Qualitative Aspects of Decision Making - A Challenge for Decision Research

Roland W. Scholz and Alf Zimmer

Psychological research on decision making is developing its own history, dynamics and trends. Traditionally, John v. Neumann and Oskar Morgenstern's work *Theory of games and economic behavior* (1944) is considered as the cradle of the interdisciplinary scientific field of decision research. From an *qualitative* point of view, the major contribution of v. Neumann and Morgenstern may be seen in making allowance for an an *optimization of behavior in social contexts*. The aim of their work was *to model and to understand rational behavior in the face of the uncertainty given by social contexts and markets*. As we know, the MATHEMATICIAN v.Neumann and the ECONOMIST Morgenstern used a strictly normative approach, based on *quantitative* and axiomatically formulated concepts of *probability* and *utility*. Two major PHILOSOPHICAL roots of the economic-game theory approach can be identified. On the one hand there is James Mill´s (1789) and Jeremy Bentham's (1848) quantitative approach to utility. On the other hand the concept of *probability as a rational or real number* has to be mentioned, which was theoretically developed by Jaques Bernoulli (1713) and Daniel Bernoulli (1777) through the *laws of great numbers* and the conceptual pivot of the principle of *maximizing expected utility*.

> Therefore one may state: the quantification of expectation which accompanied the use of probability and utility in the everyday language of Western countries (c.f. Gigerenzer, 1996) is a feature of the second half of the 20th century .

Clearly the game theory approach strongly affected many other sciences, particularly psychology. The concept of strategies and utility-like-outcomes was incorporated into social psychology (e.g., Thibault and Kelley, 1959 or Deutsch, 1949). However there is also a psychological approach to the analysis of decision behavior which is mostly independent of the game theoretical framework, i.e. the Brunswik'ian *Theory of probabilistic functionalism* (Brunswik, 1955), which has been "overlooked" for some time now. The main aim of Brunswik was to understand how a perceptual mechanism may cope with a bunch of varying and unreliable cues (Brunswik, 1942). One of his paradigms was *probability learning*. Within the basic experimental procedure, subjects are confronted with two differently coloured light bulbs, which light up a certain probability for example a 20% chance for the red and an 80% for the green bulb. Brunswik had to realize, that subjects did not follow the game theoretic principles of optimality. Instead of constantly predicting the colour of the

bulb which lit up more frequently and thus maximizing the hit rate, subjects showed a remarkably different behavior. In long run experiments with up to 10.000 trials (c.f. Brunswik and Herma 1951), the relative frequencies of their forecasts approached to the frequency of the light bulb colours lighting up. According to the experimental tradition of his time, the environment in probability learning experiments usually was de-contextualized as far as possible (see Scholz, 1991). Thus the decision maker was conceived within a "*tabula rasa black box philosophy*", which was reflected by the choice of subjects : "Studies in this area have used either adult college students ... or subhuman species auch as rats ... or goldfish" (Messick and Solley 1957, p. 239).

However, we should acknowledge that probability learning is one possible outcome of behaviour and that it may not only be observed when people cope with light bulbs. This was proven by a study published in the *New England Journal of Medicine* regarding tonsillectomies (Bakwin, 1945, for the following see Carrol and Johnson, 1990, p. 10). Subjects were a panel of three physicians who had to screen all 389 5th-grade pupils from one town. The panel recommended that 45% of the boys undergo surgical removal of their tonsils. The physicians were thanked and dismissed. Then a second panel of three physicians was recruited and asked to examine the 215 boys who had been judged by the first panel *not* to need surgery. If there was complete agreement between the panels of physicians, then none of these boys should have been judged to need tonsillectomies. However, again 46% were judged to need surgery. It was as if the inital screening had never occurred! Finally, the second panel of physicians was dismissed. A third panel was recruited and examined the 116 boys who had been twice cleared. The third panel also diagnosed 44% of these boys as needing tonsillectomies.

> We may note that just after the game theoretic framework of behavior was developed, clear evidence was provided, that the individual's behavior was often not optimized with respect to expected utility.

Although, at the outset deviations of *"rational behaviour"* should have been acknowledged, the conceptual framework of a quantitative rationalistic modelling of human decision behaviour has dominated decision research right into the late sixties. This is clearly expressed in the summary of the widlely quoted Peterson and Beach (1967) paper on *Man as intuitive statistician: "In general the results indicate that probability theory and statistics can be used as the basic for psychological models that integrate and account for human performance in a wide range of inferential tasks."*

> In general it can be said that at the end of the sixties psychological decision research had chosen an exclusively quantitative, de-contextualized approach, which was oriented toward the conception of man as a *rational beeing*.

A paradigm switch was provided by the seminal work of Kahneman and Tversky on judgemental heuristics, particularly that of *representativeness* (Kahneman and Tversky, 1972) and *availability* (Tversky and Kahneman, 1973), which dominated research on judgement and decision making for almost two decades. According to Kahneman and Tversky, probability judgements are systematically biased, because people apply rules of thumb like inferential heuristics. The approach refers to the propositions of bounded rationality and acknowledges the limited capacitative and operative abilities of memory. Many experimental demonstrations of the fallacious and biased human decision behaviour, particularly in probability judgements, have been presented. However, one should note that the Kahneman and Tversky paradigm still heavily relied on the v. Neumann and Morgenstern framework: Not as a mean of description but as a point of reference. This also holds true for models in which "subjective perspectives" were introduced, for instance in Kahneman and Tversky's prospect theory (1979, 1993). Though assumptions on S-shaped subjective utility functions and particularly the assumptions of individual threshholds reminiscent of Lewin´s levels of aspiration, already entail qualitative aspects, the normative reference models (and within prospect theory also the descriptive model) stick to the "*utility x probability"* framework.

Certain shortcomings of the judgement and heuristic approach had been criticised very early. From a cognitive psychology point of view "a) the limited number of heuristics, b) their vague definition, c) the lack of rigorous theory development" (Wallsten, 1983, p. 21; see also Scholz, 1981, Jungermann, 1983; Zimmer, 1983) have to be mentioned. The abstracts and summary of a Conference held at the Centre of Interdisciplinary Research in 1982 (cf. Scholz, 1983) formulated major perspectives for overcoming the abovementioned deficiencies and challanged a radical cognitive and theory driven approach. Later, the insufficient task analysis (c.f. Birnbaum & Mellers, 1983; Scholz, 1987; Gigerenzer & Murray, 1987) or the misleadigness of certain items (May, 1987) were object of critique.

Thus, one may conclude: The concept of *bounded rationality* and the *heuristics and biases program* has been proven to be an generally fertile approach particularly when it takes into account that the individual's information processing does not meet the requirements of the probability calculus, e.g. Bayes rule. However, in principle, it

remains within the v. Neumann and Morgenstern concept of (subjective) utility and probability, excluding different notions of probability and the analysis of the subject-task relation in experimental tasks. Though subsequently some of this criticism was met by more precise descriptions, particularly of the cognitive processes involved in the available heuristic, a more radical step should be taken into the understanding of qualities or qualitative aspects in decision making.

This volume on *Qualitative Aspects of Decision Making* deals with three issues that may widen research on judgement and decision making:

- Firstly, the ***concepts*** and their (formal or semantic) relations in normative and cognitive modelling are addressed. Particularly *alternative representations of uncertainty* are thus treated which reflect different qualities of knowledge.

- Secondly, the ***meaning*** of the decision to the subject's world and its environment. Thus it will be concluded that a ***contextualization*** of the task and a theory of the subject task relation is required (cf. also Fischhoff, 1996).

- Thirdly, the ***complexity*** of a decision task may be perceived of as a specific quality which, for example, requires multiple representations and strategies of knowledge integration.

We will briefly describe some of the main points of the different papers. The reader may note that only two chapters have been written by authors which were not present at the above mentioned 82-Meeting at Bielefeld (see Scholz 1983).

The chapters of this volume vary with respect to the focus on the above three issues. Alf C. Zimmer's paper deals primarily with the issues of **contextualization** (including meaning) and **complexity** in decision making when discussing the question *Why do Real-World Problems Necessitate a Qualitative Approach to Decision Making?* In a rather typically European manner, he refers to both an historical perspective and a philosophy of science point of view. Zimmer presents a series of salient examples from the legal, environmental, and technical sciences,which reveal the limits of quantitative modelling of uncertainty and risk. The multi-layered nature of the meaning of the risk concept now seems to be widely acknowledged by decision researchers. However we doubt, whether the different mental representations and qualitatively different cognitive activities involved in real world risk assessment and decision making are as yet suitably acknowledged. As Zimmer stresses, complex situations have only have one but many right solutions: Furthermore quantitative and

qualitative approaches show typical incommensurabilities. However this does not imply a departure from quantitative modelling or from the concept of rationality but instead challenges us with a new integrative perspective.

The **concept** of uncertainty is looked at in detail in the subsequent two chapters. In problem solving, communicating or information processing there are several reasons for avoiding quantitatively "precise" probabilities. For example the *events*, the *uncertainty,* or the *representation* may be vague and thus qualitative probabilities seem to be the most appropriate method. The Chapter on *Combining Linguistic Probabilities* of Thomas S. Wallsten, David V. Budescu and Chen Jung Tsao reports two background assumptions and five principles of linguistic information processing. When referring to the different approaches for combining linguistic probabilities within the framework of fuzzy set theory and to the extended empirical research in this field, a sixth principle is postulated as regards the combining of uncertainty statements from two sources. In order to test this principle an experimental study is reported. Subjects were confronted with judges statements on the validity of typical almanach questions. The results suggest that subjects do use simple averaging strategies when processing multiple inputs, but they are sensitive as to whether or not the underlying judgments are independent.

The Paper *Risky Choice with Fuzzy Criteria* presented by Greg C. Oden and Lola L. Lopes presents the SP/A theory. SP/A stands for security-potential/aspiration theory and provides a modelling of both the utility and the uncertainty component of decision making.

The theory integrates three approaches. Firstly, on a structural level, the SP/A theory may be considered as an extension of Tversky and Kahneman's (1992) cumulative prospect theory. It combines the decumulative weighting procedure with an aspiration level formation and thus models the simultaneous consideration of losses and gains in lottery choices.

Secondly, a lexicographic semi-order assumption is introduced to explain decisions in the context of conflicting SP and A devices. The lexicographic semiorder assumption is essential for the procedural level of the theory.

Thirdly, a fuzzy proportional approach is introduced which allows both for compositional treatment and a grading of qualities and intensities which may be tied with choice alternatives. Quite notably, the fuzzy logical predicates are modelled on an *experiential level*, particularly the feedback from lottery choices.

The SP/A theory allows for an integration of the security-mindedness and potential-mindedness in decision maker's risky choice behavior. However, quite solidly within the economic tradition of risk modelling, this integration is conceptualized via a sophisticated (Gaussian) mathematical and thus quantitative basis. However, as the authors note, the modelling is based on a couple of qualitative assumption (rather than data) and uses concepts like aspiration level, which from its initial definition by the scholars of Kurt Lewin (cf. Dembo, 1931; Hoppe, 1931) are qualitative entities.

Medical problem solving is one of the major fields of applied decision research. As stressed in the paper of John Fox and Richard Cooper on *Cognitive Processing and Knowledge Representation in Decision Making under Uncertainty,* established concepts and theories of cognitive psychology have been divergent in some aspects from decision making research. When using a production system approach, the authors modelled medical students diagnostic judgements in a realistic, but carefully designed task environment. Particularly the statistical relationships between diseases and symptoms were precisely known by a reference set of conditional probabilities. However in the information processing architecture (i.e., the reasoning mechanism and the working memory) no use is made of quantitative representations. All probabilities of diseases are represented implicitly through the availability of knowledge in the working memory. Thus the model of the physician's working memory is kept within the frame of concrete, directly accessible declarative knowledge, as it is provided by case specific experience an does not apply the classical concept of quantified probability.

The access of concept of conditional probability underlying Bayesian reasoning is one well known obstacle of human decision behavior and cognitive development. Gerd Gigerenzer argues in his paper on *Ecological Intelligence: An Adaption for Frequencies* that humans are able to sample frequentistic probability information appropriately, if they have access to frequencies in a kind of representative sampling. Though it may be doubted whether physicians actually sample unconditional and conditional event series in a statistical manner (particularly in considering comparable cases) Gigerenzer convincingly reveals that frequencies have necessarily to be qualitatively assessible in mental representations to provide reliable (frequentistic) probability statements. Thus one of the messages of this chapter is that *frequency itself is a quality.*

In his paper *Reasons for Uncertainty: From Frequencies to Stories,* Helmut Jungermann is broadening both the **concept of meaning** and the range of

contextualization in probability reasoning. As the subtitle already indicates, in Jungermann's theoretical approach, subjective uncertainty is embedded into the individual's interpretation and representation of evidence, arguments and contexts. An example of probability information that individuals in the Western World will usually encounter repeatedly is probability information about the side effects of drugs. Do informations like "rarely", "occasionally", or "frequently" have a context free interpretation? How does the severity of the base rate event matter? Experimental results in realistic settings show clear evidence of a strong effect of contextualization (see also Wallsten, 1990). Various examples are presented which provide insight into the foundation and the degrees from freedom of mental causation in uncertainty reasoning. Jungermann refers to a 'model of complex causation', a rule based system (somewhat similar to Fox & Cooper's approach), in which ambiguity may be modelled as degrees of matching. Quite often, the very context of probability information is acquired by descriptions. This has already been partly reflected in Tversky & Koehler's (1994) support theory or Pennington & Hasties (1993) explanation based models. Jungermann's clear analysis, however, opens horizons for meaningful contextualizations and the conversational paradigm, which are quite often dismissed (see aboved). He concludes by discussing the multitude of facets within uncertainty semantics and thus challenges both philosophy and epistemology as part of qualitative decision analysis.

The chapter *Some Evidence in support for a Qualitative Approach in Decision Making* by Alf C. Zimmer points at the misleadingness and missing robustness of quantitative numerical information in complex environments. There are various reasons for the superiority of verbalas compared with numerical information. Crucial is, firstly, the apparent inadequacy of seemingly precise numbers which is reflected in Sir Karl Raimond Popper's statement *It is better to be vaguely right than to be precisiely wrong*. Secondly, quantitative representations quite often do not meet the requirements of the (current) human cognitive ergonomics. This may, for instance, be illustrated by the confusion which digital time information like *The time is 18 before three* may cause. Thirdly, vocabularies of qualitative information belong to the core of syllogistic communication in colloquial reasoning. Thus Zimmer applies fuzzy numbers (see also Wallsten et al.) not only to the qualifiers in the well known Toulmin (1964) model of argumentation but also as fuzzy evaluations of operators. When referring to a marketing study, Zimmer argues that hypothesis formation including abduction and deduction, as it was already described by Charles S. Peirce, are underlying the well known availability and representativeness heuristic. It is quite

noteworthy that Zimmer applies and uses his theory actually in real market research consultations.

Medical, buisiness, and environmental decision making are favourite fields for the application of quantitative decision making. Applied decision making commonly entails a prescriptive component in the sense that one wants to know which decision is best or at least more adequate. Thus we meet the epistemological problem of verification, particulary in complex environmental real world decisions. The chapter on *Mastering the Complexity of Environmental Problem Solving by the Case Study Approach* by Roland W. Scholz, Harald A. Mieg, and Olaf Weber introduces four epistemic and epistemological dilemmas that are tied to complex decision making. For instance the analytic dilemma entails the "social nature of truth". Even mathematical may not be formally verified but are consented in a social process. Furthermore the dilemma of representation the inferential dilemma, and the knowledge integration problem are discussed. These dilemmas all refer to conflicting qualitatively different evidence or arguments which have to be reasonably synthesized. The case study methodology is introduced as a research strategy. When presenting a complex case study on regional development, principles and methods are introduced which allow for the integration of differerent types of knowledge integration. These Methods, like Formative Scenario Analysis have recently been elaborated and successfully been applied in urban planning and development (cf. Scholz et al. 1997).

As the title A*spects of Qualitative Decision Making* the volume does not cope with all relevant qualitative aspects of decision making. Particularly institutional aspect (cf. Beach, 1990 or Kleindorfer, Kunreuther, & Schoemaker, 1993) are not considered in detail. Nevertheless the issue presents many aspects which challenge new approaches and strategies in decision research.

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