
*The average number of units held in period 2 after a gain (resp. after a loss) should be the same in the lottery/free-choice and portfolio/free-choice treatments.*

### Maximization of a Prospect-Theory Value Function

Prospect theory was introduced by Kahneman and Tversky (1979) as a descriptive theory of decision under risk. Under prospect theory individuals behave as if maximizing the expectation of a value function.[12] The value function has three important characteristics: (i) It is defined over gains and losses relative to a specific reference point. (ii) It is S-shaped, i.e. it is convex for losses and concave for gains. (iii) The value function is steeper for losses than for gains, $v(x) < -v(-x)$ for $x \neq 0$, a feature called loss aversion, and it has a kink at the origin. The reference point turns out to be crucial for risk taking. Different assumptions about what reference point subjects use to evaluate outcomes can lead to very different predictions about risk taking and about the effect of prior outcomes on risky choice. To be fair, it should be noted that prospect theory was designed to understand single period decision making. What we need in this context is an extension of prospect theory to a dynamic setting.

It is easy to see that if, for example, the reference point always equals the status quo (current wealth) prior outcomes have no effect on risky choice. However, if the reference point does not fully reflect prior gains or losses there is scope for an influence of prior outcome on subsequent risky choice. The important point is that different reference points induce different behavior, and that the reference point may be influenced by the presentation format of the decision problem. Unlike in the case of expected-utility maximization, we cannot rule out prospect theory as an explanation for behavior on the basis of different behavior in treatments that differ only in presentation format. It is precisely the point of framing effects based on prospect theory that reframing equivalent options can induce different setting of reference points and, consequently, different behavior. Framing effects refer to the case that different phrasing of *the same outcomes* results in different choices.[13] In prospect theory, framing effects result from the S-shape of the value function together with the fact that the reference point, relative to which gains and losses are measured, can be manipulated by the phrasing of outcomes.

### The Evidence in Thaler and Johnson (1990)

Thaler and Johnson (1990) study in an experiment how subjects frame decision situations under risk in the presence of a prior outcome. Using a sample of undergraduate and MBA students, Thaler and Johnson demonstrate that prior gains and losses affect the willingness to take risk, see the following example; the percentage of students that chose each option is in parentheses.

---

[12] To derive our hypotheses, we do not need to consider the probability weighting function nor do we need to take into account the cumulative form of prospect theory, see Tversky and Kahneman (1992).

[13] The classic example of a framing effect is the Asian disease problem developed by Kahneman and Tversky (1981).

1. You have just won $30. Choose between:
(a) A 50% chance to gain $9 and a 50% chance to lose $9 *(82 percent)*
(b) No further gain or loss *(18 percent)*

2. You have just lost $30. Choose between:
(a) A 50% chance to gain $9 and a 50% chance to lose $9 *(36 percent)*
(b) No further gain or loss *(64 percent)*

There is a clear influence of prior outcomes on risky choice. Following a gain, a large percentage of subjects is risk-seeking. Conversely, after a loss the majority of subjects is risk averse. Thaler and Johnson interpret their findings as indicating that "a prior gain can increase subjects willingness to accept gambles. [...] In contrast, prior losses can decrease the willingness to take risks." (p. 643-644).

Thaler and Johnson (1990) termed the phenomenon that risk taking increases in the presence of a prior gains the house-money effect. Translated to our experiment this hypothesis implies that subjects increase (or leave constant) the number of units held after a gain.

*Hypothesis:* House-money effect

*A gain in the first period leads to an increase (or no change) in the number of units held in the second period.*

Similarly, the Thaler-Johnson result that prior losses decrease the willingness to take risk translates into the following hypothesis.

*Hypothesis:* Increased sensitivity following a loss

*A loss in the first period leads to a decrease (or no change) in the number of units held.*

A simple hypothesis about the reference point can explain such behavior. If subjects in our experiment use the wealth they bring to the experiment as reference point, any outcome of the experiment will be seen as belonging to the gain domain. The initial endowment in the experiment is a first gain, that, over the course of the experiment, can be increased through further gains or reduced through "losses".[14] In this way, all possible outcomes in the experiment lie in the "gain part", i.e. the concave part of the value function. This part is typically assumed to be a power function $v(x) = x^{\alpha}$ (Tversky and Kahneman 1992), where $0 < \alpha < 1$, which implies decreasing absolute risk aversion. Under this extra assumption then, subjects would take greater risk following a gain in the experiment and reduce risk

[14] Note that this is different from Thaler and Johnson's quasi-hedonic editing hypothesis. According to quasi-hedonic editing, only losses would be integrated with prior gains whereas gains would be separated. The framing we describe means that losses and gains are integrated.

taking following a "loss". Without the additional assumption of decreasing absolute risk aversion over gains, we cannot make any prediction about behavior, just as in the case of expected-utility maximization.

From all the treatments in our experiment, the "lottery/assigned choice" treatment is the one that is closest to the experimental situation studied by Thaler and Johnson (1990). Recall the type of questions they asked: "You have just won $30. Choose between: (a) A 50% chance to gain $9 and a 50% chance to lose $9, or (b) No further gain or loss". Clearly in such situation there is no free choice that leads to the prior outcome. Nor is there a portfolio (with some risk) carried over from a previous period as in our portfolio treatment.

In our experiment we replicate a question from Thaler and Johnson (1990) on subjective reaction to losses. When do losses hurt most, in isolation, or after a gain, or after a loss? The majority of subjects in Thaler and Johnson (1990) state that a given loss hurts more when it occurs after a loss than when it occurs alone. Conversely, a given loss hurts less when it occurs after a gain than when it occurs in isolation. Thaler and Johnson (1990) interpret this as an indication that prior losses "sensitize people to subsequent losses of a similar magnitude" (p. 656), while prior gains are perceived as - in gambling parlance - "house money" and that "losing some of «their money» doesn't hurt as much as losing one's own cash." (p. 657). Barberis, Huang and Santos (2001) stress this interpretation and use it to motivate their theory of investor behavior:

> *"[...] how loss averse the investor is, depends on his prior investment performance. After prior gains, he becomes less loss averse: the prior gains will cushion any subsequent loss, making it more bearable. Conversely, after a prior loss he becomes more loss averse: after being burned by the initial loss, he is much more sensitive to additional setbacks." (p. 2)*

Given the suggestiveness of the question, we expect to confirm the Thaler-Johnson results – irrespective of actual risk-taking behavior in the experiment.

*Hypothesis:* Subjective Reaction to Losses

> *Subjects indicate that losses hurt more after a prior loss and less after a prior gain relative to the case of no prior outcome.*

## Evidence on Escalation of Commitment

Thaler and Johnson (1990) document that a prior loss decreases risk taking. There is, however, some evidence, experimental and otherwise, that indicates the opposite behavior.[15] The psychological literature on escalation of commitment (e.g. Staw 1997) studies repeated (rather than one-shot) decision making under uncertainty in the face of negative feedback about prior decisions.[16] It documents the tendency to stick to or even intensify risky courses of action (e.g. investment projects) following losses. Contrary to the evidence in Thaler and Johnson (1990), escalation of commitment indicates greater risk taking after a loss than after a gain.

A typical "escalation situation" is faced by investors who have lost money in stocks or mutual funds. Odean (1998a) documents the "disposition effect" (Shefrin and Statman 1985) in the trading behavior of individual investors, Weber and Camerer (1998) document the disposition effect in an experiment. Both studies find, that investors sell stocks that trade above the purchase price (winners) relatively more often than stocks that trade below purchase price (losers). Also, investors purchase additional shares of winners relatively less often than they purchase additional shares of losers (Odean (1998a)). Odean (1998a) and Weber and Camerer (1998) interpret this behavior as evidence of decreased risk aversion after a loss and increased risk aversion after a gain.

One major explanation for escalation of commitment is based on the value function from prospect theory (e.g. Brockner 1992). Consider the case when subjects use the wealth they bring to the experiment *plus* any initial endowment in the experiment as reference point. In this case, any loss during the experiment will be perceived as a loss, not as a reduced gain as in the hedonic-editing case, which, in our experiment, that subjects take greater risk following a loss. The intuition is that, due to the convex shape of the value function over losses, following a loss any subsequent loss hurts relatively less and any subsequent gain is particularly sweet, because it (partly) offsets the prior loss. The following results can be easily derived.

*Result: If initial wealth serves as a reference point in all decisions of the sequence, maximization of the expectation of an S-shaped value function, that is strictly convex for losses and strictly concave for gains, implies that risk-taking after a loss is at least as great as initial risk-taking.*

---

[15] Thaler and Johnson (1990) themselves do find special situations where a prior loss leads to *increased* risk-taking. These situations are characterized by the opportunity to exactly break even, i.e. the gamble involves a gain that would exactly offset the prior loss. Thaler and Johnson term this observation the break-even effect.

[16] Related strands of the psychological literature study entrapment (e.g. Brockner and Rubin 1985) or the sunk-cost fallacy (e.g. Arkes and Blumer 1985).

This leads to the following hypothesis which is based on the previous data cited above (for the case of free choice):

*Hypothesis:* Escalation of commitment

> *A loss in the first period leads to an increase (or no change) in the number of units held in the second period.*

For the case of a prior gain, there is no such unambiguous result. Intuitively, a prior gain has two effects: It moves the outcomes of subsequent gambles into or closer to the gain region, this effect may increase risk aversion due to the concave shape of the value function over gains. But a prior gain also moves the status quo away from the kink of the value function at the origin, where risk aversion is locally infinite. This reduces risk aversion.

The literature on escalation of commitment suggests that it matters for behavior whether subjects perceive the initial decision as "initiating a course of action". This is the case in our portfolio treatment. Here subjects are likely to think about their decision in period 2 as a decision to change their initial decision (in period 1). By contrast, in the lottery treatment we would expect subjects to be less likely to perceive the initial decision as initiating a course of action, since there is no "portfolio" of units carried over from one period to the next. Consequently, we would expect less escalation of commitment in the lottery treatment.

*Hypothesis:* Presentation format matters

> *The portfolio treatment induces a stronger tendency toward escalation of commitment.*

### *The Self-Justification Hypothesis*

The second major explanation for escalation of commitment - based on cognitive dissonance theory - is the self-justification hypothesis (Staw 1976). The self-justification hypothesis states that individuals stick to a course of action because they feel the need to justify or rationalize their initial decision in the face of losses.

> *'Put simply, people do not like to admit that their past decisions were incorrect, what better way to (re)affirm the correctness of those earlier decisions than by becoming even more committed to them." (Brockner 1992, p. 41)*

So under the self-justification hypothesis, we would expect escalation of commitment, i.e. increased risk taking following a loss, and we would again expect escalation of commitment to be more pronounced in the portfolio treatments.

In contrast to the prospect-theory based explanation for escalation of commitment, the self-justification hypothesis predicts different behavior in the free and assigned-choice treatments. In the case of free choice the decision in the first period is undertaken freely and with the understanding that adverse outcomes are possible. Such a condition is favorable to the creation of cognitive dissonance (Gilad, Kaish and Loeb 1987), which - according to the self-justification hypothesis - creates a preference for sticking with the initial decision later on. In the case of assigned choice, there is no commitment in the first period. Put differently, in the assigned-choice treatments there is no initial decision "to be justified" in later decisions. So, in these treatments, the motive of self-justification should be absent. If self-justification were the driving force behind escalation of commitment in our experiment, then we would expect any tendency toward escalation of commitment to be more pronounced in our free-choice treatments.

*Hypothesis:* Self-justification
*There is less escalation of commitment in the assigned-choice treatments.*

## IV. Results

Analyzing the results of our experiment is straightforward. We simply compare the average number of units held, i.e. the risk taken, in the different experimental treatments. These averages together with the standard deviations (across subjects) are presented in Table 1. We also report median values.

**Table 1: Summary statistics on the number of units held**

| | Period 1 | Following gain | Following loss |
|---|---|---|---|
| **Portfolio/free choice (N=34)** | | | |
| Average | 6.1 | 5.2 | 8.0 |
| Standard deviation | 2.6 | 3.5 | 3.1 |
| Median | 6 | 5.5 | 10 |
| **Portfolio/assigned choice (N=31)** | | | |
| Average | 6 | 5.1 | 8.5 |
| Standard deviation | 0 | 3.0 | 2.3 |
| Median | 6 | 4 | 10 |
| **Lottery/free choice (N=35)** | | | |
| Average | 7.6 | 7.6 | 6.7 |
| Standard deviation | 2.3 | 2.6 | 3.4 |
| Median | 8 | 8 | 7 |
| **Lottery/assigned choice (N=33)** | | | |
| Average | 7 | 7.8 | 6.7 |
| Standard deviation | 0 | 3.1 | 3.0 |
| Median | 7 | 9 | 7 |

There are clear treatment effects. The average number of units held is influenced by the prior outcome. E.g. in the portfolio/free-choice treatment, the average number of units following a gain is 5.2 and the average number of units following a loss is 8.0. Moreover, the link between prior outcome and risk taking reverses its sign across different treatments. While the portfolio format induces less risk taking after a gain than after a loss, we have the opposite effect in the lottery treatment. Assigned choice vs. free choice does not seem to have an impact on subjects choice.

Consider first the portfolio/free-choice treatment. The influence of prior outcomes on risk taking in this treatment is summarized in Figure 2 which depicts the (sorted) difference in the number of units held after a gain and after a loss across subjects.

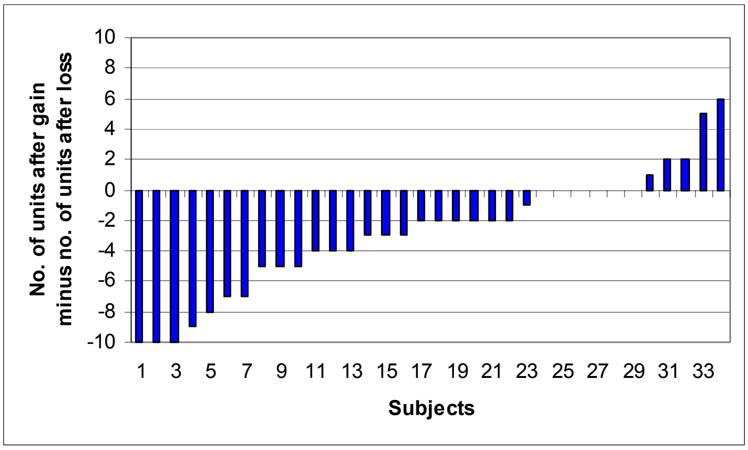
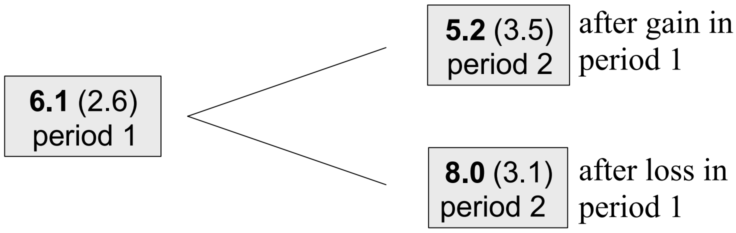



**Figure 2:** Behavior in the portfolio/free-choice treatment. Difference in the number of units held after a gain and after a loss.

The majority of subjects (23 out of 34) held more units following a loss than following a gain. Such behavior runs counter to the hypotheses derived from Thaler and Johnson (1990) which imply greater risk-taking following a gain than following a loss. Figure 3 provides the relevant statistics.

**Figure 3:** Average number of units held in the portfolio/free-choice treatment. Standard deviations in parentheses.




| Comparison of number of units | *p (Wilcoxon)* | *p (Binomial)* |
|---|---|---|
| Period 2 after gain / period 2 after loss | 0.001 | 0.001 |
| Period 2 after gain / period 1 | 0.196 | 0.345 |
| Period 2 after loss / period 1 | 0.001 | 0.000 |

*p*-values are based on two-sided Wilcoxon and Binomial tests and in the case of the Wilcoxon test on the asymptotic distribution of the test statistic.

A (non-parametric) Wilcoxon test indicates that the difference in average holdings after gains and losses is highly significant ($p$=0.001).[17] To understand where this difference comes from, we look at how risk taking after gain or loss compares with risk taking in the first period. A prior gain leads to reduced risk-taking, but this effect is insignificant ($p$=0.196). A prior loss leads to increased risk-taking and this effect is highly significant ($p$=0.001). So it appears that the difference in behavior after gain and loss is mainly driven by increased risk taking following a loss, i.e. we observe strong escalation of commitment. Our observations are inconsistent with either the house-money effect or the hypothesis that a prior loss decreases risk taking.[18]

Next, consider the lottery/free-choice treatment. Compared with the portfolio/free-choice treatment only the presentation format differs. Figure 44 summarizes behavior in this treatment analogous to Figure 2.

[17] We do not use the parametric $t$-test since our observations do not come from a normal distribution (the number of units is constrained between 0 and 10) and the sample size is small. We also report $p$-values from a binomial test. The $p$-values quoted in the text refer to the Wilcoxon test. All reported $p$-values are from two-sided tests.

[18] We also examined differences in second-period behavior based on risk taking in the first period. A Mann-Whitney test indicates no significant difference in the difference of the number of units held after a gain and after a loss for those subjects that took greater than average risk in the first period versus those subjects who took below average risk. Subjects with below average risk in the first period increase their risk significantly more than subjects with above average risk in the first period ($p$=0.041), however, but this effect is probably best explained by the fact that the upper bound on risk taking (10 units) binds relatively more often for subjects who already hold more units: Of those subjects who took above average risk in the first period (i.e. held six or more units) 15 out of 18 hold ten units following a loss, while of those who took below average risk in the first period, only 6 out of 16 held ten units after a loss.

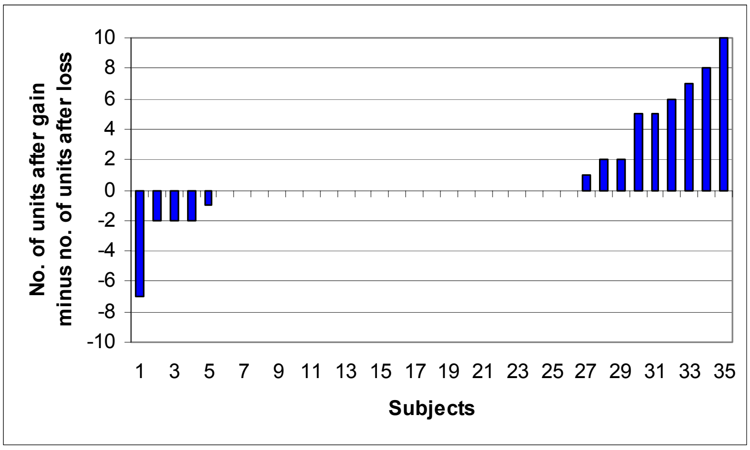
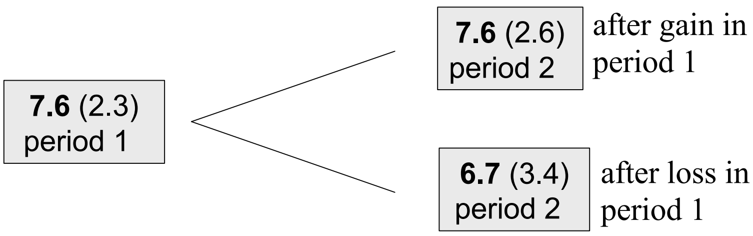



**Figure 4:** Behavior in the lottery/free-choice treatment. Difference in the number of units held after a gain and after a loss.

The difference to the portfolio/free-choice treatment is evident. Here the majority of subjects (21 out of 35) holds the same number of units after a gain and after a loss. Their behavior is completely unaffected by whether there is a prior gain or loss. 9 subjects take greater risk after a gain, 5 take greater risk after a loss. The average number of units held is slightly increased after a gain and slightly reduced after a loss.

**Figure 5: Average number of units held in the lottery/free-choice treatment. Standard deviations in parentheses.**




| Comparison of | *p (Wilcoxon)* | *p (Binomial)* |
|---|---|---|
| Period 2 after gain / Period 2 after loss | 0.122 | 0.424 |
| Period 2 after gain / period 1 | 0.378 | 0.581 |
| Period 2 after loss / period 1 | 0.116 | 0.791 |

*p*-values are based on two-sided Wilcoxon and Binomial tests and in the case of the Wilcoxon test on the asymptotic distribution of the test statistic.

As Figure reveals, however, none of theses differences are significant. So in the lottery/free-choice treatment there is no effect of prior outcomes on risky choice.[19]

[19] We again compared behavior in the second period for subjects who took above average risk in the first period and those who took below average risk. There are no significant differences (based on a Mann-Whitney test).

The remaining two treatments use an assigned choice in the first period. Subjects could only decide on the number of units in the second period. Behavior in the portfolio/assigned choice treatment was very similar to the free-choice case, as is clear from Figure (compare Figure 22 for the portfolio/free-choice treatment).

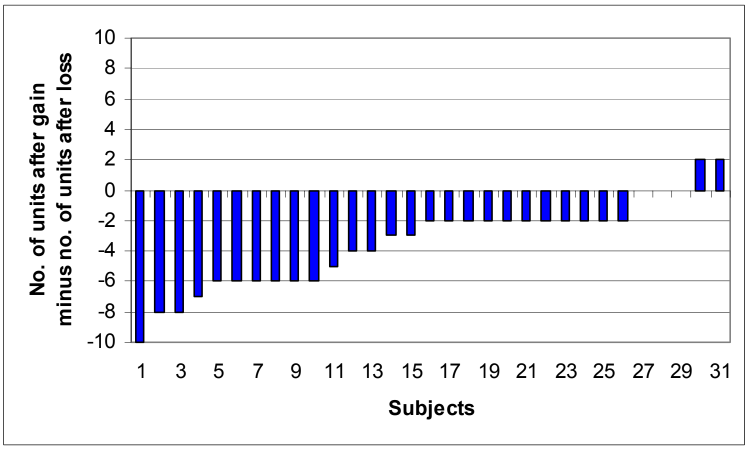
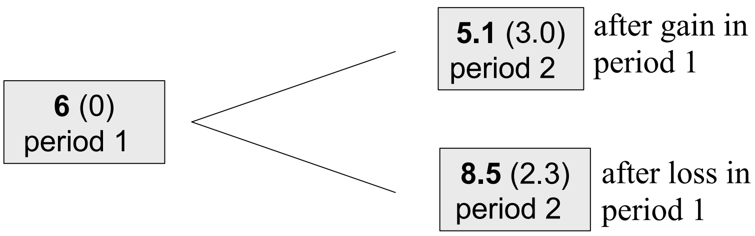



**Figure 6:** Behavior in the portfolio/assigned-choice treatment. Difference in the number of units held after a gain and after a loss.

If anything the assigned choice induces a greater preference for escalation of commitment, i.e. for increased risk taking after a loss. The majority, 26 out of 31 chose to hold more units following a loss than following a gain.

**Figure 7: Average number of units held in the portfolio/assigned-choice treatment. Standard deviations in parentheses.**




| Comparison of number of units | *p (Wilcoxon)* | *p (Binomial)* |
|---|---|---|
| Period 2 after loss / after gain | 0.000 | 0.000 |
| Period 2 after gain / period 1 | 0.057 | 0.720 |
| Period 2 after loss / period 1 | 0.000 | 0.000 |

*p*-values are based on two-sided Wilcoxon and Binomial tests and in the case of the Wilcoxon test on the asymptotic distribution of the test statistic.

Once again this difference stems largely from an increase in the number of units held after a loss (8.5 units) relative to the first period (6 units) (see Figure7). Units held decline slightly following a gain, but this effect is only marginally significant under a Wilcoxon test ($p$=0.057) and insignificant under a binomial test ($p$=0.720).[20]

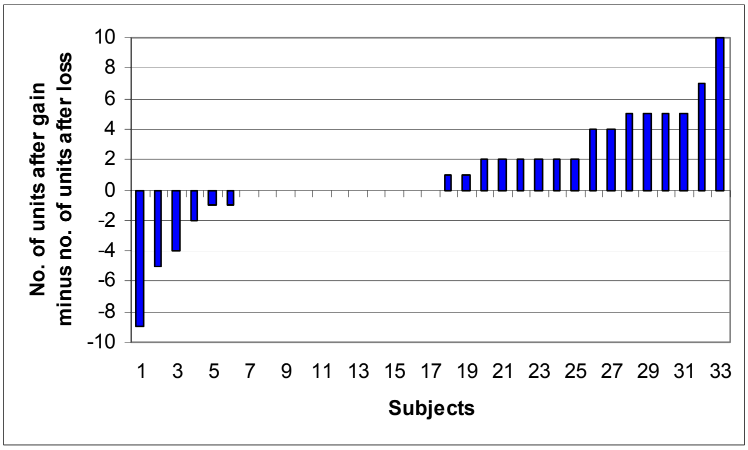
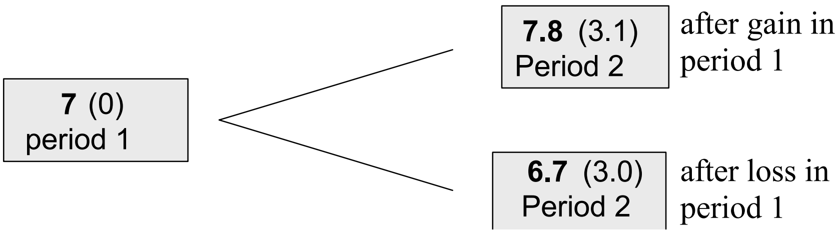



**Figure 8:** Behavior in the lottery/assigned-choice treatment. Difference in the number of units held after a gain and after a loss.

Figure 8 summarizes behavior in the lottery/assigned-choice treatment. The relative majority of subjects (16 out of 33) chose greater risk following a gain than following a loss. Behavior conforms to the hypotheses of Thaler and Johnson (1990): There is greater risk-taking following a gain than following a loss. Figure  reports statistics for this treatment.

**Figure 9: Average number of units held in the lottery/assigned-choice treatment. Standard deviations in parentheses.**




| Comparison of number of units | *p (Wilcoxon)* | *p (Binomial)* |
|---|---|---|
| Period 2 after loss / after gain | 0.041 | 0.052 |
| Period 2 after gain / period 1 | 0.028 | 0.029 |
| Period 2 after loss / period 1 | 0.801 | 1 |

$p$-values are based on two-sided Wilcoxon and Binomial tests and in the case of the Wilcoxon test on the asymptotic distribution of the test statistic.

[20] The large difference in $p$-values from the Wilcoxon and the binomial test reflect the fact that the absolute frequency of increases and decreases in risk taking was about the same (14 increases versus 17 decreases), which leads to a high $p$-value for the binomial test, and the fact that the average magnitude of increases was lower than that of decreases (2.1 is the average increase, -3.4 is the average decrease) which explains the much lower $p$-value from the Wilcoxon test.

The difference in risk taking following gains and losses is statistically significant ($p$=0.041). We also report differences in second-period choices to the assigned choice from the first period. Relative to the assigned choice in the first period, risk taking is significantly increased after a gain and insignificantly decreased after a loss.

Bearing in mind that the assigned-choice and free-choice treatments refer to objectively different decision situations, there is an interesting effect in the variability of second-period choices across these treatments: The percentage of subjects choosing the same number of units after a gain and after a loss is higher in the free-choice treatments (Table 2).

**Table 2: Percentage of subjects choosing the same number of units after gain and after loss**

| | Portfolio format | Lottery format |
|---|---|---|
| Free choice | *18%* | *60%* |
| Assigned choice | *10%* | *33%* |

Apparently, the assigned-choice condition induces a greater variation in second-period choices relative to the free-choice treatments in the same presentation format. Under a binomial test, this difference is significant in the lottery format ($p$=0.027) and insignificant in the portfolio format ($p$=0.475).

In our questionnaire, we asked questions taken from Thaler and Johnson (1990). These questions were designed to ascertain "subjective reaction to losses" as a function of prior gains or losses. Thaler and Johnson (1990) present evidence that losses are less painful after a prior gain and more painful after a prior loss. Our results are in Table 3.

**Table 3: Subjective Reaction to Losses**

Consider the following two events: (a) you lose DM $x$. (b) you lose DM $x$ after gaining DM $y$. We are interested in the emotional impact of the loss of DM $x$ in both cases. Are you more upset about the loss of money when it occurs alone (a). or when it occurs directly after a gain (b)? Of course you are happier in total in (b). but we are interested only in the incremental impact of the loss. Below you will find several questions of this type. In each case please compare the incremental effect of the event described. If you feel there is no difference you may check that. but please express a preference if you have one.

(a) You lose DM 20
(b) You lose DM 20 after having lost DM 60
The loss hurts more in:

| | | | |
|---|---|---|---|
| Portfolio/free choice | (a) 18% | (b) 62% | (no preference) 21% |
| Lottery/free choice | (a) 29% | (b) 57% | (no preference) 14% |
| Portfolio/assigned choice | (a) 23% | (b) 61% | (no preference) 16% |
| Lottery/assigned choice | (a) 36% | (b) 52% | (no preference) 12% |
| *Results of Thaler-Johnson (Cornell MBAs)* | (a) 13% | (b) 55% | (no preference) 31% |

(c) You lose DM 20
(d) You lose DM 20 after having gained DM 60
The loss hurts more in:

| | | | |
|---|---|---|---|
| Portfolio/free choice | (a) 76% | (b) 6% | (no preference) 18% |
| Lottery/free choice | (a) 80% | (b) 6% | (no preference) 14% |
| Portfolio/assigned choice | (a) 61% | (b) 26% | (no preference) 13% |
| Lottery/assigned choice | (a) 82% | (b) 15% | (no preference) 3% |
| *Results of Thaler-Johnson (Cornell MBAs)* | (a) 70% | (b) 9% | (no preference) 21% |

The amounts used in the original Thaler-Johnson questions were \$9 and \$30 instead of DM 20 and DM 60. Some percentages do not add up to 100 percent due to rounding.

We essentially get the same results as Thaler and Johnson (1990). Subjects on average indicate that prior gains decrease the discomfort caused by a given loss and that prior losses increase the discomfort of a given loss.

We find these results remarkable for two reasons. First, they replicate very well the results obtained by Thaler and Johnson (1990) whose results are also given in Table 3. Second, the answer to these questions appear not to be related to the actual decisions taken the experiment: Behavior is very different between the lottery and portfolio treatments, still, the answers to the question on subjective reaction to losses are very similar in all treatments. A different way to see this is to compare the risk-taking behavior of those subjects that gave answers consistent with the Thaler-Johnson results, i.e. those who indicated that a loss in isolation hurts less than following a loss and more than following a gain, with the behavior of those who answered differently. Comparing these two groups, a Mann-Whitney test shows that for any treatment, the difference between the number of units held after a gain and after a loss is not significantly different ($p$-values>0.2). The answers with respect to this type of Thaler-Johnson question does not seem to be related to the change in risk attitude after a gain or a loss.

Finally, we asked subjects to indicate what they thought when making their decisions in the experiment. 108 out of our 133 subjects responded to this question. There is a great variation in the responses given, but by and large, they indicate a reasonable understanding of the experimental setup: Subjects typically indicate that they were aiming to "maximize profits" and also mention the risk of losses. It is interesting to note how many subjects gave answers along the lines of our various hypotheses about behavior. Ten subjects in the portfolio treatments mentioned profit-taking (e.g., "a sure profit is more important than the opportunity for further profit", "[...] in case of a gain, secure the gain[...]), six subjects in the portfolio treatments gave answers in line with escalation of commitment (e.g., " in case of a loss, 'hold the stock'[sic!]", "when the price decreased in period 1, I buy because it is cheaper"). By contrast, in the lottery treatments only a single subject mentioned a profit-taking motive and two subjects gave answers in line with escalation of commitment. Few subjects indicated a desire to limit their losses (2 subjects, "the relative risk is bigger after a loss", "limiting of losses") and no-one indicated that he or she thought risk was less painful following a gain, as the results of Thaler and Johnson (1990) would suggest.

## V. Interpretation

We designed our experiment to address two questions: What is the effect of prior outcomes on risky choice, and which factors influence this effect? We find that there is an effect of prior outcomes on risky choice and that this effect depends strongly on the presentation format of the decision problem and that it does not depend on whether the prior outcome results from a free choice or not.

There is a strong framing effect. Behavior differs significantly between the portfolio and lottery treatments (both for free-choice and assigned-choice), even though there is only a difference in presentation format. In the portfolio treatment subjects became less risk averse after a loss whereas in the lottery treatment subjects showed a small increase in risk aversion. This effect can result from the S-shape of the value function together with the fact that the reference point, relative to which gains and losses are measured, is manipulated by the phrasing of outcomes.

We find that our results make sense in the light of what we know from the literature on escalation of commitment. In the portfolio treatment, where the first-period decision can be seen as initiating a course of action, there is strong escalation of commitment. In the lottery treatment, however, where there is no "portfolio" of units carried over from one period to the next, there is no escalation of commitment. This suggest that the initial decision is not perceived as "initiating a course of action," which eliminates escalation of commitment.

There are different explanations for escalation of commitment. Most prominent are the self-justification hypothesis and framing effects based on prospect theory. Escalation of commitment in our experiment does not seem to be driven by the desire for self-justification. Assigning the first-period choice in the portfolio treatment does not weaken or eliminate escalation of commitment.

### *Alternative Explanations*

Our results are open to alternative explanations. Maybe the behavior in our portfolio treatments reflects a belief that a loss in the first period is more likely to be followed by a gain in the second period than by another loss. Such a belief could be a consequence of the processes that give rise to the gambler's fallacy (Tversky and Kahneman 1971). Such an argument fails to explain, however, why the behavior is different in the portfolio and lottery treatments.

Maybe profit-taking in the portfolio treatments reflects the misunderstanding that gains need to be realized to count for the earnings from the experiment. We stressed in the instruction that this is not the case. In any case, the majority of subjects escalate their commitment to losers that is they purchase additional units following losses. Clearly such behavior cannot be driven by the idea that the value of units does not count for final pay.

Another explanation is based on the fact that a loss in the portfolio treatment involves a price decrease. The price decrease could induce a tendency toward buying based on the (naive) logic that a low price means a good buying opportunity. We cannot rule out such an explanation based on our experiment. We know, however, from a different experiment, that this logic alone does not explain behavior after losses in a portfolio setup. Weber and Camerer (1998) study trading of assets at exogenous prices. They do find evidence of a disposition effect, i.e. escalation of commitment, in their "portfolio/free-choice treatment". In a second treatment, however, in which the portfolio is automatically sold at the end of each trading period the disposition effect is greatly reduced. Note that in this automatic-selling treatment losses are still associated with a lower price.

Yet another explanation for behavior in the portfolio treatments is naive portfolio rebalancing. Subjects might sell after a gain and buy after a loss so as to keep the portfolio weight of the risky asset constant. Such behavior would be optimal under expected-utility maximization with constant relative risk aversion if log-returns of the asset were i.i.d. normally distributed. In our design, where price changes rather than rates of returns are i.i.d., portfolio rebalancing is consistent with expected-utility maximization only if the utility function exhibits increasing absolute risk aversion. This does not, of course, preclude the possibility that subjects were naively using the heuristic to have constant portfolio weights.[21]

### *Limitations of the Experiment*

Our results can be challenged on the following grounds: There was no scope for learning, the within-subjects design is "unrealistic", the experiment did not involve any real losses, and the amounts at stake were very small. We discuss these challenges in turn.

Subjects participated in only one sequence of two periods. They were not given the opportunity to become acquainted to the experimental setup through trial rounds and there was no learning from "prior plays". Note that all experimental treatments are the same in this respect, but there may still be a concern to what extent behavior in the experiment reflects deliberate choice or just confusion. That subjects were not simply confused (with the confusion working in different directions in different treatments) can be seen from the responses to the open question at the end of the experiment where subjects displayed a reasonable understanding of what was going on in the experiment. Also, in the experiment we had subjects make all the relevant calculations, such as the calculation of gains, losses, cost of purchase of units, on their own. By checking these calculations we can make sure that subjects understood the basic procedure. The large majority of subjects did not make a mistake in their calculations (113 out of 133). Our results are essentially unchanged if we leave out subjects that made mistakes in their calculations from our analysis.

We avoided repetitions in our design so as to avoid tiring the subjects by asking the same (or very similar questions) over and over again. This means, however, that our data

[21] It has been suggested to us that the difference between treatments can also be explained by perceived autocorrelation which is positive in the portfolio treatment and zero in the lottery treatment. We see no reason to believe that story as we only spoke in terms of units in both treatments. In addition, this explanation does not fit the increase in holdings after a gain in the lottery/assigned choice treatment.

do not allow us to address the question of learning. Here we simply rely on other experimental work that has used similar setups with many repetitions and concluded that there was not much change in behavior from “early plays” to “late plays.” We discuss the relation of our results to this work in the next section.

A second challenge to our interpretation of the results is that within-subject design to get at the impact of prior outcomes is unnatural and unrealistic. We find it important to stress that there is of course a difference in asking for the behavior in the face of gains or losses after the gain/loss has actually occurred or before (as we do). E.g. Shafir und Tversky (1992) have found that subjects sometimes find it hard to think through conclusions they would draw if hypothetical events were to occur. We chose the within-subjects design because it makes our results more easily comparable to those of Thaler and Johnson (1990) who also use a within-subjects design. And, as we will discuss in the next section, our results are similar to those obtained in studies that use a between-subjects design.

Finally, our experiment does not involve real losses in the sense that it was not possible that subjects would leave the experiment with less money than they brought to the experiment. It is plausible that risk-taking behavior is influenced by whether real losses in this sense are possible.

## VI. Relation to Pre-Existing Evidence

Our experiment demonstrates that risk taking can be influenced by prior outcomes and that this influence depends on the presentation format of the choice problem. As the statistics show, our results are significant so we can have confidence in the validity of our results in the context of our experiment. Moreover, as we argue in this section, our results replicate well those from other, similar but different experimental studies. This suggests that subjects in our experiment were well calibrated relative to theses other studies. Finally, non-experimental evidence from actual investment choices suggests that some investors display a similar pattern of behavior as subjects in our portfolio treatment. The replications of other experimental findings and the similarity to non-experimental findings, should make the reader believe our results for each treatment even more. This would strengthen our main contribution: the organizing explanation of these diverging results presented so far.

### *Other Experimental Evidence*

#### Portfolio-Treatment

In our portfolio treatment we essentially look at a very simple dynamic problem of portfolio choice. Dynamic portfolio choice is also studied by Weber and Camerer (1998). They find strong evidence of the disposition effect. Similarly, we find strong evidence of escalation of commitment, i.e. of increased risk-taking following losses.

While their setup is similar in that they have subjects make a sequence of portfolio decisions, it is important to stress some of the differences. In their setup subjects face assets with uncertain return distributions, and returns are determined in each period.[22] In our setup, the exact return distribution is known and actual gains or losses are determined only at the end of the experiment.

Our results in the portfolio treatment are also related to the large psychological literature on escalation of commitment (e.g. Staw 1997), that demonstrates in a number of experiments the tendency to stick to or even intensify losing courses of action.

#### Lottery-Treatment

In the lottery treatment, subjects are confronted with a sequence of two identical rounds of a betting game. This is essentially the situation studied by Gneezy and Potters (1997). We find that there is no significant effect of prior outcomes on risky choice in this treatment (in the free-choice case). So do Gneezy and Potters (1997). They compare the risk taken by subjects who have just experienced a loss with the risk taken by subjects who have just experienced a gain and find that the risk taken is (insignificantly) larger after a loss. The main differences between our experiments are that Gneezy and Potters (1997) use more rounds of the betting game and determine payoffs each period.[23]

#### Questionnaire

We used questions translated from Thaler and Johnson (1990) to explore subjective reaction to losses. In line with their results we find that the incremental effect of a loss is smaller after a gain and greater after a loss than in isolation.

---

[22] Weber and Camerer (1998) also use six assets instead of just one and 14 trading periods instead of just two.

[23] See Gneezy, Kapteyn and Potters (2002) for a demonstration that these effects even show up on a market level.

### *Observed Investor Behavior*

There is by now a large and growing literature that documents that some investors are influenced by prior gains and losses (e.g. Grinblatt and Keloharju 2001, Odean 1998a). Investors appear to have a preference for holding losers (stocks with paper losses) rather than winners (stocks with paper gains), a finding that was termed the disposition effect by Shefrin and Statman (1985). This preference manifests itself not only in a reluctance to realize losses, but also in a tendency to purchase additional shares of losers rather than winners (Odean 1998a). This is of course precisely the kind of behavior that we observe in our portfolio treatments.

In a study of the trading behavior of professional futures traders, Coval and Shumway (2000) contrast the hypotheses whether gains increase or decrease risk-taking (conversely for losses), just like we do in our experiment. They find precisely the same result as we do in our portfolio treatments: Gains lead to decreased and losses lead to increased risk-taking.

We stress that all the observation of investor behavior mentioned so far concern the influence of prior gains or losses on an individual asset for the trading of this particular asset. At the portfolio level, there is some evidence of positive feedback trading that can be interpreted as increased risk taking after gains (Bange 2000). The design of our experiment does not allow us to distinguish between the behavior at the level of the portfolio and at the level of the individual asset. Since there is only one asset, gains or losses on this asset are synonymous with overall gains and losses.

## VII. Conclusion

Prior outcomes affect risky choice. We find that there is a strong link between prior outcome and risky choice in the portfolio treatment, a treatment in which subjects were confronted with a dynamic portfolio choice problem under risk. When confronted with the same decision problem (in the sense of probability distributions over outcomes) but in a different presentation format, there is a less pronounced link *working in the opposite direction*. The alternative presentation format, our lottery treatment, presents the decision problem, using the same neutral wording, as a sequence of rounds of a lottery (betting game).

In the portfolio treatment, subjects take significantly greater risk following a loss than following a gain. This difference reflects escalation of commitment (Staw 1976), i.e. increased risk-taking following a loss. In the lottery treatment there is greater risk taking after a gain than after a loss. This difference reflects the house-money effect (Thaler and Johnson 1990), i.e. increased risk taking following a gain. Our results can be explained as framing effects based on the value function of prospect theory. We do not find evidence in favor of the self-justification hypothesis as an explanation for escalation of commitment.

Just like Thaler and Johnson (1990), we find that making generalizations about risk-taking preferences is difficult. Given that a simple reframing of options can lead to very different behavior, predictions of behavior have to be based on predictions of how individuals frame their options. However, researchers in finance are typically not interested in risk-taking preferences *in general*, but rather risk-taking preferences in the specific context of investment decisions. Our experiment suggests that the perception of investments as ongoing courses of action is likely to induce a tendency toward escalation of commitment. We find it interesting to note that behavior in the portfolio treatment, the treatment that resembles most closely the context of actual investment decisions, conforms to the predictions of the disposition effect, a pattern of behavior that has been observed in actual investment decision making.

Our work is important to understand investors' behavior in a sequential decision making context. Financial advisors might learn to understand why clients are sometimes more or less risk averse in seemingly identical situations. In addition, the results are important for modeling asset pricing. We show under which conditions the risk attitude can change in which way, which could be a basis for more appropriate behavioral assumptions in financial models.

## References


Ang, Andrew, Geert Bekaert, and Jun Liu (2000): Why Stocks May Disappoint, NBER Working Paper No. W7783.

Arkes, Hal R. and Catherine Blumer (1985): The Psychology of Sunk Cost, *Organizational Behavior and Human Decision Processes*, 35, 124-140.

Arrow, Kenneth (1971): *Essays in the Theory of Risk-Bearing*, Chicago: Markham Publishing Company.

Bange, Mary M. (2000): Do the Portfolios of Small Investors Reflect Positive Feedback Trading, *Journal of Financial and Quantitative Analysis*, 35, 239-255.

Barberis, Nicholas, Ming Huang and Tano Santos (2001): Prospect Theory and Asset Prices, *Quarterly Journal of Economics*, 116, 1-53.

Barberis, Nicholas, Andrei Shleifer and Robert Vishny (1998): A Model of Investor Sentiment, *Journal of Financial Economics*, 49, 307-343.

Barberis, Nicholas and Richard Thaler (2002): "A Survey of Behavioral Finance", *forthcoming in the Handbook of the Economics of Finance.*

Brockner, Joel (1992): The Escalation of Commitment to a Failing Course of Action: Toward Theoretical Progress, *The Academy of Management Review*, 17, 39-61.

Brockner, Joel and Jeffrey Z. Rubin (1985): *Entrapment in Escalating Conflicts: A Social Psychological Analysis*, New York: Springer.

Coval, Joshua D. and Tyler Shumway (2000): Do Behavioral Biases Affect Prices?, University of Michigan Working Paper.

Daniel, Kent, David Hirshleifer, and Avanidhar Subrahmanyam (1998): Investor Psychology and Security Market Under- and Overreactions, *Journal of Finance*, 53, 1839-1885.

De Bondt, Werner F.M. and Richard H. Thaler (1995): Financial Decision-Making in Markets and Firms: A Behavioral Perspective, in Jarrow, Robert, Vojislav Maksimovic, and William T. Ziemba (eds.): *Handbooks in Operations Research and Management Science: Finance*, Amsterdam: North-Holland.

De Long, J. Bradford, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldmann (1990): Positive Feedback Investment Strategies and Destabilizing Rational Speculation, *Journal of Finance*, 379-395.

Gilad, Benjamin, Stanley Kaish and Peter D. Loeb (1987): Cognitive Dissonance and Utility Maximization, *Journal of Economic Behavior and Organization*, 8, 61-73.

Gneezy, Uri and Jan Potters (1997): An Experiment on Risk Taking and Evaluation Periods, *Quarterly Journal of Economics*, 112, 631-645.

Gneezy, Uri, Arie Kapteyn, and Jan Potters (2002): "Evaluation periods and asset prices in a market experiment“, *forthcoming in the Journal of Finance.*

Gomes, Francisco J. (2000): Loss Aversion and the Demand for Risky Assets, Harvard University Working Paper.

Grinblatt, Mark and Matti Keloharju (2001): What Makes Investors Trade?, *Journal of Finance*, 56, 589-616.

Hirshleifer, David (2001): Investor Psychology and Asset Pricing, *Journal of Finance*, forthcoming.

Hong, Harrison and Jeremy C. Stein (1999): A Unified Theory of Underreaction, Momentum Trading and Overreaction in Asset Markets, *Journal of Finance*, 54, 2143-2184.

Kahneman, Daniel and Amos Tversky (1979): Prospect Theory: An Analysis of Decision under Risk, *Econometrica*, 47, 263-291.

Marcus, Alan J. (1989): An Equilibrium Theory of Excess Volatility and Mean Reversion in Stock Market Prices, NBER Working Paper 3106.

Odean, Terrance (1998a): Are Investors Reluctant to Realize their Losses, *Journal of Finance*, 53, 1775-1798.

Odean, Terrance (1998b): Volume, Volatility, Price, and Profit When All Traders Are Above Average, *Journal of Finance*, 53, 1887-1934.

Rabin, Matthew (2000): Risk Aversion and Expected-Utility Theory: A Calibration Theorem, *Econometrica*, 68, 1281-1292.

Selten, Reinhard (1967): Die Strategiemethode zur Erforschung des eingeschränkt rationalen Verhaltens im Rahmen eines Oligopolexperiments, in Sauermann, Heinz (ed.): *Beiträge zur experimentellen Wirtschaftsforschung*, Vol. I, Berlin: J.C.B. Mohr (Siebeck), 136-168.

Shafir, Eldar and Amos Tversky (1992): Thinking Through Uncertainty: Nonconsequential Reasoning and Choice, *Cognitive Psychology*, 24, 449-74.

Sharpe, William F. (1990): Investor Wealth Measures and Expected Return, in Sharpe, William F. (ed.): *Quantifying the Market Risk Premium Phenomenon for Investment Decision Making*, The Institute of Chartered Financial Analysts, 29-37.

Shefrin, Hersh and Meir Statman (1985): The Disposition to Sell Winners too Early and Ride Losers too Long: Theory and Evidence, *Journal of Finance*, 40, 777-790.

Staw, Barry M. (1976): Knee-Deep in the Big Muddy: A Study of Escalating Commitment to a Chosen Course of Action, *Organizational Behavior and Human Performance*, 16, 27-44.

Staw, Barry M. (1997): The Escalation of Commitment: An Update and Appraisal, in Shapira, Zur (ed.): *Organizational Decision Making*, Cambridge University Press, 191-215.

Thaler, Richard H. and Eric J. Johnson (1990): Gambling with the House Money and Trying to Break Even: The Effects of Prior Outcomes on Risky Choice, *Management Science*, 643-660.

Tversky, Amos and Daniel Kahneman (1971): Belief in the Law of Small Numbers, *Psychological Bulletin*, 76, 105-110.

Tversky, Amos and Daniel Kahneman (1981): The Framing of Decisions and the Psychology of Choice, *Science*, 211, 453-458.

Tversky, Amos and Daniel Kahneman (1992): Advances in Prospect Theory: Cumulative Representation of Uncertainty, *Journal of Risk and Uncertainty*, 5, 297-323.

Weber, Martin and Colin F. Camerer (1998): The Disposition Effect in Securities Trading: An Experimental Analysis, *Journal of Economic Behavior & Organization*, 33, 167-184.

Zuchel, Heiko and Martin Weber (2001): The Disposition Effect and Momentum, SFB504 Discussion Paper 01-26, Universität Mannheim.

# Appendix: Instructions and Decision Sheets[24]

### *Portofolio Treatment: Instructions*

Thank you for participating in our experiment on decision under risk. The experiment will last about 20 minutes. The instructions for the experiment are simple and if you read them carefully, you can earn money, that will be paid to you in cash immediately after the experiment.

In the experiment you can use fictitious money, to buy or sell units of a fictitious commodity. Over the course of the experiment the price of a unit changes. Thereby you can gain money (if the price rises) or lose money (if the price drops). The following section explains the course of the experiment in detail.

Please ask, if anything is not clear to you. Raise your hand, I will come to you.

**Instructions for the Experiment**

Together with this instruction you have received an „Information and Decision Sheet“ and a „Questionnaire“ (stapled together). Please note your decisions and answers on these sheets. Please work on the „Information and Decision Sheet“ first and then on the „Questionnaire“.

The experiment proceeds in two successive periods. In both periods you can first make a decision on the purchase or sale of units. Subsequently the price of a unit changes.

*Period 1:*

You have money at your disposal. At the beginning of period 1 you decide how many units to buy. You can buy 0 to 10 units. You keep the money that you do not use to purchase units. Please find precise information on your Information and Decision Sheet. After you have made your decision, the price of a unit changes.

*Period 2:*

At the beginning of period 2 you can sell units at the new and changed price or purchase additional units at the new price. The total number of units must remain between 0 and 10. Please find precise information on your Information and Decision Sheet.

Please note: The actual price change in period 1 will be determined at the end of the experiment by throwing a die. You must therefore **make two decisions in period 2**: One for

[24] Translated from German; the original instructions and decision sheets are available upon request.

the case that the price dropped in period 1, one for the case that the price rose in period 1. Only one of the decisions will – depending on the actual price change in period 1 – be used in the end. You do not know in advance which decision will be used.

- **Please note that the price changes in period 1 and period 2 are independent.**
- **The only restriction for all your decisions is that your total number of units has to be between 0 and 10.**

When you have finished the Information and Decision Sheet, please fill in the brief Questionnaire.

After you have filled in the Information and Decision Sheet and the Questionnaire, please come to us. You can then no longer change your decisions and answers. We will then determine the actual price changes and you will receive your pay for the experiment.

**How is your pay for the participation in the experiment determined?**

Your pay is equal to your total amount. Your total amount is the sum of the value of your units and your money at the end of period 2.

**Total amount = Value of units + Money**

The value of your units at the end of period 2 is equal to your number of units multiplied by the price of a unit at the end of period 2. Your money is equal to your initial 6 DM minus the cost of purchases of units plus the proceeds from the sale of units. Your stock of money can be negative. However, the parameters of the experiment are chosen such that it is not possible to reach a negative total amount regardless of which decisions you make.

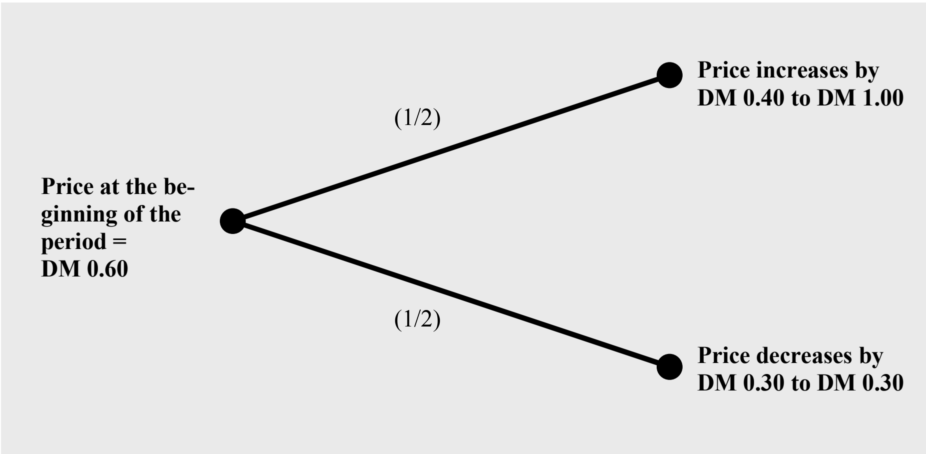
First we determine the price change in period 1 by throwing a die. This determines at the same time which of your decisions for period 2 is used. If the price rises in period 1, your decision for his case is used. If the price drops in period 1, your decision for this case is used. By throwing a die once more we determine the price change in period 2. With this information we calculate your total amount that will be paid to you in cash.

*Portfolio Treatment: Information and Decision Sheet*

# Period 1

You begin this period with **DM 6**.

The initial price of a unit is DM 0.60. In period 1 the price will either increase by DM 0.40 (with probability 1/2) or decrease by DM 0.30 (with probability 1/2).




How many units do you purchase at a price of DM 0.60? Please pick a number of units between 0 and 10.

| |
|---|
| **Your decision:** |
| How many units do you purchase at a price of DM 0.60? ___________ |
| You keep the money that you do not use to purchase units. |
| Your money after the purchase of units DM___________ |

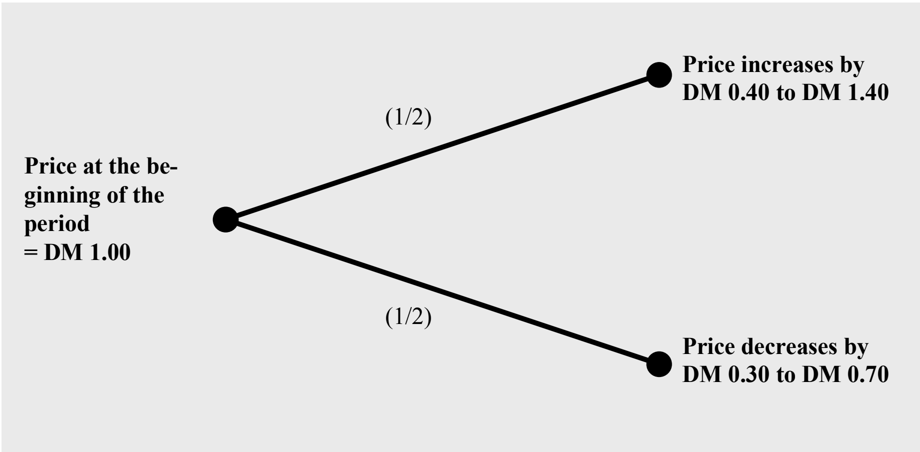
# Period 2 in the <u>case of a price increase</u>

You begin this period with ________ units *(= number of units that you purchased in period 1)* .

The price of a unit has increased in period 1 and is now DM 1.00.

| | |
|---|---|
| Your total gain from units in period 1 is therefore<br>*(=number of units times the price increase of DM 0.40)* | DM__________ |

In period 2, the price will again either increase by DM 0.40 (with probability 1/2) or decrease by DM 0.30 (with probability 1/2).




At the beginning of the period you can purchase additional units at the price of DM 1.00, or you can sell units, **under the sole restriction that your total number of units remains between 0 and 10**, or you can leave your number of units unchanged.

**The situation at the end of period 1:**

Your number of units at the end of period 1 __________

Your money at the end of period 1 DM__________

**Your decision:**

How many units do you *purchase* at the price of DM 1.00? __________

Total cost of the additional units DM__________

How many units do you *sell* at the price of DM 1.00? __________

Total proceeds from the selling of units DM__________

**The new situation:**

Total number of units after purchase or sale: __________

*(Make sure that the total number of units is between 0 and 10)*

Your money after purchase or sale DM__________

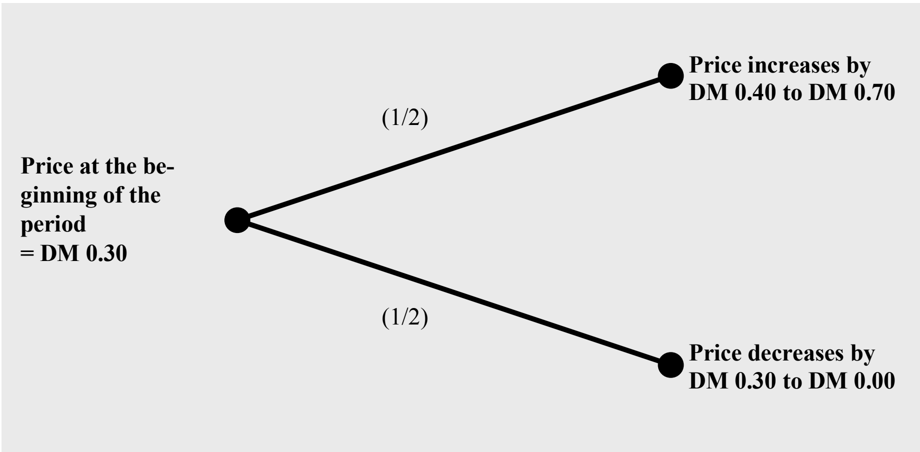
# Period 2 in the case of a price decrease

You begin this period with ________ units *(= number of units that you purchased in period 1)* .

The price of a unit has decreased in period 1 and is now DM 0.30.

| | |
|---|---|
| Your total loss from units in period 1 is therefore<br>*(=number of units times the price decrease of DM 0.30)* | DM__________ |

In period 2, the price will again either increase by DM 0.40 (with probability 1/2) or decrease by DM 0.30 (with probability 1/2).




At the beginning of the period you can purchase additional units at the price of DM 0.30, or you can sell units, **under the sole restriction that your total number of units remains between 0 and 10** , or you can leave your number of units unchanged.

**The situation at the end of period 1:**

Your number of units at the end of period 1 __________

Your money at the end of period 1 DM__________

**Your decision:**

How many units do you *purchase* at the price of DM 0.30? __________

Total cost of the additional units DM__________

How many units do you *sell* at the price of DM 0.30? __________

Total proceeds from the selling of units DM__________

**The new situation:**

Total number of units after purchase or sale: __________

*(Make sure that the total number of units is between 0 and 10)*

Your money after purchase or sale DM__________

### *Lottery Treatment: Instructions*

Thank you for participating in our experiment on decision under risk. The experiment will last about 20 minutes. The instructions for the experiment are simple and if you read them carefully, you can earn money, that will be paid to you in cash immediately after the experiment.

In the experiment you can use fictitious money, to buy units of a fictitious commodity. Units generate a single random payoff and then disappear. Thereby you can gain money (if units pay out something) or lose money (if units do not pay out anything). The following section explains the course of the experiment in detail.

Please ask, if anything is not clear to you. Raise your hand, I will come to you.

**Instructions for the Experiment**

Together with this instruction you have received an „Information and Decision Sheet" and a „Questionnaire" (stapled together). Please note your decisions and answers on these sheets. Please work on the „Information and Decision Sheet" first and then on the „Questionnaire".

The experiment proceeds in two successive periods. In both periods you can first purchase units. These units generate a random payoff at the end of the period and then disappear.

*Period 1:*

You receive money that you can use to purchase 0 to 10 units. At the beginning of period 1 you decide how many units to buy. You keep the money that you do not use to purchase units. Please find precise information on your Information and Decision Sheet. After you have made your decision, units either pay out a positive amount or nothing. All units in period 1 pay out the same amount.

*Period 2:*

You again receive money that you can use to purchase 0 to 10 units. Your units from period 1 have disappeared. At the beginning of period 2 you decide again how many units to buy. Please find precise information on your Information and Decision Sheet.

Please note: The actual payoff in period 1 will be determined at the end of the experiment by throwing a die. You must therefore **make two decisions in period 2**: One for the case that units generated a positive payoff in period 1, one for the case that units did not pay out anything in period 1. Only one of the decisions will – depending on the actual payoff in period 1 – be used in the end. You do not know in advance which decision will be used.

- **Please note that the payoffs of units in period 1 and period 2 are independent.**
- **The only restriction for all your decisions is that your total number of units has to be between 0 and 10.**

When you have finished the Information and Decision Sheet, please fill in the brief Questionnaire.

After you have filled in the Information and Decision Sheet and the Questionnaire, please come to us. You can then no longer change your decisions and answers. We will then determine the actual payoffs and you will receive your pay for the experiment.

**How is your pay for the participation in the experiment determined?**

Your pay is equal to your total amount. Your total amount is equal to the money you received at the beginning of periods 1 and 2, minus the cost of purchases of units, plus the payoffs of units in both periods.

**Total amount = Money at beginning - Cost + Payoffs of units**

The parameters of the experiment are chosen such that it is not possible to reach a negative total amount regardless of which decisions you make.

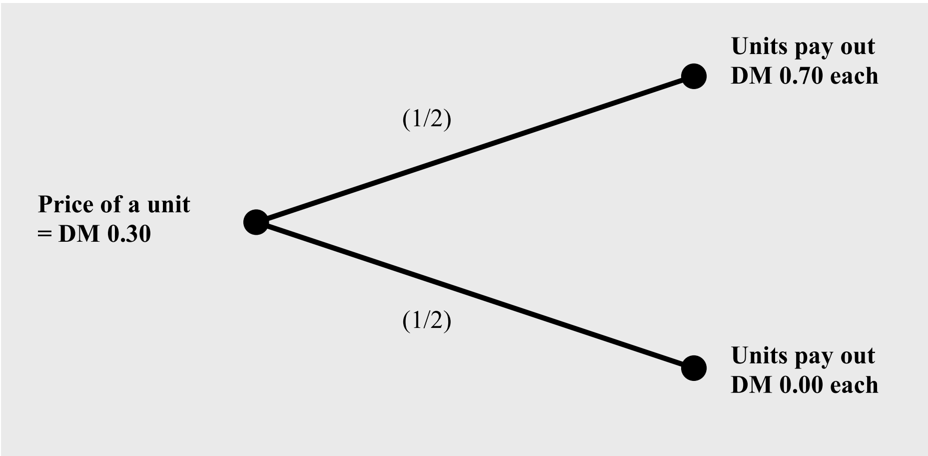
First we determine the payoff of units in period 1 by throwing a die. This determines at the same time which of your decisions for period 2 is used. If there is a positive payoff in period 1, your decision for his case is used. If the payoff is zero, your decision for this case is used. By throwing a die once more we determine the payoff of units in period 2. With this information we calculate your total amount that will be paid to you in cash.

### *Lottery Treatment: Information and Decision Sheet*

# Period 1

You begin this period with **DM 3**.

The price of a unit is DM 0.30. At the end of the period, units will either pay out DM 0.70 (with probability 1/2) or nothing (with probability 1/2). All units have the same payoff.




How many units do you purchase at the price of DM 0.30? Please pick a number of units between 0 and 10. You keep the money that you do not use to purchase units.

| |
|---|
| **Your decision:**<br>How many units do you purchase at a price of DM 0.30? ___________<br>Total cost of the purchase of units DM___________<br>*(=number of units purchased times price)* |

# Period 2 in <u>the case that units paid out something</u>

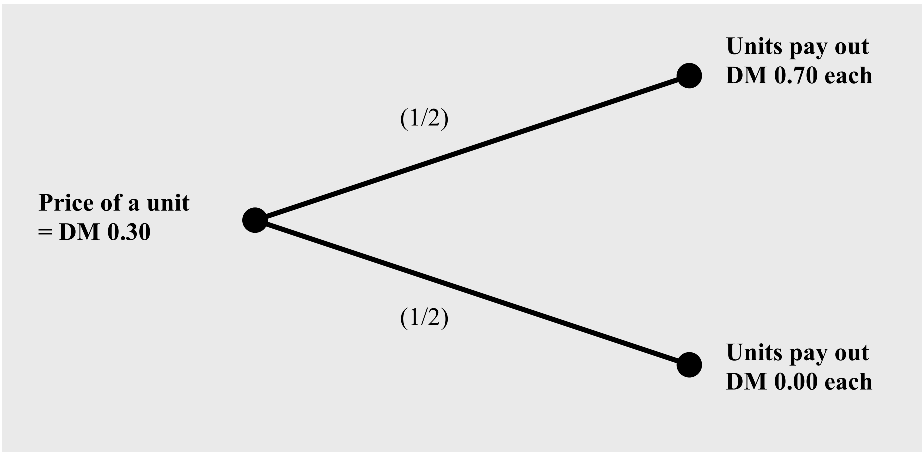
In period 1, units paid out DM 0.70 each.

| | |
|---|---|
| Your gain from units in period 1 is therefore | DM___________ |
| *(=Your number of units in period 1 times the payoff of DM 0.70 per unit minus the total cost of units* | |

You begin this period with 0 units.

You receive again **DM 3**.

The price of a unit is DM 0.30. At the end of the period, units will again either pay out DM 0.70 (with probability 1/2) or nothing (with probability 1/2). All units have the same payoff.




You can purchase units under the sole restriction that the number of units is between 0 and 10. You keep the money that you do not use to purchase units.

| | | |
|---|---|---|
| **Your decision:** | | |
| How many units do you purchase at a price of DM 0.30? | ___________ | |
| Total cost of the purchase of units | | DM___________ |

# Period 2 in <u>the case that units paid out nothing</u>

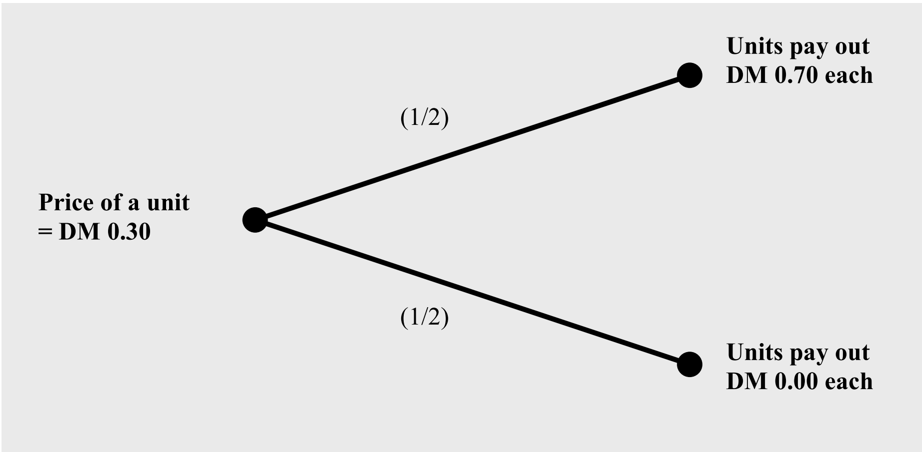
In period 1, units paid out DM 0.00 each.

| | |
|---|---|
| Your loss from units in period 1 is therefore<br>*(=Total cost of units purchased in period 1)* | DM___________ |

You begin this period with 0 units.

You receive again **DM 3**.

The price of a unit is DM 0.30. At the end of the period, units will again either pay out DM 0.70 (with probability 1/2) or nothing (with probability 1/2). All units have the same payoff.




You can purchase units under the sole restriction that the number of units is between 0 and 10. You keep the money that you do not use to purchase units.

| | |
|---|---|
| **Your decision:** | |
| How many units do you purchase at a price of DM 0.30? ___________ | |
| Total cost of the purchase of units | DM___________ |

***Questionnaire***

Consider the following two events: (a) you lose DM $x$. (b) you lose DM $x$ after gaining DM $y$. We are interested in the emotional impact of the loss of DM $x$ in both cases. Are you more upset about the loss of money when it occurs alone (a), or when it occurs directly after a gain (b)? Of course you are happier in total in (b), but we are interested only in the incremental impact of the loss. Below you will find several questions of this type. In each case please compare the incremental effect of the event described. If you feel there is no difference you may check that, but please express a preference if you have one.

1. (a) You lose DM 20

   (b) You lose DM 20 after having gained DM 60

   The loss of DM 20 hurts more in:

   ☐ (a) ☐ (b) ☐ (no difference)

2. (a) You lose DM 20

   (b) You lose DM 20 after having lost DM 60

   The loss of DM 20 hurts more in:

   ☐ (a) ☐ (b) ☐ (no difference)

Your age__________________________________________________

Gender______________________ ☐ female ________________ ☐ male

Major____________________________________________________

Semester in school___________________________________________

In which country were you raised?__________________________________

Your own income from all sources before taxes in 2000:
Do not include income from other household members.

☐ 10,000 DM or less
☐ 10,001 DM to 30,000 DM
☐ 30,001 DM to 60,000 DM
☐ 60,001 DM or more
☐ no information

What did you think when making the decisions on your „Information and Decision Sheet?

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________