

Seventh Research Conference on Subjective Probability, Utility and Decision Making

1979

Göteborg
Sweden

August 27–31

CONFERENCE INFORMATION (Part 1)

Major Papers, Abstracts of Specific Papers and Details
of Working Groups

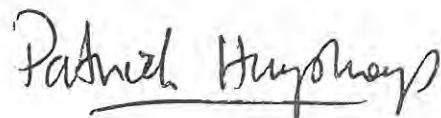
Organizing Committee: Lee Beach (USA) · Patrick Humphreys (UK) · Ola Svenson
(Sweden) · Lennart Sjöberg (Sweden) · Tadeusz Tyszka (Poland)

Conference Information

This volume is divided into four parts:

- PART A (ORANGE) is a provisional version of the conference program. A few changes will inevitably have to be made between now and the conference, and a revised program will be circulated later. This will also list the discussant for each Major paper (omitted from the provisional program as arrangements for discussants had not been finalised as this volume went to press).
- PART B (Blue header) contains the Major papers for the conference, which are meant to be read by participants ahead of time. At each Major Paper session, the Author(s) will spend 10 minutes on brief comments on the paper, followed by 15 minutes of comments from an invited discussant, followed by 20 minutes of general discussion.
- PART C (Green header) contains summaries of the Specific papers to be presented at the conference. Each will be presented in full (25 minutes) at a Specific paper session, followed by 10 minutes of general discussion.
- PART D (Yellow header) contains outlines of the seven Working Groups arranged for the conference. These will meet twice (in parallel session) during the conference. At the first meeting the convenor(s) will introduce the group, and survey material of potential interest, followed by general discussion. It is hoped that this will stimulate informal contacts and discussions between participants outside the formal part of the conference program. The final session of the working groups are scheduled for the last day of the conference, where the fruits of these discussions may be brought together.

We look forward to welcoming you in Göteborg.



for the organising committee

PART A: CONFERENCE PROGRAMME

This programme is provisional, changes may have to be made, and these will be notified to participants at the start of the Conference.

Sunday August 26

17.00 - 21.00 Registration and informal reception at the University of Göteborg Department of Psychology, Skårs Led 6, Göteborg.

Monday August 27

Morning

Chairperson: *Lennart Sjöberg*

9.00 - 9.10 *Opening of the Conference:* Introductory session

9.10 - 9.55 *Major Paper:* "Decisionetics": The art of helping people to make difficult decisions. *Helmut Jungermann, West Germany.*

9.55 - 10.30 *Specific Paper:* Experiences with MAUD: Aiding decision structuring through re-ordering versus automating the composition rule. *Patrick Humphreys & Wendy McFadden, England.*

10.30 Break

11.00 - 12.45 First meeting of the working groups (parallel sessions)

12.45 Lunch.

Afternoon

Chairperson: *Lawrence D. Phillips*

14.30 - 15.05 *Specific Paper:* An information processing model for multidimensional strategies. *Oswald Huber, Austria.*

15.05 - 15.40 *Specific Paper:* The effort of making a decision: How do we decide how to decide? *Eric J. Johnson, USA.*

15.40 - 16.15 *Specific Paper:* On the validation of descriptive theories of Human Decision making. *Francis D. Tuggle & F. Hutton Barron, USA.*

20.00 Open meeting of the Organising Committee to discuss the publication of the Proceedings of the Conference. Four copies of each specific paper must be submitted to the Organising Committee at or before this meeting.

Tuesday August 28

Morning

Chairperson: *Ola Svenson*

9.00 - 9.45

*Major Paper: Structuring Decision Problems.
Detlof v. Winterfeld, USA.*

9.45 - 10.30

*Major Paper: Organisations and Uncertainty.
Lawrence D. Phillips, England.*

10.30

Break

11.00 - 11.35

*Specific Paper: Decision processes in urban
development: perspectives from economics and psychology.
Robin Hogarth, Claude Michaud & Jean-Louis Mery, France.*

11.35 - 12.10

*Specific Paper: Hierarchical goal structuring and
pupils' job-choice: testing a decision aid in the field.
K. Michael Aschenbrenner, Dorothee Jaus and Cypriano
Villani, West Germany.*

12.10 - 12.45

*Specific Paper: Information seeking in an open decision
situation. Tibor Englander, Hungary & Tadeusz Tyszka,
Poland.*

12.45

Lunch

Afternoon

Chairperson: *Sarah Lichtenstein*

14.30 - 15.05

*Specific Paper: Attractiveness of Decision rules.
Thomas Adelbratt & Henry Montgomery, Sweden.*

16.00 - Late

BOAT TRIP to Denmark and back. A *work-in-progress session* is scheduled on the boat (16.00 - 17.30) for contributors who wish to give short accounts (less than ten minutes) of work in progress, curious findings, etc. The programme for this session will be arranged at the Conference, and interested participants should contact Sarah Lichtenstein at the Conference before midday Tuesday.

Wednesday August 29

Morning

Chairperson: *Lee Roy Beach*

9.45 - 10.30

*Major Paper: Rational and personal aspects of risk.
Charles Vlek & Pieter-Jan Stellen, Netherlands.*

Wednesday August 29 (contd.)

- 10.30 - 11.15 *Major Paper: Decision making and experience.
Berndt Brehmer, Sweden.*
- 11.15 *Break*
- 11.35 - 12.10 *Specific Paper: The relationship between the
probability assessor and the outcomes of an event
as a determiner of subjective probability.
Dan Zakay, England.*
- 12.10 - 12.45 *Specific Paper: Studies of a model for evaluating
judicial evidence. Robert W. Goldsmith, Sweden.*
- 12.45 *Lunch*
- Afternoon *Chairperson: Carl Axel Staël von Holstein*
- 14.30 - 15.30 *Invited lecture: The philosophy of decision making.
Klemens Szaniawski, Poland.*
- 15.30 *Break*
- 15.50 - 16.25 *Specific Paper: Differences in calibration for past
and future events. George Wright & Ayleen Wisudha,
England.*
- 16.25 - 17.00 *Specific Paper: Decision making in a dangerous world:
some insights from psychological research. Paul Slovic,
Baruch Fischhoff & Sarah Lichtenstein, USA.*

Thursday August 30

- Morning *Chairperson: Patrick Humphreys*
- 9.00 - 9.45 *Major Paper: Kurt Lewin and Modern Decision Research.
Lee Roy Beach & James A. Wise, USA.*
- 9.45 - 10.30 *Major Paper: Emotion and Decision Making. Masanao Toda,
Japan.*
- 10.30 *Break*
- 11.00 - 11.35 *Specific Paper: Volitional problems in carrying
through a difficult decision: The case of drug
addiction. Lennart Sjöberg & Gudrun Olsson, Sweden.*
- 11.35 - 12.10 *Specific Paper: Multiplying and multiplicative
processes: An analog model for multiplicative judgment.
Lola L. Lopes, USA, & Per Hakan S. Ekberg, Sweden.*
- 12.10 - 12.45 *Specific Paper: A new model of decision under risk.
Maria Nowakowska, Poland.*
- 12.45 *Lunch*

Thursday August 30 (contd.)

<u>Afternoon</u>	Chairperson: <i>Tadeusz Tyszka</i>
14.30 - 15.05	<i>Specific Paper:</i> Evaluation and modification of voting consequences by Mean-Variance analysis of voters' satisfaction. <i>Yoshinori Tomiyama & Yutaka Sayeki, Japan.</i>
15.05 - 15.35	<i>Invited lecture:</i> Decision making and strategic planning in society. <i>W. Switalski, Poland.</i>
15.35	Break
16.00 - 16.30	<i>Invited lecture:</i> Decision making and strategic social planning. <i>Lars Ingelstam, Sweden.</i>
16.30 - 17.00	<i>Discussion</i>
20.00 - Late	CONFERENCE DINNER. Host: <i>Jim Wise</i>

Friday August 31

<u>Morning</u>	Chairperson: <i>Lennart Sjoberg</i>
9.30 - 11.00	Final meeting of working groups (parallel sessions)
11.00	Break
11.30 - 12.45	<i>Closing session</i>

PART B: MAJOR PAPERS

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'Decisionetics'
The Art of Helping People
To Make Personal Decisions¹

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1. Introduction

Most psychologists who work in the area of decision theory have been asked by friends--or by themselves--whether they could use the technology developed in decision research to handle some particular personal problem. In the past, when answering could not be avoided, the question ordinarily evoked helpless responses like "too complicated," "too rational," etc.; summing up essentially as "inappropriate." However, with recent expanded and diversified applications of decision-aiding methods, this has changed, albeit without yet having found a clear focus. This paper is an attempt to help focus things a bit by examining the literature on decision counseling from a decision-theoretical point of view and by discussing some conceptual and technical aspects of personal decision making as well as the role that decision theory might have.

What distinguishes personal decisions from the decisions most often studied in decision research? The essential characteristic of "personal" decisions is that the decision maker himself has to bear the consequences of the action taken; the decision concerns his/her individual private life. Examples are easy to find: Less important decisions like buying a car, renting an apartment, choosing a menu, and generally all trivial buying and consuming decisions; more important decisions like choosing a career, getting married or divorced, having a child or not, and generally all vital life-decisions. In contrast, the decisions studied in most research are made within some institutional, organizational or social setting and the consequences primarily affect other people. The distinction is certainly somewhat blurred, since most personal decisions also have consequences for other people (e.g., by definition the decision to have a child has quite important consequences for the child), and most "other" decisions also have consequences for the decision maker him/herself (e.g., a commander's decision may have consequences for his own life). The point is, however, that in both cases, these consequences are usually treated only as side-effects and not as the main effects to be considered when making the decision.

Why devote particular attention to personal decisions and not consider the fact that they are "personal" as just one feature of decisions as so

many have been listed in the literature? It is likely that there are severe limitations on the degree to which the results--research and technologies--we have obtained for the "other" decisions (e.g., see Fischer, Edwards & Kelly, 1978) generalize to personal decisions. The latter seem to have particularly salient characteristics, with respect to the problems as well as to the decision maker (e.g., emotion and stress), which might have a high significance for research on or application of decision aids. Other or modified approaches are probably indicated.

First, I will take a look at the existing approaches for aiding people in making personal decisions. It seems appropriate to examine not only the decision theoretic literature, however, but also those approaches that have been in use outside of decision theory for a long time, namely, in psychotherapy and counseling. But having some basic faith in the reasonableness of the decision theoretic conception, I will restrict my examination to those therapeutic and counseling approaches that emphasize helping people make personal decisions and that implicitly use a decision theoretic rationale. The focus of the examination of the literature, however, will be on the approaches that are explicitly derived from or based upon decision theory. Following this discussion I will outline a conceptual frame for classifying different kinds of personal decisions, and using this frame, discuss some aspects of existing and/or potential decision-theoretically oriented aids.

2. The state of the art

2.1 Outside of decision theory-therapeutic and counseling approaches

The distinction between therapy and counseling is even less clearcut now than it was in the days when one could contrast five years of psychoanalysis and one-session career counseling. Although both forms of helping people still exist, today they represent extremes of a continuum on which the middle part has gained increasing importance and has attracted increasing research interest. A normal distribution characterizes the situation quite well; the ordinate represents some variable in which time, money and narrowness of the approach are combined. The specific techniques used are quite often the same or very similar in therapeutic and counseling approaches (e.g., behavior modification techniques), and here any labeling is more a question of taste than of substance. This is particularly true for approaches concerned with decision problems. The only criterion for discrimination--also of limited value--is that therapy usually considers the client's problem as being embedded in more general personality disorders and, therefore, does not confine itself to solving the particular problem the client presents, while counseling takes the client's problem more or less at face value and thus

focuses on helping the client to solve just this problem. Although this criterion, too, reflects more a difference in emphasis than a fundamental distinction, for convenience it will be used--as well as the self-labeling of authors--to group the approaches of interest in the following section.

2.1.1 Therapeutic approaches

In general, psychotherapies aim at strengthening the "Ego functions" of the clients, i.e., at helping them to cope with and perhaps change reality. This includes strengthening their capability to choose. It is not important here whether the clients' incapacity is seen as due to motivational processes (as in psychoanalysis) or due to learning processes (as in behavior therapy), although it certainly has consequences for the way in which a therapist tries to help a client. The point is that the capability and freedom to make choices is an aim of all approaches.

The more non-directive approaches emphasize self-insight and self-understanding which, at first glance, seems not to be related to choice and decision. But self-insight or self-understanding are, of course, not goals in themselves. Rather, they are better considered as fundamental prerequisites for the ability to make choices or decisions. Indeed, what seems to be a decision problem might, on closer examination, turn out to require a much more comprehensive approach toward making a person capable of deciding in general, instead of merely solving the immediate decision problem.

However, remembering that decision theory is our pivot, I will not go further into this. Rather, I will turn to the more directive approaches toward decision problems. Among those, the cognitive therapies which increasingly have gained significance in the last ten years are of particular interest (Meichenbaum, 1977; Kendall & Hollon, 1979). For the most part, the first step here consists of making the person understand that he/she has a choice in how he/she feels or behaves, and that he/she has (some) control over life. The second step, then, aims directly at helping the client to make a decision; either a particular decision like getting a divorce, or a more general decision to change his/her customary behavior (like giving up smoking). Proposed step-by-step procedures for this purpose closely resemble decision-theoretic concepts. Greenwald (1973), for instance, in a book entitled Decision Therapy, suggests that the therapist helps the client through the following steps:

- (1) State your problem as clearly and completely as you can..
- (2) Examine your past decisions which helped create the problem.
- (3) List the payoffs for the past decisions which are behind the problem (e.g., avoidance of anxiety).
- (4) Describe the context in which you made the original decision.

- (5) Examine alternatives to your past decision.
- (6) Choose your alternative and decide to put it into action.
- (7) Support yourself in carrying out the new decision (pp. 299-300).

The most important step is considered to be the third one, the examination of action alternatives in terms of payoffs. However, no help is given on specifically how to perform this examination.

A bit more elaborate system is proposed by Mahoney (1977) who "applies empirical skills of problem-solving to intimate personal problems" (p. 353) in what he calls a "Personal Science" approach. In this therapy, "the therapist is viewed as a technical consultant or coach whose assistance will primarily take the form of instruction and training in the development of relevant coping skills. Therapy is used as an apprenticeship in these skills" (p. 353). He distinguishes seven steps (which are mnemonically represented by the letters in the word "science"):

- (1) Specify general problem area (labeler, affect, sphere, urgency, goals).
- (2) Collect data (biomedical status, cognitive status, affective status, assessment of problem-relevant skills, current physical, social and phenomenological correlates, retrospective assessment).
- (3) Identify patterns or sources (portions primarily attributable to physical environment, to social environment, and to cognitive factors).
- (4) Examine options (survey potential goals, and means).
- (5) Narrow and experiment (eliminate unfeasible options and least-feasible options, select or consolidate most-feasible options, rehearse the option and its consequences, revise [if necessary] and implement).
- (6) Compare data (frequency, intensity or magnitude, duration patterning).
- (7) Extend, revise, or replace (continue or expand, revise, replace, assess attribution) (pp. 353-356).

The steps and how they can be performed by a therapist are described in detail in Mahoney's work. The procedure is supposed to be neither routinely applied nor focused on a particular problem. Rather, the aim of the therapy is "to set up learning experiences which will facilitate the development of coping skills which are relevant to the current problem as well as future or additional areas of personal crisis" (p. 356).

A technically very eclectic but theoretically very relevant approach is Ellis' "Rational-Emotive Therapy" (e.g., Ellis, 1977; Ellis & Harper, 1975). According to this approach, people do not directly react emotionally or behaviorally to the events they encounter in their lives; rather, people cause their own emotions and behaviors by the way they interpret or evaluate the events they experience. Or, in RET-terms: the activating event (A) does not directly cause the emotional or behavioral consequence (C). Rather, (C) is the result of beliefs with respect to the event (B). This is abbreviated as the ABC of the theory. Emotional or behavioral disturbances are consequently explained by the client's irrational beliefs or evaluations which the therapist has to detect and to correct. In decision-theoretic terms, the therapy has

three functions. First, it strengthens the client's decision capability by showing that people largely control their destinies by believing in and acting on the values or beliefs they hold; that external events contribute to but do not actually cause feelings and that people largely feel the way they think. Second, it breaks up the client's existing internal causal schema by demonstrating that it is his/her own irrational beliefs which cause his/her disturbances; it opens new possibilities for action by building up a new internal model of actions, events, and consequences. Third, it detects and destroys the specific irrational beliefs of the client and replaces them by rational beliefs and values; i.e., it changes parameter values for expectations and utilities. A study by Fiedler & Beach (1978) on assertiveness (a problem also discussed by Ellis and his group quite often) is congruent with this line of reasoning. They were interested in the reasons why assertive behavior occurs in one situation and not in another, and why some people tend to be assertive and others do not. Applying an expectancy/decision model, their results suggest that people may consider the consequences of being assertive when making a decision about how to behave. Moreover, it was found that the difference between subjects who chose an assertive response and those who did not lies in the latter's belief that it was highly probable that bad consequences would occur if they were assertive rather than in their evaluations of how bad or how good those consequences would be. The study thus suggests some specific "irrational" beliefs which might often cause debilitatingly non-assertive behavior and which should be taken into account in therapeutic or training programs.

Many techniques have been proposed to achieve what might, from a decision-theoretic point of view, be called "changing utilities and expectancies." The most prominent technique is desensitization, developed in behavior modification theory but used in cognitive therapies as well (e.g., Bower & Bower, 1976). It aims at reducing anxiety in some specific future situation by letting the client imagine him/herself acting and reacting positively in successive events of increasing similarity to the anxiety-arousing situation. The client should thus have less fear when he/she actually experiences the difficult situation later. The techniques are devised such that the client learns to have thoughts which help him/her to cope with stress and reduce his/her anxiety. In Bower & Bower's approach to assertiveness, for instance, "the method requires that you make up your own stress-coping remarks, memorize them, and recite them feelingly as an internal monolog whenever you enter any stressful situation" (p. 59). Very similar is a technique proposed by Maultsby (1977), a student of Ellis, which is called "rational-emotive imagery."

Following an ABC-analysis, the technique aims at extinguishing the irrational emotional responses to the external situations in which they occur and learning personally desirable responses to the same situations. The client "recreates in his mind the events of the original situation exactly as they happen, but with two important exceptions: (1) Instead of picturing himself irrationally feeling and behaving as he did, he pictures himself thinking only the rational thoughts" (produced during the therapy); "(2) At the same time that he sees himself thinking rationally, he is to try to make himself feel emotionally appropriate to his rational thoughts" (p. 227). Janis and Mann (1977) proposed a technique they called "Outcome Psychodrama" to help clients overcome their resistance to exploring the potentially negative consequences of some choice. It is basically roleplaying in which the client is requested to describe, in the present tense, the situation some time after the choice was made (e.g., one year in case of a career decision); the counselor plays the role of being the counselor to whom the client returns after the particular period of time. The main purpose of the technique is to explore possible negative consequences with the implicit assumption that clients will see that these consequences are usually not as serious as they anticipated; however, it might well happen that clients using all their imagery powers will find the possible bad consequences much worse than they ever thought before. The technique's scope goes beyond the evaluative aspects: It helps a client to imagine possible future states of affairs in a more concrete and realistic way and thus develop a better internal model of the decision situation. Janis and Mann report several studies on marital and career counseling in which the technique was successfully applied.

Another group of techniques is centered around behavioral contracts (e.g., DeRisi & Butz, 1977). Their purpose, however, is not to evaluate alternative options and make a decision. Rather, they help the client to behaviorally implement the cognitively-made decision, i.e., to hold onto the decision and act on it. A contract specifies the behavior to be performed as a consequence of the decision as well as the rewards that will result if the behavior is realized and the punishments if it is not. The negotiation of a contract--either between a client and himself ("self-contract") or between the client and the counselor--then consists of defining rewards and punishments such that the desirable behavior has a higher utility than the undesirable behavior, to speak in decision-theoretic terms. (For awhile a popular contract in the U.S. was to require the client to send \$100 or more to Richard Nixon as a penalty for the undesired behavior.)

An exercise that combines the process of making a decision as well as

signing a contract that commits the client to the decision is given by Bower and Bower (1976) in their guide to assertiveness: "Thinking rationally about the consequences of your assertion" (pp. 24-25). The client is requested to develop a mental picture of some scene that usually threatens him/her, to assess the likelihood of successfully asserting him/herself, to estimate the positive and the negative utility of the consequences resulting from assertive behavior, and to then sign a contract with him/herself when he/she is willing to show the assertive behavior.

2.1.2 Counseling approaches

Counseling approaches for helping clients to make decisions in general or to make a specific decision, also are often centered around some step-wise procedure similar to the stages distinguished in the decision-theoretic literature (e.g., Krumboltz, 1966; Evans & Codey, 1969; Gelatt, Varenhorst, Carey & Miller, 1973). The procedure proposed by Krumboltz and Thoresen (1976) is typical: The aim is "to analyze the situation in which the client's indecisiveness occurs, to enable him to discriminate the type of response that might be best in particular circumstances" (p. 10):

- (1) Formulate the problem by specifying the client's goals and values.
- (2) Commit time and effort (which means, for instance, to sign a contract between client and counselor specifying the amount of time that each will devote).
- (3) Generate alternative solutions.
- (4) Collect information about the alternatives.
- (5) Examine the consequences of the alternatives.
- (6) Re-evaluate goals, alternatives and consequences.
- (7) Successively eliminate the least desirable alternatives until a tentative choice has been made.
- (8) Generalize the decision-making process to new problems (pp. 11-13).

A technique suggested by Carkhuff (1973) is somewhat more formalized, but unfortunately the rationale for the formalization seems rather arbitrary:

- (1) Define a goal, identify aspects of the problem that are amenable to decision making.
- (2) Develop alternatives that are possible and meaningful.
- (3) Generate the client's list of personal values that are affected by the decision and rank-order these values; assign them weighted scores, with the first ranked item receiving the largest weighted score and the last ranked value receiving the lowest weighted score.
- (4) Rate each alternative of action according to each value; if an alternative contradicts a value, assign a positive valence; use all five valences (++ , + , +-, -, --).
- (5) Multiply the weighted score of each value by the contradiction or accordance rating.
- (6) Sum the positive and negative values for each alternative action.

The client is given a "problem-solving matrix" to perform the required assessments and calculations.

Another technique, proposed by Janis and Mann (1977), also aims "to aid people making vital decisions, to help them survey all the viable alternatives and explore the consequences of each" (p. 405). The "Balance Sheet Procedure" has six steps that are performed using a balance sheet grid:

- (1) Open-ended interview: The counselor discusses with the client the most

salient alternatives and their consequences (in five steps described in detail by the authors). (2) Introducing the balance sheet grid: To stimulate the client to think about non-salient considerations, he/she is given the sheet which consists of eight cells to be filled in (2 x 4 matrix). The four main categories are (a) tangible losses and gains for Self, (b) tangible gains and losses for Others, (c) self-approval or self-disapproval, (d) social approval or disapproval: By separating the positive and the negative anticipations, eight cells result. The client fills out one grid for each alternative. (3) Using a list of pertinent considerations: The client is shown a list of pertinent considerations to encourage him to explore neglected pros and cons. (4) Identifying the most important considerations: Here the client rates each potential consequence in terms of its importance for each alternative. (5) Exploring alternatives: If any new alternatives have come up during the session, the procedure is repeated for each additional alternative. (6) Ranking the alternatives: Finally, the client is asked to rank the actions in terms of what now seems best to him/her.

The procedure has been used by the authors and others for career-counseling, for helping people making health-related decisions such as whether to undergo surgery, and other personal problems (Janis & Mann, 1977, pp. 135-169). Career counseling is one area in which many efforts have been made to develop effective techniques. Of particular importance from a decision-theoretic point of view was Gelatt's proposal of a decision-theoretic framework for counseling (Gelatt, 1962). However, the theoretical impulse was not followed by efforts to devise systematically developed and evaluated techniques. Most procedures are basically step-wise techniques as already described, differing very little from each other except for their graphical and technical make-up. They were developed for pupils (Bundesanstalt fuer Arbeit, 1976; Zingle & Fox, 1969), for students' selection of a college (Hammond, 1965), for midcareer counseling (Waters & Goodman, 1977), and for career counseling in general (Tolbert, 1974; Moore, 1976; Weissman & Krebs, 1976).

A comprehensive counseling program developed by Harren (in press), based on Tiedeman's model of career decision making (Tiedeman, 1961), includes two aspects of decision making: Anticipation and action. Anticipation is concerned with the facts, alternatives, options and consequences out of which the decision is to be fashioned and reflects the aspirations, hopes, expectations and constraints which determine the form of the decision. Tiedeman distinguishes four anticipatory steps:

(1) Exploration, marked by vague generalized concerns but little progress towards choice. (2) Crystallization, characterized by the recognition of alternative choices through elimination of some inappropriate options. (3) Choice, represented by definite commitment with some degree of certainty to a particular goal. (4) Clarification, an elaboration of the consequences of the commitment but delaying overt action until circumstances are appropriate for action. (The three steps for action that Tiedeman distinguishes are all associated with overt action towards implementing the choice and are thus of no direct relevance in this context).

Harren's program, intended for college freshmen and sophomores, consists of

self-contained modules to be used in small groups. It progresses from an evaluation of the student as a decision maker (i.e., his/her decision-making style, etc.), then focuses on the student's idiosyncratic attributes, values, styles, and competencies, and finally introduces considerations of external factors relevant to career decisions. To help the student actually make a decision, the balance sheet procedure described above is used. Specific techniques used in the course of the program (e.g., an "Assessment of Career Decision Making" questionnaire) have proven to be rather reliable measure of the decision-making style; evaluation of the program as a whole is in progress. One particularly interesting feature of the program is its focus on expanding career options of both men and women in non-traditional careers.

A computer-based "System of Interactive Guidance and Information" (SIGI) has been proposed by Katz (1966; 1973). Its first part, the value system, includes gathering information about the applicant's values (e.g., importance ratings of actual job outcomes on a set of 10 value dimensions) in an intensive interaction between counselor and client. Some minimum level of acceptability for each outcome dimension also is defined in this part. The second part, the information system, provides the actual likelihoods that a particular occupation will lead to a particular outcome, based upon statistical data. These probabilities are then multiplied by the importance ratings and summed, resulting in a "sum of value returns" for each occupation. The third part, the prediction system, represents the chances that a particular applicant with certain skills, grades and personality characteristics will attain a particular occupation. This score is then multiplied by the SVR to produce an expected value score for each occupation. Studies support the usefulness of the system in that as compared to a control group, subjects using SIGI planned more thoroughly, differentiated better between the phases of the decision process, and considered the system as very helpful (Chapman, Morris & Katz, 1973). Other computer-based systems have been developed for educational and vocational guidance. However, most of them emphasize information gathering rather than decision making; a special issue of the Journal of Occupational Psychology reviews and evaluates this area (Jackson, Sneath & Wallis, 1978).

A fairly new approach in counseling is the development of diagnostic instruments with respect to decision-making competence. Katz, Norris and Pears (1978), for instance, suggest a diagnostic measure of competencies in career decision making which is essentially based on subjectively-expected utility (SEU) theory. The student evaluates certain aspects of alternative occupations and is informed about the likelihood that the alternatives will fulfill these aspects. The scores for each occupation can be calculated

and be compared with the student's overall rating. The instrument can be used to stimulate the student to gather information and to discuss possible differences between his/her ranking and the "logical" ranking. Diagnostic instruments less focused on particular careers or occupations have been proposed by Jones (1976) and Harren (in press). Related to this approach is the research by Beach, Campbell and Townes (in press) on birth-planning decisions which will be discussed later in this paper.

In summary, therapeutic and counseling approaches to decision making can be characterized by the following features: (1) The proposed aids are all analytic in the sense that they require the client to apply a prescribed procedure in a guided, systematic attempt to analyze the problem and the situation; most of them are rather simple and informal, few of them are theoretically based, and rarely is there a reference to the decision theory literature. (2) Most aids are concerned with the pre-choice steps and do not pay much attention to the actual decision-making step; they are focused on information gathering and value assessing and do not provide much help for bringing all the data together so that a sound evaluation of alternative options becomes possible. (3) With few exceptions, the procedures are centered around the values/utilities and do not include a consideration of the probabilities of outcomes. (4) Many approaches emphasize the biographical history of the client as a factor that explicitly should be taken into account, for instance, when alternative options are considered. Although this is found more often in therapeutic than in counseling approaches, it seems in general to be appropriate as well as important for personal decisions. (5) In large part the intention is not only to solve the immediate problem but also to help the client develop more general decision-making abilities. (6) There are few evaluation studies in some stricter sense, i.e., with defined criteria and precise designs. However, evaluation in this area is generally difficult, not only here but in decision theory as well.

2.2 Within decision theory--decision-theoretic oriented approaches

There exists only little research, based upon or derived from decision theory, on helping people making personal decisions in the decision literature. This is surprising considering that decision theorists are so fond of illustrating their approach by personal decision problems--the menu, the umbrella, the marriage, and what not. Approaches taken in the last few years, however, seem to open some interesting lines for future work. These will be described in order of increasing comprehensiveness with respect to decision aspects covered in the proposed aid.

As a very indirect decision aid, Gerdtz, Aschenbrenner, Jeromin, Kroh-Pueschl and Zaus (in preparation) developed and tested a procedure for pupils to use when choosing an apprenticeship; it aims at helping them search and process relevant information in a systematic and goal-oriented manner. The procedure consists of construction of a goal-hierarchy for which the goal is "The Best Apprenticeship":

- (1) The subjects freely collected ideas, aspects, criteria for evaluating an apprenticeship.
- (2) They then sorted these considerations into more global

and more concrete ones. (3) They were asked to find connections between more global and more specific aspects with respect to their means-ends relationship and draw lines between the respective elements, resulting in a tentative first hierarchy. (4) This first hierarchy was transferred to a magnetic blackboard and completed by having subjects rearrange elements, elaborate the hierarchy, add new elements or eliminate some element. (5) Finally, subjects were given objectives and attributes collected from experts, and asked to check them for elements possibly useful and relevant for their own hierarchies. As an end-product, each subject had his/her own goal hierarchy.

Their findings reveal that subjects who had developed their own goal hierarchy--as compared to a control group who only read a text discussing the objectives and attributes given by the experts--influenced the information-processing behavior in the predicted way. As measured by process-tracing techniques, the aid lead to a much more goal-oriented and systematic search for information and to a more effective comparison of apprenticeships on the attributes. Since the focus of the aid is on the effect of the individual's developing his/her own goal hierarchy on his/her information-processing behavior however, it remains open if this also would lead to "good" decisions. But, in contrast to the procedures reviewed in the previous section, which also aimed at helping the client's information gathering, this procedure provides a much more systematic--and empirically tested--aid for clients' information processing.

More focus on the potential decision is provided in the application of decision theory concepts to genetic counseling by Selvidge and Lubs (1976). In genetic counseling, potential parents are usually informed about their reproductive options, the various possible consequences, and the probabilities of these consequences (e.g., having an affected child, or a spontaneous abortion); they are expected to somehow retain, recall, and integrate all this information and arrive at some decision. But few people are used to thinking in probabilities and thus they have difficulties appropriately understanding the risks involved. Selvidge and Lubs looked into the probabilistic aspect of the situation, i.e., at how people's knowledge and appraisal of the uncertainties can be improved. Specifically, they were concerned with parents at risk for producing offspring having a sex-linked hereditary disease (either hemophilia or muscular dystrophy). The alternative options for those parents are to continue to have children, to continue to conceive and then decide to abort or to carry the pregnancy to term (based on prenatal tests), or to insure that they will have no (more) children (e.g., by sterilization). The first part of the procedure consisted of questioning the prospective parents about their families' medical histories and determining the probabilities of the various outcomes (normal, carrier, and affected child). In the group of prospective parents, this was done by computing the probability of producing

defective children for each couple and also explaining the general pattern of inheritance of sex-linked diseases. Questionnaires before and after counseling showed substantial improvement in peoples' judgment of their probabilities, an effect that carried over one year to a considerable degree. The second part of the procedure was to explain the ramifications of the various outcomes in terms of mental and physical effects, severity of symptoms, expected life span of an affected child, etc., as well as the financial burden and the time commitment required by parents of an affected child. Again, a questionnaire showed a clear improvement of the clients' understanding of the prognosis of the disease. The improvement of the clients' understanding of their situation by using decision theoretic concepts often might not be restricted to uncertainties and evaluations. Such an approach also might help them find available options which they might not have appreciated before, (e.g., preventing the birth of an affected child by doing a prenatal test by amniocentesis).

Even more closely resembling decision analysis is the approach taken by Pauker and his collaborators which includes the explicit assessment of utilities as well as probabilities and the recommendation of an optimal decision derived therefrom. As a comparison to the approach to genetic counseling taken by Selvidge and Lubs (1976), the procedure suggested by Pauker and Pauker (1977) for counseling in the same context is particularly interesting. The aim here is to guide prospective parents through the difficult decision process about amniocentesis, a method for prenatal diagnosis of several genetic disorders. The clients assign utilities to the potential outcomes of the pregnancy and the counselor combines those values with the known risks to produce a logical decision; with respect to the client's view of the situation, the emphasis is thus on the utilistic aspect rather than on the probabilistic aspect. The procedure uses a simple structure of the problem which, according to the authors, nevertheless reflects the dynamics of genetic counseling about amniocentesis. This structure has only "amniocentesis" and "no amniocentesis" as alternative options and does not include adoption or subsequent pregnancies as possibly relevant options and maternal complications, non-fatal fetal complications or monetary costs as possibly important aspects of the decision. (Whether the decision tree developed by the authors under these constraints is shown to the clients and open to modification is not quite clear from their article, but I assume that it is not.) While the probabilities of the various outcomes are provided by the counselor, based on a priori assessed data regarding the relevant risks, the utilities are assessed by the prospective parents, in terms of their potential cost or burden to them (i.e., on a negative utility scale). A cost of zero is assigned to the best outcome (an unaf-

affected child) and a cost of one hundred to the worst outcome (an affected child); the task is then to assign utilities to the other possible outcomes (spontaneous abortion, therapeutic abortion of affected fetus, therapeutic abortion of unaffected fetus). This is achieved by using a lottery technique. The counselor can then calculate the expected cost of each diagnostic or therapeutic option and inform the clients about the "optimal" choice: He/she may then guide them toward the appropriate action. In their first study, 90 clients received the usual non-directive counseling and then assessed their attitudes toward elective and spontaneous abortion. With these data, the "optimal" decision could be calculated and compared with the decisions actually made. There was no correlation between predicted and actual decisions, from which the authors conclude that clients might not reach logical decisions through the usual counseling procedure and that better choices might be made if explicit guidance were given, an assumption which is, of course, difficult to prove or disprove. Although the proposed procedure is a step forward in genetic counseling it seems to have two critical features: First, the rationale of the technique (i.e., of the decision tree and of the composition rule) in some way has to be made intuitively appealing for the clients if they are to be expected to understand and accept the recommended "optimal" decision. Otherwise, the recommendation might not be much of a help for them. Second, the structure of the problem is very much simplified and might thus not represent the clients' psychological situation appropriately. Not only are possibly relevant issues omitted, as mentioned above, but also the outcomes are treated as unidimensional, which might make the clients' assessments rather unreliable.

Basically the same rationale also has been used for patients with coronary artery disease where the choice is between coronary by-pass surgery and medical therapy (Pauker, 1976) and for patients with lung cancer where the choice is between surgical extirpation and radiation (McNeil, Weichselbaum & Pauker, 1978). In both of these cases, however, the procedure seems to be devised to aid the physician more than the patient in making a decision, by taking the patient's attitudes towards the potential consequences into account.

Finally, the most decision-theoretically based aid has been described by Beach, Townes, Campbell and Keating (1976) who developed and tested an aid for birth planning decisions. The aid is to help couples to explore their attitudes toward parenthood and to rationally consider the pros and cons of the issues involved. The clients' thinking is clarified by assessing their weighted utilities and expectations for the possible consequences of having or not having a (another) child as defined in a pre-established hierarchical scheme. Utilities are assigned to the bottom level elements which represent

the potential outcomes of the alternative options and weighted by their relative importance as determined by the weights they assigned to higher level categories. Subjectively expected utilities for the options can be calculated and used for prediction and/or counseling.

In a study with 200 couples who had assessed utilities, weights, and probabilities but who were not informed about their SEU's, predictions were made for the couples' actual choices over the next two years. The predictions were extremely good for those couples for whom the decision not to have a child was predicted; for those for whom the decision in favor of a child was predicted, the results showed a high number of "false alarms," i.e., the couples did not make the predicted choice (Beach, Campbell & Townes, in press). A closer look at the data for this group revealed that their SEU's for having a child indicating that for many people the choice to have a child requires more than just being a bit more in favor than against (Beach, Campbell & Townes, in press). The birth-planning hierarchy has also been used for exploring the personal motivations for childbearing of prospective parents in genetic counseling (Lubs, 1978; Townes, Priest & Ellison, in press). Based on this research, the authors have developed "The Optional Parenthood Questionnaire" (Beach, Townes & Campbell, 1978, Reference Note 1). In this questionnaire, the potential outcomes of either decision, represented on the bottom level of the scheme, are stated rather neutrally but illustrated by specific examples. The client is asked not to limit him/herself to those examples, but rather think about what things related to an issue mean to him/her personally, to interpret it and find examples associated with his/her personal situation. With this technique, a balance is found both between exhaustiveness and a reasonable level of complexity of the problem's structure on the one hand, and between imposing a structure on clients and letting them define their own structure on the other hand. The assessments are made as easy as possible (e.g., probabilities are stated by marking either "very likely," "uncertain," or "unlikely," later to be transformed into .9, .5, .1, respectively). The questionnaire can be self-administered, but the computations of the SEU's must be done by a trained person. For use by a counselor, a "Clinician's Manual" is provided which contains all information necessary for computing SEU's, for introducing a "balance beam" to illustrate the meaning of the results to clients, and for drawing a profile that shows the relative contributions of the various items to the results and thus help to systematize the counseling process. An interesting feature of the approach is that it can be conceived as representing a combination of a diagnostic and an aiding instrument where the aiding (i.e., the evaluation of the alternative options)

is derived directly from the diagnostic (i.e., the answers to the questionnaire).

Using the same rationale, Humphreys, Hildebrand and Davidson (1978) and Jungermann, Schneider and Seiler (1979) are developing aids for counseling women who request a termination of pregnancy. The hierarchies differ somewhat from each other: In the procedure used by Jungermann et al., under the constraint that only one counseling session is possible before the potential abortion can be performed, the focus is on the present and future situation of the client and of aiding her to make an acceptable decision. In the approach used by Humphreys et al., where several sessions are possible before and after the potential abortion, the procedure also focuses intensively on the biographical background of the woman and is more concerned with aiding her to understand and accept the decision she has made. In both projects, due to situational constraints as well as to the subject, no numbers are obtained from the clients and thus no numerical evaluation of the options can be computed. Instead, the point is to provide the counselor with a technique to somehow recompose the verbally assessed expectations and values as systematically as possible and to train the counselor in doing this skillfully: Such a training program has been developed as a major part of the Jungermann et al. project.

Also applying the rationale of the procedure developed by Beach et al. (1976), Prothero (in preparation) is presently developing a self-administerable decision aid for people considering a late-career change. An interesting aspect of her approach is that action-combinations, composed of immediate and subsequent acts (i.e., paths of a decision tree) are evaluated rather than only two immediate actions as is the case in the aids described above. For instance, one combination might consist of retiring and then taking a part-time job, another one of staying employed but then looking for another kind of job, etc.

In summary, the aids derived from decision theoretic research may be characterized by: (1) They are all, of course, analytic: Most are formal in the sense that assessments of expectations and values are explicitly made, either numerically or qualitatively. (2) The proposed aids are based on explicit theory and on empirical evidence, or are at least subject to empirical tests, e.g., regarding the preciseness of the clients' information processing or their actual decisions. (3) They focus on different aspects of the decision-making process--on information gathering, expectation or values, on understanding or decision. (4) Most aids emphasize helping with the actual choice; the recomposition of the assessments for the components of the problem is explicitly included, although it usually is to be performed by the counselor and not the client. (5) All aids aim exclusively at solving a particular decision problem, not at improving the clients' decision-making abilities in a more general sense. (6) Evaluation is difficult, as is the case with the therapeutic and counseling approaches; but in most studies, measures of some

evaluative nature are presented (e.g., improvement in information search, prediction of the actual behavior, etc.).

3. A framework for personal decisions

In developing a decision aid, the characteristics of the problem as well as the decision maker have to be taken into account. Relevant variables have been described by several authors; e.g., by Beach and Mitchell (1978), Vlek (1978), Miller, Merkhofer, Howard, Matheson and Rice (1976). The framework suggested in this section contains those variables which seem most relevant for personal decision problems and for individuals who have to make personal decisions. However, not all kinds of personal decision problems will be considered. In the present context, the focus is on decisions for which aids have been or could be developed. As such, we will define the relevant decisions as those for which a person is in principle willing to spend time in thinking about the decision to be made in view of the potential gains or losses involved.

3.1 Characteristics of personal decision problems

The influence of task characteristics is, of course, mediated by the decision maker's perception of those characteristics and one therefore has to define the task characteristics as the decision maker's interpretations of the demands and constraints of the specific task (Beach & Mitchell, 1978). With this reservation, a few salient characteristics seem to be sufficient to describe the problems mentioned in the foregoing section, or others which can easily be generated by the reader through introspection or retrospection. Table 1 shows how these variables characterize personal decision problems. Table 1 shows these characteristics in a scheme in which structural variables (on the left) and a situational variable (at the top) divide decision problems into 16 categories. The cell to which a particular decision problem belongs depends upon the objectively given or subjectively perceived state of each of the defining variables. For instance, the decision between abortion and no abortion might, for some women, take place under high time pressure, for others under low time pressure. I will first comment on the three structural task characteristics (continuity possible vs. discontinuity inevitable, reversible vs. irreversible, short-range effects vs. long-range effects) and then on the situational characteristic (low vs. high time pressure).

Insert Table 1 about here

- Continuity possible vs. discontinuity inevitable:

Two kinds of personal decision problems can be differentiated. The first is in terms of whether the status quo is one decision alternative (i.e., continuity is possible) but, either that the (positive) utility of the status quo decreases relative to the utilities of some new attractive

alternative(s) (e.g., new lover[s]), or that the utility of the status quo is recognized as actually being negative and therefore new alternatives are considered (e.g., discovery of husband/wife being unfaithful or bankrupt). The second is in terms of whether the status quo cannot be maintained since it is deteriorating and thus the decision alternatives do not include it (i.e., discontinuity is inevitable). For instance, a person can stay in his/her career and not have to elect a midcareer change, while a student having completed his/her education cannot live without some occupation and has to decide between several possibilities. Formally, this variable is represented by the branches representing immediate options in the decision tree: That is, in the first case the tree contains a branch "keep status quo" while there is no such branch in the second case (or one with an obvious tremendous negative utility that therefore is practically not considered at all). More psychologically, a situation of the first kind might often be perceived by persons as one where no decision or change has necessarily to be made while in a situation of the second kind avoidance of making a decision is impossible.

- Reversible vs. irreversible:

Personal decisions might be easy to reverse like buying something for which exchange is possible, or might be impossible to reverse, like sterilization. Some decisions are a mixture of reversibility and irreversibility in that the person has to retain the chosen alternative for some period of time before he/she can reverse it (Beach & Mitchell, 1978, p. 445). Most decisions are in principle reversible but only under great difficulty, like a midcareer change, or with a very low probability, like getting remarried to the same person after a divorce. Formally, the decision tree might or might not include subsequent acts through which the decision maker--in case the consequences of some immediate action turn out badly--can either return to the status quo ante or strive for some other, new status. It is related to the amount of time or money a person would want for considering the decision as well as the stress a person might experience when making the decision.

- Short-range effects vs. long-range effects:

In some decision problems, long-range effects of the decision have to be taken into account (i.e., at least one of the alternative options has long-range effects to be considered) because the decision might strongly influence the future, like in choosing to train for an occupation. In others, only short-range effects are relevant for the decision maker, like in buying some product; however, in reality, decisions with apparently only short-range effects might turn out to have severe long-range effects, like when a person

who stopped smoking decides to have just this one cigarette--it might be the end of his/her abstinence. Formally, this variable comes into the decision tree by the definition of the client's time horizon and the ramifications of the tree. For the decision maker, the demand to anticipate the consequences of his/her decision for only the short term or for the long term represents differing degrees of difficulty and complexity for his/her decision-making process.

- Low time pressure vs. high time pressure:

Personal decision problems also differ in the time that is available for making them. Sometimes there is ample time for deliberation, like in family planning decisions; although there is usually some deadline, the decision can be considered far ahead. In other situations, the time pressure is high either because some decision that could have been made before has been postponed too long, or because the problem came up very suddenly like when a woman has to decide between terminating a pregnancy or carrying it to term. In contrast to the other three variables, this one cannot be mapped into the formal model of a decision tree; it rather represents a condition of the situation in which the decision maker has to make his/her choice. Time pressure, as it is perceived by the decision maker, is a function not only of the situation, but also of the complexity and significance of the decision to be made: While five days might represent a high time pressure for a woman considering abortion, ten minutes also might represent high time pressure for a person who has to decide what to order while the waiter is standing at the table.

All personal decision problems vary, of course, with respect to the uncertainty and the significance of their potential consequences. The degree is a function of the structural and situational characteristics of the task as well as of the decision maker's attitudes and beliefs. However, one can assume that all situations in which a decision aid would be considered involve some minimum uncertainty and have some minimum significance to their consequences, or the person would not bother with the aid. An example of a decision problem with, presumably, very low uncertainty about the consequence which for this and other reasons usually is not solved by applying a decision aid, is if one should get married to a specific person: an example of a problem of, presumably, low significance, also usually not being helped with a decision aid, is if one, while standing under a nice warm shower, should finish the shower with cold water. The difference between the examples is that in the first case the use of a decision aid often would pay, in the second it would not.

3.2 Characteristics of the decision maker

- Cognitive aspects:

It can be assumed in general that individuals in personal decision situations vary in their cognitive aspects as do nonpersonal decision makers, e.g., in their memory, attention, imagination, etc. They do not have any particular knowledge about the problem or any particular capability regarding decision making due to specific experience or training. However, it would be important to investigate how task and situation variables of personal decision problems influence the decision makers' cognitive abilities. For instance, Sieber (1974) found that subjects in a situation of high significance, relative to subjects in a situation of low significance, showed a decrease in their ability both to generate warranted subjective probability and to assess their state of knowledge accurately.

A salient characteristic of individuals when they make decisions with long-range effects, might be that they are extremely uncertain about how they would feel if particular consequences would actually occur. The anticipation of possible changes in the utilities over time seems to be rather difficult, since people assume either that the environment will not change or that it will change in an anticipated way (Davidson & Jaccard, in press).

- Motivational aspects:

It follows from the definition of "personal decisions" that individuals in such situations differ from other decision makers (including themselves in other situations) in their ego-involvement. Although sometimes other persons, within the family, or some larger social context, might be affected by the decision to be made, the ultimate goal of the decision maker is basically some private individual satisfaction, which is not to say that the welfare of others is not taken into account. In other decision situations, this motivational component might also be extant but it is usually either not prevalent or not admitted, and consequently not explicitly considered.

With respect to other motivational characteristics like time preferences or tolerance of ambiguity, individuals making personal decisions probably do not differ particularly from other decision makers.

- Coping patterns:

There is a large body of research in social and clinical psychology that does not fit easily into the conceptual framework of decision theory although it is also concerned with decision behavior (cp. Feger, 1978; Janis & Mann, 1977; Thomae, 1974). In the case of personal decisions, it seems particularly important to take notice of the knowledge gained in

these areas. This is largely covered in Janis and Mann's book, Decision Making (1977, Reference Note 2).

Janis and Mann (1977) propose a model of decision making that derives mainly from Janis' earlier studies on psychological stress. The antecedents of decision-related stress are aspects of decisional conflicts which the authors understand as approach-avoidance conflicts in particular. Such aspects are, for instance, a commitment to adhere to the present course of action, insufficient time for deliberation, or the loss of hope about finding a solution. Stress then results in "hot cognitions" (Abelson, 1963) and often in defective coping patterns. The model specifies the "conditions relating to conflict, hope, and time pressure that mediate distinctive decisional coping patterns" (p. 72). The focus is upon the decision maker's answers to basic questions evoked by some challenging event demanding a decision: (1) If he/she does not consider the risks serious if he/she were not to take some action to change the present situation, he/she will react with "unconflicted adherence"--which might turn out to be a defective coping pattern if the risks were actually serious since it will lead to incomplete search for information and appraisal of the alternative options. (2) If the decision maker considers the risks of no change as serious but does not consider the risks of some immediately available action as serious, he/she will react with "unconflicted change"--which also might turn out as a defective behavior if the situation were misjudged. (3) If the decision maker considers change as well as no change as risky but has no hope of finding a better solution, he/she will react with "defensive avoidance," a defective coping pattern that can take several forms: Defensive lack of interest in the problem, inattentiveness to threatening cues, shifting the responsibility, procrastinating, or bolstering the preferred alternative (e.g., by exaggerating favorable consequences or minimizing unfavorable consequences, by denying aversive feelings, etc.). (4) If the decision maker has some hope of finding a solution but is under time pressure he will react with "hypervigilance," a defective coping pattern popularly referred to as panic, where, for instance, obvious alternatives are overlooked. (5) If the decision maker is not under time pressure and deadline, he can react with "vigilance," the optimal behavior representing a thorough search for information and evaluation of the alternative options.

3.3 Types of decision problems and decision makers' behavior

The foregoing description of characteristics of the decision problem and of the decision maker may be used to identify certain types of situations mentioned in the decision literature.

- Emergency decisions (e.g., urgent surgery, abortion, etc.) are demanded in situations with high time pressure and, frequently, irreversible and significant consequences of the decision. The focus of the decision maker often is on avoiding an impending deterioration of the status quo. Some of the effects of time pressure on a decision maker's behavior seem to be restriction of attention to certain portions of incoming information, ignoring of entire dimensions of evidence, and focusing on short-term solutions (Vlek, 1978; Wright, 1974). Janis (1977) formulates a model of emergency decisions that is a special case of the general model Janis and Mann (1977) propose. According to this model, in emergency situations "defensive avoidance" and "hypervigilance" become the predominant coping patterns which will generally lead to maladaptive actions (cp. also Janis & Mann, 1977, pp. 52-67). One might add, however, that sometimes "to be coldly rational is to rely heavily on intuition" (Bellman & Smith, 1973, p. 9).

- Change decisions (e.g., having a child, buying a house) offer themselves to or thrust themselves upon a person when, in principle, maintenance of continuity is possible but either some attractive alternative to the status quo becomes apparent or the status quo is in danger of deteriorating. In any case, depending upon the degree of potential gain or loss involved, the decision maker either will feel stimulated/urged to consider a change or will remain in unconflicted inertia (Janis & Mann, 1977, p. 73).

- All-or-none decisions (e.g., sterilization, menu) present themselves to the decision maker as irreversible--and often unique--decisions. Here, the emphasis is on the potential regret rather than on the uncertainty of the situation.

- Vital decisions (e.g., career, medical treatment)--as opposed to trivial decisions like buying a car or choosing a menu--are characterized by their long-range effects on the person's future or, more generally, their broad ramifications for the person's life. This usually implies that the potential consequences are uncertain as well as significant.

All of these types of decision problems are particularly prominent on one variable but may vary on the other variables as well as in the significance and uncertainty of the consequences of the decision. Some decision problems belong to all categories: The decision, for instance, either to have a child or to terminate pregnancy is urgent, status quo challenging, irreversible and vital, and requires consideration of very uncertain and significant consequences--one of the most difficult situations.

4. Implications for aiding personal decision making

The ideas outlined in the previous section suggest some ways of thinking

about decision aids. In what follows, I will try to link the characteristics of both decision problems and decision makers to characteristics of existing or potential decision aids. This should provide a basis for (a) a more specific appraisal of the existing aids, and (b) an appraisal of the functions aids can reasonably serve and the requirements they should fulfill to do so.

4.1 Aspects of focus

Decision aids may focus on different aspects of decision behavior, i.e., they may be guided by different intentions about the respect in which a person can or should be helped. Three main functions of aids can be distinguished: How to arrive at a specific decision, how to implement and maintain a decision once it is made and how to improve general decision-making abilities.

4.1.1 Arriving at a decision

To help people make a decision is, of course, the obvious and usual function of decision aids. The steps in this process (structuring the problem, assessing uncertainties and utilities, evaluating the alternative options) are normally considered as stages leading to some recommended decision. In the context of personal decisions, however, these steps can be considered as distinct objectives on which an aid may focus:

(a) Structuring the problem: Here the aim is to clarify the client's view of the problem and possibly to challenge his/her perspective. This includes specifying available courses of action, possible future events, and possible consequences resulting from these actions and events using some sort of "cognitive simulation" (Toda, 1976). In many situations, it might be important to examine the client's categorization of the problem with respect to relevant task characteristics. For instance, is there really a deadline or can the decision be postponed for further information gathering (e.g., medical treatment)? Is the decision really irreversible? Perhaps the problem can be structured so that instead of being one big, difficult, irreversible decision, it can become several small, possibly more easily reversible decisions (e.g., career change)--a strategy called "incrementalism" (Miller & Starr, 1967; Janis & Mann, 1977, p. 33).³

Counseling also could include, or be exclusively focused upon exploring the uncertainty feelings (e.g., by drawing influence diagrams) or the client's value system (e.g., by constructing goal hierarchies) (cp. Jungermann, in preparation); techniques like playing an "outcome psychodrama" (Janis & Mann, 1977) or constructing "mental scripts" (Abelson, 1975) might be used for these purposes. Focusing solely on structuring might be indicated, for instance, when it provides a sufficient basis for clients to work out decisions themselves or when clients would be particularly sensitive to being urged

towards some specific decision. An example of the former case is the aid developed by Gerdts et al. (in preparation) for helping pupils select an apprenticeship and an example of the latter case is the aid being developed by Humphreys et al. (1978) for women considering an abortion. The approach seems similar to many of the therapeutic and counseling procedures discussed above, but the difference is that the techniques employed can be derived from and tested within the conceptual framework of decision theory, giving the counseling process a much safer (if you will) basis than other counseling procedures can.

(b) Assessing uncertainties and utilities: Here, the focus is on helping people explicitly think about their expectancies and/or values, either after the problem's structure has been developed or within a priori defined structure. This includes not only eliciting the client's subjective probabilities and utilities and considering their possible change over time, but in addition and as before challenging the client's appraisals. This holds particularly for those of the client's expectancies that the counselor might regard as inappropriate either on the basis of available statistical data or in comparison to other people; the studies by Selvidge and Lubs (1976) and Fiedler and Beach (1978), mentioned earlier, represent examples for both cases, respectively.

The reasons for restricting the focus of the decision aid to uncertainties and utilities usually are the same as the reasons for focusing solely on structure in other circumstances, i.e., the assumption that the client can integrate the information once it is clarified for him/her and the wish to avoid having the client reject a decision prescribed by the counselor. Among the previously discussed aids, the one by Selvide and Lubs (1976) represents an example: Subjective probabilities were elicited, challenged, and changed in a genetic counseling context but the client made the decision. Similarly, procedures like the "balance sheet" by Janis and Mann (1977) or the hierarchy for abortion counseling developed by Jungermann et al. (1979) aim, in the end, at a decision but they do not provide an explicit integration process or decision rule for the assessed expectancies and values. The advantage of decision-theoretic derived techniques for counseling even for these predecision steps has been emphasized above.

(c) Evaluating the alternative options: This, of course, is the core of decision-theoretically oriented aids. Based on assessed expectancies and utilities, the alternative options are explicitly evaluated by applying some sort of an expectancy-model-based rule, usually the SEU-algorithm. In all existing decision aids, this is not done by the client nor is it explained to him/her, and given the complexity of the arithmetic it seems doubtful that another way

is possible for personal decision making, perhaps with rare exceptions like simple schemes for buying things. Aids of this kind seem indicated whenever a decision has to be made very soon and the client is able and willing to understand and accept the basic rationale of the procedure; when the time pressure is low the latter requirement is easier to achieve. Examples of this type of aid are the procedures suggested by McNeil et al. (1978) and Beach et al. (1978): Both of these are for birth planning, the first based on an EU-model and the second on an SEU-model. This approach, as compared to the other approaches for counseling in personal decision problems has the unique advantage that it does not stop with exploring the client's view and appraisal of the situation but explicitly includes the decision part by providing a rationale for evaluating the alternative options. In the area of personal decision making, however, caution seems advisable when developing such aids: Most often it is very important for the decision makers to arrive at the decision themselves since they will have to live with its consequences. But, when they do not understand the theoretical or computational basis of the rationale, the recommended decision might easily look like it is being pulled out of a hat by the counselor and might be met with dumb compliance, stubborn protest, or mere indifference. Clearly, a counseling process that uses such an aid cannot stop with telling the client which option came out best; rather, it has to use the aid as a basis for further discussion and it has particularly to give the client the opportunity to revise previously expressed opinions in case the derived decision does not appeal to him/her.

4.1.2 Implementing and maintaining a decision

To help a person carry through a decision once it is made seems to be far outside of the area of decision theory; it certainly has not received much attention thus far. This might be worth changing, particularly in problems of so-called addictive behavior like smoking, drinking, and over-eating. The difficulty lies not in arriving at the "big" decision to abstain from or to regulate the undesirable behavior; that decision is made many times. The real difficulty is in maintaining that decision in tempting situations when "small" (local) decisions have to be made. For a discussion of determinants of relapse that entails many considerations described below, see Marlatt and Gordon (1979). Aid might be provided for these situations by an anticipatory analysis which, consistent with decision theory, focuses on the structure of the situations as well as on expectancies and values (G. A. Marlatt & L. R. Beach, personal communication).

(a) Anticipation of structural aspects: Here, the emphasis is on gaining an insight into the characteristics of situations that can lead a person to vio-

late his/her resolutions. This includes two considerations: First, one might show how seemingly small decisions, none of which are themselves directly contrary to the resolution, may lead to the point that it is only a little step to reverse the resolution. Beach and Marlatt (personal communication) have called those decisions "Apparently Irrelevant Decisions," the acronym for which is, unfortunately AIDS. For instance, a person who is abstaining from alcohol may buy some wine "just in case friends drop in," put it in the refrigerator some evening because the probability of visitors seems high, open it and taste it "just to make sure the quality is okay"--and not be sober for the rest of the evening. An aid could be to provide the person with cognitive maps, with decision trees for the potentially dangerous situations. In this context, research findings regarding attitude-behavior consistency are of relevance; they reveal the importance of identifying the behavioral sequences that must be completed prior to the performance of the behavior of interest since they seem to attenuate the relation between behavioral intention and the actual behavior to a considerable degree (Davidson & Jaccard, in press).

Second, one might analyze critical situations more closely to see why persons do something that they actually do not want to do. For instance, in social situations like parties where everybody has a drink and becomes funny (or thinks he does), persons might simply not know what to do when they are offered a drink, i.e., they do not have feasible alternative actions at hand. Moreover, they might at that moment consider the probable long-range effects of a drink with respect to their decision to stop drinking (G. A. Marlatt, personal communication). Technically, in the former case, the decision tree does not include important immediate options, in the latter case, it is too short in terms of subsequent events and actions. Aiding a person would then consist of enlarging the decision tree, i.e., the person's perspective of the situation. On the other hand, anxious persons might anticipate long-range effects of their decisions which in fact have only a very small probability of occurring and which could be neglected, e.g., where assertive behavior is concerned. There, the decision tree is too long and should be cut down in the course of the counseling.

(b) Anticipation of expectancies and values: This means reflecting the evaluations of alternative options in terms of the probabilities and utilities of possible consequences as they might be prevalent in critical situations. For instance a person wanting to be assertive might, in challenging situations, have particular high subjective probabilities of negative consequences of assertive behavior (cp. p. 8). Or, a person wanting to stop smoking might discount strongly the negative utilities for delayed effects of not having a

cigarette (e.g., no guilt, no cough) in favor of the negative utilities of immediate effects (e.g., regret, being unsocial). Ainslie (1975) discusses the research on impulsiveness--the choice of apparently less rewarding over more rewarding alternatives--on the hypothesis that the effectiveness of rewards declines as the rewards are delayed from the time of choice, i.e., that people discount positive utilities of delayed consequences of a decision. Here aiding could consist of not only making these expectancies and values explicit in the counseling procedure but also developing and using techniques which might prevent discounting. Several techniques suggested within cognitive therapies work basically on this principle, e.g., the technique of contract-negotiating mentioned earlier.

4.1.3 Improving decision-making abilities

To help people develop a more generally improved ability to make personal decisions might become an important educational task in a time in which many people have to make more, and more complex, decisions--and are expected to make correct decisions. The focus might be more on generally improving problem-solving or decision-making abilities, or on developing strategies for rather specific but repeated decisions, like purchasing decisions. Many approaches for training decision makers have been suggested (Goodman, Fischhoff, Slovic & Lichtenstein, 1978). The variation in scope and sophistication among the existing procedures is considerable, ranging from computer-simulation techniques (e.g., Doerner, Kreuzig & Reither, 1978) to very simple paper-and-pencil exercises (e.g., Abrego & Brammer, 1979; Russell & Thoresen, 1976). Since basically all these approaches aim at "teaching decision theory," they should also apply to training in making personal decisions. Thus there seems no need to discuss this potential function of decision aids separately.

4.2 Aspects of technique

Since most persons have no training or experience with quantitative analysis, decision aids must be constructed such that their rationale as well as the results they produce can easily be understood and accepted by the client. This probably can be achieved most easily if aids utilize cognitive and behavioral strategies that are familiar to the decision maker or that he can at least understand and imitate, i.e., to make the aid "an adjunct to intuition and not a replacement to it" (Alleridge, 1972, p. 251). For instance, an individual's particular information-processing model can be used for the construction of a aid to make multi-attribute comparisons (Gerdtz et al., in preparation). A comprehensive discussion of an application of information-processing theory to career decision making is given by Harren and Pitz (1978), while Slovic (in press) is more generally concerned

with understanding and improving decisions from an information-processing point of view. Let us look briefly at a few technical points related to these issues:

(a) Strategies: In the first place, care must be taken to determine which decision strategy should be chosen as the basis for the potential aid. It must represent the best compromise between the characteristics of the task and situation as well as the potential decision maker's cognitive, motivational, and behavioral characteristics (Beach & Mitchell, 1978; Janis & Mann, 1977; Vlek, 1978). So far, most attention has been paid to SEU-models, or general expectancy-value-models. However, aids based on these might not always be appropriate or optimal, particularly for situations involving time pressure. Other strategies, like search for some "satisficing" alternative (Simon, 1957), elimination by aspects (Tversky, 1972), or others might serve the intended aim much better.

(b) Decomposition: The assumption of decision-theoretically based aids is that decomposing a complex problem makes understanding and judgment easier for a person. But the question about the degree of decomposition that is appropriate for various kinds of problems has yet to be studied. Moreover, increasing the number of action possibilities might often be helpful but it may sometimes lead to confusion. Conversely, restricting the number of action possibilities may sometimes be relieving but it may make the client feel hemmed in (Alleridge, 1972; Keeney, 1977).

Two examples of quite different degrees of decomposition are represented by the procedure proposed by McNeil et al. (1978) in which one holistic judgment of the utility of having a (unaffected) child is required from the client, and the procedure developed by Beach et al. (1978), in which the question of having a child is decomposed into 68 specific considerations to be evaluated by the client.

(c) Standardization: Because it is impractical to develop a unique structure for each client's particular personal decision problem, one usually prefers to use a standardized, a priori structure. With such a structure, the problem is to assure that it covers most of the things which might be relevant for most persons with that particular kind of decision problem without making the structure too complex. The dilemma is between being too exhaustive, on the one hand, and imposing an inadequate structure on the client's problem on the other hand. One solution to this dilemma is illustrated by the procedure developed by Beach et al. (1978) in which the elements are defined neutrally but illustrated by specific examples that merely serve to stimulate the client to think about this aspect of having a child and to interpret it

with respect to his/her own personal situation. -

(d) Numbers: One of the greatest difficulties in using decision theory for decision aids in personal decisions is that most people are unfamiliar with (and perhaps opposed to) using numbers when thinking about personal decision problems. Even in business contexts, operationalization through (monetary) numbers becomes awkward when values like tradition or ethics are concerned (Keeney & Raiffa, 1976, p. 4). In terms of assessment, this can sometimes be by-passed through using verbal labels (e.g., very likely uncertain, unlikely for expectancies) which later are transformed into numbers in case a numerical evaluation of options is intended. This might particularly be indicated when emotions are at stake, i.e., technically, the probabilities and utilities of emotions as potential consequences are to be assessed, since many people feel uneasy or even unable to turn their feelings into "cold" numbers. In terms of recomposition, there is, first of all, the general question of the legitimization of the applied algorithms (e.g., expectancy-value models); Fischhoff (1977) has discussed some problems related to this. Second, there is the problem of the clients losing contact with the process when "their" decision is being calculated in a way they do not really understand. Maybe some more intuitively appealing heuristics for integrating the clients' assessments can be developed; otherwise it seems more suitable to have the counselor perform the calculations without the client's participation and then discuss the results and their implications with the client.

4.3 Aspects of application

For a specification of the conditions under which aids could be developed that are either self-administerable or administered by a counselor, and how in any case the aid should be designed and used, studies are necessary which take into account the respective knowledge from social and clinical psychology; so far, very little can be said on this issue.

(a) Self-administered aids: One can distinguish between automated and written aids. The only area in which automated aids for personal decision making have been developed is career and vocational counseling (Jackson, Sneath & Wallis, 1978), but most of these techniques are not directly decision-theoretically oriented (p. 13). However, this field seems to be the only one in which computerized technology would probably be worthwhile and appropriate; the situation usually is not overly emotionally stressful and the structure of the problem, for the most part, can be determined a priori. More generally, personalized computing with keyboard consoles at one's home might someday provide a basis for the application of all kinds of automated aids. On the other hand, written aids for aiding personal decisions could become feasible

in the near future, at least if one extrapolates from the boom in self-help behavior therapy manuals (Glasgow & Rosen, 1978). If cognitive psychologists could think of mnemonics, why shouldn't decision theorists come up with "decisionics"?⁴ The only self-administerable written aid that presently exists is the birth planning questionnaire by Beach et al. (1978), but even there, self-administration has its limits since the calculation of SEU's and their communication to the client is performed by the counselor. Another one, concerning late-career change decisions, is being developed by Prothero (in preparation). For problems not associated with much emotional and temporal stress, there is no reason not to turn the aiding technique into written materials; particularly for repeatable decisions like purchase decisions for which several popularized decision-theoretic-like schemes already exist.

(b) Counselor-administered aids: For vital and emotional decision problems, the application of an aiding technique by a counselor is desirable and often probably indispensable. First of all, only a counselor can determine if the client's problem is really a decision or if he/she actually needs some other form of help, e.g., psychotherapy. But even when the decision is the problem, the contribution of the counselor can be important since in situations of high ego-involvement misjudgments by the client are very likely, due to lack of information or to unconscious resistance against changing his/her perspective (Janis & Mann, 1977); the counselor is not only an expert with the aid, but usually also is an expert on the issues. This fact may lead a client to recognize his/her own biases and thus to make a more rational decision. Several "stumbling blocks" which typically occur in the counseling process regarding decision problems are discussed by Krumboltz & Thoresen (1976). It is evident, therefore, that counselors have not only to understand the technique in itself but they also have to be trained in applying the technique appropriately, or at least to be given a manual for its use.

4.4 Aspects of evaluation

It is well-known that the problem of evaluating decision aids is both crucial and difficult (e.g., Fischhoff, 1977; Goodman et al., 1978; Humphreys, 1977; Pauker & Pauker, 1977). With regard to objective criteria, for instance, it is difficult to measure the contribution of an aid because one cannot evaluate it on the basis of the quality of the outcome, since this is not only a function of the decision itself, but also of uncertain events. With regard to subjective criteria, research on attitude change shows that the commitment to a decision has a strong effect on a person's beliefs and values (Janis & Mann, 1977). Some suggested ways (e.g., Goodman et al., 1978; Glasgow & Rosen, 1978) are: Assessing the importance

of judgmental biases for the optimality of decisions, helping people assess the quality of their own decisions and to learn from experience (maybe in ways suggested by Fischhoff's (1975) work on hindsight) and identifying predictors of counseling outcome, examples of which might be clients' return to the counselor or client's relapses.

Reference Notes

1. Beach, L. R., Townes, B. D., and Campbell, F. L. The Optional Parenthood Questionnaire. The questionnaire has been published by the National Organization for Non-Parents which, in turn, changed its name to the National Alliance for Optional Parenthood. This organization is an educational group that stresses that parenthood should be rationally considered before it is decided upon.
2. Janis, I. L. and Mann, L. Decision Making. New York: The Free Press, 1977. While this book presents the relevant research findings from social psychology, particularly on attitude formation and change, and clinical psychology, particularly on stress, two forthcoming books by Janis have an emphasis on applied aspects: Janis, I. L. Counseling on Personal Decisions: Theory and Research on Short-Term Helping Relationships. Yale University Press (in preparation); and Wheeler, D. and Janis, I. L. Making Vital Decisions: A Guidebook. The Free Press (in preparation).

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Footnotes

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- ² I want especially to thank Lee Roy Beach who, through his work and his comments and his sense of humor, has had a considerable impact on the direction and development of this paper.
- ³ On the other hand, this last strategy might result in a stepwise increase in commitment and actually lead to locking a person into a career, for instance, without his/her every actually having made a decision about it (Janis and Mann, 1977, p. 35).
- ⁴ In case the reader might have wondered, this is the origin of the title of this paper.

Table 1
Structural and Situational Characteristics of Personal Decisions

Sturctural Task Variables		Situation Variable	
		Low Time Pressure	High Time Pressure
Reversible	Short-range effects		·
	Long-range effects	· · ·	·
Continuity Possible	Short-range effects		
	Long-range effects	· · ·	
Irreversible	Short-range effects		
	Long-range effects	· · ·	
Reversible	Short-range effects		
	Long-range effects	· · ·	
Discontinuity Inevitable	Short-range effects		
	Long-range effects	· · ·	
Irreversible	Short-range effects		
	Long-range effects	· · ·	

STRUCTURING DECISION PROBLEMS¹

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INTRODUCTION

Roughly speaking, decision analysis can be subdivided into four steps: structuring, modeling, assessment, and numerical analysis. In the structuring phase, a decision problem is formulated into a formally acceptable and manageable decision analytic format. In the modeling step the mathematical relations between structural elements are expressed, for example, as a multi-attribute evaluation model, or a time preference model. In the assessment part the numerical inputs of such models, the probabilities and utilities, are specified. In numerical analysis the implications of the model are explored, including the determination of optimal decisions and sensitivity analyses.

Most decision analytic research focussed on the last three steps of the analysis. But flat maxima and sensitivity analyses of linear models (see v. Winterfeldt and Edwards, 1973; Einhorn and Hogarth, 1975; Dawes and Corrigan, 1974; Wainer, 1976, 1978; Fischer, 1972) suggest that errors in these steps seldom lead to large penalties in terms of expected value or utility. Attention was thus drawn to the importance of structuring decision problems.

Structuring was and to some extent still is considered the "art" part of decision analysis. It consists of an imaginative and creative process of translating an initially ill defined decision problem into a set of well defined elements, relations, and operations. Using mainly hierarchical concepts, the structuring process seeks to formally represent both the environmental (objective) parts of the decision problem and the decision maker's or expert's (subjective) views, opinions, and values. Typically the result is a more or less complex decision tree representing the sequential aspects of the decision process and a value or goal tree representing the goals and objectives for decision making.

Recently, a number of authors have made advances in turning this art of structuring into a science. Early attempts to classify and categorize decision problems (see MacCrimmon and Taylor, 1973; Taylor, 1974; v. Winterfeldt and Fischer, 1975; Miller et al, 1976) were expanded into a complex taxonomy by Brown

and Ulvila (1977). Guidelines for selecting an appropriate decision analytic approach were developed in MacCrimmon (1975), Brown and Ulvila (1977) and Johnson and Huber (1977). Techniques for extending and refining traditional structuring methods in decision analysis were developed in Miller (1970), Miller et al (1976), Keeney and Raiffa (1976), and Sage (1977). And finally, Humphreys (1977), Kelly (1978) and others discuss computerized decision aids for structuring parts of the decision problems (e.g., goal trees and decision trees).

The first three sections of this paper will review this literature on structuring under the headings

- o taxonomies of decision problems and analytic approaches;
- o concepts and methods for selecting an appropriate analytic structure;
- o extensions and refinements of traditional structuring concepts.

Two conclusions emerged from this review and motivated the subsequent parts of this paper:

- 1) Structuring research is still limited to a few traditional hierarchical concepts. Only a few novel approaches (e.g., influence diagrams) or specific structures (e.g., signal detection structures) have been developed.
- 2) Although structuring research has much to say about analytic distinctions between decision problems and models (e.g., whether a problem is multiattributed or not), it has little bearing on substantive problem distinctions (e.g., the differences between a typical regulation problem and a typical investment problem).

Both shortcomings are traced back to the "elicitation" philosophy of decision analytic structuring, according to which structuring tools are mere skeletons to be filled with the "flesh" of the decision makers' or experts' views, perceptions and values. Almost by definition, such an elicitation philosophy ignores structures implied by the substantive characteristics of decision problems.

An argument is made that ignoring substantive problem aspects limits the capability of transferring decision analytic structures and models to similar problems.

As an alternative, the concept of prototypical decision analytic structures is introduced. Such structures are more specific than the usual decision trees or goal trees. They are developed to meet the characteristics of a specific problem, but are at the same time general enough to apply to substantively similar problems. As an illustration, IIASA's development of a prototypical decision analytic structure for environmental standard setting will be described. Finally, several typical classes of decision problems will be examined and some requirements for prototypical structures will be discussed.

TAXONOMIES

The taxonomies described in the following typically classify decision problems on one hand and analytic approaches/solution strategies on the other. In most taxonomies the distinguishing categories are analytic in nature (e.g., whether a problem is multiattributed or not) and they attempt to slice the universe of problems or solution strategies into mutually exclusive and exhaustive sets. The purpose of such taxonomies is twofold: to facilitate the identification of an unknown element (e.g., a medical decision problem) with a class of problems (e.g., diagnostic problem); and to aid the process of matching classes in the problem taxonomy (e.g., diagnostic problems) with classes in the analytic taxonomy (e.g., signal detection models). Both identification and matching are clearly useful steps in structuring decision problems for analysis.

MacCrimmon and Taylor (1973) discuss on a rather general level the relationship between decision problems and solution strategies. Decision problems are classified according to whether they are ill structured or well structured, depending on the extent to which the decision maker feels familiar with the initial state of the problem, the terminal state, and the transformations required to reach a desired terminal state. Three main factors contribute to ill

structuredness: uncertainly, complexity, and conflict. For each category MacCrimmon and Taylor discuss a number of solution strategies. These strategies include, for example, reductions of the perceptions of uncertainty, modeling strategies, information acquisition and processing strategies, and methods for restructuring a problem.

Taylor (1974) adds to this classification scheme four basic types of problems: resource specification, goal specification, creative problems, and well structured problems (see Figure 1), depending on the decision maker's familiarity with the three subparts of the problem. Taylor discusses what types of decision strategies are appropriate for each of these problem categories, for example, brainstorming for creative problems and operations research type solution for well structured problems.

 Insert Figure 1 about here

v. Winterfeldt and Fischer (1975) present a simple classification scheme for evaluation problems and models. The classification scheme is based on three main factors: uncertainty, time variability, and multiple objectives. Problem complexity is defined by the presence or absence of these factors. A fourth factor, multiple decision makers or multiple affected groups may be added. Such a scheme leads to a natural match between problems and decision analytic models (e.g., riskless multiattribute models, time preference models under uncertainty, etc.).

Miller et al (1976) present a more comprehensive classification framework which categorizes decision situations and types of models used. Decision situations are categorized according to the nature of the decision problem (e.g., complex-simple; unique-recurrent), the preferences and the resources of the decision maker (e.g., single objective vs. multiple objectives), and the interaction among people participating in the decision process (e.g., number of people involved, organizational structure). Models are distinguished along relatively traditional lines, including deterministic vs. probabilistic models, static vs. dynamic models, and types of interdependencies among model variables.

FIGURE 1
Types of Problem Structure
(Taylor, 1974)

<u>Problem Type</u>	<u>Initial State</u>	<u>Terminal State</u>	<u>Transformation</u>
Type I, Resource Specification Problems	Unfamiliar	Varies	Varies
Type II, Goal Specification Problems	Varies	Unfamiliar	Varies
Type III, Creative Problems	Varies	Varies	Unfamiliar
Type IV, Well-Structured Problems	Familiar	Familiar	Familiar

Howell and Burnett (1978) recently developed a taxonomy of tasks and types of events with the intention to assess cognitive options for processing probabilistic information for each taxonomy element. Uncertain events are classified according to three dichotomies:

- frequentistic - not frequentistic;
- known data generator - unknown data generator;
- process external - internal to the observer.

Task characteristics are complexity, setting (e.g., real life vs. laboratory), span of events, and response mode characteristics. For each event/task combination Howell and Burnett discuss how different cognitive processes may be operating when making probability judgments. For example, in estimating frequentistic events with unknown data generators, availability heuristics may be operative.

Vlek and Wagenaar (1979) present a problem taxonomy which includes aspects of the taxonomies of MacCrimmon and Taylor, v. Winterfeldt and Fischer, and Miller et al. As new categories Vlek and Wagenaar introduce "availability of choice alternatives" (e.g., a reject-accept mode for one alternative vs. pick one out of k) and stress and situational factors.

Brown and Ulvila (1977) present the most comprehensive attempt to classify decision situations and analytic approaches. Their taxonomy includes well over 100 possible characteristics both for problems and analytic structures. Decision problems are defined according to their substance and the decision process involved. "Substantive" taxonomic characteristics are mainly derived from the analytic properties of the situation, i.e., amount and type of uncertainty, and amount and type of stakes, types of alternatives. Only a few elements of this part of the taxonomy can be directly related to problem content, i.e., current vs. contingent decision, operating vs. information act. The taxonomic elements of the decision process refer mainly to the availability and constraints of the decision maker, e.g., reaction time, available resources. Thus substance and process of the decision problem is categorized along identical lines as decision situations in Miller et al.

Brown and Ulvila created an analytic taxonomy in correspondence with the problem taxonomy. The analytic taxonomy classifies the main options an analyst may have in structuring and modeling a decision problem. The taxonomy includes factors such as user's options (amount to be expended on the analysis), input structure (type of uncertainty), elicitation techniques (type of probability elicitation). These categories identify options, both at a general level (optimization, simulation, and Bayesian inference models) and special techniques (e.g., reference gambles, or Delphi technique).

Most of the above taxonomies do well with regard to the purpose of distinguishing and identifying classes of analytic approaches/solution strategies. This comes as no surprise, considering the analytic or psychological background of those who created the schemes. On the other hand, the problem taxonomies are somewhat empty. This is partly due to the analytic character of the categories used (uncertainty-no uncertainty, ill structured-well structured) and partly to the attempt to slice the whole problem set into mutually exclusive classes. As a consequence, the problem classes identified within the taxonomies have few distinguishing content features. For example, none of the above taxonomies allow to distinguish between a typical siting problem and a typical regulation problem in a meaningful way, although both types of problems represent generic problem classes.

CONCEPTS AND METHODS FOR MATCHING PROBLEMS AND ANALYTIC APPROACHES

Most taxonomies include some ideas or principles of matching problems and analysis. MacCrimmon and Taylor attempted to match their basic type of decision problems with cognitive solution strategies; Howell and Burnett speculate which cognitive processes may be invoked by typical task/event classes in probability assessment; v. Winterfeldt and Fischer identified for each problem category appropriate multiattribute utility models. But in none of these papers explicit matching principles or criteria for the goodness of a match are given. Rather, matches are created on the basis of a priori reasoning about the appropriateness of a strategy, model,

or a cognitive process for a particular class of decision problems.

Brown and Ulvila attempted to make the matching process more explicit by creating a third taxonomy, called the "performance measure taxonomy". This taxonomy evaluates analytic approaches on attributes like "time and cost measures," "quality of the option generation process," "quality of communication or implementation," etc. Different problem classes have different priority profiles on the performance measure categories. Similarly, different analytic approaches have different scoring profiles on the performance measures. An analytic approach is to be chosen which has high performance on the priority needs of a particular problem. Brown and Ulvila discuss the "goodness of fit" of several analytic approaches to a number of decision situations in terms of these performance measures. For example, they argue that a contingency type analysis (an element of the analytic taxonomy) is appropriate for decision problems that occur repeatedly and require a fast response (elements of the decision situation taxonomy) because contingency type analysis allows fast calculations (elements of the performance measure taxonomy).

Several authors have developed logical selection schemes, which can identify an appropriate analytic approach or model based on selected problem features. MacCrimmon (1975), for example, developed a sequential method for selecting an appropriate model for multiattribute evaluation. The first question to be answered is whether the purpose of modeling is normative or descriptive. Further questions include whether the type of problem has occurred frequently before, if there are multiple decision makers with conflicting preferences, and whether alternatives are available or have to be designed. All questions are of the yes-no type and together create a flow chart to select among 19 possible models. For example, if the purpose of modeling is normative, if direct assessments of preferences (e.g., ratings) are valid and reliable, and if the type of problem has frequently occurred before, regression models or ANOVA type models would be appropriate.

Johnson and Huber (1977) and Kneppreth, Hoessel, Gustafson, and Johnson (1977) discuss a three step procedure for selecting a multiattribute utility assessment approach. In the first step,

the characteristics of the multiattribute problem are listed, including discreteness vs. continuity of dimensions, uncertainty vs. no uncertainty, and independence considerations. In the second step the evaluation situation is characterized on the basis of judgments about the task complexity, amount of training required for assessment, face validity required, assessment time, accuracy and flexibility. In the third and final step the profile describing the evaluation problem is compared with a profile characterizing five different generic assessment models or methods. The technique that best matches the situation profile is selected. For example, lottery assessment methods and models would be appropriate if the evaluation problem involves uncertainties, does not require high face validity, and allows for a good amount of training of the assessor.

Other authors (Miller, 1970; v. Winterfeldt and Fischer, 1975; Keeney and Raiffa, 1976) discuss which model or assessment technique is appropriate in multiattribute evaluation situations depending on the analytic nature of the problem (e.g., uncertainty vs. no uncertainty) and independence assumptions about the decision maker's preferences.

Both the taxonomy oriented and the sequential selection methods for matching problems and analysis suffer from certain drawbacks. As stated earlier, problem characteristics used in taxonomies or in selection schemes typically neglect substantive aspects of the decision problem. Consequently, an analyst may choose an analytic approach based on a match with a spuriously defined problem class. For example, when facing a medical diagnosis problem, an analyst may find that some detailed substantive characteristics of the problem (e.g., the way doctors process information, the physical format and process of information, etc.) suggest a signal detection structure. Yet, as far as I can see, none of the above matching processes would directly lead to such a structure.

EXTENSIONS AND REFINEMENTS OF TRADITIONAL STRUCTURING APPROACHES

A new concept in decision analytic structuring is called influence diagrams. (see Miller et al, 1976). Influence diagrams draw a graphical picture of the way variables in a decision model influence each other, without superimposing any hierarchical structure. For example, a decision variable (price) may "influence" a state variable (demand) and thus "influence" a final state (successful introduction of a new product into a market). Influence diagrams have been conceived mainly as an initial pre-structuring tool to create a cognitive map of a decision maker's or expert's view of a decision problem. In the present stage influence diagrams are turned into hierarchical structures and analyzed with traditional tools. But research is now underway at SRI to use influence diagrams directly in EV or EU computations.

Another generalization of the tree approach is Interpretative Structural Modeling (ISM) developed, for example, in Warfield (1974) and Sage (1977). In interpretative structural modeling, matrix and graph theory notions are used to formally represent a decision problem. First, all elements of the problem are listed and an element by element matrix is constructed. The structure of the relationships between elements is then constructed by filling in the matrix with numerical judgments reflecting the strength of the relationship, or by simply making 0-1 judgments about the existence/non-existence of a relation. Computer programs can then be used to convert the matrix into a graph or a tree that represents the problem.

Influence diagrams, value trees, decision trees, and inference trees can all be thought of as special cases of ISM. For example, in value tree construction, the analyst may begin with a rather arbitrary collection of value relevant aspects, attributes, outcomes, targets and objectives. Using alternative semantic labels for the relationships between these elements (e.g., "similar," "part of"), an element by element matrix can be filled. Finally, the analyst can explore whether a particular relational structure leads to useful goal tree structure.

A somewhat more specific extension of traditional decision tree approaches was introduced earlier by Brown (1975). Brown suggested that in some cases future acts, conditional on the occurrence of previous actions and events, may not be predictable without uncertainty, because the decision maker may be unwilling to commit himself to a conditional decision. In such cases, conditional acts may be considered as events, and probability distributions could be assessed over them.

Besides these generalizations of traditional hierarchical structuring tools, several refinements of special structuring techniques have been suggested, particularly for evaluation problems. Keeney and Raiffa (1976) devoted a whole chapter to the problem of structuring a value tree. They suggest a strategy of constructing a value tree by beginning with general objectives and disaggregating by using a pure explication logic (i.e., what is meant by this general objective?). This approach has previously been advocated by Miller (1970) and others. Mannheim and Hall suggest in addition the possibility of disaggregating general objectives according to a means-ends logic (how can this general objective be achieved?). Other disaggregation logics (problem oriented, process oriented, etc.) could be analyzed in the ISM context.

There are a number of papers that suggest more empirical or synthetic approaches to value tree construction. Of particular interest is Humphreys and Humphreys (1977) repertory grid technique. In this procedure similarity and dissimilarity judgments are used to span the value dimensions of alternatives. Other approaches are based on multivariate statistical analysis and have been suggested mainly by social indicator researchers.

Several computer aids have been developed recently to aid decision makers or experts in structuring decision problems. Some of these are discussed in Kelly (1978), and Humphreys (1977). These aids typically rely on empty structuring concepts (decision trees, value trees, inference trees, or influence diagrams) and they guide the decision maker/expert in the analytic formulation of his/her problem.

Special aids are OPINT for moderately complex problems which can easily be formulated into a decision tree or matrix structure, the decision triangle aid for sequential decision problems with a focus on changing probabilities, and EVAL for multiattribute utility problems (Kelly, 1978). In addition to these structuring and assessment aids, there are now computerized aids under development exploiting the idea of influence diagrams and fuzzy set theory.

Influence diagrams, ISM, and computer aids are indicative of a trend in structuring research and perhaps in decision analysis as a whole. This trend turns the fundamentally empty structures of decision trees, goal trees, and inference trees into more operational, computerized elicitation tools, without adding problem substance. There are clear advantages to such an approach: a wide range of applicability, flexibility, user involvement, speed, limited training, and feedback, to name only a few. It also reduces the demands on the decision analyst's time.

There is, of course, the other extreme, the prestructured, precanned problem specific version of decision analysis applicable to essentially identical situations. A military example is DDI's SURVAV model (Kelly, 1978) which applies to routing decision for ships to avoid detections by satellites. Such a structure and model can routinely be implemented with almost no additional training. In turn it gives up generalizability.

Neither extreme is totally satisfactory. The middleground of problem driven but still generalizable structures and models needs to be filled. Taxonomies may provide an input here by identifying more specific classes of problems. But as was discussed earlier, present taxonomies are not oriented towards problem substance but towards analytic distinctions. Consequently a model built to fit a particular class in, say, Brown and Ulvila's taxonomy, will still remain empty. Consider, for example, OPINT, a decision aid for structuring and numerical analyses in relatively well defined problems under uncertainty. Kelly characterizes the type of problem to which OPINT applies by

- o simple structure suffices,
- o single decision,
- o multiple criteria,
- o uncertainty,
- o well formed problem.

These are, of course, categories from the analytic taxonomies. OPINT consequently has little more substantive structure than a usual decision tree, goal tree, or payoff matrix.

The example of OPINT (and most other decision aids) shows that increasing the analytic specificity of a structure or model does not necessarily mean increasing the problem specificity. As a consequence each problem has to be structured and modelled from scratch, even if it is very similar to a previous problem. For example, using the EVAL structure and model for evaluating Army weapons procurement decisions would have little carry over to other procurement decisions of the Army. Yet it seems that procurement decisions, and particularly those in the military context, have generalizable features that could be implemented in a more specific decision analytic structure.

The questions of filling in the middleground between "too general" structures and "too specific" structures thus becomes a question of searching for generalizable features of problems that identify generic classes of decisions. These generic classes can then be modelled and structured by "prototypical decision analytic structures" which are specific enough to match the generalizable problem features and general enough to transfer easily to other problems of the same class.

At the present stage of research this search process will necessarily be inductive because too little is known about problem substance to develop a problem driven taxonomy and matching analytic structures. An inductive research strategy may attempt to crystallize the generalizable features of a specific application, or compare a number of similar applications (e.g., to siting problems), or simply use a phenomenological approach to delineate problem classes in a specific application area (e.g., regulation). In the following two sections some possibilities

for developing prototypical decision analytic structures will be discussed.

AN EXAMPLE OF DEVELOPING A PROTOTYPICAL STRUCTURE

The following example describes the structuring process in the development of a decision aiding system for environmental standard setting and regulation. The work was performed as part of IIASA's standard setting project (see v. Winterfeldt, Avenhaus, Häfele, and Höpfinger, 1978), which had both descriptive and normative intentions (how do regulators presently set standards? how can analytic models help in the standard setting process?). Because of this wide approach of the standard setting project, the research group was not forced to quickly produce workable models for specific decision problems. Consequently, its members could afford and were encouraged to spend a substantial amount of time on structuring.

Inputs into the structuring process were:

- o retrospective case studies of specific standard processes of EPA;
- o previous models suggested for standard setting;
- o field studies of two ongoing standard setting processes (oil pollution and noise standards).

In addition, the structuring process benefited much from continuing discussions with leading members of environmental agencies in the United Kingdom, Norway, Japan and the United States. Although the structuring effort was geared towards decision analysis, substantial inputs were given by an environmental economist (D. Fischer), an environmental modeller (S. Ikeda), a game theorist (E. Höpfinger), and two physicists (W. Häfele and R. Avenhaus), all members of IIASA's standard setting research team.

The overall question was: how can standard setting problems best be formulated into a decision analytic format and model such that the model is specific enough to capture the main features of a particular standard setting problem and at the same time is general enough to apply to a variety of such problems? In other words, what is a prototypical decision analytic structure for standard setting?

Since the regulator or regulatory agency was presumed to be the main client of such models, the initial structuring focussed on regulatory alternatives and objectives. In one attempt a wide but shallow alternative tree was conceived which included a variety of regulatory options ranging from emission standards, land use schemes, to direct interventions. An example for noise pollution standards is presented in Figure 2.

Insert Figure 2 about here

Coupled with an appropriate tree of regulatory objectives, a decision analysis could conceivably be performed by evaluating each alternative with a simple MAU procedure. A possible value tree is presented in Figure 3 for the same noise pollution problem.

This simple traditional structure was rejected since regulators seldom have to evaluate such a wide range of alternatives and because it does not capture the interaction between the regulators and the regulated. Also, regulators are much concerned about monitoring and implementation of standards, an aspect which a simple MAU structure does not address.

The second structure was a narrow but deep decision tree, exemplified in Figure 4 for an oil pollution problem.

Insert Figures 3 and 4 about here

In addition to the regulator's alternatives, this tree includes responses of the industry to standards, possible detection of standards violations, and subsequent sanctions. This structure was geared at fine tuning the regulators' definitions of the standard level (maximum emission, etc.) and monitoring and sanction schemes, and to assessing environmental impacts.

FIGURE 2

An Alternative Tree for Train Noise Regulation

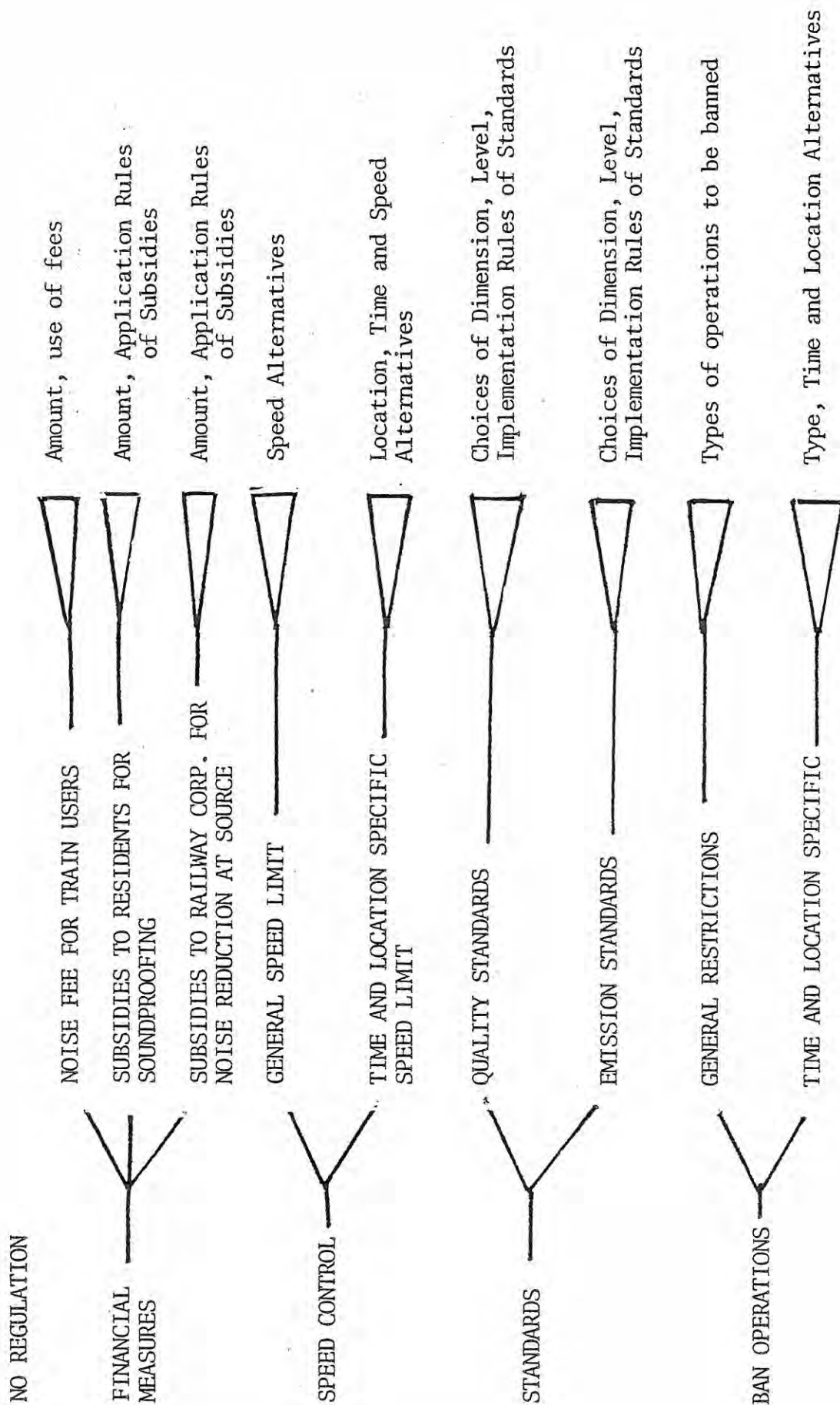


FIGURE 3
Regulatory Objectives for Noise Pollution Control

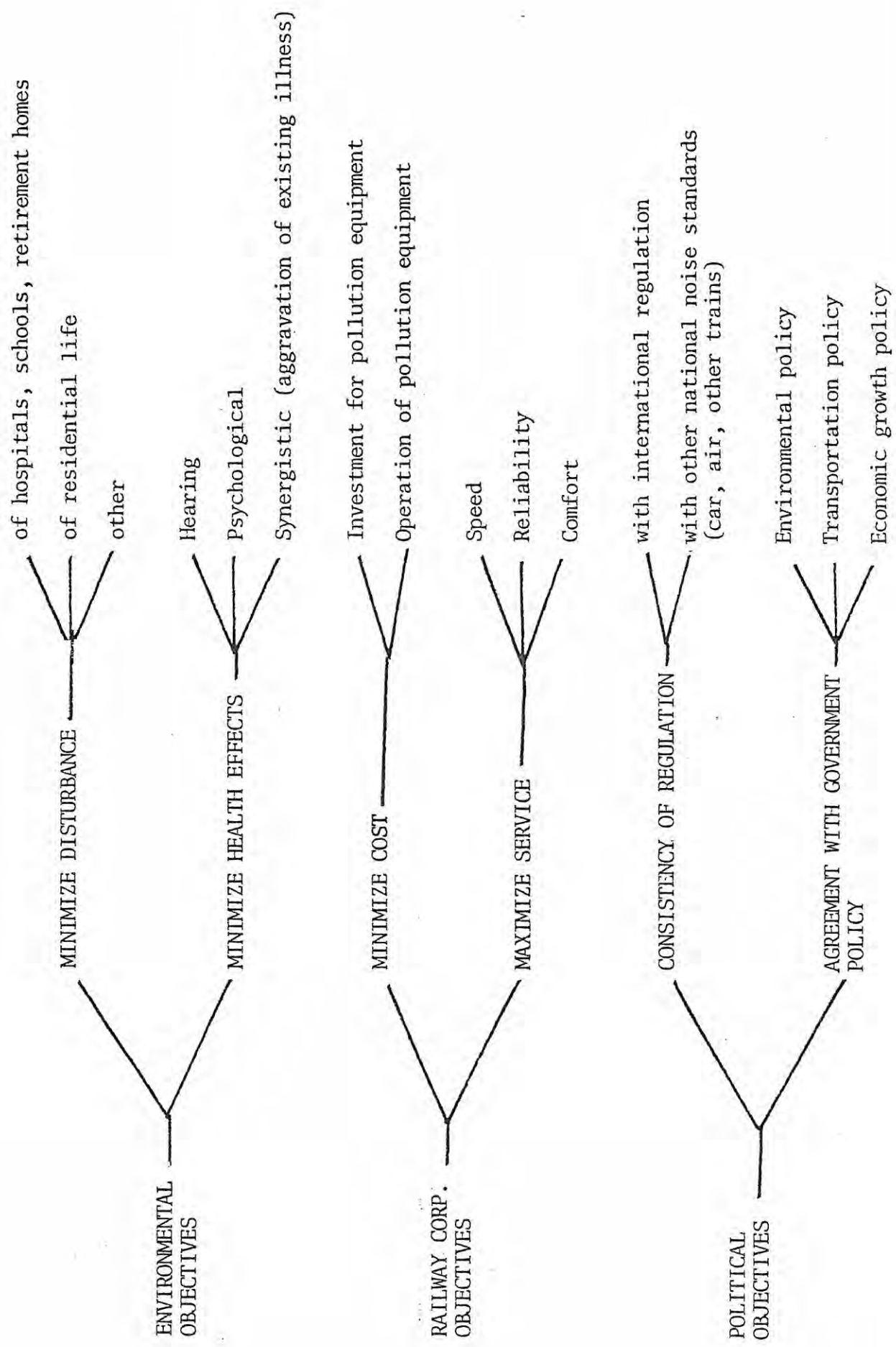
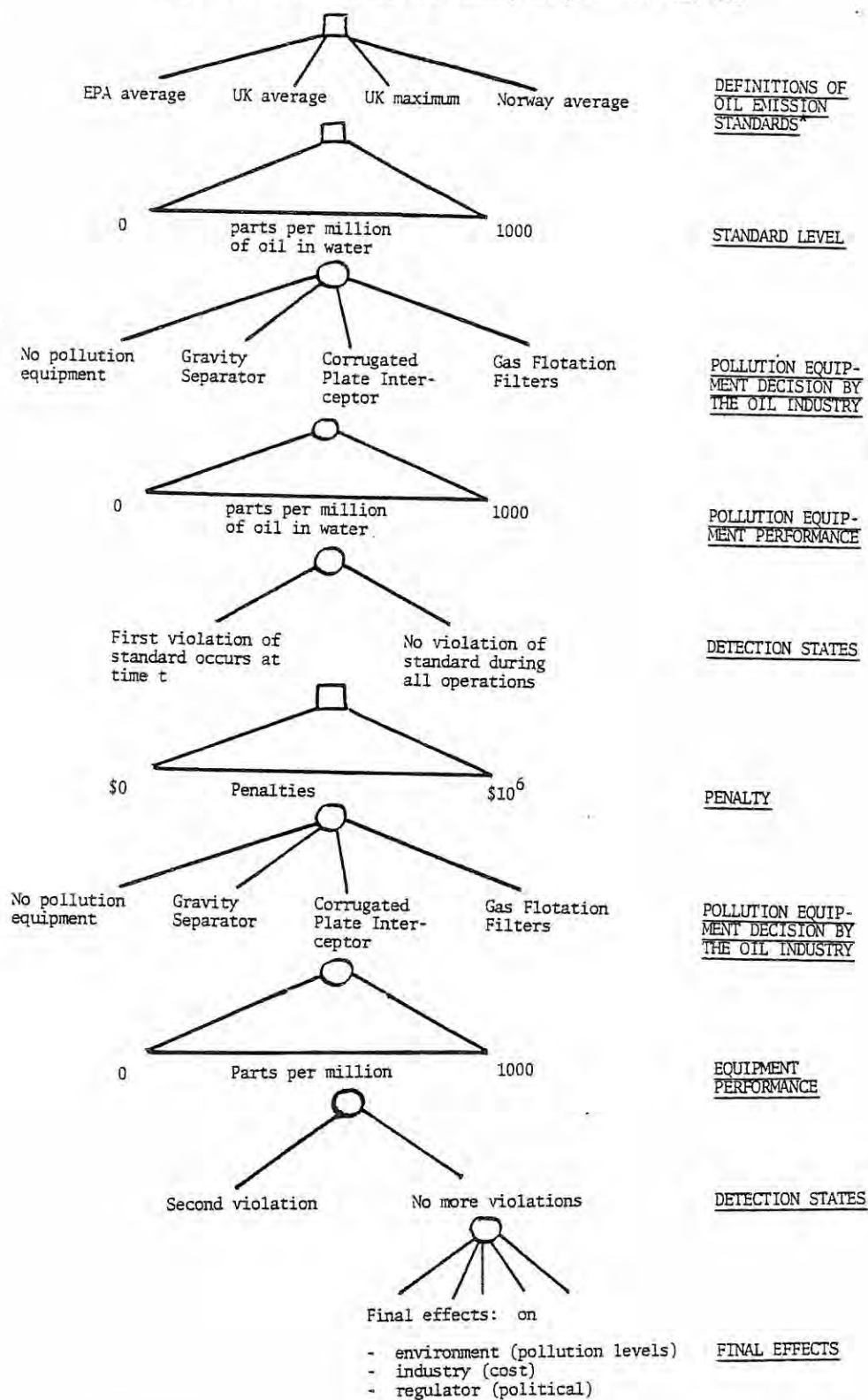


FIGURE 4

Segment of a decision tree for setting oil pollution standards



* A standard is usually defined by the number of samples to be taken, how many samples form an average, and how many exemptions from a violation are allowed. For example, the EPA average definition is as follows: four samples are to be taken daily, the average of these four samples may not exceed the standard level (e.g., 50 ppm) more than twice during any consecutive 30 day period.

The structure is specific in terms of the regulatory alternatives, but it is somewhat ambiguous in the subpart on impacts on industry and environment. It seems that the responses of industry and environmental groups constitute a major concern in regulatory decision making and thus should be modeled in more detail.

The third structure was a three decision maker model, in which the regulator, the industry/developer and the environmentalists/impacetees are represented by separate decision analytic models (see v. Winterfeldt, 1978). These models are interconnected by a signal detection type model to link the regulators' decision through possible detections of violations and sanction schemes to the industry model; and by an event tree of pollution generating events and effects which links the developer's decisions to the impacete model (see Figure 5).

Insert Figure 5 about here

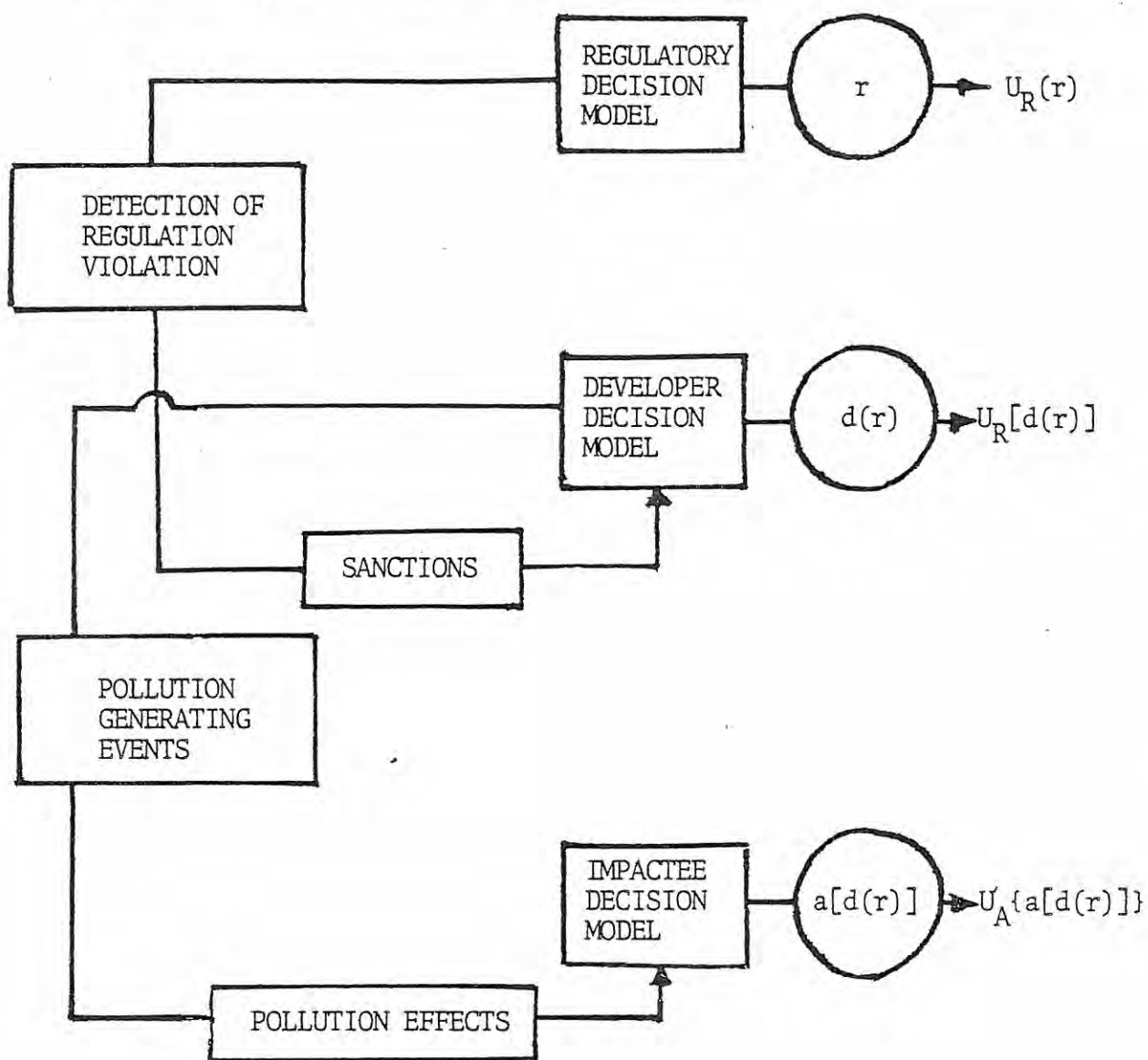
The model can be run as follows: the regulator's alternatives are left variable. The developer's response is optimized in terms of minimizing expected investment, operation, and detection costs or maximizing equivalent expected utilities. Finally, the impacetees are assumed to maximize their expected utility conditional on the regulator's and the developer's decision. At this point the model stops. The structure only provides for a Pareto optimality analysis of the three expected utilities accruing to the generic decision units.

This model allows some detailed analyses of the probabilities and value aspects of the standard setting problem, and it proved feasible in a pilot application to chronic oil discharge standards (see v. Winterfeldt, 1978). Regulators who were presented with this model, considered it meaningful, and it offered several insights in the standard setting problematique. Yet, there was a feeling among analysts and regulators that the static character of the model and the lack of feedback loops required improvement.

The final structure considered was a game theoretic extension of the three decision maker model. The structure of the game theoretic model is presented in Figure 6.

FIGURE 5

Schematic Representation of the Regulator-Developer-Impactee Model



r : variable standard of the regulator

$d(r)$: expected utility maximizing treatment decision of the developer

$a(d(r))$: expected utility maximizing decision of the impactees

 Insert Figure 6 about here

In this model the standard setting process is explicitly assumed to be dynamic, and all feedbacks are considered. In addition, transitions from one stage to another are probabilistic. The model was applied in a seven stage version in a pilot study of noise standard setting for rapid trains (Höpfinger and v. Winterfeldt, 1978).

The game theoretic model overcomes the criticisms of the static decision analytic model, but in turn it gives up the possibility for fine tuning and detailed modeling of trade-offs and probabilities. Considering such aspects in detail would have made the running of the model impossible. Therefore, relatively arbitrary (linear) utility functions and simple structures of transition probabilities have to be assumed.

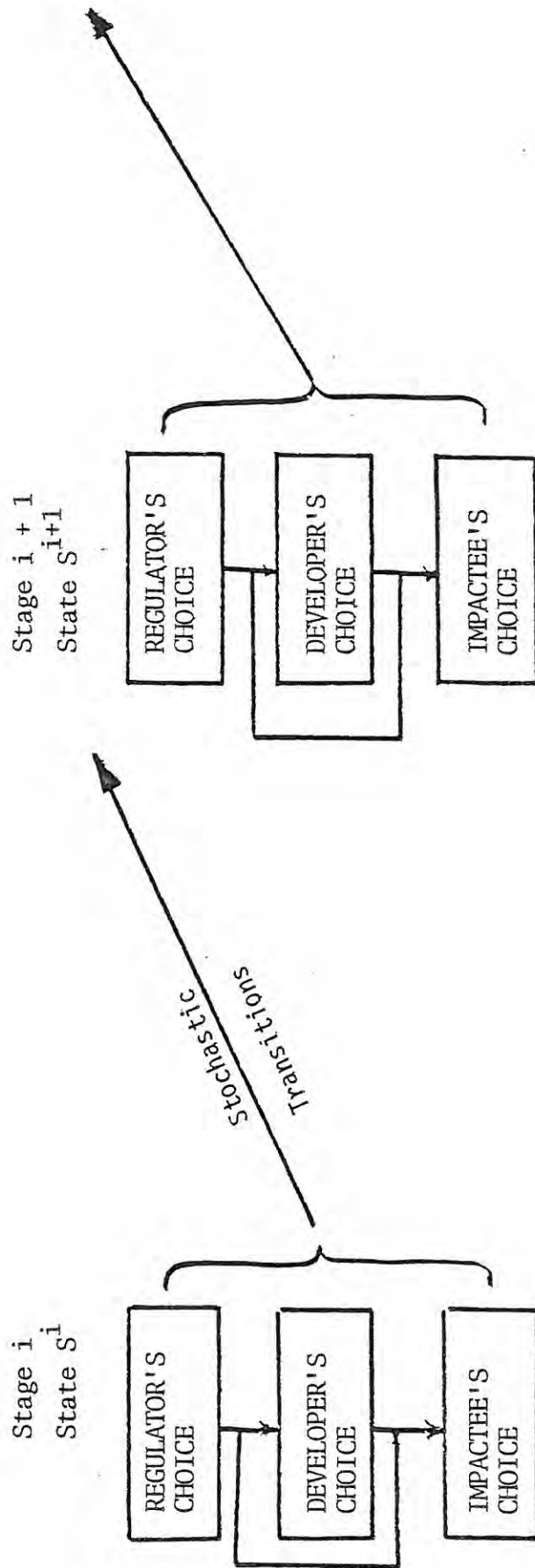
So much for the four different structures. Naturally, we did not consider all structures simultaneously, but they evolved based on our own and regulators' perceptions of the appropriateness of the representation. Such considerations included the questions: is the model meaningful? are all important aspects addressed? is it manageable from a computational point of view? and, perhaps most importantly in terms of the project objectives, is it generalizable to other standard setting problems?

The appropriateness of the different structures was never explicitly addressed, and I would also like to dodge it here. It suffices to say that the overall conclusions of many discussions with regulators, analysts, industry representatives, and the results of the pilot applications led us to accept the third structure as a prototypical decision analytic structure for relatively routine emission standard setting problems. The model is presently considered for further applications in emission standard setting and an extension to safety standards will be explored.

TOWARDS A KIT OF PROTOTYPICAL DECISION ANALYTICAL STRUCTURES

Not every decision analysis can afford to be as broad and time consuming as the previous study. Decision analysis usually has a much more specific orientation towards producing a decision rather

FIGURE 6
Game theoretic structure of the regulation problem



than a generic structure and model. Still, I think, that it would be helpful, if analysts make an effort in addressing the question of generalizability when modeling a specific problem, and extract those features of the problem and the model that are transferable. Such an inductive approach could be coupled with more research oriented efforts as the standard setting study, and with examinations of similarities among past applications. Such an approach may eventually fill the middleground between too specific and too general models and structures. But rather than filling this middleground with analytically specific but substantively empty structures and models such as OPINT or EVAL, it would be filled with prototypical structures and models such as the above regulation model, more refined signal detection models, siting models, etc.

In the following, four typical classes of decision problems (siting, contingency planning, budget allocation, and regulation) are examined and requirements for prototypical structures for these problems are discussed.

Facility siting clearly is a typical decision problem. Keeney and other decision analysts have investigated this problem in much detail and in a variety of contexts. (see the examples in Keeney and Raiffa, 1976). A typical aspect of such siting problems is sequential screening from candidate areas to possible sites, to a preferred set, to final site specific evaluations. Another aspect is the multiobjective nature with emphasis on generic classes of objectives: investment and operating cost, economic benefits, environmental impacts, social impacts, and political considerations. Also, the process of organizing, collecting, and evaluating information is similar in many siting decision. Thus it should be possible to develop a prototypical structure for facility siting decisions, simply by assembling the generalizable features of past applications.*

* I believe that Keeney's forthcoming book on siting energy facilities is a major step in that direction. Of course, it could also be a step in the opposite direction. Or in no direction at all.

Contingency planning is another recurring and typical problem. DDI addressed that problem in the military context, but it also applies to planning for actions in the case of disasters such as LNG plant explosions or blowouts from oil platforms. Substantive aspects that are characteristic for contingency planning are: strong central control of executive organs, numerous decisions have to be made simultaneously, major events can drastically change the focus of the problem, no cost or low cost information comes in rapidly, and organizational problems may impede information flows and actions. Although, at first glance, decision trees seem to be a natural model for contingency planning, a prototypical decision model would require modifying a strictly sequential approach to accommodate these aspects. For example, the model should be flexible enough to allow for the "unforeseeable" (rapid capacity to change the model structure), it should have rapid information updating facilities without stressing too much the value of information (since most information is free), and it should attend to fine tuning of simultaneous actions and information interlinkages.

Budget allocation to competing programs is another typical problem. In many such problems, different programs attempt to pursue similar objectives, and program mix and balance has to be considered besides the direct benefits of single programs. Another characteristic of budgeting decisions is the continuous nature of the decision variable and the constraint of the total budget. MAU looks like a natural structure for budget allocation decision since it can handle the program evaluation problem (see Edwards, Snapper, and Guttentag, 1977). But neither the balance issue nor the constrained and continuous characteristics of the budget are appropriately addressed by MAU. A prototypical decision analytic structure would model an evaluation of the budget apportionment, or the mix of programs funded at particular levels. Such a structure would perhaps exploit dependencies or independencies among programs much like independence assumption for preferences.

Regulation covers a class of decision problems with a number of recurrent themes: three generic groups involved (regulators, regulated, beneficiaries of regulation), importance of monitoring and sanction schemes, usually opposing objectives of the regulated

and the beneficiaries of regulation, and typically highly political objectives of the regulator. In the previous section, the more specific regulation problem of standard setting was discussed, and a prototypical decision analytic structure was suggested. A decision analytic structure for regulation in general can build on the main features of the standards model.

This list could be continued, including private investment decision, product mix selection, resource development, diagnostic problems, etc. But the four examples hopefully are sufficient to demonstrate how prototypical decision analytic structuring can be approached in general. In my opinion, such approach to structuring could be at least as useful for the implementation of decision analysis as computerization of decision models. Besides the technical advantages of transferability, prototypical decision analytic structures would serve to show that decision analysts are truly concerned about problems. Today decision analysis books have chapters such as "simple decisions under uncertainty" and "multi-attribute evaluation problems." I am looking forward to chapters such as "siting industrial facilities," "pollution control management," and "contingency planning."

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Organisations and Uncertainty

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ABSTRACT

Uncertainty has figured prominently in modern writings on organisations. Most theorists are agreed that the structure of an organisation can be affected by the extent of uncertainty encountered in various functional areas, and that efficiency results only when the structure of the organisation is appropriate for the degree of uncertainty. For example, centralised, bureaucratic organisations are more suitable under conditions of high certainty, so the argument goes, while decentralised, entrepreneurial organisations are better at handling uncertainty. Most theorists would consider this formulation to be oversimplified, and other influences, such as the power of management relative to unions, the kind of technology used by the organisation and embodied in its products, the size of the organisation, and so forth, are postulated as interacting with uncertainty to affect organisational structure and function.

The first section of this paper provides an overview of the major theoretical approaches that consider the effects of uncertainty on the organisation. We consider not only influences on structure, but also the impact of uncertainty on organisational functioning, including the role relationships of individuals in the organisation. The section concludes with a critique of the varying interpretations of uncertainty encountered in this literature. Some theorists, for example, have located uncertainty in the environment, while others consider it to be a characteristic of decision makers.

The second section uses the framework provided by decision theory in an attempt to clarify and extend findings reviewed in the first section. Some of the conclusions that emerge from this section are:

1. Whatever its structure, and organisation may be characterised by a "Zeitgeist" that causes individuals in the organisation to be unaware of or misperceive uncertainty.
2. Neither centralisation nor decentralisation of all decision making functions is the appropriate response to uncertainty.
3. Appropriate organisational responses to uncertainty are determined by careful analysis of the decision making function, with limits of discretion for a given role set differently for the probability and utility components of decisions.

for acceptable risk, which may either deal with the probability of a specified loss or with the magnitude of a just-credible accident?

In this paper we will attempt to formulate some answers to the above questions. Our main concern will be, that (1) the definition of 'risk', (2) possible human reactions to risky situations, and (3) fundamental aspects of risky decisions, are treated in a coherent fashion. To the extent that this proves possible, we may end up with a reasonable language for discussing the seriousness and the acceptability of the risks of widely different societal and individual activities. Our treatment of 'risk' originates as a by-product from a large-scale empirical study on 'personal risk experience'²⁾. Due to limitations of both space and time, and due to the scope and complexity of the problem of 'risk acceptance', our discussion will be concise and informal.

2. What is 'risk'?

A number of definitions of risk will be briefly reviewed, mainly to revive the reader's memory. Comprehensive overviews of formal definitions of risk and the risk-preference relationship have been published by Coombs (1972), Libby and Fishburn (1977) and, very recently, by Schaefer (1978). The latter report might be considered to be a natural predecessor to the present paper.

For our discussion it will be convenient to refer to a simple decision tree. Figure 1 represents the choice between options A and $\bar{A}$. Option A is characterized by an uncertain event whose outcome is either a gain or a loss. There is a probability p^+ to obtain a gain C^+ , which has utility $u(C^+)$. With a (complementary) probability p^- one may obtain a loss C^- , which has utility $u(C^-)$.

Option A might, for example, represent the intention to transport a cargo of liquid petroleum gas (LPG). With a, presumably high, probability the transport is expected to proceed without any problems, and an intended goal will be reached. With a, presumably small, probability a road accident may occur whereby the LPG-tank breaks and its contents explode.

In figure 1, what is meant by 'risk', and what would it mean to 'accept' the risk(s) of option A? A qualitative definition of 'risk' might be: the complete description of possible undesired consequences of a course of action, and of their probabilities and (dis)utilities. Such a definition,

²⁾ This project, entitled "Personal experience of risks for the population in an industrialized area", is carried out under responsibility of the University of Groningen and under the auspices of the Committee on Risk Analysis of the Netherlands Royal Institute of Engineers.

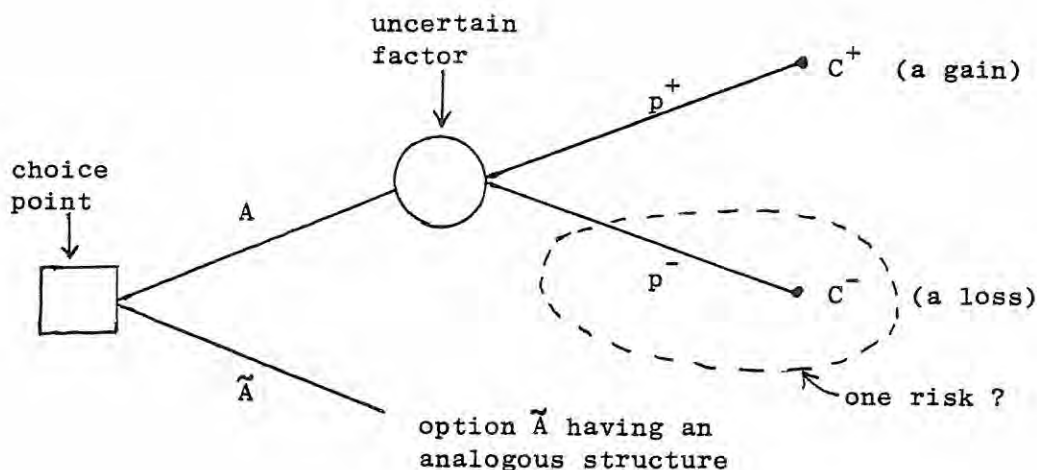


Figure 1: Decision tree representation of the choice between two options, A and $\tilde{A}$, which have analogous structures of uncertain consequences. p^+ and p^- represent the probabilities of winning and losing, while C^+ and C^- represent the possible gain and loss, respectively.

however, hardly offers any criteria for decisions on risk acceptance. Rather, the risk of a well-defined course of action should be defined as a quantitative variable called "the seriousness of the risk(s)". Let us consider five alternative definitions in the light of figure 1.

2.1. 'Risk' is the probability of loss. In figure 1: $R_1(A) = p^-$. This definition ignores the size of the possible loss, although it assumes that possible losses can be distinguished beforehand. It is useful to the extent that probabilities of differing losses can be transformed into probabilities of a standard loss, e.g. the death of one person during one hour of involvement in a risky activity (cf. Starr, Rudman, and Whipple, 1976). Working with simple laboratory gambles, Payne (1975) obtained evidence for the fact that probability of loss is a prime determiner of personal judgments of 'seriousness of risk'. Recent discussions on 'large-scale' industrial-societal activities suggest that this might not be true for risks involving really serious consequences.

2.2. 'Risk' is expected loss, i.e., the product of the probability and the (dis)utility of the possible loss³⁾. With reference to figure 1: $R_2(A) = p^-u(C^-)$. This definition originates from economics (Domar & Musgrave, 1944). It is also known from mathematical statistics, when some stochastic variable is to be estimated. Risk-as-expected-loss is a component of total expected utility. This definition allows one to talk about separate risks of an

³⁾ A variant of this definition is: 'risk' is the product of probability and undesired effect. As an analysis in terms of 'size of effect' necessarily implies a utility scale for 'seriousness of the effect', we prefer to talk consistently about utilities of (negative) consequences. We would not, however, close our eyes for the problem of 'personal accident evaluation'.

activity. In figure 1, the probability p^- of ending up with the loss C^- would represent one risk. When there are several risks associated to the same activity, the total risk (average expected loss) would simply be the probability-weighted sum of all possible undesired consequences. Notice that here, too, it is assumed that such consequences can be identified beforehand.

2.3. 'Risk' is the variance of the probability distribution over the utilities of all possible consequences. From figure 1: $R_3(A) = p^+ p^- [u(C^+) - u(C^-)]^2$. This definition takes losses and gains into account, and it does not require an a priori discrimination of desired and undesired consequences. It describes a risk parameter which is independent of total expected utility. To the extent that expected losses are sought to be compensated by expected benefits, risk-as-variance will generally be correlated with risk-as-expected-loss.

2.4. 'Risk' is the semi-variance of the utility distribution mentioned under 2.3. This definition is similar to the preceding one, but it is restricted to undesired consequences. Thus it might add an extra dimension to definition 2.2: one may not only consider the expected loss, but also the average squared deviation of the possible losses around their mean value (the expected loss).

2.5. 'Risk' is a linear function of the expected value and the variance of the distribution of consequences (Pollatsek & Tversky, 1970), where a free (personal) parameter is the relative weight assigned to each of these components. Neither Coombs & Bowen (1971) nor Payne (1975) confirm the empirical validity of this definition; they found that probability of loss in itself plays a significant role.

It is somewhat different to appreciate the results of experimental studies testing the empirical validity of these various definitions of risk⁴⁾. In the first place, laboratory tests which are representative of real-life are hard to design. Secondly, a concept like risk-as-expected-loss tends to be neglected because of the fact that it is a component of total expected utility; it cannot, therefore, be treated as a parameter affecting preference strength in an independent manner. At the same time, however, it seems to be the most practical definition, as it allows for analyses of separate unwanted consequences. Thirdly, and perhaps most importantly, there is very little control on how test subjects interpret

⁴⁾ Detailed overviews of elementary decision theory, and of empirical research on decision making under uncertainty may be found in Coombs, Dawes & Tversky (1970), Lee (1971), and Vlek & Wagenaar (1979). See also Slovic & Lichtenstein (1968), for a discussion of dimensions of risky decision.

instructions regarding required judgments of 'riskiness'. Perhaps 'seriousness of risks' (or: 'dangerousness') gets a different interpretation across different courses of action, depending upon the context of the decision problem, the amount and type of control one may exert, and the types of possible consequences.

We feel encouraged to continue on a more speculative and less formal course by some conclusions from recent studies. Having reported a series of precise experiments on the role of risk and expected value in determining preferences, Coombs, Donnell, and Kirk (1977, p. 36) conclude that

"the several good and bad aspects of lotteries other than expected value are cognitively composed into a one-dimensional variable that mediates preferential choice conditional on expected value. We call this variable risk".

Schaefer (1978) refers to the various 'risk dimensions' that are being proposed as obvious determinants of risk acceptance in recent analyses (e.g. Starr, 1969; Lowrance, 1976; Rowe, 1977; Fischhoff, Slovic, Lichtenstein, Read & Combs, 1978):

"Can all these aspects be taken into account to formulate a single theory of risk? Which are the mutual interconnections?" (Schaefer, 1978, p. 43)

3. Acceptability of risk.

Having assessed the riskiness of a proposed activity, we still are to decide whether the risks are acceptable. In terms of figure 1 'acceptability of the risk of A' implies that the decision maker would - at least in principle - be willing to select and carry out option A. Absolute acceptability would mean, that the attractiveness of A exceeds an adopted criterion value (which might be the utility of the status quo): Option A may be carried out if there are no better options available. Relative acceptability would refer to the comparative attractiveness of A among the set of available options. Thus we (optimistically) equate 'acceptability of risks' with 'attractiveness of course of action': decisions on risk acceptance (should) follow the general pattern of a formal decision analysis (which is not without criticism, see e.g. Kates, 1977, p. 26/27).

Acceptance and rejection of risk is viewed by some as following from 'risk attitudes'. These may be reflected in characteristic shapes of a curve representing utility as a function of some value attribute⁴⁾. Someone having a concave utility curve would weigh losses more heavily than comparable gains: he is risk-averse (alternatively, one might say that he overestimates the probability of loss relative to the probability

of gain). Someone with a convex utility curve would weigh gains more heavily than comparable losses: he is a risk seeker (alternatively: he might overestimate the probability of winning relative to the probability of losing). In this conceptualization 'risk' is a by-product of utility assessment; 'seriousness of risk' might be defined as the variance of the distribution of possible consequences; but one would not need to know the 'seriousness of risks' in order to be able to decide on risk acceptance: one judges the attractiveness of the option as-a-whole, not the seriousness of its associated risks.

An other strategy of decision relies on so-called norms for the acceptability of risks. On the basis of statistical analyses of historical data Starr (1969) made the following suggestions: (1) for so-called 'voluntary' activities the public is willing to accept a 1000 times greater risk (probability of death) than for involuntary activities; (2) the statistical risk of death from ('natural') diseases seems to be a psychological yardstick for judging the acceptability of other risks; and (3) the acceptable level of risk of an activity is roughly proportional to the 3rd power of its associated benefits. Starr's suggestions have proven untenable in a critical re-analysis by Otway and Cohen (1975), and they have been criticized on both statistical and psychological grounds by Slovic, Fischhoff and Lichtenstein (1977). Nevertheless, they constitute interesting research hypotheses deserving to be empirically tested.

In order to understand and further specify such hypotheses, however, one would want to examine what psychological mechanisms are operating under 'voluntariness of exposure' to risks; one might wonder whether 'risk of death from diseases' as a yardstick should perhaps be generalized towards the notion of a 'constant (optimal) level of risk acceptance'; and one might ask to what extent a weighing of risks against benefits does indeed underly risk acceptance decisions, which seems to be determined by a host of other factors as well.

The various risks of an activity may be charted in a graph representing accident probability as a function of size-of-catastrophe (see e.g. Starr, Rudman & Whipple, 1976). We might call such a graph the risk profile of an activity. Starr et al. (1976) point at a 'law of risk' reflected by the logarithmic relationship between probability and magnitude of possible accidents, which seems to exist for various activities. Some regulatory agencies (e.g. the Dutch provincial department of water-ways 'Provinciale Waterstaat Groningen', 1977, and the Rotterdam regional public authority 'Openbaar Lichaam Rijnmond', 1978) have proposed to draw into such graphs criterion lines which would separate the acceptable risk profiles from the unacceptable ones. Figure 2(a) gives an example. If risk is defined as the

product of the probability and the (dis)utility of an accident - as we prefer to do - such criterion lines would imply a utility scale for accident size (e.g., in terms of number of fatalities). For the logarithmized axes of figure 2(a) a criterion boundary of constant 'just acceptable' risk should be a straight line. We may change the solid curve into a straight line by transforming the abscissa from a number-of-fatalities-scale into a utility-scale. The resulting utility curve for number-of-fatalities is represented by figure 2(b).

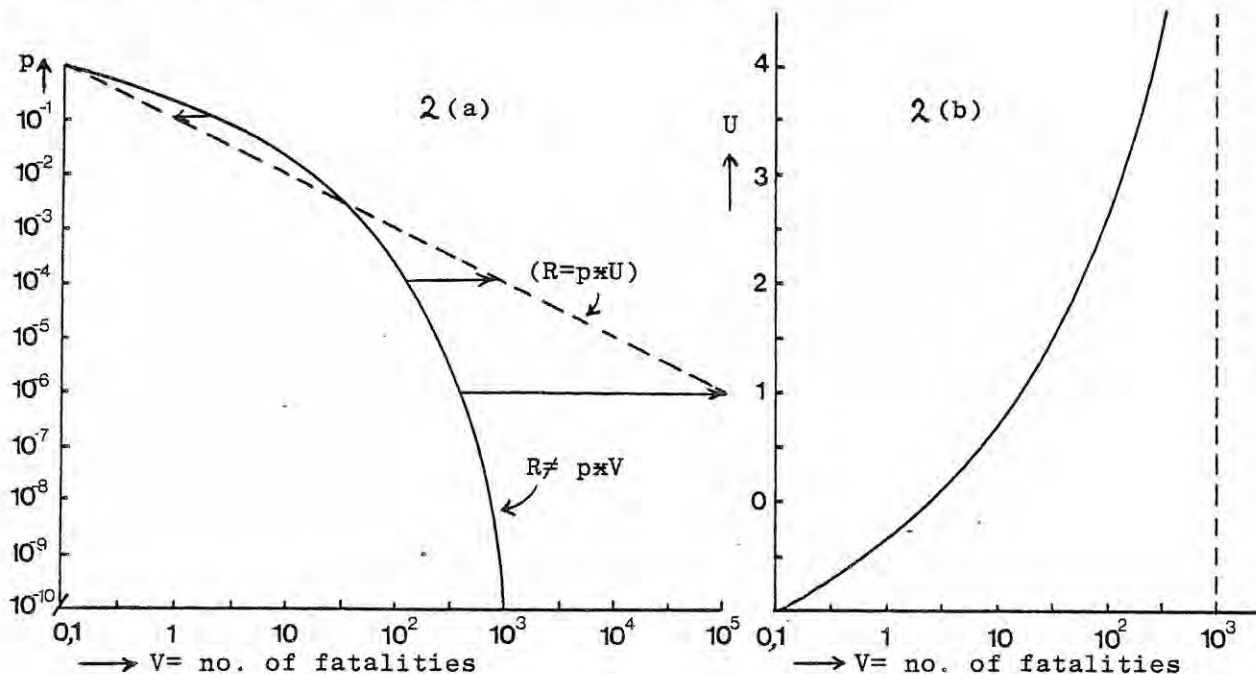


Figure 2. Panel (a) represents a critical curve of "just acceptable risk" in a graph of accident-probability against size-of-accident (no. of fatalities). Both the ordinate and abscissa are logarithmic scales. The dashed line in (a) would represent constant risk as a product of p and $u(V)$ which would be the required transformation of the V -scale. The implied utility function for 'seriousness of accident' is given in panel (b). The dashed line in (b) indicates that there is, in fact, a 'maximum admissible accident'.

Let us draw two conclusions from the above discussion. First, to discuss problems of 'seriousness of risk' and 'acceptability of risk' in a meaningful and consistent way, we have to adopt a definition of risk. We propose 'risk-as-expected-loss' (definition 2.2 above) as a practical solution. Secondly, since 'risk' is concentrated upon accidents and their magnitudes, any risk acceptance policy should have a collection of evaluation scales for 'seriousness of accident' as one of its pillars. Third, when it comes to a weighing of risks against benefits, one obviously needs evaluation scales for intended benefits as well. For a reasonably complete risk acceptance decision strategy, therefore, 'risk analysis' in the classical sense has to be accompanied by an analysis of intended goals and expected

benefits⁵⁾.

4. What is 'personal risk experience'?

'Perceived risk' or, more broadly, 'personally experienced risk', may be delineated in various ways. In general, it might be defined by describing the whole complex of measurable human reactions to a risky (decision) situation. Specifically, we may distinguish: (1) physiological measurements such as heart rate, electric skin conductance, and muscle tension; (2) behavioral measurements like revealed preferences, approach and/or avoidance behavior, and the realization of safety precautions; and (3) 'cognitive' measurements such as verbal descriptions, opinions, estimates of probability and utility, expressed preferences, and the like. Decision-theorists in the Von Neumann and Morgenstern tradition (should), of course, prefer behavioral measurements, whereas in fact many of them work with 'cognitive' measurements. Physiological measurements are unduly neglected in research on decision making (if we exclude psychophysics).

When 'perceived risk' is taken to stand for 'the detailed description and evaluation of a risky decision problem', one may want to distinguish a number of 'stages of decision process' (see, e.g. Janis & Mann, 1977; Vlek & Wagenaar, 1979). Peculiarities and weaknesses of personal risk analysis may then be identified at each hypothetical decision stage.

Several theories about human behavior in the face of risk deserve to be briefly discussed here. In his theory of a constant level of risk acceptance, Wilde (1978) states, that the caution with which a risky activity is carried out, is directly related to the judged seriousness of risks. By consequence, the actual number of accidents occurring during the activity tends to remain constant. Imposed safety precautions, e.g. in road traffic, will therefore only have a temporary effect: after a while the public discovers that things have become safer, so that they can relax their behavioral safety requirements (e.g. drive faster while wearing a safety belt).

The idea of a constant personal level of risk acceptance is discussed more precisely in theories on sensation-seeking versus anxiety-reduction. Zuckerman (1976) proposes a "two-factor theory of approach and withdrawal

⁵⁾ This remark may sound rather obvious to American readers who are already familiar to a methodology called 'risk-benefit analysis' (see ref. Starr, 1972). To European readers, however, and especially those practically dealing with industrial and government problems of risk analysis, the necessity of 'benefit analyses' may not yet seem to be fully understood.

from novel or risky situations'. It implies that an individual is characterized by an optimal level of arousal from novel or risky situations. The strength of a sensation-seeking drive increases as novelty or risk cause this optimum arousal level to be approached. Anxiety, however, increases monotonically with increasing novelty or riskiness. Therefore, when riskiness increases beyond the optimal arousal level, anxiety is going to dominate the sensation-seeking drive. The original approach activities of the subject change into acts of withdrawal: sensation seeking turns into risk avoidance. Zuckerman's (1976) model is summarily represented in figure 3.

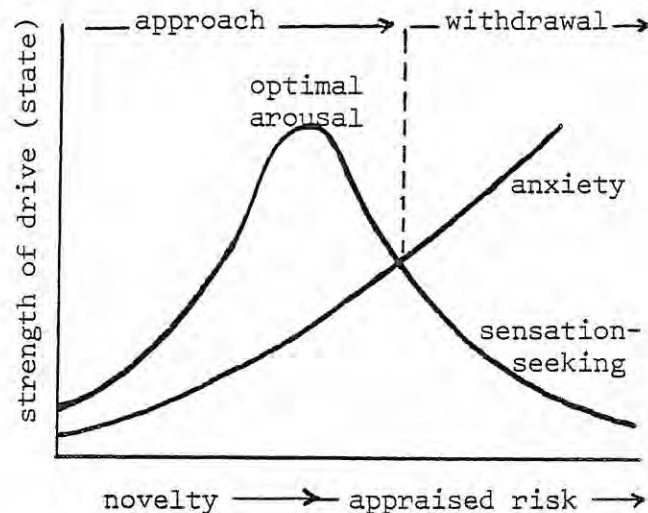


Figure 3. Sketch of Zuckerman's two-factor theory of approach-withdrawal reactions to novel or risky situations (see text).

A third theory of human reactions to risk is Janis & Mann's (1977, ch. 3) 'conflict model of decision making'. These authors state that there are four critical questions in emergency decision situations:

- (1) "Are the risks serious if I don't take protective action?" If the answer is "no", one may carry out the proposed action without problems, since its risks are judged acceptable. If the answer is "yes" or "perhaps" one goes on to the next question.
- (2) "Are the risks serious if I take the most available protective action?" If not, one may carry out the safer course of action, which now has acceptable risks. If "yes" or "perhaps", one asks the next question.
- (3) "Is it realistic to hope to find an acceptable solution?" If the answer is "no", the proposed action and all possible alternatives have unacceptable risks, and one supposedly gets into a state of 'defensive avoidance'; one attempts to gain time, displace responsibilities and/or justify the choice of too risky a solution. If the answer is "yes" or "perhaps" the next question is asked.
- (4) "Is there sufficient time to search for and evaluate an acceptable alternative?" If "no", one gets into a state of 'hypervigilance' with respect to signs of danger and possibilities for escape. Behavior is characterized by quick and impulsive choices. If the answer is "yes" or "perhaps", one adopts a state of normal vigilance; a thorough search and evaluation of an acceptable alternative appears possible.

Janis & Mann (1977) point at the fact, that any personal decision analysis is necessarily incomplete as long as the answer to the four questions is "no": one does not need to, or one cannot, thoroughly search for and evaluate possible alternative actions.

Let us draw a few conclusions. First, 'personal risk experience' may be measured at several different behavioral levels and in terms of (many) different variables. It is essential to specify exactly what measures one has in mind when one talks about 'perceived risk' or a related concept. Secondly, several theories suggest, that there is an optimal and rather constant level of risk acceptance. This seems to be paralleled by a critical balance between sensation-seeking and anxiety; and it may be more deeply resided in a person's capacity for processing information in problem solving and decision making. Thirdly, having to act under increasing levels of risk may have serious consequences for a person's information processing and decision strategies.

Let us now return to the problem of what it is in a decision situation, that might lead a person to judge that situation to be "risky".

5. Aspects of risk: fundamental characteristics of risky decision problems.

In the past there has been quite an amount of research into so-called personal risk taking tendencies (e.g. Kogan and Wallach, 1967). The unsuccessfulness of this research (cf. Slovic, 1971) may be due to the possibility that 'perceived risk' is situationally determined rather than personally (Kozielecki, 1974). Patterns of personal risk experience may be systematically related to fundamental characteristics of risky decision situations, such as, for example, one's relative freedom of choice, the controllability of decision consequences, and the type of basic need which is either fulfilled or frustrated by final consequences. Social factors, or the degree of confidence one has in experts or regulators may also very well have significant contextual effects on personal risk acceptance tendencies.

Such and many more 'aspects of risk' are being proposed and discussed in recent literature on risk analysis (Lowrance, 1976; Rowe, 1977; Ravetz, 1977; Kates, 1977; Fischhoff et al., 1978). In our own research, thorough examination of these proposals has led to additional aspects of risk.

The fact that such aspects have been proposed, forces the conclusion that, among other things, (accident-)probability and utility are too abstract, too formal, too global and therefore insufficient variables of risky decision. On the other hand, however, we hope to demonstrate that most of the various informal, concrete, specific, and more-encompassing

aspects of risk can be given a decision-theoretically meaningful interpretation.

In the following, some 31 specific 'aspects of risk' will be briefly presented and discussed. On psychological grounds they may be grouped under 11 categories. Seven of these categories pertain to the individual decision situation. They are summarized in table 1 (p.19). The remaining 4 categories comprise summary- and contextual variables. These are summarized in table 2 (p.20). We start with what Rowe (1977, p. 119) has called "the four most significant factors": (1) voluntariness, (2) controllability, (3) discounting in time, and (4) discounting in space. The several aspects of risk will be numbered through from 1 to 31. Occasionally we will refer back to the decision tree representation of figure 1.

5.1. Voluntariness of exposure.

Exposure to risks follows upon the actual selection of a risky activity. This category applies to the choice point in figure 1. Several factors determine whether the exposed person has, or had, little or much freedom to choose for or against (the risks of) option A.

(1) Availability of options. Perceived freedom is greatest when there is an optimum number of available options; when they are roughly comparable in attractiveness; and when all options have a positive rather than a negative over-all expected utility (Harvey & Smith, 1977, ch. 5).

(2) Personal influence on the decision generally influences someone's feelings of responsibility towards controlling consequences and accepting possible accidents. It is obviously related to someone's position in a group power structure.

(3) The possibility of radically changing and/or correcting the chosen action, when in execution, will enhance feelings of voluntariness, since one may shift or withdraw from the activity. This aspect of risk overlaps with aspects of 'controllability' to be dealt with below.

(4) The importance of intended benefits may be derived from elementary human needs, as well as from central personal or societal values. The more important the intended benefits are judged to be, the less "voluntary" one will feel the choice to be: the activity simply has to be undertaken. Human needs and values are often ordered in so-called need hierarchies (e.g. Maslow, 1970). Alderfer (1972) critically examined Maslow's 6-stage need hierarchy to end up himself with three basic (complexes of) human needs: "existence, relatedness, and growth" (see also aspect 16 below).

'Voluntariness of exposure' is an important factor in risk acceptance decisions. Starr (1972, quoted in Lowrance, 1976) has remarked that "we

are loath to let others do unto us what we happily do to ourselves". Otway & Fishbein (1977) found that nuclear power stations are mainly judged 'dangerous' because they imply 'involuntary exposure' to risks, and this was negatively valued by their subjects.

5.2. Controllability of consequences.

As soon as a course of action has been chosen (e.g. branch A in figure 1), an adequate control of its possible consequences becomes a relevant task. Concentrating on the risks we realize that in practice there always is an undivided accident-process. In order to discriminate chance-aspects from effect-aspects, we must somewhat (but now always) arbitrarily cut the accident-process in two halves. 'Controllability' then may be specified under four 'aspects of risk', as follows.

(5) Accident-probabilities may be more or less influenced by safety measures. In many cases an activity may be carried out in either a safe or an unsafe manner. Accident-probability may thus partly depend upon (trained) human skills, the existence of adequate written regulations, and the appropriateness of required equipment.

(6) Accident-probabilities are dependent upon opportunities for human error, recklessness, and sabotage. This factor supplements the preceding one (5).

The personal controllability of success- and failure-probabilities is an essential variable in human decision behavior. Research by o.a., Cohen & Hansel (1959), Howell (1971) and Walesa (1975) has demonstrated that subjects generally prefer to gamble for skill-dependent outcomes in comparison to purely chance-dependent outcomes, even if the probabilities of winning and losing have been equated. Langer (1975) has called this phenomenon "the illusion of control". It explains, e.g., the fact that so many automobilists overestimate the safety of their own driving (Svenson, 1978).

(7) Accident-effects may be more or less influenced by rescue operations. When the accident occurs, one may have done, or do, something to contain its net effects. Earthen dams around crude oil storage tanks are examples of a priori rescue measures. Activities of fire brigades and surgical teams may be termed a posteriori rescue operations.

(8) Accident-effects may be more or less reversible. If an accident has fully taken place (safety measures and rescue operations all having failed), the extent to which final consequences can be reversed, or undone, may be positively related to risk acceptance.

'Controllability of decision consequences' seems to be one of the most important psychological factors in personal risk experience. Harvey &

Smith (1977, ch. 4) conclude that 'perceived control' depends upon the extent to which someones actions (co-)determine the consequences of any activity, but also upon the amount of prior knowledge about possible consequences. In a pilot-study on risk perception Swaton et al. (1976) end up with an ordering of (pictures of) various risky activities along an "active-passive" dimension, which is best described by the varying amount of control a potential victim has over his situation. In Otway & Fishbein's (1977) study another reason for judging nuclear power as 'dangerous' appeared to be the passivity with which the risks had to be lived with. In a somewhat larger factor-analytic study on attitudes about nuclear energy, Otway, Maurer & Thomas (1978) identified a primary 'psychological risk factor' which grouped together such aspects as 'involuntary exposure', 'uncontrollable consequences' and 'possibility of large catastrophes'.

5.3. Distribution of consequences in time.

Time-preferences (cf. Von Winterfeldt & Fischer, 1975) have a strong effect upon the evaluation and weighing of consequences. The simplest hypothesis is that, in general, man prefers immediate or short-term realization of desired benefits, and delay or long-term occurrence of undesired consequences. Tolerance for delay of benefits, however, increases as one grows up, and this seems to depend upon the increasing capacity to substitute 'symbolic activities' for the short-term acquisition of the real thing (Mischel, 1974). Effects of time-of-occurrence may be separately considered for benefits and undesired consequences of an activity.

(9) Intended benefits may be obtained sooner or later.

(10) Undesired consequences may have immediate or delayed effects.

The implications for risk acceptance are that risks might be compensated by the immediacy of benefits, and that undesired consequences with delayed effects (e.g. pollution, radiation, smoking) are discounted. The latter suggestion was nicely corroborated by the young subjects of Nisan & Minkowitch (1973). In choices among risky options having possible immediate losses, they preferred relatively high-probability/small-loss risks. When options were characterized by one-week-delayed losses, they would rather opt for relatively small-probability/large-loss risks. Ekmand & Lundberg (1971) found that the self-reported 'emotional involvement' of subjects gradually decreased with the extent to which a stimulus event had taken place longer ago, or would take place in a more distant future.

5.4. Distribution of consequences in (social-)geographical space.

What has just been said about time-effects may analogously apply to effects of the spatial distribution of consequences. Here we are dealing with distance-preferences. Again, an obvious hypothesis is: whatever happens further away from a person will affect him or her to a lesser extent. Again, we consider benefits and undesired consequences separately.

(11) Benefits may occur closer-by or farther away.

(12) Undesired consequences may occur at a greater or shorter distance.

Ekman & Bratfisch (1965) observed that self-reported emotional involvement of subjects gradually decreased with increasing geographical distance between the subject and the location of the stimulus event. In a pilot-study Maderthaner et al. (1976) found that the risks of nuclear power were judged highest by subjects living at a moderate distance (abt. 1,5 kms) of a nuclear power station. Those who lived farther away or closer-by (tenants of holiday homes at abt. 500 m.) judged the risks to be appreciably lower. Maderthaner et al.'s (1976) findings should probably be explained by a number of different aspects of risk, not just varying distance.

Distant consequences are likely to affect other people rather than oneself or one's close friends and neighbors. To the extent that the benefits of an activity are enjoyed "here", while the risks exist "there", we may speak of social inequity in the distribution of desired and undesired consequences. Social inequities may be defined in terms of other aspects such as, e.g., voluntariness of exposure, or controllability of consequences. Their existence and continuation, however, seem to be best explained in terms of distance-effects.

5.5. Context of probability assessment.

Ignoring the normally high probability of intended benefits, we believe that three factors strongly affect personal assessments of accident probabilities.

(13) Personal probabilities depend upon judged (relative) accident frequencies.

(Relative) frequency judgments may be based on selective perception or recall of past events (Vlek, 1970). They are dependent upon the way statistical information is presented (Wagenaar, 1977). Extremely small frequencies may easily lead to 'impossibility' judgments (cf. Jordan, 1968; Slovic, Fischhoff, Lichtenstein, Corrigan & Combs, 1977).

(14) Personal probabilities depend upon the imaginability of events causing an accident to occur. Imaginability of accident-causation is, of course, strongly dependent on relative frequency. It also depends, however,

upon the availability from memory, and the ease of mental construction, of the accident scenario (Tversky & Kahneman, 1974). Imaginability of consequences lies at the root of the time and distance preferences discussed before.

(15) Probabilities may be assessed with greater or lesser ambiguity.

Such ambiguity increases total uncertainty. Experimental subjects appeared to be willing to pay extra money for reductions in chance-ambiguity (Becker & Brownson, 1964). Ambiguity may be seen as an attribute that affects total expected utility in a negative way (Toda & Shuford, 1965).

5.6. Context of accident-evaluation.

Accident-effects are often multidimensional. The following factors are believed to influence personal estimates of the seriousness of accidents.

(16) An accident is more serious to the extent that it violates central values or frustrates basic needs. This connects to aspect 4 (importance of intended benefits), where Alderfer's (1972) 3-stage need hierarchy was mentioned. Rowe (1977, p. 67) offers an eight-stage 'hierarchy of risk consequences' concerning: premature death, illness and disability, survival factors, exhaustible resources, protection of rights and property, belonging and love, egocentric (personal status) aspects, and self-actualization. Otway & Pahner (1976) distinguish physical/biological harm to man and environment, damage to the psychological well-being of persons, and damage to social structures and cultural values. In light of such consequence-classifications an accident may be judged to be more or less catastrophic, or 'dreadful'.

(17) Accident-effects may be more or less imaginable. We separate this aspect from aspect 14 above although it may interact with it. Accident-effects may be judged as more serious the better one can imagine them.

(18) The seriousness of an accident may be assessed with greater or lesser ambiguity. Any of the factors contributing to 'seriousness of accident' may leave room for ambiguity in assessing over-all seriousness. Greater ambiguity about 'how the victim will feel' may increase judged seriousness of the accident.

5.7. Combinations/interactions of accident-probability and -seriousness.

In the combined evaluation of probability and (dis)utility - i.e., in judgments of 'risk' - there seem to be one 'aspect of risk' and a few judgmental biases.

(19) Equivalent expected losses may be categorized as (relatively) high-probability/small-loss risks versus low-probability/large-loss risks.

Starr, Rudman & Whipple (1976) have labeled the seemingly 'natural' variations along this dimension 'a law of risk'. Slovic, Fischhoff, Lichtenstein, Corrigan & Combs (1977) noted that U.S.-inhabitants insure

themselves more often against high-probability/small-loss risks than against rare, but catastrophic accidents such as floods and earthquakes. Differences in the rate of accident occurrence, and in corresponding opportunities for adaptation and learning, may explain such findings.

Besides this aspect of risk we emphasize the occurrence of interactions between judgments of probability and utility, such as 'optimism' vs 'pessimism' (see the review by Sjöberg, 1976), and of positive effects of increasing certainty on consequence utility (cf. Kahneman & Tversky's (1979) 'certainty effect').

5.8. Knowledge about the risky activity.

A decision maker may be knowledgeable about different aspects of a risky activity.

(20) One may be more or less informed about the benefits.

(21) One may have heard, read or seen more or less about the risks.

(22) One may have had a greater or lesser personal accident experience.

Aspects 21 and 22 are separated, as it seems plausible that direct accident experience leaves stronger memory traces than does indirect information.

Blomkvist (1978) notes that public information about risks of public transportation is often inadequate, while 'irrational' phobias may prejudice the evaluation of risky courses of action. Non-experienced accidents are very difficult to imagine; man basically is a trial-and-error learner who is strongly conditioned by his actual experiences (Slovic, Fischhoff & Lichtenstein, 1976).

5.9. Mental/physical condition of the subject.

Risky activities are always judged by (groups of) human individuals. The state or condition of the judge may deeply influence his risk assessments.

(23) Relatively permanent personal characteristics such as, e.g. sex, age, education, and neuroticism, may be more or less favorable to risk acceptance.

(24) Relatively temporary personal conditions such as, e.g. fatigue, and various kinds of (drug-)intoxications, may strongly influence risk acceptance.

As aspects 23 and 24 in fact refer to whole complexes of hypothetical influences, it is too hard to separate out and document the many possibilities here. The following aspect may be ordered under both 23 and 24.

(25) Someone's daily life may, on average, imply a high or a low total risk level. Too often the fact is ignored that the risks of proposed new activities are added to those already accepted. In light of this risk-accumulation it seems unreasonable to compare new risks with already-accepted ones, and to decide that the new ones are acceptable when they are smaller than the old ones (cf. Starr, 1969).

5.10. Social considerations, norms and motives.

It is beyond the scope of this paper to explore the role of social factors in depth. It is obvious, however, that their effects must be considerable, especially when an individual cannot, or does not want to carry out his own personal decision analysis. Let us consider just a few important factors.

(26) The ratio of intended benefits to expected losses of an activity may be favorable or unfavorable to the subject compared to significant other persons. This factor is studied in the context of social comparison theory (Festinger, 1954). One hypothesis is, that people generally strive for benefit/loss ratio's that are higher than, but not too different from those that exist for significant others.

(27) Voluntariness of exposure may be more or less evenly distributed among the population. This is an aspect of social equity which has been discussed in section 5.4. (spatial distribution).

(28) Controllability of consequences may be more or less evenly distributed among the population. This aspect of social equity concerns the distribution of knowledge, power, and other means for adequate control.

(29) Social norms and customs may cause certain risks to be always, or never, questioned. Examples seem to be: the risks of medical care ("don't talk about it"), and the personal handling of electrical installations ("please be careful!").

5.11. Confidence in experts and regulators.

One's own judgment, freedom of choice, and power of control are often severely limited. Such personal limitations may be lived with, to the extent that one can have confidence in those, whose expert and entrusted task it is to analyze and take far-reaching decisions.

(30) Experts and regulators may be more or less (thought to be) substantively informed about the subject-matter of the decision.

(31) Experts and regulators may be (thought to be) following more or less suitable methods and procedures of decision making.

It seems plausible that there often exists a trade-off relationship between someone's degree of confidence in experts/regulators and his tendency to start his own personal decision analysis. Public authorities who are aware of this will tend to make confidence-raising decisions. The latter, as one knows, are not necessarily optimal.

6. Aspects of risk: summary, and relation to 'acceptability of risk'.

The 31 aspects of risk discussed above are summarized in tables 1 and 2, where, at the same time, hypothetical relationships with risk acceptance

tendencies are suggested. Sometimes an aspect of risk could only be formulated too globally to allow for a reasonable specific hypothesis. In such cases the tables contain almost trivial suggestions. Table 1 (page 19) comprises the first 7 categories of aspects of risk. These mainly pertain to the individual description and judgment of a risky activity. In table 2 (page 20) the last 4 categories of aspects of risk are summarized. These concern either summary variables or more global contextual aspects.

7. Structure and coherence of the set of aspects of risk

In the preceding text we have attempted to give each aspect of risk a decision-theoretic interpretation. Different aspects of, e.g., 'voluntariness of exposure' and of 'controllability of consequences' appeared to pertain to different components of the decision tree representation of figure 1. This was also true for other aspects of risk.

In figure 4 (page 21) we present the results of an attempt to draw up an ordered structure of aspects of risk which is meaningful from a decision-theoretic point of view. We encourage the reader to compare the psychological categorization of aspects of risk in tables 1 and 2 with the decision-theoretic structure in figure 4, which will be explained below.

The judgment about the acceptability of a risky activity is directly influenced by the 'utility of intended benefits' and the 'seriousness of risks and dangers'. Also, it is directly influenced by 'voluntariness of exposure', 'condition of subject', 'confidence in experts/regulators', and 'social factors'. Since this is a paper on 'risk', aspects of risk have been elaborated in most detail under 'seriousness of risks and dangers'. 'Accident-probability' and 'seriousness of accident' are considered as formal abstractions from a number of lower-ordered aspects of risk. Their influence may be surrounded by more or less 'ambiguity'. For reasons of space, the categories labeled 'state of subject' (5.9), social factors (5.10), and 'confidence in experts/regulators' (5.11) have not been elaborated in figure 4.

From top to bottom a feedback-loop has been drawn into the figure. The underlying thought is, that one can only obtain adequate knowledge about a risky activity, when it is, or has been, actually carried out. This implies, that at some point in time someone has decided that the activity was acceptable. The acquired knowledge primarily concerns the nature and value of benefits and losses. In addition, however, one may obtain information about social effects of the activity and about the manner in which it affects one's own mental/physical condition. The dashed part of

Table 1: First 7 categories of fundamental aspects of risky decision problems. The implied relationships with 'acceptability' are hypothetical. See table 2 for more global characteristics.

IT IS HYPOTHESIZED, THAT THE RISKS OF AN ACTIVITY ARE (UNTHINKINGLY, TACITLY, VOLUNTARILY, OR PERFORCE) MORE READILY ACCEPTED TO THE EXTENT THAT:

(5.1. VOLUNTARINESS OF EXPOSURE)

- (1) there are fewer comparable options available;
- (2) someone's personal influence on the decision is larger;
- (3) correction or change of the selected action is easier;
- (4) the importance of intended benefits is larger;

(5.2. CONTROLLABILITY OF CONSEQUENCES)

- (5) accident probabilities can be influenced by safety measures;
- (6) there is more room for human error, recklessness, and sabotage;
- (7) accident-effects can be contained by rescue operations;
- (8) accident-effects are reversible;

(5.3. DISTRIBUTION OF CONSEQUENCES IN TIME)

- (9) intended benefits are obtained at a shorter term;
- (10) undesired consequences have delayed (a.o.t. immediate) effects;

(5.4. DISTRIBUTION OF CONSEQUENCES IN SPACE)

- (11) intended benefits materialize at a shorter (social) distance;
- (12) undesired consequences occur at a greater (social) distance;

(5.5. CONTEXT OF PROBABILITY ASSESSMENT)

- (13) judged (relative) accident-frequency is lower;
- (14) imaginability of accident-causation is less;
- (15) final assessment of accident-probability is less ambiguous;

(5.6. CONTEXT OF ACCIDENT EVALUATION)

- (16) an accident violates less central values or less basic needs;
- (17) imaginability of final accident-effects is less;
- (18) final assessment of accident-seriousness is less ambiguous;

(5.7. COMBINATION OF ACCIDENT-PROBABILITY AND 'SERIOUSNESS')

- (19) risks are of the type 'relatively high-probability/small-loss';

Table 2: Final 4 categories of fundamental aspects of risky decision problems. The implied relationships with 'acceptability' are hypothetical. See table 1 for more specific aspects of risk.

IT IS HYPOTHESIZED, THAT THE RISKS OF AN ACTIVITY ARE (UNTHINKINGLY, TACITLY, VOLUNTARILY, OR PERFORCE) MORE READILY ACCEPTED TO THE EXTENT THAT:

(5.8. KNOWLEDGE ABOUT THE RISKY ACTIVITY)

- (20) one is better informed about intended benefits;
- (21) one has heard, read, or seen less about the risks;
- (22) one has a lesser relevant personal accident experience;

(5.9. CONDITION OF THE SUBJECT)

- (23) someone's permanent condition favors risk acceptance;
- (24) someone's temporary condition favors risk acceptance;
- (25) someone's accumulated 'risk-load' is lower (or: more optimal);

(5.10. SOCIAL CONSIDERATIONS)

- (26) the benefit/loss ratio is relatively favorable the subject;
- (27) voluntariness of exposure is equitably distributed;
- (28) controllability of consequences is equitably distributed;
- (29) social traditions, norms and customs favor risk acceptance;

(5.11. CONFIDENCE IN EXPERTS/REGULATORS)

- (30) experts/regulators are (thought to be) substantively competent;
- (31) experts/regulators are (thought to be) using optimal strategies.

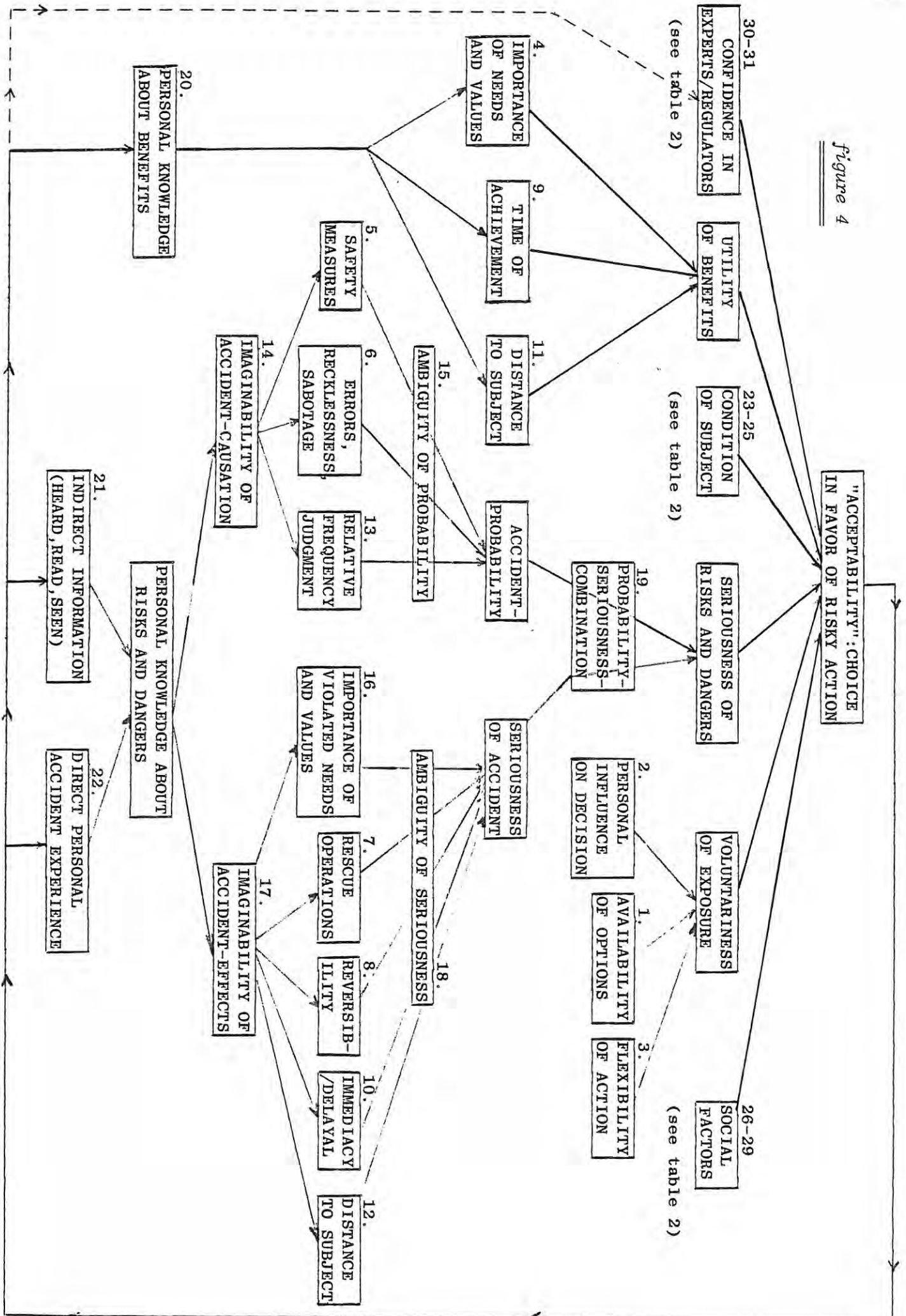
the feedback-loop indicates that one may not process the available information oneself, but let it pass on to the responsible experts and regulators.

8. Fundamentally different kinds of risky activities.

Given this large collection of aspects of risk, quite a few basically different kinds of risky activities could theoretically be distinguished. In reality, however, the various aspects are strongly interrelated, mainly for two reasons. First, there are aspects of risk which overlap or mutually influence each other. This is, e.g., the case with 'imaginability of accident-causation', 'judged accident-frequency', and 'ambiguity of probability assessment'.

Secondly, there exists a certain 'natural' correlation and clustering

figure 4



of aspects of risk. At one side, for example, there are activities about which most citizens in our society have personal freedom of choice and control. From the individual's viewpoint, such activities are often characterized by voluntariness of exposure, controllability of consequences which are limited in time and space, and fairly imaginable accident-scenarios and -effects, while the risks are of the type 'relatively high-probability/small-loss'. One might say that such activities originate from small-scale psycho-technical systems.

At the other side, there is a class of activities which are only undertaken under strong government supervision and control. From the individual's viewpoint they are often characterized by the opposite of the above-mentioned aspects. One might say, that such activities originate from large-scale socio-technical systems.

These two classes of activities are fundamentally different from one another, and they may elicit radically different personal risk experiences. Fischhoff et al. (1978) had 76 'politically enlightened' respondents judge some 30 risky activities with respect to each of 10 different aspects of risk. A subsequent factor-analysis revealed 2 clusters of aspects. Factor I, which explained about 60% of the variance, discriminated risks which had been judged to be 'involuntary, delayed, unknown to exposed, unknown to science, uncontrollable, new, catastrophic, and dreadful', from their opposites. Examples are the risks of: nuclear energy, use of pesticides, food coloring, use of spray-cans and food-preservatives, as opposed to: several individual sports, fire fighting, police work, riding (motor) bicycles, and hunting. The second, less important, factor seemed to separate 'fatal, dreadful, and catastrophic' risks from their opposites. Future studies might expand upon this research to discover and describe basically different psychological risk patterns, as they relate to fundamental aspects of risky activities.

A basic hypothesis of cognitive psychologists seems to be that man is a limited and often biased processor of information. To some extent this is reflected in the way in which the various aspects of risk have been documented and explained. From these arguments one might derive a Leitmotiv for decision making about newly proposed large-scale activities of socio-technical systems. Sjöberg (1977, p. 26) has phrased this as follows:

"Avoiding large-scale and vulnerable technological systems may then be a sort of superordinate rational principle that should be taken into account in addition to risk analyses of those systems themselves. (...) Maybe common sense rationality is more rational than articulated risk analyses after all."

In section 9 the suggestion is made that 'common sense rationality' in fact implies a value-orientation.

9. What value may the structured collection of aspects of risk have?

First of all, the collection brought together in tables 1 and 2 and in figure 4 provides a positioning and structure of basis characteristics of risky decision problems. As such it may strengthen possibilities for meaningful discussion and analysis of risky activities.

Secondly, the scheme of figure 4 may be used as a normative framework for rational decisions about risk acceptance. As such it certainly is demanding, but the complexity of risk acceptance decisions is also acknowledged by others:

"The judgment of a risk being 'worthwhile' presupposes the following: that each person undergoing the risk has access to the best available knowledge of its causes, its probability of occurrence and its likely consequences; that he can assess the probable costs and benefits of the given risk in comparison to those arising from other possible courses of action; and that he is free to choose whether he will expose himself to the risk or not" (Ravetz, 1977, p. 38).

If we distinguish between informative and evaluative aspects of risk, it may be contended that, in figure 4, the evaluative aspects dominate. Risk acceptance decisions seem to depend more strongly upon a so-called 'value-orientation' (cf. Stallen & Meertens, 1977) than upon factual information and inference about the system underlying the activity. Evaluative questions are: "How preferable are voluntary exposure, controllable consequences, time- and spatial limitations of consequences, and delegation of responsibility to experts and regulators?" They seem to dominate informative questions like: "Which cause-effect-relationships characterize the system; how much room is there for safety measures and/or sabotage; what final accident-effects may occur; how large is the historical relative accident-frequency?"

Third, the scheme of figure 4 may be used as a framework for describing risk judgments of (groups of) individual persons. Relevant questions are: which subset of risk-aspects is most pertinent for certain people? Are structural relationships among several aspects different for different people? May 'powerlessness' and 'indifference' be reflected in an ill-differentiated perception of risks?

Finally, the scheme of figure 4 is flexible. However it is going to be used, it may (and should) always be tuned towards the particular risky activity under consideration. Perhaps it then will soon appear that a reduction and condensation is both necessary and desirable for a more parsimonious distinction of fundamentally different kinds of risky activities. At all times, however, a rational economic-statistical decision theory may at most (continue to) provide a number of organizing principles.

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Decision making and experience

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In 1959, Goldberg published a study in which he compared experienced clinical psychologists and secretaries with respect to their ability to make diagnoses of brain damage. The diagnoses were made from the Bender Gestalt Test, a widely used instrument developed for the purpose of making diagnoses of this kind. The results were as clear as they were surprising: There were no differences between the two groups, clinical psychologists were no better than secretaries in making these diagnoses.

Although these results are particularly striking, Goldberg's study is but one of many studies showing that even considerable experience with a clinical task does not make people very good at making the decisions required by this kind of task (see, for example, Goldberg, 1968, for a review of research on clinical judgment).

One reaction to this kind of findings has been to consider them confirmation of one's worst suspicions about clinical psychologists and psychiatrists. A more interesting way of looking at them is, however, to remind oneself that even psychiatrists and clinical psychologists are people just like the rest of us, and to note that we have in this literature a solid body of evidence that people just do not learn from experience. This may be a startling conclusion and certainly one that goes against some of our most cherished beliefs:

That experience improves our judgments and decisions.

It is possible to understand this conviction in terms of its roots in British empiricist philosophy, but the strength of the conviction suggests that it may serve, not only our scientific understanding, but that it has ideological functions as well (see Greeno, et al, 1978, for a discussion of this point). It is, however, a conviction that at least psychologists have not been able to keep without considerable cost. Part of this cost is that we have come to have what can only be called a perverse conception of the nature of experience.

This conception of experience is very well illustrated in the model of experience which is manifest in psychological experiments on learning, and it is nowhere more clearly expressed than in the so called paired-associates paradigm. In experiments in this paradigm, the subject is given a list of word pairs and asked to learn to give the second member of each pair as his response when presented with the first member as a stimulus. This is a task which subjects learn with little difficulty, thus seemingly vindicating the hypothesis that experience leads to valid knowledge. What these results show, however, is only that experience can lead to a modification of a person's mind. It does not show that the knowledge obtained in this manner will be valid, for as an object of knowledge, there is something very peculiar about a list of paired associates. This is that we know exactly what there is to be learned from this list. In the words of Karl Popper (e.g., 1963), the peculiar thing about such a list is that truth is manifest. The process of acquiring knowledge therefore becomes a simple matter of creating a mental picture

of the task, and if this picture is a faithful one, it also constitutes knowledge about the world. Thus, in this case, experience does indeed leads to valid knowledge.

But note why this is the case. The guarantee of validity is certainly not in experience itself. There is nothing in the experience which suggests that a given stimulus word will be followed by the same response word on each and every trial. The guarantee of validity does not come from experience. It comes from the experimenter who has assured the subjects, not only that there is something to learn, but also what there is to learn. This, rather than experience as such, guarantees the validity of the knowledge acquired in this paradigm. The paradigm thus may very well model the situation in teaching, where the teacher decides for the pupil what the truth should be in a given case, but it certainly does not model the situation in which a person is learning from experience.

Take the case of a clinician learning about diagnoses and treatment from his personal experience with patients. In this case, nobody will be able to tell him what there is to learn, or even whether there is anything for him to learn. He may learn what his colleagues think the correct diagnosis and treatment should be, but this is only learning about another person who knows what he thinks, but not about the patients. And just because the kind of treatment selected turns out to lead to recovery, this does not mean that the decision was correct, for, this recovery may have many causes other than the treatment given. Take, as an example, the belief in the efficacy of penicillin as a cure for sore throats! Penicillin, as we know, is a good cure for diseases

caused by bacteria, but sore throats are usually caused by viruses rather than bacteria, and for these, penicillin is not effective. Nevertheless, the patient recovers, but that is not because of the penicillin, but because the body's general ability to fight disease.

In these kinds of situations, then, truth is no longer manifest. Indeed, this is only the beginning of our problems. It is not only the case that the truth is not readily apparent; we may also distort the situation by our actions, so that what we could have learned will not be learned. We will return to this problem later in the paper, and we will start with the simpler case when we do not act, but learn from just observing the world.

Learning from observing the world

The problem of induction. The psychological problem of learning from experience is, of course, only the old philosophical problem of induction. As philosophers after Hume have agreed, this problem cannot be solved; inductive judgment cannot be justified in the way deductive judgment can be justified. The judgment may very well be true, and serve as a guide to action, but it cannot be shown to be true. The fact that it works says little about its truth, it just tells us that it works, and the explanation for why it works may be very different from what we think it is.

Whereas philosophers have given a lot of thought to the problem of induction, psychologists have generally not thought very much about the corresponding problem of learning from experience. They have been content to note that people change from experience, but they have not considered whether this

change leads to better knowledge. Instead, they have tended to take it for granted that experience leads to valid knowledge. Nor have they considered the problem of where our faith in experience may come from, given that the things we learn cannot be justified. Instead, they have simply accepted Hume's psychological theory of induction. This theory holds that as we experience many things of a similar kind, a "habit of mind" makes us believe that we will see even more things of this kind. Thus, when we have seen five white swans, we tend to believe that the next swan will be white also.

The problems with this theory are well known and have to do with the problem of similarity (Popper, 1963). It is all very well to say that our belief is strengthened when we see many similar things, but how do we know that the things that we encounter are really similar and instances of the same thing? This may not be very much of a problem in a psychological experiment on induction, such as a concept learning experiment where the things are colors and simple geometrical figures, stimuli that our evolutionary history has taught us to recognize. But what about the more complex stimuli encountered in the real world such as psychiatric patients, or political decision problems? Here, we have to contribute to the learning process by first deciding what things are similar and what things are not similar to form a basis for our induction. But for that, we need to have an idea of what the relevant characteristics are, i.e., we need to know what characteristics will lead to a useful classification. In short, we need to know what we are to learn, in order to learn it.

The learning process, therefore, cannot simply be a case of forming a mental picture of the world. It must be an active process of hypothesis testing. This leads to two problems for research; viz., the problem of where our hypotheses come from, and that of how we test our hypotheses. We now turn to brief review of what psychological research has to say on these two problems.

Hypothesis testing theories

Hypotheses testing theories have a long history in experimental psychology. Interestingly enough, the first theory of this kind was developed for discrimination learning in the white rat (Krechevsky, 1932) at a time when most psychologists would not allow a person to think or have hypotheses for fear of being accused of mentalism. This theory has then come to set the pattern for subsequent theories of this kind in psychology especially those within the area of concept learning. The most well known being that of Bruner, Goodnow, and Austin (1956).

The distinguishing characteristic of the situation to which these theories are supposed to apply, is that the subjects' task is to discover which of the dimensions of a series of stimulus objects are useful for dividing these stimuli into two or more classes.

For these theories, it is not very difficult to decide where the subjects' hypotheses come from. The hypotheses are simply sampled from the stimuli. The theories assume that the subjects are able to analyze the stimuli into their relevant components, and that they then try the usefulness of these components, either one by one, or in some combination.

These theories are thus only new versions of the old abstraction theories for concept formation. In their actual application, the theories tend to bypass the problem of abstraction, however, in that they are applied to the learning of stimuli, the components of which are already well formed concepts such as color and form. These experiments, therefore, are set up in such a way that the experimenter is certain that the subjects already have the hypotheses relevant to the task. This means, however, that these experiments do not tell us what we need to know, and the extension of these theories to situations where the components are not well learned concepts becomes very problematical. In short, we do not know whether these theories really apply to the learning of new concepts (see Bolton, 1972).

This is not the place to review all the results obtained with the experimental paradigms that have grown out of this conceptualization of concept learning, especially since there are already good reviews available (see, for example, Bourne, 1966, for a short introduction). One result is, however, of great interest in the present context. This is that subjects learning these kinds of tasks do so by means of trying to confirm hypotheses, rather than by trying to refute incorrect hypotheses, and that they rely mainly on those tests which provide them with positive information about the concept, i.e., information telling them what the concept is, and that they tend to neglect negative information, i.e., information telling them what the concept is not (see Bruner, et al., 1956, and the paper by Mynatt, Dokerty, & Tweney, 1977).

Confirmation will, of course, not teach the subjects about the actual validity of their hypotheses, but it will

only tell which hypotheses work, although the reason why the hypotheses work may be very different from what the subject thinks. In fact, it is clear that this kind of strategy may actually prevent the subjects from finding even rather simple relations in the task. An experiment by Wason (1960) gives a good illustration of this. In Wason's experiment, subjects had to find a simple rule by generating triplets of numbers. The rule was a simple monotonic series, so that any three numbers in an ascending order was correct, e.g., 1, 2, 3, or 1, 501, 10 000. However, an infinite number of complicated series will fulfill the condition of monotonicity, and subjects would use all sorts of rules, which fulfilled this condition, in addition to what the subjects thought that they did. Their rule would give them the correct answer, but it would nevertheless not be the correct rule, and a majority of subjects actually failed to find the simple rule of monotonicity.

In concept learning experiments, the neglect of negative information leads to slow and inefficient learning, but the strategy makes sense when one considers the conditions under which people usually have to learn. Negative information is clearly useful in a concept learning experiment where the subjects know the dimensions of the world. For example, if there are red and green squares, knowing that a green square is not an instance of the concept immediately tells us what the concept is. But to be told that a cat is not an elephant when one does not even know how many different kinds of animals there are, will not teach us very much about elephants. Being told what an elephant is, on the other hand, is highly useful

but not that this is the case only because there is a guarantee of truth in the very fact of being told. This can be given because this statement informs a person, not about the world as such, but about the kinds of concepts people have.

When we have to learn from outcomes, it may, in fact, be almost impossible to discover that one really does not know anything. This is especially true when the concepts are very complex in the sense each instance contains very many dimensions. In this case, there are too many ways of explaining why a certain outcome occurred, and to explain away our failures of predicting the correct outcome. Because of this, the need to change is not apparent to us, and we may fail to learn that our rule is, in fact, invalid, not only for particular cases but for the general case also. This is very clearly demonstrated in a series of experiments by Fischhoff and Slovic (1978). Their experiments show that even very limited amounts of experience with complex stimuli, such as handwriting samples and common stocks, leads to high and unwarranted confidence in one's ability to classify these stimuli when the subjects believe that they are in possession of a good rule for making the classifications.

However, even though the hypothesis-testing theories mentioned above are a step towards a general theory of how people classify stimuli, and thus also a step towards a theory of how people learn from experience, they are clearly not sufficient. This is because they do not cover the important problem of how relations between variables are learned. We now turn to this problem.

Learning relations between variables. A typical judgment task, such as a diagnostic problem in clinical psychology, requires, not only that one learns to classify patients but also, and perhaps to a greater extent, that you learn relations between variables, e.g., the relations between various symptom configurations and treatment outcomes. The process of learning the relations in tasks of this sort, e.g., the relation between MMPI scores and degree of illness, is made difficult by the fact that the relations among the variables are probabilistic rather than deterministic.

These tasks differ from the classification tasks discussed above in that it is not even theoretically possible to construct hypotheses by sampling aspects from the stimulus configurations. A relation between two variables is not defined by any single instance, and even if multiple instances are available, they have to be ordered for the before the relation can be detected. Such an ordering does, of course, presuppose a hypothesis about the nature of the relation being looked for, so ordering does not provide any automatic solution.

Since the hypotheses about the nature of the relation between variables cannot come from the stimulus objects, they have to come from the subjects. That is, the subjects have to contribute the hypotheses. It is thus clear that what will be learned in this case will very much depend on what kinds of hypotheses the subjects will bring to the task.

In a series of studies, we have used various forms of probabilistic inference tasks to investigate this problem. hypotheses about relations that subjects bring to these kinds

The tasks have required the subjects to learn to use one or more cues to infer the state of a criterion variable which is imperfectly correlated with the cues. The only information given to the subjects is the correct criterion value on every trial, so learning takes place on the basis of outcome feedback only.

The first few studies (Brehmer, 1974; Brehmer, Kuylenstierna, & Liljergren, 1974) were directed at the problem of how subjects find the functional relations between two variables. The results agreed quite closely with the predictions from a hypothesis sampling model based on the assumption that subjects have a limited number of hypotheses which are ordered in a hierarchy according to strength, and that they sample and test hypotheses in the order determined by the relative strengths of these hypotheses. Later experiments have shown, however, that subjects are also able to construct some new hypotheses not in their hypothesis hierarchy, and that they are thus not limited to learning only the few rules about which they have hypotheses in their hierarchy (Brehmer, 1976a, 1979; Brehmer & Kuylenstierna, 1979). But even though such constructions are possible, linear hypotheses are by far the dominant ones. This has been interpreted to mean that linear relations are the most common relations in real world inference tasks (Brehmer, 1974). However, the results of Dawes and Corrigan (1974) suggest a different interpretation.

Dawes and Corrigan showed that a linear model, and even one with unit weights, provides a good approximation to most judgment tasks. If equipped with such a model, the person is simply

not likely to find any better model. It is only in the, probably rare, case when the relations between a cue and the criterion is not conditionally monotone, that the subjects may find that there is a better alternative to their linear model. Thus, if the cognitive system had to use only one model to use for judgment, a linear model is what it ought to use. Under these circumstances, it is hardly surprising that this is indeed the most common model used by subjects.

Further studies showed, however, that functional rules, such as linear and U-shaped functions were by no means that only rules considered by subjects in these tasks, even though they tended to prefer these kinds of rules. Figure 1 gives a summary of the results of our experiments.

 Insert Figure 1 about here

As is shown in this figure, subjects prefer to assume that there is a rule, rather than that there is no rule, that this rule is deterministic, rather than probabilistic, that the values to be predicted from the cue values do in fact depend on these cue values, rather than on other aspects such as trial number, that the rule is functional, rather than non-functional, and that the rule is a positive linear function, rather than any other function. If the hypothesis about linearity fails, the subjects try some of the other functional rules before backtracking their decision tree, trying a non-functional rule, or a rule that does not assume cue dependence, such a sequential rule, meaning that the ordinal number of the cue values, rather than their actual values are used to form

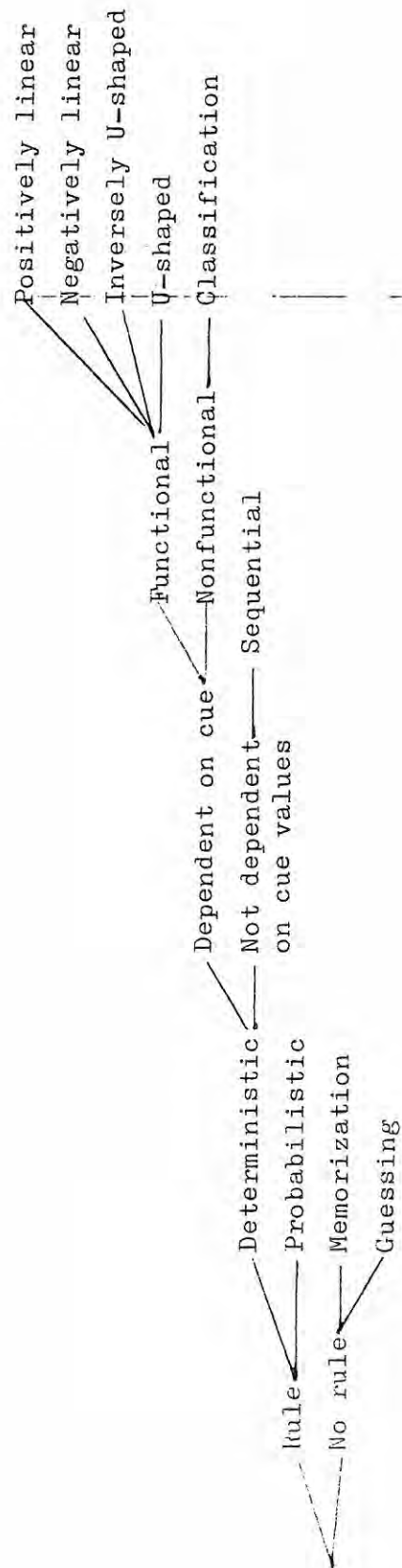


Figure 1. Summary of results from studies on probabilistic inference tasks

their hypothesis. For example, the subjects may believe that low criterion values are regularly followed by high criterion values, or vice versa. When these rules also fail, the subjects tend to assume that there is no rule at all, rather than to seriously consider the possibility that the rule may be probabilistic in character. Therefore, they go to a memorization strategy, or they may just give up and guess.

The result that the subjects do not seem to consider the task to be probabilistic, or to use a strategy appropriate to a probabilistic task, agree with those obtained under other kinds of circumstances by Tversky and Kahneman (1978). In this and other papers, they have shown, that when subjects have to estimate probabilities, they generally do not follow the rules of probability calculus. Instead, they use various heuristics such as representativeness and availability. The results in Tversky and Kahneman (1978) strongly suggest that the subjects' incorrect use of information, such as their neglect of base rates, can be explained by assuming that the subjects believe that the relations in the experiment are causal, rather than statistical, in nature. Consequently, they use inference rules appropriate to deterministic tasks, rather than the rules appropriate to probabilistic tasks. In this context, it is interesting to note that Wason and Johnson-Laird (1972) earlier invoked the same kind of hypothesis to explain why subjects failed to follow adequate logical rules in another kind of task also requiring the use of a formal schema for making inferences. Specifically, Wason & Johnson-Laird found that subjects did not understand the logical relation of implication ("if, then") and that they tended to consider this relation equivalent to a double implication ("if, and

only if"), as would be appropriate for a causal task. They also showed that task content had a very strong effect on the subjects' inference rules, a finding consistent with those of Tversky and Kahneman (1978), but which has only rather limited support in probabilistic inference tasks requiring the subjects to use cues for making inferences (Brehmer & Kuylenstierna, 1979b). Taken together, however, these results provide considerable evidence that determinism, or causality, is a very basic schema used by people to make sense of the world.

While this may be a useful schema in many circumstances, it nevertheless leads to rather dramatic errors in many circumstances (see Tversky & Kahneman, 1978), so it is clearly not universally applicable.

This leads to the important question of whether it is possible to improve the subjects' performance by informing them of the basic probabilistic character of the task. In a series of experiments we have studied the effects of giving this kind of information in inference tasks requiring the subjects to use probabilistic cues to make inferences about a criterion variable (Brehmer & Kuylenstierna, 1978, 1979b; Johansson & Brehmer, 1979). Specifically, we have used various forms of instructions to explain to the subjects that the task is probabilistic, ranging from a simple statement that it is impossible to make perfect inferences on every trial because the task is probabilistic to explicit graphical explanations in terms of scatter diagrams. This has not led to any improvement in performance. We have then tried to explain to the subjects, not only that the task is pro-

probabilistic, but also what kind of strategy is applicable to these kinds of tasks, i.e., that they should look for the regression function and use it consistently. When this also failed, we thought that this may be because the subjects could not test their hypotheses about the rule for the task, so we therefore also informed the subjects about magnitude of the errors to expect, given that they had found the optimal, rule to help them evaluate their performance.

Again the results were negative, as they were also when the tasks were given a content which clearly suggested that the relations between cues and criterion were probabilistic, and which was interpreted by the subjects to mean that the task was probabilistic, as assessed in a separate experiment. Regardless of instructions or task content, the subjects showed the typical behavior for these kinds of inference tasks: suboptimal performance due to inconsistent inference strategies with inconsistency being a monotone function of the uncertainty of the task.

These results, taken as a whole, strongly suggest that people simply do not have the cognitive schemata needed for efficient performance in probabilistic tasks. These experiments are, of course, laboratory experiments using college students as subjects. However, there is evidence that these results are not limited to the laboratory. Experienced clinicians behave in the same manner as the subjects in these experiments when making inferences in tasks with which they have years of experience (Brehmer, 1976b)

These results, then, support the earlier results on clinical inference in that they show that people do not learn optimal strategies from experience even if they are given massive amounts of practice. The reason why the subjects fail to improve in these tasks seem to be that they lack the necessary basic schemata to help them understand and use the information provided by their experience. Rather than using the appropriate statistical schemata, subjects use an inappropriate causal or deterministic schema, and this prevents them from learning as much as they could.

These findings raise the problem of why the subjects fail to detect the probabilistic nature of these tasks, which is so obvious to the experimenter.

Upon reflection, this is, perhaps, not so strange. The characteristic of probabilism is, of course, not manifest, but it has to be inferred. This means, first, that the subject has to have an adequate notion of probabilism among his schemata for organizing his experience, and, second, that he has some criterion for when a task should be considered probabilistic. There is, of course, no absolute criterion of probabilism, so it can only be evaluated in comparison with some deterministic hypothesis. One way of doing this is to assume a functional, or other, rule and evaluate the fit of this rule. However, it is clear that this will put the subject in quite a bind, for to evaluate his rule, he has to make some assumption about the error in the system, and to evaluate the error, he has to make assumptions about the rule. It would seem, therefore,

that the only way in which a subject could do this would be to try all his rules, and then shift to a statistical strategy, when he can find no more rules to try. Although the subjects certainly seem to follow the first part of this strategy, they fail to switch to the statistical rule when they have run out of deterministic rules. Instead the subjects seem to think that there is some deterministic rule for the task, but that they cannot find it. It is, of course, impossible to prove them wrong; the fact that they cannot find the rule does not prove that there is no rule. This illustrates that for a person with a firm belief in the deterministic character of the world, there is nothing in his experience that would force him to discover that the task is probabilistic and to give up the notion of determinism. To detect the probabilistic nature of the task, the subject clearly has to have the hypothesis that it is probabilistic he can discover the probabilism of a given task.

If a subject cannot detect that a given task is probabilistic, it is not surprising that he does not have a general statistical approach. On the other hand, the notion of determinism is just as hidden from experience, it is therefore legitimate to ask why subjects do not have the opposite approach, i.e., why they do not have probabilism as a basic schema and fail to detect when the task is deterministic. Such an approach ought to be at least as compatible with their experience as the deterministic approach.

Some observations by Piaget and Inhelder (1975) are relevant here. They point out that the notions of chance and probability cannot develop until a person has reached the

stage of formal operations, and that it can develop only in contrast to the schema of order, or causality. They then document in a series of experiments that the notion of probability is indeed dependent on the nature of the persons' general cognitive structures, and that it develops only after the schema of causality has firmly established around the age of 11 to 12 years.

These results, then, suggest that the notion of order is developmentally prior to that of probabilism. If so, it is no longer surprising that the subjects in our experiments do not entertain probabilistic hypotheses, especially in consideration of all the results which show that not very many people enter the stage of formal operations.

To summarize, our discussion shows that subjects do not seem to be able to learn to perform optimally in probabilistic inference tasks, and that this is due to lack of adequate schemata for handling the probabilistic aspect of the world. This may seem surprising, but it can be understood if we remember that the probabilism of a task is not manifest, and that it can be detected only by a person, who already has the notion of probabilism in his cognitive equipment. In short, probabilism must be invented before it can be detected. This, in turn, requires considerable cognitive development on the part of the person. We may get some appreciation for how hard it is to make this invention if we remember that probability calculus was not invented until the seventeenth century. One explanation why it had to take so long, consistent with the interpretation by Piaget and Inhelder of the development of the child, is that it was only at this point in time that the notion of causality

had reached such a level that it could provide a suitable contrast against which to evaluate disorder. Be that as it may, the fact that probability calculus is such a late invention, despite that it would have been useful long before it was invented, is evidence that an adequate understanding of probabilism is very hard to come by from our experience.

Learning when the outcomes are dependent upon judgment

So far, we have considered only the case when a person learns passively by observing the world. This, however, is not the only, or perhaps even the most common, case. Often, and this is certainly the case in clinical situation, a person has to act on his judgment, i.e., by prescribing a cure, and the outcome from which he is to learn will depend not only on the quality of the person's judgment, but also on the nature of his actions. The most fundamental characteristic of action is its selective nature; doing one thing precludes doing another. Thus, giving one kind of therapy precludes giving another. Furthermore, action may be selective also in that it is directed only at some of those who could have received it. For example, scarce resources may force us to treat only a limited number of all those who apply for treatment. As we shall see, the possibilities of learning from experience may be extremely limited in this case. Specifically, there will be a number of factors that prevent us from detecting that our judgment is fallible. Let us first consider the case when our judgment is fallible and the treatment we prescribe is of little value. Under these circumstances, we may easily be led to conclude that we have a useful treatment, as well as good judgment.

Consider the case where a psychologist has invented a new form of therapy. He now wishes to show its usefulness. However, he cannot give therapy to everyone, who wants it, so he makes the reasonable decision to give therapy only to those who need it the most, i.e., to those he judges to be most ill. He then goes on to give his therapy to those people and then makes a new judgment concerning the status of his patients. Almost inevitably, he will now find that they have improved, and he will be led to conclude that his treatment was useful, and that he made the correct judgment concerning his patients. The problem is that there is a very likely alternative explanation: that the improvement he observed is simply a regression effect. Since his judgment is likely to be unreliable (indeed, the results from studies on clinical inference would suggest that his judgment would most likely be grossly unreliable), it will change from the first to second time so that those patients were given low judgments on the first occasion will, on the average, be given higher judgments on the second occasion, and vice versa. This is likely to be a common mechanism for it must often be the case that the resources are limited, forcing us to select cases for treatment, and if we select extreme cases, the regression effect will automatically insure that our method will appear useful. Under these circumstances, nobody should be surprised that old methods of therapy are never given up but always found useful by clinical experience, and abandoned only for new methods presumably found useful for the very same reason as the old ones. Nor should anyone be surprised that as a treatment becomes more

widely available, and thus is given to more or less severely disturbed patients, its effect will seem smaller.

Kahneman and Tversky (1973) have pointed to some tragical consequences of the regression effect: That it makes us use punishment rather than reward for influencing behavior. This is because punishment is likely to be given to those judged to be bad, i.e., to those who appear to be low with respect to the characteristic being judged. These people are, of course, exactly those who would be judged to have improved from the first to the second occasion simply because of the regression effect. Rewards, on the other hand, are likely to be given to those who are judged to be good, i.e., to those judged to have a high value. For these people, the regression effect will work in the opposite direction, so that they will seem to have a lower score on the second occasion. Thus, it is clear that one's experience will, tend to prove that punishment is an effective means for improving performance, and that reward is not only ineffective, but perhaps even harmful. Kahneman and Tversky document by examples that this is indeed what people learn from their experience, contrary to what a person who has studied the psychological literature on the effects of reward and punishment would expect. A person's experience, it seems, will not necessarily tell truth.

Let us now consider the opposite case, that when our judgment has little or no validity, but we have a powerful and efficient treatment. This case has recently been analyzed in detail by Einhorn and Hogarth (1978). In their interesting and important paper, they show how, under these circumstances,

we may easily be led to overestimate the validity of our judgment.

In part, the problems with this case should be well known to social scientists: It is simply the case of self fulfilling prophecies. Einhorn (1979) uses the example of the effects of deciding to fund a grant application. Regardless of the validity of the judgment of value or deservedness of the research application, it is clear that those who get grants are going to produce more and probably also better research than those who do not get grants, thus confirming the judgment of the granting agency that those who got the grants were indeed those who should have had them. There is, of course, no grounds for saying anything about the validity of the judgment on the basis of these outcomes. To do so, it is necessary to distentangle the effects of the treatment, i.e., giving the grant, from the judgment. But this can be done only by not acting on one's judgment, and by using some other means of resource allocation, e.g. random distribution. But this is, of course, exactly what is not likely to happen, especially when the resources are scarce. In such a situation we are thus not likely to find the true validity of our judgment.

As we have already pointed out, the problem of learning from our experience when we also have to act upon our judgment is that the very fact that we do something will preclude getting the information we need to evaluate our judgment. Action is always selective, meaning that as we select certain cases for treatment, we by that very act also select other cases who do not get treatment. The only

cases we can observe, therefore, are the true positives and the false positives.

In many situations, this may not be such a problem. Given that the selection ratio is extreme, it is clear that we may actually get only true positives, even if the validity of our judgment is extremely low. Scarce resources thus tends to give us an inflated sense of judgment ability. As the resources get less scarce, and the selection ratio less extreme, our judgment is going to appear less and less good. Perhaps this is the reason why we now have so much more concern about unnecessary surgery than we had 20 years ago when the resources for hospital care were less adequate than they are today.

While the need to act may logically preclude learning about the validity of one's judgment, the psychological effects may not be as great as one might expect. The problem of learning about the validity of one's judgment in the present case is basically that of learning about the relation between two dichotomous variables. The judgment dichotomizes the independent variable into two categories: those who do and those who do not get treatment, and the dependent variable is dichotomized into those who succeed and those who do not, e.g., those who get well and those who do not.

This particular learning task has received considerable attention (Jenkins & Ward, 1965; Smedslund, 1963; Ward & Jenkins, 1965). The results show that the subjects, when learning these tasks, tend to focus only on the number of true positives, i.e., they follow the same strategy of using only confirming evidence as we have observed earlier. This is, of course, not very satisfactory from a logical point of

view. It makes sense, however, when we consider that under natural circumstances, e.g., when people have to learn about the validity of their judgment, they will not have access to all four outcomes. Thus, it may not be so surprising that people have not learned the optimal way of coping with tasks of this sort.

Sofar, we have mentioned two aspects of the task that may give us a false sense of judgmental ability: the efficiency of our treatments and the selection ratio. However, it should also be clear that the base rate of the trait being judged is extreme, this will also affect our sense of judgmental ability. For example, if 90% of the patients who come to a clinical are schizophrenic, it is not a great achievement to be able to correctly identify 80% of all patients as schizophrenic although an 80% hit rate may sound impressive when we do not know the base rate, and may thus lead us to trust our judgment.

It should also be clear that there will be interactions among judgmental validity, selection ratio, base rate, and the efficiency of our treatment, and that the rate of positive hits will vary with all four of these factors. Einhorn and Hogarth (1978) present a formal model of how these factors interact. The importance of this model for future research on judgment and decision making can hardly be overestimated. It provides a needed first step towards a more adequate conception of what a person's experience really is like, and this is, of course, a prerequisite for a more adequate conception of what a person may learn from that experience. Hopefully, the work of Einhorn and Hogarth will inspire others to continue their work and provide us with a more complete picture of the nature of experience.

Conclusion

We started this paper by discussing some results that seemed to contradict one of our deepest convictions: That experience leads to better judgment and decisions. Our further analysis of the problem has shown, however, that our faith in experience is, if not totally without foundation, so at least far from well grounded. This is because it is founded on an untenable conception of nature of experience, a conception that assumes that truth is manifest and does not have to be inferred. A more adequate understanding of the nature of experience leads to a far more pessimistic view of what its effects may be. This, in turn, leads to less surprise about the results of studies on judgment and decision making. It seems that these results are exactly what they should be, and if we do not learn from experience, this is largely because experience gives us very little information to learn from.



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KURT LEWIN AND MODERN DECISION RESEARCH

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This paper is divided into three parts. In the first part we briefly discuss some of the major concepts of Lewinian Psychology, more to refresh the reader's memory than to give a thorough overview. In the second part we draw some parallels (and point out the absence of some) between Lewinian field theoretical concepts and some of the major factors in decision theory and suggest some ways the former might contribute to the latter. In the third part we examine some ways in which field theoretical ideas have developed in other areas and some implications for decision research. The argument in this third part of the paper will be that at present, decision theory fails to capture an important aspect of decisions--the way in which decisions often seem to "emerge"--and that field theory might well be able to do so. This is vague, even to us, and therefore, this paper, of necessity, is an extremely tentative beginning.

I

Lewin's theoretical work, you will recall, is founded in the Gestalt tradition and can be viewed as a broad scale argument against and then current idea that psychology is merely descriptive and that real explanation would occur at more "basic" molecular levels such as elementary learning mechanisms or physiological processes. In place of this, his system is an attempt to characterize the molar psychological reality of the individual--both the conscious and unconscious aspects--and the motivations that lead to changes in that reality. To do this, Lewin adopted and modified topology, a then new "branch of geometry dealing with the most general properties of space, being concerned with transformations which preserve certain properties and invariants. . . . Topology . . . does not require the making of assumptions about quantitative

properties of psychological phenomena--assumptions which do not seem to be justified by the nature of these phenomena" (Cartwright, 1959, p. 59). Adoption of topology meant that the language of the Lewinian system became spatial and the written form of this language was the famous "potato bug" diagrams of the life space.

The life space consists of the totality of the factors effecting the person at any moment. These factors are defined as regions in the life space and these regions can be decomposed into component sub-regions. The person is seen as a point in the space and behavior is represented as physical or psychological movement (locomotion) from region to region within the life space. Leeper (1943) in his review of Lewinian theory, suggests that regions are behavioral possibilities, which is a convenient way to think about them, although originally Lewin probably intended a richer definition.

Regions have many interesting properties but there are two that are of particular import to the present purpose. First, some regions represent barriers to locomotion; these may be physical barriers or they may be psychological barriers. In either case, locomotion is either completely blocked or in order to proceed, it must circumvent the barrier. Second, some regions are cognitively unstructured; that is, they are only vaguely defined for the person and, as a result, they may act as a barrier.

As described thus far, the system provides no reason for locomotion to occur. Moreover, topology, even had Lewin actually used it in any but a fairly superficial manner, does not include concepts of distance or direction, so it is difficult to even know how to describe locomotion if it were to occur. To solve these problems, Lewin supplemented topology and called the new version Hodology: The science of paths within the life space.

In Hodological space, motivation to locomote is provided by the force field created by the valences of the various regions. A valence is, roughly,

the attractiveness (+) or unattractiveness (-) of a region and valences are additive. The valence of a region changes as the situational circumstances change.

Paths from the region presently occupied by the person to a goal region have psychological direction and distance (extension). Two paths have the same direction if the first step for one is through the same region as is the first step of the other and if they both eventually end in the same goal region. One path has greater extension (distance) than another if the second is a subpart of the first. Unfortunately, in discussions of direction and distance these definitions often get lost and there is a distinct tendency to revert to two-dimensional, Euclidian concepts and to design the life space diagrams accordingly.

To resolve some of the confusion surrounding vectors, direction and distance, Leeper (1943) proposed that . . .

if we are to talk about vectors in the sense of directed psychological forces, and if our purpose in talking about the direction of forces is to lay the basis for a consideration of how resultants of forces are determined, our definitions should be analogous to those of vector principles in physics. Thus, if two different forces are equal in direction, they should summate--the force exerted on the person should be the total of the two separate forces, or at least should be stronger than either force operating separately.

It is easy to find examples where such summation occurs. Thus, a person might take an airplane journey both because of the urge to reach his objective and because of his desire to enjoy the trip itself; or a person in marrying might be seeking a number of values simultaneously. Such cases represent the summation of forces related to different regions of positive valence. Or a person might remain unmoved by the force related to either of two regions of negative valence, but be moved when both forces work together--as when a workman quits a job that is unpleasant both because of the foreman and because it is dangerous, whereas either condition alone would not be sufficient to cause him to quit. Or a summation might occur between the negative force away from one region and the positive force toward another, as in cases where men

volunteer for military service in order on the one hand to escape a humdrum routine at home and on the other hand to serve what they regard as an important cause and to get some excitement and adventure. All of these cases are analogous to those in physics, where, for example, two men pulling on a rope exert a force which equals the sum of their separate pulls (p. 141).

At about the same time that Leeper was writing, Cartwright and Festinger (1943) used Lewinian theory to discuss two-alternative decision making. As part of this work they wrote the following:

In this . . . case only two alternatives (A and B) are possible and assuming that they are both attractive, two forces (f_a and f_b) act upon the person in the direction of these alternatives. From the definition of the concept of force it follows that the person will choose the alternative toward which the stronger force is directed (p. 596).

After a bit more elaboration, irrelevant for present purposes, Cartwright and Festinger (1943) state:

The strength of each of the force's action on the person will depend upon how much weight or potency each situation has for the subject. Stated formalistically . . . the strength of the effective force acting on a person is equal to the strength which that force would have if there were only one situation, multiplied by the potency of the situation to which it belongs (Lewin, 1938):

$$F_a = f_a \cdot Po(S).$$

The potency of each . . . situation is determined by the subject's feeling of probability that his judgment is correct (p. 597).

This is beginning to look a lot like decision theory. (Incidentally, we altered the notation in the foregoing to avoid unnecessary confusion.)

Subsequently, Harary, Norman, and Cartwright (1959), following the lead of Bavelas (1948), attempted to translate the hodological system into linear graphs using graph theory, particularly directed graphs, with the lines of the graphs being given plus and minus signs. In this scheme the "potato bug" becomes more comprehensible to the uninitiated; its regions

become points in the graph, its paths become lines in the graph, and its valences and vectors become the pluses and minuses and the directionality of the lines. Unfortunately, it does not appear that this line of thinking was pursued to its conclusion. Graph theoretical work in psychology got caught up in the study of social networks and Lewin and hodological space seem to have been left behind.

II

By now, if only because the foregoing discussion has been deliberately structured to promote it, even the least astute reader probably sees the parallels between Lewinian theory and decision theory. However, it still may prove valuable to point them out and to remark on them briefly.

To begin with, when put in graphical form (Harary, et al, 1959), the hodological life space and its regions begin to resemble decision trees (e.g., Luce & Raiffa, 1957), hierarchically organized utility structures (e.g., Beach, Townes, Campbell & Keating, 1976), or graphically arranged Multi-Attribute Utility schemes (e.g., Deaton, 1976). However, the life space is conceived more grandly than most decision graphs because it is supposed to represent the totality of the factors effecting the person at any moment. Decision theorists seldom aim so high and, in reality, Lewinian analyses usually included only those factors (regions) that were most relevant to the problem at hand. Still, the Lewinian point, that diverse factors--sometimes unconscious, sometimes sheer fantasy--influence behavior, should not be lost. As far as we know, only two decision theoretic schemes (Beach, et al, 1976; Jungermann, 1979) make any attempt to deal with this diversity or with individual differences and, frankly, the adequacy of these attempts is difficult to assess.

The analogy between the life space and decision graphs is even more reasonable if one accepts Leeper's (1943) definition of regions as behavioral possibilities. Indeed, a path from the region in which the person presently

resides to a goal region can be thought of as a sequence of potential actions and potential events that will (or may) eventuate in attaining the goal region. As such, the valence of the goal region actually must include the valence of the entire sequence. This is particularly illustrated by the idea of a "distinguished path," the path that is more satisfactory than any of the other possible paths. Clearly, identification of a distinguished path must require evaluation of its overall promise in terms of the characteristics of its component parts and then comparison of this overall promise with the promise of other paths. This cannot be done by merely focussing on the valence of the goal region itself. When put this way, this sounds considerably like the evaluation of branches within a decision tree and identification of the one that has the highest potential.

Cognitively unstructured regions have no clearcut parallel in decision theory. True, we utilize various decision aids (what Jungermann, 1979, has called "decisionetics") to help people clarify their thinking and to decrease vagueness. But these aids are aimed less at the kind of vagueness about a region that Lewin meant than at placing fairly clear utilities and probabilities in a coherent, rational structure. Certainly subjective probabilities, although they represent uncertainty, are not the same as lack of cognitive structure. However, what Lewin means is commonly encountered; the client tells the decision analyst, "I just don't know enough about that to really be able to assign a utility or assess a meaningful probability--it's all very unclear to me." Now that is lack of cognitive structure and we do not have methods of dealing with it adequately. About all we do is to persist with our questions until the client appears to be giving solid answers, but we run the risk of inducing false cognitive structuring as a response to such pressure.

The parallel between vectors and utilities seems at first to be quite clear. In fact it is not. In his biography of Lewin, Marrow (1969) describes how Donald Adams, when translating a paper by Lewin into English, decided to use the word "valence." The German word Aufforderungscharakter had, on a previous occasion, been translated as "invitational character." Adams acknowledged that this was a literal translation but thought that it was not quite appropriate. He turned to old English dictionaries and came upon "valent" which meant value or worth, and upon "valency" which had the archaic meanings of might, power, strength and, as lessor choices, importance and significance. He modified these two words to "valence," a word that already had currency in chemistry, a currency that has transferred in part to its use in psychology. Adams suggests that Koffka urged Tolman to use valence instead of "demand. value" in his theory and, thus, a word was born. The Lewin-Adams-Tolman definition is now included in English dictionaries.

The point of recounting this little story is to emphasize that the vector conception we all identify with valence was not necessarily part of the original. True, Gestaltists (and Lewin was at Berlin with Wertheimer, Koffka, and Kohler) talked generally about fields and forces. But, as Leeper (1943, p. 64) points out, valences are not forces. Valences are the affective attributions given to a region by the organism, while a force is the result of that valence and other conditions of the life space. One such condition is discussed above, the potency of the situation, $Po(S)$, (Cartwright & Festinger, 1943). In this case the force, the urge toward an alternative (Leeper, 1943, p. 65) is a product of valence and potency. In fact, valence seems to be very like a utility, potency is very like a subjective probability, and force (urge) is very like a subjective expected utility.

The valence, and the force, of a region also is influenced by the psychological distance between that region and the region occupied by the

person. In effect, the valence is discounted or diminished as a function of the distance. When distance is defined as remoteness in time of attaining the goal region, this diminution is very similar to Ainslie's (1975) carefully developed ideas about how the utility of an outcome decreases as a function of how long it will be before that outcome accrues to the decision maker. A similar development is needed for cases in which distance is defined in terms of effort of traversing the path and the complexity of the path.

Insofar as directed graphs capture the Lewinian concept of path direction, there may be a place for direction in decision formulations. As things stand now though, it is not generally included. Indeed, the original concept may have been necessitated merely by the choice of topological diagrams as the language for the theory rather than by any intrinsic psychological necessity.

Finally, we come to the question of barriers. In most decision analyses, decisions are made by selecting a course of action from among a set of available alternatives. This way of defining decisions acknowledges barred actions by eliminating them from consideration. In many cases this probably is reasonable--why bother to evaluate things you cannot do anyway?

However, there are cases in which barriers are extremely important. One is when a plausible course of action (path) is psychologically barred. That is, for some reason the decision maker regards some component (region) of the action as a barrier when an objective observer would not make that evaluation. This may be expressed as disutility for the component or as an aberrant subjective probability. (For example, if a path to a college degree contains a course in biology and I hate having to cut up worms (disutility) then the biology course is a barrier.) Or, it may be expressed as ignorance or vagueness (recall that cognitively unstructured regions can be barriers). However it may be expressed, the required solution usually

consists of some form of education; for example, behavior therapy to change extreme disutilities (dissection of worms), actuarial statements about risk in order to change subjective probabilities, and additional information about the situation in question in order to reduce vagueness.

The second form of barrier is physical. This means that there is some obstruction that bars the person from selecting some course of action even though it might otherwise be the preferred course (the distinguished path). Davidson and Jaccard (in press) have discussed this in the context of using expectancy theory to predict persons' contraceptive choices. The problem they encountered was that a fair number of persons for whom the theory predicted a positive choice in fact did not make that choice. The question is whether the theory mispredicted because it is wrong or because those decision makers would have performed the predicted behavior if they could but barriers exist that prevent them from doing so (e.g., nonavailability of contraceptive means).

Evidence on this question was obtained by Beach, Mai-Dalton, and Marshall (1979) who used multi-attribute utility theory to predict who out of a large sample of commuters would elect to ride the bus to work. A large percentage (56%) of the commuters that the theory predicted would elect the bus did not do so; they drove their cars instead. Comparison of these commuters' component utilities with those of the commuters who were predicted to ride the bus and who habitually did so showed that the two groups were very similar. Moreover, both of the groups' utilities were quite different from the utilities of those commuters the theory predicted would drive to work and who, indeed, did so.

Forty-six percent of the mispredicted cases (those predicted to use the bus but who drove instead) wrote comments on their questionnaires. Of these comments 38% indicated physical barriers that prevented them from using the bus to commute. For example, two different carpenters commented that

they worked at different sites each day and, having to take their heavy tool chests with them each time, the bus was simply not an available alternative.

Having drawn these parallels between Lewinian field theory decision theory it seems to us that there is something important about the former that does not have a parallel in the latter. In some ways decision theory resembles the theoretical views against which Lewin was arguing when he turned to field theoretical concepts. As is the case in so much of psychology, decision theory relies heavily upon fractionating the behavior of concern into carefully delineated variables and cleanly defined rules for linking these variables. For applied decision making this probably is advantageous because it permits one to get a handle on the problem. However, as a description of unaided human decision making it is patently inadequate. The notion that all (or even many) decisions are made by deliberate evaluation of utilities and probabilities and conscientious application of some form of the maximization rule, is absurd. In fact, our mutual introspection suggests that most decisions "emerge" in some way. And, this impression of emergence is much more compatible with Lewinian field notions than with decision theoretical concepts--a continuous, flowing process rather than a discrete, abrupt process.

This is not to say that the parallels explored above are invalid or that we think decision theory is bankrupt. However, it does seem reasonable to us to explore the "continuous, flowing" part of Lewinian theory a bit further and to see what such exploration offers in terms of "decision emergence."

III

In any field theory, the delineation of a field is a summary of all the forces, as it were, that effect behavior at a given instant. This is, however, not to be construed as simply an exhaustive description of "stimuli". For a theory to be a field theory, the exact character of the behavior also must be

specified before the field concept becomes operationalized. The notions of "force" and "behavior" thus become co-dependent entities, and neither exist, even in abstraction, without the other. What a field theory does, then, is to dissolve the dualism between organism and environment, stimulus and response, or any similar pair of entities. We ask the reader to reflect for a moment upon what a fundamental theoretical shift this proposes, particularly with respect to the stance of traditional American behaviorism. It is little wonder, given the milieu, that the notion of "Life Space" seems often to have been misinterpreted as merely a rich formulation of the perceptual appreciation of the physical world. The "potato bug" diagrams themselves contribute to this by representing the person as a point within closed contours.

A spatial representation that more closely captures the essence of a field theory would remove both the points and the contour and deal directly with the properties of space itself. This is exactly what happens when, today, the systems engineer creates a "state-space" model of a system by using the theory of differential equations. A system's state is the smallest collection of numbers that together uniquely predict the system's behavior. Each "state-of the system" is a point in an n-dimensional Euclidean space, and the set of all points is the "state space". Note that the dimensions of the "state space" are not dimensions descriptive of a stimulus "outside" the system. Rather, they are specified by the differential equations

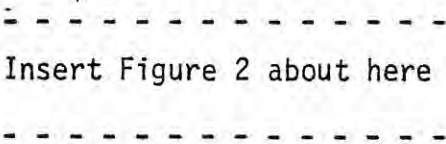
$$(1) \quad \frac{dx_i}{dt} = f_i(t, x_1, x_2, \dots, x_n), \quad i = 1, 2, \dots, n$$

that express a continuous relationship between changes in time and changes in the x_i variables that characterize the system. As the system's state changes over time, it traces out a trajectory, as it were, through the state space.

 Insert Figure 1 about here

This trajectory (Figure 1) is never arbitrary. It is the geometrical representation of the range of solution graphs for the system of differential equations. Imagine every point in the space as having affixed to it a vector whose orientation is determined by the equations. Then we have a vector field, which induces on the space an underlying geometrical structure. A solution to (1) for example, appears as a curve in the n -dimensional Euclidean space R^n . At every "point" on the curve, there is a vector tangent to the curve at t .

Ecologists make significant use of such phase portraits to describe predicted relations among species. A famous set, the Volterra-Lotka predator-prey equations, describe the changes that occur in two species X and Y where one feeds upon the other. In the XY plane, the projection of the phase portrait of the equations looks like the Figure 2.



All the possible solutions are periodic about a stable center point, determined by the ratio of growth and death rates each of the species induces upon the other. The phase portrait shows that trajectories can follow a closed path, spiral toward the point, or even toward the origin--if one of the species' numbers is reduced to zero.

In mathematical systems theory, then, we find the kind of notions that Lewin labored over brought to their most definitive exposition. The similarities are worth emphasizing, because they illustrate just how profoundly different from behaviorist conceptions Lewin's ideas were.

"The 'Life Space' indicates the "totality of facts that determine the behavior of an individual at a certain moment" (Lewin, 1936, p. 12) and thus "it is necessary to find methods of representing person and environment in common terms as parts of one situation."

The phase- or state-space of a system achieves such a representation through a system of differential equations, which express how different "system variables" change with respect to time and with respect to each other. While Lewin somewhat erroneously used a point in the life space to represent the individual, a point in the state-space represents at any given instant the individual state of the system. Where Lewin talked of "paths" in the Life Space, the systems theorist speaks of "trajectories" or of a successive path of system states that are determined by possible solutions to the differential equations that model the system. In the words of the late C. H. Waddington (1977), "the pathway of change is canalized", (p. 106) a condition he expressed through the word "chreod" which means "necessary path". The mathematical derivation of such "chreods" give implicit substance to another Lewinian idea, that of "stability" in regions of the life space. As we have seen with the Volterra-Lotka equations, there are singularities or points of stability in the state space about which system states are so "canalized". In a similar position Lewin had tried to express paths around regions of stability in the life space.

Another Lewinian concept that achieves a modern recreation is that of a "barrier" which he represented as a boundary across paths in the life space, in a manner not unlike neighbors' fences. Now, however, mathematical systems theory shows that a boundary is more rightly seen as a localized orientation of the vector field that affects the system trajectory or chreod. The system cannot enter certain states because the processes of change continually transform it away from them. Barriers are transformatal constraints on successive system states, and not externally induced entities. They are better visualized as a topography of the state space itself, rather than as an element within that topography. It is as if (the abstract) space itself were filled with valleys, hills and ridges of being.

In this regard, Lewin had also labored under a very restrictive idea of what kinds of spaces were describable topologically. All of his diagrams show an adherence to the type of Euclidean Space we inhabit and intuit. But recent investigations by Thom (1975) and Mandelbrot (1977) have provided the foundation for spatial structures of vastly elaborated complexity. Mandelbrot has developed what he calls "Fractals" to describe constructions whose fractional dimension strictly exceeds their topological dimension. The result has been a technique that has been successfully applied to the modeling of forms ranging from clouds to coastlines, rivers, trees, and even music. The meanings of "form" and "similarity" here acquire extrapolations far beyond the picture plane we stereotypically conjure. One wonders what the expression "form of a decision" might take in such a scheme, and immediately senses how "qualitatively" different a decision theory must be in order to support a spatial imagery that would be as different from a decision tree as a fractal form is from Lewin's idea of topology.

Inasmuch as this is an admittedly speculative and idea-generating paper, perhaps it is worthwhile to put the visual cart before the mathematical horse and suggest how Thom's "Catastrophe Theory" might be involved in the modeling of a decision process. Appealing to introspection for a moment, one could say that this is exactly the sort of model that is needed when a decision or a resolution of action emerges after a long and arduous segment of "soul-searching".

In Figure 3, the parameter's surface is defined by the dimensions of utility and risk while the behavior axis is represented as Information Processing Load.

- - - - -
Insert Figure 3 about here
- - - - -

An individual, starting the "decision process" at 0, proceeds through the space until encountering the "cusp" at 1 - the moment of decision, and then undergoes a sudden and discontinuous drop in Information Processing Load that had been the cognitive effort of the decision process.

The problem with this scenario is in the choice of risk and utility as control parameters. In order to obtain a Cusp catastrophe in such a [cause X effect] space, it is necessary to have two conflicting control parameters. If we continue to see information processing load as the "effect", then increases in one parameter must increase information processing load, while increases in the other parameter should decrease it. In the diagram in Figure 3, it is more reasonable to see the control parameters operating cooperatively to select a level of risk and utility that appears as an acceptable decision. But even incorrect examples may be instructive. In this one, the behavior axis is essentially a measure of "what happens at the moment of decision". Suppose, as psychologists, we intuitively accept for a moment that something of cognitive importance does happen at the climax of a decision process, and that it could reasonably be a discontinuous effect resulting from a succession of small continuous changes in the process control parameters. Then the error in the above example becomes apparent. Utility and risk as control parameters have nothing to do with how "formed" or developed the decision might be. If we view these measures as reflecting the value and certainty of possible outcomes then they must be invariant with respect to any state-position of the decision maker engaged in the process.

So now an interesting question is raised: Could it be that concepts of utility and uncertainty, dear as they are to the hearts of decision theorists, are inappropriate to modeling the flow of a decision process from initial realization to concluding resolution? Imagine instead that these measures

are treated as externalities. They are (at the least) satisfying criteria that the decision maker occasionally holds against a forming plan of action, but they in no way guide the decision process itself. In this view, a decision process does not consist of computing value and uncertainty indices for well established alternatives of action. Rather, it is a process of successively forming and testing half-conceived actions against criteria that may only incidentally involve value and uncertainty. At any particular point in the process, the drive is to more clearly formulate or "see" an emerging action rather than more carefully compare it with other well-formed action alternatives.

What sorts of control variables might be engaged in such a process? We propose that these would likely be variables that are sensitive to how well-formed a decision structure is--variables like "opportunity of choice" or "time pressure from competing interests". These types of variables would be conflicting, because one would drive the process toward successive elaboration of action plans, while the other would move the decision maker toward an earlier and simpler response.

But now, from considering such spatial metaphor, a theory of decision processes has begun to look very different from a theory of decision analyses. The purpose of the former becomes to describe the emergence process of a decision, rather than its overall competitive worth. Are there any grounds for such an interpretation of "decision process"?

Max Black (1975) has argued a very similar point of view for what he calls "heuristic rationality". This is a conception of rationality that "...conforms to the procedure actually adopted by sufficiently intelligent and skillful persons who are faced by genuine problems of what to do" (Black, 1975, p. 3). The procedure of heuristic rationality is "ill-defined, dynamic and sequential." The goal may only emerge during the course of inquiry, along with the discovery of possible actions and expected consequences.

The starting position may be rather unspecified, and the goals and means only become progressively clearer as the decision maker tries to achieve the task that is only partially defined. In this process, Black sees the criterion of rationality as deriving from the validity of inferences used by the individual. Such a procedure is deemed rational if it can be (in part) logically connected to having good reasons, so that it may be at least retroactively attributed to those reasons. So, from the point of view of heuristic rationality, "untidy as it may seem, the use of 'indubita', together with imaginative projection of possible courses of action...tested by trial or imagination...is preferable as a way of finding justifiable action to any available alternative"(Black, 1975, p. 13).

Although he does not offer a descriptive model of the process of heuristic rationality, it should be evident that his discussion is aimed squarely at seeing a decision process as something from which a decision emerges or comes into form. Since the whole question of whether "rationality" can be rightly applied as a label here depends upon the way this comes about, the argument is rather academic unless the appropriate descriptive model can be found.

It is this kind of descriptive model for which a contemporary Lewinian field theory seems most suitable. The value of a field theory is that it describes how a form emerges from the interactive forces that compose the field. While most discussions of field models (see Alexander, 1966) are predisposed toward evolving physical forms, we have seen that, both in the qualitative analysis of differential equations, and in the derivation of more complex topologies, there is nothing that is restrictive to physical forms. All that is necessary is to give the notion of "form of the behavior" or "form of the decision" a strict definition in terms of the state or control process variables that with it define the field (see Appendix A for an example).

It is a long way from the "potato bug" to the abstract field theoretical notions of systems theory. We have avoided the rigorous details, because

- a. We wish to inspire other decision theorists to take a closer look at field models, and
- b. We don't consider ourselves quite up to the task yet.

But we hope that our discussion of both the content and form of Lewinian field theory will give the reader some appreciation of what such ideas might imply for an expanded decision theory. This would be a decision theory built on the idea of the decision itself as the goal of a field induced by the interacting variables that control the process of decision forming. In the representation of such a field, it becomes both meaningful and practical to speak of the "barriers", "paths", and "regions" that eluded Lewin and that were all but abandoned by the generation succeeding him. Only the most recent developments in mathematical conceptions of what form, dimension and field actually entail allow such a revitalized perspective now.

In adopting this view, we have borrowed from physical analogies and visual metaphors. Regardless of one's taste for this practice in building models, we feel that such an attempt is good for the theorist's imagination and productive of insight into areas (i.e. decision forming) that would not be otherwise amenable to careful consideration. Of course, the real value of such a speculative exercise is that it might inspire a testable model from someone more adept at that sort of enterprise than ourselves. We hope so, because as a field of inquiry, decision theory currently needs a stimulative dose of fresh thinking. If just a few ask what can be learned from the physicist, the systems theorist, or Lewin about constructing a field theory of decision making, our purpose will have been realized.

Lewin once wrote that "Nothing is so practical as a good theory." In terms of pragmatism, his own theory of Topological Psychology once seemed to

believe this observation. But for a process theory of emergent decision making, the premise might yet be fulfilled.

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FIGURE CAPTIONS

FIGURE 1: A 'Trajectory' of a System Over Time in its Phase Space

FIGURE 2: The Projection of Possible Solution Graphs for the
Volterra-Lotka Equations in the XY Plane

FIGURE 3: A Hypothetical 'Cusp Catastrophe' Representation of What Happens
Cognitively at the 'Moment of Decision'

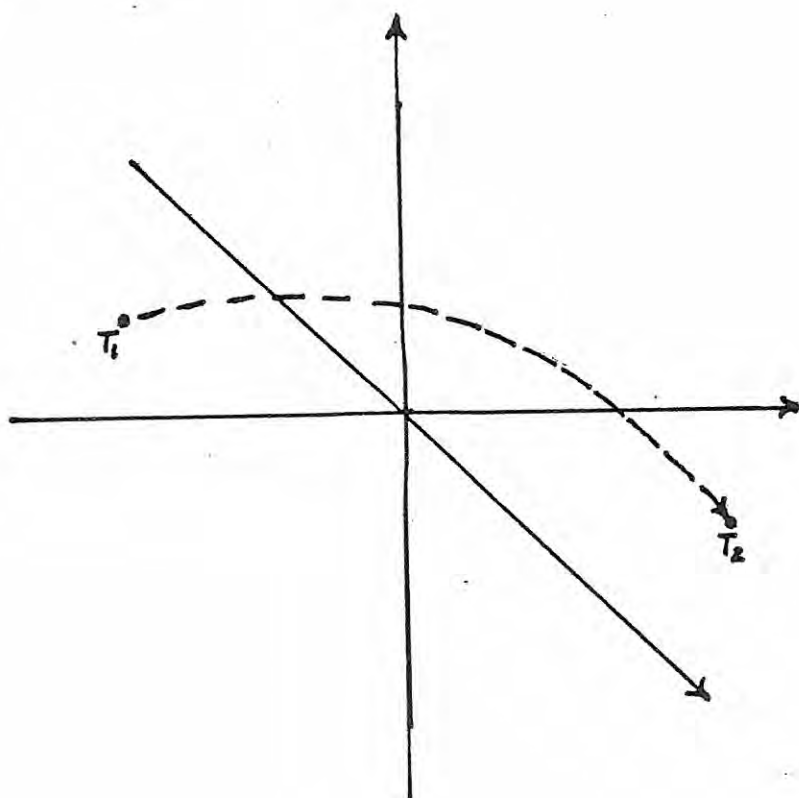
Figure 1

Figure 2

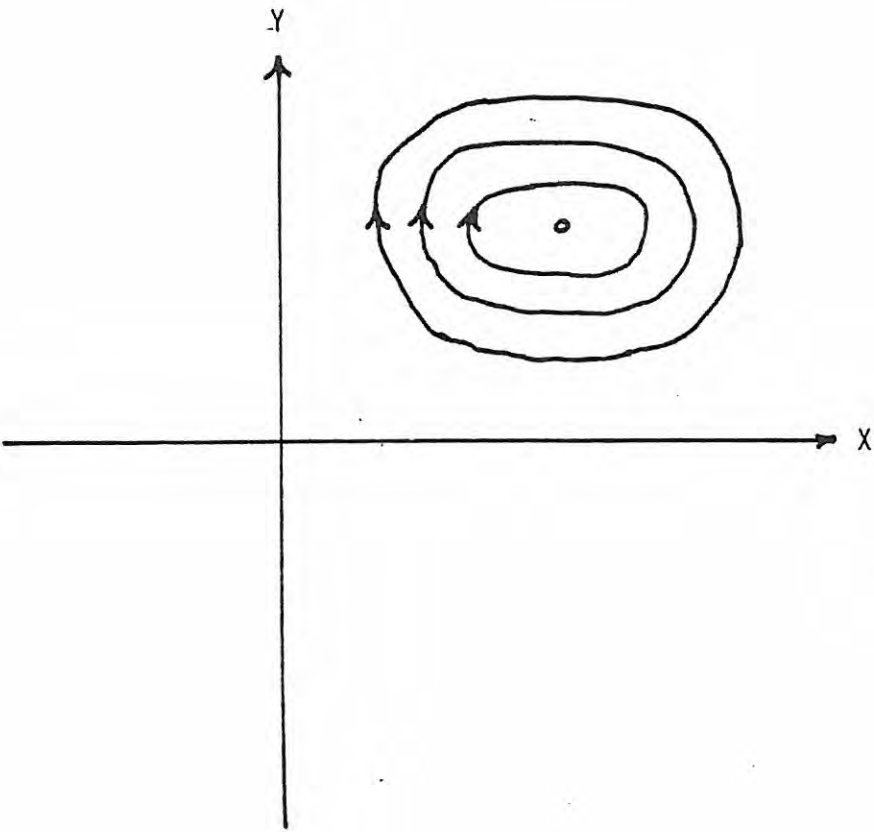
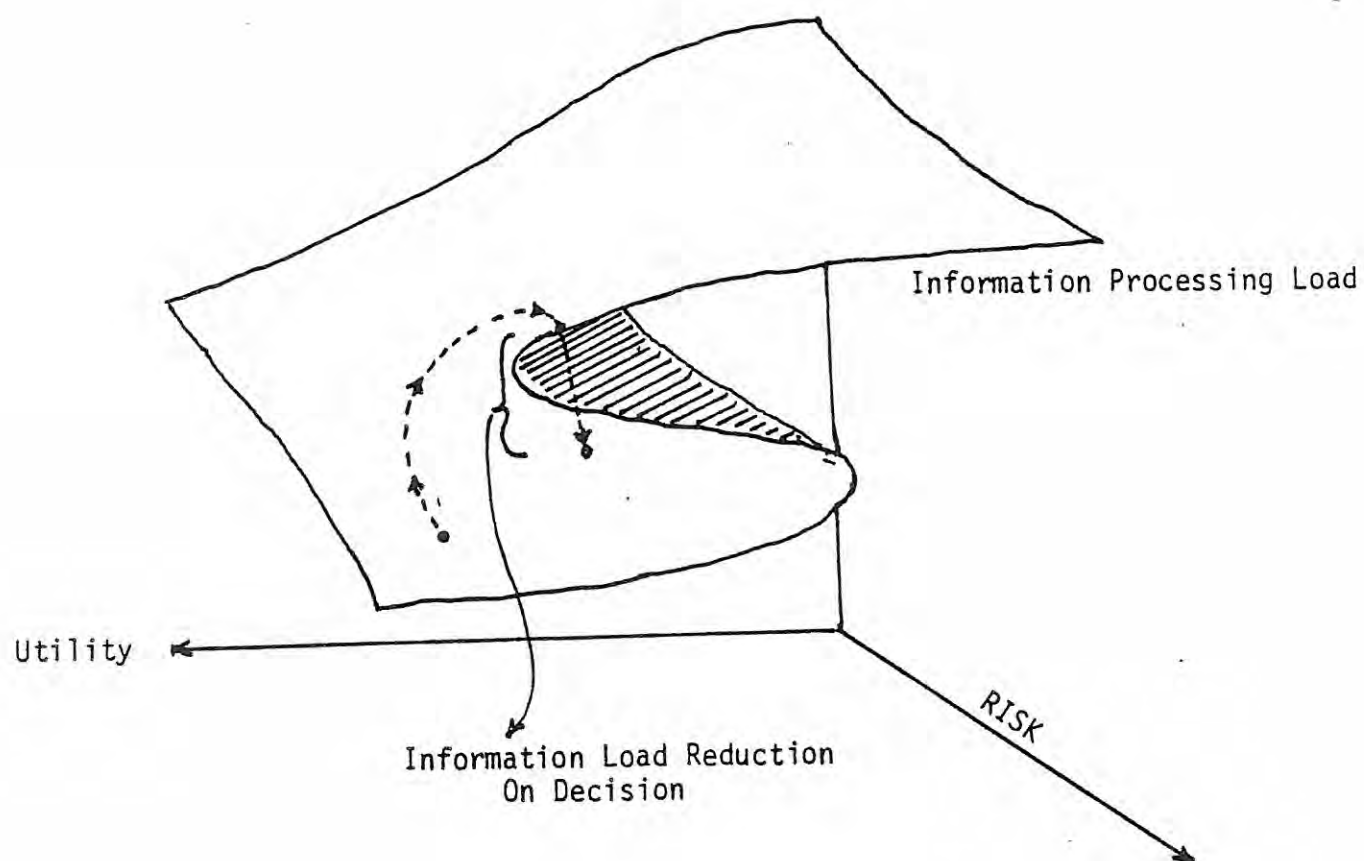


Figure 3

Appendix A

The only serious attempt we know of to use the kind of ideas outlined in this paper is by Griesinger (1974, 1978). This author specifies a procedure for constructing a general utility function from field sources, accompanied by a response rule that predicts behavioral responses to the field. Drawing from the analogy of a potential energy field in physics, he proposes that psychological force be defined as the gradient on a scalar field of utility, $F = \nabla U$. If the utility field is also the smoothest function possible in source-free space, the differential equation for utility,

$$\nabla^2 U = 0$$

becomes identical to Laplace's equation from potential theory. Then by analogy,

$$\nabla^2 U = -g(r)$$

describes the utility field in the region of what Lewin had called "valenced objects" or sources of satisfaction. This is also identical (except for sign) to the general Poisson equation for the behavior of the potential field about source densities in space.

In the context of a rat constrained on a linear runway at position x and approaching a goal, the Poisson equation becomes

$$d^2U/dx^2 = -k \delta (X-X')$$

where X' is the position of the goal,

k is the valence of the goal,

and $\delta(X-X')$ is the Dirac delta function
(in keeping with the analogy of a physical field).

For positions on the runway before the goal, $U = (k/2)(X-X') + \text{constant}$.

Involved with this derivation of utility are important differences from its usual interpretation under the Von Neumann-Morgenstern axioms. Here,

the utility field increases linearly as the rat approaches the goal. But this is dependent not only on the valence of the goal, but on the dimensionality of the space, i.e., the "one dimensional" runway that leads to the goal. If the rat were free to move about a tabletop, for instance, the utility function would take the two dimensional solution to Poisson's equation for a point source,

$$U = -a \log r + b$$

where r is the radial distance from the 'valenced object' and a and b are scaling constants.

Of course, the generation of utility functions in this fashion does not guarantee their empirical predictiveness in describing the running speed of rats. Griesinger (1978) claims success when pairing the above derivation with a Newtonian model of running, but for our purpose here, it is sufficient to note the operational feasibility of the field analysis. It is possible, by developing the analogy between a potential field in physics and a utility field in psychology, to develop a predicted utility function for a situation that is subsequently open to empirical scrutiny.

Griesinger (1978) has also utilized the Schrodinger equation from quantum mechanics as an analog decision rule to relate the generalized utility field to the propensity for choosing alternatives that have attributes in the "vicinity" of a point r in the field. Here, we are dealing with an attribute space, so that "vicinity" may be more reasonably interpreted as the similarity of an alternative to a valenced object. Avoiding the details of his development, we will be content to note again that the derivation of the preference function requires specifying the relevant attributes of the alternatives, the utility field, and the alternatives available. Again, the evaluation of alternatives becomes bound up with the cognitive construction of how those alternatives are represented.

Although the utility function in this case refers to a pure choice situation, some of its properties are relevant for the sort of decision process model we have considered--one in which a decision successively emerges from a controlling (utility) field. Without offering a formal proof, we propose that if such a model is based on the notion of a generalized utility field, then the point at which the decision comes into form must be a singularity, and utility must be maximal at that point. In this context, utility has become a measure of the formingness of the decision. Utility, as an index of the process, is maximal when the decision is made. It should also occur at singular points, since in a phase space, equilibria appear as singular points, and the decision should, at the least, occur at a point where the field forces are in equilibrium and the stability of a decision is thus achieved. (Once a 'decision' is made, it should be stable with respect to the forces that would otherwise continue the decision process, i.e., a person should be much less likely to "change their mind" after a decision is made than before.)

EMOTION AND DECISION MAKING

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Whatever the philosophers claimed,
the main use of logic was to justify
your emotions. From a novel by
Philip Jose Farmer

1. Emotion, Utility and Rationality

Imagine a boy contemplating at his breakfast table in a merry Sunday morning if he could get away without eating the detestable spinach. He sends a surreptitious side glance toward his mother. Finding that she is already a bit irritated by his hesitation, he mouths all the spinach in resignation and tries to swallow it in one gulp to shorten the loathsome act, urged by the fear of spanking which any more delay would certainly invite. Not that he is particularly afraid of being spanked. But then he is expected to cry more by humiliation than by pain, an ungainly ritual which would surely spoil his expansive mood of Sunday morning.

This is a decision process that the boy is up against. All that is described above with many emotion-relevant terms can be transcribed into decision theoretical expressions in terms of utility, subjective probability and information. For example, it is the information obtained through the boy's observation on his mother's state of mind that caused to increase the probability of the worst outcome contingent upon his alternative course of action of not eating the spinach. This tipping the scale, the boy decided upon the other alternative of the highest expected utility, that of eating the spinach as quickly as possible.

I began this paper with this example for two purposes: The first is to suggest that an emotional process, or more precisely, an internal process describable in emotion-relevant terms, is a decision process. The second is to suggest the vice versa, i.e., a decision process is an emotional process. To the first I anticipate little objection. To the second I expect a violent one, in particular from the decision theorist. A novelist, however, would approvingly smile at the suggestion. This difference in the attitudes of the two professionals is apparently based, first, on the common sense understanding of the irrationality of the emotions, and a decision theorist, even an empirically oriented, would tend to assume for the human nature to be basically rational (otherwise, he wouldn't have been interested in decision theory in the first place), and a writer would generally assume the opposite. This disparity in the opinion, however, is not my immediate concern. My concern is about the truthfulness of the common sense belief that the emotions are basically irrational. If they are, how could they have survived the long phylogenetic development over tens of millions years, inasmuch as we could trace down the origins of some of human emotions into subhuman animals?

Before going any further on this issue of rationality, let me point out that, in the above example of a spinach-hating boy, most of the emotion-relevant terms are suggesting the grades of 'utilities' attached to the consequences of various acts involved, though crudely. Emotions are thus closely linked to personal values. However, if these emotional terms are replaced by utilities, we are sure to

(miss many of the rich implications contained in the original terms, the implications which enable us to imagine to some extent the character of the boy, the family atmosphere and so on. This implicational deprivation in the decision theoretical formulations (Who would buy a novel written strictly in decision theoretical terms, even however exact the expressions are?) is apparently based on the fact that utilities are exogenous variables in the decision theory; the 'rational' reasoning

process of the decision theory begins when all the utilities have been given or measured, asking no question about why the utility of a certain terminal state should be such-and-such nor whether all the utilities given are consistent with each other as a value system. This modesty of the decision theory about utility is rather puzzling, considering that it has Bayesian theories for subjective probability. Leaving the realm of normative decision theory and going into the empirical, the need for understanding personal value systems, among other things, cries itself out for attention (Vlek and Raaij, 1977; Koziielecki, 1978)

In these years it has been widely realized that the actual decision making is a complicated process; it begins with the conception of a decision problem, triggered most typically by a cognition that something has gone wrong, but it could also be the opposite, i.e., that of some new delightful possibility opening up all of a sudden. The problem conception will then be followed by a variety of cognitive information processing operations such as the shaping up the structure of the problem, hunting for necessary information, generating alternative plans for behavior, evaluating possible outcomes together with relevant probabilities for each of the alternatives, deciding on one which appears the best, setting up a volition for its execution and so on (e.g., Toda, 1976, 1978a; Slovic, Fishhoff and Lichtenstein, 1976). Irrespective of the structure of the model, any theory of actual decision making which takes up some of these aspects of the decision process may be called a cognitive decision theory.

Why I wanted to draw the reader's attention to this issue is partly because how a person appraises personal values (or utilities) of various personal states should be an integral part of such a theory, but also because I believe that such a theory can be built on the basis of rationality in spite of its empirical orientation. Needless to point out that the human information processing capacity is limited both in its biological hardware, the brain, and in its basic genetic software, it is conceivable that the struggle for survival which the genus Homo has undergone through millennia should have upgraded the

latter through his capacity for learning and the improvement in formal and informal educational methods. The assumption of rationality, even as an approximation, is obviously useful because of its deductive power, a rare merit which only cognitive decision theory possesses among predominantly inductive behavior theories.

Suppose that one such theory is built with a fair success. Then the rationality principle would make us realize what type of constraints are likely the critical limiting factors on our cognitive operations. Then we may also realize that some of these constraints are not unremovable. If some constraints turn out to be based on the capacity of the brain, an external information processing device may be built to augment it, and this possibility has already been partly a reality in a form of various computer-assisted decision aids. If other constraints are known to be due to some hitherto unnoticed 'mental blocks,' then they may even be removed only by bringing attention to their existence. All these advantages may be ascribed to what I called the externalization of internal processes; once some subconscious operation is brought into broad daylight, we may jointly work upon it and improve the procedure as a conscious operation (Toda, 1976).

Now let us get back to emotion. Emotion perhaps is the least externalized human internal process. Note that we can hardly make a conversation without referring to some emotional processes. Our literatures tirelessly and endlessly describe various phases of the emotions. Nevertheless, comparatively speaking, the emotions are rarely admitted to enter into a scientific scene. This is partly because they are difficult to tackle scientifically, and partly because they have been thought as something 'un-science personified,' something diametrically opposed to 'reason,' following the tradition set by Descartes. This latter view, however, is completely unfounded. As I have been emphasizing, rationality is a relative notion; the performance of a rational system depends upon the constraints under which the system is operating. As many ethological evidences demonstrates, even including Darwin (Darwin, 1872; Lorentz, 1952;

Hebb and Thompson, 1954), many human emotions have deep phylogenetic roots in pre-human animals, and so there is every reason to believe that emotions have survival merits with animals. In other words, they are mechanisms operating more or less rationally under sets of constraints different from those for the humans, particularly when the cognitive information processing capacity is very limited. The humans apparently have not relinquished the emotion system;

on the contrary, there are enough evidence indicating that they have expanded and refined the system with the aid of the fortified cortex. A dilemma has arisen as the extended cortex also caused to develop another internal system of cognitive information processing based on different principles, and their functions seem not to work always in a complete harmony (Toda, 1978a). So this has come to create a new constraining condition severely hampering the overall rationality of human beings, the condition that should be eliminated, as, otherwise, the genus Homo could very well be doomed (Osgood, 1978; Toda, 1978b). And this is the task to which I would particularly like to call the decision theorist's attention. Strange this may sound, but the emotion system is a rational system with its own set of constraints, and individual emotion functions as a specific internal process, in fact as a decision process, only it is genetically preprogrammed. But since this is the theme to be expounded in the later sections of this paper, let me concentrate here on the relationship between the emotion and the personal valuation.

As evident in the example of the spinach-hating boy, emotion-relevant adjectives and verbs are clearly indicative, to the reader of any such description, of the boy's personal values about the objects and the situations they are referring to. Note also that, in spite of so many emotion-relevant terms used in describing the boy's decision situation, the boy himself could have remained cool and unemotional. When we say someone fears that something bad might happen if he does a certain thing, the person himself is often not in a state of fear but he is just anticipating a fear he might feel as a consequence of an act he may take. De Rivera quotes from Truman's Memoirs to demonstrate how

such an anticipatory emotion could influence important political decisions:

"In deliberating whether or not to resist the invasion of South Korea, President Truman (1956) reports considering how he would feel about himself if he, as President, failed to resist the aggressive action of another nation." (de Rivera, 1968, 1977). Such a case, however, may not be exceptional nor limited to important political decisions. In considering alternative resort places for the vacation site, one would probably try to imagine some typical or highlight situations he would experience in each of the alternative places, and the emotional feelings accompanying these images such as joy, relaxation, irritation and so on may be taken into account, together with the monetary expenses, in determining the total worth of the place. So anticipatory emotions could well be playing a critical role even in a person's non-emotional decision process.

Could this suggest that the emotions are the ultimate source of all the personal values? Some emotion theorists appear, in effect, to believe so, when they identify emotion with motivation. Tomkins, e.g., assumes that a person is maximizing positive affects and minimizing negative affects (Tomkins, 1970). James (1902) suggests his reader to imagine a person who is entirely devoid of emotion, no joy, no fear, no greed, no ambition, no anger, nothing. Is there still anything left for him worth making a decision about? So there is a possibility that the supposition holds. Nevertheless, one should never make a rash identification of emotional positive and negative feelings with personal values. One may have an anticipatory fear feelings about some bad consequence, which, however, does not necessarily mean that the consequence is bad because it arouses fear. If an emotional feeling itself is a direct value indicator, no one would be able to enjoy a horror movie. So for the moment it seems a much sounder position to consider, with Ortega y Gasset (1957), that emotion reveals valuable objects, and we do evaluate, very often, the utility of a state by the emotion it will arouse. Stating this way, it opens up a very interesting possibility. Taking for granted that emotions are

genetically inherited programs for decision making, whose rationality holds only under a primitive environment and with considerably restricted information processing capacity, we can now put the rationality of a person's value system in question, instead of just accepting it as something sacrosanct, since a personal value system should have been built under the influence of emotions, and the latter may not fully rational in the contemporary human society. We may even improve a personal value system by externalizing its dependence upon emotions.

This issue of rationality of a personal value system acquires further significance when it is considered in the context of corporate decision making, when the decision maker has a great power and his decision may influence the welfare of many, like that of President Truman. Any such decision maker is assumed to operate under the value system of the corporate body, but Truman in this case allowed his decision to be guided by his personal values. Few, however, could blame Truman in this particular respect. Indeed, decision theory claims that an individual makes his decisions exclusively on the basis of his utilities; or his personal values, and corporate decision makers should be no exception. Any social planners, including decision analysts, must have a bitter experience or two of frustration occasioned by the rejection of their 'flawless' plan by the decision maker to whom the plan was submitted--rejection either with no stated reason, or with an irrelevant one, or with a twisted rationalization for the rejection, or even with an honest one: the legislator does not like the plan, which he admits as good, but will cause him lose votes. Incidentally, this constituency feedback mechanism is important for steering politicians to fulfill their roles properly, though it is far from sufficient as it involves patent biases such as favoring 'popular' policies too much and too often. Even without this mechanism, however, the human societies, democratic or not, are generally equipped with a paraphernalia of socially accepted and enforced rules which function toward letting corporated decision makers identify their personal values with those of the public. If a corporate

decision maker does a good job, he will be praised, honored, become famous, get promoted, and so on. On the other hand, if he does his job poorly, or if he pursues his private values which are in disagreement with the public welfare, he will be punished, blamed, humiliated and will lose his job, like President Nixon. Note that a substantial portion of these social rules are non-material, emotional ones, and they often play far more important roles than the material rewards and punishments at the critical moment, like in the case of President Truman's decision.

So emotions have important social functions to fulfil, as will be emphasized again later. But, of course, this is not the whole story of the role of emotions in society; its effectiveness backfires and causes great damages, too. As a corporate decision maker is also an individual, he is also under the sway of emotions, and when he is, his cognitive field, or decision scope, tends to center around the target of his emotion, thus obliterating important long range considerations. Rash actions and hasty decisions done under the influence of a strong emotion is easy to check, however. Far greater damages are done by those decisions whose emotion-based character passes unnoticed even by the decision-maker himself, because he rationalizes.

Everyone learns to rationalize his emotional actions in the contemporary society, as the society stands on the basis of its members' suppression of asocial emotions. If everyone tries to physically hurt anyone who aroused his anger, our cooperative society would immediately collapse. So when succumbed to an impulse, one should provide a well-stated reason, to extricate himself not only externally from punishment and blames but also internally from degrading himself from his own standard. The finding of Sjöberg and Johnson that people make twisted rationalizations when they break their pledge of giving up smoking may be a good evidence in point (Sjöberg and Johnson, 1976). Perhaps, this habit of constant rationalization would be the reason why we tend to believe ourselves being less emotional and more rational than we really are.

There is essentially nothing wrong in the fact that our values are largely

determined by the emotions such as love, joy, pride and so on, as long as we are aware of the fact that they are also determined by greed, hate, fear and the like. By externalizing all these, our cognitive system may finally be able to come up with a solution for how to live with emotions harmoniously. For the moment, the situation is the contrary. Interestingly enough, our ignorance about emotions is guarded by the emotions themselves. In any culture there are objects, material objects or beliefs or symbolic objects or whatever, which social mores and institutions insist to be valued very high, often with no rational reason. To talk about them are usually touchy because we are often deeply indoctrinated to respond to such an object with emotion. Just let me mention one such example. History reveals beyond doubt that countless inter-community, or international, bloody strifes have occurred contending over some disputed border territory, and in many cases the disputed areas were none but a narrow strip of barren land useful to nobody. Nevertheless, this piece of land could cause all kinds of belligerent emotions in the members of the two communities or nations. Countless rationalizations are made, too, to account for the importance of claiming sovereignty over the disputed piece of land, but if someone proposes a rational solution to resolve the dispute, he would find that all ears are turned away.

There are numerous cases of this sort, enough to make one ostracized ten times over if he voiced his doubts about the high values of all of them. This, however, is a fool's errand. The important thing to do is to let people realize how much we are under the control of emotions and not the other way around, and how often we are thinking in the way Osgood calls 'Neanderthal thinking,' though I am sure that Neanderthals should have lived far more in harmony with their emotions than we do today (Osgood, 1978).

Now I am afraid I have put too much emphasis upon the irrational sides of the emotions. In the remaining sections I will concentrate upon their rationality on their own sake, in order to help externalize the real nature of emotions unemotionally.

2. Emotion as a Dynamic Decision Process

In the previous section I suggested that emotion was to be viewed as a dynamic process, in particular, a decision process. In this section I will elaborate this view, more or less on the ground of the existing theories of emotion.

The process of emotion begins with a cognition of the person's own state. Consider the emotion of fear, for example. In order for this emotion to take place, the presence of some 'fearful' object must be brought into attention. A fearful object is typically (though not necessarily) an animate object that may bring harm to the person. The strength of a fear emotion will be greater as the possibility of actually being harmed is greater, the amount of the expected harm severer, and the expectation of the emergence of the object less. In the case of fear, the whole process often develops very quickly, but we may discern the following aspects of the emotion aroused by the cognition: the feeling of fear; the physiological changes in various parts of the body and the brain, including adrenalin discharge into the blood--the changes that may be subsumed under the generic term arousal; the facial, postural and verbal expressions of fear; and the action sequence characteristic to fear, to freeze, to flee or to fawn, depending upon the strength of the fear.

For the understanding of these basic aspects of emotions, let us take up a few other examples. Consider anger and joy. The emotion of anger will be initiated by the cognition that the person is harmed by another agent, where the harm may be physical or non-physical, and the emotion is usually stronger when the incident is less expected. Hebb and Thompson reported that their male chimpanzee showed anger by approaching a female chimpanzee in heat just brought into the next cage when the approach was blocked by the cage partition, only under the condition that he was led to believe by the human handler that he would be given admittance to the next cage (Hebb and Thompson, 1954).

Following this type of cognition, the anger will be felt. Arousal will

take place. The angered person's face will show the emotion and his fists may be clenched. There will be a readiness, an urge or a tension, to lead the person to take some kind of aggressive behavior directed toward the offender. The actual execution of the behavior may temporarily be suppressed, particularly when the anger is not too strong and the offender is relatively powerful. When this temporal suspension does happen, there will be further cognitive information processing going on, appraising the situation, the advisability and non-advisability of an actual attack, possible strategies for the attack, the strengths and the weaknesses of the target of attack, the intent of the offence, and so on, and these cognitions may in turn increase or decrease the strength of the anger and the urge to attack. It is beyond doubt that this is a dynamic process of decision making. Then what is the major distinction between an emotion-based decision process and non-emotional decision process?

Before going into this problem, let me consider joy. The emotion of joy, particularly a strong one, is created by a cognition that his state is suddenly improved, such as when the person is given an unexpected gift, such as when one learned of his unexpected promotion. The person feels joy, will get excited (arousal), exhibit a joyful expression. But apparently there seems no characteristic category of immediate behavior that marks off the emotion of joy. One may jump, dance or sing a song, but these antics may be regarded more properly as the person's expression of joy rather than as a behavior.

Now consider the initial cognition part of the emotion process. As shown in the above example, an emotion process seems to be activated typically when a discontinuous change is recognized to have taken place in one's state, a change that implies a large 'jump' in the value of the person's 'expected utility' including the utility of the current state. Apparently the strength of the emotion aroused is positively correlated with the absolute value of this expected utility difference, and, the unexpectedness of the change, although mention of this latter factor may be redundant as the change in expected utility automatically implies the unexpectedness of the change. In

any case, notice that this is the most likely situation for the onset of a decision process even if the cognition doesn't trigger an emotion, since such a change will naturally demand for a reappraisal of whatever activity one is engaging in.

If a decision problem is conceived without emotion, the person may then set forth to an elaborate predecisional cognitive information processing. If an emotion is activated and an immediate action is temporarily suspended, the person will also engage in a cognitive information processing. In either case, the decision for a certain action (including no action) will be reached in due time. So, up to this point, the two processes are categorically identical. Neglecting temporarily the arousal and activation part of the emotion process, the critical difference may be found only in that, with emotion, the alternatives of action is preselected contingent upon the category of the emotion, which in turn depends upon the category of the original cognition. Even though a similar dependence may also be pointed out for the non-emotional decision process, the set of alternatives brought under consideration, or the decision scope, may differ from person to person, depending upon the person's past experience, intelligence and a variety of other factors. On the other hand, a considerable uniformity is observed across people about the repertoire of actions likely to be chosen under each emotion. The only plausible conclusion we can draw from this comparison seems that the emotion process is a pre-programmed decision process.

By being preprogrammed I mean that the emotion programs are genetically built-in, as it is the most natural explanation to account for the homogeneity, which is observed not only across people but also across species over the phylogenetic development. In order to make this supposition more convincing, I should also demonstrate the rationality, or the efficiency, of having such a system for survival, particularly when a large cortex is missing with its power of elaborate information processing needed to carry out much less restricted non-emotional decision procedures.

Before going into this demonstration let me briefly go over some of the major theories published so far to give the reader a rough overview of the problems involved. As my description will hardly be thorough and unbiased, the interested reader is referred to, e.g., Strongman's book for a better and extensive review on the literature (Strongman, 1978).

It will be needless to point out the difficulty inherent in the study of emotion, the difficulty enough to have discouraged many psychologists from undertaking systematic, extensive studies of this otherwise fascinating subject. The difficulty is multi-fold, but let me mention just the major two. The first is the difficulty in experimentally controlling emotions. But this type of difficulty has never been unsurmountable. Already, quite a few ingenious experiments have been conducted. What we need most urgently in this respect are good ideas to illustrate exactly what kind of experimental evidences are in demand, for which we first need a good theory. The second difficulty is the ambiguity concerning what is emotion and what is not. Try to list up emotional terms, and you will soon encounter border-line cases. Is 'hope' an emotion? Is 'annoyance' an emotion? But why should we bother? What is important is not to define the extent of the notion of emotion which is fuzzy in any case, but to uncover the internal and external structures of psychological (and physiological) mechanisms of the family of emotions, and often fringe members of a family turn out quite informative in clarifying the family structure. Note also that the emotion process has many aspects, and the emotion researchers are not always in agreement about which aspect is to be regarded as the most typically emotion, or about in what sequence these aspects appear in the emotion process. I think, however, that these issues are at best of a secondary importance, and they will be little discussed, if at all, in this paper.

Undoubtedly it was McDougall (1910, 1923, 1928) who first put emotion in its right perspective with its various aspects, though he applied the term instinct to the programmed, dynamic nature of the emotion, which he functionally separated from emotional feelings. He discussed such aspects of emotion as

cognition, arousal, the tuning of attention to the target object, the impulse to act in a certain manner which has a survival merit, though the terminology he used for them were different. He admitted that the cognition and the action to take part in emotion are modifiable through learning according to the experiences of pleasure and pain. He also distinguished pure emotions from mixed emotions, the issue which is important but not yet settled. His use of the term instinct was rather unfortunate, as he certainly meant something far more flexible than a fixed sequence, though kinship of emotion to instinct cannot be denied. It is probably natural to surmise that the evolutionary process has produced first emotion from instinct and then non-emotional decision making from emotion, whereby the flexibility of the decision program has been greatly enhanced each time an innovation was introduced.

Arousal had been the major issue with early thinkers, and still is with physiologists interested in emotion. Of course, I should not fail to mention James and the famous James-Lange theory, the popularized version of which states that one feels sad because he cries. What James actually contended is as follows: First a person perceives an environmental fact, which is followed by some bodily changes, and the emotion is the feeling of these bodily changes (James, 1884). What James considered the bodily changes in emotion took place in viscera and skeletal muscles, the assumption which, together with his main theory, was strongly criticized by Cannon (1915, 1927, 1931) who assumed that the major emotional bodily changes were thalamic, and these changes were not enough different to distinguish different emotions. This assumption of Cannon has further been modified by later investigators who keep finding that broader and broader bodily areas are responsible for the emotional arousal, thalamus, limbic system, CNS, autonomic nervous system, viscera and what not. This is not much surprising as the emotion process is a process which utilizes all the functions of the human body; as emotion typically handles emergencies, no available resources should be left idle. (See (Arnold, 1960) and (Gellhorn, 1968) as examples of elaborate physiological models of emotion.) Though I have

no intention to go into the modern physiological theories of the emotional arousal, it is noteworthy that Lacey and Lacey found an evidence indicating the existence of an inhibiting center for emotional processes around the nucleus of the tractus solitarius (Lacey and Lacey, 1970), since some such center is needed to inhibit emotional arousal, a leverage for controlling emotions. It seems, however, that we have hardly come any closer today to the goal of obtaining a satisfactory hardware diagram to explain the physiological activities of emotional arousal and its inhibition. Though having such a diagram may help, the analysis of software can be done entirely independently of the knowledge of its supporting hardware.

If arousal is the process to prime the supporting hardware for whatever activity that should follow, the expression aspect of emotions is obviously intended for communication. Since Darwin (1872) the facial expressions accompanying emotions have drawn considerable interest, and much research effort has gone into this area both with animals and men. Frijda, for example, let his Ss rate photographed emotional expressions portrayed by an actress and factor-analysed the results (Frijda, 1953, 1969). It seems to me that much is yet desired of this type of research methods and of factor analysis. As a means of communication between humans, and between animals, too, as the emotional information content depends jointly on the expressions and the context, and of the latter photographs usually tell very little. Furthermore, in the case of human beings, often facial expressions play only a secondary role in the transmission of emotional messages in comparison to verbal utterances. Concerning the usefulness of factor analysis in the emotion studies, I think it would generally yield very little novel findings. Factor analysis is good at discovering a very crude dimensions of the entity of which little is known. Imagine, for example, that someone carried out a factor analytic study on the functional descriptions of all the components of a computer, and I expect that he will get factors like information storage, power conduction, supporting frames and things like that. How much knowledge one can acquire with this kind of

results will depend upon one's ignorance. However, if one wants to go any further for the understanding of how a computer operates, he must proceed from there to an attempt of drawing a system diagram describing how each component is functionally coupled with those of the others. The same may be said to some extent about Davitz's study (Davitz, 1969) using verbal materials. Though his method is very elaborate with useful technical innovations, his final result obtained by factor-analysing word clusters is rather disappointing; the four dimensions he obtained, activation, relatedness, hedonistic tone and competence, are rather ambiguous or self-evident.

On the other hand, the ethological studies concerning the facial expressions of animals produce more interesting results, in the sense that they give us clues on how many of the human emotions we can trace back in animals. For example, van Hooff points out the similarity of the two distinct facial expressions of catarrhine monkeys to human smile and laughter, suggesting different underlying internal processes for these two expressions, a derivation made from the differential social contexts under which they take place (van Hooff, 1967. Also see Eibl-Eibesfeldt, 1970).

Now let me skim over the rest of the issues very briefly.

Continuum: Quite a few authors maintain the view that emotions are just extreme cases of our internal process characterized by a comparatively high level of arousal (e.g., Duffy, 1962). This will be quite true, but an important point to realize is that these extreme members of the continuum which are called emotions do not by themselves form a continuum. Anger and fear may coexist, but they do not seem to blend into a single emotion, and for a good reason: one cannot simultaneously attack and flee.

Motivation: In the behaviorists' tradition, a drive, such as that of hunger, aroused on the basis of some proprioceptive stimulation, causes an organism to initiate a food-hunting behavior. The similarity between this classical motivation process and the emotion process has been pointed out by many, and some argue that they are one and the same. For example, Tomkins

makes a cogent argument that it is not the internal stimulation itself that releases the typical behavior pattern such as food-hunting but it is the cognition, which inevitably amplify the perceived cause, that leads to a behavior through an emotional arousal (Tomkins, 1970). Schacter's experiment on obesity provides a good supporting evidence for that the internal 'hunger stimulation', whatever it is, is not by itself a decisive factor to cause hunger motivation with everybody (Schachter, 1967).

Imagination: Pradines discussed the emotion-arousing power of imagination (Pradines, 1958). But what is imagination? No concrete 'image,' visual, auditory, tactual and so on, may be needed in the cognitive operation called imagination, though it will help to solidify the operation. The most important aspect of this operation is to be considered as constructing a hypothetical cognition such as "If I am promoted to so-and-so position....." or "If my rival such-and-such is promoted to the position instead of me....." which will enable the person to evaluate the utility of these hypothetical states, most directly by the emotional feeling the cognition will arouse. Note that I am not contending that the anticipatory emotion is the only, and thus automatic, means for estimating utilities, but that the use of anticipatory emotion for evaluation is economical and efficient even though unprecise as it is making use of the preexisting system of emotions, and so it will be utilized most of the times when available. Apparently, the cognitive system is firmly in control of this evaluation-through-imagination situation, since one is usually not carried away by anticipatory emotions; the anticipatory, or 'hypothetical' nature of the cognition is definitely registered in the consciousness, suppressing the link between the emotional feeling and action, in the same way as in the case of horror movie audience.

Pleasure and Pain: As I have discussed in the first section, the relationship between emotions (including anticipatory ones) and values is no simple issue. It is quite true that each emotional feeling has positive and negative 'tones,' called by different authors in various names such as pleasure-pain,

pleasantness-unpleasantness, positive and negative affects, hedonistic tones and so on, and undoubtedly this is the dimension that is utilized for evaluation in anticipatory emotions. Furthermore, it is true that these positive and negative affects themselves work as motivators under certain conditions; someone may try hard to change his cognition so as not to feel anger, and some other may indulge in happy daydreams with or without the aid of alcohol and similar drugs. But, obviously, such is far from a universal phenomenon. Also note that when used in value estimation, how the strength of affect is converted into utility is far from clear.

Feeling: In the above argument I pointed out one possible use of emotional feeling as an evaluative device. There are other ideas about the possible roles emotional feelings, or feelings in general. Pribram considers the main role of feelings as that of monitoring the results of cognitive appraisal of on-going activities (Pribram, 1970), and Pradines, who used the term sentiment, ascribes it for regulating actions (Pradines, 1958). This is a topic closely connected to the role of consciousness, however, and cannot be elaborated in any further here. (See for further arguments, Mandler, 1975).

Uncertainty: Siminov relates emotion with the insufficiency of information (Siminov, 1970). From the decision process characteristics of emotion, the existence of a close link between uncertainty and emotion should be obvious (too obvious in the cases of surprise and anxiety), and this issue truly deserves a very serious attention.

Mood: Mood may be said to differ from emotion in that a certain mood may be triggered without a cognitive cause and does not lead to any specific type of actions. Nevertheless, it is clear that mood is a close kin of emotion, and serves as the background for the emotions; under a depressive mood, for example, negative emotions seem more easily to be triggered. It is also agreed that mood is more or less contagious, although Nowlis's works on the effects of drug-induced moods are not yet conclusive (Nowlis, 1963, 1965). In this vein, I like to draw the reader's attention to the following

Schachter's comment on the behavior of the epinephrine injected Ss in the famous Schachter-Singer experiment; these Ss, being unable to explain the arousal caused by the drug of whose effect they were kept ignorant, behaved exactly like the stooge whose behavior was either euphoric or bitter: "[They] tend to catch the stooge's mood with alacrity." (Schachter, 1970, underline by the present author.) Though I cannot discuss this ingenious piece of experimental work here, I like to regard it as a typical mood contagion experiment, and I think the contagious property of mood is very important because of its social function, as will be discussed in the next section.

The Organization of the Family of Emotions: It will perhaps be a question to come to anybody's mind why there are so many emotions and how they are relating to each other. It is therefore more than natural that someone gets an idea sooner or later of constructing a multidimensional pigeonhole system, one hole for each emotion, so that the whole family of emotions are orderly classified and neatly labeled.

In spite of the inherent fascination of the task, or just because of it, one should note the danger inherent in this attempt of creating a fallacy, to be referred to as the pigeonhole fallacy. Suppose that no appropriate proper emotion has been found for a certain hole in the pigeonhole system, wouldn't there be a strong temptation for the proponent of the system to assign to it a substitute, even if its membership to the emotion family looks rather dubious? Or, wouldn't one, perhaps subconsciously, ignore those members of the emotion family which don't fit to his system? Some such artificiality is apparent in all the pigeonhole systems so far suggested. Such an artificiality of the pigeonhole system applied to the family of emotions seems to result mainly from the two sources: First, the verbal labels of the emotions should have been developed in any culture primarily for the purpose of efficient communication, and under its harsh pragmatism little room should be left for aesthetic considerations to come into play, such as neatly fitting the whole family of emotions into a balanced pigeonhole system. Furthermore, note that

the emotion process has many distinct aspects and some aspect of it may be more characteristic to some emotion than the others, or an aspect may be shared by many emotions. So from the point of view of practicality, it is no surprise that the connotations of emotional terms are very uneven; some refer to individual emotions, some to feelings, attitudes, strengths of arousal, behavior patterns and so on.

It is, therefore, a truism that a scientific terminology of emotions are badly in need. Nevertheless, we must first have a good notion of what this new terminology is going to describe before any such language is to be developed, and for the moment there seems no alternative other than carefully sifting out all the informational contents involved in each and all the emotion relevant terms in the natural language.

The second major source of the artificiality of pigeonhole approaches is closely related to same issue. In order to develop a pigeonhole system, one needs a set of basic dimensions, the number of which must be manageably small. But no one yet knows how many dimensions the emotions really have, and the fact that all the pigeonhole approaches so far developed completely disagree with each other simply attests the need for a broader approach.

In spite of all these faults pigeonhole approaches do have their strategic merits, too. They force the investigators to take a grand view, to take the whole family of emotions within a single scope, and while attempting to put each member side by side, the chances are high that whatever hidden dimensions of emotions are brought into awareness. So I believe it is significant that the two new works in this field, of de Ravela and of Kemper, set their basic dimensions (though different ones) both in the interpersonal, or dyadic, relational setup (de Rivera, 1977; Kemper, 1978). I think this development is quite significant, since, as Izard emphasized strongly, not only the emotional expressions and emotional behaviors are mainly directed at other persons (Izard, 1972), these authors have also revealed that the emotion arousing cognitions are made in the context which is primarily interpersonal.

Since space does not permit me to go any further in discussing their approaches, let me just list the dimensions employed in the three major works in this field. Plutchik: Intensity, Similarity and Polarity (defining which emotion is to be put opposite to another in the system) (Plutchik, 1970). De Rivera's model consists of four dimensions. The first binary dimension is concerned with whether the object of emotion is the other (in the dyad) or the self, like in the case of 'contempt' and 'shame.' The second and the third dimensions bear upon his hypothesis that the effect of an emotion includes an attempt to transform the dyadic relation, either to decrease or increase the distance between the two. So this distance aspect is represented by his second binary dimension, and the third is concerned with which of the two, the self or the other, is to be moved to produce the desired distance effect. The fourth dimension possesses three values labeled as Belonging, Recognizing and Being, about which no brief explanation will do. Kemper's model is very elaborate, and discussing only the dimensions he used hardly does justice to it. Basically, however, his model is based on five dimensions, power of the self, status of the self, power of the other, status of the other, and the responsible agent. I should warn the reader, to avoid any hasty misunderstanding, about his definition of 'status' which is rather peculiar, roughly meaning a faculty of drawing the other's service without coercion.

3. A Structural Theory of Emotion

In this last section I will describe only a very broad outline of a theory which I am intending to develop. The major purport of the theory has been stated more than enough in the previous sections. To recapitulate: The emotions are the programs for decision making developed through the process of evolution. As such the whole family of emotions should form a rational system, though the rationality may be degraded in the case of the modern Man because of their greatly enhanced cognitive information processing power and of the artificial environment they have created under the name of civilization. As

a research strategy toward such a theory in its starting phase I propose to begin with a conceptual task which I might call a zigsaw puzzle approach. A stage may be set by imagining a rather primitive way of life when the human beings are not much above socially organized animals, so that the principle of rationality can function in maximal efficiency with its deductive, explanatory power. Then we will consider the survival values for each emotion. That, however, cannot be done without taking into account other emotions functionally tied with the first.

Consider, for example, anger. Suppose that a tribesman tried to steal a valued possession of another and was caught red-handed by the owner. The latter will naturally be angered. The anger will show through his expression and the imminence of attack will be recognized by the offender, to arouse a fear in him. The emotion will make him cringe if he cannot flee. The show of submission in the offender usually appeases the anger of the offended considerably, and the punishing attack may be abated in its ferocity if not entirely abandoned.

Now suppose that they both possessed no emotion so they had both to go through non-emotional decision processes. By discovering the attempted theft, the owner of the object may realize that he has three alternative options open for his action. The first is to pass up the offence and let the offender go scot-free. The offender will then quite probably try it again and may succeed next time. The second is to attack him for the purpose of punishment. But a direct attack will invite a counter-attack, and even if the attacker is superior in the fighting power, he himself might be harmed in the brawl, too. He may also warn the offender of his intended attack in the expectation of making the offender surrender voluntarily and without a fight. The last course may be best if it succeeds, but there is also a risk that offender, being warned, may stage a surprise attack. Therefore, the offended had better be prepared physically for the possibility of treachery, and he should watch the offender closely for any telltale signs. So the outcome of this deliberate

decision making coincides exactly with what the anger emotion does, and the latter does it much more quickly because the whole process is preprogrammed in anger. Needless to say, this time-saving aspect is of crucial importance in a primitive environment, where a real danger surreptitiously stalks up on one without a warning. So the adrenalin surge in one's blood stream caused by fear should be instantaneous to enable the person to survive by running with a maddening speed.

As I have discussed in the second section, the cognition of any unexpected, abrupt turn of event seems to create an arousal, including some energy release. At this point the emotional state may be called that of a 'surprise', and the person had better be aroused irrespective of the nature of the change, as any abrupt change may mean a possibility of danger. A more detailed appraisal of the situation will immediately follow, however, turning the surprise either to 'joy' or 'fear' or something else.

So this may explain why even joy causes arousal. Joy, however, seems to urge one to no immediate action, and this is understandable. The person's state has been improved, and improvement does not, in principle, presents a problem. There are, however, expressions. A joyous person will at least smile. As the intensity of the emotion goes up, the person may shout, jump up, dance or even cry. Since these antics apparently have no direct practical purposes to serve, they are to be regarded more as expressions than actions, as I mentioned before. What is then the content of communication these expressions intend to convey?

Even though one may attain a joyous state for himself, it will certainly be more common that such is brought by a benefactor. Whatever the motivation of the benefactor would have been, the fact that the person's cognition caused joy rather than suspicion attests that the person believes that he has gained by the benefactor's favor, making it worth to encourage the benefactor by demonstrating his pleasure. So dogs wag tails and cats purr. A human may show at least a broad smile, followed often by culturally coded acts or utterances

of gratitude, signifying either comradeship or obeisance, which may be taken as an indirect promise for his future repayment of favor.

What if, then, there is no benefactor, and what is the purpose of jumping, shouting and all these wild acts? Are they just exaggerated expressions for joy or is the person simply spending off the aroused energy? I think there is something more. Imagine a child given a wonderful present. What the child does immediately afterwards will be to show off the present to friends. From this I conjecture that an improved state generally means an increased power in the social context, and showing off is a procedure to demonstrate the increased power and to get the social recognition for it. The socially recognized power of a person may be referred to as his status, and as such status plays important roles in social interactions, resolving possible conflicts just by comparing the levels of status of the persons concerned without recourse to raw confrontations of a power against another power.

I believe that the notions of power and status so introduced are extremely important in understanding interpersonal interactions (e.g., Toda and Shinotsuka, 1978), and, indeed, it could be demonstrated that they are crucial factors in determining the emotion-arousing cognitions, although I cannot go any further into this topic here. The implication this argument bears on the emotion of joy is that the jumping, shouting and the like antics following strong joy might very well be another manifestation of the showing-off activity.

Note that the showing-off is essentially a risky activity, as it is quite likely to invite 'envy' of others. This then leads us to another aspect of the emotion of joy. Though the connection is not so direct and obvious as in the case of anger and aggression, note that a person in joy usually feels an urge toward having a conviviality; gather close friends and have a celebration party. Of course, the obvious purpose in the host's mind for having a conviviality would be that of prolonging the jovial mood; as mood is most contagious among close friends, or among whom I call the person's coalition members, the jovial mood may intensify in a merry party through a sort of positive feedback

process. But this does not seem to exhaust the social functions such a conviviality is intended to perform. First, it will strengthen the cognized bonds among the coalition members, and by so doing, it will suppress potential dangers coming from the envy emotion of the person's fellow members. Note that envy is aroused most strongly by an upgraded power or status of another person with whom the person in consideration customarily compares his power and status (Festinger, 1954). But if this another person is recognized as his coalition partner, and as such the person is, to attest to their partnership, indeed sharing whatever he got, a free treat and a free gift topped with a jovial mood of comradeship, the feeling of envy may possibly be diminished. (Of course, celebration parties are, particularly those formalized ones, could also be a means to show off power and status.)

So this topic has led us to another important issue of the social coalitions. The survival merit of joining a true coalition is too obvious to deserve mentioning. On the other hand, to be a member of a shaky coalition is very risky; since a coalition demands mutual trust of its members to reap its benefits, one would have to suffer greatly if his partner is tempted to defect. As I have been assuming, the primitive men and animals may not be able to do detached (non-emotional) calculations about pros and cons for forming a certain coalition. So if the system of emotions does exist to provide them with a means of behaving rationally without making detailed information processing, the system should also include elements for evaluating the merits of coalitions and protecting coalitions from possible dangers of defecting members. The contagion of moods will certainly work as a homogenizing agent among coalition members; by sharing the same mood, they would tend to have similar emotions, and thus may think and behave similarly. Also, this seems the right place for the protagonist emotion of love to come in. Even though the notion of love is over-loaded, the love as a strong emotion seems to allow no other interpretation but to form, and maintain, an unconditional coalition. So unless the object of love is genetically determined

like in the case of parental love, the emotion of love is aroused by a certain evaluative cognition of a potential coalition partner--though the modus operandi of this love cognition still remains mostly in mystery. Once the love emotion is aroused in a person, it then creates strong desires for the same emotion to be reciprocated by the target person, for the total sharing between the couple, in particular the sharing of emotions, which all seem to indicate the coalition-forming function of love. The emotion of love may or may not persist after a mating coalition is formed. But once formed, it will be protected, to some extent, from potential defection of one of its members by another strong emotion called jealousy to be aroused conditional to the partner's defection.

Jealousy is undoubtedly a complex emotion, anger being its major component. Now let me turn to anger again, and consider it in this context.)

Note that

defection is something that one ought not to do, and this cognition of 'injustice' often seems an essential ingredient of the anger-arousing cognition. If a child is punished for his mischief as anticipated, he may feel sorry for him but will not be angered. But if he thinks that the punishment is given unjustly, or harsher than he thinks just, the punisher would have to face a strong protest. Anger will thus operate in keeping the social order as people think it ought to be. This also explains why angered person is appeased by seeing the offender showing submission or repentance. Submission demonstrates that the infringed social rules (often those of observing the proper status difference) are restored, and repentance proves that the offender will follow the rules since then. So in the case of vicarious aggression, the aggressor may not just be trying to spend his pent-up aggressive urge and energy. If this is all there is to it, anger must not be appeased just by observing submission or fear in the offender. The anger-based aggression, therefore, should be seen more in the light of justice-restoring (as the offended sees it) activities than as an attempt to give harm to the offender, and when this is infeasible for one

reason or another, the offended may twist his attribution a little bit to find an attackable culprit so that his justice restoring urge is satisfied.

Naturally, it is this twisted thinking--twisted attribution in the above example, twisted subjective probability in wishful thinking and illusory 'hope,' and twisted utility in dissonance reduction (Festinger, 1957)--that seems to be doing the greatest damage to the society. Everybody rationalizes their emotions and decision makers with vast powers are no exception; while rationalizing people regard themselves as rational beings.

The situation is, however, not entirely hopeless. We can control emotions, and emotions are meant to be controlled; if the workings of emotions are entirely automatic and self-sufficient, there ought to be no need for the feelings of emotions to exist. If the feeling of emotions is a monitor as Pribram claims, then its sole purpose is to aid the conscious control of them. And we are certainly controlling our emotions to some extent in order to survive in this complicated environment called civilization, for which the system of emotions is not meant to cope with efficiently. But the control fails ever so often, and damages are done through uncalled-for emotional activities and the subsequent twisted rationalizations.

I believe that the only remedy for this problem will come from the following two suggestions: First, give citizenship to the emotion in our society, and stop pretending that we are not emotional animals. Secondly, externalize emotions and teach children the workings and meanings of emotions. This will probably inhibit rationalizations to some extent, and also make them alert to the other people's rationalizations. Of course, this would put parents and politicians in an awkward position unless, according to the first suggestion, they are also taught not to expect anyone to be entirely rational. To stop rationalizing entirely is an impossible task, as the urge toward rationalizing is also emotion-based. However, we may proceed step by step toward constructing a society in which people live more harmoniously with their emotions, a goal which can be achieved, if ever, only through non-emotional, rational analyses

of emotions.

In this section I have only very briefly sketched my line of approach toward a functional system model of emotions, with which I might happily go on indefinitely if the space permits. However, I hope that the reader has obtained a good idea how the approach will proceed in its first stage of conceptualization, which will be followed by the second stage of empirical confirmation once a workable model has been obtained.

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It was my original intention to write another section in this paper to introduce my own thinking on how a socio-psychological decision theory of emotions should take shape in a form of a functional system model. As the space does not permit me to do this, it will be done in another occasion.

PART C: ABSTRACTS OF SPECIFIC PAPERS

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Experiences with MAUD: Aiding decision structuring through re-ordering versus automating the composition rule.

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Initially, automated Decision aids were designed with the goal of "bootstrapping" the decision maker by automating a normatively prescribed composition rule, expected to be superior to the intuitive composition rule that would be employed by the Decision Maker, unaided. Subsequently, it was realised that structuring and decomposition operations might be profitably aided as well (Selvidge, 1976). This paper will describe findings implying that it is the structuring capability of a decision aid which is most highly valued by decision makers who are initially unsure about the preference structure of their problem and about their own goal structure, even though the aid, MAUD (Humphreys & Wisudha, 1979) was originally conceived as a bootstrapping aid in the investigation of subjective preferences between multiattributed alternatives.

Maud was used in the field, taking it (via a portable terminal, acoustic coupler and the public telephone network) to 40 decision makers in four groups working in different contexts in the arts and mass media. The four contexts studied were: (1) development and selection of television commercials by campaign planners in an advertising agency; (2) allocation of funds to arts projects by members of a local government arts committee; (3) selection of film programmes by the management of a small arts-oriented cinema; (4) selection of materials for inclusion in a media studies course by a teaching group at a college of further education. The analyses of the "logs" produced by MAUD of these sessions will be presented under the following headings.

- (i) "Bootstrapping" the composition rule: Convergence between intuitive and MAUT-predicted preference orderings.

No external validation criterion for preference orderings existed in any of the above 4 contexts. Hence the starting point for investigating the potential efficacy of "bootstrapping" the composition rule was an analysis of convergence of MAUT-predicted orderings with intuitive preference orderings. With the exception of group (2) the degree of convergence was found to match the tightness of the feedback loop between selection of choice alternatives, action, and consequences for the decision maker. A tight feedback loop existed for members of both groups (1) and (2), but while members of group (1) needed to make trade-offs on

the basis of their believed "true" subjective value-wise importance weights for attribute dimensions and demonstrated high convergence. On the other hand, members of group (2) were principally interested in manipulating the "accepted" value-wise importance weights for dimensions under discussion in their committee in order to "push" particular projects, and hence the MAUT composition rule was inappropriate for their (sometimes nefarious) purposes within the group decision making context.

(ii) Implications of convergence results for aiding decisions

Traditional MAUT-validation arguments based upon convergent validation (Humphreys, 1977, section 6.2) would claim that high convergence indicates high validity. Slovic, Fischhoff and Lichtenstein (1977) have pointed out that such arguments are fallacious under the "bootstrapping" rationale. MAUT-predicted preference orderings which mimic intuitive preference orderings are no better than such orderings and hence no bootstrapping has been accomplished.

In fact, the response of our decision makers in the four groups was exactly the opposite of that predicted under the "convergent validation" argument. Members of group (1) liked the system, but found it redundant as an aid, since it only confirmed their intuitive (unaided) compositions. Members of group (2) found it betrayed their intuitive compositions. Members of groups (3) and (4) demonstrated a gradual increase in their (initially very low, or even negative) convergence over sessions. They were happy with neither their intuitive nor the MAUT-predicted preference ordering but demonstrated a strong desire to continue with more sessions with MAUD. So what was MAUD helping these people with? In order to find out, multidimensional unfolding analyses were performed on the decomposed MAU assessments from the MAUD logs. We found that low convergence went with more complex preference structure where the locus of ideal points of the attribute dimensions within the preference spaces usually formed a loop rather than a line (implying a much more complex regret structure about non-chosen alternatives under any weighting scheme within this space.)

Analysis of debriefing interviews (carried out after each MAUD session) indicated that such complex preference structures resulted from the over-laying of 2 or more simpler preference structures associated with different goals which the decision maker was trying to "keep alive" at once. The resulting complex preference structures were in fact incoherent and no composition rule applied within them (intuitive or MAUT-prescribed) could resolve the incoherence, and form an acceptable preference structure.

A further analysis of convergence is presented, demonstrating that the increase in convergence over sessions with MAUD lay in consciousness

raising about the structure of the value wise importances of attribute dimensions, rather than about the representation of choice alternatives on dimensions.

(iii) Aiding decision means aiding the structuring of the Decision problem

This section of the paper demonstrates how the results outlined in (ii) indicate that what was being aided by MAUD during sessions with decision makers was the re-structuring of the decision situation in such a way that goal confusion is reduced, and the preference structure clarified, so that a coherent composition rule can be applied in reaching a decision, and that such activities completely dominate the biases and heuristics conventionally investigated in experimental studies of MAU compositions. We also refute the two principal counter arguments against this conclusion, namely (a) "MAUD forced people to start over-simplifying things, and all the changes over sessions follow from this", and (b) "It's all a mathematical artefact".

Counterargument (a) is refuted through an analysis of the mean number of attribute dimensions introduced into the MAU decomposition in first and last sessions with decision makers (which actually increase in number). Counterargument (b) is refuted through the adduction of convergent validation for our thesis from analyses on four independent sources of data drawn from the MAUD logs. This includes analyses of the relationship between the extent to which decision makers re-ordered their preference structures during their sessions with MAUD (by introducing and subsequently deleting dimensions) before applying a composition rule. A three-way relationship is demonstrated between such re-ordering activity, changes in convergence over sessions and nature (line/loop) of the resulting preference structure.

We conclude that MAUD - instigated consciousness raising lead to re-ordering activity followed by increase convergence between intuitive and MAUT-predicted preference orderings.

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AN INFORMATION-PROCESSING MODEL FOR
MULTIDIMENSIONAL STRATEGIES

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One component of the decision-process in a multidimensional context are the cognitive strategies the DM uses to amalgamate his or her dimensionwise preferences. Several authors have proven that people use simple strategies like the Lexicographic-ordering- or the Majority-strategy (for a recent review cf. SVENSON (in press)).

In the present paper an information-processing (=IP) model is developed which enables the formulation of a rich variety of strategies (including the simple strategies mentioned above) and hierarchies of strategies on the base of relatively few elementary information processes. The concept of IP-systems and languages utilized here is the well-known one of NEWELL & SIMON (1972, Ch.2), therefore a detailed discussion is not necessary.

A is a list (vector) of alternatives $x, y, z, \dots$; D is the list $D_1, \dots, D_n$ of dimensions (attributes), each dimension D_i is a list of different levels of that dimension.

Two types of elementary information processes are distinguished:

(1) those assumed to be not specific for decision making, e.g.: $\Rightarrow X$...assigns the name X to the output of the previously executed process; COMBINE(X,Y)...combines X and the list Y; $X \leftarrow Y$...sets X equal to Y. The next two examples are subroutines based on such elementary processes: SELECT(L,M)...selects any list of L from which at least a part is a list in M (L and M are lists of lists); FOR ALL (m) IN (M) DO α ...instruction α is executed in turn with each element m of the list M.

(2) those assumed to be specific for decision making:

CODE(α)...assigns one element of the personal code list to α . E.g.: A gambler may code a possible win of 15 \$ as 'high' (or as 'more than 10 \$', or simply as '15 \$', depending on his or her personal code).

Let M be a list, M^C the list of code-levels corresponding to the elements of M, Rel an ordering relation over M^C .

$\text{MAX}(M; \text{Rel})$...selects the maximal element(s) of M ,
 $\text{MIN}(M; \text{Rel})$...the minimal element(s) of M , according to
 the relation Rel over M^C . E.g.: $\succeq$ be the relation of
 greater or equal weight, then $\text{MAX}(D; \succeq)$ selects out of D
 the dimension(s) with the highest weight.
 $\text{EQUIV}(M; I)$...tests whether or not the equivalence-relation
 on I (defined over M^C) holds between all elements of M .
 $\text{CONCATENATE}^C(X, Y)$...output is the code-level assigned to
 the combination of X and Y . If e.g. the DM uses a nu-
 merical code, this operation may correspond to the
 summation, other codes require other CONCATENATE -ope-
 rations, for some codes no such operation may exist.
 $\text{DIFF}^C(X, Y)$...computes the subjective difference between
 X and Y and assigns a code-level to that difference.
 $\text{CRITERION}(D_i)$...output is one level of the dimension D_i .

Strategies are formulated as sequences of these elemen-
 tary information processes. As an example the program for
 the Lexicographic-concatenation-strategy is presented.
 Using this strategy the DM first selects the most impor-
 tant dimensions. Then the values of each alternative x on
 these most important dimensions are concatenated (e.g.
 summed), and that alternative(s) is (are) chosen which
 has (have) the highest concatenated value. Several DMs
 were observed using this strategy in a decision task with
 numerically presented information.

```

1  CODE(D)
    MAX(D;  $\succeq$ )  $\Rightarrow$  Dmax
    FOR ALL (x) IN (A) DO 3
    MAX(C; R)  $\Rightarrow$  Max *)
2  SELECT(A, Max)  $\Rightarrow$  M
    Output  $\leftarrow$  M
    STOP
3  FOR ALL ( $D_i$ ) IN (Dmax) DO 4
    CONCATENATE( $x_{Dmax}$ )  $\Rightarrow$   $x_{Dmax}$ 
    COMBINE(C,  $x_{Dmax}$ )  $\Rightarrow$  C
4  CODE( $x_i$ )
    COMBINE( $x_{Dmax}, x_i$ )  $\Rightarrow$   $x_{Dmax}$ 

```

*) R is the common
preference-
indifference-
relation

The output of a strategy is a list A' of alternatives
 ($A' \subseteq A$). If A' contains more than one alternative, an-

other strategy has to be applied. Programs of hierarchies of strategies use strategies as subprograms.

The most important advantage of the formulation of cognitive strategies in an IP-model is that the IP-model creates a common theoretical base for all strategies.

This allows a detailed analysis of the complexity of cognitive strategies. Among the aspects determining the complexity of IP-strategies are: (1) number of memory registers necessary to store provisional results; (2) the length of the program; (3) complexity of the elementary information processes involved; (4) cost of coding the information for the elementary processes involved; (5) amount of information input necessary.

Another point is that instead of hypotheses about the use of simple strategies in dependence of characteristics of the decision task and the DM, it is possible to state such hypotheses on a more cognitive level, via hypotheses about the application of elementary information processes.

As an example consider the following hypothesis about the use of a specific type of cognitive strategies in dependence of the type of information presentation: Strategies involving the operations CONCATENATE and DIFF require a code enabling their application. It is assumed that the type of information presentation influences the DM's personal code: if the information is (1) presented in numerical form, using the same score-system on all dimensions, it is more likely that the DM utilizes a numerical code than if the information is (2) presented in different ways on all dimensions (graphically, verbal descriptions, numbers, etc.). Thus, if the information is presented according to case (1), it is easier to perform the operations CONCATENATE and DIFF. Hence strategies involving these operations (Concatenation- and Lexicographic-concatenation-, Greatest-attractiveness-difference-strategy) should be used more often in case (1) than in case (2).

This hypothesis is tested with an experiment which is already in performance. The result of the experiment will be available in June.

The Effort of Making a Decision:
How do we decide how to decide?

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How do people choose among various decision rules? Ideally, a decision-maker should choose a rule that ensures selection of the best alternative. In this paper, we limit our discussion to riskless, multi-attribute choice, in which all the available information is static and the attributes are independent. Under these conditions, the additive utility rule serves as the definition of an optimal strategy. It is also the sole decision rule that always selects the best alternative in these circumstances.

The basic premise of this paper is that despite the additive utility rule's unique status, it is not always the best decision rule. Two characteristics of real world decision environments contribute to this paradox.

1. Other decision rules are capable of selecting the superior alternative a high percentage of the time (Thorngate, Note 1). This is particularly true of the many real world situations in which the attributes exhibit a positive intercorrelation (Einhorn, B. Kleinmuntz & D. Kleinmuntz, Note 2).
2. Human information processing limitations may prevent the decision-maker from executing the optimal choice rule. A variation of this argument is that the

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additional processing effort required by the optimal rule may not be worth a small increase in accuracy.

Given two choice rules both of which select the best alternative a high percentage of the time, which does the decision-maker use? A view of man as a limited information processor suggests that the better rule is the one that requires the least cognitive effort. Thus an "optimal" decision rule not only selects the superior alternative, but does so with the least cognitive effort.

This notion of effort underlies much process tracing research currently conducted in decision making. For example, Payne's (1976) "contingent processing" is motivated by the assumption that certain rules are easier to use during certain phases of the decision task. Without a notion of effort in behavioral decision theory, there would be little reason to expect decision-makers to use anything but the additive utility rule. It is these information processing considerations that may account for much of the "satisficing" behavior observed in human decision-makers (Simon, 1956).

The explicit role of effort in theories of decision behavior requires a concrete method for categorizing decision rules by effort. Previous research has used either the experimenter's intuition as to difficulty, or the subjective self-reports of subjects. Neither of these methods is rigorous enough to establish a metric for decision effort.

The rest of the paper is devoted to the establishment of such a metric through the development of a model of decisional effort. This model is based on the simplifying assumption that effort is

a direct function of the number of mental operations required to execute a given decision rule.

In the paper we develop process models of several common decision rules: additive utility, additive difference, lexicographic, conjunctive, and elimination by aspects. These models are designed to be as efficient as possible, given the mathematical statements of the rule. For example, the additive utility rule is usually stated:

$$U(x) = \sum_i U_i(x_i)$$

Our process model shows that for each alternative, the decision-maker would be required to perform one multiplication for each of m attributes and $m-1$ additions to estimate the overall utility of the alternative. To find the best alternative, the decision-maker must make $n-1$ comparisons where n is the number of alternatives in the choice set. Thus the total number of mental operations, or total effort, is $2nm-1$.

Similar calculations are performed for each of the other decision rules discussed. After developing estimates of effort for each rule, the paper compares the various effort values as the numbers of alternatives and attributes are increased. These comparisons explain many task effects observed in process traces of decision making, e.g. Payne, (1976) and Wright (1975). The model also provides a theoretical framework for phenomena discussed in reviews of the process tracing literature (Svenson, 1979). Lastly natural extensions of the present model are discussed, including the need for empirical work to derive better estimates of the cost of various mental operations.

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ON THE VALIDATION OF
DESCRIPTIVE THEORIES OF HUMAN DECISION-MAKING

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Descriptive models of individual human decision-making serve several purposes. Two main purposes are prediction and explanation. By prediction we mean the correspondence between observed outcomes and outcomes specified by the model. By explanation, we mean the ability to understand the presumed causal interconnections between the inputs and outputs. Other purposes include control, as in a formal organization in which management evaluates the actions of subordinates. The model could be used to train or teach the process to others. It could be used as a basis for improving the process, that is, changing it so the outcomes which result conform more closely to some normative standards. The model could be used to study the sensitivity of the outcomes to variations in the inputs and the mediational processes. But an unvalidated or poorly validated model subverts these purposes.

Research into the psychology of human problem-solving by the development of computer simulation models of a subject's verbal utterances (called his protocol) has been convincingly successful and productive over the past decade (cf. Newell and Simon, 1972), notwithstanding problems associated with computer simulation models (Dennett, 1968) and protocol analysis (Frijda, 1967). However, a number of issues peculiar to the domain of decision making arise. How does one judge the descriptive adequacy of a decision model? And, does one need a model of the decision process or is a model of the eventual outcome sufficient?

The backdrop, to which the techniques of judging the adequacy of descriptive models of decision-making will be applied, is a computer

simulation program developed by Tuggle and Barron (1977). This program, called SIDIP for Simulation of Individual Decision-making through Information Processing, models three different subjects each making nine different decisions under uncertainty. Eight different action alternatives confronted each subject for each decision. SIDIP correctly predicts all 27 action alternatives selected by the three subjects.

Two basic validation methods have historically been considered sufficient -- a process method and Turing's test (1963). Having argued that process validation is necessary for face validity, the process method considers both qualitative and quantitative aspects of individual processes. Turing's test judges the similarity of a subject's actual protocol and a protocol from a decision model.

SIDIP is validated in both senses. The model is a process model; however, since it is based on protocols a strong correspondence between observed and modelled processes is to be expected. On the other hand, using Turing's test, judges were unable (on a statistical basis) to distinguish actual and simulated protocols, although decision theoretic protocols can be rather easily distinguished on the basis of "behavior" matching.

However, these two historically adequate validation procedures (cf. Van Horn, 1971) fail to convey any information about how much data has been "explained," how much theory has been "validated," and how much theory is necessary to provide the "explanation." A more revealing methodology for the validation of descriptive models of human decision-making is called for. Thus we scrutinize SIDIP through the methodological paradigm erected by Tuggle (1978). This methodology allows one to determine whether or not the focal model is adequate, whether or not it is too complex or should be made more complex, whether or not the model development process should continue or cease and whether or not the "final" model produced should be accepted or rejected.

In that methodology one begins by defining the set of behaviors to be explained (call it U). For our purposes, this consists of not only the 27 outcomes (action alternatives to be selected) but also the 274 intermediate behaviors emitted by our three subjects and recorded in their protocols. The second phase consists of selecting a model form (SIDIP in this case), developing a metric of theory content, and specifying what is the minimally acceptable level of robustness (explanatory

power) and parsimony (explanatory yield). (Explanatory power is the percentage of U explained by the theory; explanatory yield is the number of behaviors explained per unit of theory.) Finally, one develops and successively refines the model until the set U is explained, explanatory yield drops too low, or the rate of progress toward the desired explanatory power is too slow and the modeler discards this model form for another one. SIDIP is subjected to this methodology. Set U consists of 301 behaviors. The final form of SIDIP (cf. Tuggle and Barron, 1977) is a computer program with a two-layered structure to it: "strategy" and "tactics." As 18 "tactical" subroutines are employed, it is natural to polarize the metric of theory content along the lines of the number and "size" of the subroutines used. Reasonable a priori levels of robustness and parsimony are an explanatory power of 80% and an explanatory yield of 3. By then tracing through the iterative model development and validation methodology, we hope to illustrate the steps necessary to validate descriptive models of human decision-making and to impress upon modelers the necessity of carrying out this systematic validation process while the model is being developed.

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AbstractDecision processes in urban development : Perspectives from
economics and psychology

by

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This paper describes an applied research project in the field of urban planning. The problem stimulating the research is the following : Interventions by local authorities in France to plan certain types of urban development have frequently been unsuccessful. Either desired effects have not occurred, have occurred with considerable delay , or in some cases have produced effects contrary to those intended. Furthermore, these results have been surprising in that local government intentions would seem to be in the interests of most of the community. For example, in the southern town of A many local traders and businessmen took a long time to avail themselves of the facilities of new industrial zones at a time when their businesses were severely disrupted by congestion in the downtown area. In the Riviera town of C, measures taken by authorities both to relieve downtown congestion and to reduce the number of holiday homes in the center of town backfired. Congestion and holiday homes both increased. Furthermore the property market collapsed in the sense that although prices remain high, there are many unsold apartments and local building firms face considerable economic difficulties.

The research attempts to understand these phenomena by appealing to notions developed in both economics and psychology. The contribution of economics is from the theory of "rational expectations" (Muth, 1961). This theory posits that economic agents base their anticipations (e.g., of rates of unemployment, prices etc.) on a theoretical economic model. Thus, they have ideas as to what the levels of these variables should be and their evolution (i.e., trajectory) across time. This leads, inter alia, to ideas concerning what is or what is not normal. Furthermore, in the short run at least, such expectations can be quite resistant to evidence of a contradictory nature. Anticipations in the form of "rational expectations" can be considered the outcome of a causal means of reasoning based on a theoretical ("rational") model. If such "rational" expectations are shared by many economic agents, they can become an important variable in economic activity.

The psychological inputs to the study are notions from studies of judgment and decision making. Specifically, the models on which economic agents form "rational expectations" are likened to schemata (Bartlett, 1932) or scripts (Abelson, 1976) which can be depicted as cognitive maps (Axelrod, 1976). It is furthermore explicitly recognized that different economic agents (or types of agent) have different cognitive maps, varying for example on dimensions of complexity and stability. Consequently, economic agents can differ considerably in how they react or fail to react to the same information. In particular, the research throws some light on the differential ability of people to act on information of a concrete or abstract nature.

Two notions introduced in the work, and which apply particularly to the smaller economic agents observed, are termed psychological regret and procedural uncertainty. The former refers to the regret a person thinks he will incur if he makes an incorrect decision; it is inversely related to both experience with that type of decision and the extent to which it is "reversible". Procedural uncertainty refers to the state of uncertainty induced by facing an important decision for the first time. The person not only suffers from uncertainty concerning "state" variables, but uncertainty as to how to handle the problem. These two concepts appear to have some power for explaining when people will delay making a decision.

The methodology of the research consists of interviewing different persons involved in the decision making processes of concern. For example, at A we interviewed different "types" of economic agent (businessmen). At C, we have so far interviewed local government authorities and some real estate agents. (At the time of writing this abstract, April 1979, the interviews are far from complete). The objectives of these interviews (conducted in unstructured and semi-structured style), are to attempt to understand each situation as seen from the viewpoints of different types of economic agent. This understanding we represent in the form of a "cognitive map" for each type of economic agent which (hopefully!) yields a glimpse of the causal chains people see, how they construct their "problem space", and thus what meaning they are able to give to different kinds of information. By subsequently contrasting the cognitive maps of different economic agents we aim to reconstruct the chain of observed events.

The overall aim of the research is to develop a conceptual framework for analyzing the decision behavior generated by several actors each pursuing their own goals within the same situation. The framework presented in the paper has many fathers; theoretical notions and empirical findings in both economics and psychology, as well as many of our own observations at A and C. Indeed, it is interesting to observe which particular notions from "behavioral decision theory" we have or have not found useful. Since the research methodology used is highly subjective we are careful not to generalize from our two "case studies". However, we plan to apply the framework for analyzing other economic decisions in the future and so to test its generality.

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Hierarchical Goal Structuring and Pupils' Job Choices: Testing a Decision Aid in the Field

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Abstract

Pupils from lower levels of school make poor job choices due to their inferior information acquisition and processing abilities in this field. For this reason Gerdts, Aschenbrenner, Jeromin, Kroh-Püschl & Zaus (1979) developed a six step procedure for guiding pupils in developing their own goal hierarchy of objectives connected to the choice of a job. They showed the effectiveness of this decision aid in improving pupils' information processing behavior in hypothetical apprenticeship choices under controlled laboratory conditions. Their results encouraged testing the effects of this decision aid in two field experiments: In experiment I pupils were given the decision aid one day before they attended a regular consultation at the employment office. The consultations were tape recorded for analysis. Experiment II tested the effects of the decision aid on the occupational knowledge acquired during the following three months.

Subjects 48 pupils at the beginning of the ninth (and last) grade of the German Hauptschule (main school) who had not yet decided about an apprenticeship. Twelve of them were dropped for technical reasons. The remaining 36 pupils were grouped into 18

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control and 18 experimental subjects. Each group further consisted of 9 boys and 9 girls, since the advisors from the employment office had told us that girls show inferior information processing - what we did not believe. Pupils were run in individual sessions.

Pupils from the experimental group were instructed and guided in constructing their individual goal hierarchy for evaluating apprenticeships. The hierarchy construction started with a collection of ideas, which were then sorted into more global and more specific aspects. In step 3 the pupils were explained means-ends relations and had to attach specific aspects to more global ones according to this relation. In step 4 the structure developed so far was transferred to a magnetic blackboard where the pupils could arrange their objectives into a hierarchy. For this the objectives were written on plastic slips which adhered to the blackboard. This hierarchy was then thoroughly completed. Finally, the pupils received an unsorted pile of further objectives which they could integrate into their hierarchy.

On the average the pupils hierarchies contained 35 objectives most of which were self-generated.

The control group read and discussed an information brochure about choosing a job and objectives of job choices.

The next day the pupils attended an individual consultation at the employment office - a service used by about 70% of all German pupils. The consultations were tape recorded, the protocols transcribed and broken up into small phrases each referring to a single task assertion or reference (cf. Payne et al., 1978). The transcripts were then cast into a kind of flow diagram displaying the order in which alternatives, attributes, and alternatives' attribute levels were mentioned in the consultation, and the cognitive operations, e.g. asking for information, evaluating, comparing, setting criteria, etc. the pupil applied to them.

A multivariate analysis of variance of the numbers of alternatives, attributes, and operations in the protocols yielded a significant treatment effect ($p \leq .05$). Univariate tests showed that the experimental group used more attributes of jobs, set more criteria, and did more often evaluate and compare alternatives' attribute levels. The multivariate test did not show a significant difference

between girls and boys nor an interaction of sex and treatment.

About three months later the same pupils were invited again for experiment II and were interviewed about their progress in choosing. They were asked for the alternatives they had considered and for their current preference order for these alternatives. Then the reasons speaking for the more preferred and against the less preferred jobs were thoroughly inquired. These reasons were formulated as attributes, and an attributes times alternatives matrix was constructed together with the pupil (e.g. if a pupil had told that he did not like job X since it required too much sitting, he was asked for the relative amount of time one has to sit at this and all the other jobs). Finally, the alternatives in the completed matrix were evaluated by a simple weighted additive multiattribute utility procedure.

While there was no difference in the number of alternatives considered, experimental pupils used about twice as much and more differentiated attributes than the control pupils. Contrary to our expectation the correlations between intuitive rankings and multiattribute evaluations were about the same and high in both groups. But one has to account for the difference in number of attributes in evaluating this result. Boys and girls differed in the utility of their best alternative as compared to the utility of the best possible alternative. Girls' best alternatives had less utility for them than boys' best alternatives - which might confirm the fact that girls have less chances in our society.

Viewed together the results show that developing one's own goal hierarchy for a difficult decision problem improves the decision making process in the short and in the longer run.

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Information seeking in an open decision situation

Tibor Engländer and Tadeusz Tyszka

Recently various process tracing techniques appeared to be useful for inferring the ways of information integration and decision rules people apply in decision making. The research concerns, however, the well defined rather than open decision situations. The purpose of our experiment was to fill this gap. Its main question was what information seeking patterns people adopt in open decision situations. The subjects were 16 two last year students of the Architecture Department of the Budapest University. They attended two sessions. In the first session each subject individually faced two open decision problems one after another. They were: job selection problem and architecture book edition decision. The subjects were to make a choice from three fields in which architects are employed, and among the books belonging to three fields of the architecture, respectively. In both cases two alternatives were available within each field. To get any additional information the subject was to ask definite questions till he or she found a job place for himself or the book he or she would prefer to be edited. After having made a decision the subject was to mark a confidence degree in his or her choice on a special scale.

After some two weeks the subject was given six descriptions of work places. They contained answers to all the questions any of the subjects asked on the first session, except

those he himself asked / phase 2/. The task was to select one of the job offered. Then the subject was given the same set of six job descriptions, this time containing answers to all the questions the subjects asked, including his own. / phase 3/. Again, the choice and the confidence assessment was made.

Here are the main results:

- In both decision tasks, subject's information seeking patterns can be characterized by both: /1/ unequal number of questions concerning various alternatives, /2/ low degree of comparability of information concerning different alternatives. The most prominent in the first characteristic is the fact that the chosen alternative almost always attracted the greatest number of questions. The information comparability, or as we call it parallelity level of information seeking, has been expressed by the index showing for how many alternatives one aspect was investigated, on the average. We have found that in both tasks only 2.3 out of 6 possible alternatives were, on the average, examined per aspect.

- Using the parallelity index as well as a few other indices we have distinguished the following strategies of information seeking:

- / I / the strategy of parallel examination - all the alternatives being examined more or less with the same accuracy, and examination concerning the same aspects for different alternatives.

- / II / the strategy of narrowing down the number of alternatives

- first the subject examines all the alternatives / in a relatively parallel way/, then some of them are eliminated and only few are further examined.

/ LII / the 'autistic' strategy - here, like in the strategy I all the alternatives are examined with similar number of questions, but unlike in strategy I, different aspects are put in reference to different alternatives.

/ IV / the satisficing strategy - here one alternative / field/ is examined at a time, usually without coming back to previously considered alternatives, and the last examined alternative being chosen.

Our general conclusion is that although only a small number of the protocols may be accounted for by the Simon's satisficing principle, even smaller number of them may be described as a simple alternatives comparison in given respects. A majority of the subjects seemed to use both kinds of judgements - those based on satisficing principle as well as those based on maximizing principle. At the same time, the way of their combining is in some cases quite unclear / cf. the 'autistic' strategy/.

Comparing subjects' choices among the job offers in phases 1 and 3, we found that eight out of twelve subjects participating in both sessions changed their decisions. At the same time the subjects were usually more confident

in their decisions of the phase 3. If that last result has something to do with a quality of decision / only according to a subjective standard, of course/, it suggests that the decision problem formulation, and especially the attributes identification, are those elements of decision process which are to be aided in human decision making.

ATTRACTIVENESS OF DECISION RULES

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In recent years a great number of decision rules have been reported, axiomatized and empirically supported (cf. Montgomery & Svenson, 1976). Some of these rules are used in decision aid consulting, i.e. for aiding individuals to make difficult decisions. We know, however, very little about peoples' reactions to decision aids based on these rules. Do people find it natural to think and reason in terms of decision rules? And if they do, are certain rules more attractive and meaningful than others? The main purpose of the present study was to elucidate these questions.

In previous studies think-aloud data have been used to examine decision rules used by subjects. As an alternative, retrospective reports were used in the present study, partly to avoid the often burdensome analysis of long protocols and partly to investigate whether it is possible to get meaningful data from retrospective reports on the decision rules used in a choice process. The study further examined the attractiveness of particular rules in different situations and the relationship between rated attractiveness and actual usage of the decision rules.

Four choice experiments were conducted with 15 subjects in

each. In the first two experiments job offers were used as options. In the last two experiments the subjects could choose between five or two apartments.

All sessions took place in small groups and followed the same general procedure. First the subjects were presented with the choice alternatives. Then, before deciding, they were carefully instructed about the meaning of six decision rules (conjunctive, disjunctive, lexicographic, maximizing number of attributes with greater attractiveness, addition of utilities and addition of utility differences), and asked to rate the applicability of each with regard to the choice situation described to the subjects. When the subjects had made their choice, they were told to write a report on how they had been reasoning. If possible this should be done with special reference to the decision rules. The subjects were also asked to pick out the most important rule. Finally, all subjects were asked to rate the difficulty and level of confidence when choosing. (Rated applicability was the primary measure of the attractiveness of decision rules. Rated difficulty and confidence were supposed to be more indirect measures).

In three of the four experiments there was a significant difference ($p < .05$) between the attractiveness of the decision rules. The most popular rules were addition of utilities, addition of utility differences, and the conjunctive rule. The mean level of the ratings was 3.8 for the two former rules and 3.2 for the conjunctive rule. (A 5-point scale was used). The attractiveness level for a single rule was quite stable across situations, except for the conjunctive rule. This rule was rated as less applicable in cases where the similarity between

the options was high and as more applicable when the similarity was low.

The actual usage of the decision rules as reported by the subjects was in good agreement with the rated attractiveness. A weak tendency toward a preference for more simple rules (conjunctive, disjunctive, lexicographic) could be found, however, in the real choice situation. Generally the subjects reported that they used two rules, and the most popular combinations were conjunctive rule - addition of utilities and conjunctive rule - addition of utility differences. The subjects applied more complex rules and considered these to be of relatively greater importance in those cases where the alternatives were relatively similar to each other.

The confidence ratings were higher when a simple rule had been used. There was no connection, however, between confidence and the number of rules used. As could be expected, there was a negative correlation between confidence and rated difficulty of the decision ($r = -.52$).

It appears that subjects' retrospective reports had some validity. In general they are in line with the "minimization of cognitive effort principle" suggested by Montgomery & Svenson (1976). The temporal order between the rules fits well with this principle inasmuch as retrospective reports indicated that the subjects tended to use simple decision rules before they used more complex ones. The fact that simple rules often were reported to be used in situations with dissimilar alternatives, also seems to be in accordance with an endeavour to minimize

the cognitive effort. That is, in such situations it may be easier for the subject to use a simple rule for finding the alternative which is closest to his or her wishes.

Obviously, certain rules were judged as more attractive than others and this property seems to be rather stable. The conjunctive rule is an exception, but the rule depends so heavily on whether there is anything to reject or not, that it becomes very sensitive to situational factors.

The value and accuracy of these findings will be discussed both in relation to the traditional debate on the validity of retrospective reports, and in relation to the results of two control experiments, where no instructions about decision rules were given.

The relationship between the probability assessor and the outcomes of an event as a determiner of Subjective Probability

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Slovic (1966) explored the manner in which the desirability of an event influences its judged probability. Seven hypothesized dependencies of Subjective Probability upon value were tested. The results did not support exclusively any one of the hypothesized dependencies. Desirability was found to bias probability estimates in a complex manner and individual differences were found to be an important source of variance as some of the subjects were consistently optimistic and some were consistently pessimistic.

The experimental task used by Slovic in his experiment was one which "created real emotional involvement from subjects" (ibid,p.15). The reason for that was that the outcomes of the event whose probability of occurrence was estimated by the subjects, had direct influence upon them. The present study investigates the influence of the relationship between the probability assessor and the outcomes of an event on the Subjective Probability estimated for the occurrence of that event.

We might define two main types of events: 1) Personal event, which is an event that its occurrence influences directly the probability assessor (PE), 2) Non-Personal event, which is an event that its occurrence does not have any direct influence on the probability assessor (NPE).

The hypothesis is that there will be a difference between the Subjective Probability estimated for PE (SPP) and between the Subjective Probability estimated for NPE (SPN), and that the difference will be dependent upon the value of the event. More precisely, it is assumed that when the value of an event is positive SPP will be higher than SPN but when the value of an event is negative SPP will be smaller than SPN ($SPP > SPN$; $SPP < SPN$).

In order to test the hypothesis a questionnaire consisting of 14 questions was designed. Seven questions were about positive value events (e.g., to succeed in marriage) and seven questions were about negative value events (e.g., to be hurt in a road accident).

26 Subjects were asked to estimate SPP (e.g., the probability that you will be hurt in a road accident) and SPN (e.g., the probability that someone whom you don't know but who is of the same population as you will be hurt in a road accident) for each one of the positive and negative events. The order of questions and the order of estimating SPP and SPN was varied randomly across subjects.

For each subject the means of SPP and SPN were computed separately for the positive events (SPP+; SPN+) and for the negative events (SPP-; SPN-). The data was analysed by a two-way repeated measure ANOVA, one factor being probability type (SPP or SPN) and the other factor being value type (positive events or negative events). The means of SPP and SPN are presented in table 1.

Table 1: Means of SPP and SPN

	Positive events	Negative events	
SPN	.42.22692	46.53846	44.38269
SPP	31.79231	27.67692	29.73462
	37.00962	37.10769	37.05865

The main effect of Probability type was found to be significant ($F = 32.2$, $df = 1;25$, $P = 0.01$) but the main effect of value type was not significant. However, the interaction between Probability type and value type was found to be significant ($F = 16.9$, $df = 1;25$, $P = 0.01$). This interaction is presented in figure 1.

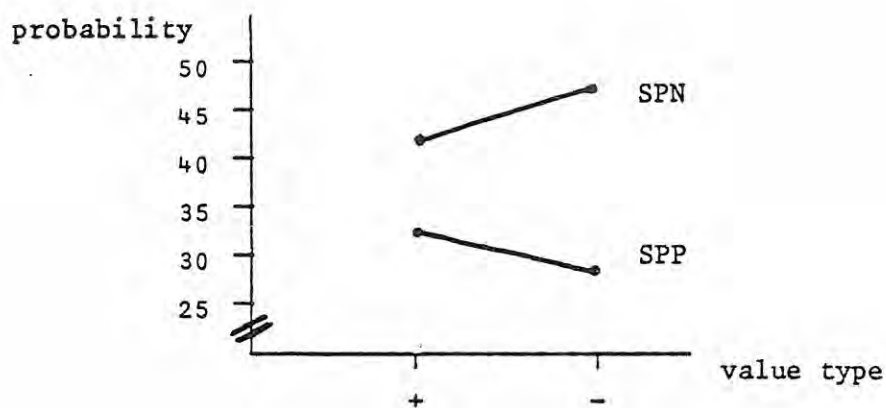


Figure 1: Interaction between Probability type and value type

However, by analysing the individual data, the following patterns (see table 2) emerge:

Table 2: Individual patterns of SPP and SPN estimation

type of pattern	Relationship between SPP+ and SPN+	Relationship between SPP- and SPN-	% of subjects
A	$SPP+ > SPN+$	$SPP- < SPN-$	61.5
B	$SPP+ < SPN+$	$SPP- > SPN-$	15.3
C	$SPP+ < SPN+$	$SPP- < SPN-$	7.7
D	$SPP+ > SPN+$	$SPP- > SPN-$	7.7
E	$SPP+ = SPN+$	$SPP- = SPN-$	3.9
F	$SPP+ = SPN+$	$SPP- < SPN-$	3.9

Referring back to table 1, we see that the overall mean of SPN+ is greater than that of SPP+, despite the fact that most of the subjects estimated SPP+ to be greater than SPN+. The reason for this is that those subjects estimated SPP+ to be greater than SPN+ only to a small degree while those who thought that they were not as lucky as others estimated SPP+ to be less than SPN+ to a large degree.

It seems as if subjects felt much more confident in their luck concerning negative events ("It won't happen to me") than concerning positive events and when they felt they were not lucky again this had a strong effect.

The results indicate that individual differences play an important role in determining Subjective Probabilities and that by taking into account the factor of the relationship between the probability assessor and the outcomes of an event we might better understand the assessor's behaviour than by taking into account the value of the event by itself.

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Studies of a model for evaluating judicial evidence (Summary)

Robert W. Goldsmith

A model for evaluating judicial evidence is described. Termed the evidentiary value model, it is contrasted with the more conventional type model, denoted as the theme probability model. In the following, the term judge refers to a person--judge, jury member or at the pretrial stage the prosecutor--who evaluates judicial evidence to make a decision; a theme is an hypothesis of concern to the judge and to which evidence may relate; a relationship of formal implication between two propositions means one of these can be logically derived from the other. According to the theme probability model the judge's goal in evaluating evidence is to assess $P(t|d)$, the probability that a given theme is true (t) on the basis of the evidence (d). According to the evidentiary value model, on the other hand, the judge's goal is to assess $P(e|d)$, the probability that either a causal or a formal implicative relationship is found between the evidence, or some part of it, and the theme in question (e denoting either form of relationship). A causal relationship here may be either one of the theme being a cause of the evidence or of the evidence being a cause of the theme. Similarly, a relationship of formal implication may mean either the evidence formally implying the theme or the theme formally implying some portion of the evidence. All four types of relationship are termed evidentiary relationships. The presence of an evidentiary relationship (or, equivalently, the presence of evidence which stands in an evidentiary relationship with the theme) is said to prove the theme. Thus, $P(e|d)$, referred to also as the evidentiary value which the evidence has for the theme, represents the probability that the evidence proves the theme. Proof here means, however, not an overt demonstration that the theme is true but simply the presence of an appropriate evidentiary relationship, regardless of whether the judge hypothesizes it or not. At the same time, an evidentiary relationship may be partly a function of the judge in the sense of depending upon what definition of causality or formal implication he implicitly makes use of or would be willing to accept. An evidentiary relationship is said to be present if the true relationship between the evidence and the theme corresponds with whatever definition of causality or formal implication is viewed as appropriate. In a descriptive version of the model this is the definition the judge implicitly avails himself of, whereas in a normative version it may be some other definition considered more adequate.

Although a theme cannot be proved without being true, it can be true without being proved. Thus, the evidentiary value of the evidence, $P(e|d)$,

can never be higher than the theme probability, $P(t|d)$, and under most conditions it would be lower. Since the discrepancy between the two measures should tend to be particularly great when the evidence is sparse or consists primarily of base-rate information, use of the evidentiary value model is seen to provide the judge a special incentive to seek or demand evidence relating as specifically as possible to the events in question. An aid to conceptualizing this aspect is the distinction the model makes between evidentiary facts (facts for which the judge considers an evidentiary relationship with the theme to be possible and which he thus assigns evidentiary value) and auxiliary facts (facts which the judge assigns no evidentiary value but nevertheless utilizes in assessing the evidentiary value of one or more evidentiary facts). According to the model, the judge employs a separate criterion for adequacy of investigation or information search in connection with each potential evidentiary fact. Only if the criterion is met is the fact assigned evidentiary value, although if not it can still be used as an auxiliary fact in assessing the evidentiary value of any evidentiary fact to which it may pertain. Use of the criterion provides the judge a further incentive to seek or demand evidence relating as specifically as possible to the theme.

Normative rules stipulating what the combined evidentiary value of two or more evidentiary facts must be, given the evidentiary value which each possesses separately, are described and their derivation is discussed. Three types of rules are involved, those dealing with compatible evidence (the respective facts all support the theme), conflicting evidence (part of the facts support the theme and part of them support the negation of the theme) and chains of evidence (a theme supported by one or more of the facts serves as an evidentiary fact in support of a second theme).

For both models, evidence is defined as encompassing only the information, testimony and material already presented to the court (and deemed admissible, if rules for this apply). According to the evidentiary value model, what the judge assesses for any given theme is $P(e_1 \text{ or } \dots \text{ or } e_j | d)$, where each of the elements $e_1, \dots, e_j$ represents the proof of the theme by a particular evidentiary fact. Since before the trial begins no evidence has accrued and the set $\{e_1, \dots, e_j\}$ is an empty one, assessments of evidentiary value should at this point be zero for any theme to be considered. This aspect of the model is suggested to better represent the unbiased attitude which the judge can be thought to ideally possess at the start of a trial than would any particular level of a priori theme probability assumed in terms of the theme probability model. No logical contradiction of

Bayes' theorem is involved, however. Rather, the hypothesis which the proposition e_1 or ... or e_j represents changes as new evidentiary facts are added, making Bayes' theorem inapplicable, since that theorem makes no stipulation of what the probability should be if the hypothesis itself changes. This does not deny the role of the judge's prior knowledge and experience when confronted with an evidentiary fact, but it means that such information is not directly relevant until a specific evidentiary fact appears. On the other hand, Bayes' theorem would apply here to revisions of the assessed evidentiary value of a given evidentiary fact as new auxiliary facts are added.

For the theme probability model the probabilities to be assessed imply two possible events (outcomes): that the theme is true and that it is false. Here a decision criterion can be expressed in terms of the probability of either event, since the probabilities of the two sum to 1.0. For the evidentiary value model, on the other hand, there are three such events: that the evidence proves the theme, that it disproves the theme (proves it to be false), and that it neither proves nor disproves the theme (i.e., that the evidence is without evidentiary value). The latter two events, to be sure, may often be conveniently considered as a single event, viz. that the evidence does not prove the theme. A decision criterion here could be expressed either in terms of the probability that the evidence proves the theme or that it does not prove the theme, but not in terms of the probability that the evidence disproves the theme. The latter probability is important, however, when evidentiary facts which constitute counterevidence are found; these reduce (in accordance with the appropriate rules mentioned above) the evidentiary value of facts which support the theme. Reasons are discussed for assuming that for criminal cases the relations just described make the evidentiary value model more in line with the aims of the judicial system whereas for civil cases the two models can be seen as about equally tenable.

In two empirical investigations which are reported, lawyers of long experience were presented with authentic or constructed criminal case material which they were to analyze aloud. Results of the first study, in which subjects (23 prosecutors) were also to make a series of probability assessments, suggested considerable use of an evidentiary value model and of the criteria it entails for adequacy of information search. Results of the second study, in which subjects (20 judges, 20 prosecutors) were also given a half-structured interview regarding their manner of evaluating evidence generally, supported the assumption that most judges and prosecutors utilize both models but base their decisions in criminal cases primarily on assessments made with help of an evidentiary value model.

Differences in Calibration for Past and Future Events

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This study examines differences in calibration for past and future events across groups of individuals, and within individuals. For an individual to be perfectly calibrated for every event assessed $.X$ probability of occurrence then $X\%$ of all events so assessed should be correct. Lichtenstein, Fischhoff & Phillips (1977) in reviewing research on calibration concluded that the most common form of miscalibration is "over-confidence". That is for all events assessed $.X$ probability less than $X\%$ actually occurred.

Deriving directly from this general finding of over-confidence Lichtenstein & Fischhoff (1979) have investigated training for calibration. They found that comprehensive feedback via scoring rules produced considerable improvement in calibration. The improvement in calibration generalised to tasks different in difficulty level (overall percentage correct), content and response mode. However, generalisation failed completely for assessment of fractiles.

Initially, this finding of the effectiveness of training would seem to be of tremendous importance for all types of decision making for if the realism of an individual's probability assessments can be improved then it follows that when these improved assessments are input into a decision analysis the overall quality of the decision improves without the addition of any extra knowledge, information or expertise.

By contrast the present study questions the validity of present research and findings on calibration of probability. One calibration curve reported by Fischhoff & Beyeth (1975), based on group data, puzzled Lichtenstein et al (1977).

This curve, based on a full range-task, is remarkably close to the identity line characterizing a perfectly calibrated assessor. Lichtenstein et al commented:

The resulting calibration curve, based on 1921 assessments, is sub-optimal at 0 and 1, and shows a dip at .7, but is otherwise remarkably close to the identity line. Why? The subject received the usual instructions. They were not experienced in probability assessments. They were run in large classroom groups.

We argue here that the reason for this finding of perfect calibration is due to the nature of the questions. Fischhoff & Beyeth asked 150 Israeli students to assess the probability of 15 then-future events, possible outcomes of President Nixon's much-publicized trips to China and Russia. An example of the events are, "President Nixon will meet Mao at least once". These questions contrast with the more usual calibration question, "The Suez Canal is a hundred miles long" which deal with already known events or "almanac" questions. Why should the nature of the questions affect calibration? Phillips & Wright (1976) have shown that individuals give more verbal probabilistic responses to questions concerning future events than to almanac questions when asked to "Write a reasonable and appropriate response" to questions such as, "Will it rain tomorrow?", or "Is Bagdad the capital of Iraq?". Phillips & Wright found almanac questions tend to elicit responses such as "Yes", or "No", or "Don't know".

In terms of Phillips & Wright's (1977) model almanac questions are seldom elaborated to the third probabilistic processing stage.

Stronger evidence that probability assessments for past events are, in general, badly calibrated comes from the cross-cultural work of Wright Phillips, Whalley, Choo, Ng, Tan & Wisudha (1978). Using two-choice alternative past events as calibration questions they found Asian student samples remarkably poorly calibrated compared to a British student sample. However, the British sample were still over-confident in their assessments, apparently confirming Lichtenstein et al's general conclusion.

Wright et al concluded that:

.... any extrapolation of the technology of decision analysis to Asian cultures should be approached with caution, for the subjective probabilities required as inputs may be meaningless.

However, a recent experiment which sampled the same Indonesian student population produced a remarkably good calibration curve, based again on grouped data. The questions used were then-future events presented in a two-choice alternative form. 95% credible intervals computed around the plotted points of the curve include the identity line, characterizing a perfectly calibrated assessor, up to the .9 assessment level. The curve is much improved on the original past event curve for the Indonesian students and the 95% credible interval only just includes, at lower assessment levels, the calibration curve for past events given by the British students.

Interestingly, the proportion of 100% assessments given by the Indonesians for the past events is much higher than that for the once-future-events ($p < .001$) even though the overall difficulty of the first task, was much higher than that for the second task (.53 as opposed to .75 of items correctly answered, respectively). This finding supports Phillips & Wright's (1977) model; questions concerning past events are seldom elaborated to the third, probabilistic processing stage. Also in support of the model we found that the proportion of 50 per cent assessments given by the Indonesian students is less for the once-future events than for past events ($p < .05$). In other words, past events are seen in terms of 100% certainty or, failing that, in terms of 50% sure. They are seldom seen probabilistically. This finding may account for the prevalence of Slovic Fischhoff & Lichtenstein's (1976) "certainty illusion" for past events. By contrast future events tend to be seen probabilistically. Also, probability assessors tend to give realistic or calibrated probability assessments for future events. This interpretation of calibration research also enables easy integration of the meteorological work of Murphy & Winkler (e.g., 1974) and Root (1962). These investigators have consistently reported near perfect calibration for then-future forecasts of precipitation.

Discussion and Conclusion

The major conclusion from this study is that future events are seen in terms of probability whereas past events are seen in terms of certainty or total uncertainty. Probability assessments for past-events are, generally over-confident whereas probability assessments for future events are realistic.

A major implication is that calibration studies using past-event or "almanac" type questions will reveal "over-confidence" that is not present in future-event probability assessments. Training techniques to help probability assessors become better calibrated or less over-confident may be inappropriate. Real-life decisions deal with uncertainty in the future and, as we have shown, people can deal with this type of uncertainty quite adequately. An unwanted effect of training may lead intuitively well-calibrated probability assessors to be under-confident.

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Decision Making in a Dangerous World:
Some Insights from Psychological Research

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Abstract

Citizens of modern industrial societies are presently learning a harsh and discomfoting lesson, i.e., that the benefits from technology must be paid for not only with money, but with environmental degradation, anxiety, illness, injury, and premature loss of life. Although the public has some control over the level of risk to which it is exposed, reduction of risk typically entails reduction of benefit, thus posing serious dilemmas for society. Policy makers are being required, with increasing frequency, to "weigh the benefits against the risks" when making decisions about technological enterprises.

This paper will explore the role that the psychological study of judgment and decision processes can play in helping individuals and society cope with risk. It will be organized around three general questions: (a) what are some of the basic issues involving societal risk? (b) what do we already know about how people behave in decision-making situations that is relevant to these issues? (c) what more do we need to know and how might we acquire that knowledge?

More specifically, the paper will examine such questions as:

1. What determines perceived and acceptable risk? Why do people protect themselves against some hazards and ignore others of equal or greater magnitude?
2. How can people's values be assessed and used to guide societal decisions? Is it meaningful to attach monetary values to loss of life?

3. How can technical information about risk best be communicated to people?

4. What role should government play in regulating safety? How can safety standards be made responsive to public concerns?

We shall argue that policies designed to regulate hazards must be based on an understanding of the ways in which people think and feel about risk and uncertainty. Without such understanding, well-intentioned plans may not achieve their goals.

One source of understanding comes from systematic empirical research. We shall describe the major results of our own research program over the past five years. One conclusion from this research is that economic models are an incomplete basis upon which to make predictions about people's behavior in situations of risk. People are, at best, "boundedly rational," and bounded rationality is quite different from economic rationality. One demonstration of this comes from our research on insurance behavior which shows that, contrary to economic theory, people prefer to insure themselves against relatively high probability hazards having minor consequences rather than against the rare serious threats for which insurance is most needed.

Bounded rationality also distorts people's perceptions of risk in ways that have serious consequences. This is shown by recent studies in which we have examined the perceptions of both experts and laypersons for a large variety of hazardous activities and technologies. This research leads us to the following conclusions:

1. Cognitive limitations, coupled with the anxieties generated by facing life as a gamble, cause uncertainty to be denied, risks to be distorted, and statements of fact to be believed with unwarranted confidence.

2. Perceived risk is influenced (and sometimes biased) by the

imaginability and memorability of the hazard. People may, therefore, not have valid perceptions, even for familiar risks.

3. The risk perceptions of the experts we studied corresponded closely to statistical frequencies of death.

4. In contrast, while lay people's risk perceptions were based in part upon frequencies of death, there were some striking discrepancies. These discrepancies could not be attributed to lay people having erroneous views of annual fatality frequencies. Indeed, their estimates of those frequencies were reasonably accurate. Instead, it appears that for lay people, the concept of risk includes qualitative aspects such as dread and the likelihood of a mishap being fatal.

5. Lay people's risk perceptions were also affected by technology's catastrophic potential which, for nuclear power at least, they assessed quite differently than the experts.

6. Neither experts' nor lay people's risk perceptions were related to variations in the judged seriousness of different kinds of death.

7. Disagreements about risk should not be expected to evaporate in the presence of evidence. Definitive evidence, particularly about rare hazards, is difficult to obtain. Weaker information is likely to be interpreted in a way that reinforces existing beliefs.

The paper will close by examining the significance of these conclusions for the role of expert and lay judgment in the process of hazard management. Implications for the management of nuclear power and automobile safety will be given particular emphasis.

VOLITIONAL PROBLEMS IN CARRYING THROUGH A
DIFFICULT DECISION: THE CASE OF DRUG ADDICTION

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Decisions are obviously important in understanding human action. However, they constitute only one component in the total flow of action, and in order to understand the success or failure of a certain plan one must also consider processes other than decision processes. One particular problem which has been studied in our laboratory is the problem of volition in the field of addictive behavior. People typically make many decisions they afterwards find hard to realize. Most people who are smokers have some experience with this particular kind of difficulty. It is a well-known fact that most smokers state that they wish to give up smoking and that they have also tried to do so, perhaps several times, but failed. Why are decisions of this type not carried through? What are the kinds of difficulties encountered and are there techniques whereby such difficulties can be at least partially overcome?

Previous studies were concerned with smoking (Sjöberg & Johnson, 1978; Sjöberg & Samsonowitz, 1978), obesity (Sjöberg & Persson, 1980) and alcoholism (Sjöberg, Samsonowitz & Olsson, 1978). In these studies persons with various addiction problems were interviewed in the process of trying to fight their addiction, in most cases actually in trying to quit completely their addictions. We followed the persons for a period of some six months and interviewed them three times during this period asking about their experiences of

success and failure. We particularly tried to get information about the reasoning and decisions they made, about their emotional states at critical points in time and about techniques that they might have used to fight their difficulties.

The findings in these studies were the following. First, difficulties to pursue a decision were encountered particularly in situations which contained some kind of emotional stress. It is noteworthy that emotional stress could be either positive or negative. In most cases it concerned some negative events in the lives of the persons, such as quarrel in the family, difficulties at work, etc. However, in some cases people encountered grave difficulties to pursue their decisions also in situations where they were in a particularly good mood, for example at a party with a lot of nice people and a stimulating atmosphere. Second, we found that decisions to give up attempts, at least for the time being, of trying to quit an addiction typically were preceded by some kind of short-sighted and twisted reasoning which also in retrospect by the persons themselves was judged to be clearly below their cognitive level and their insight into the problems connected with their addiction. Particularly, we often found that people would reason in a short-sighted manner implying that they could make a temporary exception to their principle^{al} decision of abstaining, in spite of their knowledge that such exceptions very often lead to complete failure and to a consumption level quickly rising to or above the original level of addictive consumption. Thirdly, we also found that people used several techniques

with some success to fight their addictions. We were particularly interested in two classes of techniques. The first class concerned attempts to push tempting thoughts away from consciousness, perhaps coupled with taking up some activity that could not easily be combined with the addictive behavior in question and which had some intrinsic value and interest. The second class of techniques concerned bringing to mind values that would strongly argue in favor of sticking to the original decision of abstention. Two classes of values seem to be in^{ut} work here: values that emphasize the consequences of failure or the consequences of success, and

values that emphasize restrictions put on behavior by oneself or preferably by institutions or other people. It is our impression that values of the latter kind are particularly potent in guiding action.

There were some differences between the various addictive groups. We found that smokers tended to use an all or none-strategy, i.e., they decided to give up smoking completely and a failure with one single cigarette often triggered a domino effect bringing them quickly back to or above the original level of consumption. However, obese persons trying to decrease their food consumption often used a more stepwise strategy. They proceeded in small steps and also found it easier to accept their own failures and often compensated their failures with stronger diet and increased physical exercise. Both obese persons and smokers often used the technique of bringing up values to mind but smokers more frequently also used the technique of pushing away tempting thoughts. Comparing these two groups to the group of alcoholics, several differences emerged. The alcoholics had weak value structures and rather rarely used the technique of bringing up values. They were generally little guided by attempts to regulate their own behavior and found it difficult to abstain from alcohol except in the context of an institution where drinking was prohibited. In the group of alcoholics we also encountered a few exceptions to the rule that volitional failures usually occur in emotionally stressful situations.

In interpreting these results theoretically we have favored an approach using a concept of psychological energy. In emotional stress there is an ^{excessive} ~~accessive~~ requirement of psychological energy. This, in turn, brings with it a decreased amount of energy available for the cognitive processes involved in thought and judgment and, hence, there is a risk of short-sighted and twisted reasoning. Bringing up values to mind invests, however, the system with more energy to sustain to a given decision in the face of emotional difficulties. We conclude that the techniques for fighting difficulties are not cognitive processes but rather techniques for handling and transferring psychological energy

from one action system to the other. It is striking, indeed, that the cognitive side of the action difficulties we have studied seems to be quite trivial. There is really no question other than that the smokers, for example, are well aware that their smoking habit may cause serious damage to their health. So, in this sense, they do not seem to need an improved level of knowledge or more sophisticated cognitive processing to make and pursue their decisions. What they need is some way of finding the psychological energy needed to sustain to their difficult decision in the face of all of the emotional stress stimuli that people encounter in their daily lives.

In the present study, we wished to extend and generalize the findings for smoking, obesity and alcoholism to the field of drug addiction. For this purpose, we carried through another study of interviews with young drug addicts who were in the process of trying to give up their addictive habits. The patients were followed for about eight months and were interviewed three times each during this period. The findings to be presented in more detail at the conference on the whole verify the conclusions reached in the other studies. The problems encountered by the drug addicts were, thus, particularly grave in the face of various types of emotional stress, their failures were preceded by twisted and short-sighted reasoning and they showed evidence of knowledge and use of several of the techniques that we had encountered in previous studies.

Finally, we wish to speculate about the problem of regulated action in a more general sense. In particular, we wish to point out that the studies quoted so far have been concerned with a problem of trying to abstain from a certain type of action. In many cases the problems that people encounter in regulating their activity are to actually stick to a certain type of activity which they need to carry through in spite of various types of distractions, frustrations and fatigue. Such problems are, as we all know, encountered by people in many situations. One close example is that of academic studies. How do you go about planning and pursue such studies in the face of all the types of difficulties mentioned?

Here we think that a key concept is the concept of interest which is suggested to be an emotional state by e.g. Izard (1977). To sustain a demanding activity one probably has to experience often or preferably continuously the pleasant emotion of interest. This would be particularly so in the absence of strong external restraints on behavior. Hence, a study of interest would be important for understanding difficulties that students have and for generating ideas about how to help towards the overcoming of such difficulties. In another study we are at the present pursuing this particular orientation in the field of natural sciences and mathematics (Sjöberg & Adrianson, 1979).

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Multiplying and Multiplicative Processes:
An Analog Model for Multiplicative Judgment

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In some judgment tasks, such as the joint probability task (Lopes, 1976) or the risky decision task (Anderson & Shanteau, 1970; Shanteau, 1974), people produce data that are essentially multiplicative. Such data are sensible and even rational when viewed from the perspective of normative rules which specify how such judgments "ought" to be made. However, the data pose serious problems when viewed from a psychological perspective since there is good reason to doubt that subjects in these tasks have actually multiplied in any computational sense of the word.

If subjects are not multiplying, why are their data multiplicative? One possibility is that they are using serial fractionation, a form of analog multiplication in which the judge fractionates or reduces some salient initial quantity one or more times in direct proportion to quantities associated with other stimulus information. Serial fractionation has several advantages as a mechanism for multiplicative judgment. First, it is a special case of anchoring and adjustment (Tversky & Kahneman, 1974), which is a more general mechanism for integrating quantitative information. Second, it is mathematically equivalent to numerical multiplication. Third, it can be used directly with quantities which are expressed non-numerically or imprecisely. Fourth, and perhaps most importantly, it is computationally simple and puts no demands on short term memory beyond that of carrying forward the result of the last fractionation.

Experiments on numerical estimation reported elsewhere (Lopes, 1977; Lopes & Ekberg, 1979) have provided some evidence for the hypothesis that serial fractionation is a naturally occurring process in certain multiplicative tasks. However, the fact that these experiments used rating data limits the degree to which conclusions can be drawn about the prevalence of serial fractionation in non-rating contexts. In the present report we describe an experiment which looked for evidence that serial fractionation occurs internally as a sub-process in tasks for which the overt response is choice rather than judgment. Specifically, we asked subjects to choose between gambles and sure things in a way which allowed access to data bearing on whether the gambles were evaluated through serial fractionation or not.

Serial Fractionation in Risky Decision Making

In risky decision making, subjects judge the worth of gambles each described by an amount (or item) to be won and a probability of winning. Under the serial fractionation hypothesis it is possible to predict the order in which these two pieces of stimulus information will be processed. The argument runs as follows. The amount to be won and the final worth of the gamble both lie on the dimension of subjective worth, while the probability of winning lies on a dimension which is roughly equivalent to subjective certainty. This gives amount to be won a natural salience in the judgment task (Slovic & MacPhillamy, 1974) which makes it likely that, if gambles are evaluated through serial fractionation, amount to be won will serve as the anchor or initial quantity, and will therefore be processed before probability of winning.

The present experiment used a primed response time method to test for evidence of the processing order predicted by the serial fractionation hypothesis. Subjects

were asked to choose between gambles and sure things, i.e., between a $\frac{2}{7}$ th chance to win 39¢ and 11¢ for sure. It was expected that for each pair, subjects would compare the subjective worths of the gamble and the sure thing and then choose whichever was larger. The choice problems were presented under two conditions. In the value-primed condition, subjects were first given the value of the sure thing and the value of the amount to be won, and then somewhat later were given the probability of winning. In the probability-primed condition the situation was just reversed, with the value of the sure thing and the probability of winning being presented before the value of the amount to be won. We predicted that subjects would be relatively fast in the value-primed condition since amount to be won and probability of winning were being presented in the order in which they would normally be processed. For the probability-primed condition, however, subjects were predicted to be relatively slow since under ordinary circumstances they would only use probability of winning after amount to be won had already been processed.

Method

Stimuli and design. The stimuli were 60 sure thing/gamble pairs, of which 12 were experimental pairs and 48 were fillers. The gambles in the experimental pairs were constructed according to a 6×2 , probability $\times$ value level, nested design. The probabilities of winning were $\frac{1}{7}$, $\frac{2}{7}$, $\frac{3}{7}$, $\frac{4}{7}$, $\frac{5}{7}$, and $\frac{6}{7}$. Each of these was paired once with a low amount (6¢-22¢) and once with a high amount (24¢-46¢). The sure thing amount for each experimental pair was set equal to the expected value of the gamble rounded to the nearest cent. The fillers for the experiment were 48 sure thing/gamble pairs, half of which had expected values which favored choice of the gamble, and half of which had expected values which favored choice of the sure thing.

The stimulus pairs were presented to the subjects on a computer controlled video terminal. In the value-primed condition, the amount of the sure thing and the amount to be won in the gamble were presented first, with the probability of winning being added to the stimulus display three seconds later. In the probability-primed condition the amount of the sure thing and the probability of winning the gamble were presented first, with the amount to be won being added to the stimulus display three seconds later. The experimental pairs were presented to each subject four times in each of the two priming conditions, yielding four replications of the basic design.

Procedure. Thirty-one introductory psychology students from the University of Wisconsin were run individually in the experiment. They were told that they would be allowed to choose between pairs of games in which one was a sure thing and the other was a gamble, and were instructed that although the amount of the sure thing would always be less than the amount to be won in the gamble, the sure thing would sometimes be a better choice than the gamble and sometimes a worse choice. Subjects indicated their choices by pushing one of two buttons. They were given a maximum of five seconds to respond following the completion of each stimulus display. In order to encourage careful choices, a subset of trials was selected at random during the experiment for actual play after the experiment was over. At this time, subjects were either allowed to play the gambles or were given the amounts of the sure things depending on the choices which had been made for those trials during the experiment.

Results

The results of the experiment are shown in Figure 1, plotted as a function of the probability of winning the gamble, with priming condition as the row

parameter and value level as the panel parameter. The data are the mean response times averaged over both subjects and replications. The effect of priming on

 Insert Figure 1 about here

response time is of central importance for the serial fractionation hypothesis. As predicted, responses in the value-primed condition were faster than responses in the probability-primed condition, with a mean difference of 103 msec, $F(1,30) = 12.80$, $p < .01$.

In evaluating the success of the serial fractionation hypothesis, it was important to exclude three alternative explanations for the observed differences in the priming conditions. Although space does not allow detailed explication of these alternatives, it is useful to sketch what the alternatives were and what data was used to exclude each. (1) Subjects might have been faster in the value-primed condition because they based their choices on a direct comparison of sure thing amount and amount to be won in the gamble. This alternative was excluded because it would have predicted some consistent relationship between subjects' choice of gamble or sure thing and the relative magnitudes of sure thing and amount to be won in the gamble, and no such relationship was found in the data. (2) Differences between value-primed and probability-primed responses might have reflected an artifact of differences in the outcome of the choice process rather than differences in the time required to evaluate gamble/sure thing pairs. This alternative was excluded on two counts: First, priming condition had no effect on choice outcome, and second, the priming effect was maintained even when gamble choices and sure thing choices were analyzed separately. (3) Subjects might have used qualitatively different strategies in the two priming conditions with the value-primed strategy being faster. This alternative was also excluded on two counts: First, the time allowed in the present experiment was far too short to permit trial-to-trial shifts in strategy, and second, such strategy shifts (if they occurred) would have tended to produce different choice outcomes for the two conditions (e.g., Lichtenstein & Slovic, 1971) and such differences were not found to occur.

Discussion

The results of the present experiment are consistent with the hypothesis that subjects judge the value of gambles via serial fractionation even when the judgment operation is embedded within a choice task. Although the present data cannot do more than demonstrate that amount to be won and probability of winning are processed in the order predicted by the serial fractionation hypothesis, they converge with previous research (Lopes & Ekberg, 1979) which suggests that serial fractionation occurs naturally and frequently as a response in many situations eliciting multiplicative judgments.

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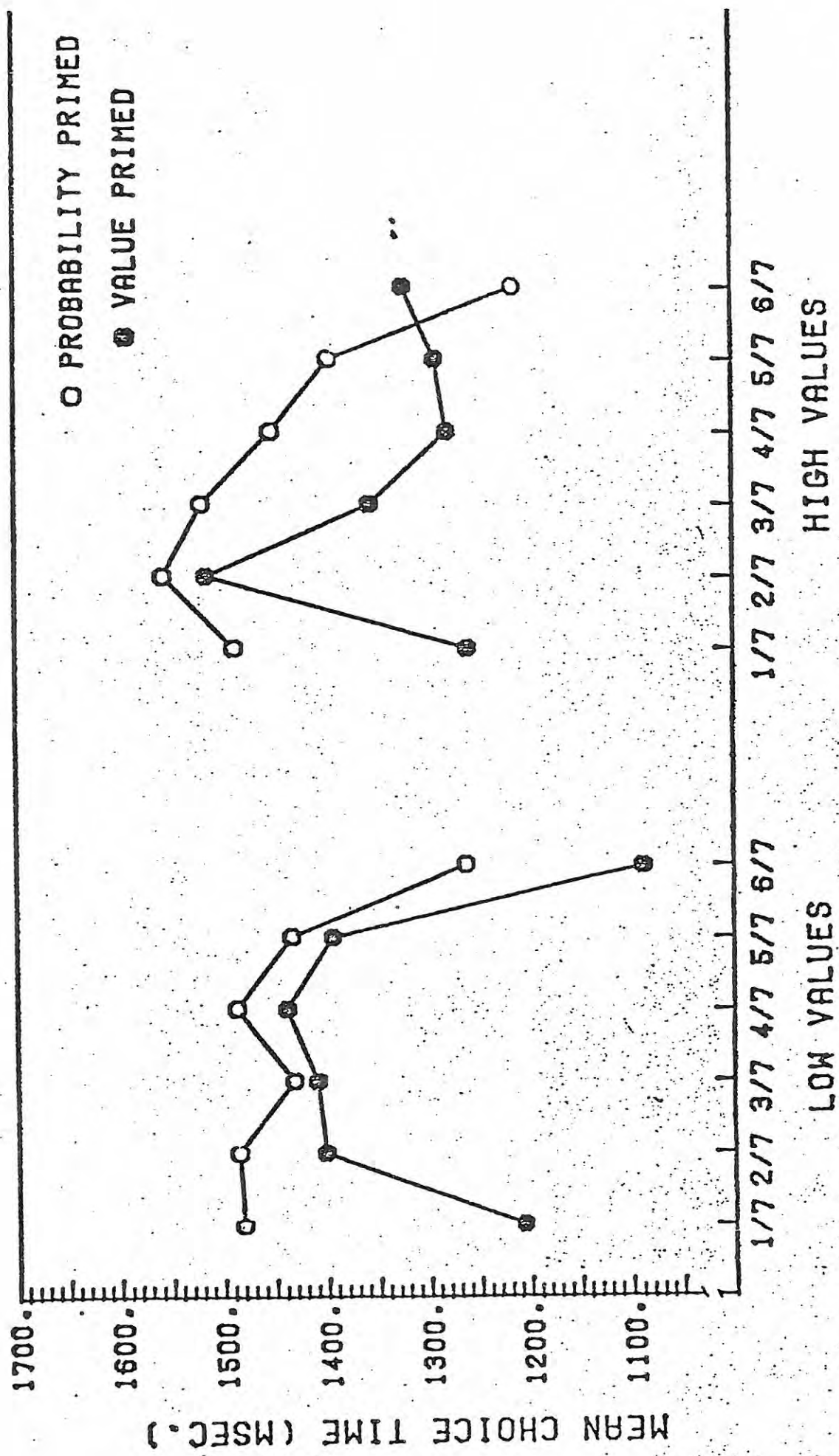


Fig. 1

A new model of decision under risk

Maria Nowakowska, Warszawa

The main problem of the model is to show how taking into account the psychological context may explain the apparent irrationality of certain decision behaviours, of the form of "abnormal risk areas", where too high probability of success makes the safe option preferable to a risky one.

The model is a generalization of two well known models, of SEU and of achievement motivation of Atkinson. The psychological context of the choice between a safe and a risky option is introduced in the form of a configuration of two psychological motives, namely motive M to achieve success, and motive F to avoid failure.

The model concerns a situation in which a person is to choose between a safe option, whose result b is known, and a risky option, which costs c , and may bring either a success and connected with it economical reward r , or failure and loss (assumed to correspond to zero of the utility scale). The subjective probability of success is p . It is assumed that the incentive value of success is $g(p) + r$, where $g(p)$ is the utility of "success as such", and the incentive value of avoiding failure is $h(p)$. To get a possibility of comparison with the model of Atkinson, it was further assumed that $g(p) = 1 - p$, and $h(p) = -p$. Moreover, the unit of utility scale was chosen so that utility of "success as such" is $1/2$ for $p = 1/2$.

The expected utility of the risky option R is $u(R) = pM(1-p+r) + (1-p)F(-p) - c$, while the utility of the safe option S is b . The risky option will be chosen in case when $u(R)$ exceeds $u(S)$, which reduces to a quadratic inequality for the probability of success p :

$$(1) \quad (M - F)p^2 - (M(r+1) - F)p + k < 0,$$

where $k = b + c$. The analysis of the solutions of inequality (1) leads to the following two theorems.

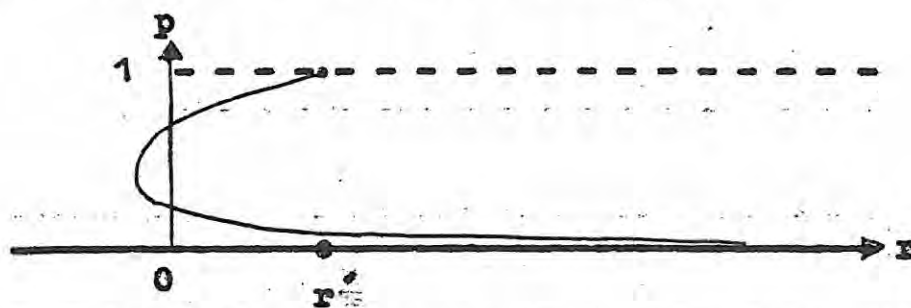
THEOREM 1. Suppose that $M > F$, i.e. the decision maker has stronger motive to achieve success than to avoid failure. Then the risky option will be chosen if $(M(r+1)-F)^2 > 4k(M-F)$ and either $Mr > k$, $p' < p \leq 1$, or $Mr \leq k$, $r \leq (M-F)/M$ and $p' < p < p''$, where p' and p'' are the roots of the left hand side of (1), that is, they are equal

$$\frac{M(r+1) - F \pm \sqrt{(M(r+1)-F)^2 - 4k(M-F)}}{2(M-F)}$$

THEOREM 2. Suppose that $M < F$, i.e. the decision maker has stronger motive to avoid failure than to achieve success. Then the risky option will be taken, if $Mr > k$ and $p' < p \leq 1$.

The main consequence of these two theorems is the discovery that under some circumstances the risk area, i.e. the set of values of p , for which the risky option is better than the same one, may not reach the value 1, but be of the form $p' < p < p''$ (such risk areas are called abnormal). The phenomenon of abnormal risk areas occurs only for subjects with $M > F$ (success-oriented).

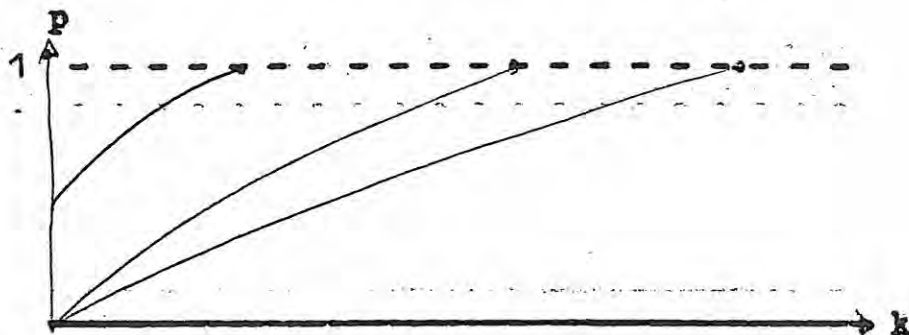
The conditions appearing in Theorems 1 and 2 allow the study of behaviour of risk areas for changing values of the parameters k, r, M and F . A typical picture of change of risk area, under the change of r , for $M > F$ is



For $r > r'$ all risk areas are normal: they extend from the lower curve, representing the smaller root p' , to 1. For $r < r'$ the risk areas are abnormal: they lie only between the two curves, where the upper branch represents the larger root p'' . It is of considerable interest that the risk areas are not empty even for some negative rewards r , when the loss

is partially compensated by the satisfaction from success, equal $1-p$.

Another typical picture, of change of risk area under the change of parameter $k = b+c$, for $M < F$ is as follows.



The particular graphs correspond to various values of r . As may be seen, for every r , there exists maximal k , beyond which the risk area is empty (i.e. safe option is better than the risky one, regardless of p). The upper curve corresponds to small r , and shows that even when the cost k is zero, the risky option becomes better than safe one only when the chances of success p exceed a certain threshold. For larger r (two lower curves) this threshold is zero (i.e. costless risky option is better than the safe one, even for small chances of success).

The analysis of behaviour of risk areas leads to an interesting discovery, namely that the traditionally accepted symmetry between the motives M to achieve success and F - to avoid failure, is not valid. Indeed, it suffices to observe that some of the conditions in Theorems 1 and 2 depend on M , but do not depend on F .

This discovery is of crucial importance in controlling the risk areas of the subjects, e.g. in attempting to induce as many people as possible to suggest innovations.

Evaluation and Modification of Voting Consequences

by

Mean-Variance Analysis of Voters' Satisfaction

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1. Introduction

Since Condorcet discovered his celebrated "voting paradox" in 1785, various difficulties in the majority rule have been mentioned from theoretical and practical viewpoints. A most blatant objection to the majority rule was given by Jean-Charles de Borda in support of his Borda rule, or the sum-of-ranks method. For example, let us see the following profile of preferences: (1) abxyz, (2) bxzya, (3) zabxy, (4) abyzx, and (5) byxaz. In this case, the majority winner is a, while the Borda winner is b. Obviously, the Bordarian result may appear to be quite reasonable, might be better than the majority result. The source of this "reasonableness" in the Bordarian result has been said to exist in people's intuitive use of the rank-position information in their utility judgment for each alternative. In fact, Fishburn (1973) proposed, so-called, "Permuted Dominance Condition," which takes the rank-score of each alternative into account in the most basic judgment for the dominance relation of the pairs of alternatives, and which is known to be incompatible with the Weak Condorcet Condition. All kinds of different versions of Bordarian weighting schemes for the rank-scores satisfy this PDC, and would choose b as the winner in the above case.

However, when we examine the above profile, there seems to exist another reason for the objection to the majority result. As we may easily see, the social order obtained by the majority rule is; abxyz. Now, let us see how Voter 1's preference was reflected on the majority result. The preference order of Voter 1 has been completely reflected on the majority result, which may give some impression that Voter 1 is decisive over the result of the majority rule. On the other hand, let us see how Voter 2's preference was reflected on the majority result. We may intuitively conclude that the preference order by Voter 2 has been almost completely ignored in the majority result. Let us compare this outcome with the result of Borda rule. The Borda result is; bax(yz). Although Voter 1's preference order is still dominating in the social order, his apparent decisiveness on the result seems to be much weaker than before, and the apparent decisiveness of Voter 2 on the Bordarian result seems to become much stronger than before. Therefore, we may conclude that, at least in the above case, the majority rule yielded more inequality of voters' satisfaction than the Borda rule did.

In the present paper, some criteria are proposed to evaluate the inequity of voters' satisfaction to the obtained "social order." Thus it would be possible to find a direction to modify the resulting order

to obtain the higher degree of equity among voters on the satisfaction with the result, in sacrifice of the least of the total level of the voters' satisfaction.

2. Model

Measurement of Inequity. Throughout the rest of this paper, we shall assume that individual preferences, to be denoted, P_i , should be linear, i.e, irreflexive, connective, and transitive. We also assume that every "social order" considered here should be linear, denoted, B, M, P , etc. Now, for a given "social order," P , let us define a real-valued function, $s_i(x, y; P)$, such that $s_i(x, y; P) = 1$ if and only if (x, y) is in both P_i and P , and $s_i(x, y; P) = -1$, otherwise. Then the scale of individual voter's satisfaction, t_{ip} , to the obtained social order, P , is defined as the total sum of the ss for all the pairs of alternatives.

For the measurement of the inequity among voters' satisfaction, we propose the variance, $V(P) = \sum_j (t_{jp} - \bar{t}_p)^2 / N$, where N is the number of voters. We shall also propose a measure for the overall level of satisfaction among voters to P as the mean, $E(P) = \sum_j (t_{jp} / N) = \bar{t}_p$. For example, in the case presented in Introduction, Majority order, M , shows, $V(M) = 12.8$, and $E(M) = 4.0$. On the other hand, Bordarian order, B , shows, $V(B) = 3.8$, and $E(B) = 3.4$. Obviously, the Bordarian order appears to realize more of the equity than the majority order does, with a small decrease of the overall satisfaction to the result.

Modification of Social Order. It can be shown that the majority order always yields the maximum possible mean for any given profile of individual preferences. Therefore, any modification of a given social order to get more of the equity of individual satisfaction necessarily results in a farther deviation from the majority order in terms of the overall satisfaction to the result. Therefore, in order to obtain a reasonable resolution for social order, we shall start from the majority order, modifying it step by step to obtain the satisfactory level of equity among voters, with as small decrease of the mean as possible to obtain that level.

Starting from any given linear order, it would be possible to obtain a number of "modifications" of order, by alternating the order of an adjacent pair of alternatives. Although all of such "modifications" yield the smallest step of decrease in the mean, some may yield even an increase of the variance. In order to choose the best possible modification from these orders to obtain the largest decrease of the

inequity, we have developed a method of successive modification, called "Maximum Covariation Method," which has been proved to yield the maximum decrease of the existing inequity (variance) with the smallest change of the overall level of satisfaction (mean).

3. Simulation

Simulation 1. The first simulation was done to investigate the general tendencies of various existing social decision rules, Majority Rule (MR), Borda Rule (BR), and Double Plurality Rule (DP), in terms of the mean and the variance of the voters' satisfaction. One thousand profiles of preferences were randomly generated for each of the cases with 3, 5, and 7 voters for 3, 4, 5, 6, and 7 alternatives, thus obtaining the total of 15,000 profiles. Results clearly indicate that the DP yields the largest variance in almost every case, the MR generally yields the second largest variance, and the least variance was obtained by the BR in most cases. The analysis of the simulation result for the mean, the BR yielded means slightly below the means of MR, the maximum possible level of the overall satisfaction. The DP, on the other hand, tended to yield slightly smaller means than the BR, although the difference was quite small. Thus we may conclude that the overall level of satisfaction (the mean) was not distinguishably different among the present social decision rules, and that the Borda Rule would be the best choice for obtaining the equity of individual satisfaction to the social order. The Double Plurality Rule may be the worst choice, for yielding the greatest variance.

Simulation 2. The second simulation was done to see the step by step process of modifying the majority order, according to the proposed Minimum Covariation Method. The analysis was done for all the different types of profiles for 3 voters with 3 alternatives under the assumption of neutrality and anonymity. Then 12 profiles were arbitrarily selected from the profiles generated in Simulation 1. It was found that in some cases the minimum variance had already obtained in the majority result. In most cases in which the minimum variance has not been reached, a large decrease of variance obtained only by a single step of the smallest modification of the majority order.

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PART D: OUTLINE FOR WORKING GROUPS

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NOTES

- (i) The working group on Interactive Computer aids to decision problems replaces the working group on "Decision Making Efficiency" and the "Decision Aids Forum" advertised in the conference brochure.
- (ii) Limited quantities of background papers are available for the working groups on Risk Analysis and Interactive Computer aids to decision making. They will be sent to conference participants indicating a serious interest in joining the relevant group on receipt of their conference fees.

HELPING PEOPLE MAKE DECISIONS:

Working group on Hierarchically Structured Decision Aids

Convenors

Barbara Beach
Lee Roy Beach
University of Washington

and

Helmut Jungermann
Technical High School, Darmstadt

This workshop follows from Jungermann's Major Paper, "Decisionetics: The art of helping people to make personal decisions." We will begin with an example that should be of personal interest to participants. This will serve as a vehicle for a nuts-and-bolts discussion of some of the practical and technical considerations involved in using hierarchically structured, non-computerized, aids. Next, the question of how to derive appropriate hierarchical structures will be explored. Finally, some examples of hierarchical aids will be given along with the results of their use in four areas; whether to attempt to have a (another) child, whether to commute to work by bus or by private car, whether to continue smoking or to quit, and whether to terminate pregnancy by abortion. Participants are invited to bring examples from their own work, particularly if there are difficulties that the workshop may be able to work on and be of help.

Barbara H. Beach

Helmut Jungermann

Lee Roy Beach

Convenor

Baruch Fischhoff
Decision Research
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In recent years decision theory has been extended to some of the most serious problems facing modern civilization, how to deal wisely with the risks posed by adopting new technologies and those posed by foregoing their benefits. The nascent profession responsible for this extension is risk assessment.

The scope and pervasiveness of problems of risk require an extraordinary degree of cooperative effort on the part of specialists from many fields. Technical issues require the efforts of physicists, biologists, chemists, and engineers. Social issues involve lawyers, political scientists, geographers, sociologists, economists and psychologists. Specialists in decision making attempt to coordinate this diverse expertise and organize it in a manner conducive to improved decisions.

In a risk assessment, risks are identified, their probabilities assessed and their consequences estimated. The resulting analyses are then compared with assessment of likely benefits from the proposed technology and its substitutes. These comparisons are then incorporated, somehow or other, into a decision-making process that reflects the political, social, ideological and economic realities of the society doing the deciding.

Although risk analysis has great promise for ordering and clarifying these important decisions, each step of the process is fraught with difficulties. This workshop will consider the potentials and problems of risk analysis. The following list of questions touches on some of the topics which participants may wish to address from the perspective of their own professional and national experience.

A. Technical Questions

1. Are present systems for identifying hazards effective? If not, how can they be improved?
2. What is the state of the art regarding the assessment of probabilities? Can very small probabilities be adequately quantified? How do assessment procedures go astray? How can they be improved?
3. How adequately can the hazardous consequences of an event be modeled? Can any risk analysis take proper account of secondary and higher-order consequences? What are the proper units with which to describe consequences?

4. Are different methodologies needed for identification of the risks posed by new technologies and those inherent in existing technologies? Likewise, are there different identification procedures for risks to physical and social or psychological well-being? How do we spot hazards arising from the conjunction of two or more technologies? How do we avoid false alarms, due to aversive consequences coincidentally related to technologies?

5. Are risk assessors utilizing state-of-the-art methods in probability assessment? Are they aware of the large impact subtle changes in assessment procedure can have on their estimates? Are some risks ignored because they are hard to estimate? Should there be a division of labor between experts who gather information and experts who convert that information into probabilities?

6. Are hazards ignored because they are difficult to quantify? How can the value of direct questioning procedures (e.g., "How much is it worth to you as a user of this facility to have that power plant shielded from view?") be maximized? How should conflicting answers derived from different procedures be amalgamated?

B. Social Questions

1. Research indicates that people have difficulties coping intellectually with risk. What are the implications of this for risk-regulatory actions?

2. What is the effect of information on controversy over technological risks? Is it true that "properly informed" people will agree with the technologists or will public forums and debates do little or nothing to allay fears and conflicts? Can the information pertaining to specific risks be communicated to the public in ways that will increase their overall understanding of risk questions?

3. If properly informed people persist in beliefs not reflected in the risk assessor's rational model, should the model be changed? (For example, what if they insist that no amount of benefits will compensate them for the remote, but horrific risk associated with recombinant DNA research?) How should public participation in a risk assessment be arranged to maximize the quality and acceptability of its product?

4. How should we go about answering the question "How safe is safe enough?" Can a model be developed to describe and predict "acceptable" risk? What should be the considerations in such a model and how should they be assessed? Can a monetary value be placed on a human life in a manner that will be useful for decision making? Can severity of various illnesses and injuries be quantified and used as inputs in the model?

5. Are existing mechanisms for regulating risk consistent with one another? If not, why, and are these reasons justified? How do current practices constrain future solutions?

C. Methodological Questions

1. Are there any significant differences between technology assessment, cost/benefit analysis, risk/benefit analysis and decision analysis? If so, what are they? What is the appropriate division of labor between them? Are they being oversold by their proponents?

2. What are the advantages and disadvantages of decision analysis as a general framework for analyzing decisions about risk? Can decision analysis ever be politically acceptable when applied to controversial issues?

3. Can these methods become "number games," with component figures being imperceptibly juggled until a predetermined conclusion is supported?

4. Every stage of an analysis has some uncertainty associated with its product, be it a model, a utility or a probability. How should this uncertainty be assessed and expressed? How is such uncertainty compounded over the components of an analysis? Are errors in different components likely to cancel or magnify one another? Is there a point at which the total uncertainty becomes so large as to render that component of the analysis useless?

5. What makes a risk assessment "acceptable?" Some risk assessments seem to get ready acceptance and serve as a basis for societal response with a minimum of conflict, contradiction or doubt. Others only seem to fuel debate. Are differences in the specific hazard, the assessment content, the methods used, the judgment process employed, and the communication of the assessment related systematically to their acceptability?

D. Institutional Questions

1. Who will be out to "get" analyses and analysts, and bend them to their own needs? How can outside pressures be minimized? How can analyses be made responsive to the perceived needs of decision makers and the public without becoming subservient to them? What action, if any, is needed to promote and regulate useful analyses?

2. How can cadres of qualified analysts be trained and recruited? How can the independent review of analyses be institutionalized? How can the conflicting views of different experts be integrated?

3. How can we guarantee that problems common to many (or all) analyses will be attacked in a concentrated fashion? How can the overlap between analyses be minimized but the impact of their mutual implications be maximized?

INTERACTIVE COMPUTER AIDS TO DECISION MAKING WORKING GROUP

Convenors

Patrick Humphreys
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Decision Analysis Unit
Brunel University, England

This workshop replaces the Decision Aids forum and the workshop on Decision Making efficiency originally advertised in the conference brochure. Some of the ideas to be presented for discussion develop from the Major Paper, "Organizations and Uncertainty", and from a paper on structuring heuristics¹ which will be sent to participants indicating a serious interest in joining the group.

Current decision aids which have been developed at the Decision Analysis Unit, Brunel University, and at Decisions and Designs, Inc., McLean, Va. will be demonstrated at the initial session of this working group. They will cover interactive structuring and decomposition involving both probability and utility, and hierarchical decomposition. Most were originally designed for operation on the IBM 5100 series of portable computers, but we would like to concentrate on raising conceptual and man-machine-analyst interfacing problems, rather than discuss hardware and software implications.

These initial demonstrations will undoubtedly open up questions which can be examined in subsequent discussion in the working group. Participants will have their own questions that they wish to raise, but the following are examples of problems which the working group might wish to consider. They relate both to the development of interactive and to the implications of the development and utilization of such new technologies for organizational structure within client institutions.

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1. Humphreys, P.C., & Wooler, S. Structuring Decisions: the role of structuring heuristics. Technical Report 79-3. Uxbridge, England: Decision Analysis Unit, Brunel University, 1979.

QUESTIONS

- 1) To what extent will it be possible to develop computer software on a modular basis involving standard (sub)structures which simply need to be configured to model a particular problem. At what level should these modules be formed? A high level modular system involves the use of a taxonomy of decision problems², whereas a low level modular system involves uncertainty and preference structuring elements manipulating probabilities or utilities which form 'building blocks' from which the structural representation of a particular problem may be constructed.
- 2) Where should such systems be developed? What are the roles of universities and commercial organizations in developing these aids? If an interdisciplinary or inter-organizational team is required, how might it be put together and funded?
- 3) Is it possible to develop interactive computer-based aids to the point where they can be used intelligently and efficiently by people without a specialist training in decision analysis? What sort of training should be provided for such people, and who should provide it?
- 4) What is the nature of the role of a technical specialist with responsibility for the use and implementation of decision aiding tools within a commercial organization?

2 See the Major Paper by Detlof von Winterfeld, pp.B37-B65, above.

PREDECISIONAL STRUCTURING WORKING GROUP

Convenors

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The basic purpose of predecisional structuring is to carefully define a decision problem and cast it in a format for preceding analysis. Such a task must be carried out regardless of the methodology to be used in the analysis. Of course, it is very likely that the structuring will be refined in subsequent steps of the analysis. There are basically four important aspects of predecisional structuring. These involve defining the following:

1. The set of alternatives,
2. A set of objectives and associated attributes (measures of affectiveness) to indicate the degree to which those objectives are achieved,
3. A list of the groups potentially impacted by the alternatives being considered and, for public problems, specification of groups with some decision making powers and responsibility, and
4. The chronology of events (i.e., a decision tree) indicating the information which could be obtained to help appraise alternatives.

One of the key concepts in defining the range of alternatives to be considered is constraints. For instance, economical constraints may limit the possibility of implementing expensive alternatives. However, it is often the case that the range of alternatives are too narrowly focused.

In these cases, it is helpful to search for a wider range of alternatives by informally probing the values of the decision-maker (or decision-makers) and then generating alternatives which appear to have potential for being good. This indicates the interplay between specifying alternatives and defining objectives.

In a sense, the objectives should be the driving force behind a decision problem. If one can clearly layout what is desired, the thought process can better be focused on "how can one best achieve these objectives". It is easy to state in very general terms what the objectives are, but the substantive part of becoming specific is more difficult. One must be very careful not to mistake means objectives and ends objectives. Problems regarding this are often identified and alleviated in the process of defining attributes to measure the degree to which each of the final lower-level objectives are achieved.

On many important problems, there are several groups of individuals who are impacted and who care about those impacts. Some of these groups may also have decision making responsibilities in the problem. For instance, if an organization is proposing a certain project which requires government approval, if certain groups do not agree or do not support the project, they may challenge it with the regulatory agencies as well as through the courts. It may be appropriate to consider such possibilities in the structuring of a decision problem.

In specifying the chronology of events in a decision tree, it may be possible to identify creative alternatives for achieving the stated purposes. It is often easy to overlook "process alternatives" which involve designing a process which will lead one to a specific alternative, rather than directly choosing a specific alternative itself. It is also quite easy to overlook the possibility of obtaining information which may help in evaluating the various alternatives.

It has often been said that the predecisional structuring aspect of an analysis is the most critical. At the same time, it is that aspect of the analysis which receives the least formal attention. Predecisional structuring is necessarily a creative process, but it need not be as unsystematic as is often the case. Consequently, this working group will focus on two specific issues: 1. development of a better outline of the components of predecisional structuring and 2. suggestions for improving the predecisional structuring process through analysis or other systematic procedures. Additional concerns of working group participants will be defined and discussed at the conference itself.

PROCESS TRACING OF DECISION MAKING WORKING GROUP

Convenor

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The making of a decision is obviously a process extended over time. The duration of a decision process may vary from seconds to years. However, regardless of how long the process lasts, it may typically be described as a sequence of cognitive operations following each other in time. This is a consequence from two facts:

- (i) People can only process a limited amount of information at the same time;
- (ii) Decision problems typically require processing of fairly large amounts of information.

In earlier years the study of decision processes was hampered by the behavioristic dogma. However, in the present situation, when behaviorism has been replaced by information processing psychology, there are surprisingly few process tracing studies of decision making. There are powerful methods for studying decision processes, such as think-aloud protocols or latency data. Promising attempts have been made to formulate process models of decision making. Still, little has been done. I think that the reflections that may arise from this fact is a suitable point of departure for the discussions in the working group on process tracing of decision making. More specifically, I would like to suggest that the following questions are discussed:

A. Questions on process tracing methods

One reason for the lack of interest in process tracing studies may be scepticism or lack of knowledge with respect to the suitability of think-aloud data or other process data. The following questions are focused on think-aloud data, but may

easily be reformulated to cover other process tracing methods:

- 1) Are subjects unable to think aloud on important aspects of their decision processes? Think-aloud data primarily reflects verbal conscious thought processes (Ericsson & Simon, 1979). To what extent do decision processes possess these characteristics?
- 2) Does the requirement of think aloud disturb subjects' thought processes? Ericsson & Simon's (1979) review indicates that thinking aloud usually have small effects. To what extent is this true for decision processes?
- 3) It usually means a great deal of work to analyze think-aloud data. There are practically no standard procedures for the analysis of such data. Will this also be true in the near future? The sheer amount of data may be great which implies that it is difficult to get a good overview of important patterns or trends. Retrospective reports are more comprehensive but are they trustworthy? Are there other ways of getting more comprehensive data?

B. The real life vs. laboratory problem

The process tracing approach may be difficult to use in real life decision making. For example, to get think-aloud data from political decision making could be difficult. In general, there are ethical and other obstacles to get on-the-spot observations of "real" decision processes. On the other hand, few attempts have been made to conduct such studies. Shall we try more? If yes, which decision situations are suitable? What kind of data should be collected? What kind of interesting information can we get from such studies?

C. How should decision processes be described?

Montgomery & Svenson (1976) suggested that a decision process may be described in terms of different decision rules (disjunctive, conjunctive, lexicographic, etc.) which are used

at different points of time (see also Svenson, 1979). Others have described the process in terms of a computer program (e.g. Payne, Braunstein & Carrol, 1978; Tuggle, Barron & Day, 1973).

- 1) Which level(s) of detail is (are) most suitable for describing decision processes? For example, does the writing of simulation problems imply a serious risk of getting lost in technical and other inessential details?
- 2) Which basic concepts should be used in the descriptions? Is the decision rule concept fruitful? It may be conjectured that people very seldom use general decision rules but rather are guided by more specific "schemata" or "scripts" when they make their decisions (Abelson, 1976). It is also possible that people only use one or two basic decision rules, such as the dominance rule or the conjunctive rule, and that what they are doing in a decision process is to restructure the choice alternatives in such a way that a decision can be made from such a basic rule. To the extent that this is true, it may be interesting to search for heuristics which people use to restructure or edit the choice alternatives.
- 3) To which extent is it possible to profit from concepts and ideas in other fields of cognitive psychology? Certain strategies in a decision may be more feasible than others because of short-term-memory limitations. The problem of finding relevant information in one's long-term-memory may be critical in some decision processes. Many decision processes involve much problem solving. To which extent should these and similar facts be incorporated into the description of decision processes? Shall we postpone such a broader description until we know more about decision making in particular and cognitive processes in general?
- 4) Shall we try to incorporate feelings, social pressures and other non-cognitive factors into a process model of decision making?

D. What is the use of process tracing studies?

Despite the obvious process character of decision making, non-process models are still developed in this field (e.g. Kahnemann & Tversky, in press). Can such "static" models predict behavior as well as process models (Einhorn, Kleinmuntz, & Kleinmuntz, 1979)? I think that even if the answer is yes, it is still important to get process knowledge about decision making. Which reasons may be given for this standpoint?

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DECISION MAKING AND ACTION WORKING GROUP

Convenor

Lennart Sjöberg
University of Göteborg

The summary for this working group is not yet available.
It will be included in the next volume of conference
information.

GROUP DECISION MAKING WORKING GROUP

Convenor

Dirk Wendt
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In this working group, we will mainly discuss research topics provided by the participants of the group.

Moreover, we will try and scan the experimental literature on group decision making, searching for open problems, contradictory issues, and questions worth while future research, and discuss such possibilities.

The focus of the working group should be on empirical rather than normative approaches.

It can be anticipated that the topics to be discussed will include game theory approaches to group decision making, techniques for eliciting and aggregating group opinions (with respect to both probability and (multiattribute) utility assessment), interaction processes within groups during the emergence of such opinions, and possibly the influence of social motives upon individual decision making.

