Illusion of control as a source of poor diversification: An experimental approach[*]

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May, 2004

Abstract

This paper investigates factors influencing individual portfolio allocations with particular focus on the role of illusion of control. By forming their portfolio of two risky lotteries and one risk-less alternative, subjects are requested to reach a target investment profit, whereby equal diversification between the two risky lotteries is part of the solution space. Subjects however excessively invest in the lottery for which they can determine the outcome by rolling the die themselves indicating that they are prone to illusion of control. However, the effect vanishes with experience. In contrast, presenting random sequences of prior outcomes reduces biased investments. In line with the excessive extrapolation hypothesis, the more positive outcomes observed from past draws, the more likely is a positive prediction for this lottery, which is then followed by higher investment. Also, offering a default portfolio strongly determines final allocations.

Keywords: Investment decisions; Portfolio selection; Egocentric biases; Illusion of Control; Experimental economics

JEL-Codes: C91, D80, G00, G11

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[*]I am thankful for valuable comments by Uwe Cantner and Werner Güth and for research assistance by Bettina Bartels and Håkan Fink.

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1 Introduction

The behavior of the private investor has gained increasing interest ever since privatized pension and social security plans have become popular. Defined contribution plans, where participants are given some degree of freedom to decide in which funds to invest, are an important vehicle of retirement savings. Their main characteristics are tax-deferrable contributions and a retirement income that is contingent on investments. In the US, 401(k) plans are the most prevalent form of defined contribution plans[1], since employers have tax incentives to match the contributions of their employees. However, in many countries (like in Australia, Thailand, Denmark, Switzerland, Spain), private pension plans are an important part of social security. In others they have been recently adopted (e.g., in Mexico 1997, Poland 1999, Sweden 2001), or are at least vividly discussed as a solution to the expected long-term financial insolvency of public pension systems (like in India, Japan, Germany and France). The common element of these various private retirement saving systems is that more responsibility is shifted to lay people, who are then required to choose an optimal bundle of investments that will guarantee their retirement consumption.

However, the task to choose an optimal portfolio of funds is far beyond trivial. Even if the investor was able to assess the own risk preference, the number of investment opportunities is overwhelming. Therefore, it is not surprising that even judgments of financial professionals deviate from rational calibration and are susceptible to a number biases and cognitive illusions (e.g., Glaser et al. 2003, Hogarth and Makridakis 1981, Shanteau 1995, Stephan and Kiell 2001, Tyszka and Zielonka 2002). Inexperienced people in financial matters, e.g., employees who are required to make contributions to their saving plans, are even more likely to be influenced by judgmental heuristics that may lead to bad investment decisions.

Moreover, little time is devoted by employees to track the development of their investments: about 60% of 401(k) plan participants spend less than 5 hours per year monitoring their investments, and about 70% adjust their allocation plan less frequently than once a year (Mutual of Ohama Insurance Company 2002), whereby on average, 40% of participants report to be never active. The average employee thus seems to attend to his retirement plan only once, i.e. at the time of creation. To no surprise have many financial consultants and plan providers expressed their concern about the trend towards

[1] In 2001, the balances in 401(k) accounts amounted to $ 1.76 trillion, that corresponds to 44% of all assets in private trusteed retirement plans (data from McDonnell (2002) and Holden and VanDerhei (2003)). With respect to defined contribution plans, 401(k) plans account for 83% of all assets.

greater freedom of choice in retirement plans. Hence, it becomes growingly important to investigate lay-peoples' strategies in picking investments in order to advise avoiding the most common traps.

A broad concern in this regard is the poor diversification characterized by a high portfolio concentration on a few stocks. A prominent aspect thereof is excessive own company investment, where individuals concentrate their retirement investments on the source of their day-to-day income. Several explanations, like investment in the familiar, excessive extrapolation of past returns or the simple misunderstanding of the risk concept, have been suggested to understand why usually risk-averse individuals forego the merits of diversification.

The present study proposes a further explanation for poor diversification and investigates portfolio choice from a cognitive perspective. In a simple portfolio choice task, it is examined whether illusory control can account for excessive investments in options, on which individuals feel to have more control. If such an effect is found, it has to be clarified whether it endures experience. To gain further insights into individual portfolio choice, additional treatments are considered, studying (i) the effect of offering a default portfolio on the investment strategy, (ii) the relation between past random outcomes, the prediction of the current outcome and subsequent investments, and (iii) the enlargement of the investment choice set on risk taking.

The paper is organized as follows: section 2 reviews some related literature, section 3 describes the experimental design and procedure, section 4 presents the findings and section 5 concludes with a brief discussion.

2 Related Literature

By investigating diversification strategies of participants in 401(k) plans, Benartzi and Thaler (2001a) report that individuals frequently employ a $1/n$-heuristic, i.e. they distribute their savings equally among funds offered, regardless of the number or kind of alternatives (e.g., stock funds, bond funds). This evidence implies that investments are neither made on the basis of risk assessment nor on considerations of the target pension income, leaving the authors to conclude that individuals are not able to pick a portfolio on their efficiency frontier. In 2000, Sweden introduced the Premium Pension Scheme as an instrument of privatized retirement saving, which provided a natural environment to investigate employees' strategies in choosing their investment funds. Hedesström et al. (2004) identified a number of common cognitive biases such as extremeness aversion, diversification heuristic, default bias as well as a strong preference for funds containing domestic equity.

Recently, a number of field studies tried to identify factors that influence participation and contributions in 401(k) pension plans. Iyengar et al. (2003) and Huberman et al. (2003), for instance, conducted extensive surveys using data from nearly 800.000 employees and found that participation increases with income, the percentage of contributions that is matched by the employer, and the availability of own company stock as an investible fund.

A surprising observation is that the probability of participation in a pension plan decreases with the number of funds offered in the plan. This is particularly remarkable as standard economic theory suggests that individuals can never be worse off with a larger choice set. However, findings from consumer research suggests that too much choice can be detrimental to the motivation to actually buy something (Iyengar and Lepper 2000), also known as the "choice overload" phenomenon.[2] The difficulty to make a decision when facing many options renders the marginal utility of the expanded choice set declining. In the context of investment plans, the typical employee's behavior reflects that an increasing number of options comes at the cost of complexity (Mottola and Utkus 2003): while an average defined contribution plan offers 15 investment options, the majority of employees invests in only 3 options, with 40% investing in only one or two.

Remarkably, the choice overload phenomenon disappears when company stock is offered in the plan. However, excessive portfolio allocation to own company stock is a serious problem in defined contribution plans. Coca Cola's retirement saving plans, for instance, consists of 80% Coca Cola stocks. This strategy is hazardous: in case of bankruptcy, employees do not only loose their source of income but also large parts of their retirement savings. This risk should be also evident to the general public ever since the US energy-trader Enron has collapsed. As an cause for own company investment, the "familiarity effect" is often suggested (Iyengar et al. 2003): employees choose their company's stocks because they feel more familiar and more knowledgeable about it. The familiarity hypothesis is supported by the evidence that people tend to invest in geographically close companies (Huberman 2001). Also, stock price movements suggest that highly reputed companies are overpriced while companies that look bad in the public eye are underpriced (DeBondt 1998), which gives reason to the to conjecture that individuals buy stocks of companies that are representative for good performance

[2]Although consumers find a large array (24 or 30 items) of a product, like exotic jams, more appealing, they are more likely to buy a product and are more satisfied with their choice when only a small array (6 items) is presented.

or that are familiar from the media.

Apparently, many investors do not grasp the concept of diversification, i.e., that portfolio risk is reduced by the covariation between stock returns (DeBondt 1998). "Many investors fail to realize that the investment performance of a single stock is much riskier than that of a diversified portfolio" (Benartzi and Thaler 2001b, p. 3). This impression is confirmed by Mitchell and Utkus (2003b), who find that private investors consider company stock to be less risky than a diversified alternative. Individuals rather believe to handle risk by regularly restructuring their portfolio and trading actively. However, this "false belief in universal liquidity builds an illusion of control" (DeBondt 1998, p. 836).

Another explanation for own company investment is provided by Benartzi (2001), who argues that individuals excessively extrapolate past returns and subsequently invest more in companies that they perceive as lying above the average. Empirical evidence seems to support this hypothesis: whereas employees of companies that experienced the worst performance during the last 10 years allocated only 10% of their discretionary contributions to company stock, employees of companies that experienced the best performance allocated nearly 40% to company stock. Similarly, Huberman and Sengmüller (2002), who analyzed data from 401(k) plans, found that employees base their changes in contributions mainly on recent returns and react more strongly to returns above the Standard&Poors 500 index than to returns below. However, while non-experts usually expect the continuation of a past trend in prices (DeBondt 1993), economic experts too often predict contrarian developments, resembling a gambler's fallacy (DeBondt 1991). Although excessive extrapolation of past returns might be an important factor for investment decisions, it is not obvious why this phenomenon should be restricted to own company stock only. A further explanation for excessive investment in specific equity, like the own company, could be that employees feel to exercise some control on the performance of their company. Although this influence is in fact marginal, the "illusion of control" may account for the attractiveness of company stock. In this study, the idea is explored in a simple investment setting.

In the psychological literature, illusory control belongs to the more general class of egocentric biases, among overconfidence and unrealistic optimism (see, e.g., DeBondt and Thaler 1995, Fischhoff et al. 1977, Weinstein 1980), and is defined as "an expectancy of a personal success probability inappropriately higher than the objective probability would warrant" (Langer 1975, p. 313). Especially when introducing skill-related factors (e.g., familiarity with a task; a die throw) in a mere chance task, individuals feel inappropriately confident in predicting the outcome. In a classical experiment, Langer (1975) demonstrates that people who select their lottery ticket asked higher selling prices than people who have been assigned a ticket. Similarly, Davis et al. (2000) finds that casino bettors places riskier bids on their own dice rolls than on others'.

Illusion of control is augmented by a feeling of skill or competence, even when the outcome is purely determined by chance. In an experiment by Heath and Tversky (1991), subjects first had to answer knowledge questions and state how confident they were that their answer is right. Afterwards, they could bet on either their confidence judgment or an equiprobable chance event. The results demonstrate that people even pay a premium to bet on their own judgment, yet only when they consider themselves knowledgeable.

There are circumstances, however, in which illusion of control is not persistent: Dixon (2000), for instance, finds that illusory control is attenuated by purposeful instructions, Koehler et al. (1994) observe illusion of control only in single shot gambles but not in a setting of multiple games, and Ladouceur and Mayrand (1984) are unable to find illusion of control in a repetitive gambling task with different feedback conditions.

Although considered as important for stock market phenomena (see, e.g., Shefrin 2000, Shiller 2000), illusion of control has until now not received much attention in empirical or experimental studies of financial decision making aside from the gambling context. An experimental study that is closely related to the present one was done by Charness and Gneezy (2003), who investigate common biases like ambiguity aversion, myopic loss aversion and illusion of control in the context of investing in a risky lottery. Their results indicate that although subjects are willing to pay for reducing ambiguity, they actually invest less in the lottery. Furthermore, subjects pay a premium to be able to monitor and change their investments more frequently (in line with myopic loss aversion), but are not willing to pay for exercising more control (i.e., on the winning numbers of the lottery). Thus, illusion of control did not have an influence on investments, which is partly in contrast to the results of the present study.

Most of the evidence in finance, and even in behavioral finance, relies on the analysis of field data. While field studies allow for the estimation of the real world magnitude of a behavioral phenomenon, only experiments provide the opportunity to vary factors in a controlled way and to concisely identify causal relationships. Some behavioral and especially cognitive aspects, such as illusion of control, cannot be measured in the field. Still it is important to identify these behavioral regularities on a fundamental level in the laboratory to infer their relevance for the specific area, such as investment decisions, in the field.

The present study contributes to the existing literature by applying the effect of illusory control to a portfolio selection task that requires diversification. Do individuals invest more in an lottery for which they can control the chance move? We vary the extent of illusion of control by either assigning subjects one of two lotteries on which they can exercise control or by letting them choose (without additional cost). The well established evidence, that people dislike to depart with a default alternative (Samuelson and Zeckhauser 1988), is availed to see if the preference for the status quo mitigates excessive investment in one alternative that is caused by the illusion of control. Furthermore, also the excessive extrapolation hypothesis has not yet been examined in the context of portfolio choice. In this study, it will be explored if it is a general phenomenon that is already prevalent in a simple investment setting. Additionally, the effect of increasing the variety of the choice set on the riskiness of investments is investigated.

Results indicate that although illusory control accounts for distorted investments, the effect abates with experience. The default portfolio offered indeed affects subjects' final allocations even when the default option is rejected. Presenting sequences of previous randomly determined outcomes, initially induces subjects to invest less risky. Predictions of future outcomes are positively correlated with investments for one of the alternatives, confirming the relevance of excessive extrapolation for investments. The enlargement of the choice set has a minor effect on diversification but does not discourage risky investment. Generally, subjects become less risk-averse over time but invest more risk-averse subsequent to an investment failure.

3 Experimental setup

3.1 Investment setting and procedure

Overall, 210 subjects of Jena University participated in the experiment that was conducted computerized using z-Tree (Fischbacher 1999) at the Max Planck Research laboratory. The age of the 86 male and 124 female participants ranged from 18 to 33 years and they earned on average Euro 12.5, (standard deviation of Euro 6.1), including a show-up fee of Euro 3.5. Upon arrival at the Max Planck Research Laboratory, participants were randomly seated in cubicles and instructions for the first stage were distributed (see the Appendix).

The experiment consisted of two stages. In the first stage, subjects had to make decisions between 10 pairs of lotteries to obtain an indicator of their risk attitude. The procedure has been taken from Holt and Laury (2002) with the intention to compare risk

Table 1: Lottery choices in the first stage

Nr.	Lottery X			Lottery Y		
	$p(\overline{x})$	$\overline{x}$	$\underline{x}$	$p(\overline{y})$	$\overline{y}$	$\underline{y}$
1	0.1	2	1.6	0.1	3.85	0.1
2	0.2	2	1.6	0.2	3.85	0.1
3	0.3	2	1.6	0.3	3.85	0.1
4	0.4	2	1.6	0.4	3.85	0.1
5	0.5	2	1.6	0.5	3.85	0.1
6	0.6	2	1.6	0.6	3.85	0.1
7	0.7	2	1.6	0.7	3.85	0.1
8	0.8	2	1.6	0.8	3.85	0.1
9	0.9	2	1.6	0.9	3.85	0.1
10	1.0	2	1.6	1.0	3.85	0.1

attitudes with actual portfolio allocations. Table 1 shows the list of 10 lottery choices where all amounts are displayed in Euro. While the prizes of both lotteries $\overline{x}$, $\underline{x}$, $\overline{y}$, and $\underline{y}$ remain constant, the probabilities of the high prizes $p(\overline{x})$, $p(\overline{y})$ increase from choice 1 to 10 (with $p(\underline{x}) = 1 - p(\overline{x})$ and $p(\underline{y}) = 1 - p(\overline{y})$). A risk-neutral individual would choose lottery X four times and then switch to lottery Y at the fifth choice. At the end of the experiment, one of the ten choices was randomly selected for each participant to be paid out. Instructions for the investment task in stage 2 were distributed after completion of the first stage.

The second stage comprised in total six periods. However, to avoid diversification effects over periods, only one of the six periods was randomly selected by a die throw and paid out at the end of the experiment (see also the instructions in the Appendix). In each period, subjects faced an investment task where they had to distribute their endowment of 100 ECU[3] among three[4] possible investments denoted as A, B and C. A and B are risky lotteries with two possible returns each, a_1, a_2 and b_1, b_2, with probability $p = 0.5$ and C granted a sure return $\bar{c}$. The realizations of lotteries A and B are independent. Table 2 gives on overview of the parameters used for the three investment alternatives in all six periods. The values varied only marginally in every period so that learning of the investment situation over periods was easily possible.

Subjects were told that they their investment profit had to exceed a specific target threshold l, which was set to 150 ECU for each period. Profit below this threshold was

[3]The exchange rate to Euro was 20:1, i.e. 100 ECU corresponded to 5 Euro.
[4]Except for the "variety treatment" where the number of alternatives was 7.

Table 2: Returns of investment options in each period

Period	Investment A		Investment B		Investment C
	a_1	a_2	b_1	b_2	$\overline{c}$
1	2.5	0.33	3	0.5	1
2	2.5	0.2	3	0.7	1
3	2.4	0.25	3	0.75	1
4	2.67	0	3.3	0.5	1
5	2.5	0.33	2.8	0.67	1
6	2.6	0.4	2.8	0.6	1

lost,[5] whereas profit equal to or exceeding $l = 150$ represented period income. The actual returns of the lotteries were determined separately by a six-sided die that – depending on the particular treatment described below – was thrown either by the experimenter or the subjects themselves. After each period, subjects learned whether their investment profit exceeded the target level and if so, how much they had earned. However, subjects were informed that only one out of the six periods would be randomly selected to be paid out at the end of the experiment.

Let us denote the share of the endowment invested in alternatives A, B and C by $\mathtt{a}$, $\mathtt{b}$, and $\mathtt{c}$, respectively, with $\mathtt{a} + \mathtt{b} + \mathtt{c} = 100$. Assuming that subjects maximize the probability to reach the target level, an appropriate diversification strategy can be characterized by the solution space of the following system of inequalities:[6]

$$\mathtt{b} \geq \frac{(l - 100\overline{c}) + \mathtt{a}(\overline{c} - a_2)}{b_1 - \overline{c}} \tag{1}$$

$$\mathtt{b} \leq \frac{(l - 100\overline{c}) + \mathtt{a}(\overline{c} - a_1)}{b_2 - \overline{c}} \tag{2}$$

$$\mathtt{b} \leq 100 - \mathtt{a} \tag{3}$$

with $a_1, b_1 > \overline{c} > a_2, b_2$. Inequality 1 ensures l with probability $1/2$, for (a_1, b_1) and (a_2, b_1), whereas inequality 2 ensures l with probability $1/4$, for (a_1, b_2). The intuition is

[5] This procedure of reaching a target resembles aspiration levels as suggested by the concept of bounded rationality. Not only does it help to make the merits of diversification clear to subjects, it also stresses the saliency of payments: the endowment is only of value if subjects succeed in multiplying it.

[6] The assumption that individuals try to maximize the probability of reaching their profit target and therefore grant a positive income is weaker than the assumption of μ, σ-preferences, that is required to calculate the optimal portfolio allocation according to standard portfolio theory (Markowitz 1952). However, risk neutral individuals who decide only upon expected value of the portfolio should invest solely in B, the prospect with the higher expected return. Still, the elicitation of individual risk attitudes (see section 4) justifies the general assumption of risk-aversion.

Table 3: Ranges of investments in A, B and C that maximize the probability to reach the target profit for all six periods

Period	Investment A	Investment B	Investment C
1	$46.88 \leq a^\star \leq 56.25$	$40.63 \leq b^\star \leq 50.00$	$0 \leq c^\star \leq 12.49$
2	$41.67 \leq a^\star \leq 53.57$	$41.67 \leq b^\star \leq 55.56$	$0 \leq c^\star \leq 16.66$
3	$43.06 \leq a^\star \leq 54.55$	$41.15 \leq b^\star \leq 54.55$	$0 \leq c^\star \leq 15.79$
4	$42.00 \leq a^\star \leq 54.55$	$40.00 \leq b^\star \leq 53.85$	$0 \leq c^\star \leq 18.00$
5	$43.05 \leq a^\star \leq 52.71$	$43.72 \leq b^\star \leq 54.55$	$0 \leq c^\star \leq 13.23$
6	$41.67 \leq a^\star \leq 54.17$	$41.67 \leq b^\star \leq 55.00$	$0 \leq c^\star \leq 16.66$

simple: by diversifying across both investment alternatives, the probability to exceed the target investment profit can be increased from $q = 0.5$ – the winning probability for each of the two options – to $q' = 0.75$.[7] The only case where the target can never be reached is when both lotteries yield the low return. The ranges for diversification strategies with the highest probability to meet the target are displayed for all six periods in Table 3. Figure 1 illustrates the solution space for period 1 that is created by equations 1, 2, and 3 graphically. Even though the investments that offer the target profit with highest possible probability allow for some variation in the portfolio composition, the naive strategy of equal diversification among the two risky investment alternatives ($\texttt{a} = 50$, $\texttt{b} = 50$) is always an element of the solution space.

Since deviations in action space are accompanied by considerable differences in payoff space, the design strengthens the payoff-relevance of diversification for a rather small-stake experiment. By setting period income to 0 whenever the threshold is not met, a risky investment strategy, e.g., investing only in the option with the higher expected return, is reflected in a considerable chance to exit the experiment without investment earnings.[8]

3.2 Treatments

Nine different treatments were considered to investigate factors that influence individual portfolio selection. In the *control treatment* subjects (n=30) simply faced the investment decision described above, where the experimenter determined the outcomes of the investments by throwing a die separately for each lottery at the end of every period.

[7] This objective closely resembles the safety-first criterion of portfolio selection proposed by Roy (1952), which avoids the complex expected utility calculus. Instead, the investor seeks the portfolio that minimizes the probability of producing a return below a specified level.

[8] However, in any case subjects were compensated with the show up fee and earned a small amount according to their lottery choice in stage one.

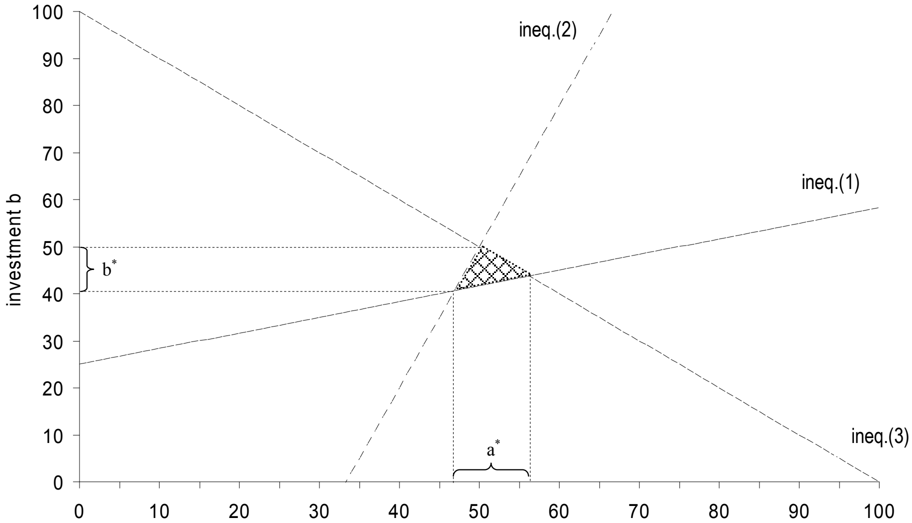

Figure 1: Solution space for investments a and b in period 1

At an odd number (1,2,3) the investment realized the high return a_1 or b_1, respectively, and at an even number (2,4,6) the investment realized the low return a_2 or b_2. In the first three experimental treatments, illusion of control was induced by telling subjects that (i) they could determine the outcome for one of the investments by throwing the die themselves and that (ii) they could individually choose the three winning numbers for this investment. One group of subjects (n=17) could determine the outcome of investment A (*IOC-A treatment*) and the other group (n=15) the outcome of investment B (*IOC-B treatment*). In a consecutive session (n=30), subjects were offered to choose on which investment they would like to exercise control by throwing the die (*IOC-choice treatment*), and again they could select the three winning numbers of this lottery.[9]

To investigate whether the default portfolio offered affects portfolio composition, three treatments were considered, in which illusory control for option B was induced just like in treatment *IOC-B*. Subjects where offered a default portfolio that contained either only option A (*default-A treatment*, n=20), only option B (*default-B treatment*, n=20), or that was equally diversified among all options A, B and C (*default-diverse treatment*, n=20). In all three treatments, subjects could decide to accept this allocation, or to

[9]The fact that in the control treatment one die throw determined the return of the investment for all participants while in the illusion of control treatments, subjects individually threw the die for one of the two investments creates more heterogeneity in payments in the illusion of control treatments than in the control treatment. However, this has no immediate consequence for the individual investment task, since it should be anyhow irrelevant if the die for one investment is thrown by the subject or the experimenter.

Table 4: Summary of presented random outcomes for both investments in treatment 'random history'

Period	Investment A		Investment B	
	frequency of outcome			
	a_1	a_2	b_1	b_2
1	4	1	2	3
2	1	4	0	5
3	2	3	2	3
4	2	3	3	2
5	3	2	2	3
6	2	3	3	2

reject it and compose their own portfolio at no additional cost.

To analyze whether the illustration of the random process and the prediction of future outcomes affects investments, a further treatment was considered. Specifically, subjects were presented with a list of outcomes determined by five random die throws[10] (*random history treatment*, n=30) for both risky investment alternatives A and B. Table 4 summarizes the outcomes of die throws presented to subjects in each period. Subjects first were asked to predict the next random outcome and second, to state their confidence of being correct in their prediction by adjusting a ruler ranging from 0% to 100% certainty.[11] To incentivise predictions, 10 ECU were added to subjects' period income for each correct prediction. In the light of the excessive extrapolation hypothesis, this treatment allows to examine (i) whether the prediction of the next outcome is not random but particularly related to the prior outcomes presented, and (ii) whether investments are contingent on predictions.

The last treatment investigated if the increase of the choice set has an adverse effect on risky investment (*variety treatment*) as suggested by the choice overload hypothesis. The number of risky alternatives to invest in was increased from two to six. However, in order to keep the basic investment setting comparable to the *control treatment*, two of the four alternatives added to the choice set were perfectly positively correlated to investment A and two were perfectly positively correlated to B. The additional investment alternatives were both inferior in their high and low returns to the investment they were correlated with, which ensures that the solution derived for the basic setting of two risky alternatives still holds. Table 5 gives an overview about the investment

[10] The die throws were generated randomly before the experiment started.

[11] It was duely explained that, for instance, a confidence level of 100 means to be correct 100 times out of 100 predictions. However, the subjective confidence was not monetarily rewarded.

alternatives offered in the *variety treatment*. Although the corresponding investments A and B were always listed as third and sixth alternatives, respectively, (named C and F, as seen in Table 5), they will be conveniently referred to as A and B in the results section.

Table 5: Returns of investment options for the variety treatment in each period

Period	Investments A		B		**C**		D		E		**F**		G
	a_1	a_2	b_1	b_2	c_1	c_2	d_1	d_2	e_1	e_2	f_1	f_2	$\overline{g}$
1	1.4	0.1	1.2	0.2	**2.5**	**0.33**	1.1	0.2	1.33	0.33	**3**	**0.5**	1
2	1.25	0.1	1.4	0	**2.5**	**0.2**	1.2	0.33	1.33	0.2	**3**	**0.7**	1
3	1.4	0.1	1.33	0.2	**2.4**	**0.25**	1.2	0.33	1.25	0.1	**3**	**0.75**	1
4	1.2	0	1.4	0	**2.67**	**0**	1.33	0.2	1.25	0.25	**3.3**	**0.5**	1
5	1.4	0.1	1.33	0.2	**2.5**	**0.33**	1.2	0.33	1.4	0.25	**2.8**	**0.67**	1
6	1.25	0.2	1.1	0.33	**2.6**	**0.4**	1.4	0.2	1.33	0.25	**2.8**	**0.6**	1

Note: A, B and C as well as D, E and F are perfectly positively correlated.

All treatments were conducted in separate sessions. In the IOC treatments, subjects who determined the return of an investment privately by throwing the die at their desk were always monitored by an experimenter. All public die throws made by the experimenter were monitored by a randomly selected participant. At the end of the experiment, the period to be paid out was determined again by a six-sided die. Subjects' earnings at the end of the experiment consisted of the show-up fee, the earnings from one randomly selected lottery choice task of stage one, and the earnings from the investment task in one random period of stage two. Subjects had to fill out a short socio-demographic questionnaire asking for their gender and age, before they were privately paid.

4 Results

Since the employed experimental manipulations are rather weak, the expected results represent a lower bound of the effect in the sense of a worst-case scenario. This section starts with a brief descriptive overview of risk attitudes elicited in stage one as well as general investment behavior of the control group, then proceeds with observations from the various treatments, and finally concludes with some general dynamics of investment behavior over time.

According to the lottery comparisons of stage 1, subjects are risk neutral if they switch from alternative X to Y at the fifth choice, risk-loving if they switch before, and risk-averse if they switch afterwards. Considering only those subjects who exhibit monotonic

Table 6: Mean investments (standard deviations) in alternatives A, B and C in the control treatment

Period	Investment A	Investment B	Investment C
1	22.5 (20.1)	61.7 (27.7)	15.9 (23.4)
2	29.9 (23.4)	57.3 (27.0)	12.8 (17.2)
3	28.3 (26.1)	61.7 (26.7)	10.0 (16.7)
4	27.9 (28.2)	60.5 (27.6)	11.6 (18.0)
5	26.1 (24.8)	64.5 (27.7)	9.3 (16.3)
6	31.5 (25.7)	59.7 (26.7)	8.8 (15.7)

choice behavior in probabilities[12] (176 out of 210), 9.1 % (n=16) can be classified as risk neutral, 86.9% (n=153) as risk-averse and 4.0% (n=7) as risk loving.[13]

Compared to the solution space presented, subjects tend to overweight investment B and underweight investment A in their portfolios, as seen in Table 6 listing the average investments made by subjects in the control treatment.

4.1 Illusion of control

Observation 1 *Subjects invest more in an alternative when they exercise control on its return and less in the alternative where they do not. This is especially pronounced when subjects can choose the investment alternative on which to exercise control. However, the effect of illusion of control on investments abates over time.*

The boxplots in Figure 2, that list again the number of observations for all nine treatments, show that all differences between the treatments with illusory control have the expected sign, i.e. investment in A is higher and investment in B lower by subjects who exercise control on A, and vice versa. Observation 1 however relies on a number of statistical comparisons between the *control treatment* and treatments *IOC-A*, *IOC-B* and *IOC-choice*, presented in Table 7.

The repercussions of illusory control are especially visible for investments in lotteries over which subjects lack control: subjects in the IOC-A treatment invest in period 1

[12]Denoting $p(\overline{x}) = p = p(\overline{y})$, lottery X is preferred to lottery Y if

$$\frac{u(\underline{x}) - u(\underline{y})}{u(\overline{y}) - u(\underline{y}) - (u(\overline{x}) - u(\underline{x}))} > p$$

with the left hand-side being positive for the experimental parameter constellation.

[13]Subjects who did not switch to the higher sure payoff in lottery 10 were also excluded from this analysis, since it can be assumed that they did not exhibit effort in making their choice.

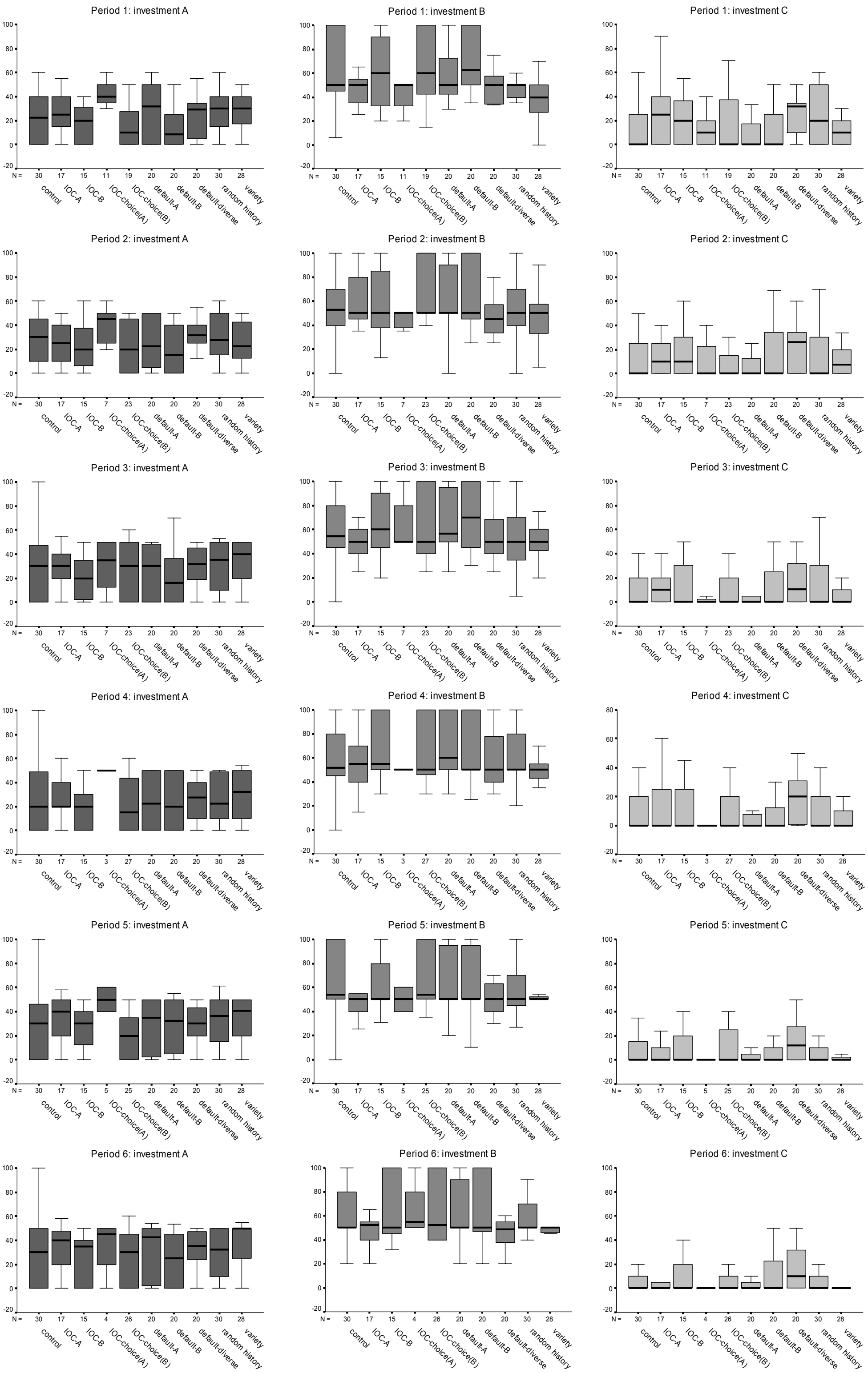

Figure 2: Boxplots for investments A, B and C in all six periods

significantly less in option B than subjects in the control treatment[14] Comparing subjects who exercise control on A to those subjects who exercise control on B (IOC-A vs. IOC-B) reveals that in period 1 the former subjects invest marginally more in option A.

Since investment in option B is already high in the control group (over 60% on average), no additional effect is found for subjects who are assigned to exercise control on B (IOC-B treatment). However, when participants are able to choose the investment option on which to exercise control, the augmenting effects on investment are more pronounced:

Subjects who choose A for determining the return invest most of the time, i.e in periods 1,2,4 and 5, more in A than subjects in the control treatment (see also Table 7). That more investment in lottery A results in simultaneously less investment in B holds only for the first period.

That subjects who chose B to exercise control on (IOC-choice(B)) invest more in B and less in A than subjects in the control treatment can only be statistically confirmed for period 2. Although, this tendency is also obvious in other periods, the already strong bias towards option B provides little room for a statistically significant increase in investment due to illusory control.

However, comparing the two subgroups who can choose the investment option to exercise control on within the IOC-choice treatment demonstrates the expected differences: in the majority of periods (1, 2, 4 and 5) subjects who choose lottery A invest significantly more in A than subjects who choose B. For periods 1 and 2, this relation holds also in the opposite direction, i.e., subjects who choose B invest more in option B than subjects who choose A.

[14] Since the variability is obviously different among treatments, robust rank order tests (Siegel and Castellan 2000) are employed. Significance levels are only available for 10%, 5% and 1% margins and are reported one-tailed.

Table 7: Significant differences for treatments concerning illusion of control

Treatments		Investment	Period	Means (Standard Deviations)				Robust rank order test		
1	2			Treatment 1		Treatment 2		$\grave{U}$	m,n	p
Control	IOC-A	B	1	61.7	(27.7)	48.2	(22.0)	1.75	30,17	$< .05$
IOC-A	IOC-B	A	1	27.1	(16.5)	18.1	(16.6)	1.32	17,15	$< .10$
Control	IOC-ch.(A)	A	1	22.5	(20.1)	37.3	(20.1)	2.15	30,11	$< .05$
			2	29.9	(23.4)	39.3	(15.7)	1.40	30,7	$< .10$
			4	27.9	(28.2)	50.0	(0.0)	4.69	30,3	$< .05$
			5	26.1	(24.8)	42.0	(24.9)	1.64	30,5	$< .10$
		B	1	61.7	(27.7)	50.5	(27.4)	1.29	30,11	$< .10$
Control	IOC-ch.(B)	A	2	29.9	(23.4)	20.0	(21.3)	1.29	30,23	$< .10$
		B	2	57.3	(25.8)	70.7	(26.6)	1.34	30,23	$< .10$
IOC-ch.(A)	IOC-ch.(B)	A	1	37.3	(20.1)	15.6	(17.3)	2.96	11,19	$< .01$
			2	39.3	(15.7)	20.0	(21.3)	2.93	7,23	$< .05$
			4	50.0	(0.0)	21.3	(21.9)	4.37	3,27	$< .05$
			5	42.0	(24.9)	20.9	(19.7)	1.99	5,25	$< .05$
		B	1	50.5	(27.4)	66.1	(29.6)	1.50	11,19	$< .10$
			2	48.6	(15.5)	70.7	(26.6)	2.69	7,23	$< .05$

4.2 Influence of the default portfolio

To investigate whether the composition of the default portfolio offered affects final allocations in the presence of illusory control, the three treatments *default-A*, *default-B*, *default-diverse* are compared to treatment *IOC-B* that serves as a control.

In general, the percentage of subjects who accept the default portfolio is relatively constant at 35% in the *default-B* treatment, and ranging from 0% to 25% in the *default-diverse* treatment. In the *default-A* treatment, the default portfolio is always rejected. However, despite the low acceptance rates of the defaults portfolios, the final allocations are still remarkably influenced by the offer.

Observation 2 *The final portfolio allocations are considerably affected by the default portfolio offered.*

When the default portfolio contains only lottery A (treatment *default-A*), the alternative on which subjects do not have control, investment in A is significantly higher than in the *IOC-B* treatment ($\grave{U}(15, 20) = 1.72, p < .05$), even though all subjects rejected the default portfolio in the first place. This effect, however, cannot be confirmed for later periods. Between *default-B* and the *IOC-B* treatment no significant difference is found. Portfolios in *IOC-B* are already biased towards lottery B, which is not elevated offering a default portfolio that contains only B. The equally diversified default portfolio in treatment *default-diverse* induces subjects to invest less in the otherwise overweighted lottery B, at least in periods 4 ($\grave{U}(15, 20) = 1.50, p < .10$) and 6 ($\grave{U}(15, 20) = 1.36, p < .10$). For other periods, statistical differences can not be confirmed. However, comparing the treatments with different defaults directly provides a more informative impression.

In period 1, investments in A are significantly higher in the *default-A* treatment than in the *default-B* treatment ($\grave{U}(20, 20) = 2.23, p < .05$), but investments in B are significantly lower ($\grave{U}(20, 20) = 1.69, p < .05$). This effect disappears in later rounds. More persistent effects are found when comparing the treatment with an equally diversified default portfolio (*default-diverse*) with the other two default-treatments (see Table 8): subjects invest on average less in lottery B, more in lottery A (although statistically confirmed only for period 1) and more risk-averse (in alternative C) than in the *default-B* treatment. Similarly, investments in B are lower in the *IOC-diverse* treatment than in the *default-A* treatment, and risk-free investments are higher. The proportions of lottery A in the portfolio are similar in both treatments. This evidence suggests that especially offering a well diversified default portfolio persistently leads to more diversified final portfolio allocations and therefore attenuates poor diversification. The effects of illusory

Table 8: Significant differences among treatments with different default portfolios

default-B – default-diverse					
Inv.	Period	Means (Stand. Dev.)		Robust rank order test	
		def.-B	def.-div.	$\grave{U}(20,20)$	p
A	1	14.7 (17.2)	24.6 (17.5)	1.98	$< .05$
B	1	70.7 (25.5)	50.1 (17.3)	3.13	$< .01$
	2	64.0 (28.2)	48.3 (18.8)	1.77	$< .05$
	3	68.2 (27.3)	55.2 (21.3)	1.43	$< .10$
	4	67.0 (28.5)	56.4 (21.2)	1.33	$< .10$
	6	64.5 (28.9)	51.6 (23.2)	1.50	$< .10$
C	1	14.7 (18.8)	25.3 (17.2)	2.00	$< .05$
	2	15.8 (21.9)	22.9 (19.7)	1.36	$< .10$
	4	11.0 (21.6)	18.1 (15.9)	2.32	$< .05$
	5	11.5 (22.7)	15.2 (15.1)	1.66	$= .05$

default-A – default-diverse					
Inv.	Period	Means (Stand. Dev.)		Robust rank order test	
		def.-A	def.-div.	$\grave{U}(20,20)$	p
B	2	63.0 (28.0)	48.3 (18.8)	2.27	$< .05$
	3	65.6 (25.7)	55.2 (21.3)	1.40	$< .10$
	4	68.5 (24.5)	56.4 (21.2)	1.87	$< .05$
	5	64.8 (24.8)	55.9 (21.6)	1.36	$< .10$
	6	61.8 (24.7)	51.6 (23.2)	1.66	$= .05$
C	1	12.5 (21.9)	25.3 (17.2)	2.84	$< .01$
	2	9.0 (17.3)	22.9 (19.7)	2.56	$< .01$
	3	9.8 (21.4)	15.4 (16.4)	1.77	$< .05$
	4	8.0 (17.3)	18.1 (15.9)	2.77	$< .01$
	5	6.5 (14.9)	15.2 (15.1)	2.42	$< .05$
	6	7.0 (15.5)	17.1 (21.8)	1.87	$< .05$

control seem to be overruled. In the particular investment setting, the proportions of investment B can even be reduced to or near the theoretically suggested level.

Turning now to the two treatments that do not deal with illusion of control, the results of the *random history* treatment are presented first.

4.3 Relation of past random sequences, predictions and investments

Observation 3 *Illustrating the random process that determines the investment returns induces more diversified and less risky investment behavior in the first period. However, the effect disappears quickly with task experience.*

Subjects who are confronted with a sequence of random die throws invest in the first period more in lottery A ($M_{RH} = 29.2, SD_{RH} = 16.9, M_C = 22.5, SD_C = 20.1, \grave{U}(30,30) =$

$1.31, p < .10$) and less in lottery B ($M_{RH} = 46.7, SD_{RH} = 19.4, M_C = 61.7, SD_C = 27.7, \grave{U}(30, 30) = 2.28, p < .05$) than subjects in the control group. Furthermore, investments are less risky, expressed by a higher proportion of C in their portfolios ($M_{RH} = 24.2, SD_{RH} = 20.8, M_C = 15.9, SD_C = 23.4, \grave{U}(30, 30) = 1.94, p < .05$). Neither effect is traceable in later periods. It seems that the saliency of the random process initially induces more cautious investment behavior which becomes less important as subjects gain experience.

Observation 4 *On aggregate, individuals are overly optimistic in their predictions for both lotteries. The prediction of a high return for B is more likely the more high returns subjects see in the randomly determined history of B. Also, a high return prediction for B is followed by a higher investment in B confirming excessive extrapolation.*

Additionally to seeing the sequence of previously realized returns for both investments, subjects had to predict which return will materialize for each investment and state their certainty. According to Binomial-tests, predictions are not made randomly. Overall, subjects more often predict a high return than a low return for both lottery A (low: 36.1%, high: 63.9%) and B (low: 30%, high: 70%), which indicates that, on aggregate, people are overly optimistic.

On the basis of literature on excessive extrapolation (e.g., Benartzi 2001, DeBondt 1993) it is hypothesized that subjects are more likely to expect a trend continuing than reverting, and subsequently invest more in an asset for which a high outcome is predicted. This relation is confirmed for investment B: the larger the number of high returns subjects have seen in the history of random die throws that was presented to them, the more likely they are to make a high return prediction (Spearman's $\rho = .16, p = .02$). A high prediction, in turn, leads to higher investment in lottery B, which is even confirmed when controlling for the history presented, i.e., the number of high returns that were visible (partial correlation: $\rho_{predB-investB.histB} = .13, p = .04$). Remarkably, this effect cannot be confirmed for lottery A. It is possible that subjects pay higher attention to information and prediction of the lottery they generally favor. Still, the predictions for A and B are unrelated to the actual return that was realized in the previous period (Spearman correlations: $\rho_A = -.06, p = .25, \rho_B = -.03, p = .36$).

Subjects' certainty is independent of the prediction (high or low) for both risky investments, but reflects overconfidence for lottery B: in total, 64% of subjects state a certainty of over 50% for B (significantly more than expected by random choice: Binomial-test, $p < .01$), whereas only 52% do so for investment A. Furthermore, there is a positive correlation between the certainty stated in predicting B and the actual investment in B (Spearman's $\rho = 0.15, p = .02$).

The final treatment *variety* investigates how investment behavior changes when the set of risky alternatives is increased by the factor 3. Recall however, that the lotteries added were inferior to the two basic lotteries A and B.

4.4 Increase of the choice set

Observation 5 *An increase in the investment variety by inferior alternatives leads to marginally but not persistently more diversification. Contrary to the choice overload hypothesis, no increase in risk-free investment is observed.*

Compared to the control treatment, subjects in the variety treatment only invest significantly less in lottery B in periods 1, 3 and 5 ($\grave{U}_1(30, 28) = 3.96, p < .01, \grave{U}_3(30, 28) = 1.59, p < .10, \grave{U}_5(30, 28) = 1.43, p < .10$) and more in lottery A only in periods 5 and 6 ($\grave{U}_5(30, 28) = 1.54, p < .10, \grave{U}_6(30, 28) = 1.40, p < .01$). Contrary to the choice overload hypothesis, no effect for risk-free investment is observable. Tendentiously, investments in the risk-free alternative are even lower when a larger variety is presented. Apparently, subjects quickly learn which alternatives are inferior, and a choice set of seven alternatives is not enough to induce an overload of information.

4.5 Behavior over time

To obtain a more detailed picture of factors influencing portfolio choice and learning processes in the investment task, the dynamics for the pooled data set over periods is considered. Since the three investments are interdependent, a multivariate general linear model (GLM) with investments `a`, `b` and `c`, respectively, as dependent variables and the following independent factors is employed: period (1 to 6), risk attitude (risk, 1=risk loving, 2=risk neutral, 3=risk averse) inferred in stage one, treatment (treat), returns of investment A (winA) and investment B (winB) in the previous period as dummies (0=low, 1=high), and the achievement of the profit target of $l = 150$ in the previous period (target, 0=no, 1=yes).

Observation 6 *Risk aversion as elicited by lottery comparisons translates into more risk-free investment, higher investment in the generally less risky lottery A and lower investment in the riskier alternative B throughout periods.*

Table 9: Multivariate general linear model on investments `a`, `b` and `c`

	Parameter Estimates					
	investment `a`		investment `b`		investment `c`	
Indep. Var.	coeff. (std.)	p	coeff. (std.)	p	coeff. (std.)	p
constant	-0.41 (4.98)	.945	95.01 (5.80)	.000***	5.12 (3.68)	.165
period	0.88 (0.51)	.084*	0.30 (0.59)	.614	-1.07 (0.37)	.004***
risk	8.36 (1.53)	.000***	-11.79 (1.78)	.000***	3.44 (1.13)	.002***
winA	-0.70 (1.53)	.648	-2.679 (1.79)	.134	1.82 (1.13)	.109
winB	-7.20 (2.33)	.002***	-0.74 (2.72)	.785	5.08 (1.72)	.003***
target	9.13 (2.38)	.000***	1.31 (2.77)	.636	-8.43 (1.76)	.000***

Note: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 9 shows that the coefficient of the risk index (1=risk loving, 2=risk neutral, and 3= risk averse) is positive and significant for investments in lottery A and in the risk-free alternative C, and negative and significant for lottery B.

Observation 7 *Subjects become less risk-averse over time.*

The proportion invested risk-free declines over time (see Figure 2), which is confirmed to be significant in the GLM results of Table 9. One possible reason is that subjects learn how to well diversify over time, because investment in C is usually higher than required. Although investment in A increases slightly yet not significantly over time, overall no apparent convergence of A and B to the proposed levels can be observed, which contradicts this conjecture.

Observation 8 *People invest more risky, i.e., less in the risk-free alternative, after exceeding the profit target in the previous period.*

Put differently, after failing the profit target, subjects invest more risk-averse, i.e. more in alternative C. This finding contradicts the hypothesis of loss recovery or escalation of commitment (Staw 1976), predicting more risky behavior after a loss, but is in accordance with findings that individuals are more risk taking after a gain in dynamic settings, called the house money effect (Ackert et al. 2003, Thaler and Johnson 1990, Weber and Zuchel 2003). Moreover, investment in option A is higher after exceeding the target, whereas investment in alternative B remains unaffected.

The success of the two risky alternatives A and B in the previous periods has no straightforward consequences for the present investment: investment in alternative A is lower and risk-free investment in C higher when alternative B has achieved the high return in the previous period, while investment in B is entirely unaffected. The realized return of A in the previous periods does not have consequences for subsequent investments.

5 Discussion

Illusion of control is well known to influence behavior in gambling situations by making chances appear higher than objectively justifiable. However, can it also account for systematic shifts in investments towards shares that seem to be controllable? By employing a simple portfolio choice task, where subjects can invest in two risky lotteries and a risk-free alternative, the present study aims to explore the role of illusory control for investments, particularly for diversification. In other words, it is investigated whether a lottery becomes more attractive when subjects can exercise control on the outcome, e.g., by throwing a die and picking the winning numbers. Investigating this phenomenon is important in the face of the well-established evidence that many portfolio allocations, particularly in retirement saving plans, are poorly diversified and massively biased towards own company stock. The stream of explaining this phenomenon offered in this chapter is that individuals feel to have more control on the performance of their company than on others'.

Moreover, the relevance of another explanation why individuals favor a specific stock, e.g., own company, is investigated in this simple portfolio selection setting. Benartzi (2001) claims that individuals excessively extrapolate past returns and consequently invest more in companies that recently performed very well. To avoid deceiving participants in the experiment, true random sequences of outcomes were shown before asking subjects to make predictions for both risky investment alternatives, prior to the investment task. Therefore, the sequences of previous outcomes are not explicitly varied. Although, both illusory control and excessive extrapolation have been related to investment decisions before, the present study is the first to consider their relevance in a controlled experiment that requires diversification.

The results show that both, illusion of control and excessive extrapolation can evoke shifts in investments. It is difficult, however, to draw conclusions on the relative strength of the two phenomena, since they are not directly comparable. Remarkably, both effects are not universally observable but in most of the cases only for either one of the risky investment alternatives. Illusion of control increases investment in the alternative that is generally less favored, whereas investment in the already favored alternative remains unaffected. This is possibly due to the fact that an already high base level of investment does not leave much opportunity to statistically confirm an increase. Subjects seem to develop an intrinsic liking of one alternative over the other, most likely on the basis of expected value. This preference is partly, yet, not entirely shaped by illusion of control.

Excessive extrapolation, however, occurs only for the generally, i.e., also in the control treatment, more popular alternative. The results show that investments are contingent on predictions, at least for the favored alternative, but cannot directly be related to the random sequence of previous outcomes. Still, it is not clear, whether individuals invest more in this alternative because they made high predictions before, or whether they make high predictions because they intrinsically like the investment. Predictions are on aggregate overly optimistic for both risky investments. However, the fact that a relation between the random sequence presented and the predictions made, and between predictions and investments, respectively, exists only for the alternative that is generally favored, supports the assumption of wishful thinking: individuals seem to direct their attention and optimism towards the alternative for which they developed an intrinsic liking. This is an interesting point to be clarified in future research. Do people excessively extrapolate previous price movements mainly for stocks they already intrinsically favor, like own company stock? Previous research based on field data has not yet been able to provide an unambiguous answer.

An important aspect of the study is the provision of swift feedback on investment success and the possibility to become familiar with the task over periods. The effect of illusion of control on investments abates over time implying that it is not resistant to task experience. However, the experimental manipulation is fairly weak, and the findings rather represent a lower bound of the phenomenon. In everyday life, illusion of control, like other egocentric biases, serves the purpose of protecting one's self-image that is continually challenged. The bias is therefore less transparent and likely to prevail more easily. The investment task employed is very simple since it consists only of two risky lotteries and a risk-free alternative with zero interest. This renders an optimal decision only easier and the irrelevance of control over the chance move more salient, in contrast to the complex setting of financial markets. Also, real life investment decisions often lack instant and unambiguous feedback on success which makes learning more difficult. Under these circumstances, an illusion of control might even be more persistent.

In view of an institutional design that might guide individuals to consider a broader range of alternatives, the influence of offering different default portfolios on final allocations is addressed. Evidence implies that the default portfolio is highly influential. Although the vast majority rejects the portfolio offered, final allocations are shaped by the suggested diversification strategy that represents an important anchor. Hedesström et al. (2004), for instance, also find that one third of participants in the Swedish Premium Pension Scheme refrain from making a choice of funds and rather leave their investments in the default fund. This has important implications for the design of retirement saving plans. Since employees are anchored to the defaults offered and report to rarely restructure their investments, it is crucial to consider well how recommendations should be designed.

An additional treatment of increasing the number of risky alternatives by a factor 3 did not result in more risk-averse behavior as suggested by the literature on choice overload. However, the four added alternatives could easily be identified as being inferior to the two others, therefore the manipulation is clearly too weak. To create disutility from additional choice, the complexity of the task has to be considerably higher.

As for the general behavioral patterns, risk attitude is found to be related to investment behavior confirming the expedience of eliciting risk attitudes by lottery choices. The observation that individuals are more risk-seeking after exceeding the profit target, and conversely more risk averse after a failing it, confirms the house money effect (Thaler and Johnson 1990), but raises another interesting question: after failing the profit target, do subjects realize that their investment strategy was too risky and diversify more? Results answer this in the negative as subjects on average invest more risk-free, but do not markedly change their diversification strategy in other respects.

Generally, one might argue that the experimental setting does not duely reflect the complexity of real financial decisions. For employees' deciding on their retirement savings, additional factors like brand names, familiarity, and recent news play a major role. However, in a simple lab setting such a confoundedness of effects can be avoided. Instead, one can concisely isolate the impact of one variable on behavior, which provides a first step to assess structural relationships on a fundamental level. Although the act of choosing simple lotteries is different from picking stock stocks, funds or securities, the basic claim remains the same: diversification does not reflect natural behavior. This, however, does not necessarily contradict the finding that people employ an 1/n heuristic when confronted with various choices, e.g., among stock funds and bond funds, which they cannot easily evaluate. In complex decision situations, such a heuristic may be prevalent (see, e.g. Read and Loewenstein 1995, Simonson 1990). As soon as another cue becomes available, like the possibility to invest in own company stock, the focus of attention is shifted and other behavioral forces, like illusory control or excessive extrapolation, shape the investment decision.

Therefore, sponsors are well advised to consider investors' cognitive limitations when designing retirement saving plans. To attenuate, for instance, own company investment, one has to carefully consider that this tendency reflects the underestimation of risk that may result from different behavioral sources, like illusion of control, too optimistic return predictions, or simply inertia to stick with the default offered. Plan design indeed becomes an increasingly important issue (Benartzi and Thaler 2001b, Mitchell and Utkus 2003a): financial advisors are concerned, for instance, about the number of funds offered, the possibility to invest in company stock, and how to illustrate the benefits of diversification. It is vital to assist investors in making their retirement savings on a more elaborate consideration of their risk attitude and desired retirement income profile.

Appendix: Instructions (translated from German)

The instructions of the nine different treatments are presented in the following. Paragraphs of instructions that are specific to the treatments are indicated by the treatment heading in [ ].
Thanks for participating in this experiment! Please, do not communicate with other participants. If you have a question, please raise your hand and an experimenter will answer your question privately.
The money you earn will be paid to you in cash at the end of the experiment. Decisions are anonymous and cannot be traced to any name. For your participation, you receive a show up fee of Euro 3.5. Depending on your decisions you can earn additional money.
The experiment consists of 2 phases. You obtain the instructions for phase 2 after completion of phase 1.

Phase 1:

For ten different situations, you have to choose one of two options X or Y. These 10 different situations will be presented on screen. Each of the two option yields 2 possible monetary outcomes (all amounts are denoted in Euro), one high and one low that are paid out according to the probabilities noted. While the two possible outcomes remain constant in all 10 situations, their probabilities vary.
Options X and Y will be presented on screen in the following way:

This means, for instance, in the first situation: option X yields with probability $\frac{1}{10}$ Euro

2 and with probability $\frac{9}{10}$ Euro 1.60. Option Y yields with probability $\frac{1}{10}$ Euro 3.85 and with probability $\frac{9}{10}$ Euro 0.10.

On the right hand side, you have to click the option you choose. For option X, click the left circle and for option Y the right circle. Please note, that at the end of the experiment (after phase 2), only one of these 10 situations will be randomly chosen to be paid out. All situations are equally likely, i.e. the computer picks a random number from 1 to 10 and thereby determines the situation that will be paid out.

Subsequently, a second random number is generated that determines whether the option you chose yields the high or the low outcome. In order to do so, again a random number Z in the range of 0 to 10 (with 2 decimals) is generated. For the case described above, where probabilities are $\frac{1}{10}$ and $\frac{9}{10}$, respectively, the outcome is determined as follows.

At a random number between 0 and 1 ($0 \leq Z \leq 1$), i.e., with probability $\frac{1}{10}$, the option yields the higher outcome: this is 2 Euro if you chose option X and 3.85 Euro if you chose option Y. At a random number between 1 and 10 ($1 < Z \leq 10$), i.e., with probability $\frac{9}{10}$, the option yields the lower outcome: that is 1.60 Euro if you chose option X and 0.10 Euro if you chose option Y.
The range of the random number Z that yields the high or low outcome of options X and Y is adjusted according to the probabilities.

Phase 2: {*For all treatments except variety treatment*}
Phase 2 consists of 6 rounds of the same design. In every round, you obtain an endowment of 100 ECU (experimental currency units). 100 ECU correspond to 5 Euro. You have now the role of an investor and you have to decide, how to distribute your endowment of 100 ECU over 3 different investment alternatives A, B and C. The investment alternatives A, B and C are of the same sort in each round, but the actual returns can differ in numbers in every round. In the following, the investment alternatives of round 1 will be presented and explained.

We denote the amount that is invested in A with a, the amount invested in B with b and the amount invested in C with c.

Investment A:

- yields with probability one half (50%) two-and-a half of amount a. In this case, your profit from investment A is **2.5*a**.
- yields with probability one half (50%) one third of the amount a. In this case, your profit from investment A is **0.33*a**.

Investment B:

- yields with probability one half (50%) three times the amount b. In this case, your profit from investment B is **3*b**.
- yields with probability one half (50%) half of the amount b. In this case, your profit from investment B is **0.5*b**.

Investment C:

- yields with certainty exactly the amount c. Your profit from investment c is 1*c.

Investment decision

Your task is to decide on the amounts a, b and c. Each of these amounts can lie within the range of 0 to 100 (with a maximum of 2 decimals), but the amounts have to sum up to 100 ECU, your endowment. The sum of the returns of the 3 investment alternatives represent your investment profit.

[***Control treatment:***]

The investment return will be determined with a six-sided die that is thrown by the experimenter. The die is thrown separately for investment A and B, so that the returns of A and B are independent. In case of an odd number (1,3,5), the investment yields the high return and in case of an even number (2,4,6), the investment yields the low return. Therefore, the probability for both returns of A and B is one half.

[***IOC-A treatment:***]

The investment return will be determined with a six-sided die, whereby you will determine the return of investment B by throwing the die yourself. Before you decide on your investments, you have to pick the three winning numbers of investment A, i.e., the numbers at which investment A yields the high return. At the remaining three numbers, investment A yields the low return. An experimenter will come to your place to let you exercise the die throw.

The return of investment B is determined by a die throw of the experimenter. In case of an odd number (1,3,5), investment B yields the high return and in case of an even number (2,4,6), investment B yields the low return. Therefore, the probability for both returns of A and B is one half.

[***IOC-B treatment:***]
The investment return will be determined with a six-sided die, whereby you will determine the return of investment B by throwing the die yourself. Before you decide on your investments, you have to pick the three winning numbers of investment B, i.e., the numbers at which investment B yields the high return. At the remaining three numbers, investment B yields the low return. An experimenter will come to your place to let you exercise the die throw.
The return of investment A is determined by a die throw of the experimenter. In case of an odd number (1,3,5), investment A yields the high return and in case of an even number (2,4,6), investment A yields the low return. Therefore, the probability for both returns of A and B is one half.

[***IOC-choice treatment:***]
The investment return will be determined with a six-sided die. Before you decide on your investments, you have to choose for which of the two investment alternatives A or B you want to throw the die and thereby determine the return. Furthermore, you have to pick the three winning numbers of this investment, i.e., the numbers at which the respective investment yields the high return. At the remaining three numbers, the investment yields the low return. An experimenter will come to your place to let you exercise the die throw.
The return of the other investment is determined by a die throw of the experimenter. In case of an odd number (1,3,5), the investment yields the high return and in case of an even number (2,4,6), the investment yields the low return. Therefore, the probability for both returns of A and B is one half.

[***default-A, default-B, and default-diverse treatments:***]
On screen, specific amounts of a, b and c are proposed. If you want to accept this proposal, please click "yes" and press the OK Button. If you do not want to accept this proposal, click "no" and press the OK Button. In the latter case, you can change the amounts a, b and c on the subsequent screen.

The investment return will be determined with a six-sided die, whereby you will determine the return of investment B by throwing the die yourself. Before you decide on your investments, you have to pick the three winning numbers of investment B, i.e., the numbers at which investment B yields the high return. At the remaining three numbers, investment B yields the low return. An experimenter will come to your place to let you exercise the die throw.
The return of investment A is determined by a die throw of the experimenter. In case of an odd number (1,3,5), investment A yields the high return and in case of an even number (2,4,6), investment A yields the low return. Therefore, the probability for both returns of A and B is one half.

[***Random history treatment:***]
The investment return will be determined with a six-sided die that is thrown by the experimenter. The die is thrown separately for investment A and B, so that the returns of A and B are independent. In case of an odd number (1,3,5), the investment yields the high return and in case of an even number (2,4,6), the investment yields the low return. Therefore, the probability for both returns of A and B is one half.
Prediction of returns
To give you an illustration of the random process determining the returns, you will find the outcome of five die throws that have been exercised for each investment before the experiment listed on screen, together with the particular die number. Before you decide on your investments, please make a prediction which return (high or low) will occur for A and for B. For each correct prediction, additional 10 ECU are added to your round income. Furthermore, please adjust on a scale from 0% to 100% how confident you are that your prediction is correct. Please note the following: stating 100% means that out of 100 guesses, you are right a 100 times. On the opposite, stating 0% means that you feel that out of 100 tries, none of your guesses is correct.

[***Variety treatment:***]
Phase 2 consists of 6 rounds of the same design. In every round, you obtain an endowment of 100 ECU (experimental currency units). 100 ECU correspond to 5 Euro. You have now the role of an investor and you have to decide, how to distribute your endowment of 100 ECU over 7 different investment alternatives A, B, C, D, E, F and G. The investment alternatives A, B, C, D, E, F and G are of the same sort in each round, but the actual returns can differ in numbers in every round. In the following, the

investment alternatives of round 1 will be presented and explained.

We denote the amount that is invested in A with a, the amount invested in B with b, the amount invested in C with c, and so on.

Investment A:

- yields with probability one half (50%) 1.4 times the amount a. In this case, your profit from investment A is **1.4*a**.
- yields with probability one half (50%) one tenth of the amount a. In this case, your profit from investment A is **0.1*a**.

Investment B:

- yields with probability one half (50%) 1.2 times the amount b. In this case, the profit from investment B is **1.2*b**.
- yields with probability one half (50%) one fifth of the amount b. In this case, your profit from investment B is **0.2*b**.

Investment C:

- yields with probability one half (50%) two-and-a half of amount c. In this case, your profit from investment A is **2.5*c**.
- yields with probability one half (50%) one third of the amount c. In this case, your profit from investment A is **0.33*c**.

Investment D:

- yields with probability one half (50%) 1.1 times the amount d. In this case, your profit from investment A is **1.1*d**.
- yields with probability one half (50%) one fifth of the amount d. In this case, your profit from investment A is **0.2*d**.

Investment E:

- yields with probability one half (50%) 1.33 times the amount e. In this case, your profit from investment A is **1.33*e**.

- yields with probability one half (50%) one third of the amount e. In this case, your profit from investment A is **0.33*e**.

Investment F:

- yields with probability one half (50%) three times the amount b. In this case, the profit from investment B is **3*b**.
- yields with probability one half (50%) half of the amount b. In this case, your profit from investment B is **0.5*b**.

Investment G:

- yields with certainty exactly the amount c. Your profit from investment g is **1*c**.

The returns of the investments A, B, and C are interdependent, and so are the returns of the investments D, E and F. This means that if A yields the high return, B and C also yield the high return. If A yields the low return, B and C also yield the low return. The same holds true for investments D, E and F: if investment D yields the high return, E and F also yield the high return. If D yields the low return, E and F also yield the low return. How the returns are determined is explained below in more detail.

<u>Investment decision</u>
Your task is to decide on the amounts a, b, c, d, e, f, and g. Each of these amounts can lie within the range of 0 to 100 (with a maximum of 2 decimals), but the amounts have to sum up to 100 ECU, your endowment. The sum of the returns of the 7 investment alternatives is your investment profit.
The investment return will be determined with a six-sided die that is thrown by the experimenter. Once, the die is thrown together for A, B and C, and once it is thrown together for D, E and F in common. The returns of investments A, B and C are thus interdependent, and so are the returns of investments D, E and F. However, the returns of the first three investments (A, B, C) are independent from the returns of the second three investments (D, E, F). In case of an odd number (1,3,5), the investments yield the high return and in case of an even number (2,4,6), the investments yield the low return. Therefore, the probability for both returns of A, B, C, D, E, and F is one half.

{*All treatments*}
As investor, your income target is 150 ECU, i.e. 1.5 times your endowment. An investment return of 150 ECU and more is counted as your round income. In case of an investment return lower than 150 ECU, your round income is 0.

This phase consists of 6 independent rounds. In each round, you face again 3[15] new investment alternatives. Your investment target remains the same in each round, and you have to repeatedly decide, how to distribute your endowment of 100 ECU.

Payment at the end of the experiment

Your round income in one of the six rounds is randomly selected for payment. Therefor, the experimenter throws a six-sided die at the end of the experiment. When the number 1 occurs, the income of round 1 is paid out, when number occurs 2, the income of round 2 is paid out, and so on.

[15] Seven in the variety treatment.

References

Ackert, L. F., Charupat, N., Church, B. K. and Deaves, R.: 2003, An experimental examination of the house money effect in a multi-period setting, *Mimeo* . Federal Reserve Bank of Atlanta, Research Department.

Benartzi, S.: 2001, Excessive extrapolation and the allocation of 401(k) accounts to company stock, *Journal of Finance* **56**, 1747–1764.

Benartzi, S. and Thaler, R. H.: 2001a, Naive diversification strategies in defined contribution saving plans, *American Economic Review* **91**, 79–98.

Benartzi, S. and Thaler, R. H.: 2001b, Using behavioral economics to improve diversification in 401(k) plans: Solving the company stock problem, *Mimeo* . Anderson School, UCLA.

Charness, G. and Gneezy, U.: 2003, Portfolio choice and risk attitudes: An experiment, *Mimeo* . University of Chicago, Graduate School of Business.

Davis, D., Sundahl, I. and Lesbo, M.: 2000, Illusory personal control as a determinant of bet size and type in casino craps games, *Journal of Applied Social Psychology* **30**, 1224–1242.

DeBondt, W. F. M.: 1991, What do economists know about the stock market?, *Journal of Portfolio Management* **18**, 84–91.

DeBondt, W. F. M.: 1993, Betting on trends: Intuitive forecasts of financial risk and return, *International Journal of Forecasting* **9**, 355–371.

DeBondt, W. F. M.: 1998, A portrait of the individual investor, *European Economic Review* **42**, 831–844.

DeBondt, W. F. M. and Thaler, R. H.: 1995, Financial decision-making in markets and firms: A behavioral perspective, *in* R. Jarrow, V. Maksimovic and W. T. Ziemba (eds), *Finance: Handbooks in Operations Research and Management Science 9*, North Holland, Amsterdam, pp. 385–410.

Dixon, M. R.: 2000, Manipulating the illusion of control: Variations in gambling as a function of perceived control over chance outcomes, *Psychological Record* **50**, 705–719.

Fischbacher, U.: 1999, z-Tree: Zurich toolbox for readymade economic experiments: Experimenter's manual, *Working Paper* **21**. Institute for Empirical Research in Economics at the University of Zurich.

Fischhoff, B., Slovic, P. and Lichtenstein, S.: 1977, Knowing with certainty: The appropriateness of extreme confidence, *Journal of Experimental Psychology: Human Perception and Performance* **3**, 552–564.

Glaser, M., Langer, T. and Weber, M.: 2003, On the trend recognition and forecasting ability of professional traders, *Discussion Paper in Financial Economics* **3904**. Center for Economic Policy Research.

Heath, C. and Tversky, A.: 1991, Preference and belief: Ambiguity and competence in choice under uncertainty, *Journal of Risk and Uncertainty* **4**, 5–28.

Hedesström, T., Svedsäter, H. and Gärling, T.: 2004, Identifying heuristic choice rules in the Swedish Premium Pension Scheme, *Journal of Behavioral Finance* pp. 32–42.

Hogarth, R. and Makridakis, S.: 1981, Beyond discrete biases: Functional and dysfunctional aspect of judgmental heuristics, *Psychological Bulletin* **90**, 115–137.

Holden, S. and VanDerhei, J.: 2003, 401(k) plan asset allocation, account balances and loan activity in 2001, *EBRI Issue Brief* **255**. Employee Benefit Research Institute.

Holt, C. A. and Laury, S. K.: 2002, Risk aversion and incentive effects, *American Economic Review* **92**, 1644–1655.

Huberman, G.: 2001, Familiarity breeds investment, *Review of Financial Studies* **14**, 659–680.

Huberman, G., Iyengar, S. and Jiang, W.: 2003, Defined contribution pension plans: Determinants of participation and contribution rates, *Mimeo* . Columbia Business School.

Huberman, G. and Sengmüller, P.: 2002, Company stock in 401(k) plans, *Mimeo* . Columbia Business School.

Iyengar, S. S., Jian, W. and Huberman, G.: 2003, How much choice is too much? Determinants of indiviudal contributions in 401(k) retirement plans, *Mimeo* . Columbia University.

Iyengar, S. S. and Lepper, M. R.: 2000, When choice is demotivating: Can one desire too much of a good thing?, *Journal of Personality and Social Psychology* **76**, 995–1006.

Koehler, J. J., Gibbs, B. J. and Hogarth, R. M.: 1994, Shattering the illusion of control: Multi-shot versus single-shot gambles, *Journal of Behavioral Decision Making* **7**, 183–191.

Ladouceur, R. and Mayrand, M.: 1984, Evaluation of the "illusion of control": Type of feedback, outcome sequence, and number of trials among regular and occasional gamblers, *Journal of Psychology* **117**, 37–46.

Langer, E. J.: 1975, The illusion of control, *Journal of Personality and Social Psychology* **32**, 311–328.

Markowitz, H. M.: 1952, Portfolio selection, *Journal of Finance* **7**, 77–91.

McDonnell, K.: 2002, Retirement plan assets: Year-end 2001, *Facts from EBRI* **September 2002**. Employee Benefit Research Institute, http://www.ebri.org/facts/0902fact.pdf.

Mitchell, O. S. and Utkus, S. P.: 2003a, Lessons from behavioral fiance for retirement plan design, *Pension Research Council Working Paper 2003-6* . Wharton School, University of Pennsylvannia.

Mitchell, O. S. and Utkus, S. P.: 2003b, The role of company stock and retirement plan diversification, *in* O. S. Mitchell and K. Smetters (eds), *The pension challenge: Risk transfers and Retirement Income Security*, Oxford University Press, Oxford, UK, pp. 33–70.

Mottola, G. R. and Utkus, S. P.: 2003, Can there be too much choice in a retirement savings plan?, *Research Report* . The Vanguard center for retirement research.

Mutual of Ohama Insurance Company: 2002, 401(k) plan preferences study, *Summary Report* .

Read, D. and Loewenstein, G.: 1995, Diversification bias: Explaining the discrepancy in variety seeking between combined and separated choices, *Journal of Experimental Psychology: Applied* **1**, 34–49.

Roy, A. D.: 1952, Safety-first and the holdings of assets, *Econometrics* **20**, 431–449.

Samuelson, W. and Zeckhauser, R.: 1988, Status quo bias in decision making, *Journal of Risk and Uncertainty* **1**, 7–59.

Shanteau, J.: 1995, Expert judgment and financial decision making, *in* B. Green (ed.), *Proceedings of The First International Stockholm Seminar on Risk Behaviour and Risk Management*. June 12-14.

Shefrin, H.: 2000, *Beyond greed and fear*, Harvard Business School Press, Boston.

Shiller, R. J.: 2000, *Irrational exuberance*, Princeton University Press, Princeton, N.J.

Siegel, S. and Castellan, N. J.: 2000, *Nonparametric Statistics for the Behavioral Sciences*, second edn, McGraw-Hill, New York et al.

Simonson, I.: 1990, The effect of purchase quantity and timing on variety-seeking behavior, *Journal of Marketing Research* **27**, 150–162.

Staw, B.: 1976, Knee-deep in the big muddy: A study of escalating commitment to a chosen course of action, *Organizational Behavior and Human Decision Processes* **16**, 27–44.

Stephan, E. and Kiell, G.: 2001, Decision processes in professional investors: Does expertise moderate judgmental biases?, *Mimeo* . University of Kassel.

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

Tyszka, T. and Zielonka, P.: 2002, Expert judgments: Financial analysts versus weather forecasters, *Journal of Psychology and Financial Markets* **3**, 152–160.

Weber, M. and Zuchel, H.: 2003, How do prior outcomes affect risk attitude?, *Mimeo* . University of Mannheim.

Weinstein, N. D.: 1980, Unrealistic optimism about future life events, *Journal of Personality and Social Psychology* **39**, 806–820.