ADA038460

1

DECISION MAKING RESEARCH

DEPARTMENT OF PSYCHOLOGY
DEPARTMENT OF MANAGEMENT AND ORGANIZATION
UNIVERSITY OF WASHINGTON, SEATTLE, WASHINGTON

DECISION MAKING RESEARCH
DEPARTMENT OF PSYCHOLOGY
UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON

A MECHANISM FOR DECISION STRATEGY SELECTION AND SOME IMPLICATIONS[1]

Jay J. J. Christensen-Szalanski

and

Lee Roy Beach[2]

University of Washington
Seattle, Washington

Technical Report 77-8

February 1977

Office of Naval Research Contract N00014-76-C-0193

(Terence R. Mitchell and Lee Roy Beach, Investigators)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER TR-77-8	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A Mechanism for Decision Strategy Selection and Some Implications		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Jay J. J. Christensen-Szalanski Lee Roy Beach		8. CONTRACT OR GRANT NUMBER(s) N00014-76-C-0193
9. PERFORMING ORGANIZATION NAME AND ADDRESS Decision Making Research Department of Psychology NI-25 University of Washington, Seattle, WA 98195		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Organizational Effectiveness Research Programs Office of Naval Research Arlington, VA 22217		12. REPORT DATE February 1977
		13. NUMBER OF PAGES 10
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)

387 783

18. SUPPLEMENTARY NOTES

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

Decision Strategy	Decision Maker's Repertory
Payoffs	Expected Benefit
Benefits	Costs
Decision Task Characteristics	Time Constraints

was proposed

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Beach and Mitchell (1976) proposed a contingency model for the selection of decision strategies. The strategy that the decision maker sees as offering the greatest expected net gain is the one selected; i.e., selection is based on a cost-benefit analysis. The present paper explores this selection mechanism in greater detail and examines the implications of variations in the costs and benefits. The effects of externally imposed time constraints (deadlines) on decision strategy selection and subsequent confidence in the adequacy of the decision also are discussed.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

A Mechanism for Decision Strategy Selection and Some Implications

Jay J. J. Christensen-Szalanski and Lee Roy Beach

University of Washington

Beach and Mitchell (1976) have examined the question of why decision makers do not always select optimal methods for making decisions. They refer to these methods as strategies and define them as (1) the procedures the decision maker engages in when attempting to choose among alternative courses of action and (2) the decision rule that dictates how the results of those procedures will be used to make the final choice. They describe a variety of strategies, ranging from formal decision analysis with all of its prescriptive procedures and aids to very informal strategies such as the use of homilies or habit.

Strategy selection is seen as contingent upon the characteristics of the decision task, both of the problem itself and of the environment in which it is encountered, and upon the characteristics of the decision maker, particularly his or her knowledge (repertory) of strategies, ability to use them, and characteristic manner of approach to problem solving. The selection mechanism consists of a simple cost-benefit analysis: The strategy that appears to offer the greatest expected net gain is the one selected. The purpose of this paper is to explore more fully this selection mechanism and some of its implications.

Benefits

In most decision tasks the potential payoffs and losses are fairly explicit and therefore the decision maker knows the utility, U_c, of making the correct decision ("correct" being the decision that would eventuate in realization of the payoffs) as well as the utility of an incorrect decision, U_i.

Costs

Beach and Mitchell (1976) note that using a decision strategy involves time, effort, and sometimes money--resources that the decision maker resists expending. These are costs that are incurred before the outcome of the decision is known and as such they must be balanced against potential benefits that a strategy could be expected to yield. Of course, strategies differ in the costs that their use incurs; complex, formal, highly analytic strategies cost more to use than simple rules-of-thumb or flipping a coin. It is assumed that the decision maker has an idea of how much it would cost to use any of the strategies in his or her repertory. Cost is designated $\overline{U}_e$.

Probability

For any given set of Decision Task Characteristics (Beach & Mitchell, 1976) there is associated with each strategy in the decision maker's repertory a subjective probability, P_c, that the strategy will lead to the correct decision or, $1-P_c$, to an incorrect decision. Changes in task characteristics change these probabilities but to simplify exposition we will assume here that task characteristics remain constant and that the subjective probabilities for each strategy therefore remain constant.

Beach and Mitchell (1976) state that in Western cultures most people believe that the more thoroughly and systematically one approaches a decision the greater are the chances of being correct. That is, more analytic, formal strategies are seen as having a higher probability of being correct, P_c. This is an arguable assumption and one for which it is easy to find exceptions. However, the assumption serves to simplify presentation and we will discuss alternatives later in the article.

Selection

For any strategy the product $P_c U_c$ is the expected benefit from its use for the decision task at hand and the product $(1-P_c)U_i$ is the expected benefit (positive or negative) if it results in an incorrect decision. Thus, the subjective expected benefit of a strategy is $P_c U_c + (1-P_c)U_i = P_c(U_c-U_i) + U_i$, which is the linear function illustrated in Fig. 1. Note that for $P_c = 1.00$ the maximum payoff, U_c, defines the upper end of the line and for $P_c = .00$ the minimum payoff, U_i, defines the lower end; the slope is their difference. If U_i were negative it would lie below the $U = 0$ point on the ordinate.

Insert Fig. 1 about here

Cost, $\overline{U}_e$, is assumed to increase with the complexity of the strategies and increasingly complex strategies are assumed to have higher probabilities, P_c, of yielding correct decisions. Therefore $\overline{U}_e$ is an increasing function of P_c. We think that the increase is most likely to be geometric because for very complex strategies a slight relative increase in complexity may require a large absolute increase in demands upon the decision maker. Of course there must be individual differences among decision makers, and some persons may have no complex strategies in their repertories with the result that their cost functions may approximate straight lines.

We have plotted $\overline{U}_e$ as a positive utility instead of the negative one that it actually is because it is easier to relate it conceptually to the expected benefit line. For a specific decision task the difference between the two functions for every P_c is the net expected gain for using a strategy that has that particular P_c of yielding a correct decision. The decision maker should select the strategy associated with the P_c for which this difference is maximal, P_c^*. Mathematically, P_c^* is at the point at which a line tangent to the bottom of the cost curve would be parallel to the expected benefit line. Graphically, P_c^* is at the point at which the space between the cost curve and the expected benefit line is widest. Intuitively, P_c^* is at the point at which the decision maker thinks he stands to make the most profit for the least cost. In essence, a level of acceptable risk, P_c^*, is defined at the point of maximal net expected gain and the strategy that has a level of risk most similar to P_c^* is the one that the decision maker should select; a less risky strategy increases costs and a more risky one decreases expected benefit, either of which decreases net expected gain.

Variations

Using Fig. 1 as a starting point, consider the results of the following variations.

Expected benefit. If either U_c or U_i is increased or decreased the slope of the expected benefit line will change. This change will define a new level of acceptable risk, P_c^*, and will result in a change of strategy if the new P_c^* lies close to the P_c associated with some other strategy. Moreover, if asked about his or her level of confidence in the potential correctness of the forthcoming decision, the decision maker's answer should reflect the change in P_c^*. If U_c were increased, for example, a higher P_c^* is defined and the person should use a subjectively more accurate strategy and be more confident in his or her decision.

If both U_c and U_i are increased or decreased by the same amount (difficult if one does not know the decision maker's utility function) the expected

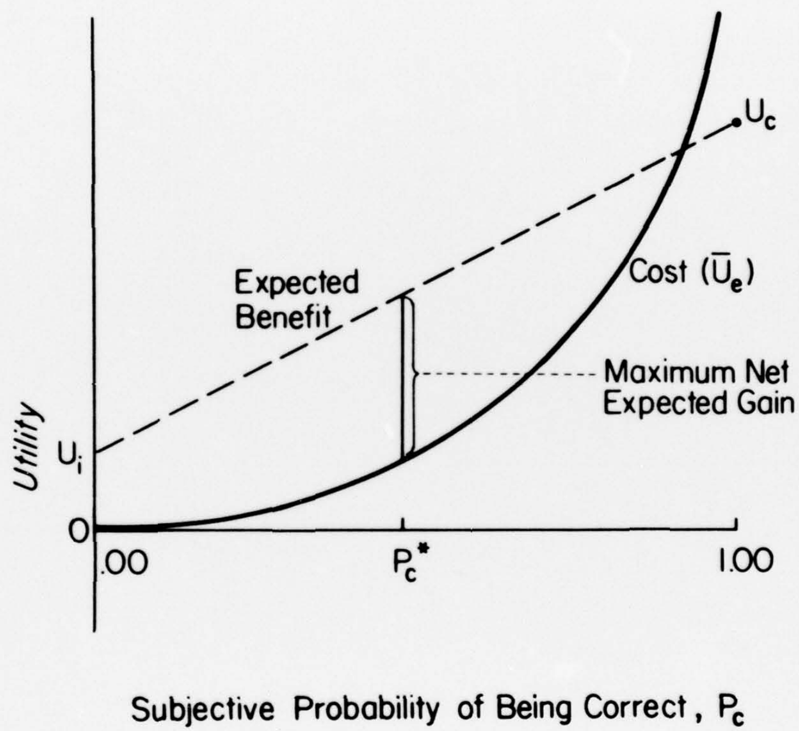

Utility
U_i
0
.00
P_c^*
1.00
U_c
Expected
Benefit
Cost ($\bar{U}_e$)
Maximum Net
Expected Gain
Subjective Probability of Being Correct, P_c

Figure 1

benefit line will rise or fall with no change in slope. Therefore, there should be no change in the defined level of acceptable risk, P_c^*, the strategy should remain the same, and confidence in success should not change.

U_c and U_i can be manipulated in many ways. Money is most commonly used but there are other ways. The negative payoff for an incorrect decision could be increased, for example, by increasing the decision maker's accountability for an incorrect decision through imposing a fine, forfeit, or the promise of social scorn. It could be decreased by assigning the decision to a non-cohesive group so that accountability for failure is diffuse and less personal. This assignment should result in selection of less costly and less potentially accurate strategies.

To carry this a bit further, consider two payment plans. The first plan offers the decision maker a commission of $1,000 for a correct decision and nothing for an incorrect decision. The second plan offers the decision maker a salary of $500 and a commission of $500 contingent upon the decision being correct. Which plan should the employer prefer if he wants the decision maker to use the best, highest P_c, strategy in his repertory?

Insert Fig. 2 about here

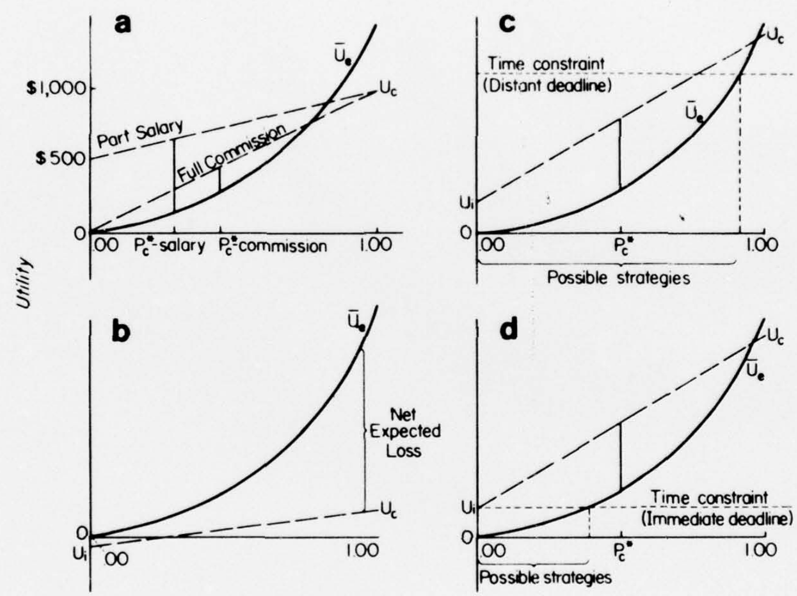
For the first plan U_c = \$1,000 and U_i = 0. For the second plan U_c = \$1,000 but U_i = \$500 (see Fig. 2a); with $500 already in hand even if the decision is incorrect the slope of the expected benefit line is one half of what it is when the whole $1,000 depends on a correct decision. A flatter line defines a lower level of acceptable risk, P_c^*, and a less promising strategy. So, the decision maker should try to persuade the employer to offer the second payment plan and the employer should try to persuade the decision maker to accept the first plan. In fact, the employer should even try to impose a penalty for an incorrect decision in order for force U_i below the zero point and thereby increase the slope of the line which will increase P_c^* and lead the decision maker to select a more promising strategy.

Costs. Anything that changes the difficulty of the decision task changes the cost function. Beach and Mitchell (1976) outline some variables that are likely to be relevant and we will not repeat that discussion here. However, fatigue is an additional variable of interest that they did not examine. When a decision maker becomes fatigued and consequently must put more effort into the task, the cost curve rises. Since the expected benefit curve remains constant, a rise in the cost curve will define a new, lower P_c^* with the consequent selection of a new strategy and a lower level of confidence in the potential correctness of the decision. Anything that reduces fatigue (or at least the feeling of fatigue) should have the opposite effect. Perhaps this is why a cup of coffee or a cocktail after work often changes a decision maker's confidence in his or her decisions. Indeed, the overconfident drunken driver may be the classic example.

When costs, $\bar{U}_e$, are so high, or payoffs so low, that the cost curve lies above the expected benefit line (Fig. 2b) the decision maker should avoid making a decision or should use the strategy with the P_c^* dictated by the minimal expected net loss (as opposed to the maximal net gain in the usual case).

Suppose the cost function is a straight line instead of a curve and that it increases with P_c. If it lies above the expected benefit line and the lines are not parallel, the conclusions of the last paragraph apply. If they are parallel no strategy is better than any other in terms of net expected gain so the decision maker should be indifferent about which strategy is selected. If the cost line is below the expected benefit line and nonparallel, net expected gain should be maximized.

6-A



Subjective Probability of Being Correct, P_c

Figure 2

Suppose that for some decision task the decision maker does not view the world in the way we have described it; for him or her P_c and strategy complexity are not related in the way we have assumed. In the extreme case, suppose that simple, nonanalytic strategies are seen as having high P_c and complex ones are seen as having low P_c. If $\overline{U}_e$ is still positively related to the degree of strategy complexity, the cost curve in Fig. 1 would be completely reversed--high costs for low P_c and low costs for high P_c. If the expected benefit line remains as it is in Fig. 1, the decision maker should avoid low P_c, high complexity strategies and should select extremely high P_c, simple strategies. A possible example of this sort of thing might be decisions about the merit of works of art in which immediate impression might be preferred to cold, logical analysis.

Finally, suppose that for some task the decision maker's cost curve is not monotonic with P_c; it might reverse a few times or often. The basic maximization of expected net gain rule still holds for the decision maker but for us, as experimenters, things would be very difficult.

Time. Few decision tasks permit unlimited time for their completion. For low levels of P_c, and the attendant simple strategies, this often is not a problem. But deadlines and other time constraints often eliminate highly complex strategies from consideration for selection. Since time is a cost, a deadline has the same effect as dividing the cost curve, $\overline{U}_e$, at some point and considering for selection only those strategies related to values of P_c that lie below (left of) that division (see Fig. 2c). If the designated P_c^* for the decision at hand normally lies below the division point, no change in strategy or confidence will result from the imposition of the time constraint. If it lies above the division point (Fig. 2d) the decision maker will have to use the strategy that has a P_c lying at or slightly below the division--the most complex strategy that can be executed within the time available. This change will be reflected in decreased confidence in the decision's correctness. Moreover, if the decision maker is using this time-constrained strategy when a more complex one is dictated by the P_c^* for the decision problem, anything that increases the slope of the expected benefit line will have no effect on strategy selection or confidence since the decision maker's strategy selection is limited by the time constraint. Anything that decreases the slope of the expected benefit line or raises the cost curve will have an effect on strategy or confidence only if the new P_c^* becomes less than the P_c associated with the time-constrained strategy.

We do not think that decision makers consciously make all of the computations implied by Figs. 1 and 2. Nonetheless, even in the midst of current doubt about "man as an intuitive statistician" it does not seem overly charitable or naive to recognize that people actually do consider the potential payoffs and costs of engaging in various acts, however roughly and imperfectly they may do it, and that they use these considerations to guide their behavior. Those who are distressed by the assumption of a modicum of rationality on the part of decision makers can take comfort in the paradox that is introduced--a decision maker operating as we have described may rationally select a strategy that, from a decision theoretic point of view, is quite irrational.

Reference

Beach, L. R., & Mitchell, T. R. A contingency model for the selection of decision strategies. Technical Report 76-6, University of Washington, December, 1976.

Footnotes

[1]This research was supported by Office of Naval Research Contract N00014-76-C-0193 (Terence R. Mitchell and Lee Roy Beach, Investigators). The authors thank Ms. Carlyn Christensen-Szalanski for her help.

[2]Reprints may be obtained from Professor Lee Roy Beach, Department of Psychology (NI-25), University of Washington, Seattle, Washington 98195.

Office of Naval Research
Code 452
800 N. Quincy St.
Arlington, VA 22217

Director
U.S. Naval Research Lab.
Washington, DC 20390
ATTN: Technical Information Division

Defense Documentation Center
Building 5
Cameron Station
Alexandria, VA 22314

Library, Code 2029
U.S. Naval Research Lab.
Washington, DC 20390

Science & Technology Division
Library of Congress
Washington, DC 20540

Psychologist
ONR Branch Office
1030 E. Green St.
Pasadena, CA 91106

Research Psychologist
ONR Branch Office
536 S. Clark St.
Chicago, IL 60605

Psychologist
ONR Branch Office
495 Summer St.
Boston, MA 02210

Director
Cybernetics Technology Office
ARPA, Room 625
1400 Wilson Blvd.
Arlington, VA 22209

Dr. Russell Bernard
Dept. of Sociology & Antro.
West Virginia University
Morgantown, WV 26506

Dr. Davis B. Bobrow
University of Maryland
Dept. of Government & Politics
College Park, MD 20742

Dr. Arie Lewin
Duke University
Duke Station
Durham, NC 27706

Dr. Lyman W. Porter
University of California
Dean, Graduate School of Administration
Irvine, CA 92650

Dr. Manuel Ramirez
Systems and Evaluations
232 Swanton Blvd.
Santa Cruz, CA 95060

Dr. Paul Wall
Division of Behavioral Science
Tuskegee Institute
Tuskegee, AL 36088

Navy Personnel R & D Center
Code 01
San Diego, CA 92152

Mr. Luigi Petrullo
2431 N. Edgewood St.
Arlington, VA 22207

Dr. John J. Collins
6305 Caminito Estrellado
San Diego, CA 92120

Commanding Officer
1 Psychological Research Unit
Chancery House
485 Bourke St.
Melbourne vic 3000 AUSTRALIA

Director, Engineering Psychology Programs, Code 455
Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217

Lt. Col. Henry L. Taylor USAF
OAD(E&LS) ODDR&E
Pentagon, Rm, 3D129
Washington, D.C. 20301

Human Factors Plans, OP987P7
Office of the Chief of Naval Operations
Dept. of the Navy
Washington, D.C. 20350

Personnel Logistics Plans
OP987P10, Office of the Chief of Naval Operations
Dept. of the Navy
Washington, DC 20350

Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
Code RD-1
Washington, DC 20380

Office of Naval Research
International Programs
Code 102IP
800 North Quincy Street
Arlington, VA 22217

Naval Analysis Programs, Code 431, Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

Operations Research Program
Code 434
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

Statistics & Probability Program, Code 436
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

Information Systems Program
Code 437
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

Dr. M. Bertin
Office of Naval Research
Scientific Liaison Group
American Embassy, Room A-407
APO San Francisco 96503

Naval Electronics Systems
Command, Human Factors
Engineering Branch, Code 4701
Washington, D.C. 20360

CDR Paul Nelson
Naval Medical R&D Command
Code 44, Naval Medical Center
Bethesda, MD 20014

Director, Behavioral Sciences
Department
Naval Medical Research Inst.
Bethesda, MD 20014

Dr. George Moeller, Head
Human Factors Engineering Br.
Submarine Med. Research Lab.
Naval Submarine Base
Groton, CT 06340

Bureau of Naval Personnel
Special Assistant for
Research Liaison
PERS-OR
Washington, DC 20370

Dr. Fred Muckler
Manned Systems Design, Code 311
Navy Personnel Research and
Development Center
San Deigo, CA 92152

LCdr Mike O'Bar, Code 305
Navy Personnel Research and
Development Center
San Diego, CA 92152

CDR P. M. Curran
Human Factors Engineering Br.
Crew Systems Department
Naval Air Development Center
Johnsville, Warminster, PA 18974

Mr. Richard Coburn
Head, Human Factors Division
Naval Electronics Lab. Center
San Diego, CA 92152

Dr. Alfred F. Smode
Training Analysis & Evaluation
Group, Naval Training Equipment
Center, Code N-00T
Orlando, FL 32813

Mr. J. Barber
Headquarters DA
DAPE-PBR
Washington, DC 20546

Dr. Joseph Zeidner, Director
Organization & Systems Res. Lab.
U.S. Army Research Institute
1300 Wilson Boulevard
Arlington, VA 22209

Dr. Edgar M. Johnson
Organizationa & Systems Research
U.S. Army Research Lab
1300 Wilson Boulevard
Arlington, VA 22209

Technical Director
U.S. Army Human Engineering Labs
Aberdeen Proving Ground
Aberdeen, MD 21005

U.S. Air Force Office of
Scientific Research
Life Sciences Directorate, NL
Bolling Air Force Base
Washington, DC 20332

Chief, Human Engineering Div.
Aerospace Medical Research Lab
Wright-Patterson AFB
Ohio 45433

Dr. Donald A. Topmiller
Chief, Systems Effect. Branch
Human Engineering Division
Wright Patterson AFB, OH 45433

Lt. Col. Joseph A. Birt
Human Engineering Division
Aerospace Medical Research Lab.
Wright Patterson AFB, OH 45433

Lt. Col. John Courtright
Headquarters
AMD/RDH
Brooks AFB, Texas 78235

Dr. E. Weiss
Office of Science Information
National Science Foundation
1900 Pennsylvania Avenue
Washington, D.C.

Journal Supplement
Service
American Psychological Assoc.
1200 - 17th St. N.W.
Washington, DC 20036

Mr. Edward Connelly
OMNEMII, Inc.
Tyson's International Bldg.
8150 Leesburg Pike, Suite 600
Vienna, VA 22180

Dr. Victor Fields
Montgomery College
Dept. of Psychology
Rockville, MD 20850

Dr. Bruce M. Ross
Catholic University
Department of Psychology
Washington, DC 20064

Dr. Robert R. Mackie
Human Factors Research, Inc.
Santa Barbara Research Park
6780 Cortona Drive
Goleta, CA 93017

Mr. Alan J. Pesch
Eclectech Associates, Inc.
P.O. Box 179
North Stonington, CT 06359

Dr. A. I. Siegel
Applied Psychological Services
404 E. Lancaster Street
Wayne, PA 19087

Dr. W. S. Vaughan
Oceanautics, Inc.
3308 Dodge Park Road
Landover, MD 20785

Director, Human Factors Wing
Defense & Civil Institute of
Environmental Medicine
P.O. Box 2000
Downsville, Toronto, Ontario CAN

Dr. A. D. Baddeley, Director
Applied Psychology Unit
Medical Research Council
15 Chaucer Rd., Cambridge,
CB2 2EF ENGLAND

Major David Dianich
DSMS
Building 202
Fort Belvior, VA 22060

Dr. Bertram Spector
CACI, Inc. - Federal
1815 N. Fort Myer Drive
Arlington, VA 22209

Dr. C. Kelly
Decisions and Designs, Inc.
Suite 600, 7900 Westpark Dr.
McLean, VA 22101

Mr. George Pugh
General Research Corp.
7655 Old Springhouse Road
McLean, VA 22101

Mr. Gary W. Irving
Integrated Sciences Corp.
1532 Third Street
Santa Monica, CA 90401

Dr. Amos Freedy
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Paul Slovic
Oregon Research Institute
P.O. Box 3196
Eugene, OR 97403

Dr. A. C. Miller III
Stanford Research Inst.
Decision Analysis Group
Menlo Park, CA 94025

Dr. R. A. Howard
Stanford University
Stanford, CA 94305

Dr. Ward Edwards, Director
Social Science Research Inst.
University of Southern Calif.
Los Angeles, CA 90007

Mr. Frank Moses
U.S. Army Research Institute
1300 Wilson Boulevard
Arlington, VA 22209

Robert G. Gough, Major, USAF
Associate Professor
Dept. of Economics, Geography,
and Management
USAF Academy, Colorado 80840

Dr. T. Owen Jacobs
P.O. Box 3122
Ft. Leavenworth, Kansas 66027

Dr. Gary Poock
Operations Research Department
Naval Postgraduate School
Monterey, CA 93940

Dr. Jesse Orlansky
Institute for Defense Analyses
400 Army-Navy Drive
Arlington, VA 22202

Prof. Carl Graf Hoyos
Institute for Psychology
Technical University
8000 Munich, Arcisstr 21
Federal Republic of GERMANY

Dr. Arthur Blaiwes
Naval Training Equip. Center
Orlando, FL 32813

Dr. William A. McClelland
Human Resources Research Office
300 N. Washington Street
Alexandria, VA 22314