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Illusion of Control as a Source of Poor Diversification: Experimental Evidence

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This paper investigates factors that influence individual portfolio allocations, with particular focus on illusion of control. Participants in the experiment form their portfolios of two risky lotteries and one risk-free alternative with the target to reach a predetermined income. Subjects show illusion of control as they excessively invest in a lottery when they are in charge of the chance move. This finding is amplified when self-selection is possible and mitigated when a well-diversified default portfolio is offered. Presenting sequences of chance moves prior to investment does not affect diversification. In line with excessive extrapolation, the higher the number of observed positive prior outcomes, the more likely is a positive prediction and in turn a higher investment.

Keywords: Investment decisions, Portfolio selection, Egocentric biases, Illusion of control, Excessive extrapolation, Unrealistic optimism, Experimental economics

INTRODUCTION

The behavior of the private investor has increasingly attracted 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 which funds to invest in, are an important vehicle of retirement savings. In the United States, 401(k) plans are the most prevalent form of defined contribution plans.[1] Also in many other countries, such as Australia, Thailand, Denmark, Switzerland, and Spain, private pension plans are already an important part of social security or at least actively discussed as a solution to the expected long-term financial insolvency of public pension systems, as in India, Japan, Germany, and France. The common element of the various private retirement saving systems is that more responsibility is shifted to lay-people, who are 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 financial professionals are susceptible to numerous cognitive biases and illusions (Stephan and Kiell [2006], Tyszka and Zielonka [2002], Glaser, Langer and Weber [2007]). Inexperienced people in financial matters are even more likely to be influenced by judgmental heuristics that may lead to bad investment decisions.

Moreover, little time is devoted to track the development of investments; for instance, about 70% of 401(k) participants adjust their allocation plan less frequently than once a year, and 40% of participants report to be never active (Ohama Insurance Company [2002]). To no surprise, many financial consultants and plan providers have expressed their concern about the trend toward greater freedom of choice in retirement plans. Hence, it becomes growingly important to investigate lay-peoples' strategies in picking investments to advise avoiding the most common traps.

A broad concern in this regard is 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, such as 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

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examined whether illusion of control can account for excessive investments in alternatives over which individuals seemingly 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 and (ii) the relation between past, randomly determined outcomes and predictions as well as subsequent investments.

The paper is organized as follows: the next section reviews some related literature followed by the description of the experimental design and procedure. Subsequently, findings are presented and finally discussed in a brief concluding section.

RELATED LITERATURE

Strategies of Individual Investors

When investigating diversification strategies of participants in 401(k) plans, Benartzi and Thaler [2001a] find that individuals frequently employ a 1/n-heuristic; that is, they distribute their savings equally among the offered funds regardless of their characteristics. This indicates that investments are neither based on risk assessments nor on considerations of the desired pension income and suggests 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 for choosing their investment funds. Hedesström, Svedsäter, and Gärling [2004] identify a number of common cognitive biases such as extremeness aversion, diversification heuristic, default bias and a strong preference for funds containing domestic equity.

One concomitant of domestically biased and therefore poorly diversified portfolios is excessive allocation to own company stock which poses a serious problem in many defined contribution plans. In 2001, for instance, Procter & Gamble's retirement saving plans consisted of 93% Procter & Gamble stocks (Poterba [2003]). 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, like in the case of U.S. energy trader Enron.

A possible behavioral 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 above average. Empirical evidence seems to support this conjecture as employees of companies that experienced the worst performance during the last 10 years allocated only 10% of their discretionary contributions to company stock, and employees of companies that experienced the best performance nearly 40%. Similarly, Huberman and Sengmüller [2004], 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 S&P 500 index than to returns below. Excessive extrapolation of past returns thus might be an important bias in investment decisions; however, it is not obvious why it should be restricted to own company stock.[2]

Apparently, many investors do not grasp the merits of diversification, that is, to reduce risk by stock return covariation (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 [2003, p. 3]). This impression is confirmed by Mitchell and Utkus [2003], who find that private investors consider company stock to be less risky than diversified funds. 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]).

Illusion of control, however, could influence portfolio choice also in a different way. Poor diversification and especially excessive own company investment could be caused by employees' feelings of having some control on the performance of their company and therefore stock values. Although this influence is in fact marginal, this illusion may contribute to the attractiveness of company stock.

Illusion of Control

In the psychological literature, illusion of control belongs to the more general class of egocentric biases, among overconfidence and unrealistic optimism (Fischhoff, Slovic and Lichtenstein [1977], Weinstein [1980], DeBondt and Thaler [1995]), 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 or 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 ask higher selling prices than people who have been assigned a ticket. Similarly, Davis, Sundahl, and Lesbo [2000] find that casino bettors places riskier bids on their own dice rolls than on others.

Illusion of control is usually intensified by a feeling of skill or competence, even when the outcome is purely random. In an experiment by Heath and Tversky [1991], subjects first had to answer knowledge questions and state how confident they were about their answer being correct. Afterwards, they could bet on either their confidence judgment or an equiprobable chance event. The results show that people even pay a premium to bet on their own judgment, yet only when they consider themselves knowledgeable. Some circumstances seem to mitigate illusion of control: Dixon [2000], for instance, finds that illusion of control is attenuated by purposeful instructions, and Koehler, Gibbs, and

Hogarth [1994] as well as Ladouceur and Mayrand [1984] observe illusion of control only in single shot but not in multiple games.

Although considered as important for stock market phenomena (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 a gambling context. An experimental study that does attend to the phenomenon is provided by Charness and Gneezy [2003], who investigate common biases such as ambiguity aversion, myopic loss aversion, and illusion of control when investing in a risky lottery. Their results indicate that 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 partly contradicts the results presented here.

This experimental study contributes to the existing literature by testing different psychological determinates of diversification strategies with a particular focus on the impact of illusion of control. Do individuals invest more in a lottery when they are in charge of the random device that determines its outcome? We vary the extent of illusion of control by either assigning subjects one of two lotteries for which they can exercise the random draw or by letting them choose the respective lottery (without cost). Furthermore, two additional factors of portfolio choice are investigated. First, the well established evidence that people dislike to depart with default alternatives (Samuelson and Zeckhauser [1988]) is applied to see whether the preference for the status quo mitigates excessive investment due to illusion of control. Second, the excessive extrapolation hypothesis is examined for the first time in the context of portfolio choice.

Results indicate that illusion of control can create distorted investments. The offer of a default portfolio indeed affects subjects' final allocations even when the default option is rejected. Presented random histories of lottery draws influence outcome predictions and these, in turn, affect investments as anticipated by the excessive extrapolation hypothesis. Generally, subjects become less risk averse over time but invest more risk-averse subsequent to an investment failure.

EXPERIMENTAL SETUP

Investment Setting and Procedure

Overall, 182 subjects of Jena University were recruited for participation using ORSEE (Greiner [2004]). The experiment was conducted computerized using z-Tree (Fischbacher [2007]) at the Max Planck Research Laboratory. The age of the 73 male and 109 female participants ranged from 18 to 32 years, and they earned on average €12.5 (standard deviation of €6.1), including a show-up fee of €3.5. Upon arrival at the Max Planck Research Laboratory, participants were randomly seated in cubicles and instructions for the first stage were distributed.[3]

TABLE 1
Lottery Choices in the First Stage.

	Lottery X			Lottery Y		
Nr.	$p(\overline{x})$	$\overline{x}$	$\underline{x}$	$p(\overline{y})$	$\overline{y}$	$\underline{y}$
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

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 was taken from Holt and Laury [2002] with the intention of explaining portfolio allocations by risk attitudes. 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 two 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 was randomly selected by a die throw and paid out at the end of the experiment. In each period, subjects had to distribute their endowment of 100 ECU[4] among three 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 $\overline{c}$. 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 throughout periods so that learning of the investment situation was easily possible.

Subjects were told that 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 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,

TABLE 2
Returns of Investment Options in Each Period.

Period	Investment A		Investment B		Investment C
	a_1	a_2	b_1	b_2	$\bar{c}$
1	2.50	0.33	3.00	0.50	1
2	2.50	0.20	3.00	0.70	1
3	2.40	0.25	3.00	0.75	1
4	2.67	0.00	3.30	0.50	1
5	2.50	0.33	2.80	0.67	1
6	2.60	0.40	2.80	0.60	1

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

subjects learned whether their investment profit exceeded the target level and if so, how much they had earned. Subjects were informed that only one out of the six periods would be randomly selected to be paid out.

Let us denote the share of the endowment invested in alternatives A, B and C by a, b, and c, respectively, with $a + b + c = 100$. 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]

$$b \geq \frac{(l - 100\bar{c}) + a(\bar{c} - a_2)}{b_1 - \bar{c}} \quad (1)$$

$$b \leq \frac{(l - 100\bar{c}) + a(\bar{c} - a_1)}{b_2 - \bar{c}} \quad (2)$$

$$b \leq 100 - a \quad (3)$$

with $a_1, b_1 > c > a_2, b_2$. Inequality (1) ensures l with probability ½ in case of (a_1,b_1) and (a_2,b_1), whereas inequality 2 ensures l with probability ¼ in case of (a_1,b_2). The intuition is 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 in Table 3 for all six periods. Figure 1 illustrates the solution space for period 1 that is created by inequalities (1), (2), and (3) graphically. Although 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 (a = 50, 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, for example, investing only in the option with the higher expected return, is reflected in the considerable chance to exit the experiment without investment earnings.[8]

Treatments

Eight different treatments were considered to investigate factors that influence individual portfolio selection. In the *baseline treatment,* subjects (n=30) simply faced the investment

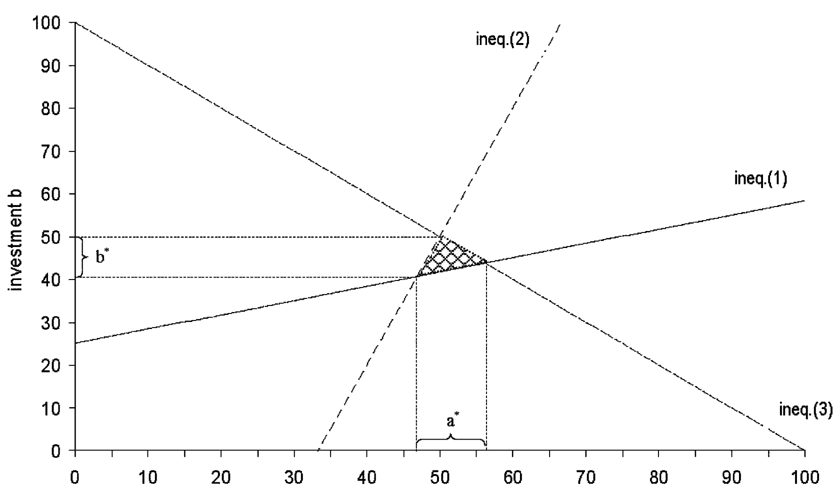

FIGURE 1 Solution Space for Investments a and b in Period 1.

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. At an odd number (1,3,5), 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.

The first three treatments look at the effect of illusion of control, which was induced by instructing subjects that (i) they will determine the outcome for one of the investments by throwing the die themselves and that (ii) they can individually choose the three winning numbers for this investment. In the *IOC-A treatment* (n = 17), subjects had to determine the outcome of investment A and in the *IOC-B treatment* (n = 15) the outcome of investment B. In a further session (n = 30), subjects were offered to choose on which investment to exercise control by throwing the die (*IOC-choice treatment*).[9]

To investigate whether offering a default portfolio affects final allocations, further three treatments were considered. In these treatments, illusion of control for option *B* was induced just like in treatment *IOC-B*. One group of subjects was offered a default portfolio that contained only option A (*default-A treatment*, n = 20), and another received only option B (*default-B treatment*, n = 20). A third group received a portfolio that was equally diversified among all options A, B and C (*default-diverse treatment*, n = 20). In all treatments, subjects could decide to accept the proposed allocation, or to reject it and compose their own portfolio at no additional cost.

To analyze whether showing samples of the random process and predicting future outcomes affects investments (in the sense of excessive extrapolation), the *treatment random history* (n = 30) was conducted. Subjects were presented with a sequence of five outcomes for both risky investments A and B that were generated by die throw before the experiment started. The numbers thrown for both lotteries were displayed on screen and it was indicated whether they had 'won' or 'lost' together with the investment return. Table 4 summarizes the outcomes of die throws presented to subjects in each period. First, subjects were asked to predict the next random outcome and second, they had to state their confidence in being correct in their prediction by adjusting a ruler ranging from 0% to 100% certainty.[10] To provide an incentive for 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.

All treatments were conducted in separate sessions. In the illusion of control 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 consisted of the show-up fee, the earnings from one randomly selected lottery choice task in 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 paid privately.

TABLE 4
Frequencies of Presented Random Outcomes for Both Investments in Treatment 'Random History'.

	Frequency of outcome			
	Investment A		Investment B	
Period	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

RESULTS

This section starts with a brief descriptive overview of risk attitudes elicited in stage one as well as general investment behavior of the baseline 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 earlier, and risk-averse if they switch later. Considering only those subjects who exhibit monotonic choice behavior in probabilities[11] (153 of 182), 8.5% can be classified as risk neutral (n = 13), 87.6% as risk-averse (n = 134) and 3.9% as risk loving (n = 6).[12]

In comparison to the solution space of the investment task presented in Table 3, subjects tend to overweight investment B and underweight investment A in their portfolios. Table 5

TABLE 5
Mean Investments (Standard Deviations) in Alternatives A, B and C in the Baseline 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)

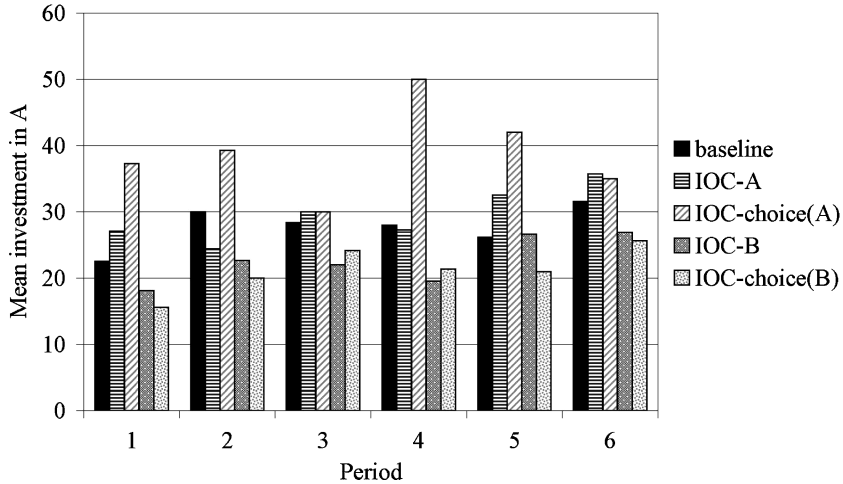

FIGURE 2 Mean Investment in A Per Period for the Baseline and All IOC-Treatments.

lists the average investments made by subjects in the baseline treatment.

Illusion of Control

First, average investments in all three alternatives by subjects in the illusion of control (IOC) treatments are compared to the baseline treatment. Figures 2 and 3 show the mean investment in A and B for the illusion of control treatments in every period. All differences between the treatments have the expected sign; that is, investment in A is higher and investment in B is lower by subjects who exercise control on A, and vice versa.

> **Observation 1** Subjects invest more in an alternative when they seemingly exercise control on its return. This is especially pronounced when subjects can choose the investment alternative to exercise control over.

Observation 1 relies on the results of a tobit regression on investments presented in Table 6.[13] This and all further regression analyses are reported separately for the first period, where experience with prior gains or losses is excluded, and periods 2 to 6 altogether. The dependent variables (investments a, b and c) are censored, that is, they lie in the interval [0, 100]. The independent variables include treatment dummies (where the baseline treatment serves as control), a dummy for *risk aversion* according to stage one (leaving risk-loving and risk-neutral individuals as residual category) and three 'experience dummies' for all periods except the first one: two dummy variables indicating whether lottery A and lottery B won in the previous period (*winA*, *winB*) and a dummy indicating whether the income target was reached (*target*). In the estimation for periods 2 to 6, period dummies are also included. In all following estimations, risk aversion, experience in previous periods and time are controlled for.

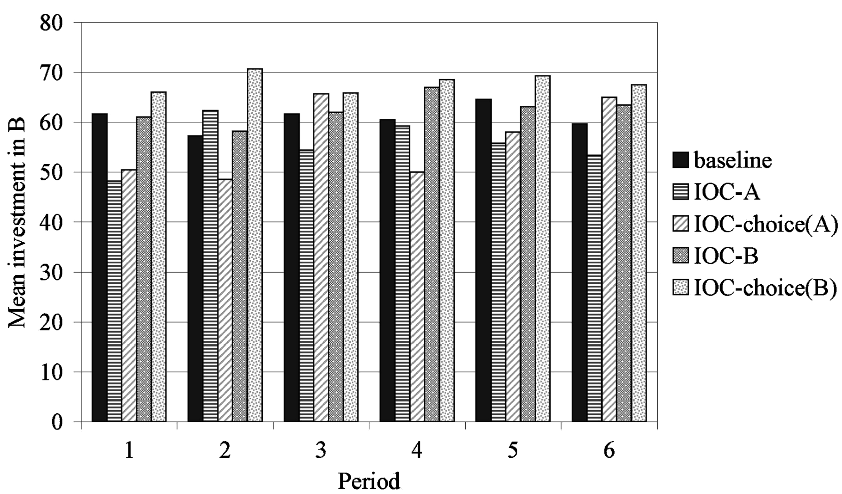

FIGURE 3 Mean Investment in B Per Period for the Baseline and All IOC-Treatments.

TABLE 6
Tobit Regression of Illusion of Control Treatments.

	Period 1			Periods 2 to 6		
Indep. Var.	Inv. A	Inv. B	Inv. C	Inv. A	Inv. B	Inv. C
IOC-A	11.22	−17.42	13.93	1.63	2.07	2.14
	(7.98)	(10.93)	(15.25)	(5.06)	(5.61)	(6.56)
IOC-B	−9.81	5.13	4.20	−14.01**	14.16**	9.37
	(9.51)	(12.45)	(17.28)	(5.89)	(6.50)	(7.30)
IOC-choice(A)	19.19**	−15.34	2.17	13.21*	−4.83	−23.37*
	(9.44)	(13.03)	(18.29)	(7.54)	(8.38)	(12.25)
IOC-choice(B)	−9.61	10.62	−0.53	−12.96***	16.58***	−3.29
	(8.01)	(10.80)	(15.11)	(4.70)	(5.19)	(6.03)
constant	−5.62	85.80***	−6.44	11.01	80.64***	−25.46***
	(9.30)	(11.65)	(16.14)	(6.98)	(7.72)	(9.78)
risk aversion		included			included	
period dummies		—			included	
experience dummies		—			included	
observations	77	77	77	385	385	385

Standard errors in parantheses.
Note. *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

These effects are explicitly addressed later on at the end of the results section and are therefore left out when reporting the results for the single treatments.

The effect of illusion of control is visible in several findings. Nearly all treatment coefficients have the expected sign for the respective investments: for instance, in period 1 subjects in the *IOC-A* treatment tend to invest more (yet not significantly) in lottery A and less in lottery B (the option over which they lack control) than subjects in the baseline treatment. For subjects in the *IOC-B* treatment, the situation is reversed. Considering only the statistically significant results, mainly periods 2 to 6 are of interest. Subjects in the *IOC-B* treatment invest significantly less in A and more in B. Although lottery B is already overweighted in the portfolios of the baseline group (over 60% on average), there is still room for an additional bias. Interestingly, the illusion of control bias toward lottery B is apparently reinforced by experience, since it does not emerge already in the first period.

When participants are able to choose the investment option on which to exercise control, the effect of illusion of control is more pronounced: Subjects who chose to control A (*IOC-choice(A)* treatment) invest significantly more in A throughout periods than subjects in the baseline treatment. Also, they leave a smaller fraction of their endowment for the riskless option C in periods 2 to 6. Subjects who chose to control B (*IOC-choice(B)* treatment) invest more in B and less in A than subjects in the baseline treatment in periods 2 to 6. Here, illusion of control appears only in later periods.

Finally, one can compare the two sub-groups who could choose the investment option to exercise control on within the *IOC-choice* treatment. The pairwise comparison per period (this time using non-parametric robust rank order tests) shows that 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 (on a 5%-margin). Also, in periods 1 and 2 subjects who choose B invest more in B than subjects who choose A.

Influence of the Default Portfolio

To investigate whether the composition of the default portfolio affects final allocations in the presence of illusory control, the three treatments *default-A*, *default-B*, *default-diverse* are (i) compared to treatment *IOC-B* and (ii) compared against each other.

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. Still, despite the low acceptance rates of defaults portfolios, final allocations are influenced by the offer.

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

Table 7 shows that when the default portfolio contains only lottery A (treatment *default-A*) investment in C is in periods 2 to 6 significantly lower than in the *IOC-B* treatment, even though all subjects rejected the default portfolio in the first place. The same applies to the *default-B* treatment. It seems that portfolios are already biased toward lottery B in *IOC-B* and therefore little changes when offering a default portfolio that contains only B. The equally diversified default portfolio (*default-diverse*) induces subjects to invest significantly more in lottery A and less in the otherwise overweighted lottery B.

TABLE 7
Tobit Regression of Default Portfolio Treatments (IOC-B As Base).

	Period 1			Periods 2 to 6		
Indep. Var.	Inv. A	Inv. B	Inv. C	Inv. A	Inv. B	Inv. C
defaultA	15.29	−3.41	−16.02	2.39	3.33	−16.39**
	(11.88)	(11.98)	(14.65)	(5.30)	(6.40)	(7.39)
defaultB	4.21	−1.86	0.60	0.07	2.85	−13.83*
	(11.83)	(11.84)	(13.88)	(5.32)	(6.41)	(7.38)
default-diverse	11.97	−16.19	11.82	8.96*	−15.99**	9.52
	(11.55)	(11.59)	(13.59)	(5.17)	(6.22)	(6.80)
constant	−19.85	92.49***	−6.42	5.80	83.15***	−12.27
	(16.32)	(13.50)	(16.05)	(7.67)	(9.24)	(11.11)
risk aversion		included			included	
period dummies		—			included	
experience dummies		—			included	
observations	59	59	59	295	295	295

Standard errors in parantheses.
Note. *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Comparing the treatments with different default portfolios directly provides a more informative impression. Table 8 shows a tobit regression that includes only the default treatments. The independent variables include treatment dummies for *default-A* and *default-B* treatments, so that *default-diverse* serves as the baseline.

Subjects in the *default-A* treatment invest less in option C, that is, less risk-averse, than subjects in the *default-diverse* treatment, but more in lottery B, at least in later periods.

Similarly, in the *default-B* treatment, risk-free investments as well as investments in A are lower than in the *default-diverse* treatment, but investments in B are higher. The regression results show that portfolios in both, the *default-A* and *default-B* treatment, are highly concentrated on lottery B.

From a different perspective, this evidence suggests that offering a well-diversified default portfolio leads to more diversified final portfolio allocations and therefore mitigates poor diversification and attenuates the effects of illusion of control. In this particular investment setting, the proportions of the otherwise overweighted investment B can be reduced close to the theoretically suggested level (see Table 9).

Finally, we now turn to the results of the *random history* treatment that does not deal with illusion of control but offers another explanation for biased portfolios.

Relation of Past Random Sequences, Predictions and Investments

Subjects who are confronted with a sequence of random die throws invest in the first period significantly less in lottery B than subjects in the baseline group (see Table 10) and tendentiously, yet not significantly, more in lottery A. It seems that the saliency of the random process initially induces more

TABLE 8
Tobit Regression of Default Portfolio Treatments (Default-Diverse As Base).

	Period 1			Periods 2 to 6		
Indep. Var.	Inv. A	Inv. B	Inv. C	Inv. A	Inv. B	Inv. C
defaultA	3.57	12.37	−26.88**	−6.79	19.38***	−25.62***
	(9.81)	(9.03)	(11.50)	(4.53)	(5.21)	(6.73)
defaultB	−7.39	14.00	−10.85	−9.34**	18.91***	−22.92***
	(9.74)	(8.88)	(10.56)	(4.33)	(4.97)	(6.39)
constant	6.39	86.00***	22.97***	6.25	83.71***	20.12*
	(18.23)	(17.20)	(7.20)	(10.71)	(12.46)	(10.52)
risk aversion		included			included	
period dummies		—			included	
experience dummies		—			included	
observations	48	48	48	240	240	240

Standard errors in parantheses.
Note. *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

TABLE 9
Mean Portfolios and Standard Deviations in the Default Treatments over all 6 Periods.

	Investment A		Investment B		Investment C	
DefaultA	27.45	(21.51)	63.75	(24.94)	8.79	(17.96)
DefaultB	21.85	(21.18)	65.67	(27.53)	12.48	(19.89)
Default-diverse	28.08	(17.09)	52.90	(20.45)	19.00	(17.90)

cautious investment behavior which becomes less important as subjects gain experience.

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.

In addition to seeing the sequence of previously realized returns for both investments, subjects had to predict which return would 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%), indicating overoptimism.

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.

On the basis of literature on excessive extrapolation (DeBondt [1993], Benartzi [2001]), 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 only for investment B: The larger the percentage of high returns subjects have seen in the history of random die throws for B, the more likely they are to make a high return prediction (Spearman rank correlation: $\rho_{\text{predB}-\text{histB}} = .16$, $p = .02$). 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: $\rho_{\text{predB}-\text{investB}\bullet\text{histB}} = .13$, $p = .04$). 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, predictions for A and B are unrelated to the actual return of both lotteries in the previous period.

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, a fraction that is significantly higher 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 ($\rho_{\text{certB}-\text{investB}} = 0.15$, $p = .02$).

Behavior over Time

To obtain a more detailed picture of portfolio allocation and learning processes, the dynamics for the pooled data set over periods is analyzed.

Again, a tobit regression model is estimated with investments a, b and c ($\in[0; 100]$), respectively, as dependent variables and with the following independent factors: *risk aversion* (1 if the subject is risk-averse according to stage 1), return dummies for both risky investments in the previous period, i.e. *winA* (1 if lottery A won) and *winB* (1 if lottery B won), a dummy for the achievement of the profit *target* in the previous period (1 if target was reached), period dummies and treatment dummies, where the baseline treatment is the one left out.

Table 11 shows that the coefficient for risk aversion is positive and significant for investments in lottery A and in

TABLE 10
Tobit Regression of Random History Treatment.

	Period 1			Periods 2 to 6		
Indep. Var.	Inv. A	Inv. B	Inv. C	Inv. A	Inv. B	Inv. C
random history	9.84	-16.11^{**}	16.88	3.46	-3.66	6.79
	(6.22)	(6.91)	(10.59)	(5.26)	(5.44)	(8.72)
constant	-10.75	101.16^{***}	-20.39	3.89	82.87^{***}	-32.25
	(10.56)	(11.24)	(17.41)	(11.63)	(12.03)	(20.13)
risk aversion		included			included	
period dummies		—			included	
experience dummies		—			included	
observations	53	53	53	265	265	265

Standard errors in parantheses.
Note. *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

TABLE 11
Tobit Regression on Investments Over All Treatments.

Indep.Variable	Investment A		Investment B		Investment C	
risk aversion	18.24***	(3.52)	−22.88***	(4.00)	17.98***	(5.57)
winA	1.00	(2.53)	−2.35	(2.88)	2.07	(3.73)
winB	−10.49***	(3.77)	5.82	(4.30)	16.46***	(6.00)
target	10.41***	(3.65)	−2.74	(4.16)	−22.29***	(5.77)
period3	0.08	(3.45)	2.70	(3.93)	−6.39	(5.04)
period4	−1.62	(3.47)	4.54	(3.94)	−6.49	(5.02)
period5	1.58	(3.49)	3.13	(3.97)	−9.85*	(5.15)
period6	4.33	(3.43)	1.00	(3.91)	−11.67**	(5.12)
constant	9.53*	(5.01)	78.36***	(5.68)	−20.85***	(7.92)
treatment dummies			included			
observations	765		765		765	

Standard errors in parantheses.
Note. *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

the risk-free alternative C, and negative and significant for lottery B.

Observation 5 Risk aversion as elicited by lottery comparisons translates into more risk-free investment, higher investment in the less risky lottery A and lower investment in the riskier alternative B.

The proportion invested risk-free declines over time as can be seen by the negative and significant dummies of periods 5 and 6.[14]

Observation 6 Subjects invest less risk averse over time.

One possible reason is that subjects learn how to diversify well over time, because investments in C are usually too high. Although investment in A increases slightly yet not significantly throughout periods, overall, no apparent convergence of A and B to the proposed levels can be observed, which contradicts this conjecture.

Observation 7 People invest more risky, that is, 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, that is, 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 in dynamic settings are more risk taking after a gain, called the house money effect (Thaler and Johnson [1990]). 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 past periods has mixed consequences for present investment: investment in alternative A is lower and risk-free investment 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 previous periods does not have consequences for subsequent investments.

DISCUSSION

Illusion of control is 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 illusion of 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, for example, by throwing a die and picking the winning numbers.

Studying this phenomenon is important in light of well-established evidence that many portfolio allocations, particularly of retirement saving plans, are poorly diversified and massively biased toward one's own company stock. A possible stream of explaining this phenomenon is that individuals think 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 is investigated in this experiment. Benartzi [2001] claims that individuals excessively extrapolate past returns and consequently invest more in companies that recently performed well. To avoid deceiving participants in the experiment, true random sequences of outcomes were shown before asking subjects to make predictions for both risky lotteries, prior to the investment task. Thus, the sequences of previous outcomes are only unsystematically varied. Although, both illusion of 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. Remarkably, both effects are not universally observable but mainly emerge only for one of the investment alternatives.

Illusion of control appears mainly for the lottery that is already overweighted in the portfolio: If individuals are assigned (illusionary) control over this lottery, portfolios become even more biased. Particularly, illusion of control seems to contain a particular self-selection aspect. When individuals can choose the lottery they want to exercise control on, investments become even more distorted. 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 than in the laboratory. Also, real life decisions usually lack instant and unambiguous feedback on success, which makes learning difficult. 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 simplicity of the investment task renders an optimal decision easier and makes the uncontrollability of the chance move more salient than the complex environment of financial markets. It is thus fair to say that the experimental manipulations are fairly weak and the findings rather represent a lower estimate of the phenomenon.

Excessive extrapolation occurs only for the generally favored alternative. The results show that investments are contingent on predictions for lottery B but cannot directly be related to the sequence of previous outcomes. Still, it is not clear, whether individuals invest more in this alternative because they have made high predictions before, or whether they make high predictions because they intrinsically like the lottery. Predictions are on aggregate overly optimistic for both risky investments. However, the fact that relations between the random sequence and the prediction, and between the prediction and the investment, respectively, exist only for the generally overweighted lottery supports the assumption of wishful thinking: individuals seem to direct their attention and optimism toward the alternative for which they have 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.

With respect to institutional design that might guide individuals to consider a broader range of investments, this study also addresses the influence of offering different default portfolios on final allocations. 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. Also Hedesström et al. [2004] 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 default offered and rarely restructure their investments, it is crucial to consider how to arrive at recommendations for different clients.

As to general behavioral patterns, risk aversion is found to predict investment behavior well which confirms 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.

The design of (retirement) saving plans becomes an increasingly important issue (Benartzi and Thaler [2003], Mitchell and Utkus [2006]). Sponsors are well advised to consider investors' cognitive limitations when designing such plans. To attenuate, for instance, own company investment, one has to carefully consider that this tendency may reflect the underestimation of risk that may in turn result from different behavioral sources, such as illusion of control, overly optimistic return predictions, or simply inertia to stick to the default offered. It is therefore vital to assist investors in basing their fund choice on elaborate considerations of risk attitude and desired retirement income.

The results of this study primarily point to some fundamental pitfalls when picking an individual portfolio. Especially employees with little financial expertise may fall prey to one of two serious misconceptions when making retirement saving plan decisions: first, they may perceive own company's performance as more controllable than it is and over-invest accordingly. Second, they may concentrate their savings on too few stocks in the illusion that the performance of a smaller portfolio is easier to monitor and is thus controllable.

However, also important implications for financial markets can be derived. A (spurious) feeling of control is usually created by own activity. This may lead investors to think that an overly active trading strategy is able to compensate for broad portfolio diversification in reducing overall portfolio risk, when in fact, frequent buying and selling is disadvantageous to investors' wealth (Barber and Odean [2000]). Especially the internet has contributed to a massive increase in trading volume (Barber and Odean [2001]) by simplifying portfolio management and making it feasible to a broad public, which, in turn, may inspire illusion of control even more. Thus, illusion of control not only easily leads to serious misinvestments but can also contribute to excessive trading activity on markets and feed bubbles. Future research should attend to these aspects and substantiate the link between illusion of control and trading activity.

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NOTES

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]).
2. While nonexperts 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]).
3. Instructions are available from the author upon request.
4. The exchange rate to € was 20:1; that is, 100 ECU corresponded to €5.
5. This procedure of reaching a target resembles aspiration levels as suggested by the bounded rationality concept (Simon [1955]). Not only does it help to make the merits of diversification clear to subjects, but it also supports the saliency of payments: the endowment is only of value if subjects succeed in increasing 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 $\mu - \sigma$-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 results on the elicitation of individual risk attitudes justify the general assumption of risk aversion.
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. In any case subjects were compensated with the show-up fee and earned a small amount according to their lottery choice in stage one.
9. The fact that in the baseline treatment one die throw determines the return of the investment for all participants while in the illusion of control treatments, subjects individually throw the die for one of the two investments creates more heterogeneity in payments in the illusion of control treatments than in the baseline 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.
10. It was duly explained that, for instance, a confidence level of 100 means being correct 100 times out of 100 predictions. Subjective confidence was, however, not monetarily rewarded.
11. 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.
12. 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.
13. The advantage of a regression analysis in comparison to non-parametric comparisons of distributions is that potentially influential personal characteristics, like risk attitude, or situational parameters, such as win or loss experiences, can be controlled for. However, all results can essentially be reproduced in nonparametric pairwise treatment comparisons.
14. Note, that the base period in this regression is in fact period 2, since period 1 is not considered because of lagged variables. Taking period 1 as baseline instead, risk-free investment decreases significantly over all periods.

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