

Anderhub, Vital; Güth, Werner; Knust, Florian

Working Paper

On saving and investing: An experimental study of intertemporal decision making in a complex stochastic environment

SFB 373 Discussion Paper, No. 2000,2

Provided in Cooperation with:

Collaborative Research Center 373: Quantification and Simulation of Economic Processes, Humboldt University Berlin

Suggested Citation: Anderhub, Vital; Güth, Werner; Knust, Florian (2000) : On saving and investing: An experimental study of intertemporal decision making in a complex stochastic environment, SFB 373 Discussion Paper, No. 2000,2, Humboldt University of Berlin, Interdisciplinary Research Project 373: Quantification and Simulation of Economic Processes, Berlin, <https://nbn-resolving.de/urn:nbn:de:kobv:11-10047057>

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On Saving and Investing

-An experimental study of intertemporal decision making in a complex stochastic environment -*

Vital Anderhub, Werner Güth and Florian Knust

Abstract

The experimental situation presents a complex stochastic intertemporal allocation problem. First, two initial chance moves select one of three possible termination probabilities which then determines whether "life" lasts 3,4,5, or 6 periods. Compared to Anderhub et al. (1997) participants are allowed to invest into a risky, but profitable asset. We investigate whether the willingness to invest can help to explain saving behavior, i.e. experimentally observed intertemporal decision making.

*The financial support of the Deutsche Forschungsgemeinschaft (SFB 373, C5) and the TMR-project "Savings and Pensions" by the European Commission is gratefully acknowledged.

1 Introduction

Optimal intertemporal decision making in a stochastic environment requires considerable analytical skills. Boundedly rational decision makers typically fail in achieving the best outcome. This explains why experimental studies of intertemporal decision making (see the selective survey of Anderhub and Güth, 1999) may offer stylized facts which can guide our intuition about how boundedly rational decision makers generate choices.

The study at hand continues previous experimental research (Anderhub, Güth, Härdle, Müller, and Strobel 1997, Anderhub 1998, Anderhub, Müller, and Schmidt 1998, Brandstätter and Güth, 1998) which all rely on variations of the same basic experimental design. Its main feature is the complex stochastic nature of future expectations combining the difficulties of Bayesian updating with those of dynamic programming (studies with stationary stochastic processes are Hey and Dardanoni 1988 and Köhler 1996).

According to the basic experimental setup a "life" consists of at least 3 and at most 6 periods $t = 1, 2, \dots, T$ with $3 \leq T \leq 6$. At the beginning an initial endowment of 11.92 ECU (Experimental Currency Unit) is available. Denote by x_t the expenditures in period t and by S_t the remaining capital in period t , i.e. $S_1 = 11.92$. Since $S_{t+1} = S_t - x_t$ a participant is forced to decide between spending more in period t or keeping more for the future. Although Anderhub et al. (1997), have also studied another intertemporal utility function, we restrict attention to the version where

$$U = x_1 \cdot \dots \cdot x_T = \prod_{t \leq T} x_t.$$

If $T < 6$ and $S_{T+1} > 0$, the amount kept for the future is lost. Conversely, $x_t = 0$ implies the worst result. This illustrates the conflict when saving for an uncertain future.

How is the final period T stochastically determined? In the experiment three differently colored dice (green, yellow, and red) represent three different termination probabilities ($\frac{1}{6}$ for green, $\frac{1}{3}$ for yellow, and $\frac{1}{2}$ for red) to be applied after the 3rd period. After the choice of x_1 , one die is taken out, after choosing x_2 the second one. Thus only from the

3rd period on a participant encounters a constant termination probability which is then applied repeatedly to determine whether "life" extends over $T = 3, 4, 5$, or 6 periods.

To allow for learning a participant did not "live" only once, but experiences 12 successive "lives". A minor experimental control concerned the possible sequences of "initial chance moves", namely the taking out of dice. A participant experienced all 6 sequences in a random order (1st cycle) and then again the 6 sequences in another random order (2nd cycle)¹.

Instead of imposing that participants are paid according to their average success U (in the 12 successive "lives") or according to a randomly chosen "life" participants can choose the payoff mode before starting to play. It was hoped that this self selection (see Section 4.8 of Anderhub et al., 1997) would yield an important classification of participants. Unfortunately, the results were not too encouraging. In the present study we therefore allow for more self screening.

How has this been implemented? Whereas Anderhub (1998) has reduced stochastic uncertainty (the dice represented certain "life" expectations, namely $T = 6$ for green, $T = 5$ for yellow, and $T = 4$ for red), in our experiment participants could add another uncertainty concerning their future expectations. More specifically, after choosing x_1 and before excluding the first die a participant could invest any amount y with $0 \leq y \leq S_1 - x_1 = 11.92 - x_1$ into a risky "asset" yielding $\frac{4}{3}y$ with probability $\frac{2}{3}$ and $\frac{2}{3}y$ with probability $\frac{1}{3}$ in period 2, i.e.

$$S_2 = 11.92 - x_1 + \frac{y}{3} \text{ with probability } \frac{2}{3}$$

and

$$S_2 = 11.92 - x_1 - \frac{y}{3} \text{ with probability } \frac{1}{3}.$$

The choice to invest into such a risky asset with the positive expected dividend of $\frac{y}{9}$ has been restricted to just one period. We were afraid of overburdening our participants with

¹Anderhub et al. (1997) did not find any evidence indicating that participants detected this regularity.

too many such investment decisions and further chance moves and also wanted to limit the maximal possible payoff U of the participants.

Clearly the new experimental scenario offers now two possibilities for distinguishing participants: The old discrete one of A -types (average payoff) and R -types (random payoff) and the new continuous screening variable y with $0 \leq y \leq S_1 - x_1$ indicating how willing a participant is to invest into a risky, but profitable asset.

Compared to other experimental studies (see Camerer, 1995) of risky investments our experimental scenario has the advantage that the risk resulting from investing is not the only one. It is rather embedded in a highly stochastic environment where self-imposed investment uncertainty combines with exogenously imposed uncertainty, here whether T will be 3, 4, 5, or 6. In our view it is important to learn how the existence of exogenously imposed risk (which always exists in life) interacts with risky investment behavior. One reasonable hypothesis along these lines is, for instance, that exogenously given risk crowd out voluntary risk taking.

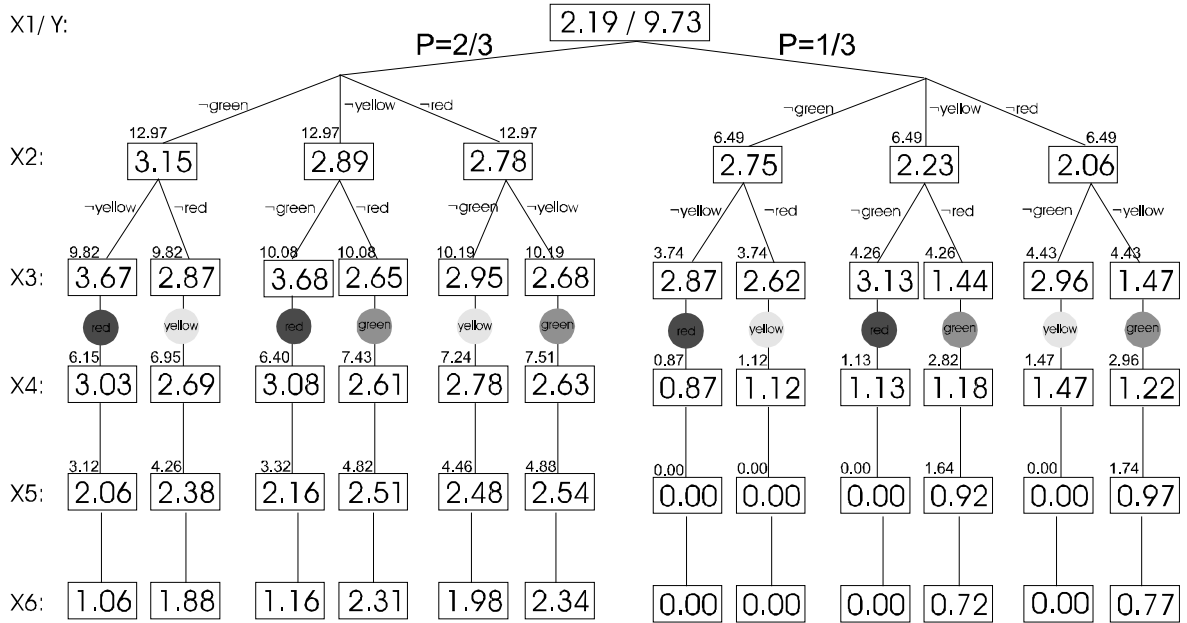


Figure 1: Optimal solution for the case of risk neutrality

As in Anderhub et al. (1997) and Anderhub (1998) we have derived the optimal trajectories for a risk neutral decision maker whose expected payoff is $U = 80.54$ ECU (see Figure

1). After $x_1^* = 2.19$ the initial choice determines whether the green ($\neg green$), the yellow ($\neg yellow$), or the red ($\neg red$) die is taken out. This is followed by the chance move determining whether investment $y^* = 9.73$ is yielding $\frac{4}{3}y$ (with probability $\frac{2}{3}$) or $\frac{2}{3}y$ (with probability $\frac{1}{3}$). After x_2 is chosen, the second die is taken out. Finally after x_t for $t \geq 3$ it is randomly decided whether $T = 3, 4, 5$, or 6 . The optimal choices for the respective chance events are listed inside the boxes whereas the residual funds S_t resulting from those choices are indicated above the boxes. Our experimental software automatically implemented the choice $x_6 = S_6$ although rare choices $x_6 < S_6$ might have singled out participants who have not understood basic aspects of the intertemporal allocation problem.

2 Experimental design

Our design corresponds to the one of Anderhub et al. (1997) except for the necessary changes in the instructions as well as in the software required by the additional second decision stage in period $t = 1$ when a participant chooses y with $0 \leq y \leq S_1 - x_1$. In the instructions (see appendix for the English translation) the novel sections are indicated by italic letters. Further helpful devices were a short information showing the probabilities for the three differently colored dice, a protocol of the own previous experiences, and a calculator.

Fifty participants were invited by leaflets to register for an experimental session which would last at most 2 hours. Actually the time needed for the 12 successive "lives" ranged from 13 to 103 minutes (without the time for reading and understanding the instructions in the beginning). In addition to the payoff relevant choices x_t and y we also asked for plans regarding future expenditure levels although previous results have shown that many participants try to answer such questions quickly rather than carefully. Dropping such questions might, however, influence behavior and thus the possibility to compare our results to previous ones. Each participant also answered the 16PA-personality questionnaire (Brandstätter, 1988) which can be used to account for individual differences in intertemporal decision making (Brandstätter and Güth, 1998).

Participants were mainly students of economics and business administration of Humboldt University of Berlin. Although the maximal payoff expectation U is much larger due to

the possibility of engaging once into a risky, but profitable asset, the average earning does not reflect this. Although in our experiment the maximal payoff expectation $U = 80.54$ ECU (1 ECU = 0.50 DM) exceeds the one of $U = 35.16$ ECU (1 ECU = 1 DM) in the Anderhub et al. 1997 experiment, the average earning of 39.72 ECU (49% efficiency) is much smaller than the average payoff 27.62 ECU (79% efficiency) in the Anderhub et al. experiment.

How sensitive is the payoff expectation to changes in the new decision variable y ? To illustrate this we have derived for all possible decisions y the optimal intertemporal allocation behavior $x_t^*(y)$ for $t = 1, 2, \dots, 6$ and all possible chance events for the case of risk neutrality². For given y one computes the optimal consumption as in Figure 1 for $y^* = 9.73$. Let $U(y)$ denote the payoff expectation resulting from these optimal trajectories for a given investment y . In Figure 2 it is graphically illustrated how $U(y)$ depends on the investment level y . To the right hand side of the optimal investment level $y^* = 9.73$ the decline of $U(y)$ is much steeper³. In general, wrong choices y can drastically reduce the payoff expectation $U(y)$. Choosing $y = 0$ instead of $y^* = 9.73$ means, for instance, to cut one's payoff expectation by more than half.

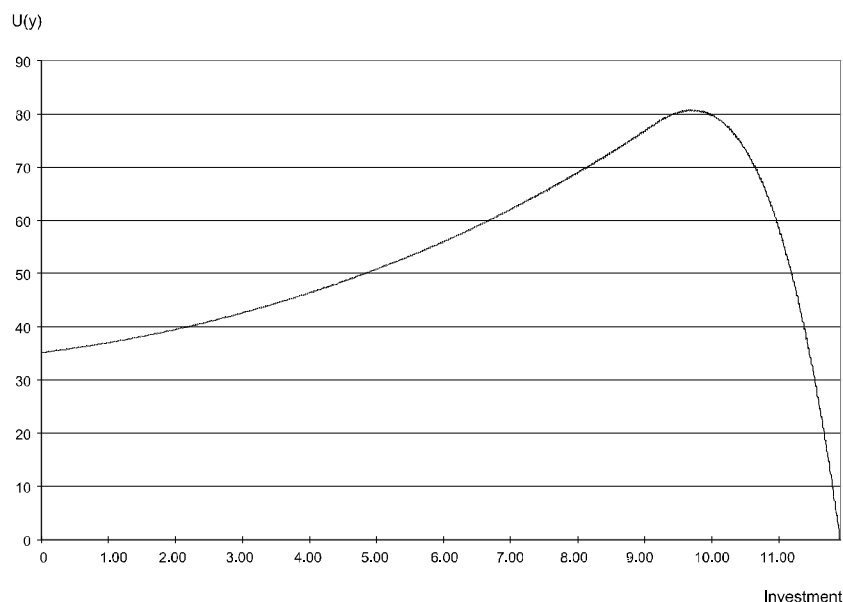


Figure 2: Expected value $U(y)$ depending on investment y

²Note that risk neutrality implies that the optimal investment level y^* is the maximal one, i.e. $y^* = S_1 - x_1$.

³If y approaches $S_1 = 11.92$ this means that x_1 converges to 0 what implies $U(y) \rightarrow 0$ for $y \rightarrow S_1$.

Of course, one cannot expect that participants are aware of how $U(y)$ depends on y . But they nevertheless understand the risks of too large investments, e.g. in the sense of $y \geq 10$, and that underinvestments, e.g. in the sense of $y < 9$, are less dangerous. Clearly, a general attitude to under- and even more to overinvest can explain why participants have earned less than in previous experiments although they could have earned more.

3 Experimental results

In view of the earlier studies we mainly analyse the investment decision y which is the new (screening) variable. On average more than half of $S_1 - x_1$ is invested in the risky prospect (see Figure 3 which displays the average y and the available funds $S_1 - x_1$ for the 12 successive "lives"). Of course, larger investments y imply on average a larger variance of actual earnings (see scatter plot in Figure 4).

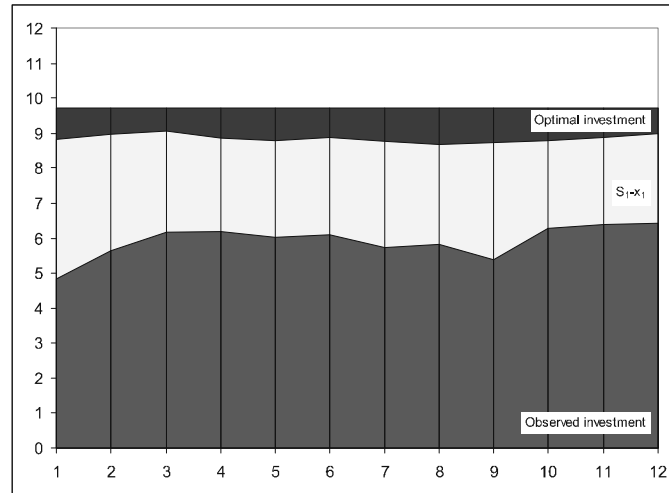


Figure 3: Average investment $\bar{y}$, optimal value y^* and average available funds $\bar{(S_1 - x_1)}$

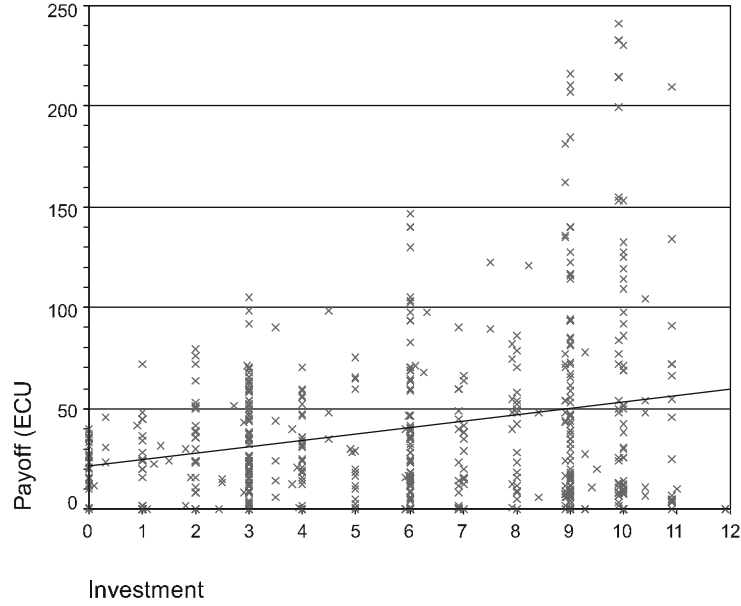


Figure 4: Investment y and the resulting monetary gains U

Of the altogether $50 \cdot 12 = 600$ plays 224 or 37.33% rely on full investment $y = 11.92 - x_1$. How the average absolute and relative investment share $\bar{\varnothing}y$ and $\bar{\varnothing}y/(11.92 - x_1)$, respectively, depends on the payoff type (R for random and A for average) as well as on experience (1^{st} versus 2^{nd} cycle) is described by Table 1. A -types slightly increase their investment and R -types slightly decrease it with experience, both absolutely and relatively. Note, that only five participants chose the random payoff procedure.

	payoff type					
	A (N=45)		R (N=5)		<i>both</i> (N=50)	
	1^{st} cycle	2^{nd} cycle	1^{st} cycle	2^{nd} cycle	1^{st} cycle	2^{nd} cycle
$\bar{\varnothing}y$	5.86	6.11	5.50	5.05	5.83	6.00
$\bar{\varnothing}(y/(11.92 - x_1))$	.66	.69	.59	.55	.65	.68

Table 1: Average investment ($\bar{\varnothing}y$) and average investment share ($\bar{\varnothing}(y/(11.92 - x_1))$) depending on payoff mode and experience

In Figure 5 we have illustrated how often participants have chosen different y -levels. None of the 50 participants has chosen 12 different investment level y , and only one participant has always relied on the same y -choice, namely $y = 3.00$ ECU. The main tendency is to try out 3 to 5 different y -levels.

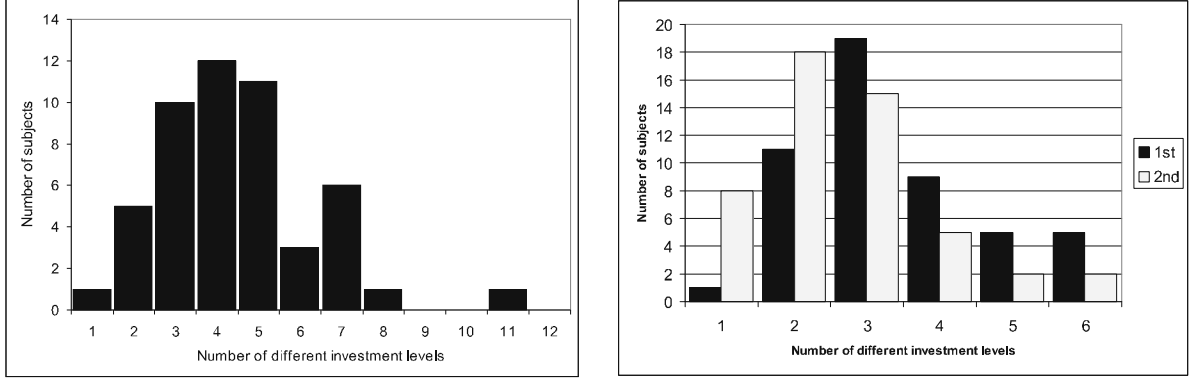


Figure 5: Number of different investment levels
(all 12 rounds left – separated by cycles right)

During the second cycle the average number of different y -levels is 2.62 which is smaller than the corresponding level 3.42 for the first cycle. During the second cycle the number of investment levels stabilizes at using 1 to 3 different levels. Of course, y -choices are often prominent numbers, e.g. 3.00, 4.00, 6.00, 9.00, 9.92, or 10.00 are chosen 104, 28, 86, 80, 26, and 39 (in total 363 of 600) times. It is conspicuous that the most frequent numbers are not only prominent number, but numbers which are also prominent for the investment returns, i.e. in this case if they can be divided by 3 (3.00, 6.00, and 9.00).

In Figure 6 one can see how lucky investments (411 of 600 plays) led to higher average consumption choices $\emptyset x_t$ in periods $t = 2$ to 6 than unlucky ones (189 of 600 plays) where the average starting condition is described by $\emptyset x_t = 3.07$ and $\emptyset y = 5.91$. Even in the last and most unlikely period $t = 6$ one usually consumes much more after a lucky investment than after an unlucky one (the frequency of $x_6 = 0$ is 8.1% (11/136) for the left branch of Figure 6 and 16.8% (9/57) for the right one). The frequency of reaching a certain box, i.e. of the respective chance moves, is always indicated above the respective box in Figure 6.

One of the most interesting results is, that the mean of x_1 is essentially higher than for the benchmark case of the optimal solution. Even though the optimal x_1 -decision for this game ($x_1 = 2.19$) is lower than for the game without the possibility of investment ($x_1 = 2.49$, see Anderhub et al. 1997), the observed values for x_1 are significantly higher for this experiment ($\bar{x}_1 = 3.07$) than for the game without ($\bar{x}_1 = 2.64$) the possibility of investment (Mann–Whitney–U test, $p = 0.019$).

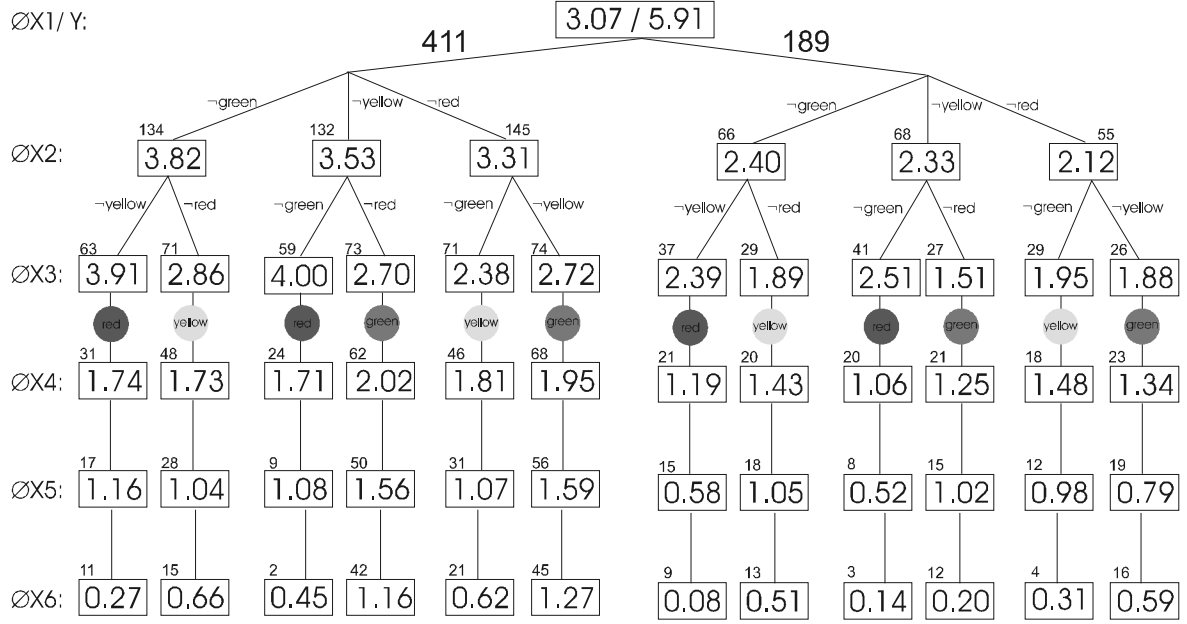


Figure 6: Average observations

In many experimental studies of risk-taking (e.g. Levin, Snyder and Chapman, 1988) a gender effect could be observed, which can also be found in our experiment. Altogether we had 38 male and 12 female participants. The mean investments are significantly higher for male ($\bar{y} = 6.53$) than for female ($\bar{y} = 4.00$) participants (Mann–Whitney–U test, $p = 0.003$).

Reinforcement learning (e.g. as formulated by Bush and Mosteller, 1955, or Erev and Roth, 1998) predicts that success of an action strengthens the tendency for this particular action. Applied to investment behavior thus lucky investments should lead to larger or equal investments later. On the other hand it has been argued (Kahneman and Tversky,

1979) that losses lead to more risk taking since one wants to recapture what has been lost (on financial markets this can explain the frequent phenomenon of "Overriding losses", e.g. Weber and Camerer, 1992). In Table 2 we distinguish the three possibilities, namely an increase of the investment level ($y_t > y_{t-1}$), equal ($y_t = y_{t-1}$), or lower ($y_t < y_{t-1}$) investments for the two possible chance events. The share 78.36% of cases with $y_t \geq y_{t-1}$ after bad luck exceeds the corresponding share 74.41% for previous good luck. Also for the more narrow concept of strict reinforcement (in the sense of $y_t > y_{t-1}$) the result is with 32.16% for bad and 27.44% for good luck to reinforcement learning is not supported. It rather seems as if good and bad experiences inspire investments.

	unlucky in $t - 1$	lucky in $t - 1$	total
$y_{t-1} > y_t$	37	97	134
$y_{t-1} = y_t$	79	178	257
$y_{t-1} < y_t$	55	104	159
total	171	379	550

Table 2: Reinforcement learning

Since from period $t = 3$ on a later period $t + 1$ is less likely even boundedly rational intertemporal allocation behavior should satisfy the requirement $x_t > x_{t+1}$ for $t = 3, 4$, and 5. According to Table 3 many participants set at least often the same value even when the time horizon is uncertain, i.e. $x_t = x_{t+1}$ (for $3 \leq t \leq 5$). For $T = 6$, for instance, only 40.4% of the 193 plays are characterized by $x_3 > x_4 > x_5 > x_6$ whereas 74.1% satisfy the weaker requirement $x_3 \geq x_4 \geq x_5 \geq x_6$ (for similar results see Anderhub et al., 1997, and Anderhub, 1998).

	cases	%						
$T \geq 4$	402	100.0		cases	%			
$x_3 > x_4$	293	72.9						
$x_3 \geq x_4$	370	92.0	$T \geq 5$	278	100.0		cases	%
			$x_3 > x_4 > x_5$	146	52.5	$T = 6$	193	100.0
$T \geq 5$	278	100.0	$x_3 \geq x_4 \geq x_5$	226	81.3	$x_3 > x_4 > x_5 > x_6$	78	40.4
$x_4 > x_5$	199	71.6	$T = 6$	193	100.0	$x_3 \geq x_4 \geq x_5 \geq x_6$	143	74.1
$x_4 \geq x_5$	251	90.3	$x_4 > x_5 > x_6$	108	70.6			
$T = 6$	193	100.0	$x_4 \geq x_5 \geq x_6$	158	81.9			
$x_5 > x_6$	147	76.1						
$x_5 \geq x_6$	171	88.6						

Table 3: Reacting to uncertain time horizon

4 Self-selection and intertemporal allocation behavior

In addition to the differences of $R(\text{andom})$ or $A(\text{verage})$ types, we want to ask whether participants with low or high average investment levels or with low or large variance of individual investments, show differences in their intertemporal consumption pattern. To answer such questions we need some measures allowing such comparisons:

$$\begin{aligned}
c &= \frac{x_1 + x_2 + x_3}{11.92 \pm y/3}: && \text{the share of totally available funds } 11.92 \pm y/3 \\
&&& \text{spent in certain periods} \\
S_6 &: && \text{the amount left for consumption } x_6 \text{ in period 6} \\
v_i &= \sum_{t=1}^{11} |y_t - y_{t+1}|: && \text{the volatility of investment levels over time}
\end{aligned}$$

We separate the rounds with high or low investment and whether the investment was profitable or not. Compared to the optimal level c^* of c which is 0.80 for lucky and 0.54 for unlucky investment, the observed average shares (see Table 4) are less sensitive to the success of investments. In spite of the small differences, the c -values for good luck are significantly larger than those for bad luck (Mann-Whitney-U test: low investment $p = .088$; high investment $p = .011$; all investment levels $p = .004$).

	$y < \bar{y}$ (low investment)		$y > \bar{y}$ (high investment)	
	unlucky	lucky	unlucky	lucky
$\frac{x_1+x_2+x_3}{11.92 \pm y/3}$	.73	.76	.71	.73
S_6 (if $t = 5$)	0.56	0.68	0.28	1.12
% $x_t > x_{t+1}$	.77	.76	.73	.66

Table 4: Measures of low and high investors

The average difference ΔS_6 of S_6 between good and bad luck is naturally larger for high investments ($y > \bar{y}$) than for low ones ($y < \bar{y}$). Compared to the difference $\Delta S_6^* = 1.54$ for $y^* = 9.73$ implied by optimality even the observed distance $\Delta S_6 = .84$ for "high investors" is too small.

		Mean Investment		Σ
		low ($y < \bar{y} = 5.91$)	high ($y > \bar{y} = 5.91$)	
$v_i = \sum_{t=1}^{11} y_t - y_{t+1} $	low (< 13.78)	16 (14)	14 (16)	30
	high (> 13.78)	8 (10)	12 (10)	20
Σ		24	26	50

Table 5: Number of different types of participants

Now we measure the average individual investment level $\bar{y}$ and the individual volatility v_i for each participant. The larger average volatility v_i for high investors ($v_i = 14.79$) rather than low investors ($v_i = 12.69$) had to be expected. But the v_i -distributions of high and low investors do not differ significantly (Mann-Whitney-U test, $p = .225$). The overall average of the volatility is $v_i = 13.78$. Of course, optimality implies $v^* = 0$.

The distribution of the individual investment levels $\bar{y}$ is double peaked with a spike at $\bar{y} \sim 3$ and another more dispersed peak for $\bar{y} \sim 7$ and 8 (see Figure 7 – left); the split level $\bar{y}$ in Table 4 is at $\bar{y} = 5.91$. Figure 7 (right) displays the distribution of v_i , i.e. the volatility of individual investments over time which is essentially single-peaked.

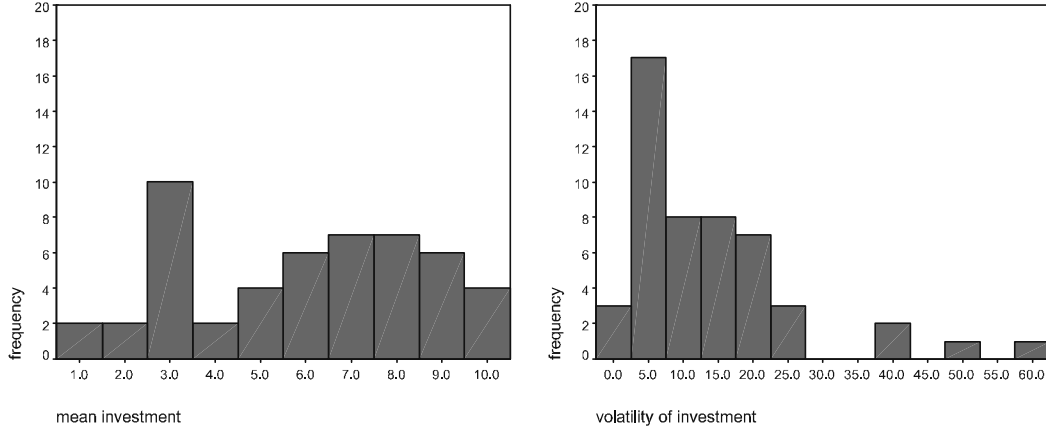


Figure 7: Histogram of mean investment (left) and volatility of investment (right)

In order to test the interdependence of low or high volatility and the low or high investment level we compare in Table 5 the observed frequencies with those (in brackets), implied by independence. In all cases the difference is 2, i.e. there is no clear-cut deviation from independence.

		Mean Investment		
		low ($y < \bar{y} = 5.91$)	high ($y > \bar{y} = 5.91$)	Σ
$\sum_{t=1}^{11} y_t - y_{t+1} $	low (< 13.78)	.76	.67	.72
	high (> 13.78)	.75	.67	.71
	Σ	.76	.67	.72

Table 6: Percentage of $x_t > x_{t+1}$ ($t > 3$)

Table 6 reveals for all 12 ("lives") $\cdot$ 50 (participants) = 600 plays how the basic rationality requirement $x_t > x_{t+1}$ for $t > 3$, i.e. the percentage of its confirmation, depends on low versus high volatility, respectively investment level. If we compare the distribution $x_t > x_{t+1}$ -percentages for low investors ($y < \bar{y}$) with the one for high investors ($y > \bar{y}$), the effect that „low investors“ are more rational is not significant (Mann-Whitney-U test, $p = .258$). The lower "rationality" of high investors is mainly due to high, but unlucky investors. Apparently their frustration or even anger made them less careful.

5 Conclusions

The "savings game", as introduced by Anderhub et al. (1997), confronts participants with highly stochastic future prospects where some uncertainty (concerning the termination probability to be applied after period $t = 3$) is gradually resolved (by taking out dice) and some remains, namely whether "life" ends in period $T = 3, 4, 5$, or 6. In the experiment, analysed above, participants can voluntarily add another risk by investing more or less of the available funds $11.92 - x_1$ into a profitable, but risky prospect.

In our view, such an experiment is interesting for essentially the following two reasons: First, one studies investment behavior under the natural circumstances the investment risk causes just one of the many uncertainties. Unlike in our study most experimental studies of decision making under uncertainty (see Camerer, 1995, for a survey) focus on situations where the investment risk is the only experimentally controlled risk. By repeating our modified savings game we can also investigate how stable investment attitudes are. Since most y -levels, namely 58.5%, were interior in the sense of $0 < y < 11.92 - x_1$, most participants were neither extremely risk averse nor risk neutral or risk loving. The rather large individual average volatility $v = 13.78$, furthermore, indicates that risk attitudes were rather unstable or path dependent although normative decision theory offers nothing to account for this (if one neglects income effects which appear as negligible in our context).

Our second reason for the experimental study at hand is to provide another (continuous) screening variable for self-selection of the A - or R -payment mode. Only 5 of our 50 participants chose the R -mode who, on average, invested less in absolute and relative terms (see Table 1). Since the R -mode causes already one additional uncertainty, namely whether a successful or unsuccessful "life" will determine the monetary win, one could conclude that the R -choice crowds out risky investments. In view of the small number of R -types such conclusion can, however, not be statistically validated.

Our detailed analysis of "low and high investors" above did not reveal any striking differences concerning their intertemporal allocation behavior as, for instance, measure by their c , S_6 , and v -parameters. What matters more is whether one has been lucky in

investing or not where this, of course, is more important when the invested amount y is large. Individual risk attitudes seem to matter more for self-imposed risks (here voluntarily choosing $y > 0$) whereas the ways by which one copes with exogenously imposed risks (here uncertainty concerning $T = 3, 4, 5$, or 6) can be rather independent as suggested by the theory of mental accounting (see, for instance, Thaler, 1985).

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Appendix

Instructions

Your task in every round is to distribute an amount of money as good as possible to several periods. The better you do this, the higher is your payoff. Altogether you play 12 rounds. In the beginning of the experiment you can choose, whether we should draw lots to select one round for which you are paid. Otherwise you will receive the mean of your payoffs of all rounds. In any case you get your payoff in cash after evaluation of the data.

The general task of one round is to distribute a certain amount of money to several periods. Your payoff of one round is calculated by the product of the amounts allocated to the single periods. *In addition, you can invest any amount of the remaining money in the first period to a profitable but risky prospect, in order to enlarge your disposable amount in period 2 when you are lucky or to reduce it when you are unlucky.*

The difficulty is, that there is no certainty about the number of periods you have to distribute your money. The game can last for three, four, five, or six periods. Every round will last at least for three periods. Whether you reach the fourth, fifth or sixth period, will be determined by throwing a die. There are altogether three different dice with the colors red, yellow and green. The following table shows, in which cases you reach a next period.

COLOUR OF DIE	NO FURTHER PERIOD IF DIE SHOWS	NEW PERIOD IF DIE SHOWS
RED	1, 2, 3	4, 5, 6
YELLOW	1, 2	3, 4, 5, 6
GREEN	1	2, 3, 4, 5, 6

The number of periods of one round can not be higher than six. In the beginning of a round you do not know which die is used for you. You get this information after you have made some decisions. The general course of the game is as follows:

1st period) You will get a total amount of money S , which you can spend in the coming periods. Altogether you can only spend this total amount. You can choose an amount x_1 , which you want to spend in the first period. Think very careful, how much you want to spend and how much you want to save for the following periods. *In addition, you have (only) in the first period the opportunity to invest any amount of the remaining money $S - x_1$. You choose an amount y with $0 \leq y \leq S - x_1$. Now a die is thrown. If the die shows 1,2,3, or 4 the amount invested will be enlarged by $1/3$. If the die shows 5 or 6 the amount invested will be reduced by $1/3$. Accordingly, your disposable amount for the second period is higher or lower.* After your decision one of the three dice is excluded. Now you know, that only the two other dice are candidates for the chance move if you reach the fourth, fifth and sixth period.

2nd period) You are choosing an amount x_2 , which you want to spend in the second period. You can not spend more than you have left from the total amount after the first period. After your decision another die is excluded. Now you know, which die remains to be thrown for the fourth, fifth and sixth period.

3rd period) You are choosing an amount x_3 , which you want to spend in the third period. After this decision the computer will throw the remaining die in order to decide whether you reach the fourth period. If you do not reach the fourth period, the round ends here. The amount which is not spent until now is lost.

4th period) If you have reached the fourth period, you choose an amount x_4 . For reaching the fifth period, the die will be thrown again.

5th period) If you have reached the fifth period, you choose an amount x_5 . For reaching the sixth period, the die will be thrown again.

6th period) If you have reached the sixth period, you do not have to make a decision, because all remaining money is spent automatically.

Your payoff is calculated by the product of all amounts you spent in the periods you reached. For instance if you experienced exactly four periods, your payoff is determined

by $G = x_1 \cdot x_2 \cdot x_3 \cdot x_4$. When you have reached for instance all six periods, your payoff is determined by $G = x_1 \cdot x_2 \cdot x_3 \cdot x_4 \cdot x_5 \cdot x_6$ where x_6 is the amount you have left after the fifth period. Please think about the following: If you spend in one period an amount of 0, your payoff will be also 0, because one of the factors is 0. This can happen, for instance, if you spend all money in the fourth period and reach the fifth period. Then you have to spend 0 in the fifth and perhaps also in the sixth period and therefore you get the payoff 0. You have to weigh up between the risk of spending all your money early or making your money useless if the game ends.