

Satisficing in Financial Decision Making A Theoretical and Experimental Attempt to Explore Bounded Rationality

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First version: August 2005

This version: June 2006

Abstract

In this paper, we apply the bounded rationality approach to an investment situation. In a simple setting where an investor decides between a riskless bond and a risky asset, we distinguish three aspiration levels: a lowest threshold that one wants to guarantee, an aspiration level given by investing all risk-free, and an even higher return level representing a real success. The ranges for such aspirations are naturally determined by the parameters. These three aspirations allow us to classify investors as actual or only potential satisficers, as well as risk shy or more open to risk. In the experiment, participants are first asked for their lowest and highest aspiration before investing. Thus, we can test whether they behave as predicted by their aspiration type. By presupposing specific cardinal utility functions, we also compare the bounded rationality approach to the rational choice-approach.

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1 Introduction

When knowing an individual's risk preference, the rational-choice approach offers a (usually) unique prediction of investment behavior, i.e. a specific portfolio choice. However, given the actual heterogeneity of individual portfolio choices as observed in experimental studies (see Camerer 1995, for an older survey), such clear-cut predictions may be a problem rather than a blessing. Using the binary lottery-technique¹ would yield a unique optimal choice that, however, cannot account for the large variance in individual behavior (see, for instance Dittrich et al. 2005). Also, the vast literature on behavioral finance (e.g., Barberis and Thaler 2003, Hirshleifer 2001) reports many findings questioning the empirical validity of the rational choice-approach, e.g., in the form of the capital asset pricing model (see Sharpe 1964, Lintner 1965, Mossin 1966).

Hard-core rational choice theorists might argue that it is better to have a theory that sometimes fails than to have no theory at all. What we therefore want to find out is

- whether the central concept of bounded rationality theory, namely the idea of satisficing (see Simon 1955) can predict how portfolio choices are made and
- whether this prediction leaves enough ambiguity, e.g. by being set-valued rather than unique, to account for individual heterogeneity.

The literature drawing upon bounded rationality is as vast as it is vague in the use of the notion, mostly relating to so called anomalies and biases. In contrast, we directly relate to aspirations and satisficing behavior as propagated by Simon (1955). Previous research in this area has mostly advanced the modeling of aspiration adaption (Sauermann and Selten 1962) and explored concession making on aspiration ladders in simple bilateral interactions, like bargaining situations (see, for instance, Tietz et al. 1978, Tietz 1992, 1997, Selten 1998). This study is, to the best of our knowledge, the first attempt to directly test the avails of aspirations for actual investment decisions.

¹A participant can either earn a low or a high prize and influences by his choice only the likelihood of winning the high prize. If the rewards of a portfolio are, for instance, measured by points one can experimentally induce any risk preference by transforming the point score in an appropriate way into the winning probability for the high prize.

Our experimental investment task offers investors to leave their monetary endowment idle and to invest in a risk-free but profitable bond and in a risky asset with two possible return rates. Since even boundedly rational investors will not leave their money idle, a portfolio can be sufficiently described by the investment i in the risky asset (the residual being invested in the bond).

In the experiment, participants are asked for

- their minimum return aspiration \underline{A} ,
- their success aspiration \bar{A}

in addition to actually choosing their portfolio. The theoretical analysis presupposes an intermediate aspiration level A determined by investing everything in the riskless bond. If \underline{A} has to be guaranteed one can achieve the success level \bar{A} ($> A$) with a given positive probability only by risking to miss A . This suggests a generic interval of satisfactory investments i if aspirations \underline{A} and \bar{A} with $\underline{A} < A < \bar{A}$ are not too overambitious. Since the experimental data includes the \underline{A} and \bar{A} -answers of the participants, we can directly test the satisficing hypothesis.

The data is also analyzed from a rational choice-perspective by presupposing specific cardinal utility functions whose unique parameter is also asked for in the post-decisional questionnaire, but can also be inferred from the actual investment choice i . In a purely explorative way, we investigate the correlation of aspiration levels \underline{A} and \bar{A} and this risk preference parameter.

Note that, in our view, bounded rationality has to be clearly separated not only from perfect rationality – except for simple decision tasks where both might coincide – but also from actual behavior which may mostly but not always be reasonable. The traditional advice of portfolio analysts to invest one third in real assets, one third in bonds and one third in shares may be in line with mental accounting, but can be individually inadequate. The fact that behavior is often deficient opens the possibility for advice to boundedly rational clients. Like perfect rationality, bounded rationality may require teaching and learning.

A further insight of our analysis is that the separation of preferences and decision options, on which the rational-choice approach is based, may not hold for bounded rationality. Aspirations can be partly both, goal or achievement levels, but also restrictions of the action space.

Section 2 offers a boundedly rationality-approach and section 3 a normative benchmark analysis. The experimental procedure is described in section 4. Section 5 presents the results and section 6 concludes.

2 Satisficing portfolios

Consider an investor with a positive monetary endowment e which he can

- keep idle yielding a 0-return, i.e. a return rate of 1, or
- invest in a riskless bond yielding a return rate $r > 1$, or
- invest in a risky asset yielding a low return rate l with $0 < l < 1$ with probability $1 - p$ and a high return rate $h (> r)$ with probability p where $l(1 - p) + hp > r$ and $0 < p < 1$.

Clearly, even an only boundedly rational investor will not keep his money idle. Thus we can describe a (boundedly) rational portfolio choice by the investment i with $0 \leq i \leq e$ in the risky asset meaning that the residual endowment $e - i$ is used for the riskless bond.

In our view, the completely safe option $i = 0$ suggests the **intermediate aspiration level**

$$A = re.$$

Any attempt to get more than A runs the risk to face less than A . What we therefore suggest is to characterize a boundedly rational investor by two further aspiration levels, namely a higher aspiration

$$\bar{A} > A$$

for a real success and a **minimum aspiration**

$$0 < \underline{A} < A$$

expressing what the investor wants to exclude (in the sense that he does not want to risk living with less than \underline{A}).² For a boundedly rational investor

²The general idea behind this is to elicit state specific aspirations since the risky asset can turn out to be bad (the state where one wants to guarantee \underline{A}) or good (the state where one wants to achieve the real success aspiration \bar{A}).

one can assume that he forms his aspirations \bar{A} by considering the chances at hand and that therefore his aspirations \underline{A} and \bar{A} satisfy the additional constraints $\underline{A} \geq el$ and $\bar{A} \leq eh$.

What are the implications of such aspirations? Let us denote by $R(i)$ the returns from portfolio choice i where this is, of course, a stochastic variable. From $R(i) \geq \underline{A}$ for all possible realizations of $R(i)$ we obtain

$$i \cdot l + (e - i)r \geq \underline{A}$$

or

$$i \leq \bar{i} := \frac{A - \underline{A}}{r - l}$$

with \bar{i} being positive³ due to $A > \underline{A}$ and $r > l$. By restricting himself to portfolios i with $0 \leq i \leq \bar{i}$ the investor guarantees that he will never face the situation $R(i) < \underline{A}$. By choosing $i = 0$ the investor can even guarantee the intermediate aspiration level A , but only at the cost of missing the success aspiration \bar{A} ($> A$) for sure. Let us therefore explore the chances of achieving the success aspiration \bar{A} . Due to $p < 1$ and $l < 1$ it is impossible to achieve \bar{A} with certainty. One may, however, obtain $R(i) \geq \bar{A}$ with probability p when investing enough. The condition $R(i) \geq \bar{A}$ in case of the return rate h for the risky asset is

$$ih + (e - i)r \geq \bar{A}$$

or

$$i \geq \underline{i} := \frac{\bar{A} - A}{h - r}$$

where \underline{i} is positive due to $\bar{A} > A$ and $h > r$. Note that $\bar{i} < e$ holds if the obvious requirement $\bar{A} \leq eh$ for boundedly rational formation of aspirations is satisfied. By investing at least \underline{i} the investor can induce a success in the sense of $R(i) \geq \bar{A}$ with probability p . An investor for whom $\underline{i} > \bar{i}$ or

$$A(h - l) < r(\bar{A} - \underline{A}) + \underline{A}h - \bar{A}l$$

cannot achieve \bar{A} at all without risking to fail reaching \underline{A} . In the experiment, participants are free to choose aspirations yielding $\underline{i} \leq \bar{i}$ as well as $\underline{i} >$

³This restricts the set of portfolios only when $(A - \underline{A}) / (r - l) < e$. Due to $A = e \cdot r$ this condition is equivalent to $el < \underline{A}$ what is a natural condition for a lower aspiration level of a boundedly rational investor.

\bar{i} . Thus, it depends on their choices whether or not their behavior can potentially satisfy their aspirations.⁴

3 Categorization and Hypotheses

Based on aspirations and investment decisions we can design a broad categorization of investors. If the two aspirations \underline{A} and \bar{A} are not in line with

$$le \leq \underline{A} < er \text{ and } re \leq \bar{A} \leq he \quad (UR)$$

we speak of an unreasonable (U)-type.⁵

Whenever the two aspirations (\underline{A}, \bar{A}) of a participant satisfy (UR), we speak of (R \cdot) or reasonable types. If such a reasonable type additionally satisfies $\underline{i} \leq \bar{i}$ or

$$r(\bar{A} - \underline{A}) + \underline{A}h - \bar{A}l \leq A(h - l) = re(h - l) \quad (S)$$

we say that the participant is a potential satisficer (RS \cdot) whereas participants where (UR) is valid but (S) is not are called non-satisficer types (RN). A potential satisficer is actually satisficing (RSA) if not only (S) holds but also the actual investment choice i is satisficing, i.e., if

$$\underline{i} \leq i \leq \bar{i} \quad (A)$$

If an (RS \cdot)-type is not actually satisficing we refer to him as (RSO) or only potentially satisficing. Table 1 gives an overview on the classification.

How could such type categorization be related to risk attitude? A narrow concept of risk attitude could restrict its use to (RSA)-types only, e.g. in the sense of an interval structure like in Figure 1. For the time being, we, however, can not offer a convincing way of deriving the separating levels i_a and i_n with $\underline{i} < i_a < i_n < \bar{i}$.⁶ Our hope is rather that the data collected

⁴An alternative experimental design could have restricted aspiration choices such that $\underline{i} \leq \bar{i}$ must hold.

⁵Of course, we might distinguish further among (U)-types. If, for instance, the only violation of (U) consists of $\bar{A} > he$, one might view this as an Utopian (U)-type. Similarly, if the only violation is $\underline{A} < le$, one could speak of unreasonable pessimism. Here, however, we refrain from categorizing (U)-types further.

⁶One can speculate without facts, e.g., by viewing i_a (or i_n) as a decreasing (increasing) function of $A - \underline{A}$ (or $\bar{A} - A$). In this way, individuals would via their aspirations idiosyncratically determine which portfolios they see as risk seeking, risk reducing or moderately

Table 1: Categorization of types

Reasonable?	(UR) satisfied		(UR) violated
Potentially satisficing?	(S) satisfied	(S) violated	
Actually satisficing?	$i \in [\underline{i}, \bar{i}]$	$i \notin [\underline{i}, \bar{i}]$	
Classified as	(RSA)	(RSO)	(RN) (U)

in this study but also in related studies might finally help to define such thresholds and to classify (RSA)-types further by risk-attitude.

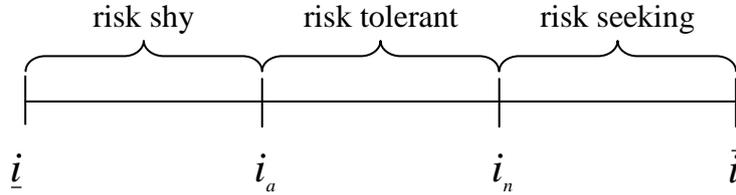


Figure 1: Categories of risky investment

However, one might also categorize risk attitude directly by the aspiration type (\bar{A}, \underline{A}) rather than indirectly via our categorization. This could, for instance, be based on the sum $(\bar{A} + \underline{A})$ as well as on the spread $(\bar{A} - \underline{A})$. Here one might argue that if both, the sum and the spread, are relatively large, the participant is rather keen (due to the large sum) and interested in large improvements (due to the large spread). Whether this speaks for risk seeking behavior can be checked by exploring the correlation of actual investment i and sum and/or spread. This illustrates how aspiration data might offer very new ideas how to define risk attitude.

Like our categorization also the direct correlation of (\bar{A}, \underline{A}) and risk attitude will be analyzed in an explorative way meaning that we neither dare to postulate the relative frequencies of (UR), (RSA), (RSO) and (RN) types nor a positive correlation of sum $(\bar{A} + \underline{A})$ and spread $(\bar{A} - \underline{A})$ with actual investments i . There is simply not enough data on aspiration formation and satisficing (see Tietz et al. 1978, for early and impressive attempts) in financial settings to provide a sound basis for such speculation. Let us illustrate the possibility of such speculative hypotheses for investors with

risky.

$\underline{i} > \bar{i}$ (RN-types). For them, one might predict small investments since participants in the experiment want to gamble at least a bit:

Hypothesis A *Investors with $\underline{i} > \bar{i}$ or, expressed by aspirations,*

$$A(h - l) < r(\bar{A} - \underline{A}) + \underline{A}h - \bar{A}l = \bar{A}(r - l) + \underline{A}(h - r) \quad (\neg S)$$

*will not engage in essential risky investments, e.g. in the sense of $i > .15e$.*⁷

Note that the left hand side of the inequality $(\neg S)$ only depends on structural parameters (since $A = er$) and is positive. Thus one possibility to satisfy $(\neg S)$ is to choose \underline{A} and/or \bar{A} large enough. This illustrates how the two aspirations \bar{A} and \underline{A} , which (in the experiment) are directly asked for, determine when and why a participant is classified as risk shy in this arbitrary sense.

If, however, $i \leq \bar{i}$ holds, the success level \bar{A} can be achieved with probability p without any risk to fall below \underline{A} . Thus there exists a (in case of $\underline{i} < \bar{i}$ generic) range of portfolios which all guarantee \underline{A} and achieve the success level \bar{A} with the same probability p . If the (non-empty) interval $[\underline{i}, \bar{i}]$ is rather large, one might speculate about the choice $i \in [\underline{i}, \bar{i}]$, e.g. by postulating

Hypothesis B *Investors with $\underline{i} \leq \bar{i}$ or, expressed by aspirations,*

$$r(\bar{A} - \underline{A}) + \underline{A}h - \bar{A}l \leq A(h - l) \quad (B)$$

will invest at least \underline{i} or, if \underline{i} is rather low (close to 0), at least $.15e$ but not more than $\min\{\bar{i}, e\}$.

If $\underline{i} \leq \bar{i}$ holds, any portfolio with $\underline{i} \leq i \leq \bar{i}$ will achieve the intermediate aspiration level $A = er$ only when it simultaneously reaches \bar{A} since

$$i \cdot l + (e - i)r < A = er$$

is equivalent to $i(l - r) < 0$ for $i > 0$. In a more comprehensive experimental study, one might try to explore the dependency of \underline{A} and \bar{A} on p by confronting participants with different probabilities p for a success return rate

⁷The threshold of essential investments is, of course, arbitrary.

of the risky asset.⁸

One might object that, at least when (cor)relating the actual investment i with aspiration data, we are (cor)relating the incentivized choice with “cheap talk”. This could have been avoided by incentivizing aspiration choices, e.g., by informing participants that they will be

- excluded from investing or at least asked to review their aspirations, if $\underline{i} > \bar{i}$ and
- constrained to investments $i \in [\underline{i}, \bar{i}]$ when $[\underline{i}, \bar{i}]$ is non-empty.

In our view, such an experiment could be a follow-up study. Here we confine ourselves to investigate in an explorative way how aspiration data can offer new ways of deriving risk attitudes and risky investments in financial settings.

4 A normative benchmark

Without assuming a specific cardinal utility function of the investor all what can be said normatively is that expected utility maximization would imply $i = e$ for rather risk neutral or even risk loving investors whereas more risk averse investors prefer interior ($0 < i < e$) investment levels i or even $i = 0$ depending on how strong their risk aversion is.

To allow more specific conclusions we assume a specific type of cardinal utilities, namely $U(x) = x^\alpha$ with $\alpha > 0$ where x denotes the monetary payoff.⁹ If $\alpha - 1$ is positive, one would be risk loving, if $\alpha - 1 = 0$ risk neutral and in case of negative $\alpha - 1$ risk averse. The expected utility for an investment level i , given by

$$U(i) = p[r(e - i) + hi - e]^\alpha + (1 - p)[r(e - i) + li - e]^\alpha,$$

can be used to characterize an interior optimum for moderate risk aversion by

$$U'(i) = p\alpha[r(e - i) + hi - e]^{\alpha-1}(h - r) = (1 - p)\alpha[r(e - i) + li - e]^{\alpha-1}(r - l)$$

⁸So far, our approach is non-Bayesian since the probability of achieving a success aspiration \bar{A} ($> A$) is exogenously given rather than resulting from the chosen portfolio.

⁹Please note, that for monetary payoff in the experiment the credit is finally deducted. It is therefore important, that the calculation of α relies on final payments where e is deducted from the investment success.

or

$$\frac{h-r}{r-l} \cdot \frac{p}{1-p} = \left[\frac{r(e-i) + li - e}{r(e-i) + hi - e} \right]^{\alpha-1} \quad (\text{A})$$

assuming, of course, that this defines an investment level i with $0 < i < e$.

Since we do not know the parameter α , we infer from the actual choice i with $0 < i < e$ the parameter α according to

$$\alpha(i) = \frac{\ln\left(\frac{h-r}{r-l} \cdot \frac{p}{1-p}\right)}{\ln\left(\frac{e(r-1)-(r-l)i}{e(r-1)+(h-r)i}\right)} + 1 = f(i) \quad (\text{B})$$

for any $i \in (0, e)$ yielding $\alpha(i) \in (0, 1)$ rather than predicting i by trying to assess α .

It is obvious from above that $\alpha(i)$ is only well defined if $(r-l)i < e(r-1)$. Thus, $\alpha(i)$ can be numerically calculated if $i < \bar{i}^* = \frac{r-1}{r-l}e$. Also, economic intuition requires $\alpha(i) > 0$,¹⁰ therefore $\alpha(i)$ can only be determined for $i > \underline{i}^* = \frac{e(r-1)(2r-h-l)}{2(r-h)(r-l)}$.¹¹ For investors with $i \geq \bar{i}^*$ all that can be said is that they are at least equally or even less risk averse than investors with $i < \bar{i}^*$. Similarly, investors with $i < \underline{i}^*$ are at least as risk averse as investors with $i \geq \underline{i}^*$.

Let now $\bar{\alpha}$ denote the limit of $\alpha(i)$.¹²

Since

$$\bar{\alpha} = \begin{cases} 1 & \text{for } i \rightarrow \bar{i}^* = \frac{r-1}{r-l}e \\ 0 & \text{for } i \rightarrow \underline{i}^* = \frac{e(r-1)(2r-h-l)}{2(r-h)(r-l)} \end{cases} \quad (\text{C})$$

we will assume for our data analysis that α is 1 whenever $\bar{i}^* \leq i \leq e$ and $\alpha = 0$ for $0 \leq i \leq \underline{i}^*$ and that it is given by $f(i)$ when $\underline{i}^* < i < \bar{i}^*$. The distribution of actual portfolio choices i thus generates a distribution of risk preference types α .

We are interested to learn how α , as inferred from the investment choice i , is related to the aspiration levels \underline{A} and \bar{A} which are directly elicited in the experiment. Is, for instance, α positively related to the spread $\bar{A} - \underline{A}$, the difference between the success and minimum aspiration, to the sum $\underline{A} + \bar{A}$

¹⁰If $\alpha(i) < 0$ the utility function is convex and therefore additional money reduces utility.

¹¹According to our experimental parameter constellation introduced in the next section $\bar{i}^* = \frac{1}{3}e$ and $\underline{i}^* = \frac{2}{30}e$.

¹²Obviously, it must be that $\bar{\alpha} < 1$ due to $ph + (1-p)l > r$.

or only to \bar{A} or \underline{A} alone?

One may argue against relating behavioral (the aspirations) and normative (risk preference parameter) notions. But in the experiment, even an “expected utility maximizer” has to come up with two aspiration levels and these two levels (\underline{A} and \bar{A}) may very well be related to his risk preference type. And why not asking which preference parameters α suggest certain aspirations and induce the distribution of investment levels i , actually chosen by only boundedly rational participants?

The two aspiration levels \underline{A} and \bar{A} are (directly) payoff irrelevant in the sense that these levels as such have no (direct) payoff consequences. Our categorization of aspiration types (and Hypotheses A and B) just claims that \underline{A} and \bar{A} determine the investment choice i of a boundedly rational investor. One may fear that the actual choice i is carefully considered whereas \underline{A} and \bar{A} , due to their (direct) payoff irrelevance, are rather carelessly stated. For a start we did not want to rely on a scenario which renders the two aspiration levels \underline{A} and \bar{A} as (directly) payoff relevant. For the comparison with the rational choice approach we therefore tried to elicit α also in a payoff irrelevant way (in addition to inferring it from the actual investment choice i).

More specifically, a post-decisional questionnaire asks to state the probability \hat{p} at which one would want to switch from investing nothing to investing everything, respectively vice versa, when only these two options are available. As α is only defined for i with $\underline{i}^* \leq i \leq \bar{i}^*$, we set i to its maximum \bar{i}^* , respectively its minimum \underline{i}^* as explained above. Otherwise, we suggest to infer $\alpha = \alpha(p)$ -type of participants by taking their stated p -probabilities to solve the equation for α . Of course, low p -choices can be justified by many (large) α -values and high p -choices by many (small enough) α -values. This can be used to compare $\alpha(p)$ with their $\alpha = \alpha(i)$ -type as inferred from their investment choice i . Clearly, $\alpha(p)$ is not (directly) payoff relevant as the aspiration levels \underline{A} and \bar{A} . In addition to comparing $\alpha(p)$ with $\alpha(i)$ we also test whether the interdependence of \underline{A} , \bar{A} (or $\bar{A} + \underline{A}$ and $\bar{A} - \underline{A}$) with $\alpha(p)$ is stronger than the one between \underline{A} , \bar{A} (or $\bar{A} + \underline{A}$ and $\bar{A} - \underline{A}$) and $\alpha(i)$.

5 Experimental Protocol

In the experiment, participants

- first learn about the investment task and answer a few control questions (see the instructions and transcript of computer screens in the Appendix),
- then are asked for their aspirations \underline{A} and \overline{A} , where we do not impose the restriction

$$el < \underline{A} < er < \overline{A} < eh.$$

but only $\underline{A} < er$,

- actually determine their portfolio with the possibility of leaving money idle, and
- finally answer a questionnaire (see the Appendix) which asks them essentially at which probability p they would switch from investing nothing ($i = 0$) to investing everything ($i = e$) when only these two options are available.

The experimental instructions describe \underline{A} as the lowest acceptable return. Similarly, \overline{A} is asked for as a “return level which you would view as a real success.” The problem is, of course, that only the actual portfolio choice determines a participant’s return $R(i)$. In our view, aspirations are seriously specified when the requirement $el \leq \underline{A} \leq er \leq \overline{A} \leq eh$ holds.

The instructions introduce the investment task not in full generality but only for the actual parameters used in the experiment, namely¹³

$$e = 1000, l = 0.8, r = 1.1, h = 1.6, \text{ and } p = 0.5,$$

By restricting ourselves to $p = \frac{1}{2}$ we avoid as far as possible all problems related to the (mis)perception of (small or large) probabilities. The post-decisional questionnaire requires participants to consider various probabilities p and asks for the probability \hat{p} at which one would be indifferent between $i = 0$ and $i = e$.

The investment task was repeated for a number of periods that was a priori not known to participants. They were informed, however, that after 15 periods the probability to continue for another period was 80 percent.

¹³All amounts in the experiment were denoted in ECU (experimental currency unit). The exchange rate to Euro was 12.5:1, i.e. 12.5 ECU corresponded to 1 Euro.

For consistency, the number of periods was randomly determined once and fixed at 17 for all sessions.

In order to capture possible learning processes over time, two different treatments were considered. In the complete repetition (CR) treatment, participants were first asked for their higher and lower aspirations, \bar{A} and \underline{A} , subsequently had to decide on taking credit and investing, and finally stated the probability \hat{p} at which they were willing to switch from zero to full risky investment.¹⁴ The whole procedure was repeated for 17 periods. In the partial repetition (PR) treatment, subjects stated their aspirations as well as the probability \hat{p} only once, in the first period. The investment decision, however, was taken in every period. Whereas the latter treatment allows only adjustment of investment over time, the former treatment additionally enables a learning process via aspiration adaptation and probability adjustment.

Ninety-six students from Jena University, 48 in each the CR and the PR treatment, were recruited to participate in the experiments using the ORSEE software (Greiner 2004). The age of the 46 males and 50 females ranged from 19 to 31 years and the average earnings amounted to 12.5 Euro (SD = 13.2 Euro) for a duration of about 50 minutes. Four sessions with 24 participants each were conducted in total. The experiment was computerized using zTree (Fischbacher 1999), a transcript of the screens can be found in the Appendix.

To ensure the financial salience of the investment task, three means were taken: first, only one period was randomly selected for payment. Second, the credit taken for investment had to be paid back after each period, so that subjects only earned their (positive or negative) net investment return. Third, subjects were instructed that possible monetary losses would have to be compensated by completion of a task after the experiment (see instructions in the Appendix). The task consisted of marking all letters ‘t’ in a text on German tax law. Each Euro lost was equivalent to half a page of work load. The maximum possible loss of 16 Euro therefore translated into

¹⁴For the data reported here the current choice of \hat{p} was not induced by monetary incentives (In the Appendix, the additional part to Screen 6 in brackets shows how the choice of \hat{p} could be incentivized so that the correct \hat{p} -choice becomes dominant). Our reason for not using monetary incentives for choosing \hat{p} is (i) to elicit rational-choice risk measures that are non-incentivized like the aspiration choices, and (ii) to avoid any possible (although rather far fetched) diversification effect, e.g., by choosing a risky investment i and a cautious \hat{p} or vice versa.

searching eight pages, which would take about 35 minutes of extra time after the experiment and would ensure that losses had to be actually suffered. In the experiment, 17 subjects made losses and left the laboratory only after completing the task.

6 Results

In a first step, we establish whether the requirements for setting sensible aspiration levels are met and consequently report behavioral types described in Table 1.

Table 2: Behavioral categories in both treatments

Treatment	(RSA)		(RSO)		(RN)		(U)		Total	
CR	390	47.8%	190	23.2%	108	13.2%	128	15.7%	816	100%
PR	300	36.8%	227	27.8%	102	12.5%	187	22.9%	816	100%
Total	690	42.3%	407	24.9%	210	12.9%	315	19.3%	1632	100%

Success aspirations of $\bar{A} < er = A$ implying $\underline{i} < 0$ cast doubt on participants' appropriate effort in decision making. The share of such careless behavior (U) is slightly below 20%. Further analysis is based only on the data that reflect the minimal bounded rationality requirement of (UR) ($el \leq \underline{A} < er \leq \bar{A} \leq eh$).

In the CR treatment, where aspirations could be changed every period, 128 (of 816) observations do not fulfill requirement (UR) for setting strictly sensible aspirations ($el < \underline{A} < er < \bar{A} < eh$). In the PR treatment, where aspirations were only stated once, 11 of the 48 subjects (22.92%) are classified as unreasonable. Considering the aspiration level as constant over time in this treatment, this number corresponds to 187 observations, leaving the remaining 629 combinations of aspiration levels and investment decisions as observations for further analysis.

As the investment task offers a fixed rate of return $r > 1$, even a boundedly rational investor will always make full use of her credit allowance. However, a small fraction of investment choices (64 in the CR treatment and in 70 in the PR treatment) did not fully utilize the credit line of 1000 ECU. Still, these observations are kept for further analysis.¹⁵

¹⁵Results reported in the following are, however, not altered when dropping these data.

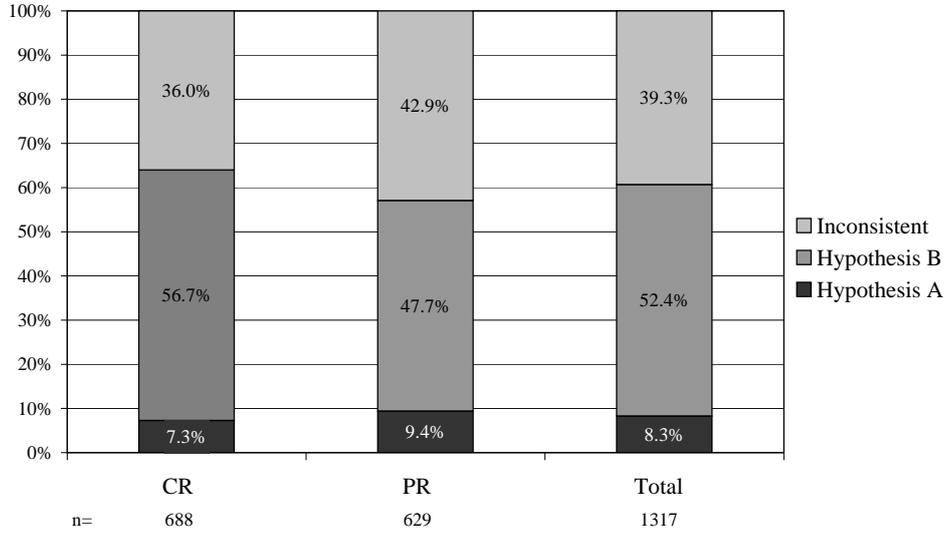


Figure 2: Frequency of investment behavior (in)consistent with the hypotheses

First, behavior in line with the predictions of Hypotheses A and B is examined. Investments i are therefore related to the stated aspiration levels. Results are reported for merged data as well as for treatments PR and CR, separately. Since decisions are independent, observations are pooled over periods.

Observation 1 *In total, about 60% of all observations that conform to reasonable aspirations are consistent with bounded rationality predictions stated in Hypotheses A and B. Specifically, about 8% are risk-shy investment decisions of non-satisficers (Hypothesis A) and around 52% are actually satisficing investments (Hypothesis B).*

As displayed in Figure 2, the proportion of investment decisions that is explained by boundedly rational behavior is fairly constant across the two treatments. Around 8% investments are risk shy investors who state aspirations such that $\underline{i} > \bar{i}$, as postulated by Hypothesis A. Another 52% of portfolios falls in the range $\underline{i} \leq i \leq \bar{i}$ that guarantees their investors \underline{A} and a one-half chance to reach \bar{A} , as suggested by Hypothesis B. Hence, nearly two thirds of all investments can be explained by a simple rule of satisficing behavior.

The remaining proportion, roughly 40% of observations that per definition consist of non satisficers (RN-types) on the one hand and of only

potential satisficers (RSO-types) on the other hand, can be further disentangled and assigned to different behavioral categories as Table 3 shows. The first category (non satisficers) refers to aspiration levels that satisfy inequality ($\neg S$), which according to Hypothesis A should result in only inessential risky investment. However, nearly half of the subjects whose aspirations satisfy inequality ($\neg S$) are not risk shy, but invest considerable amounts ($M_{CR} = 595.17, SD_{CR} = 307.88; M_{PR} = 345.58, SD_{PR} = 179.59; M_{total} = 488.91, SD_{total} = 288.03$). Overall, this behavior accounts for about 8% of observations. Subjects in the second and third category (potential satisficers) state aspirations that satisfy inequality (S) and are therefore expected to invest accordingly ($\underline{i} \leq i \leq \min(\bar{i}, e)$). Some of these participants act too risk shy (accounting, on average, for 20% of all data) and thus fail to reach their high aspiration \bar{A} with probability $\frac{1}{2}$. The others (12% overall) invest too much and thereby risk to fall below their lower aspiration \underline{A} . Subjects who fulfill bounded rationality requirements, however, do not differ from others with respect to their investment success measured by average earnings (Mann-Whitney U-Test: $z = 0.22, p = .83$).

Table 3: Investment behavior inconsistent with stated aspirations

	non satisficers (RN)		potential satisficers (RSO)				Total	
	$\underline{i} > \bar{i}$		$\underline{i} \leq \bar{i}$					
	$\underline{i} > .15e$ not risk-shy		$\underline{i} < \underline{i}$ too risk-shy		$\underline{i} > \min(\bar{i}, e)$ too risky			
	n	f	n	f	n	f	n	f
CR	58	8.4%	94	13.6%	96	14.0%	248	36.0%
PR	43	6.8%	165	26.2%	62	9.9%	270	42.9%
Total	101	7.6%	259	19.7%	158	12.0%	518	39.3%

Note: Percentages refer to the total number of valid observations, i.e. 688 for treatment CR, 629 for PR, and 1317 in total.

Observation 2 *In the CR treatment, \underline{A} and \bar{A} , risky investment i as well as switching probability \hat{p} remains constant over time. Also in the PR treatment, no time trend in investments is observable.*

Table 4 displays the results of a general linear model with repeated measures to evaluate the time trend of investments in both treatments, as well as the time trend of aspirations and the switching probability \hat{p} in treatment CR. Learning effects over periods, concerning investments but also aspira-

tions in treatment CR, can not be statistically confirmed. Also the degree of risk-aversion, expressed by the switching probability \hat{p} is not subject to experience. This finding supports the independence of repetitions.

Table 4: Time trend of behavior

General Linear Model, Within Subjects Factor: Time				
Independent variable	CR		PR	
	$F(df_h, df_e)$	p	$F(df_h, df_e)$	p
Investment i	0.486 (16,17)	.92	0.727 (16,21)	.74
Low aspiration \underline{A}	1.225 (12,21)	.33	—	
High aspiration \overline{A}	1.025 (16,17)	.48	—	
Probability \hat{p}	1.077 (15,18)	.44	—	

However, additional to general time trends we investigate whether investments react to the previous investment success. Therefore, we take the change of risky investment $\Delta i = i_t - i_{t-1}$ from period to period and regress it on (i) the investment return achieved in the previous period (a dummy variable taking the value ‘1’ for a randomly determined high return h and ‘0’ for a low return l), and (ii) the relative weight of low returns to all previously achieved returns (calculated by $\frac{\text{number of low returns}}{\text{number of low} + \text{high returns}}$).

Table 5 reveals that in the CR treatment, investments are not sensitive to previous investment success or failure, whereas in the PR treatment, participants reduce their risky investment after a high return. A higher relative number of previous investment failures, i.e. low returns, also tendentially reduces risky investments. Again, the difference in the two treatments might arise because of the more restricted set of actions in the PR treatments. In contrast to the PR treatment, where subjects can react on their experience only via changing their investment decisions, in the CR treatment they can additionally adjust aspirations and \hat{p} .

Assuming the specific type of cardinal utility, $U(x) = x^\alpha$, we compare subjects’ $\alpha(i)$ -type, as inferred by their investment decision to their $\alpha(\hat{p})$ -type, as inferred by the probability at which they would switch from zero to full risky investment.¹⁶

Observation 3 *In the CR treatment, $\alpha(i)$ and $\alpha(\hat{p})$ are significantly related from period three on. In the PR treatment, where $\alpha(\hat{p})$ is constant, no*

¹⁶To approximate α , we set $\alpha = 0$ if $i \leq \bar{i}^*$ and we set $\alpha = 1$ if $i \geq \bar{i}^*$, as argued above. A switching probability of 1 was replaced by $\hat{p} = .99$.

Table 5: Least squares regression of risky investment on previous returns

Dependent Variable: Change in risky investment $\Delta i = i_t - i_{t-1}$						
Independent variable	CR			PR		
	Coeff.	Std. Error	p	Coeff.	Std. Error	p
Constant	39.17	30.05	.19	82.90	28.74	.00**
High return in t-1	-29.31	20.75	.16	-74.42	19.03	.00**
Relative number of previous low returns	-43.63	43.58	.32	-85.25	42.72	.05

Note: ** denotes significance on the 1% level.

significant correlation between $\alpha(i)$ and $\alpha(\hat{p})$ is observed.

Table 6: Spearman rank correlation of $\alpha(i)$ and $\alpha(\hat{p})$

Period	CR		PR	
	ρ (n=48)	p	ρ (n=48)	p
1	.26	.08	.05	.74
2	.12	.41	.12	.43
3	.28	.05*	-.08	.58
4	.41	.00**	.10	.520
5	.38	.00**	.21	.16
6	.35	.02*	.04	.82
7	.38	.00**	-.03	.821
8	.48	.00**	.04	.79
9	.44	.00**	.05	.74
10	.31	.03*	.11	.47
11	.45	.00**	.13	.36
12	.56	.00**	.00	.99
13	.42	.00**	-.06	.70
14	.46	.00**	-.03	.86
15	.35	.02*	.14	.36
16	.54	.00**	.08	.58
17	.53	.00**	.13	.37

Note: ** and * denotes significance on the 1% and 5% level, respectively.

In the CR treatment, the consistency of the cardinal utility parameter α across investment and probability choices is significant except for the first two periods (see Table 6). In treatment PR, however, no such interrelation can be found in any period. Recall, that subjects stated \hat{p} only once in the first period, therefore $\alpha(\hat{p})$ remains constant over time.

Observation 4 *The interdependence of aspiration levels is higher with $\alpha(i)$ and thus with investment decisions, than it is with $\alpha(\hat{p})$ elicited from the switching probability.*

This observation is supported by Spearman rank correlations. Table 7 shows the correlations throughout periods between $\alpha(i)$ and \underline{A} , \bar{A} , $\bar{A} - \underline{A}$, $\underline{A} + \bar{A}$ for both treatments, as well as the correlations for $\alpha(i)$ and the aspirations for treatment PR. Recall, that in the PR treatment, aspirations and the switching probability were elicited only once, therefore the correlations between $\alpha(\hat{p})$ and the aspirations remain constant over periods and are not listed in the table. Only two of them are significant at a five percent margin: $\rho(\alpha(\hat{p}), \underline{A}) = -.26$; $\rho(\alpha(\hat{p}), \bar{A}) = .33^*$; $\rho(\alpha(\hat{p}), (\bar{A} - \underline{A})) = .34^*$, $\rho(\alpha(\hat{p}), (\underline{A} + \bar{A})) = .24$.

Overall, the risk parameter $\alpha(i)$ is more closely associated with aspirations than $\alpha(\hat{p})$ as indicated by more frequent significant correlations with aspiration levels. The risk parameter $\alpha(i)$ is highly correlated with the acceptance of a low return threshold: The less risk averse a person is, the higher the loss he is willing to accept in case of a bad future state of the world. Whereas a positive relation between the sum of aspirations and investments can hardly be found, the spread of aspirations seems to be more closely related to investment decisions (and thus the risk parameter elicited by investments): the larger the difference between high and low aspirations, the less risk averse the individual. In other words, an individual who is seemingly interested in large improvements is more risk-seeking. A finding that is, of course, along the lines of bounded rationality predictions.

Table 7: Spearman rank correlations of $\alpha(i)$ and $\alpha(\hat{p})$ with aspirations

Period	CR						PR					
	\underline{A}	\bar{A}	$\frac{\alpha(i)}{(\bar{A}-\underline{A})}$	$(\bar{A}+\bar{A})$	\underline{A}	\bar{A}	$\frac{\alpha(\hat{p})}{(\bar{A}-\underline{A})}$	$(\bar{A}+\bar{A})$	\underline{A}	\bar{A}	$\frac{\alpha(i)}{(\bar{A}-\underline{A})}$	$(\bar{A}+\bar{A})$
1	-.34*	-.15	.06	-.20	-.27	-.15	.03	-.23	-.09	.21	.14	.19
2	-.31*	.17	.36*	.07	-.12	.05	.02	.03	-.04	.19	.10	.22
3	-.44**	.08	.35*	-.12	-.25	.02	.07	-.05	-.24	-.01	-.01	-.01
4	-.39**	.11	.24	-.05	-.34*	.00	.12	-.10	-.27	.21	.22	.14
5	-.21	.38*	.41**	.26	-.28	.11	.16	.00	-.36*	.19	.20	.03
6	-.11	.15	.25	.16	-.29*	.00	.09	-.09	-.22	.11	.09	.121
7	-.39**	.13	.24	.00	-.35*	.09	.15	-.07	-.22	-.01	-.01	-.02
8	-.21	.17	.23	.10	-.27	-.12	.04	-.16	-.18	.09	.09	.06
9	-.32*	.11	.31*	.03	-.24	.03	.10	-.03	-.28	.25	.25	.15
10	-.28*	.15	.23	.06	-.26	-.05	.13	-.13	-.34*	.11	.17	-.03
11	-.37*	.04	.29	-.02	-.26	.00	.11	-.06	-.34*	.24	.28*	.12
12	-.41**	.19	.35*	.04	-.40**	.05	.18	-.08	-.28	.11	.13	.03
13	-.30*	.33*	.38**	.24	-.23	.19	.23	.11	-.15	.04	.02	.05
14	-.33*	.35*	.40**	.24	-.30*	.13	.18	.09	-.27	.24	.24	.13
15	-.22	.31*	.38*	.22	-.27	.12	.21	.10	-.34*	.28	.33*	.13
16	-.33*	.27	.36*	.12*	-.34*	.17	.25	.08	-.31*	.11	.13	.02
17	-.36**	.36*	.45**	.23	-.29*	.10	.18	.01	-.16	.19	.15	.19

Note: ** and * denotes significance on the 1% and 5% level, respectively.

7 Discussion

We suggest and test a satisficing approach for financial decision making and contrast it with a rational choice approach. In this endeavor, we do not maintain the separation of preferences and choice alternatives of the rational choice approach. Aspirations in our interpretation are not just “discrete utilities” but have also action content: the minimum return aspiration \underline{A} of actual satisficers is, for instance, interpreted as ruling out investment choices i not guaranteeing \underline{A} . Satisficing also must not predict just one choice, but will typically (if $\underline{i} < \bar{i}$) allow for a whole range ($\underline{i} \leq i \leq \bar{i}$) of satisfactory investment choices.

The overall findings are encouraging. Although the aspiration choices are not incentivized, they provide reliable and more natural ways of classifying investor types and predicting investment choices. The partly existing interrelation of aspiration data and risk attitude, measured by assuming a rational choice perspective, is confirming rather than not: after all, bounded rationality requires a reasonable mental representation of the choice task what will more often than not yield the same qualitative predictions as a rational choice approach.

Our analysis has used the main idea of bounded rationality theory, namely the concepts of aspiration formation and satisficing, which we, by our interpretation, have rendered applicable. Note that by assuming a rational choice perspective also hardly anything can be concluded. To predict unambiguously an optimal choice one has to specify not only the preferences or cardinal utility function but also its parameter(s). Neither of the two approaches will do without bold assumptions. The difference is which kind of data the decision maker is supposed to deliver. And here our claim is that aspiration data are much more natural and therefore more reasonably produced by (homo sapiens rather than homo oeconomicus) investors.

Of course, we are just offering an initial step of developing the theory of bounded rationality by using and testing it. Our plan is to proceed to more complex aspiration ladders as implied by distinguishing more, i.e. intermediate, states of the world. In future studies we expect to rely on less bold speculations by substituting them by earlier findings.

Appendix

Instructions for both treatments

Thank you for participating in this experiment. Please do not communicate with other participants from now on!

The money you earn will be paid to you after the experiment. All your decisions remain anonymous and cannot be related to your name. The show up fee of 2.50 Euro will be taken into account in your payment.

In the following experiment, you can invest money. For this reason, we introduce the currency ECU. The exchange rate between ECU and Euro is 12.5 to 1, i.e., 12.5 ECU correspond to 1 Euro. For your investment decision we grant you a interest free credit of max. 1000 ECU. As a first step, you have to decide how much of this credit (from 0 to 1000) you want to take.

Afterwards, you have to decide how to use the credit. You can invest this credit in 2 alternatives:

1. a risk-free alternative, where you obtain 1.1 times the amount the invested amount for sure (+10%).
2. a risky alternative with two possible outcomes: with 50% probability you obtain 1.6 times the invested amount (+60%), and with 50% probability you obtain 0.8 times the invested amount (-20%).

You have to divide your credit fully among these two alternatives according to you own liking. That means, you can invest in each of the two alternatives an amount ranging from 0 ECU to the amount of the credit you have taken, whereby the amounts invested in the two alternatives have to sum up to the credit amount.

In the experiment, you will make this investment decision repeatedly, where each decision reflects one round. At the end of each round you will be informed about your investment success. In total, there will be at least 15 rounds. The probability that after the 15th round follows a 16th round is 80%. Also after each following round, the probability that the experiment continues for another round is 80%.

At the end of the experiment one of the rounds is randomly selected for payment. The credit you have taken in this round has to be paid back fully. The investment return that exceeds the credit amount will be converted to

Euro and paid out. Please note, that in this experiment it is possible that your investment return falls short of your credit amount. In this case, you have to cover your losses by completing an additional task at the end of the experiment.

The additional task requires to search and mark specific symbols in a text. By doing so, you can compensate 1 Euro loss by correctly completing half a page. Please note, that this task can only be used to cover losses but not to increase your earnings.

Transcript of computer screens

Screen 1: Control questions

Before the experiment starts, we kindly ask you to answer some control questions to ensure your understanding of the investment task.

Choose a credit:...

Choose your investment in the risk-free alternative:...

Choose your investment in the risky alternative:...

Screen 2: Control Questions

Please answer the following questions to ensure your understanding of the investment task.

You have chose the following credit:...

You have chosen the following amounts for
investment in the risk-free alternative:...

investment in the risky alternative:...

Assume that the risky alternative yields a return of 0.8 (-20%).

Please calculate your income.

Income from risk-free alternative:...

Income from risky alternative:...

Total income in ECU:...

Total income minus credit taken (in ECU):...

Note: With a click on the icon below you can use the computer's calculator.
If you have answered all questions correctly, a click on the "OK" button will bring you to the next screen.

Screen 3: Control Questions

Please answer the following questions to ensure your understanding of the investment task.

You have chose the following credit:...

You have chosen the following amounts for
investment in the risk-free alternative: ...
investment in the risky alternative: ...

Assume that the risky alternative yields a return of 1.6 (+60%).
Please calculate your income.

Income from risk-free alternative: ...
Income from risky alternative: ...
Total income in ECU: ...
Total income minus credit taken (in ECU): ...

Note: With a click on the icon below you can use the computer's calculator.
If you have answered all questions correctly, a click on the "OK" button will bring you to the next screen.

Screen 4: Aspirationsⁱ

Now the experiment starts. Before you make your investment decision, please consider and answer carefully the following questions.

1. Assume a worst-case scenario: You have invested in the risky alternative and obtain 0.8 times the invested amount (-20%). Clearly, if you have invested an amount that is too large, this results in a loss.
Which is the maximum loss that you are willing to accept?

ⁱThis screen is repeated in each period in the CR treatment and displayed only once at the beginning of the first period in the PR treatment.

I do not want to risk a loss of more than ...!

2. Now assume a best-case scenario: You have invested in the risky alternative and obtain 1.6 times the invested amount (+60%). This results in a gain.

Which gain do you have to achieve to consider this a real success?

For a real success I have to gain at least ...!

Screen 5: Investment decision

You have stated that you do not want to risk a loss of more than

You have stated to regard as a real success at least

Your investment decision:

I choose a credit of ...

Investment in the risk-free alternative:...

Investment in the risky alternative:...

Screen 6: Switching probabilityⁱⁱ

Please consider and answer carefully the following question.

Assume you have taken the maximum credit of 1000 ECU and invest it all in the risk-free alternative. At which probability for a success of the risky alternative, i.e. the high return of 1.6, would you be willing to invest the whole credit in the risky alternative instead of investing it all into the risk-free one?ⁱⁱⁱ

ⁱⁱThis screen is repeated in each period in the CR treatment and displayed only once after the first period in the PR treatment.

ⁱⁱⁱAlthough we decided against incentivizing \hat{p} -choices in this experiment, the following paragraph illustrates how it could have been achieved:

To render this choice relevant for you, we will randomly select a probability p from the interval $0 < p < 1$ after your choice of the switching probability. If this probability p does not fall below your chosen probability, you will be investing everything and the random move takes place according to probability p for the high return rate, respectively, $1 - p$ for

I prefer to invest the whole credit in the risky alternative instead of the risk-free one, if the probability for a success of the risky venture is at least ...%.

Screen 7: Feedback after each round

The risky alternative realized a return of 1.6 (+60%) {0.8 (-20%)}

Income

from investment in risk-free alternative: ...

from investment in risky alternative: ...

Total income in ECU: ...

Total income minus credit taken (in ECU): ...

the low return rate. Of course, you will again be only rewarded for one randomly selected round.

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