Satisficing Players

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Abstract

Bounded rationality and, more specifically, satisficing in game playing assumes choosing strategies by anticipating their likely consequences. Unlike orthodox game theory, one does not require optimality and rational expectations but views satisficing as a reasoning process with several possible feedback loops. The various stages of such reasoning ask players to

- mentally represent the game, typically via simplifying (mental modeling),
- generate scenarios, i.e., point expectations concerning others' choices and chance events (scenario generation),
- form payoff aspirations for all scenarios (aspiration formation),
- try to satisfy them by successively testing choice alternatives (satisficing search).

When repeating this process, players may revise their mental representation, adapt their scenario set and aspiration profile or drop the first, the two first, or all three of these stages before exploring further strategies. Such satisficing in game playing has been confirmed experimentally by directly observing scenario generation, aspiration formation, and search for satisficing alternatives.

Keywords: Satisficing, Aspiration formation, Scenario generation, Game theory, Bounded rationality, Multiple selves

1. Introduction

Bounded rationality has been interpreted in many different ways, ranging from optimization under constraints (e.g., Rubinstein, 1998) to pure path dependence (e.g., Young, 2009), and using heuristics (see Gigerenzer and Selten, 2001). The interpretations seem to agree only on excluding common(ly known) rationality. Here we rely on a narrow definition of bounded rationality which does not deny the "shadow of the future," i.e., one chooses among choice alternatives by considering their anticipated consequences. However, we require neither rational expectations nor optimality which are viewed as unlikely border cases of bounded rationality.

Based on some general framework (Güth and Kliemt, 2011), boundedly rational players may differ in how they mentally perceive the game and typically generate their choices without Bayesian reasoning and intrapersonal payoff aggregation. We specify the process how boundedly rational players make choices in strategic settings and discuss experimental methods (Note 1) how to formally define and test the satisficing hypothesis (Note 2). Relying on supplementary data in addition to choice data, we hope to confirm the satisficing hypothesis. More specifically, we directly elicit what usually has to be inferred from choice data and try to specify the satisficing process step by step in the light of such additional data and, of course, based on introspective intuition (Note 3).

Players, who are at best boundedly rational, may not mentally perceive a game in the same way (Note 4). Such players may disagree on the player set, the strategy sets, the chance moves, and the payoff functions. Imagine a market game with sellers as players who perceive themselves as monopolists. The idiosyncratic mental representations by the different players, as formally described in section 2, are assumed as given (see Güth, 2012, for a discussion how to observe mental modeling experimentally). Given the idiosyncratic mental representation of the game, the consequences of different strategies will usually depend on what this player expects to happen beyond his own control. We refer to point expectations of others' behavior and chance events as scenarios. Such a scenario is a constellation which a player does not dare to neglect without necessarily being able to specify its probability. The belief set of a player contains all the scenarios which he considers as too relevant to neglect them when anticipating the consequences of successively tested strategies. Section 3 discusses how such beliefs allow to avoid (the need of) probabilistic belief formation and intrapersonal payoff aggregation as assumed by expected utility and prospect theory.

Restricting to games in normal form avoids all those aspects which may occur when in the course of the game players learn more about the game, their co-players and their choices inducing them to restart their deliberation process in the course of playing a sequential game. Furthermore in section 4, we assume one-dimensional goals (Note 5) like monetary payoffs and that players form a payoff aspiration for each of their idiosyncratically generated scenarios. When scenarios can be ordered from worst to best, the aspiration profile should monotonically reflect this. In other situations such ordering may not exist, e.g., when in one scenario one expects others to behave "nicely" but also "bad luck," whereas in another scenario with "good luck" others are expected to be "naughty".

In section 5 a strategy is said to be satisficing when all payoff aspirations are guaranteed what can be tested experimentally when, in addition to the usual choice data, eliciting directly the scenarios generated and the aspirations formed. Of course, for a too ambitious aspiration profile the set of satisficing strategies will be empty whereas too moderate aspirations may be satisfied by many strategies. Boundedly rational players usually will not try to determine their sets of satisficing strategies but will rather focus on few relevant strategies whose satisficing they test successively.

The steps of the satisficing process, described in section 6, are thus

- mental representation,
- scenario generation,
- aspiration formation, and
- search for satisficing strategies.

This reasoning process may be often repeated: when, for example, a satisficing strategy has been found after very little search, one will usually form more ambitious aspirations. Similarly, after not finding a satisficing strategy one may restart the process at an earlier stage, e.g. by eliminating scenarios or lowering one's payoff aspirations (see Sauermann and Selten, 1962). Rather than prematurely (due to the lack of appropriate data) speculating how to specify these steps of dynamic reasoning, in our experiments we directly elicit the results of these reasoning steps. Hopefully, one finally will be able to predict rather than to ask for the results of such reasoning steps.

Section 7 specifies optimal satisficing without probabilistic beliefs and intrapersonal payoff aggregation. Avoiding intrapersonal payoff aggregation relies on a multiple selves approach according to which players anticipate several alter egos, namely one for each idiosyncratically generated scenario. Optimality corresponds therefore to social efficiency meaning that no alter ego can get more without harming the other own selves. Such optimal satisficing is, of course, only optimal when the mental representation does not distort a player's incentives. In that case general optimality even qualifies as an equilibrium when all players entertain true point expectations.

Section 8 discusses how to test experimentally whether players are (optimally) satisficing, mainly relying on former experimental studies. Experimental methods to elicit a participant's mental representation of an experimentally induced game situation are so far more or less unexplored and therefore only briefly mentioned (see the more systematic discussion of Güth, 2012). The main focus is on experimentally incentivizing belief generation and aspiration formation to render (optimal) satisficing testable. Section 9 concludes.

2. On the Related Literature

The notion of an aspiration as an achievement level which one does not want to miss has already been mentioned in the literature (Simon, 1956). After its essential propagation by (Simon 1956 and 1957) one of the essential ingredients of aspiration formation, namely aspiration adjustment when repeating the stage of aspiration formation, has been especially studied by Sauermann and Selten (1962). Most of the applications of these concepts relied on aspirations revealed by behavioral choices in the sense that the actually achieved goal due to the observed behavior serves as a lower bound for the decision maker's aspiration (see, for example, Zwick et al., 2003).

More in line with our approach are experimental studies eliciting not only the choices but also the aspiration levels of (teams of) participants but at least partly according to prespecified goals and grid structures (see, for instance, Tietz, 1973, and Tietz and Weber, 1972).

Favorite experimental workhorses are either simple or complex scenarios. In the former case, satisficing can allow to avoid intrapersonal payoff aggregation (see Güth, 2010, and Güth and Kliemt, 2010) via specifying an aspiration for each scenario rather than assuming objective or subjective probabilities for them and adding up the probability weighted goal achievements as in expected utility and prospect theory (see, for example, Fellner et al., 2009). The latter type of experimental paradigms are complex situations for which perfect rationality in decision making is more or less impossible, at least in the course of an experiment. Such complexity does not require strategic interaction but can already be captured by individual search problems as studied in operations research.

A favorite example is the Secretary Problem (see Zwick et al., 2003) which can be described as a stopping task since several candidates (the so-called secretaries) show up one after another in a random sequential order and one candidate can be hired only on the spot, i.e., all former (later) candidates are foregone (unseen) opportunities. Again the quality of the selected candidate yields a lower bound for the aspired quality. Güth and Weiland (2011) have tried to circumvent this limitation in their experiment by offering participants routines which save search costs but also reveal aspirations more directly.

Although such successive search tasks may involve only one person, e.g. one participant in an experimental study, it is philosophically debatable whether one person implies one player or multiple selves (see Güth and Kliemt, 1996 and 2010). The usual assumption that we perfectly know all our future alter egoes (see for a striking example Becker and Murphy, 1988) is quite outrageous and can be easily avoided by our approach.

Actually, when analyzing strategic interaction of more persons nothing much changes except that one now confronts a group of satisficers. Each player mentally represents the game, possibly by denying the strategic influence of others (see Güth and Huck, 1997), via capturing his uncertainty about the other players' behavior by generating scenarios, i.e., behavioral constellations of other players and chance events which this player does not dare to neglect, possibly without being able to specify how likely these – typically few – scenarios are. When trying to apply our approach to interpersonal interaction after studying one-person decision tasks, we first allowed only for either purely probabilistic scenarios (Berninghaus et al., 2011) or excluded probabilistic events in order to focus on strategic scenarios capturing uncertainty only about other players' behavior (for example, Güth et al., 2010). Partly these studies and others will be described in some more detail below.

What all these studies, mentioned so far, have avoided is how we mentally perceive decision tasks and strategic games. When very simple, such situations may be grasped fully, especially when experimentally implemented in ways trying to guarantee such full apprehension, e.g. via control questionnaires or trial rounds. But when situations are rather complex, their mental representation will have to rely on complexity reduction, e.g. in the form of neglecting strategic interdependence, forming only few scenarios, disregarding feedback effects. etc. How this can be conceptualized more generally and then be explored experimentally would overburden the present study with focus on satisficing in strategic interaction (see Güth, 2012, for an attempt to further develop mental modeling in the light of experimental data).

3. Mental Representation of Stochastic Games

Restricting ourselves to stochastic normal form games (Note 6) $G=(S_1,\dots,S_n;u_1(.;.),\dots,u_n(.;.);Z)$, we use (for $i=1,\dots,n$) the following notation:

$S_i \neq \emptyset$: player i's set of strategies $s_i \in S_i$,

$u_i\left(s_i,s_{-i};z\right)$: player i's payoff for the strategy constellation $\left(s_i,s_{-i}\right)=\left(s_i,\left(s_j\right)_{j\neq i}\right)$ and chance event $z \in Z$,

$n\left(\geq 1\right)$: the number of players $i=1,\dots,n$,

$Z \neq \emptyset$: the set of chance events $z \in Z$ in the sense that for $\# Z=1$ the game is deterministic.

Generally, player i's mental representation $G^i=\left(S_1^i,\dots,S_{n^i}^i,u_1^i\left(.,.\right),\dots,u_{n^i}^i\left(.,.\right);Z^i\right)$

of G may allow for $S_j^i \supset S_j$ or $Z^i \supset Z$, rely on different payoff specifications $\left(u_j^i(.,.) \neq u_j(.,.)\right)$, and assume a different number of players $\left(n^i \neq n\right)$. Since boundedly rational players will usually try to simplify the game (Note 7) (complexity avoidance), we suppose $S_j^i \subset S_j, Z^i \subset Z, n^i \leq n$ for all $i, j = 1,\ldots,n$.

When sets S_j contain many strategies $s_j \in S_j$, a player j will consider only few relevant choices s_j. In an ultimatum game, a proposer, for instance, usually considers only one or two low offers in addition to the equal split offer what is usually anticipated by other players i so that $S_j^i \subset S_j$ also for $i \neq j$.

Payoffs can be misspecified $\left(u_j^i(.,.) \neq u_j(.,.)\right)$ due to neglecting certain dependencies (one may, for example, neglect the stochastic nature of a game with $\#Z > 1$) or due to attempts to simplify, e.g. by linearizing non-linear structural dependencies. A seller, for instance, may assume his cost function to be linear in spite of variable marginal costs.

We admit to know very little how boundedly rational players mentally construct G^i. Evidence on mental representations (Note 8) may be elicited by well-known techniques (see Güth, 2012, for details) like

- "speak aloud",
- video-taping group decision making, or
- trying to guarantee $G^i = G$ for all i by using a rather simple game and making sure that all its aspects are fully comprehended.

The two former methods are difficult to apply since "verbal statements" may not be conclusive enough to specify G^i. One would therefore hope that other methods like cognition tracing will help. So far elicitation methods to assess mental modeling are insufficient and seldom applied.

4. Scenario and Belief Generation

In complex settings, there may be simply too many constellations $s_{-i} = \left(\left(s_j\right)_{j \neq i}\right)$ with $s_j \in S_j^i$ of others' strategies as well as too many chance events $z \in Z^i$ to consider them all seriously in limited time and, given the relevance of the task, by investing adequate cognitive effort. Thus a player i may consciously or unconsciously disregard some of them via $S_j^i \underset{\neq}{\subset} S_j$, respectively $Z^i \underset{\neq}{\subset} Z$, when mentally perceiving the game to focus on rather few scenarios $\left(s_{-i}, z\right) = \left(\left(s_j\right)_{j \neq i}, z\right) \in \underset{j \neq i}{x} S_j^i x Z^i$. What does it mean that player i focuses attention on scenario $\left(s_{-i}, z\right)$? Our interpretation is simply that player i does not dare to neglect this possibility of events escaping his control without being necessarily able to specify a (subjective) probability for such a scenario $\left(s_{-i}, z\right)$. By this we do not exclude probabilistic beliefs, although it is essential that we do not need them. Actually, our satisficing approach allows for other uses of scenario probabilities than in orthodox decision and game theory. A player, who failed in finding a satisficing strategy may, for example, lower the aspiration levels for scenarios which he deems very unlikely.

Of course, player i usually does not entertain point expectations (s_{-i}, z). We denote by $B^i = \left\{(s_{-i}, z) : s_{-i} \underset{j \neq i}{x} S^i_j, z \in Z^i\right\}$ the set of scenarios which player i does not dare to neglect and, in the following, refer to B^i as player i's belief set. One may argue that postulating such belief (scenario) generation is easy but that predicting how and which scenarios are generated is needed (Note 9). We agree that one should aim at that but that for the time being this can be avoided by directly eliciting belief sets in the usual incentivized way, practiced in experimental economics.

To summarize: We do not require but also do not deny that a player i may generate probabilities $b_i(s_{-i}, z) \in [0,1]$ for the scenarios in his belief set. Even if he determines scenario probabilities, he may not use them for intrapersonal payoff aggregation as in expected utility or prospect theory but rather when forming or adapting aspirations. For example, players may form more ambitious aspirations for likely scenarios and lower aspirations for less likely scenarios but still refrain from intrapersonal aspiration aggregation by viewing the sum of probability weighted aspirations as their decision goal (Note 10).

5. Aspiration Formation

Given the belief set B^i, player i forms payoff aspirations $A_i(s_{-i}, z)$ for all scenarios $(s_{-i}, z) \in B^i$. In general, a player may pursue multiple goals. Here, however, we assume a one-dimensional goal, e.g., in the sense of monetary payoffs. We refer to vector

$$A^i\left(B^i\right) = \left\{A_i(s_{-i}, z) : (s_{-i}, z) \in B^i\right\}$$

as player i's aspiration profile. Thus, even for a one-dimensional goal, player i seems to face a multi-objective choice problem since i will want to earn a sufficient amount in all scenarios $(s_{-i}, z) \in B^i$. Similar to the usual reluctance to accept interpersonal payoff comparisons (Note 11), it may be that player i does not engage in intrapersonal payoff comparisons in the sense of comparing the aspiration levels of different scenarios $b_i(s_{-i}, z)$. We do not exclude intrapersonal payoff aggregation, e.g., in the sense of trying to increase one's aspiration expectation

$$\sum_{(s_{-i}, z) \in B^i} b_i(s_{-i}, z) A_i(s_{-i}, z),$$

as a goal, for example, when objective probabilities $b_i(s_{-i}, z)$ are given, e.g., experimentally induced. Nevertheless, it is important for our satisficing approach that it

- does not presuppose probabilistic beliefs $b_i(s_{-i}, z)$ and

- can avoid aggregating aspirations $A_i\left(s_{-i}, z\right)$ across scenarios.

Its underlying multiple selves interpretation (Note 12) of a player i, when choosing $s_i \in S_i^i$, considers a self-generated set of his alter egos who all have to live with the consequences of s_i but are confronting different environmental constellations $\left(s_{-i}, z\right) \in B^i$ of others' behavior and chance events. This does not rule out a (basic) optimality notion in the sense of undominated aspiration profiles, which at best boundedly rational players i often fail to meet, especially when G^i is still rather complex.

6. (Non-)satisficing Search

Rather than "optimizing," a boundedly rational player i will successively test alternative strategies $s_i \in S_i^i$ to learn whether or not they are satisfying his aspiration profile $A^i\left(B^i\right)$. We say that $s_i \in S_i^i$ satisfies $A^i\left(B^i\right)$ if

(*) $u_i^i\left(s_i;\left(s_{-i}, z\right)\right) \geq A_i\left(s_{-i}, z\right)$ for all scenarios $\left(s_{-i}, z\right) \in B^i$,

i.e., according to G^i, player i wants all his aspirations guaranteed when choosing $s_i \in S_i^i$. Formally speaking, the set $S_i^i\left(A^i\left(B^i\right)\right)$ of satisficing strategies is an intersection of subsets of S_i^i which can be empty when aspirations are too ambitious and rather large when they are too modest. Boundedly rational players will not determine the set $S_i^i\left(A^i\left(B^i\right)\right)$ but rather try out one strategy $s_i \in S_i^i$ after another to see whether $S_i^i\left(A^i\left(B^I\right)\right) \neq \varnothing$ holds.

In case of (*), player i may nevertheless continue searching, e.g., after very quickly finding a satisficing strategy. When, however, a satisficing choice $s_i \in S_i^i$ is only found at after a long search, player i will probably stop exploring further alternatives $s_i \in S_i^i$.

When a long sequence of successive tests $s_i \in S_i^i$ has not even once yielded a satisficing alternative, player i will usually consider himself as too ambitious and fear that there may not be a satisficing strategy $s_i \in S_i^i$. He will most likely engage in aspiration adaptation (Sauermann and Selten, 1962) or, even more basically, in updating his mental representation G^i of G or only his belief set B^i. Again, one can argue that one should be able to predict what is adapted (G^i or only B^i, respectively $A^i\left(B^i\right)$). As before our counter objection is that this should not be determined via speculating without facts and that one can avoid such speculating by directly eliciting the adaptation of G^i, B^i, and A^i in addition to the usual choice data. More specifically, in an experiment one can provide feedback about (*) and observe what is adapted by the participant in the role of player i.

7. The Recursive Satisficing Process

Sections 2 to 5 describe the basic steps of the recursive satisficing process, as graphically illustrated in Figure 1. After testing whether or not a strategy $s_i \in S_i^i$ meets the satisficing requirement (*), player i may only adapt his aspirations, generate or sever scenarios, or even revise his mental representation G^i. Thus, after learning whether or not $s_i \in S_i^i$ is satisficing in the sense of condition (*), player i

- can continue testing other $s_i \in S_i^i$ (d-loop),
- can go back to earlier phases of the satisficing process (the a, b, c-loops), especially after a long but unsuccessful or a seemingly quick success, and
- will finally choose one of the (so far tested) alternatives $s_i \in S_i^i$ where, according to the satisficing hypothesis, the chosen strategy $s_i \in S_i^i$ should satisfy condition (*).

In Figure 1, the d-loop captures further search for a satisficing strategy, the c-loop aspiration adaptation (early on suggested and elaborated by Sauermann and Selten, 1962, see more recently Selten, 1998) before searching again, and the b-loop that one generates a new belief set which then inspires renewed aspiration formation and search. Finally, the a-loop represents a new attempt to mentally represent the game possibly after learning that crucial aspects have been neglected before (Note 13).

<Insert Figure 1 Here>

8. Optimal Satisficing and Equilibrium Behavior

A satisficing strategy $s_i \in S_i^i$ fulfills condition (*) where, however, the set of satisficing strategies $s_i \in S_i^i$ may

- either be empty, e.g., when aspirations are very ambitious,
- or be a rather large subset of S_i^i, e.g., when aspirations are moderate.

We say that an aspiration profile $A^i\left(B^i\right) = \left(A_i\left(s_{-i}, z\right)_{(s_{-i},z)\in B^i}\right)$ is optimal for the given mental representation G^i if

- $A^i\left(B^i\right)$ is satisfiable, i.e., there exists $s_i \in S_i^i$ fulfilling condition (*) for G^i, and
- for all aspiration profiles $\tilde{A}^i\left(B^i\right)$ with $\tilde{A}^i\left(s_{-i}, z\right) > A_i\left(s_{-i}, z\right)$ for at least one scenario $\left(s_{-i}, z\right) \in B^i$ and $\tilde{A}^i\left(s_{-i}, z\right) \geq A_i\left(s_{-i}, z\right)$ for all $\left(s_{-i}, z\right) \in B^i$ condition (*) is violated.

Such basic optimality in the sense of undominatedness avoids intrapersonal payoff aggregation. If $s_i \in S_i^i$ fulfills (*) for an optimal aspiration profile $A^i\left(B^i\right)$ for given G^i, then s_i is optimally satisficing, given the representation G^i. The non-empty set of optimal aspiration profiles and optimal strategies can be large and difficult to determine algebraically. Boundedly rational players, when trying to achieve better results, do not determine these sets but rather try to improve their success by adaptation as outlined in Figure 1.

When $S_i^i = S_i$ and $u_i^i\left(s_i,\left(s_{-i},z\right)\right) = u_i\left(s_i,\left(s_{-i},z\right)\right)$ for all $s_i \in S_i$ and for all $\left(s_{-i},z\right) \in B^i$, then an optimal strategy $s_i^* \in S_i$ for given mental representation G^i is even optimal with respect to G, given the belief B^i of player i: there exists no other strategy $\tilde{s}_i \in S_i$, yielding more for player i in one scenario $\left(s_{-i},z\right) \in B^i$ and not less in all other scenarios $\left(s_{-i},z\right) \in B^i$.

If such optimality $s_i^* \in S_i^i = S_i$ with respect to G is granted for all players $i = 1,\ldots,n,$ vector $s^* = \left(s_1^*,\ldots,s_n^*\right)$ of such optimal strategies can still rely on non-rational, even inconsistent (in the sense of $s_k^i \neq s_k^j$ for players i,j with $i \neq j, i \neq k, j \neq k$) expectations. For s^* qualifying as an equilibrium, one additionally has to require that

- $\# Z = 1$, i.e., that G is a deterministic game and
- $\# B^i = 1$ meaning that all players $i = 1,\ldots,n$ entertain rational point expectations s_{-i}^* concerning their co-players' behavior since optimality and rational expectations of all players characterize equilibria (Aumann and Brandenburger, 1995).

When, however, $\# Z > 1$ holds, players may disagree on which chance events they expect.

9. Experimentally Testing Satisficing Players

To speculate about game playing presupposes an approach of how to satisfice without strategic interaction. For our definition of satisficing in game playing, all that is new in game playing is that beliefs of players i specify not only chance events z but also the behavior s_{-i} of their co-players $j \neq i$. It is therefore natural that the first experimental studies, based on our approach, have studied satisficing without strategic interaction (Fellner et al., 2009, Güth et al., 2009).

It has already been acknowledged that an algorythmic specification of the dynamic satisficing framework in Figure 1 would need theories of mental modeling, scenario generation, aspiration formation and of the corresponding adaptation dynamics (loops a, b, c, and d in Figure 1) and that, given what we know so far, such a specification would require speculating without guidance by facts. Nevertheless, crucial aspects of this dynamic satisficing process are rigorously defined and therefore testable when, in addition to the usual choice data, one directly asks for G^i, what may be very difficult and problematic, or at least for B^i and $A^i\left(B^i\right)$.

The first experimental studies based on our framework, have excluded strategic interaction $(n=1)$ and exogenously induced $Z^i = Z$ with $\#Z = 2$. More specifically, the experiments confronted participants with a simple portfolio selection task involving only one risky (financial) asset. Thus, participants had to state just two aspirations with one being at least as good as the other since one state of nature provided better results than the other (see Fellner et al., 2009). Given the two aspirations and the chosen portfolio, one can rigorously test whether or not the satisficing requirement (*) holds.

The $n=1$ task in the study of Güth et al. (2009) is more complex since $\#Z = 4$ and since the experimentally induced scenarios (in the sense of $B^1 = Z$) could not be ordered by desirability. Unlike in Fellner et al. aspiration formation has not only been just elicited but also incentivized what improved the experimental confirmation of the satisficing hypothesis (*) dramatically (Note 14).

Experiments with strategic market interaction were performed

- for a stochastic market, imposing scenarios (s_{-i}, z) for just one point belief s_{-i} concerning the other sellers' choices but full stochastic beliefs, i.e., $Z^i = Z$ for all sellers $i = 1,...,n$ (Berninghaus et al., 2011), and
- for a deterministic market $(\#Z = 1)$, where sellers $i = 1,...,n$ could generate up to six scenarios (s_{-i}, z) concerning their co-players' behavior (Güth et al., 2012).

What this illustrates is that we again only gradually elicited more data, namely just one idiosyncratically generated s^i_{-i} strategy constellation of other sellers' behavior in Berninghaus et al. (2009) and up to six such constellations s^i_{-i} in the study of Güth et al. (2012). When incentivizing not only aspiration formation but also belief generation (participants lose according to the distance of their best guess s^i_{-i} to the true choice constellation s_{-i}), the confirmation of the satisficing hypothesis (*) greatly improves and even reaches 100 % when participants become more experienced. None of these studies could confirm optimal satisficing although some of the experimental setups are simple enough to allow optimality even for boundedly rational participants.

Rather than reporting more details of these studies (see Güth et al., 2010, for a summary), let us discuss some of the methodological problems when applying our approach quite generally to the class of stochastic normal form games G. Similar to the revealed preference approach, experimental studies (Note 15) so far have tried to infer aspirations from observed choice behavior what presupposes satisficing rather than tests the satisficing hypothesis with the help of additional data allowing to directly check the satisficing condition (*). What such direct tests require is to elicit for players $i = 1,...,n(\geq 1)$

- not only their choices s_i
- but also their aspiration profiles A^i
- as based on their beliefs B^i

where, for the sake of the study at hand, we neglect (Note 16) the problem of eliciting the idiosyncratic mental representation G^i. The above mentioned experiments have shown that this can indeed be done and that it is crucial (Note 17) to incentivize not only choice behavior but also belief generation and aspiration formation.

Of course, one would also want to observe the mental representations G^i of the interacting players to control which strategic aspects are respected, respectively neglected, by them. But as already mentioned and elaborately discussed in the companion paper (Güth, 2012), so far we know very little of how participants cognitively perceive games and can only offer little advice on how to elicit the mental representations G^i of players i interacting in an objectively given game G as, for example, induced in experiments by commonly known instructions defining the rules of G.

The fact that one can rigorously test satisficing in the sense of condition (*) for given B^i and $A^i\left(B^i\right)$ when eliciting s_i as well as B^i and $A^i\left(B^i\right)$ does not mean that we have offered a complete theory of bounded rationality. So far, we

- neither have a theory of mental representation telling us how players i cognitively construct G^i when confronting G
- nor a theory of belief generation and aspiration formation in strategic interaction

but only have shown how by eliciting the results of B^i generation and $A^i\left(B^i\right)$ formation, one can rigorously test the satisficing hypothesis without them. With such data one can test satisficing rather than presuppose it as, for example, when relying on a revealed aspiration approach. It allows to rigorously test the satisficing hypothesis for game playing and points out where more theoretical and empirical research is needed.

10. Conclusions

Satisficing players perceive a game cognitively and find a satisficing mode of behavior by applying a dynamic deliberation and search process. We have presented experimental methods how one can test crucial aspects of satisficing in game playing and reported some first results of experiments eliciting not only players' choices but also their beliefs and aspiration profiles.

How games are mentally perceived is discussed in more detail in a companion paper (Güth, 2012). So far only few aspects as the formal condition of (optimal) satisficing and experimental techniques to test this are proposed. We have embedded these aspects in an intuitive context of a recursive reasoning process. In spite of the remaining shortcomings, we claim quite some progress in developing the theory of boundedly rational game playing.

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Notes

Note 1. What this means is to elicit more than choice data. When additionally observing mental modeling, eliciting belief (scenario) and goal (aspiration) data, crucial aspects of dynamic decision making can be rigorously defined and tested by the additional data.

Note 2. The experimental research initially concentrated on decision theoretic tasks without strategic interaction (e.g. Fellner et al., 2009, Güth et al., 2009, Güth and Weiland, 2011) before trying to study strategic interaction (e.g. Berninghaus et al., 2011, and Güth et al., 2012).

Note 3. In our view, introspection always filters our intuition when trying to elaborate how we think and make up our mind. Rather than denying that we acknowledge such « armchair evidence ». Of course, the final answer should rely on objective empirical evidence.

Note 4. One may question whether there exists an objectively given game or whether the game exists only in the eyes of the players. We simply assume an objectively given game as, for example, seen by a competent third party or experimentally induced.

Note 5. The endogenous generation of multiple action goals as short-term success criteria of long-term success are studied by Selten et al. (2011/2).

Note 6. For sequential games a player's mental representation may change in the course of playing the game. The task of theoretically describing how a game is mentally represented would then be more difficult. This explains why we confine ourselves to stochastic normal form games.

Note 7. On a market a seller i might, for instance, consider himself a monopolist $\left(n^i = 1\right)$ in spite of $n\left(\geq 2\right)$ sellers on the market (see for an evolutionary justification, Güth and Huck, 1997).

Note 8. Cognitively representing a strategic game is a common task of bounded rationality theory in the narrow sense of our study as well as of cognitive psychology. Unfortunately, cognitive psychology so far is more focused on categorizing linguistic terms than on categorizing (non-)strategic decision tasks.

Note 9. One should be aware that similar objections apply to the rational choice approach where one would have to predict the preferences and beliefs of all players.

Note 10. To illustrate the difficulty of such intrapersonal payoff aggregation, consider a chance move determining whether or not a player i becomes terminally ill. One would like to guarantee certain aspirations for each of these events rather than probability weight and aggregate them.

Note 11. The efficiency concept (it should not be possible to improve one without harming the others) avoids interpersonal payoff aggregation as postulated by (cardinal) welfare functions.

Note 12. This is different from the concept of agent players for extensive form games according to which each information set of a personal player defines an independent actor (see Güth and Kliemt, 1996).

Note 13. One may, for example, have realized that $n > n^i$, e.g. that one is not a monopolist on the market, captured by game G.

Note 14. There is a cost of incentivizing aspiration formation, namely participants earn only their aspirations and not their true payoff when satisficing. The elicitation of non-choice data has been changed in the light of earlier experiences with less biased but unreliable techniques.

Note 15. Güth and Weiland (2011) review some such attempts for the secretary search problem but elicit aspirations directly by devices allowing participants to save search costs and experimenters to observe aspirations.

Note 16. This, for instance, means that one only observes the strategies $s_i \in S_i^i$, which were actually tested by player i in the recursive process of Figure 1, but usually not S_i^i itself.

Note 17. Incentivizing (belief and) aspiration elicitation increases the share of satisficing behavior considerably and even leads to 100% satisficing after some learning (see Güth et al., 2009).

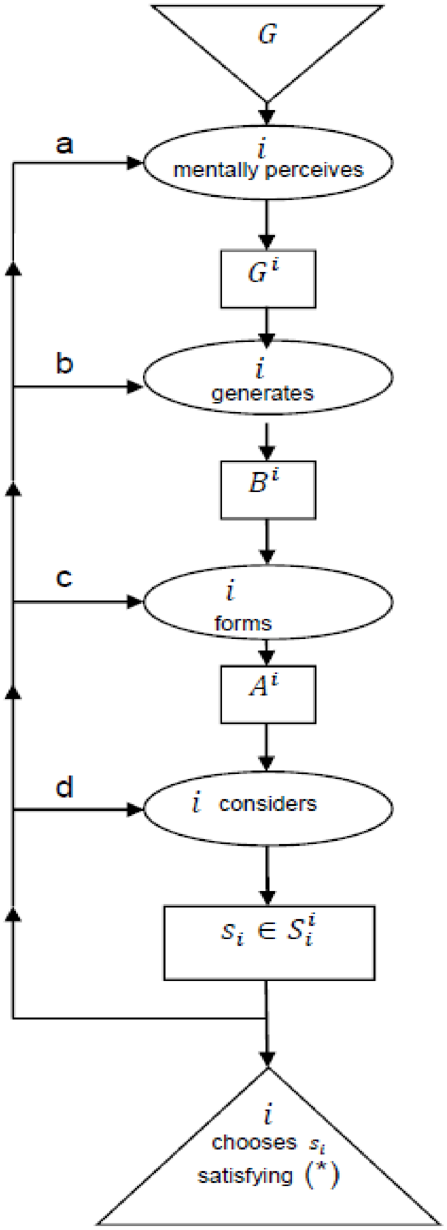

Figure 1. The satisficing process with feedback loops a,b,c and d