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Scenario-Based Satisficing in Saving: A Theoretical and Experimental Analysis

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Abstract

Contrary to the models of deterministic life cycle saving, we take it for granted that uncertainty of one's future is the essential problem of saving decisions. However, unlike the stochastic life cycle models, we capture this crucial uncertainty by a non-Bayesian scenario-based satisficing approach. Decision makers first form aspirations for a few relevant scenarios, and then search for saving plans satisficing these aspirations. In addition to formally specifying scenario-based satisficing in saving, we explore it experimentally. The results confirm that optimal intertemporal allocations are difficult to derive, and suggest that satisficing allocations can be reached easily when aspirations are incentivized.

JEL Classification: C91; D81; D90

Keywords: Intertemporal allocation decisions; Bayesian updating; Satisficing behavior

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1 Introduction

Household decision making, e.g., the choice of an optimal consumption vector, is usually analyzed without taking into account uncertainty of, for instance, the quality of experience goods. Similarly, optimal saving plans were first analyzed by abstracting from all the uncertainty of one's future. Models of life cycle (Ando and Modigliani, 1963) and permanent income (Friedman, 1957) provide a description of optimal behavior when income is deterministic. Due to decreasing marginal utility, allocation of resources to consumption in each period follows an homogenous pattern. Later on, life cycle-permanent income models were extended to account for uncertainty in income (Hall, 1978). When income is stochastic and agents fully and perfectly exploit all available information, consumption follows a random walk. In recent years, the literature on intertemporal allocation of wealth has been further developed in the direction of dynamic optimization (see, e.g., Pemberton, 1993, 1997; Adang and Melenberg, 1995).

Such Bayesian optimization exercises, though in principle very appealing, rarely provide practical advice. The decisive reason is that agents do not have well-behaved intertemporal preferences (Frederick et al., 2002), nor given probabilities for the possible developments of our life experiences. Moreover, individuals usually do not engage in the often very complex task of intertemporal optimization. Thus, the empirical research mainly tests qualitative and quantitative aspects of optimal saving. Here, contrary to the rational choice tradition of microeconomics, we rely on the satisficing approach (Simon, 1955). Our specification of satisficing accounts for uncertainty of one's own future, but it does not require Bayesian reasoning. The central idea is that the decision maker specifies likely scenarios of life experiences, forms scenario-specific aspirations, and then searches for actions satisficing these aspirations. Depending on how successful this search turns out, she decides whether to continue her search or

to adapt her aspirations.

Usually, satisficing relies on forming different aspiration levels for different basic goals. When, for instance, searching for an apartment, the decision maker may specify an aspiration for the rent she is willing to accept, an aspiration for the number of rooms she wants, and so on. In saving decisions, the decision maker typically concentrates on one basic goal: guaranteeing herself sufficient monetary means for consumption over the years she may experience. We assume that the decision maker applies her aspirations to different scenarios of possible life experiences capturing the uncertainty of her future. More specifically, we suppose that the decision maker forms scenario-specific aspirations specifying the financial means she wants to have available for consumption purposes (e.g., how much she aims to spend when living rather long, losing her job or having to retire early).

Similar to the rational choice approach, the satisficing approach with its three constituent subprocesses (aspiration formation, satisficing, aspiration adaptation) provides a flexible and rich terminology to explain why one decides in certain ways. Such flexibility, however, is a curse rather than a blessing when it comes to predict behavior because making specific predictions requires imposing rather bold assumptions. In our view, such bold assumptions are better developed in line with stylized facts of empirically observed behavior. Thus, rather than speculating on how actors satisfice when making saving decisions, we prefer to collect experimental evidence so as to learn whether and in which ways people are satisficers.¹

We rely on a two-by-two factorial design distinguishing short and long life horizon as well as low and high future income. Thus, each participant has to form four scenario-specific aspiration levels. Our only experimental treatment variable concerns how these aspiration levels are elicited: once as “cheap-talk” data, and once as incentivized choices. In the latter case, for the randomly

¹Anderhub and Güth (1999) provide a survey of experimental economics studies on saving behavior. For the psychological literature see Wäneryd (1999).

selected scenario, a participant earns her aspiration when this does not exceed her actual monetary payoff; otherwise, she earns nothing.

Our method of incentivizing aspiration choices provides a new way to test optimality without imposing risk attitudes. Optimal aspiration profiles do not allow increasing the aspiration for a specific scenario without endangering the aspirations for other scenarios. Hence, one can test optimality in a non-Bayesian way by eliciting state-specific aspirations whose profile should be optimal. Of course, optimal aspiration profiles have to be consistent, i.e., there should exist consumption or saving plans satisfying the aspirations for all scenarios. An important result of our treatment with incentivized aspirations is that participants learn to form consistent aspiration profiles, but not optimal ones, i.e., even after becoming more experienced, participants remain only boundedly rational.

The specific saving tasks are illustrated in Section 2 where, after the traditional rational choice analysis (Section 2.1), we introduce our definition of satisficing in savings (Section 2.2). The experimental protocol is described in Section 3, and the data are statistically analyzed in Section 4. Section 5 concludes.

2 The model

The basic approach can be illustrated by a simple situation in which the decision maker knows her present income or wealth y (> 0), but has a stochastic future income Y and an indeterminate length of life T . The present certain income y can be spent for either present consumption $c_1 \in [0, y]$ or saving $y - c_1$. The latter, together with the stochastic future income Y , has to finance her future consumption.

We assume that the future income and the number of future life (and, thus, consumption) periods can assume only two values, i.e., $Y \in \{\underline{Y}, \bar{Y}\}$ with $0 < \underline{Y} < \bar{Y}$, and $T \in \{\underline{T}, \bar{T}\}$ with $1 < \underline{T} < \bar{T}$. To limit the number of parameters,

we abstract from interest rates for saving funds and discount factors. A further simplification results from setting $\underline{T} = 2$ and $\bar{T} = 3$, so that the decision maker will always experience one future period, where she consumes $c_2 \in [0, y - c_1 + Y]$, but she is not sure about reaching the second future period. If she survives until $\bar{T} = 3$, then she would consume $c_3 = y - c_1 + Y - c_2$. It is important that the decision maker is unaware of Y and T when choosing $c_1 \in [0, y]$, although she knows Y (but not T) when choosing c_2 .

Rather than the usual additive intertemporal utility functions, we rely on the multiplicative intertemporal payoff specifications

$$U_T = \prod_{t=1}^T c_t \quad \text{with } T \in \{2, 3\} \quad (1)$$

so that $U_2 = c_1 \times c_2$ and $U_3 = c_1 \times c_2 \times c_3$. The reason is simply that significant differences in saving decisions go hand in hand with significant differences in intertemporal payoffs for the multiplicative, but not for the additive, payoff specification (see Anderhub et al., 2000). Thus, by our intertemporal payoff specification, we try to induce that large deviations from, e.g., optimality in action space will imply large effects in payoff space.

2.1 Rational choice analysis

Before elaborating our approach of scenario-specific satisficing, let us briefly describe the normative benchmark solution based on risk neutrality. For an optimality approach, we need to specify probabilities $q = \text{Prob}\{Y = \underline{Y}\}$ and $1 - q = \text{Prob}\{Y = \bar{Y}\}$ as well as $p = \text{Prob}\{T = 2\}$ and $1 - p = \text{Prob}\{T = 3\}$, assuming that the two chance events are independent. For any given first choice $c_1 \in [0, y]$ and realization $Y \in \{\underline{Y}, \bar{Y}\}$, the optimal second choice $c_2^* \in [0, y - c_1 + Y]$ must maximize $c_1[p c_2 + (1 - p)c_2(y - c_1 + Y - c_2)]$, implying

$$c_2^*(c_1, Y) = \frac{p}{2(1-p)} + \frac{y - c_1 + Y}{2},$$

which assumes non-negative values for $\frac{p}{1-p} \leq y - c_1 + Y$. Under this assumption,

the optimal first choice c_1^* is obtained by maximizing

$$U = c_1 q \left[p \left(\frac{p}{2(1-p)} + \frac{y - c_1 + \underline{Y}}{2} \right) + (1-p) \left(\frac{(y - c_1 + \underline{Y})^2}{4} - \frac{p^2}{4(1-p)^2} \right) \right] + \\ + c_1 (1-q) \left[p \left(\frac{p}{2(1-p)} + \frac{y - c_1 + \bar{Y}}{2} \right) + (1-p) \left(\frac{(y - c_1 + \bar{Y})^2}{4} - \frac{p^2}{4(1-p)^2} \right) \right]$$

with respect to c_1 . From the first order condition we obtain

$$c_1^* = \frac{2\Psi(1-p) - \sqrt{(1-p)^2(4\Psi^2 + \Omega - 3(p+y-py)^2 + \Theta)}}{3(1-p)^2}$$

where $\Psi = p + (1-p)(y + q\underline{Y} + (1-q)\bar{Y})$, $\Omega = 6(1-p)(1-q)(p + (1-p)(y + \bar{Y}/2))\bar{Y}$, and $\Theta = 6(1-p)q(p + (1-p)(y + \underline{Y}/2))\underline{Y}$.

2.2 The satisficing approach

In our simplified situation, there exist four different scenarios

$$(Y, T) \in \{(\underline{Y}, \underline{T}), (\underline{Y}, \bar{T}), (\bar{Y}, \underline{T}), (\bar{Y}, \bar{T})\}$$

for which the decision maker has to form state-specific aspirations $A(Y, T)$. We refer to the vector

$$\mathbf{A} = (A(\underline{Y}, \underline{T}), A(\underline{Y}, \bar{T}), A(\bar{Y}, \underline{T}), A(\bar{Y}, \bar{T}))$$

as an aspiration profile. The latter is called “consistent” if there exist saving plans guaranteeing $U(Y, T) \geq A(Y, T)$ for all four scenarios. More specifically, \mathbf{A} is consistent if it is possible to find consumption choices $(c_1, c_2(Y)) = (c_1, c_2(\underline{Y}), c_2(\bar{Y}))$ such that all four following inequalities hold simultaneously:

$$c_1 \times c_2(\underline{Y}) \geq A(\underline{Y}, \underline{T}) \tag{2}$$

$$c_1 \times c_2(\bar{Y}) \geq A(\bar{Y}, \underline{T}) \tag{3}$$

$$c_1 \times c_2(\underline{Y}) \times (y - c_1 + \underline{Y} - c_2(\underline{Y})) \geq A(\underline{Y}, \bar{T}) \tag{4}$$

$$c_1 \times c_2(\bar{Y}) \times (y - c_1 + \bar{Y} - c_2(\bar{Y})) \geq A(\bar{Y}, \bar{T}). \tag{5}$$

To check the consistency of \mathbf{A} , let us satisfy inequalities (2) and (3) with equalities, and substitute for $c_2(\underline{Y})$ and $c_2(\bar{Y})$ in (4) and (5), respectively. For

$c_1 > 0$, we get:

$$\begin{aligned} A(\underline{Y}, \underline{T}) \times \left(y - c_1 + \underline{Y} - \frac{A(\underline{Y}, \underline{T})}{c_1} \right) &\geq A(\underline{Y}, \bar{T}) \\ A(\bar{Y}, \underline{T}) \times \left(y - c_1 + \bar{Y} - \frac{A(\bar{Y}, \underline{T})}{c_1} \right) &\geq A(\bar{Y}, \bar{T}). \end{aligned}$$

Solving the latter two inequalities for c_1 yields

$$\left[A(\underline{Y}, \underline{T})(y + \underline{Y}) - A(\underline{Y}, \bar{T}) \right] c_1 - A(\underline{Y}, \underline{T})c_1^2 \geq A(\underline{Y}, \underline{T})^2 \quad (6)$$

$$\left[A(\bar{Y}, \underline{T})(y + \bar{Y}) - A(\bar{Y}, \bar{T}) \right] c_1 - A(\bar{Y}, \underline{T})c_1^2 \geq A(\bar{Y}, \underline{T})^2. \quad (7)$$

Denoting by b_1 and b_2 the term in square brackets on the left-hand side of (6)

and (7), respectively, these two restrictions can be expressed as

$$c_1 \leq \frac{b_1 - \sqrt{b_1^2 - 4A(\underline{Y}, \underline{T})^3}}{2A(\underline{Y}, \underline{T})} \quad (8)$$

$$c_1 \leq \frac{b_2 - \sqrt{b_2^2 - 4A(\bar{Y}, \underline{T})^3}}{2A(\bar{Y}, \underline{T})} \quad (9)$$

that assume real values for $b_1^2 \geq 4A(\underline{Y}, \underline{T})^3$, and $b_2^2 \geq 4A(\bar{Y}, \underline{T})^3$. The lower of the two above upper bounds is, thus, decisive for the consistency of **A**.

3 Experimental protocol

The computerized experiment consisted of 9 rounds, thereby allowing participants to learn from own experience by going through 9 “lives”. Participants knew that the length of each “life” was a stochastic variable: it could be either two or three periods, with each life-length being equally likely (i.e., $p = 0.5$). At the beginning of each life/round, participants received an income $y = 10$ ECU (Experimental Currency Unit),² and were informed that in the second period they would receive an income either of $\underline{Y} = 5$ ECU with probability $q = 0.5$ or of $\bar{Y} = 15$ ECU with complementary probability.

In every round, participants were asked to choose a consumption vector $(c_1, c_2(\underline{Y}), c_2(\bar{Y}))$, knowing that, for each scenario, whatever was left of the corresponding periodical income was saved for the following period(s). Par-

²The exchange rate between ECU and Euro was 1 to 0.15.

ticipants were informed that at the end of each life/round, one of the four possible scenarios was randomly selected, and that their monetary payoff in each life/round was given by the product of the periodic consumption levels – as expressed by Eq. (1) – for the randomly selected scenario.

Due to our experimental parameters, rationality requires risk neutral decision makers to set $c_1^* = 7.62$, $c_2^*(\underline{Y}) = 4.19$, and $c_2^*(\bar{Y}) = 9.19$, implying first period's savings of 2.38, and second period's savings of 3.19 and 8.19 for Y equal to 5 and 15, respectively. The intertemporal optimal payoffs for the four scenarios, therefore, are $U^*(\underline{Y}, \underline{T}) = 31.93$, $U^*(\underline{Y}, \bar{T}) = 101.85$, $U^*(\bar{Y}, \underline{T}) = 70.03$, and $U^*(\bar{Y}, \bar{T}) = 573.53$.

To check experimentally the satisficing hypothesis, in every round, before choosing a consumption vector, each participant had to form her own aspiration profile \mathbf{A} , i.e., she had to specify the monetary payoff she aimed to achieve in each of the possible four scenarios. After having provided their four aspiration levels and their consumption plan (with three components), participants were informed by the experimental software whether this plan was consistent or not (i.e., whether their three consumption choices guaranteed all four aspirations), and, in case of inconsistency, which of the stated aspirations was/were not met.

Regardless of whether the specified plan was consistent or not, a participant could either confirm it or continue her search, whereby the latter could be performed via revisions of consumption choices and/or aspirations. Thus, although they could always rely on a software aided satisficing routine, participants were free to confirm any feasible consumption plan irrespective of its consistency. This allows us to explore how people react to feedback of (non-)satisficing, and to answer the following research questions: when being aware that their stated consumption plan is not satisficing, do actors confirm it anyway or do they revise it? In case they revise their inconsistent plan, what are they more willing to change: consumption choices or aspirations? To reduce the likelihood of noise in the decisions to revise, a maximum of 5 revisions per round was warranted.

Our only experimental treatment variable concerns the way in which we elicited and paid for aspirations. In one treatment (henceforth, *C*-treatment), aspirations were just cheap-talk data in the sense that subjects had no monetary incentives for meaningful reporting. In the other treatment (henceforth, *I*-treatment), aspirations were incentivized: for the randomly selected scenario (Y, T) , participants earned their stated aspiration $A(Y, T)$ only if this did not exceed their actual monetary payoff, i.e., if $U(Y, T) \geq A(Y, T)$. Otherwise, their earning was nil. We expect the *I*-treatment to induce aspirations more in line with optimal choices than the *C*-treatment. The reason for this conjecture is that optimal aspirations in the *I*-treatment have to be efficient in the sense that, in case of optimal aspirations, one can only increase one scenario-specific aspiration at the cost of decreasing the aspiration for at least one other scenario.³

Regardless of the experimental treatment, at the end of each life/round, participants got individual feedback about the randomly selected scenario and their corresponding experimental earnings, whereby their win could be either the product of the periodic consumption (*C*-treatment), or their stated aspiration (*I*-treatment). Like Anderhub et al. (2000), we allowed participants to decide, at the beginning of the experiment, whether they wanted to be paid according to the average win of all 9 rounds or according to a randomly selected round.

For each of the two treatments, we ran two sessions with 32 participants each, yielding 64 independent observations per treatment. All sessions were ran computerized with the help of z-Tree (Fischbacher, 2007) at the laboratory of the Max Planck Institute in Jena (Germany). Participants (all being students from various fields at the University of Jena) were recruited using the ORSEE software (Greiner, 2004).

After being seated at a visually isolated computer terminal, participants

³Similarly to the incomparability of individual utilities in case of non-transferable utilities, this does not allow for compensation of aspiration levels across scenarios.

received written instructions (see the appendix for an English translation). Understanding of the rules was assured by a control questionnaire that subjects had to answer in order for the experiment to start. The software of the computerized experiment offered access to a calculator so that participants could easily check the numerical consequences of certain choices. Allowing for at most 5 revisions per round, sessions needed about 90 minutes.

4 Experimental results

In reporting our results, we proceed as follows. First, we present an overview of elicited aspiration levels and consumption behavior in our two treatments. Then we turn to our main questions, and try to establish whether participants voluntarily choose satisficing saving plans and, if revisions occur (either within a round or between two consecutive rounds), what is mostly revised (aspirations and/or saving plans).

4.1 Observed consumption plans and aspiration profiles

Table 1 shows the mean values of periodic consumption decisions and stated aspiration levels in each round separately for the two treatments.⁴ For each of the four scenarios and each of the 9 rounds, it furthermore lists the average relative monetary payoffs (actual payoffs divided by optimal payoffs).

Insert Table 1 about here

The ratio of actual monetary payoffs to optimal payoffs reveals that actual payoffs are higher than optimal ones in the scenarios characterized by low income. The opposite holds in case of high income. For each scenario, the differentials remain rather stable across rounds.

Consumption in the first period (c_1) is close to 7 in every round, irrespective of the treatment. Over all rounds, in the first period subjects consume

⁴Only values in correspondence to the last revision are considered.

6.98 (standard deviation: 0.164) in the C -treatment and 7.06 (standard deviation: 0.203) in the I -treatment. These values are significantly lower than the corresponding rational benchmark (one sided Wilcoxon signed rank test with continuity correction, $p < 0.001$ for both treatments), indicating that subjects tend to oversave in period 1. As to consumption in the second period ($c_2(Y)$), its overall average (standard deviation) in case of low income is 5.44 (0.203) for the C -treatment and 5.48 (0.146) for the I -treatment. The respective averages (standard deviations) in case of high income are 11.99 (0.303) and 12.25 (0.205). In the second period, whatever their income (5 vs. 15) and their incentives (C -vs. I -treatment), subjects consume significantly more than required by rationality ($p < 0.001$ always), thereby suggesting that, in period 2, in contrast to period 1, the tendency is to undersaving.⁵

Denoting by $\bar{A}(Y, T)$ the average (over rounds and subjects) aspiration in scenario (Y, T) , we find that $\bar{A}(\underline{Y}, \underline{T}) = 37.60$, $\bar{A}(\bar{Y}, \underline{T}) = 99.85$, $\bar{A}(\underline{Y}, \bar{T}) = 83.05$, and $\bar{A}(\bar{Y}, \bar{T}) = 360.95$ under the C -treatment. The corresponding values in the I -treatments are 36.10, 83.97, 77.52, and 350.94. Whatever the treatment, a long “life” ($\bar{T} = 3$ vs. $\underline{T} = 2$) tends to induce more ambitious aspirations for both possible second-period incomes Y . Similarly, a high second-period income ($\bar{Y} = 15$) triggers greater aspirations than a low one ($\underline{Y} = 5$) for both lengths of life T . The observed values are rather far from optimal aspirations (as implied by optimal consumption choices). In particular, under both treatments, elicited aspirations for the short life scenarios ($A(\underline{Y}, \underline{T})$ and $A(\bar{Y}, \underline{T})$) are significantly greater than their respective optimal values whereas the opposite applies to $A(\underline{Y}, \bar{T})$ and $A(\bar{Y}, \bar{T})$ ($p < 0.05$ for all comparisons; Wilcoxon signed rank test with continuity correction).

To check for sub-optimality of aspirations, we compute subject i 's weighted payoff loss as compared to the Bayesian benchmark solution, $wpl^i = \frac{1}{4} \sum_{s=1}^4 (U_s^* - A_s^i)$, with s being each possible scenario. We restrict the analysis to consistent

⁵Qualitatively, results do not change by focusing on the last round only.

aspiration profiles. Table 2 presents the average (over rounds and subjects) of wpl^i , separately for rounds 1 to 3, 4 to 6, and 7 to 9.

Insert Table 2 about here

Regardless of the treatment and the considered round-interval, the average weighted payoff loss is positive, revealing the sub-optimality of consistent aspirations. However, consistent aspirations are closer to optimality when they are incentivized. Wilcoxon rank sum tests reveal that the index under consideration is significantly different across treatments in rounds 7-9 and 4-6 ($p = 0.001$ and $p = 0.009$, respectively), but not in the first three rounds ($p = 0.930$).

Pairwise comparisons of stated aspirations in each scenario across treatments reveals that subjects tend to aspire more in the C - than in the I -treatment for scenarios $(\underline{Y}, \underline{T})$, (\underline{Y}, \bar{T}) , and (\bar{Y}, \bar{T}) ($p < 0.05$ always, Wilcoxon rank sum test). No statistically significant difference is detected for (\bar{Y}, \underline{T}) . However, restricting the analysis to consistent consumption plans reverts these results, and average aspirations become significantly higher in the I -treatment ($p < 0.05$ for all comparisons). Participants who care for consistency form more ambitious aspirations when the latter are incentivized.

Before determining c_1 for the first time each participant was asked whether she preferred the average payoff of all 9 rounds or the payoff of a randomly selected round. In the C (I)-treatment, 6 (5) of 64 participants decided to be paid by one round only. Seeing such participants as more risk-loving than those who opted for the average payment (cf., Anderhub et al., 2000), only few individuals display positive attitudes to risk.⁶

Looking at monetary earnings in the two treatments, subjects gain, on average, significantly more when their round-earning is given by the product of the periodic consumption levels than when it is conditional upon compliance with satisficing ($p = 0.0073$; Wilcoxon rank sum test with continuity correc-

⁶Given the few “random”-types, any attempt to correlate the selected way of payment with consumption or aspiration behavior does not yield valuable results.

tion). In light of the previous observation that aspirations in the *I*-treatment are not in line with optimal choices, this result does not come unexpected. Yet, such significant overall difference in earnings between treatments may be due to initial difficulties in setting consistent aspirations in the *I*-treatment. Within-treatment comparison of experimental earnings in rounds 3 and 9 reveal that participants in the *I*-treatment, but not in the *C*-treatment, earn significantly more in the last round than in the third one ($p = 0.001$ for the *I*-treatment, and $p = 0.2698$ for the *C*-treatment; Wilcoxon signed rank test with continuity correction).⁷ This indicates that participants in the *I*-treatment are able to improve their performance over time and learn more about the environment in which they are called to make their choices. It is worthwhile noticing that, in the last round, we cannot reject the null hypothesis that average earnings in the two treatments are the same ($p = 0.7912$).

4.2 Compliance with satisficing

We now turn to our two main research question. Do participants comply with satisficing when formulating their consumption plans? In other words, do they voluntarily set a consistent aspiration profile, fulfilling inequalities (2) to (5) simultaneously? Subsection 4.2.1 presents an aggregate data analysis of satisficing behavior. Subsection 4.2.2 provides details about individual behavior.

4.2.1 Aggregate analysis

In the *C*-treatment, out of all the $576 = 64 \times 9$ (participants \times rounds) individual observations 235 (about 41%) comply immediately with inequalities (2) to (5), meaning that the three variables of interest, c_1 , $c_2(\underline{Y})$ and $c_2(\bar{Y})$, are satisficing at first attempt for the same individual. The respective number in the *I*-treatment is 402 (or about 70%). All these immediately satisficing consumption decisions are confirmed, i.e., not revised within the round.

⁷These comparisons make sense because the same scenario was randomly selected in round 3 and round 9.

Considering the actually made choices,⁸ 61.5% out of 803 choices in the *I*-treatment are satisficing whereas only 39.1% out of 752 choices in the *C*-treatment comply with satisficing. A binomial test confirms that the distribution of satisficing choices in the two treatments is significantly different ($p < 0.001$).

Figure 1 displays the time path of “satisficers” in each treatment. The shaded horizontal lines in the figure indicate average percentages.

Insert Figure 1 about here

Regardless of whether aspirations are incentivized or not, participants seem to “learn” over time how to comply with satisficing. However, monetarily motivating subjects to report aspirations favors compliance with satisficing. In the ninth and last round of the *I*-treatment, almost all subjects implement satisficing consumption vectors. On the contrary, in the treatment with cheap-talk aspirations, less than 60% of the subjects abide by satisficing in round 9.

Table 3 separates the data of each treatment according to whether aspiration profiles in each single round are consistent or not, and, if not, whether revisions occur. The table reports both absolute numbers and (in parentheses) percentages of all observed choices.⁹

Insert Table 3 about here

In the first round, the percentage of observations leading to revisions after being informed about inconsistency is considerably higher in the *I*-treatment than in the *C*-treatment (58.33% vs. 38.46%). In the following rounds, this percentage does not differ significantly between treatments (cf., columns (1) and (2)). However, data in columns (3) and (4) clearly show that, from rounds

⁸As subjects could engage in revisions at most 5 times per round, the maximum number of feasible choices are $2880 = 5 \times 9 \times 64$ (revisions \times rounds \times subjects).

⁹To avoid redundancy, we do not give details of inconsistent aspiration profiles that do not lead to revisions. This explains why, for each treatment, the total percentages reported in the last row do not sum up to 100.

2 to 9, the percentage of consistent aspiration profiles is considerably greater in the *I*-treatment than in the *C*-treatment.

The average number of revisions per round taking place in each treatment is depicted in Figure 2. In both graphs, the 64 shadowy lines give a clue of individual decisions.

Insert Figure 2 about here

In line with the data in Table 3, on average, the highest number of revisions is undertaken in the first round, especially in the *I*-treatment. The shadowy lines indicate heterogeneity at the individual level in early rounds. Due to the substantial compliance with satisficing in later rounds of the *I*-treatment, it is not surprising that average revisions per round in case of incentivized aspirations die out completely.

To investigate which factors affect decisions to revise, we estimate a random-intercept logit model controlling for potential correlation between the same individual's choices. The dependent variable equals 1 if the subject decides to revise when informed that her consumption vector is not satisficing, and 0 otherwise. The regressors are *Round* (taking values 1–9), *Possible Revision* (taking values 0–5), π_{t-1} (the payoff most recently received), and a treatment dummy (*Treatment*) being 1 for the *I*-treatment and 0 for the *C*-treatment. The estimation results yield the coefficient of *Round* and *Possible Revision* as significantly negative ($\beta_{Round} = -0.120$, $\beta_{Possible\ Revision} = -0.302$; $p = 5\%$), confirming that both a later round and further possible revisions within one round negatively affect the likelihood to revise. Incentivizing aspirations strongly enhances the probability of revising ($\beta_{Treatment} = 2.760$; $p = 1\%$). The coefficient of the last observed payoff is close to zero and not significant at the 5% level ($\beta_{\pi_{t-1}} = -0.001$).

What do participants revise more often: their aspirations or their consumption plans? Figures 3 and 4 provide details on revision rates across rounds in

the *C*- and *I*-treatment, respectively.¹⁰ Denoting by V_t the value of the variable of interest (the three periodic consumptions and the four scenario-specific aspirations), the revision rate (r) is given by $\frac{V_{t+1}-V_t}{V_t}$. For instance, [2-1] on the horizontal axis of the histograms refers to comparisons between the various values in round 2 and round 1. Data are separated according to whether aspirations in the previous round ($t - 1$) were consistent (subfigures 3.b and 4.b) or not (subfigures 3.a and 4.a). In the analysis, 10 and 5 outliers (revision rates greater than 1000%) have been omitted for the *C*- and *I*-treatment, respectively.

Insert Figures 3 and 4 about here

Starting from the *C*-treatment, revisions occur between rounds regardless of whether choices were satisficing in the previous round or not. Thus, compliance with satisficing in the previous round does not seem to inhibit revisions, with a tendency to increase aspirations (see subfigure 3.b).

Turning to revision rates in the *I*-treatment, the pattern of the histograms in Figure 4 reflects the fact that earnings depend on fulfillment of satisficing. Failing to meet aspirations in the previous round leads to substantial revisions in consumption decisions and aspiration levels (cf., subfigure 4.a). On the contrary, if aspirations were met in the previous round, rates of revision become, in general, very small, except when moving from the first to the second round that leads to an upward revision of all four possible aspirations (cf., subfigure 4.b).

Insert Figure 5 about here

Figure 5 helps to gain a better understanding of what governs aspirations. Participants tend to set aspirations in round t equal to their monetary payoffs in the previous round ($t - 1$), especially in the *I*-treatment where such a tendency increases over time. Hence, participants do not appear to be willing to improve

¹⁰Due to the low number of revisions within each single round, we preferred to look at revision rates between rounds.

their condition and search for optimality, although they could experiment with more ambitious aspirations thanks to the five revisions in each round. This illustrates that individuals do not even try to get better if they are satisfied with their consumption plan and the resulting payoffs.

4.2.2 A closer look at the individual data

To provide a more detailed description of individual satisficing behavior, we focus on the length of “unbroken” sequence of satisficing plans that each participant undertakes, where the sequence includes the ninth and last round. In particular, we distinguish subjects as follows.

1. *Early satisficers*: if the length of such a sequence is between 7 and 9.
2. *Intermediate satisficers*: if the sequence of uninterrupted satisficing choices is between 6 and 4.
3. *Late satisficers*: if the sequence of interest is between 3 and 1.
4. *Never satisficers*: if subjects do not satisfice in the last round.

Figure 6 reports the percentage of subjects who fall in each of the identified categories.

Insert Figure 6 about here

In the *I*-treatment, most participants are early satisficers (nearly 47%), and the proportion of intermediate satisficers is also rather high (about 20%). Only a minimal percentage (about 11%) never satisfice. The data for the *C*-treatment are reversed: the proportion of early satisficers is rather low (15%), and most subjects never comply with satisficing (about 47%). It is worthy noticing that 11 (3) of the early satisficers in the *I* (*C*)-treatment meet their aspirations throughout all nine experimental rounds. Hence, the individual data analysis confirms that incentivizing aspirations helps subjects comply with satisficing.

4.3 Videotaping

To learn how people reason when implementing saving plans and specifying aspirations, in addition to the four sessions in the computer laboratory, we performed one session in the video laboratory of the Max Planck Institute (Baumann and Schmidt, 2004) with 16 female participants. The laboratory offers eight sound-proof booths, each of which is endowed with a computer, a video camera, a video screen and a microphone. Two subjects were placed in the same booth and had to decide jointly on their aspiration profile and saving plan. Participants were equally split between the two treatments: four pairs played the C -treatment and four pairs the I -treatment.

Rather than providing a word analysis of transcripts, we report the main arguments that were mentioned by one or both members of the pairs. In both treatments, irrespective of the second period's income being low ($\underline{Y} = 5$) or high ($\bar{Y} = 15$), the idea of consumption smoothing (in the sense of $c_1 = c_2$ or $|c_1 - c_2| \leq 1$) came up rather frequently (usually after numerous numerical trials rather than in the form of an analytic insight). More specifically, it has been often discussed to just leave $c_3 = 0$ (used argument: “*let us take the risk*”), to set $c_1 = c_2 = c_3$ (used argument: “*let us forget about the risk of not experiencing period 3*”), or to choose $c_3 = 1$ (used argument: “*this ensures the same payoffs regardless of the number of periods we experience*”).

Incentivizing aspirations made pairs think more thoroughly about the problem, bringing forward statements of the type: “*this plan will guarantee us a payoff of ... ECU; thus, we should not aspire more than that*”.

Whether to select the random payment or the average payment was definitely seen as a choice between a risky option and a safer one, with both partners in all pairs always agreeing on selecting the safer option.

5 Conclusions

Saving for an uncertain future is probably one of the most difficult economic decision problems. In this paper, we captured the crucial aspects of this problem by allowing for a stochastic future income and an indeterminate length of life. Contrary to the traditional rational choice approach, based on well-behaved intertemporal preferences and Bayesian reasoning, we developed a non-Bayesian, satisficing approach by postulating the formation of scenario-specific aspirations. To check experimentally the consistency of aspirations, in every round, before choosing their saving plan, participants had to specify the monetary pay-offs they aimed to achieve in each of the possible scenarios. A software aided satisficing routine informed then participants whether their plan was consistent or not (i.e., whether it guaranteed all their aspirations), and gave them the possibility of revising any aspect of their decision in case of inconsistency.

To investigate whether incentivizing aspirations affects behavior, we have considered two treatments that differed only in whether participants had monetary incentives for meaningful reporting aspirations or not.

Our results reveal that, whatever their incentives, subjects save, on average, too much initially and too little afterwards as compared to risk neutral optimality. Moreover, aspirations do not fully exploit earnings potential: under both treatments, elicited aspirations are significantly smaller than allowed by rationality for the long life scenarios and the reverse is true in case of short lives.

When considering compliance with satisficing, both the aggregate and individual level data suggest that participants set consistent aspiration profiles significantly more often in case of incentivized aspirations: in the last experimental round, nearly 100% of the participants in the treatment with incentivized aspirations implement satisficing saving plan. The respective percentage in the treatment with cheap-talk aspirations is less than 60%. The increase in con-

sistent aspiration profiles over rounds illustrates that satisficing (as the core concept of bounded rationality theory) is not always readily applied, but may have to be “learnt”.

In terms then of general messages, we can confirm that optimal intertemporal decision behavior is difficult to derive. “Learning” to guarantee an aspired consumption or saving plan seems to be easier and more likely when aspirations are incentivized.

Acknowledgment

We gratefully acknowledge the inspiring discussions with Arie Kapteyn both on our methodological approach and on the data analysis.

Appendix. Translated instructions

General Instructions: Welcome and thanks for participating in this experiment. You receive €2.50 for having shown up on time. Please read the following instructions carefully. From now on any communication with other participants is forbidden. If you have any questions or concerns, please raise your hand. We will answer your questions individually.

The experiment allows you to earn money. How much you will earn depends on your own decisions, which are anonymous and cannot be traced to your name. The unit of experimental money will be the ECU, where $1 \text{ ECU} = \text{€}0.15$.

Detailed Instructions: In this experiment, you will have to make decisions repeatedly. Altogether you will play 9 rounds. Each round can last for either two or three periods, where both durations are equally likely. This means that with a 50% probability the round will last two periods, and with a 50% probability it will last three periods.

In the first period of every round, you will be endowed with 10 ECU. In the second period of every round, you will receive an additional endowment of either 5 ECU or 15 ECU with equal probability. That is, with a 50% probability your second period's endowment will be 5 ECU, and with a 50% probability it will be 15 ECU. Thus, in each round, only one of the following four scenarios can occur with equal probability.

1. Your second period's endowment is *5 ECU* and the round lasts for *two periods*.
2. Your second period's endowment is *15 ECU* and the round lasts for *two periods*.
3. Your second period's endowment is *5 ECU* and the round lasts for *three periods*.
4. Your second period's endowment is *15 ECU* and the round lasts for *three periods*.

Your task

Your task in every round is to distribute the amount of ECU you receive over the various periods of the round.

First, you must decide how many of the 10 ECU you receive in period 1 you want to spend in period 1. You have to decide how much to spend in period 1 without neither knowing the number of periods of that round nor your additional endowment in period 2.

2. Whatever you do not spend in period 1, you save for the following period(s).

Then, you must decide how many of the ECU you have in period 2 you want to spend in period 2. You have to decide how much to spend in period 2 knowing your

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additional endowment, but not knowing the number of periods of that round. You can only spend the ECU you receive in the second period (either 5 or 15) *plus* the ECU you have left from the first period. For example, if you have left 4 ECU from the first period (i.e., you have decided to spend 6 ECU in the first period), the maximal amount of ECU that you can spend in period 2 is either $4 + 5 = 9$ when your endowment is 5 ECU or $4 + 15 = 19$ when your endowment is 15 ECU.

If you reach the third period, you do not have to make a decision because all remaining money is spent automatically in period 3.

Thus, in each round, you have to make three spending decisions: I) how many of the 10 ECU you receive in period 1 you want to spend in period 1; II) how many of the ECU you have in period 2 you want to spend in period 2 when your second period's endowment is 5 ECU; III) how many of the ECU you have in period 2 you want to spend in period 2 when your second period's endowment is 15 ECU.

After you have taken these three decisions, it will be randomly determined by the experimental software whether your second period's endowment is 5 or 15 ECU as well as whether the round lasts for two or three periods.

Your round-payoff

Your payoff in each round is equal to *the product of ECU you spent in the single periods of that round*. Suppose that it is randomly determined that your second period's endowment is 5 ECU. If the round lasts for two periods, you earn

$$\begin{aligned} \text{2-period round-payoff} = & (\text{amount spent in period 1}) \times \\ & (\text{amount spent in period 2 when your endowment is 5}). \end{aligned}$$

If the round lasts for three periods, you earn

$$\begin{aligned} \text{3-period round-payoff} = & (\text{amount spent in period 1}) \times \\ & (\text{amount spent in period 2 when your endowment is 5}) \times \\ & (\text{amount left after period 2 when your endowment is 5}). \end{aligned}$$

Please think about the following: If you spend an amount of 0 in one period, your round-payoff will also be 0, because one of the factors is 0. This can happen, for instance, if you spend all money in the second period, and it is randomly determined that the round lasts for three periods. Then you will spend 0 in the third period and therefore earn nothing. Thus, you have to compare the risk of spending all your money early with the risk of wasting your money when the round lasts for two periods only.

The decision aid

To help you decide how to distribute your ECU over the periods of each round, we provide you with a decision aid aiming at “satisficing” decisions, i.e., decisions achieving your desired round-payoff in each of the four possible scenarios.

In each round, the decision aid will guide you through the following steps.

- a. First, it will ask you to specify the round-payoff you wish to guarantee yourself in each scenario. In particular, you will have to answer the following four questions: Which round-payoff do you aspire to in case your second period’s endowment is *5 ECU* and the round lasts for *two periods*? Which round-payoff do you aspire to in case your second period’s endowment is *15 ECU* and the round lasts for *two periods*? Which round-payoff do you aspire to in case your second period’s endowment is *5 ECU* and the round lasts for *three periods*? Which round-payoff do you aspire to in case your second period’s endowment is *15 ECU* and the round lasts for *three periods*?

Note that for either duration of the round, you can aspire to a higher round-payoff when your second period’s endowment is 15, rather than 5, ECU.

- b. After having answered the four questions above, the decision aid will ask you to make your three spending decisions.
- c. Then, the decision aid will inform you whether, given your spending decisions, your payoff aspirations can be achieved simultaneously or not.
- d. If your stated aspiration *cannot* be achieved in some scenario, the decision aid will ask you whether you want to revise your decisions or not.
 - If you want to revise something, you will go back and can modify any of your spending decisions, any of your stated payoff aspirations, or both your spending decisions and your stated aspirations.
 - If you do not want to revise anything, you will directly move on to the next round.

The information you receive at the end of each round

At the end of each round, you will be informed about the randomly selected scenario as well as about your round-payoff.

Your final earnings

[Participants in the I-treatment read: Although your round-payoff influences your ex-

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perimental earnings, you will NOT receive your round-payoff, but rather *your aspiration* if it does not exceed your round-payoff. In particular, in each round, the computer will check whether, for the randomly selected scenario, your payoff aspiration is greater than your round-payoff in that scenario or not.

- If your payoff aspiration in the randomly selected scenario does not exceed your round-payoff, you earn your payoff aspiration in the selected scenario.
- Otherwise, you earn nothing.

Suppose, for instance, that the computer selects the scenario in which your second period's endowment is 5 ECU and the round lasts for three periods. If your round-payoff is 96 and your payoff aspiration for this scenario is 90, since $90 < 96$, you earn 90 ECU; if instead your payoff aspiration for this scenario is 100, since $100 > 96$, you earn 0 ECU.]

At the beginning of the experiment, you can choose whether you want to be paid for *one randomly selected round* or not. If not, you will receive the *mean* of your payoffs in all 9 rounds. In any case, you will get your payoff in cash after the experiment.

Before the experiment starts, you will have to answer some control questions to ensure your understanding of your task, and the functioning of the decision aid.

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Table 1

Average values of consumption decisions, aspiration levels and relative monetary payoffs in each treatment

<i>C</i> -treatment											
Round	c_1	$c_2(\underline{Y})$	$c_2(\bar{Y})$	$A(\underline{Y}, \underline{T})$	$\frac{U(\underline{Y}, \underline{T})}{U^*(\underline{Y}, \underline{T})}$	$A(\bar{Y}, \underline{T})$	$\frac{U(\bar{Y}, \underline{T})}{U^*(\bar{Y}, \underline{T})}$	$A(\underline{Y}, \bar{T})$	$\frac{U(\underline{Y}, \bar{T})}{U^*(\underline{Y}, \bar{T})}$	$A(\bar{Y}, \bar{T})$	$\frac{U(\bar{Y}, \bar{T})}{U^*(\bar{Y}, \bar{T})}$
1	6.68	5.79	12.17	40.70	1.16	103.75	0.82	88.57	1.14	386.43	0.71
2	7.08	5.19	11.69	38.39	1.12	105.65	0.78	85.39	1.19	363.36	0.70
3	7.03	5.27	11.52	38.91	1.12	101.89	0.84	96.48	1.16	376.26	0.76
4	7.14	5.28	12.20	39.44	1.12	115.00	0.81	83.33	1.23	360.99	0.70
5	7.08	5.30	11.68	36.43	1.13	101.59	0.81	80.42	1.18	362.31	0.75
6	6.72	5.65	12.21	35.93	1.13	92.69	0.82	79.94	1.17	340.89	0.71
7	7.05	5.57	12.30	36.40	1.19	93.51	0.79	80.02	1.23	350.87	0.71
8	7.01	5.53	12.29	36.23	1.17	91.24	0.80	74.44	1.23	352.50	0.72
9	7.05	5.39	11.86	35.93	1.15	93.37	0.80	78.90	1.20	354.91	0.73
<i>I</i> -treatment											
1	6.64	5.75	11.91	36.55	1.18	79.00	0.80	85.31	1.13	313.95	0.75
2	6.95	5.56	11.97	36.53	1.18	83.47	0.79	76.20	1.19	334.44	0.71
3	7.03	5.48	12.20	35.75	1.18	87.23	0.79	77.93	1.22	342.47	0.70
4	7.03	5.59	12.27	36.17	1.20	83.39	0.78	75.80	1.23	350.16	0.70
5	7.00	5.55	12.52	36.09	1.19	84.31	0.80	75.89	1.25	354.58	0.71
6	7.14	5.38	12.20	35.16	1.17	83.37	0.80	76.19	1.24	359.47	0.73
7	7.28	5.38	12.39	36.50	1.20	84.16	0.78	76.17	1.29	362.70	0.71
8	7.25	5.33	12.39	35.98	1.18	84.36	0.79	77.17	1.28	369.06	0.71
9	7.27	5.30	12.41	36.19	1.18	86.48	0.79	77.06	1.29	371.66	0.71

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Table 2

Average weighted payoff loss as compared to the Bayesian benchmark solution, separately for each treatment and for different round-intervals (standard errors in parentheses)

Rounds	<i>C</i> -treatment	<i>I</i> -treatment
1-3	60.909 (77.120)	61.819 (47.539)
4-6	75.771 (59.912)	55.297 (46.476)
7-9	74.330 (60.359)	49.404 (42.183)

Table 3

Frequency of consistent aspirations and of inconsistent aspirations leading to revision per round and per treatment

		Inconsistent aspirations followed by revisions		Consistent aspirations	
		<i>C</i> -treatment	<i>I</i> -treatment	<i>C</i> -treatment	<i>I</i> -treatment
		(1)	(2)	(3)	(4)
Round	1	40 (38.46%)	84 (58.33%)	24 (23.08%)	40 (27.78%)
	2	33 (34.02%)	40 (38.83%)	27 (27.84%)	48 (46.60%)
	3	18 (21.95%)	16 (20.00%)	28 (34.15%)	54 (67.50%)
	4	20 (23.81%)	23 (26.44%)	30 (35.71%)	60 (68.97%)
	5	18 (21.95%)	22 (26.44%)	33 (40.24%)	57 (66.28%)
	6	13 (16.88%)	17 (20.99%)	38 (49.35%)	58 (71.60%)
	7	14 (18.18%)	10 (13.51%)	37 (48.05%)	57 (77.03%)
	8	9 (12.33%)	8 (11.11%)	37 (50.68%)	59 (81.94%)
	9	12 (15.79%)	12 (15.79%)	40 (52.63%)	61 (80.26%)
Total		177 (23.54%)	232 (28.89%)	294 (39.10%)	494 (61.52%)

Fig. 1: Percentage of subjects complying with satisficing in each treatment

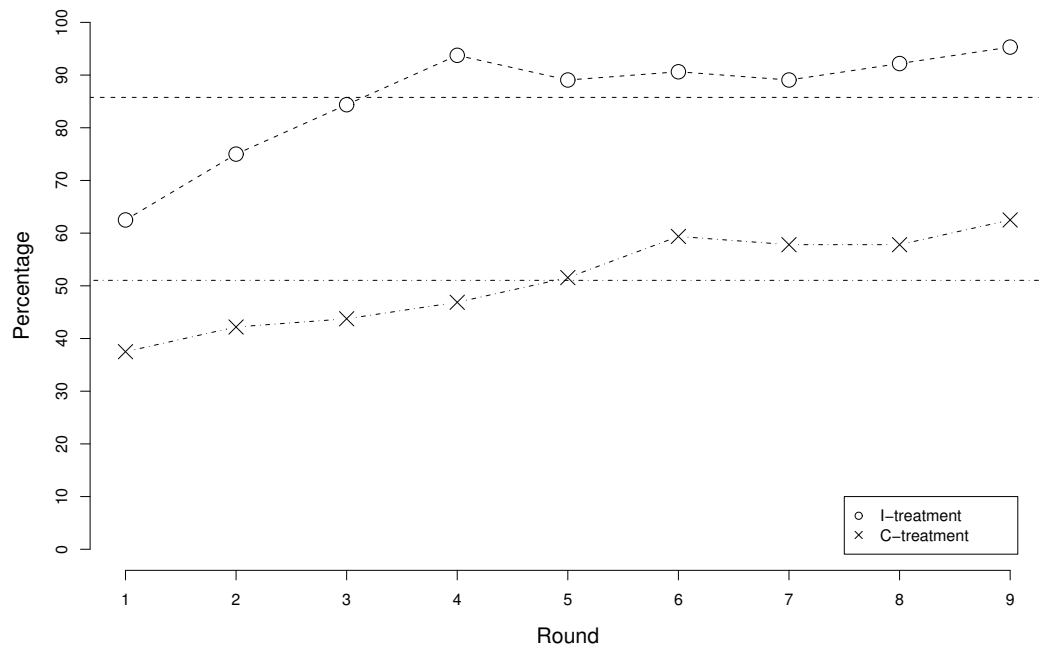
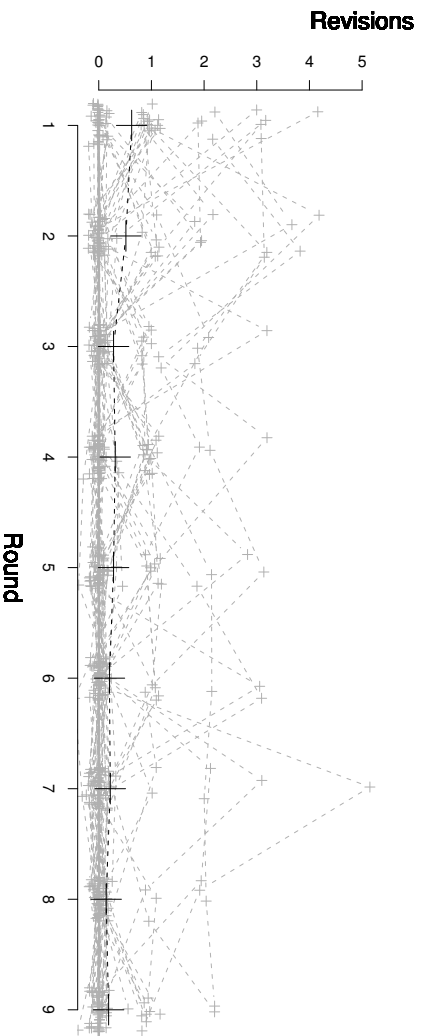


Fig. 2: Number of revisions within each single round, separately for the *C*- and the *I*-treatment

2.a - *C*-treatment



2.b - *I*-treatment

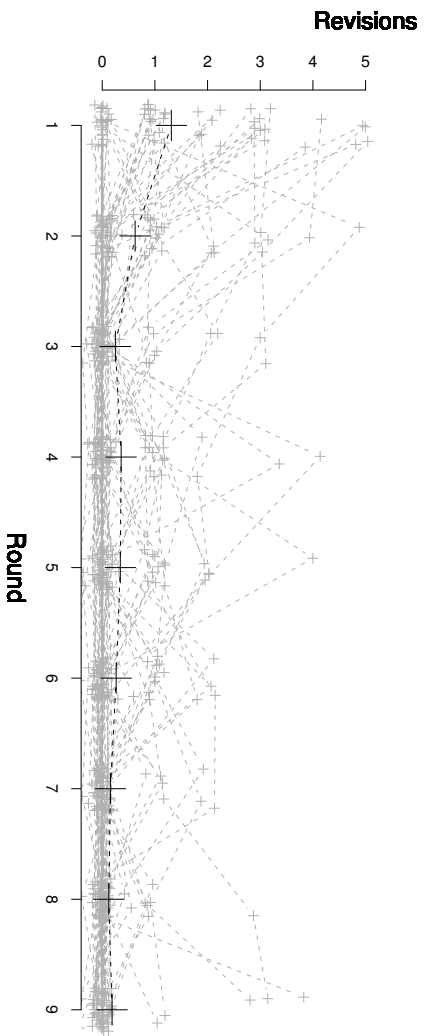
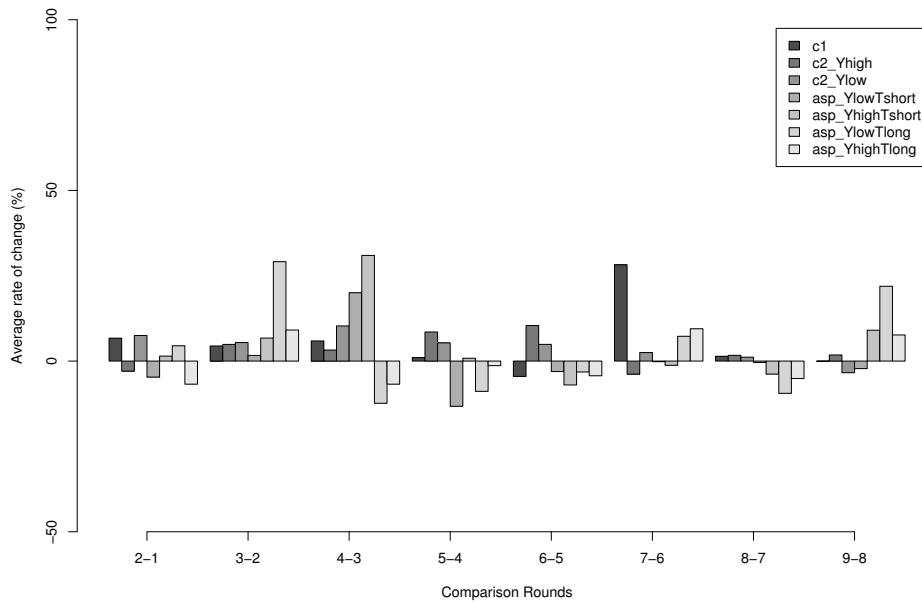


Fig. 3: Rates of revision in the three periodic consumptions and the four scenario-specific aspirations between two consecutive rounds in the *C*-treatment

3.a - Non compliance with satisficing in the previous round



3.b - Compliance with satisficing in the previous round

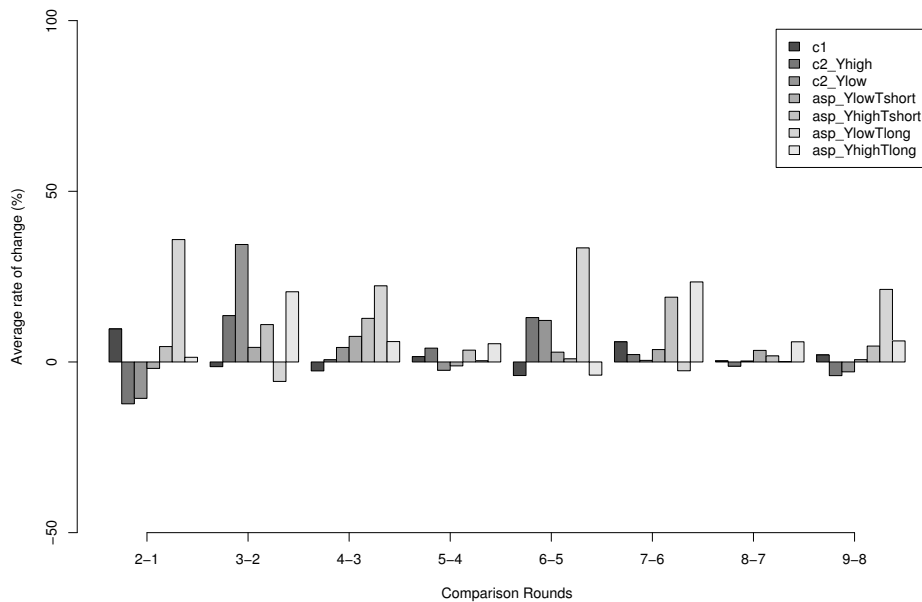
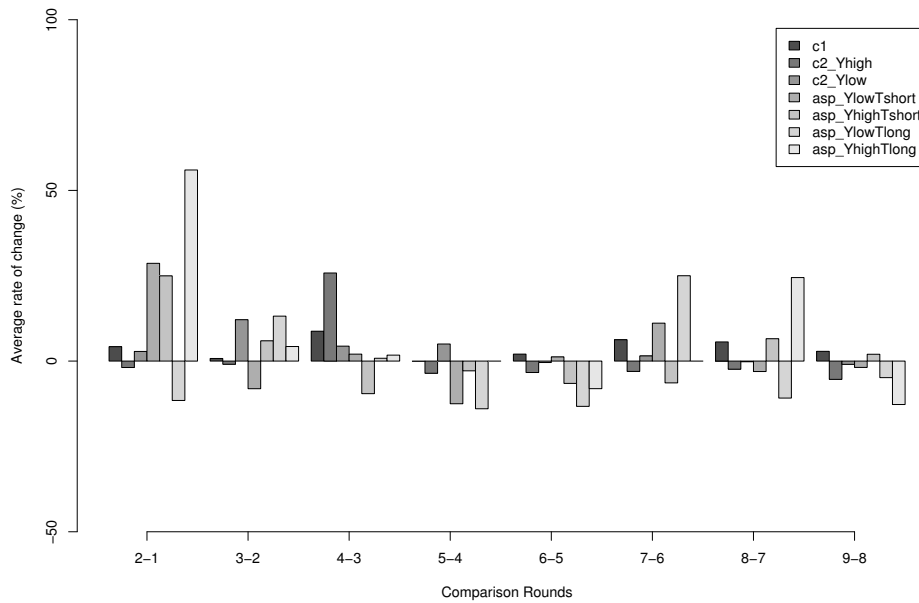


Fig. 4: Rates of revision in the three periodic consumptions and the four scenario-specific aspirations between two consecutive rounds in the *I*-treatment

4.a - Non compliance with satisficing in the previous round



4.b - Compliance with satisficing in the previous round

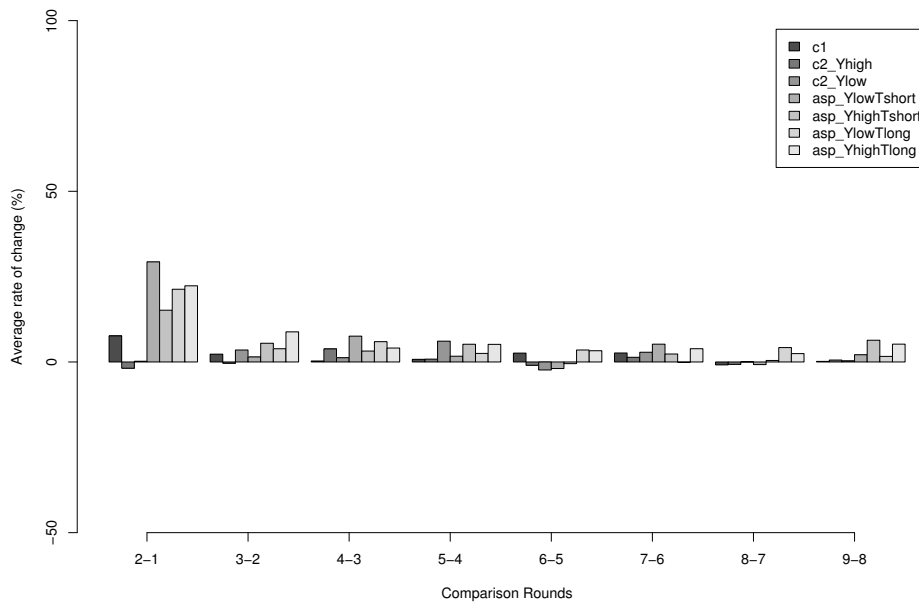
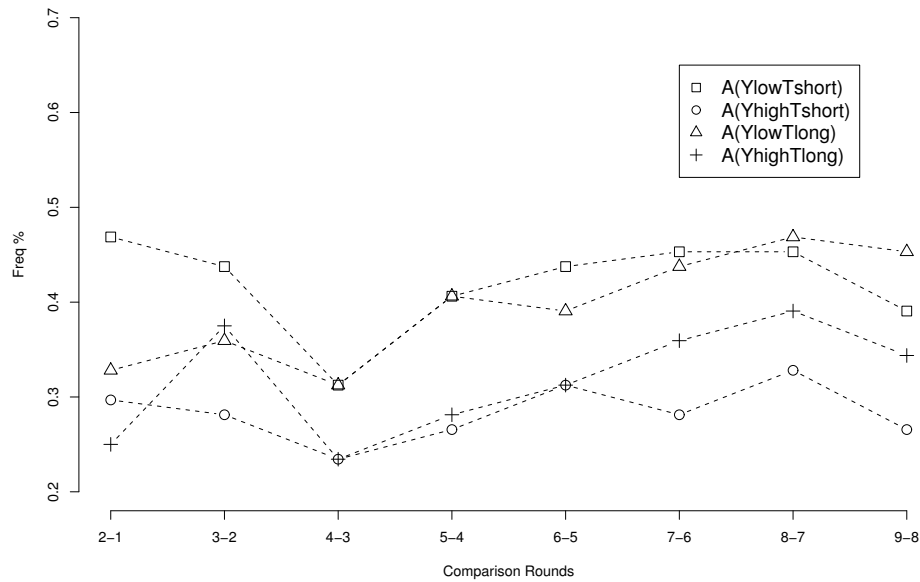


Fig. 5: Frequency of aspirations in round t equal to monetary payoffs in round $t - 1$ separately for each treatment

5.a - C -treatment



5.b - I -treatment

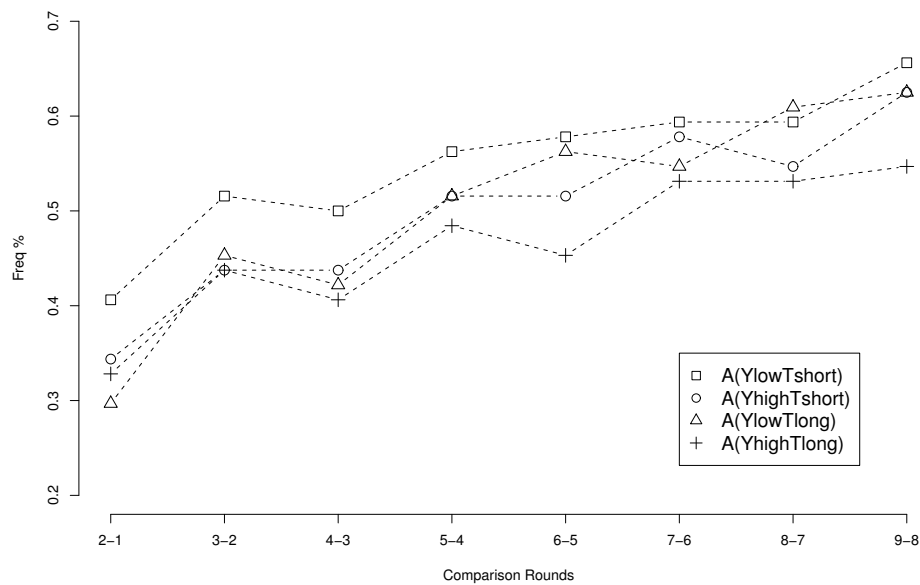


Fig. 6: Percentage of participants in accordance with each type separately for each treatment

