Technical Report 504

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A DECISION SUPPORT FRAMEWORK
FOR DECISION AID DESIGNERS

AD A110329

Ruth H. Phelps, Stanley M. Halpin, and Edgar M. Johnson

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U. S. Army

Research Institute for the Behavioral and Social Sciences

January 1981

U. S. ARMY RESEARCH INSTITUTE

FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report 504	2. GOVT ACCESSION NO. AD-A110 329	3. RECIPIENT'S CATALOG NUMBER ARI-TR-504
4. TITLE *(and Subtitle)* A Decision Support Framework for Decision Aid Designers		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) Ruth H. Phelps Stanley M. Halpin Edgar M. Johnson		8. CONTRACT OR GRANT NUMBER(s) --
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Research Institute for the Behavioral and Social Sciences PERI-OS 5001 Eisenhower Ave, Alex., VA 22333		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q162717A790
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Research Institute for the Behavioral and Social Sciences (PERI-OS) 5001 Eisenhower Ave., Alexandria, VA 22333		12. REPORT DATE January 1981
		13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)* --		15. SECURITY CLASS. *(of this report)* Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE --

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

Same

18. SUPPLEMENTARY NOTES

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Decision Making
Decision Aiding
Decision Making Structure

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*
A Decision Support Framework is presented (Figure 1) which serves two purposes: first, to organize and integrate various decision aids according to their function, and secondly to provide the decision aid designer with a systematic context in which to develop decision aids as well as examine which aspects of the decision problem would most benefit from decision aiding. The main components of the framework are discussed in detail with Army intelligence decision making examples: (1) analysis of the decision requirements; (2) development of decision aids to provide the decision maker with information as well as tools --

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for evaluating, weighting and integrating the information to make a decision;
and (3) evaluation of the success of the decision aids in leading to a logical,
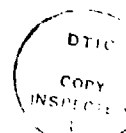rational decision.

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Office, Deputy Chief of Staff for Personnel
Department of the Army

January 1981

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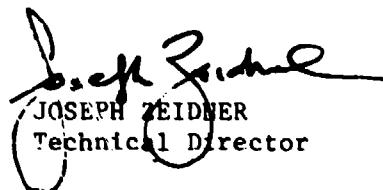
The Human Factors Technical Area is concerned with the demands of the future battlefields for increased human-machine complexity to acquire, transmit, process, disseminate, and utilize information. Research is focused on the interface problems and interactions within command, control and intelligence centers and is concerned with such areas as topographic products and procedures, tactical symbology, user-oriented systems, information management, staff operations and procedures, and sensor systems integration and utilization.

One area of special interest is the development of procedures to support and enhance the decision making process within command, control and intelligence centers. The current effort summarizes a framework which both identifies the requirements for developing and evaluating decision aids and organizes decision aids according to the functions they serve for the decision maker. This framework thus provides a concise way of categorizing already existing decision aids as well as provides guidelines for developing and evaluating new aids. Examples drawn from the areas of Army command and control and intelligence are used to demonstrate the usefulness of the framework.

Research in decision aiding is conducted as an in-house effort with additional support from contracting organizations which are selected for their unique contributions to this area. This effort is responsive to the requirements of Army Project 2Q162717A790.

JOSEPH ZEIDNER
Technical Director

A DECISION SUPPORT FRAMEWORK FOR DECISION AID DESIGNERS.

BRIEF

Requirement:

To develop and demonstrate a framework for the developers of decision aids for organizing and categorizing decision aiding procedures.

Approach:

The development of the framework was based on a study of existing decision aids, identifying differences and similarities in the purpose, decision, execution, and evaluation of the aids. The largest differences were in the service provided to the decisionmaker, e.g., provide information or logical reasoning support.

Product:

The framework developed (a) lists the steps a decision aid designer should ideally complete in the full development and implementation of the aid or aiding system, and (b) distinguishes two categories of aids, those that provide information and those that provide support for logically and rationally evaluating and integrating information in making a decision. See Figure 1 for a schematic of the framework. Army command and control examples of the two types of decision aids are summarized to help explain the use of the framework as well as distinguish the types of decision aids.

Utilization:

This framework should provide decision aid designers with an outline of steps to be followed in the cycle of development, from initial conceptualization and implementation to evaluation and revision of the aid. Special attention is devoted to the definition of requirements prior to aid development and an evaluation of the completed aid, two areas that rarely are given adequate weight in aid development. Use of the framework by system developers, both of large automated systems and small manual procedures, could enhance the useability of their systems and procedures since applying the framework requires a thorough study of the decisionmaker's requirements and constraints as well as identification and categorization of the decision aids to be developed. Since the framework is strongly based on psychological principles, it also provides an alternative to the more popular systems and engineering perspectives on decision aiding.

A DECISION SUPPORT FRAMEWORK FOR DECISION AID DESIGNERS

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A DECISION SUPPORT FRAMEWORK FOR DECISION AID DESIGNERS

INTRODUCTION

The need for decision-making support is being increasingly recognized
in a variety of disciplines: military (Kibler, Watson, Kelly, & Phelps,
1978; Levit, Alden, Erikson, & Heaton, 1977), public policy making (Hammond,
Rohrbaugh, Mumpower, & Adelman, 1977), land management (Gardiner & Edwards,
1975), medicine (Fryback & Thornbury, 1978), and oil exploration (von Winter-
feldt, 1976). Decision aids are currently under widespread development, but
little effort has been devoted to examination of the various functions de-
cision aids fulfill or to development of a system or framework for coordi-
nating related decision aids.

The purpose of this paper is to present a preliminary Decision Support
Framework which is intended to be used by the designers of decision support
systems to organize and integrate different types of decision aids into a
unifying system. The framework is both a descriptive tool to clarify the
relationship among decision aids and a type of aid itself. It will provide
the decision aid designer with a systematic context in which to develop aids
as well as to examine which aspects of the decision problem would most bene-
fit from decision aiding.

Before presenting the decision support structure, however, a few gen-
eral comments concerning the nature and function of the type of decision
support being discussed will help to define the scope and limitations of
this paper. The role of decision support is to increase the range of a de-
cisionmaker's capabilities to make a rational decision. Such a function is
accomplished by providing a decisionmaker with an informational base, as
well as organizational, computation, and psychological tools for making a
logical decision based on that information. Implicit in this role are two
assumptions: (a) Decision support is used when human judgment is a criti-
cal element, and (b) decision support in no way replaces the decisionmaker
as a problem solver. By definition, these are tools to support the human
judgment and decision-making process.

The decision support framework presented in this paper encompasses
the various functions decision aids may serve, the relationship among dif-
ferent aids, and an evaluation of those aids. While the framework is dis-
cussed in generic terms, clearly the structure and configuration of specific
decision aids will depend on the nature of the decision problem, the type
of information required, and the consequences of the decision. Conversely,
while the examples of different types of decision aids will be drawn from
Army tactical intelligence decisionmaking, the classes of aids are intended
to be general and apply to a variety of decision-making contexts.

The remainder of the paper is organized into three main sections:
(a) an overview of the Decision Support Framework; (b) a more detailed
discussion of functions of and relationships among specific classes of
decision aids; and (c) factors to be included in an evaluation of the de-
cision aids.

DECISION SUPPORT FRAMEWORK

In Figure 1 is a diagram of the Decision Support Framework. This framework is designed to depict the decision support components, not the decision process itself. The pivotal point of the framework is of course the actual DECISION to be made. Based on an analysis of that decision the REQUIREMENTS, or the information and tools needed, to make the decision are defined. Such requirements may include type of information, timeliness of information, data computations needed, and how the information should be organized, integrated, and evaluated. Lists and taxonomies such as those generated by Brown and Ulvila (1976) may be useful in determining the REQUIREMENTS for the specific decision problem. The importance of this analysis should not be underemphasized since it is the basis for determining the content and nature of the decision aids. In addition, clear and systematic analysis of the requirements is critical for insuring the validity of the EVALUATION of the decision aids.

Depending on the requirements established, the types of decision aids needed are determined. At the most basic level, there are two types of IN-FORMATION AIDS. Data-based aids make available to the decisionmaker the data on which the decision is based; these aids can best be viewed as automated data banks which make selected raw data, or perhaps summarized data, available to the decisionmaker. Data aids may select the data for a decisionmaker based on either predetermined or user-specified criteria. Calculation aids provide the decisionmaker with the results of statistical computations or other mathematical computations such as numerical changes in the data bases, distances, velocities, objective probabilities. Regardless of its form, the output of both aids is information or selected data.

In many, perhaps most, situations the decisionmaker may feel overwhelmed with the sheer volume of information available and have great difficulty in selecting the most relevant information and/or making a logical evaluation of that information. INTEGRATION AIDS are sets of procedures designed to help a decisionmaker logically evaluate and integrate the information provided by INFORMATION aids. The composition and organization of specific aids depends on the characteristics of the decision problem as well as the psychological difficulties known to influence this class of decisions. Thus, INTEGRATION aids can serve a single or a combination of functions, such as those listed in Figure 1: organizing and structuring the information, helping to overcome judgmental and cognitive limitations and biases such as faulty memory, and simplifying the evaluation and weighting of the information. The goal of every INTEGRATION aid is to help the decisionmaker arrive at a logical, rational DECISION, not to replace the decisionmaker.

Once the DECISION has been made, an EVALUATION of the various aids within the decision support framework is necessary for the decision aid designer to determine if in fact they did help the decisionmaker reach a rational decision. As shown in Figure 1, such an evaluation should consider at least the validity and reliability of the aid as well as its flexibility and the degree to which it led to an improved decision.

In summary, the proposed Decision Support Framework is designed to help logically define and organize the decision problem, describe the classes of necessary information, and provide a manageable structure for evaluating
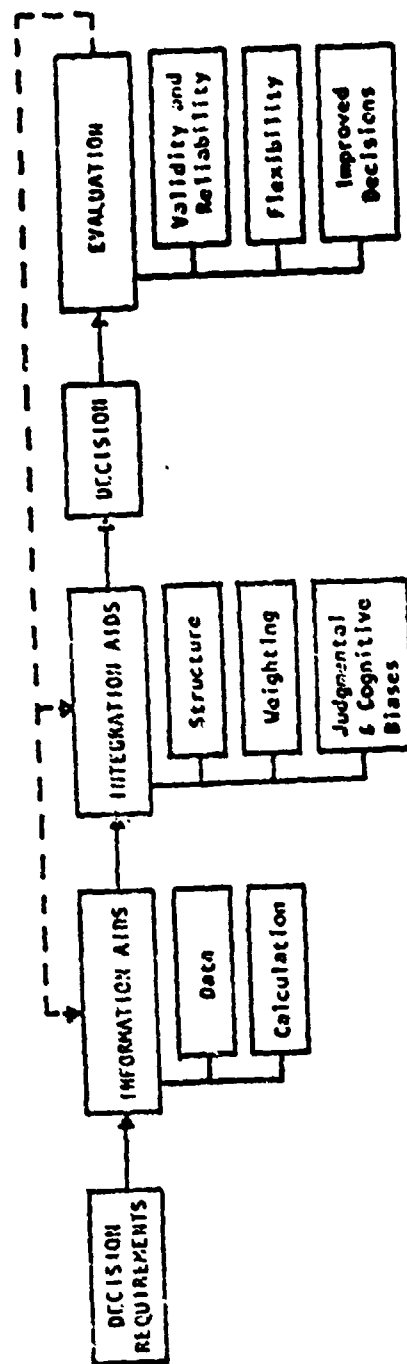
Figure 1. The Decision Support Framework. Dashed lines indicate feedback.

various decision aids. The following sections of the paper will focus on a more detailed discussion of two types of decision aids, INFORMATION and INTEGRATION, and their EVALUATION.

DECISION AIDS

The purpose of decision aids within the Decision Support Framework is to provide the decisionmaker with data on which to base a decision or with help in evaluating the data for a specific problem. While the two classes of aids, INFORMATION and INTEGRATION, are indeed based upon different purposes, such a distinction is not always clear in practice. The present framework defines the class of aid with respect to its function for the decisionmaker. Thus, although an aid may integrate, summarize, or perform some algorithm on the data, if the output of the aid is a piece of information or a restructuring of information it is considered an INFORMATION aid. Only when an aid helps the <u>decisionmaker</u> perform the summarization or evaluation of the information is it classified as an INTEGRATION aid. Such a distinction is justified by the focus of the Decision Support Framework on the actual decisionmaker as the reference or pivotal point, rather than the data or other environmental demands.

Informational Aids

Clearly no rational decision can be made without data or information. However, in many situations decisionmakers feel they do not have the type, accuracy, or timeliness of information used to make a rational decision. As shown in Figure 1 two of the many possible functions INFORMATION aids could serve are to provide data and calculations on those data to the decisionmaker. However, since the needs for INFORMATION aids will totally depend on the specifics of the decision problem, only a few general comments and an example will be presented. DATA aids are designed to fulfill this function, usually by automating a data base such that large amounts of data can be stored and readily retrieved by a decisionmaker. Data may be stored as individual items of information or summarized over some specified time period or level of detail. CALCULATION aids provide additional information by making computations on the raw data such as velocity, percentages, or even more sophisticated algorithms involving matching templates or statistically optimal solutions. However, for both DATA and CALCULATION aids the output of the aid is information which then must be evaluated and integrated by the decisionmaker.

Example: Information Aid. The U.S. Army Research Institute has developed a Graphic Movement Analysis Aid (GRAMA) to provide an Army tactical commander's staff with decision support. The specific decision problem is to determine which avenue of approach the enemy is most likely to select. The purpose of GRAMA is to identify those routes which minimize travel time and therefore are most likely. Specifically, GRAMA will help an intelligence analyst answer questions such as: "How long will it take an enemy unit to move from location A to location B, and what route will they follow?" A similar question may be asked concerning the optimal routes for as many as 10 units simultaneously moving from 10 locations to 10 destinations. To perform the calculations necessary for these questions, the computer

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algorithms require data on: (a) the road network--what is connected to what by what type of road; (b) the conditions of the move--day/night, wet/dry, vehicular/foot travel; (c) the types of units involved--how fast can they move given the conditions and the roads. GRAMA has a preloaded network of up to 600 points and their interconnections, and a "Speed" table which defines how fast an average unit can move under a combination of road and environmental conditions. The main interactive features of the program allow the user to work within this structure. Nodes may be added or deleted from the network, or specific subnetworks of interest within the larger network may be defined.

Thus, the output of GRAMA is a rank ordering of various avenues of approach based on the available data concerning environmental conditions, enemy units, etc. The commander's staff must now incorporate this with other information in determining the most likely enemy avenue of approach.

Integration Aids

The general purpose of INTEGRATION aids is to help a decisionmaker evaluate information from data aids, calculation aids as well as other sources, and then to integrate that information to make a rational decision. INTEGRATION aids are designed to help a decisionmaker ultimately relate all the relevant information to the various decision alternatives under consideration. Therefore, definition of decision alternatives is a critical preliminary step to the use of INTEGRATION aids. While a decisionmaker may require help and thus one aspect of aiding may be devoted to alternative definition, it is assumed for the present framework that the alternatives have been defined either in the decision REQUIREMENTS or as a result of the INFORMATION aids.

There is ample evidence from psychological literature that several factors degrade the quality of decisions which are based on even moderate amounts of information from single or multiple sources. The primary function of INTEGRATION aids is to help overcome or circumvent these factors. For any one decision problem the degrading factors must be identified and the aids developed to take into account those factors. While identification of the degrading factors requires considerable analysis and research on the specific decision problem, knowledge of the factors already known to interfere will help focus such efforts. Since an exhaustive list is beyond the scope of this paper, reference should be made to fairly complete descriptions available elsewhere (Tversky & Kahneman, 1974; Hogarth, 1975; Lichtenstein, Fischhoff, & Phillips, 1977; Slovic, Fischhoff, & Lichtenstein, 1977; Fischhoff & Slovic, in press). Three categories of factors which influence a decisionmaker's integration of information are listed in Figure 1 and briefly summarized here.

Structure of Information. The output of INFORMATION aids, in addition to other sources, will make available to the decisionmaker a large volume of data, summaries of data, or calculations on which to base a decision. Perhaps the most basic function an INTEGRATION aid can perform is to organize and structure this potentially overwhelming mass of information. Such structuring serves at least two functions: It allows all information to be categorized such that none is unintentionally overlooked and it also encourages

a more logical evaluation of information which varies in type as well as source. The most popular structuring techniques are based on decomposing the decision problem into a series of distinct categories of factors. These factors may be exclusive of each other, may be hierarchical in nature, i.e., some are subsets of others, or some combination of the two. Once such a structure is formed, the information can be sorted into the defined categories. Alternatively the structure can be used to determine which information needs to be gathered to arrive at a logical solution.

Weighting of Information. One of the most difficult tasks after the information has been organized into categories or factors is to assess which information is relevant for making a particular decision. The basis for determining relevance is diagnosticity; that is, the information that is most relevant is that which differentiates or discriminates among the options being considered. For example, a decisionmaker is selecting a new car and the information obtained about the potential cars is categorized into two factors: gas mileage and cost. If the three cars A, B, and C all get 30 miles per gallon, then gas mileage is not diagnostic because it does not differentiate the three cars under consideration. However, if the prices are A = $3,000, B = $4,000, C = $5,000, then price is a highly diagnostic factor since it does differentiate the options. The psychological concept of diagnosticity is often very difficult for decisionmakers to consistently apply. In the above example, it may be hard for a decisionmaker who is energy conscious to accept that gas mileage is not relevant when deciding among the cars A, B, and C. The difficulty seems to be in focusing on the factors which discriminate the specific options, and ignoring factors which in general are important but not discriminating in this decision problem.

If, as in many cases, the factors are all diagnostic, then the decisionmaker is faced with assessing the relative diagnosticity or relative weight of the factors. Procedures for assigning relative weights, based on the diagnosticity of the factors, can vary from a simple rank ordering to more sophisticated assignments of normalized subjective probabilities. In most cases, however, numerical values are assigned which correspond to the perceived relative weights. While there is no technique that can guarantee to place the factors in optimal order, psychological INTEGRATION aids are designed to help a decisionmaker determine which factors are diagnostic, then assess the relative importance of those factors.

Judgmental and Cognitive Biases. Psychological research has documented several judgmental biases which can severely degrade the quality of decisions. It is very important to recognize that these judgmental biases are not intentional and are so pervasive and compelling that training and instruction designed to help decisionmakers overcome specific biases have largely been ineffective. Because training has failed, it is even more critical that decision aids be designed to compensate or help minimize the impact of these judgmentally degrading biases. While it is beyond the scope of the present paper to discuss them all at length, a few will be briefly outlined to demonstrate the need to address such factors when designing decision aids.

One biasing factor is the illusory correlations which are inferred about the relationship of two events A and B. Because A and B are observed to co-occur a number of times, they are believed to be highly correlated with each other. However, simple co-occurrence is not sufficient evidence

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to infer correlation. It is necessary to consider how often B occurs and A does not. For example, if high gas mileage cars are also high in price, a positive correlation might be assumed. What has not been considered is the number of high gas mileage cars with low price and the low gas mileage cars with high price. Decisionmakers apparently can readily search for positive instances of the relationship between two or more variables, but have difficulty in either searching for or assimilating negative instances.

Decisionmakers also have misconceptions concerning probabilistic information. The probability of rolling an even number using a fair die is .5; the gambler's fallacy is the misperception that if a number of rolls occurs without an even number that the likelihood of one occurring soon is increased. It is commonly said that the event in question "is due." The decisionmaker fails to consider that the probabilities are based on thousands of rolls and a series of 10 rolls will not necessarily exhibit the same proportion of odd and even rolls. It is illogical to expect that an observed low or high frequency will be compensatory within a small sample.

Decisionmakers also have a tendency to inaccurately recall the confidence with which they made a decision after the decision outcome is known. In such hindsight biases, it appears that once the outcome is learned, decisionmakers unintentionally distort their perception of their predecision processes. A related problem is the feeling that when presented with new information, the decisionmaker sees the information as obvious, incorporates it, then fails to recognize that the information was not known previously. Both of these tendencies have been dubbed the "I knew it all along" effect. The danger in such a bias is that what a decisionmaker can learn from the decision outcome or the new information is severely inhibited.

When aids have been constructed to help structure and weigh information, as well as minimize judgmental biases, cognitive limitations will also be largely overcome. Simply by providing an explicit structure and making weighted information and necessary calculations readily retrievable by the decisionmaker, limitations such as memory capacity can easily be avoided. Thus, a decisionmaker is relieved of the burden of remembering all the information and evaluations of that information. In addition memory biases such as the disproportionate ease in recalling first and last information obtained will also be avoided.

Example: Integration Aid. A very critical decision problem for an Army tactical commander is to select the most advantageous course of action to pursue in attacking enemy forces, terrain, or cities. That is, what route will most quickly allow the commander's forces to reach their destination and accomplish their mission with the fewest forces, least equipment, and fewest losses. Such a decision has obviously grave consequences for many people as well as the commander. The problem is complicated by not only these consequences but by the extreme time pressure under which the information is gathered, evaluated, integrated, and a decision made. A computerized (IBM 5100) INTEGRATION aid has been developed by the U.S. Army Research Institute (Kibler et al., 1978) to help a commander both focus attention on and critically evaluate relevant information. The aid has been named TACVAL since its function is to aid in tactical evaluation of alternative courses of action.

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The structure of TACVAL is based on multiattribute utility theory, which requires that the decision problem be broken down into its contributing component parts or factors. Thus, the first step in designing the aid was to identify and define an exclusive, but not exhaustive, set of factors which would encompass the most relevant information for selecting courses of action under most circumstances. There are a total of 24 factors grouped into 5 categories organized into a two-level hierarchical structure.

To use TACVAL, a commander, or more realistically a member of the commander's staff, first defines the courses of action to be evaluated. Then, each course of action is independently evaluated on each of the 24 factors. Such evaluations involve assigning a numerical score to both the value of each alternative and the relative weight or diagnosticity of each factor for making this particular decision. After all factors are evaluated various calculations are then performed based on the user's inputs and preprogrammed algorithms. Two of these calculations are a normalized weighted average score for each course of action indicating the user's relative preferences among the alternatives and a sensitivity analysis which identifies the factors which are most sensitive to changes in the user's evaluation. In addition, there are options for editing the evaluations based on new information or reevaluation of old information and listing the relative importance of the 24 factors.

In terms of the functions of INTEGRATION aids listed in Figure 1, TACVAL performs at least the following: (a) The user searches, requests, and organizes the available information based on the 2-level hierarchical, 24-factor structure. Thus all the relevant information is systematically arranged and attention to irrelevant information can be minimized. (b) There are explicit instructions and scoring conventions built into the aid which help the user in a step-by-step fashion to evaluate the factors and assign numerical weights. Problems in determining factor diagnosticity are reduced by explicit elicitation procedures. (c) Judgmental biases are also minimized by providing the user with a hard copy of all the factors and evaluations of the alternatives on those factors. Hindsight biases are eliminated since the user has a complete record of all evaluations, updating, reevaluations, and resulting calculations. (d) Cognitive limitations such as memory overload are minimized since all evaluations and factors are explicit and information is organized within the framework. In addition since each factor is evaluated independently, the user need only be concerned with information relevant to that factor and need not be concerned with recalling other factors or information. Finally, psychological problems in combining the evaluations and weight of the factors are eliminated since they are arithmetically computed.

EVALUATION

The purpose of the EVALUATION component of the Decision Support Framework is to provide critical feedback for the decision aid designer concerning the success of the aids. In this context it is not the correctness of the DECISION that is assessed, but the value of the decision aids in making a rational decision. As shown in Figure 1, the EVALUATION step serves at least three functions, each of which will be briefly discussed.

Validity and Reliability

If the factors selected do not allow critical information to be included in assessments or the input judgments do not accurately reflect the feelings of the decisionmaker, then the output of the aid will be misleading. Validity assessments should include extensive consultation with experts to assure the factors, their labels, and definitions do in fact accurately capture the scope of the decision problem. In addition the judgments on those factors must reflect the true opinions of the user. While evaluation of the validity of input judgments can be elusive, checks such as internal consistency of judgments and questioning of the user should be attempted. Measures of the reliability of the user's judgments are also necessary, not so much to assess the user, but to be sure the procedure unambiguously elicits the user's responses. Experimental validation of both factors and judgments could include comparisons across decision problems and decisionmakers as well as variations in the factors and information.

A related validation issue is the credibility of the decision aid structure, process, and output to the decisionmaker. While the decisionmaker may not be the best expert on psychological biasing factors or information organization, the ultimate fidelity of the aid depends on the decisionmaker's acceptance. Thus, efforts should be made to assess the user's beliefs and confidence in the aid as well as abilities to make valid judgments of the information.

Flexibility

Since most decision situations are not completely static, a decision aid can never include all factors which may be of conceivable importance in unforeseen circumstances. Therefore, it is necessary to assess the flexibility of the decision aid to incorporate unique information, factors, or events. One possible approach to evaluate flexibility is to present a user with unexpected but obviously important information, then assessments of how and to what degree the information is incorporated into the decision aid structure can then be made.

Improved Decisions

While there is agreement from many disciplines that aids are necessary to support complex and consequential decisionmaking, there is very little reported evidence that decision aids do in fact lead to improved decision. Perhaps the most basic reason for this failure to evaluate decision aids is the lack of a criterion for assessing the quality of decisions. In some cases the actual consequences are too far removed from the decisions, while in others there is no realistic context in which to test the decision aids, e.g., a tactical commander at war. However, in the bulk of the cases, an objective criterion could certainly be developed even if only in hypothetical or contrived contexts. The crux of the evaluation issue lies in operationally defining the DECISION and REQUIREMENTS before the aids are even developed. Without clear objective definitions of the purposes, goals, and the decision itself, meaningful measures of the contribution of the decision aids to a rational decision cannot be made. Assuming operational

measures have been developed, experimental comparisons of decisions made with aids, without aids, with various modifications, etc., should be made to assess the contribution of the aids to making a rational decision.

As a final point on evaluation, it should be noted that in some situations the evaluation should include measures other than the rational decision. Based on the analysis of the decision REQUIREMENTS, perhaps measures such as the type and amount of information used, or the degree to which different decisionmakers resolve conflict about the decision, etc., may also be valid evaluation criteria. At times a decisionmaker is just as concerned with how the decision is made as with the decision itself.

CONCLUSIONS

The Decision Support Framework categorizes and relates different types of decision aids based on the functions they perform for a decisionmaker. However, beyond its use as an organizational tool, it requires the decision aid designer to carefully analyze the decision to determine the requirements for aiding the various functions which must be performed by the decisionmaker, as well as operationally define the decision criteria for valid evaluation of the decision aid. In short, using a complete framework such as presented here serves as a guide to help decision aiders develop logical and useable decision aids.

REFERENCES

Brown, R. V., & Ulvila, J. W. Selecting analytic approaches for decision situations, A matching of taxonomies. (DDI Technical Report 76-10). McLean, Va.: Decision and Designs, Inc., October 1976.

Fischhoff, B., & Slovic, P. A little learning: Confidence in multi-cue judgment tasks. Attention and Performance, VIII, in press.

Fryback, D., & Thornbury, J. Informal use of decision theory to improve radiological patient management. Radiology, 1978, 129, 385-388.

Gardiner, P. C., & Edwards, W. Public values: Multiattribute utility measurement for social decision making. In M. F. Kaplan & S. Schwartz (Eds.), Human judgment and decision processes. New York: Academic Press, 1975.

Hammond, K., Rohrbaugh, J., Mumpower, J., & Adelman, L. Social judgment theory: Applications in policy formulation. In M. F. Kaplan & S. Schwartz (Eds.), Human judgment and decision processes in applied settings. New York: Academic Press, 1977.

Hogarth, R. M. Cognitive processes and the assessment of subjective probability distributions. Journal of the American Statistical Association, 1975, 70, 271-289.

Kibler, A., Watson, S., Kelly, C., & Phelps, R. A prototype aid for evaluating alternative courses of action for tactical engagement. (ARI Technical Report TR-78-A38). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, November 1978.

Levit, R., Alden, D., Erikson, J., & Heaton, B. Development and application of a decision support aid for control of battlefield operations: A preliminary evaluation of a decision support complex in SIMTOS. (ARI Technical Report TR-77-A3.) Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, March 1977.

Lichtenstein, S., Fischhoff, B., & Phillips, L. D. Calibration of probabilities: The state of the art. In H. Jungermann & G. de Zeeuw (Eds.), Decision making and change in human affairs. Amsterdam: D. Reidel, 1977.

Slovic, P., Fischhoff, B., & Lichtenstein, S. Behavioral decision theory. Annual Review of Psychology, 1977, 28, 1-39.

Tversky, A., & Kahneman, D. Judgment under uncertainty: Heuristics and biases. Sciences, 1974, 184, 1124-1131.

von Winterfeldt, D. Personal communication, Seventeenth Annual Bayesian Conference, Los Angeles, Ca., Feb. 15-16, 1976.

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