THE JOURNAL OF BEHAVIORAL FINANCE, 9: 95–105, 2008

ISSN: 1542-7560 print / 1542-7579 online
DOI: 10.1080/15427560802107389

Routledge
Taylor & Francis Group

Is Satisficing Absorbable? An Experimental Study

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We experimentally investigate whether the satisficing approach is absorbable, that is, whether it still applies when participants become aware of it. In a setting where an investor decides between a riskless bond and either one or two risky assets, we familiarize participants with the satisficing calculus applied to specific portfolio selection tasks. After experimenting with this calculus repeatedly, participants can either continue using it or select their portfolio freely. The results reveal some absorbability of the satisficing approach in the simpler two-state setting, whereas more complexity renders the satisficing heuristics more difficult and their absorption less likely.

Keywords: Theory Absorption, Satisficing, Portfolio Selection, Complexity

INTRODUCTION

A behavioral theory is absorbable if it survives its apprehension (see Güth and Kliemt [2004]). In decision theoretic tasks without strategic uncertainty, theory absorption supposes that decision makers are aware of the "theory" of their behavior and still rely on it. In this study, we want to explore whether the central idea of bounded rationality theory, namely the "satisficing" approach (see Simon [1955]), is absorbable.

The satisficing approach predicts to form aspirations, to search for options satisficing them, and to adapt aspirations in the light of experience. In general, it does not offer a well-developed theory but only an intuitive terminology. To render it applicable, we rely on portfolio selection tasks where aspirations are state-specific, that is, dependent on the possible state of nature (see Fellner, Güth, and Maciejovsky [2005]). Such state-specific aspirations are said to be consistent when they define a non-empty set of satisficing portfolios.

We consider two treatments: one with two and another with three states of nature. Both treatments comprise two phases with six successive investment tasks each. In the first phase, participants are familiarized with the concept of consistent aspirations and forced, via a so-called *decision aid*, to revise their aspirations until they are consistent. Once this has been achieved, participants can freely choose their portfolio, being however informed of whether it satisfies their aspirations or not. In such a way, we can directly test whether satisficing is absorbable since we do not oblige participants to choose a portfolio satisficing all their aspirations. In the second phase, we still elicit aspirations, but participants are free to keep on using the decision aid or select their portfolio at once without having to determine consistent aspirations. Thus, in this phase, also the consistency of aspiration levels, as predicted by the satisficing approach, may be violated.

The paper proceeds as follows: The second section introduces the portfolio selection tasks and the satisficing approach. The third section is devoted to the experimental design. The experimental results are analyzed in section four, and the fifth section presents some concluding remarks.

DECISION TASKS AND SATISFICING PORTFOLIOS

The decision tasks are financial investment tasks with state-specific return rates, and states that can be ordered from the worst to the best. We allow for two or three equally probable states of nature. In both cases, participants face a credit line e (> 0) up to which they can borrow without paying interest. They can leave money idle, although this is not even boundedly rational because they can invest it in a riskless bond with a return rate r exceeding 1.

In case of only two states (see also Fellner, Güth, and Maciejovsky [2005]), the second option is a risky asset yielding a low return rate l in bad state 1, and a high return rate h in good state 2. We invariably impose $0 < l < 1 <$

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$r < h$ and $l + h > 2r$. The latter inequality implies that a risk-neutral investor prefers the risky option over the riskless bond.

In case of three states, occurring with probability 1/3 each, the risky option mentioned above yields the low return rate l in bad state 1 and the high return rate h in good states 2 and 3. The even riskier option has returns L in states 1 and 2 and H in the best state 3, where $0 < L < l < 1 < r < h < H$ and $H + 2L > 2h + l > 3r > 3$ hold. Thus, a risk-neutral investor would prefer the riskiest option over the less risky one, and the latter over the risk-free bond.

Let b be the amount invested in the riskless bond, i the amount invested in the (less) risky option in the case of (three) two states, and j the amount invested in the riskiest option in the three-state case. For two states and return aspirations A_1 in state 1 and A_2 in state 2, the investment portfolio (b, i), with $b, i \geq 0$ and $b + i \leq e$, is satisficing if

$$\text{(C.2)}\; b(r-1) + i(l-1) \geq A_1 \quad \text{and} \quad b(r-1) + i(h-1) \geq A_2$$

For three states and state-specific return aspirations A_1, A_2, and A_3, the portfolio (b, i, j), with $b, i, j \geq 0$ and $b + i + j \leq e$, is satisficing if

$$\text{(C.3)}\; b(r-1) + i(l-1) + j(L-1) \geq A_1,\; b(r-1) + i(h-1) + j(L-1) \geq A_2, \text{ and}$$
$$b(r-1) + i(h-1) + j(H-1) \geq A_3.$$

Generally, the set of satisficing portfolios is the intersection of n linear half-spaces, where n is the number of different states of nature. An aspiration vector $\mathbf{A} = (A_1, k, A_n)$ is consistent if this set is non-empty.

We assume the satisficing approach (cf., Simon [1955]) to prescribe:

i. consistent return aspirations in the sense that all conditions in (C.2) or (C.3) can be fulfilled by some allocation of e, and
ii. the choice of an investment portfolio satisficing all state-specific return aspirations, that is, in line with (C.2) or (C.3).

Our main goal is to check whether participants "absorb" the satisficing approach after having experienced it. Fellner, Güth, and Maciejovsky [2005] apply the satisficing approach to investment decisions by employing a free mode: Participants in their experiment are free to choose inconsistent aspirations without being aware of it. What is distinctive in our study is that, in order to test for absorbability of satisficing, we first *enforce* prescription (i) by means of a routine that we name "decision aid." Only when participants achieve consistency, they are free to choose their portfolio, knowing whether it is in line with prescription (ii) or not. If satisficing is absorbable, investors should not make choices at odds with their return aspirations. Subsequently, we let subjects decide whether they want to use the routine or not, thereby enabling them to violate prescription (i) as well. Investors who have absorbed the satisficing approach may refuse the aid, but must then comply with both prescription (i) and prescription (ii).

EXPERIMENTAL PROTOCOL

The computerized experiment was conducted at the laboratory of the Max Planck Institute in Jena (Germany) in April and July 2006. The experiment was programmed using the z-Tree software (Fischbacher [1999]). Overall, we ran 2 sessions with a total of 63 participants, all students at the University of Jena. Thirty-one participants faced the decision tasks with only one risky asset (henceforth, two-state treatment), and 32 the decision tasks with 2 risky assets (henceforth, three-state treatment) in a between-subject design.

In each session/treatment, participants were confronted with 12 investment decisions with changing parameters, extending the experiment over 12 periods. Table 1 lists the parameter constellations used in each treatment.[1] In each period, participants received an endowment e of 1000 ECU (Experimental Currency Unit) that they could invest in either two or three alternatives depending on the treatment. The exchange rate between ECU and Euro was 20 to 1, that is, 20 ECU corresponded to 1 Euro.

Each experimental session consisted of two phases, with six periods/decision tasks each. In phase 1, participants went through the following steps.

1. First, they learned about the investment task, and answered a few control questions (see instructions in Appendix A).
2. They were then asked for their return aspirations in each state. That is, they had to specify the monetary return they aimed to achieve in each of the possible states.

TABLE 1
Experimental Parameters in the 12 Decision Tasks of Each Treatment

Treatment Decision	Two-state			Three-state				
	l	r	h	L	l	r	h	H
1	0.8	1.02	1.3	0.5	0.8	1.02	1.3	2.5
2	0.7	1.02	1.4	0.5	0.6	1.02	1.4	2.5
3	0.9	1.02	1.3	0.4	0.8	1.02	1.3	2.7
4	0.8	1.02	1.4	0.4	0.6	1.02	1.4	2.7
5	0.9	1.02	1.5	0.6	0.9	1.05	1.5	2.8
6	0.8	1.02	1.6	0.6	0.7	1.05	1.6	2.8
7	0.9	1.05	1.3	0.5	0.9	1.05	1.5	3.0
8	0.8	1.05	1.4	0.5	0.7	1.05	1.6	3.0
9	0.9	1.05	1.5	0.6	0.9	1.10	1.5	2.8
10	0.8	1.05	1.6	0.6	0.7	1.10	1.6	2.8
11	0.9	1.10	1.5	0.5	0.9	1.10	1.5	3.0
12	0.8	1.10	1.6	0.5	0.7	1.10	1.6	3.0

3. They were informed, via the decision aid, whether their return aspirations were consistent or not. If they were not, aspirations had to be revised until they were consistent (the algorithm to check the consistency of aspiration vectors is in Appendix B).
4. When the latter had been achieved, participants could determine their portfolio choices, either (b, i) or (b, i, j) depending on the treatment, with the possibility of leaving money idle. Participants were informed whether their investments satisfied their return aspirations, but could choose their portfolio without restrictions (i.e., regardless of compliance with stated aspirations).

In each period of phase 2, the first decision that participants had to make was whether they wanted to rely on the decision aid ($\delta = 1$) or not ($\delta = 0$). If they decided to keep on using the decision aid, the experiment proceeded with the steps described above. Otherwise, participants could choose their portfolio straight away (without having to design consistent return aspirations). Although aspirations are just cheap talk-data, in the sense that subjects have no incentives for meaningful reporting, the findings of Fellner, Güth, and Maciejovsky [2005] suggest that they are nevertheless seriously considered.

To ensure the financial salience of the investment task, three means were taken. First, only one period was randomly selected for payment (with no additional show-up fee). Second, the credit taken for investment had to be paid back after each period so that subjects only earned their (positive or negative) 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 Appendix A).The task consisted of searching and marking specific symbols in a text. Each Euro lost was equivalent to half a page of work load.

TABLE 2
Descriptive Statistics on Aspiration Levels and Investment Decisions for Each Treatment

Treatment	N^a	Variable	Mean	Median	Std. deviation
Two-state	372	Profit	75.90	37.50	166.78
		A_1	12.52	0.00	208.84
		A_2	143.94	60.00	187.96
		b	623.08	800.00	380.53
		i	349.91	200.00	379.17
Three-state	384	Profit	146.23	60.00	392.55
		A_1	27.71	1.00	247.59
		A_2	80.19	40.00	206.71
		A_3	171.75	50.00	326.14
		b	475.62	500.00	361.58
		i	304.95	200.00	302.25
		j	159.02	50.00	266.29

Note. $^a N$ denotes the number of observations.

EXPERIMENTAL RESULTS

We first present a descriptive overview of elicited aspiration levels and investment behavior. Then we turn to our main question, and try to establish whether participants who rely on the satisficing routine either obligatorily (as in phase 1) or voluntarily (as in phase 2) choose satisficing portfolios, and whether participants who refuse the routine nevertheless comply with both requirements prescribed by the satisficing approach, what would suggest that the satisficing routine has been internalized.

General Results

Table 2 provides descriptive statistics on profits, stated aspiration levels and investment decisions over all 12 periods.

The average profit is positive in both treatments. Subjects are, on average, quite risk-averse: The average amount b invested in the riskless bond is significantly higher than investments i and j in the risky asset(s); in the three-state scenario, just few of the available resources are directed toward the riskiest option. On average, almost all subjects make full use of their credit allowance: Over all periods only a negligible fraction of the endowment (2.70% and 6.04% in case of two and three states, respectively) was left idle, and a small number of all portfolio choices (7.80% in the two-state treatment, and 10.94% in the three-state treatment) did not fully utilize the credit line of 1000 ECU.[2]

We checked whether allocation decisions are affected by the payoffs actually earned in the previous period. As to the two-state treatment, no significant correlation between previous profits and investment in the riskless bond is observed (Pearson's product-moment correlation $r = -0.101$, $p = 0.063$). On the contrary, in the three-state treatment, this correlation is significantly negative ($r = -0.161, p = 0.002$), meaning subjects invest less in risky assets after experiencing a low payoff.

Table 3 separates data according to phase. Regardless of the treatment, profits are, on average, significantly higher in phase 2 than in phase 1 ($p < 0.001$ for the two-state treatment, and $p < 0.05$ for the three-state treatment, two-sided Wilcoxon signed-rank tests). Return aspirations A_1 and A_2 in states 1 and 2 are also significantly higher in the second half of each treatment ($p < 0.001$ for A_1 or A_2 in phase 1 vs. A_1 or A_2 in phase 2; two-sided Wilcoxon signed-rank tests). Aspirations in the best state 3 are, instead, not significantly different across phases ($p = 0.277$). Wilcoxon signed-rank tests comparing investments in the riskless bond and in the risky asset over the first and the last six periods of the two-state treatment reveal that subjects invest significantly more in the risky asset in the second phase ($p = 0.004$ for i in phase 1 vs. i in phase 2).[3] As regards the three-state treatment, there is no statistically detectable difference in

TABLE 3
Descriptive Statistics on Aspiration Levels and Investment Decisions Separately for Phase 1 (Periods 1–6) and Phase 2 (Periods 7–12)

Treatment	Phase	N^a	Variable	Mean	Median	Std. deviation
Two-state	1	186	Profit	51.38	20.00	153.47
			A_1	–43.61	0.00	104.51
			A_2	109.87	30.00	157.44
			b	632.80	800.00	392.15
			i	333.33	200.00	387.52
	2	186	Profit	100.42	56.25	176.12
			A_1	68.64	0.00	264.97
			A_2	178.01	100.00	209.12
			b	613.36	800.00	369.35
			i	366.48	200.00	370.93
Three-state	1	192	Profit	111.71	37.00	351.72
			A_1	–72.73	0.00	160.59
			A_2	14.75	20.00	176.63
			A_3	187.36	40.00	381.78
			b	472.98	500.00	371.07
			i	302.73	200.00	309.56
			j	161.27	50.00	265.26
	2	192	Profit	180.75	100.00	427.66
			A_1	128.15	10.00	277.21
			A_2	145.64	100.00	214.18
			A_3	156.14	95.00	258.94
			b	478.26	550.00	352.77
			i	307.16	200.00	295.55
			j	156.77	50.00	268.00

Note. [a] N has the same interpretation as in Table 2.

individual portfolio choices between phases ($p > 0.05$ for all comparisons of b, i and j in phase 1 and phase 2).[4]

Do return aspirations in the worst and best state change with the experimental parameters? In the two-state treatment, the differences between A_1 and A_2 are unrelated to the differences between the two possible return rates (l and h) of the risky option: the Spearman correlation coefficient between the spread $A_1 - A_2$ and $h - l$ is 0.033 ($p = 0.529$). In contrast, in the three-state treatment, the spread $A_3 - A_1$ is significantly and negatively related to the spread $H - L$ ($\rho = -0.150,\ p = 0.003$). It seems that, in case of three states, more discrepancy in return rates frightens participants and weakens their desire for improvement.

Looking at the spread of aspiration levels over time, we find that the gap between return aspirations stays rather constant over time in case of two states (Spearman ρ between $A_2 - A_1$ and *period* is 0.004, $p = 0.94$), whereas the gap between A_3 and A_1 shrinks significantly in case of three states ($\rho = -0.241,\ p < 0.001$). A feature of our design is that participants could simplify their task and achieve consistency of aspirations by setting $A_1 = A_2$ or $A_1 = A_2 = A_3$. Hence, it may be argued that the just reported results may be due to people equalizing their aspiration levels throughout the experiment. We checked for this and found several observations with $A_2 = A_1$ or $A_3 = A_2 = A_1$ (16.13% in case of two states and 29.17% in case of three states).[5]

Compliance with the Satisficing Approach

We now investigate if participants fulfill the two requirements of the satisficing approach, that is: (i) consistent return aspirations, and (ii) investment choices satisficing the stated aspirations. To address the issue, data need to be separated depending on whether or not participants (either required or deliberately) rely on the decision aid. In fact, if they rely on the aid, they not only are forced to revise their aspirations until consistency is attained but also know, before deciding on their portfolio, if this satisfies their stated aspirations.

Over all 6 periods of phase 2, the requests for the decision aid are 44 out of 186 in the two-state treatment, and 12 out of 192 in the three-state treatment.[6] Individual decisions to use the aid or avoid it are rather constant over time: 61.28% (81.25%) of the subjects always refuse the aid in the two- (three-)state treatment, with an average within-subjects standard deviation of 0.10 (0.07). Figure 1 displays whether participants modify their choice regarding the use (or not) of the aid from one period (of phase 2) to the next separately for the two treatments. The variable *Change* (on the vertical axis) equals 0 when a subject does not vary his decision about the aid between two consecutive periods; it equals 1 otherwise. We added some white noise to the plots in order to improve the visual presentation of the data points. The figure makes it clear that most participants do not change their preferences towards the aid, thereby suggesting a high "viscosity" in individual δ-choices.

Participants refusing the aid, after having experienced it, are deemed to have "absorbed" the satisficing approach if their aspirations and investment choices are in line with requirement (i) and requirement (ii), respectively. Thus, a first check of the absorbability of the satisficing approach concerns those internalized satisficers who, without using the available routine, are able to set consistent return aspirations as well as to choose portfolios in line with their aspirations. Figure 2 shows the proportion of subjects meeting both requirements for satisficing behavior in each period of phase 2 separately for the two treatments.

On average, 76.80% (62.17%) of the subjects declining help fulfill requirement (i) in the two- (three-)state treatment. Of these, 55% (35%) also respect requirement (ii). Overall, compliance with both requirements is observed 42.25% of the time (60 out of 142 observations) for the two states, and 21.67% of the time (39 out of 180 observations) for the three states. Hence, nearly half of the choices not supported by the aid in phase 2 are consistent with satisficing in the two-state treatment, whereas such consistency holds for less than one-fourth of the choices in the three-state treatment. The highly significant difference between treatments ($p < 0.001$, Wilcoxon rank sum test) suggests that the complexity of the

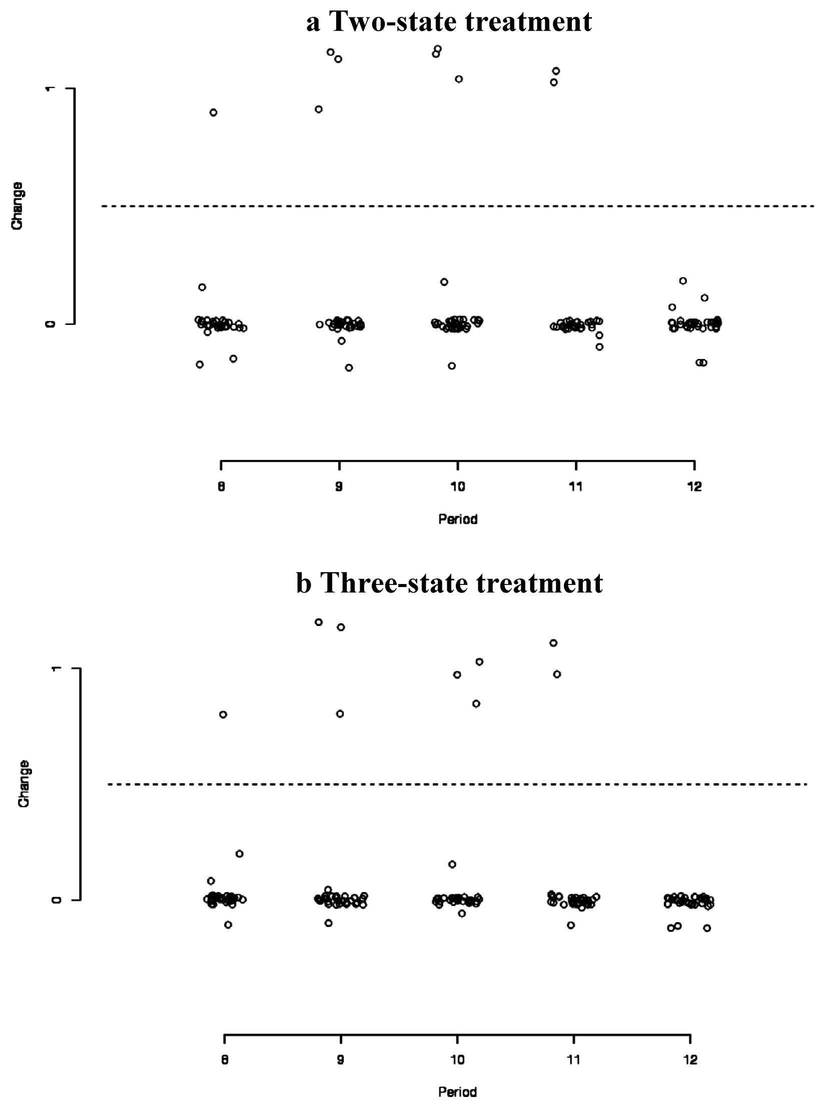

FIGURE 1 Individual Switches from Use (Refusal) to Refusal (Use) of the Aid Between Two Consecutive Periods of Phase 2

decision setting may affect people's ability to absorb the satisficing approach.

Although always higher in case of two states, the proportion of subjects who, without support of the aid, behave satisfactorily remains fairly constant over time in either treatment. One-sided Wilcoxon signed-rank tests confirm that, whatever the number of states, there is no statistically detectable difference in frequency of $\delta = 0$-choices complying with conditions (i) and (ii) between the first and the last period of phase 2 ($p = 0.258$ for the two-state scenario, and $p = 0.762$ for the three-state scenario).

Let us now turn to portfolio choices supported by the satisficing routine so as to investigate if they comply with requirement (ii), that is, if they are in line with stated aspirations. Recall that, when the routine is present, participants are informed, before deciding on their portfolio, if this satisfies their stated aspirations. Figure 3 displays the proportion of choices satisficing the stated aspiration levels in the presence of the aid in each period of both treatments.[7]

Aided choices complying with requirement (ii) are, on average, significantly more frequent in case of two rather than three states (66% vs. 36%; $p < 0.005$, Wilcoxon rank sum test). Furthermore, in the two-state treatment, participants tend to choose portfolios in line with their aspirations significantly more often in phase 2, that is, when they *voluntarily* rely on the aid ($p < 0.001$, one-sided Wilcoxon rank test). In the three-state treatment, choices obeying requirement (ii) are rather scattered in phase 2 (where, however, we can rely only on few observations), and no significant difference between phases is found ($p = 0.318$). Therefore, the employed routine is significantly more successful in helping subjects to choose satisfactory portfolios in case of two states, especially

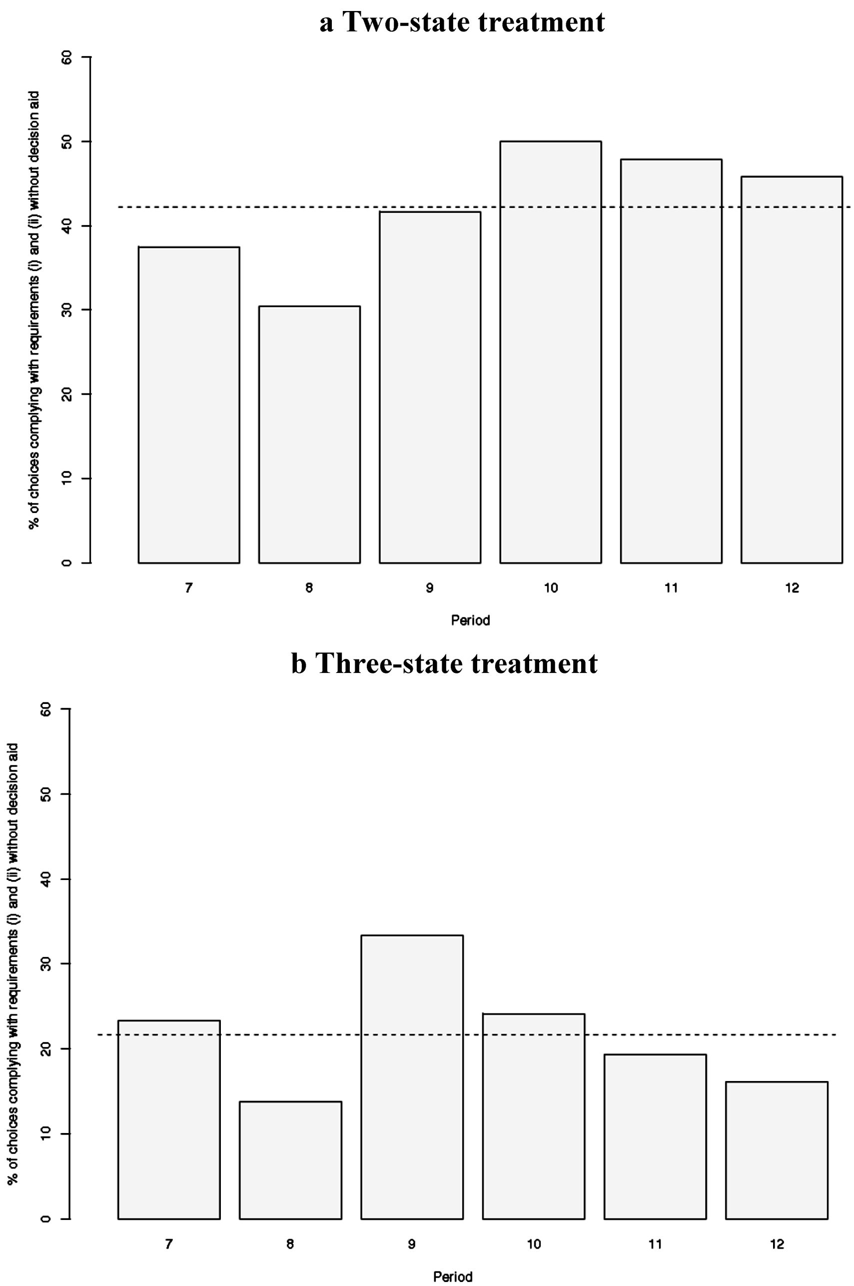

FIGURE 2 Frequency of Choices not Supported by the Aid, Complying with Both Requirements for Satisficing Behavior in Phase 2

when the request for aid is voluntary: even in the presence of the aid, an easier decision setting favors the absorption of satisficing.

Figure 4 provides information about the persistence of individual behavior across periods. The variable on the vertical axis takes value 1 when the corresponding subject changes from compliance to noncompliance with requirement (ii) and vice versa. In case of no change, the variable equals 0. According to the figure, whatever the treatment, most subjects are rather persistent in their non-compliance behavior, though individual inconsistencies are not negligible.

A natural question is whether the ability of absorbing bounded rationality requirements is somewhat related to decision time. To address this issue, we computed Spearman correlations between "periods" and "seconds needed to achieve consistency" as well as between "periods" and "seconds spent to choose portfolios complying with stated aspirations" for each treatment and each value of δ. Table 4 shows the various correlation coefficients and the associated p-values.

Without any assistance from the decision aid, the average time span (in seconds) necessary for setting consistent

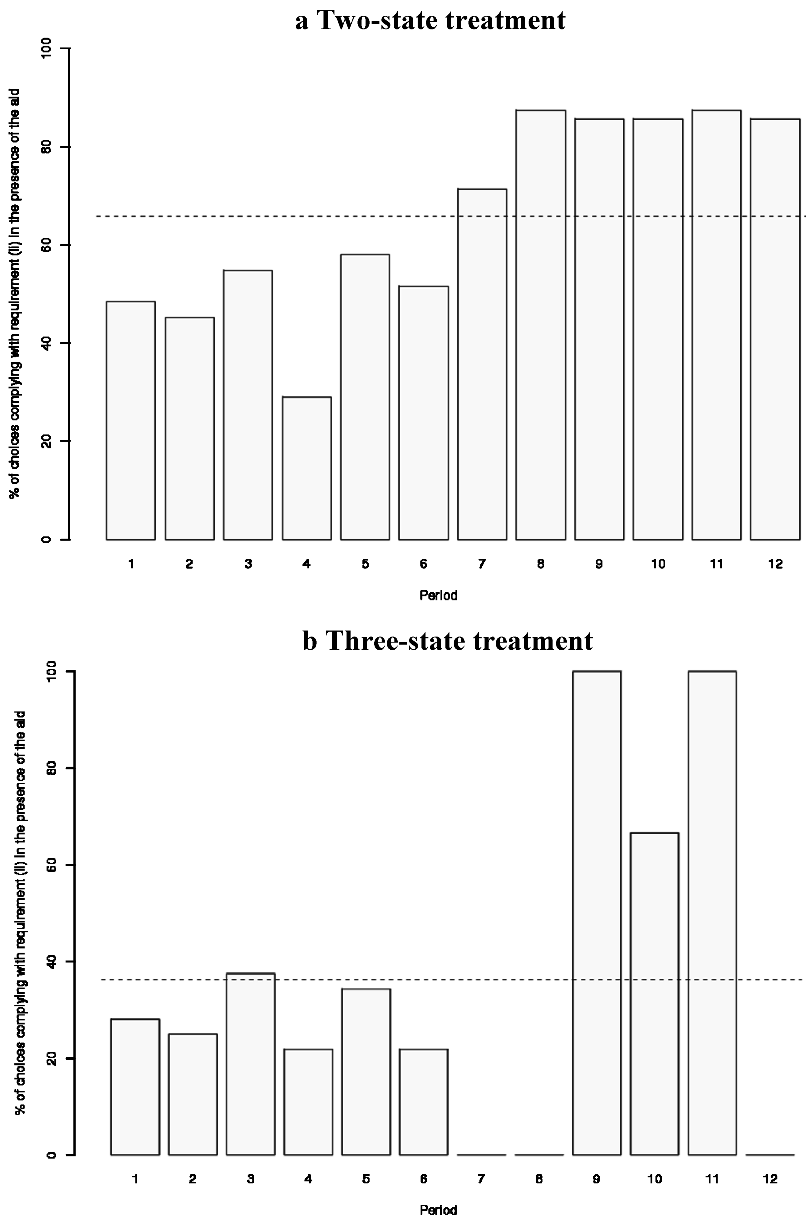

FIGURE 3 Frequency of Choices Supported by the Aid and Consistent with Stated Aspirations in Each Period of the Experiment

aspirations and for choosing satisficing portfolios decreases over time in either treatment, but the decline is significant only in case of two states (see the first and third lines in Table 4). With the aid, the correlations under consideration vary depending on the treatment and the choice to be taken. Under the two-state scenario, the seconds needed to reach consistency exhibit a significantly positive trend, while those spent in order to choose portfolios in line with stated aspirations do not change significantly with time (see the second line in Table 4). Thus, relying on the routine does not accelerate decision making in case of two states. Under the three-state scenario, on the contrary, we observe a downward trend in both the seconds needed to attain consistency and the seconds needed to choose satisficing investments (see the fourth line in Table 4). These findings indicate that fast decision making is not linked to compliance with the satisficing approach in case of two states and aid-assisted investments. Although a less demanding environment helps individuals to select portfolios in line with stated aspirations, it does not speed up decisions.

Since some participants are found to set equal aspirations whatever the return rates, it is worthwhile to distinguish them from those stating different aspirations so as to verify whether equal aspirations actually imply saving time and effort. The data indicate that, regardless of the treatment and the support of the aid, subjects with equal aspirations for different

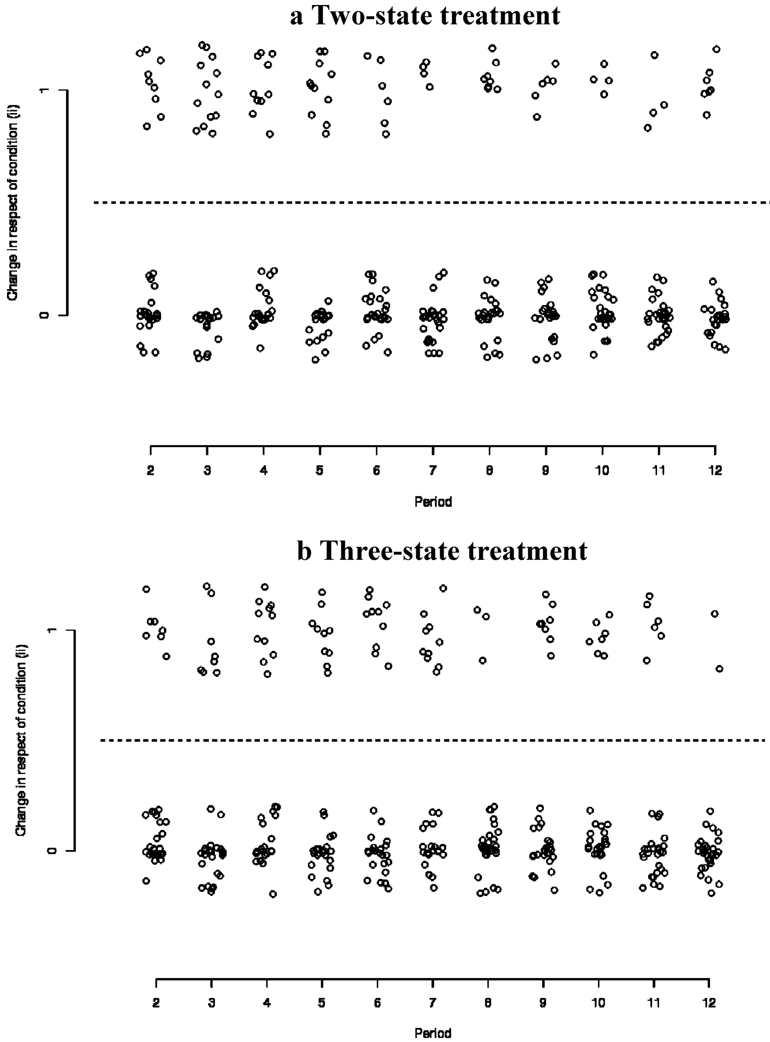

FIGURE 4 Stability of Individual (Non) Compliance with Requirement (ii) Between Consecutive Periods of the Experiment

states are faster than others both to achieve consistency and to choose satisfactory investments, although the difference is significant only for attaining consistency ($p < 0.02$ for each comparison concerning the seconds to choose consistent aspirations; $p > 0.20$ for each comparison concerning the seconds to choose satisficing portfolios; Wilcoxon rank sum tests). This evidence confirms that those with equal aspirations tend to economize on time.

TABLE 4
Spearman Correlations of "Seconds Needed to Choose Consistent Aspirations" and "Seconds Needed to Choose Satisficing Portfolios" with "Periods"

		Seconds for choosing consistent aspirations		Seconds for choosing satisficing portfolios	
Treatment	δ	ρ	*p-value*	ρ	*p-value*
Two-state	0	–0.573	0.000	–0.357	0.001
	1	0.361	0.016	–0.032	0.851
Three-state	0	–0.157	0.118	–0.228	0.207
	1	–0.599	0.000	–0.234	0.080

Do subjects who fulfill bounded rationality requirements differ from others with respect to their investment success measured by average earnings? Starting from subjects who do not want to rely on the routine in phase 2, we find that those who have "absorbed" the satisficing approach (in the sense of complying with both prescriptions) earn significantly more than those who do not have absorbed it in the two-state treatment ($p < 0.001$, two-sided Wilcoxon rank sum test), but not in the three-state treatment ($p = 0.671$).[8] As regards subjects relying on the aid and choosing portfolios in agreement with their aspirations, their average earnings are not significantly different from those of the subjects who do not comply with requirement (ii) whatever the number of states, with the lack of significance being prominent in the case of two states (for two states $p = 0.776$; for three states $p = 0.054$). The latter result is in line with that by Fellner, Güth, and Maciejovsky [2005], who found no significant difference in average earnings between subjects who comply with bounded rationality requirements and others.

CONCLUSIONS

Our concern has been to investigate whether the main idea of bounded rationality theory, namely the concept of satisficing, is "absorbable", that is, survives its apprehension. We have rendered the satisficing approach applicable by relying on portfolio selection tasks with state-specific return aspirations. One is said to behave in a satisficing manner if her return aspirations are consistent (i.e., define a non-empty set of satisficing portfolios) and her investment decisions are in line with the stated aspirations.

In the first experimental phase, a device (called decision aid) forced participants to state consistent aspirations, and informed them whether their portfolio was satisficing their aspirations or not. In the second phase, after having experienced the device repeatedly, participants could decide to rely on it or not; if not, they could select their portfolio straight away. If satisficing is absorbed, one should choose satisficing portfolios when relying (either obligatorily or voluntarily) on the aid, and should both set consistent aspirations and choose satisficing portfolios when refusing the aid.

To study whether complexity affects behavior, we have considered two treatments, which differed only with respect to the number of states of nature (either two or three) faced by the subjects.

The experiment shows evidence of absorbability of satisficing in the simpler decision setting: when confronted with only two states, nearly 50% of participants who refuse the aid after having experienced it make nevertheless satisficing choices, and about 70% of aid-assisted investments are in line with stated aspirations. However, more complexity (three rather than two states) significantly reduces the absorption of the satisficing approach: in the more complex three-asset case, fewer than one-fourth of the choices not supported by the aid are satisficing, and only 36% of aid-assisted investments match stated aspirations. Furthermore, there emerged a subset of subjects with a sort of routinized complexity reduction (cf., Egidi and Narduzzo [1997]): These subjects equalized their aspirations throughout the experiment so as to save time and effort.

These findings illustrate that people are by no means born as satisficers, but have to "learn" to absorb bounded rationality requirements, albeit the latter appears to be less easy as the task becomes more complex. In this sense, our conclusions support the bounded rationality thought that with more complexity there are fewer chances to improve decision making (Simon [1962]), where complexity is here measured by the number of equally probable states.

Further work needs to be done in order to be confident about the implications of these findings for the theory of bounded rationality. But the experimental evidence garnered here is suggestive of people's ability to absorb the satisficing approach in rather simple settings where no much computational ability is involved.

NOTES

1. Choices were elicited in a random order so as to exclude ordering effects.
2. These observations are kept in the analysis. Dropping them does not alter results.
3. To check whether the different aspirations and investments in the second phase of the two-state treatment are due to the use of the decision aid, we performed Wilcoxon rank sum tests (two-sided) comparing aspirations and portfolio choices in case of $\delta = 0$ and $\delta = 1$. No significant influence of the aid on any of the considered variables was observed ($p > 0.140$ for each comparison).
4. For the three-state scenario, variables b and i are found to differ significantly when participants require the decision aid ($p = 0.004$ for both i when $\delta = 1$ vs. i when $\delta = 0$ and j when $\delta = 1$ vs. j when $\delta = 0$).
5. In the three-state treatment, the frequency of $A1 = A2$, $A2 = A3$ and $A1 = A3$ was 10.67%, 16.66% and 3.64%, respectively.
6. The difference in requests between treatments is highly significant ($p < 0.001$, two-sided Wilcoxon rank sum test).
7. Since using the aid was compulsory in phase 1, the rates for periods 1–6 refer to the full sample. The sample size for periods 7–12 is smaller and refers only to those who willingly use the routine. Restricting phase 1's sample to the subjects who keep on (voluntarily) using the aid in at least 4 periods of phase 2 does not qualitatively change results.
8. Although compliance with the satisficing heuristics seems to somehow promote performance, this may be due to special skills of those who fulfill the requirements.

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APPENDIX

A. Instructions for the Two-state Treatment

General Instructions.

Welcome and thanks for participating in this experiment. 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.

Detailed Instructions.

In this experiment, you can invest money. For this reason, we introduce the currency ECU. The exchange rate between ECU and Euro is 20 to 1, that is, 20 ECU correspond to 1 Euro. For your investment decisions, we grant you a credit limit of 1000 ECU.

As a first step, you have to decide how much of this credit you want to take. You can take only integer amounts (i.e., 0, 1, 2, 3, . . . , 1000 ECU). The credit is interest-free, i.e., you must pay back the money that you borrow without any extra charge. Once you have taken a certain amount of your credit, you have to decide how to use it. You can invest this credit in two alternatives: A and B.

A is a risk-free bond that allows you to obtain "r" times the invested amount for sure where "r" is greater than 1. Thus, if you invest a ECU in this alternative, you get a *sure* return of r times a from your investment. Since you have to pay back the amount a that you have taken from your credit line, your 'NET' return from A is:

$$\textit{Net return from } A = (r \times a) - a = (r - 1) \times a$$

B is a risky asset with two possible outcomes, which depend on the scenario that occurs.

- If scenario 1 occurs, you obtain "l" times the amount invested in B, where "l" is smaller than 1. Hence, in scenario 1, you get a negative return.
- If scenario 2 occurs, you obtain "h" times the amount invested in B, where "h" is greater than r. Hence, in scenario 2, you get a positive return which is greater than the return from the risk-free bond.

The two scenarios are equally likely: with 50% probability you obtain "l" times the amount you invested in B, and with 50% probability you obtain "h" times the amount you invested in B. Thus, if you invest b ECU in the risky alternative, your "NET" return from B is

$$\textit{Net return from } B = (l \times b) - b = (l - 1) \times b \text{ in scenario 1,}$$

$$\textit{Net return from } B = (h \times b) - b = (h - 1) \times b \text{ in scenario 2.}$$

Your two investment alternatives and their rate of return in each scenario are summarized in the following table:

Alternative	Scenario	Probability	Return rate
A	1	1/2	r
	2	1/2	r
B	1	1/2	l
	2	1/2	H

You have to divide your credit fully between A and B. This means that you can invest in each of the two alternatives any amount ranging from 0 ECU to the total credit you have taken, provided that the sum of your investment in A and your investment in Bequals the credit you have taken. In the experiment, you will make this investment decision several times, where each time reflects one round. Every round, you will be granted a credit of 1000 ECU. The values of r, l and h will be changing every round, but they will always be such that $l< 1 < r < h$. You will learn the values of r, l, and h at the beginning of each round.

The Decision Aid.

The decision aid is designed to help you decide how to invest your credit in a given round, and make "satisfactory" decisions, i.e., decisions allowing you to achieve your desired TOTAL net return in each scenario.

Once you have decided how much of your credit you want to take, but *before* you decide how to use it, the decision aid will guide you through the following steps.

a. First, it will ask you to specify the total net return (i.e., net return from $A+$ net return from B) you wish to guarantee yourself in each of the two scenarios. In particular, you will have to answer the following two questions: Which net return from A and B do you aspire to in scenario 1? Which net return from A and B do you aspire to in scenario 2?
In the following, we will refer to the total net returns you aspire to as your *return aspirations*. Note that in the worst-case scenario, you may be willing to accept a loss. Hence, in scenario 1, your return aspiration may be negative.

b. Then, the decision aid will inform you whether your stated return aspirations can be achieved simultaneously or not, that is, whether there exists a way to divide your credit between the risk-free bond and the risky asset satisfying your return aspirations in each scenario.

c. If your stated return aspirations *cannot* be achieved simultaneously, the decision aid will ask you to revise them.

d. Only when your return aspirations can be achieved simultaneously, you can decide how to divide your credit between the two investment alternatives.

e. The decision aid will inform you whether the way in which you decide to use your credit is in line with your aspired net returns. That is, you will get to know if your investment decision satisfies your aspirations for net return in each scenario.

f. You can revise your investment decision as many times as you want, and you can stop at any time regardless of whether your selected investments satisfy your aspired net returns or not.

The decision aid will assist you in every round. In the first rounds, you are "forced" to use the decision aid. This means that you must go through all the steps mentioned above, and cannot decide how to use your credit until the net returns you wish to achieve in each scenario are possible simultaneously.

In later rounds, you can decide whether you want to use the decision aid or not. If you decide to use it, you have to go through all the steps mentioned above. If you decide not to use it, you can make your investment decision straight away. Also in this latter case, you have to specify the total net return that you wish to achieve in each scenario.

The Information You Receive at the End of Each Round.

At the end of each round, you will be informed about the result of your investment decision. That is, in each round you will get to know the net return you get from the amounts you invested in the risk-free bond and in the risky asset.

Your Final Earnings.

At the end of the experiment, one of the rounds will be randomly selected for payment. The credit you have taken in this round has to be paid back fully. The investment return exceeding the credit you have taken (i.e., the net return from your investment in A and B) will be converted to euros and paid out. Please note that your investment return may fall 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 completing half a page.

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

Please remain quiet until the experiment starts and switch off your mobile phone. If you have any questions, please raise your hand now.

B. Algorithm to Check if Aspirations Are Consistent

Let us assume that there is no idle money, i.e., $b + i = e$ or $b + i + j = e$, as required by bounded rationality.
In case of (C.2), for an aspiration vector $\mathbf{A} = (\bar{A}_1, \bar{A}_2)$:

1. Check whether $\bar{A}_1 \geq b(r-1) + (e-b)(l-1) = b(r-l) + e(l-1)$.
2. If the inequality above is satisfied, calculate b^* which solves $\bar{A}_1 = b^*(r-l) + e(l-1)$, yielding $b^* = \frac{\bar{A}_1 + e(1-l)}{r-l}$.
3. Substitute b^* for b in $b(r-1) + (e-b)(h-1) \leq \overline{A}_2$. If the inequality holds, the two return aspirations $\bar{A}_1$ and $\bar{A}_2$ are consistent.

In case of (C.3), the algorithm works in a similar way:

1. Check whether $\bar{A}_1 \geq (e-i-j)(r-1) + i(h-1) + j(L-1)$ and $\bar{A}_2 \geq (e-i-j)(r-1) + i(l-1) + j(L-1)$.
2. If both the inequalities above are satisfied, use them as equalities and solve for $i^*$and j^*.
3. Substitute i^* for i and j^* for j in $\bar{A}_3 \geq (e-i-j)(r-1) + i(h-1) + j(H-1)$. If the inequality holds, then $\mathbf{A} = (\bar{A}_1, \bar{A}_2, \bar{A}_2)$ is consistent.