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Strategies in dynamic decision making – An experimental investigation of the rationality of decision behaviour

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ABSTRACT

This paper is concerned with the question of how people tackle dynamic decision problems. It is on the interface between economics and psychology. Economic theory has a well-defined theory of how people should tackle such problems, but experimental evidence suggests that these are not empirically valid, and particularly that people find dynamic decision problems complex and cognitively demanding. Psychologists have long been aware of such issues and have developed a suite of theories to explain behaviour in such contexts, but these have been largely developed in a static context. This paper attempts to build a bridge between the two disciplines by exploring decision processes in a dynamic problem for which economic theory provides clear predictions. To aid us in this quest we use an experimental design which enables us to infer the decision rules that people are using. We identify a number of distinct decision heuristics, which could usefully be embodied into economic models of dynamic decision making.

1. Introduction

Though economists and psychologists have long been concerned with the principles and processes of decision making in conditions of risk, little is known about the way people actually tackle stochastic dynamic decision problems. Such problems are especially demanding as their solution requires a sequence of interdependent decisions which takes random changes in the decision environment – so called 'moves of nature' – into account as well as the impact of previous decisions, that is, the earlier moves of the decision maker (Edwards, 1962). This sequence of decisions is also referred to as 'decision strategy' in psychology. According to Beach and Mitchell (1978) a decision strategy is (a) a procedure the decision maker engages in, when attempting to choose among alternative courses of action and (b) a decision rule that dictates how the results of those procedures will be used to make the final choice. Up to now the question how such a decision strategy is chosen cannot be answered unequivocally. The objective of this paper is to provide further insight to dynamic decision behaviour and thereby contribute some clarification.

This paper reports on the decision-making processes that subjects appear to be using in a dynamic decision-problem which has a well-defined optimal solution. We deliberately and crucially adopt an experimental design in which preferences

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play no role in defining the optimal solution; the only thing we assume is that preferences satisfy *dominance*; this seems a minimal requirement. The assumption of dominance has various levels: the simplest is that the decision-maker, when faced with a choice between a certain amount of money x and a certain amount of money y, he or she chooses x if x is bigger than y. We require an extension of this to stochastic choice: let $X = (x_1, x_2, \ldots, x_N)$ denote a choice which leads either to a payoff of x_1, or to a payoff of $x_2, \ldots$, or to a payoff of x_N, each with probability $1/N$. Then we say that the preferences of a decision-maker satisfies dominance if he or she chooses X over Y if $x_n \geqslant y_n$ for all $n = 1, 2, \ldots, N$ with at least one of the inequalities being strict. We assume that our subjects' preferences satisfy dominance in this sense.

We present subjects with a dynamic decision problem in which there are three decision nodes interleaved with three chance nodes. The problem is carefully constructed so that there is a uniquely best optimal strategy for someone whose preferences satisfy dominance.[1] However, because of the way that the problem is presented, the implementation of the optimal strategy is not obvious to someone who is not trained. We are therefore interested in whether subjects can disentangle the complexities of the problem and (perhaps learn to) approach the optimal solution. Our experiment is designed to see what subjects actually do.

We begin our brief discussion of the contributions made by psychologists with the paper by Beach and Mitchell (1978) which suggest classifying decision strategies into *aided-analytical*, *unaided-analytical* and *non-analytical* strategies. As these names suggest, the three categories differ in their analytical degree, in the amount of required resources, and in the amount of information procurement. Aided-analytical strategies require the application of a prescribed procedure, and usually decision tools (pencil and paper, mathematics, calculators) are used to derive the implied decision. The decision process may be complex and time-consuming since all the relevant information is considered and processed as the decision is derived and implemented. According to Beach and Mitchell (1978), due to their high analytical level, these kinds of decision strategies always require training or invention. In contrast, unaided-analytical decision strategies do not make use of tools. Instead the decision-making processes is entirely carried out in the decision maker's mind. Non-analytical decision strategies comprise simple rules. These are fast decision strategies since little information is processed and the decomposition is omitted. The question that now arises is how the decision maker decides which strategy she will use in any particular decision problem.

Generally it is assumed in psychology that the decision maker has a repertoire of decision strategies from which he or she chooses (Beach & Mitchell, 1978), (Gigerenzer, Todd, & the ABC Research Group, 1999) and (Payne, 1976). This choice is contingent on two factors: the characteristics of the decision problem and the characteristics of the decision maker. The decision problem not only refers to the decision task but also comprises the decision environment (Beach & Mitchell, 1978). Decision tasks can differ in their degree of unfamiliarity, ambiguity of the problem, instability and complexity, while the decision situation can differ in respect of the irreversibility, significance and accountability of the decision as well as of time and/or money constraints (Beach & Mitchell, 1978). The second factor which influences strategy selection is that of individual differences. According to Beach and Mitchell (1978) decision-makers differ in respect of their knowledge about strategies and their chances of success, their ability to implement a particular strategy and their motivation to solve the decision problem. Bettman, Johnson, and Payne (1990) also emphasize the existence of individual differences in respect to cognitive abilities and capacities.

Beach and Mitchell (1978) incorporate both factors in their *Model of Contingency*, which postulates that strategy selection is determined by a cost-benefit analysis, where the expected costs, comprising time, effort or even money, which will emerge by the application of a certain strategy, are counterbalanced by the expected benefit. More formally expressed, the benefits are computed as the product of the probability that the chosen strategy will lead to a correct decision and the utility of making the correct decision. According to Beach and Mitchell the strategy which maximizes net gain (expected benefit minus expected costs) will be chosen. Beach and Mitchell's Model postulates that the choice for an analytical procedure is positively linear related to task and situational demands, as well as to knowledge and ability. However, if the demands become overwhelming, the linear relation breaks down and a non-analytical decision strategy will be chosen. Each of the demand components is weighted in respect to their importance so that the preference of analytical over non-analytical strategies is contingent on the decision situation. Unfortunately a key component of this approach is that it requires the calculation of "the probability that the chosen strategy will lead to a correct decision and the utility of the making the correct decision" both of which are unknown until the optimal strategy has been calculated. If this has been done, there is no need to use a sub-optimal strategy.

It is clear from the psychological literature that, rather than optimizing, decision-makers may adopt *heuristics* which may or may not approximate to the optimal strategy. Kahneman, Tversky, and Slovic (1982) following on the work of Newell and Simon (1976) were among the pioneers at identifying heuristics that people appeared to be using. Gigerenzer et al. (1999) noted that many heuristics (perhaps after a period of learning) approximated quite well the optimal strategy.

Most of the strategies discussed above mainly refer to static decision problems. But what do we know about decision strategies in dynamic decision problems? The answer seems to be 'not much'. The literature appears to be restricted to the work of Busemeyer and his collaborators (for example, Busemeyer, Weg, Barkan, Li, and Ma (2000), Mueller (2001)) and Carbone and Hey (2001). Although in the context of different dynamic decision tasks, the general conclusion of these studies was that subjects try to simplify the decision problem as much as possible by applying heuristics. However, in all these experiments there were subjects who, though not behaving optimally, tried to implement an optimal strategy but

[1] This is whether the individuals solve the problem by backward induction or by the strategy method.