

AD-A057 698

IOWA UNIV IOWA CITY IOWA TESTING PROGRAMS  
A NOTE RELATING TWO DECISION SYSTEMS.(U)  
JUN 78 C LEWIS, M R NOVICK

F/G 12/1

UNCLASSIFIED

TR-78-2

N00014-77-C-0428

NL

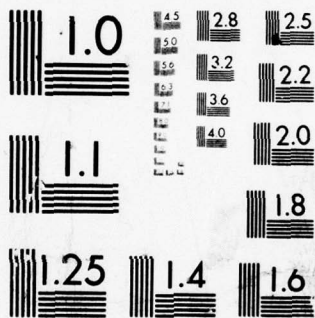
| of |

AD  
A057698



END  
DATE  
FILMED  
9-78

DDC



MICROCOPY RESOLUTION TEST CHART  
 NATIONAL BUREAU OF STANDARDS-1963-A

AD No. \_\_\_\_\_  
DDC FILE COPY.

AD A 057698

TECHNICAL REPORT 78-2  
JUNE, 1978

LEVEL #

12  
B

A NOTE RELATING TWO DECISION SYSTEMS

BY

CHARLES LEWIS

UNIVERSITY OF ILLINOIS

REPORT PREPARED UNDER OFFICE OF NAVAL RESEARCH  
CONTRACT #00014-77-C-0428

MELVIN R. NOVICK, PRINCIPAL INVESTIGATOR  
UNIVERSITY OF IOWA  
IOWA CITY, IOWA

DDC  
RECEIVED  
AUG 21 1978  
A

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED  
REPRODUCTION IN WHOLE OR IN PART IS PERMITTED FOR  
ANY PURPOSE OF THE UNITED STATES GOVERNMENT.

78 18 08 086

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report 78-2 ✓	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ⑥ A Note Relating Two Decision Systems <sup>9</sup>		5. TYPE OF REPORT & PERIOD COVERED Research Report 10/77-5/78
7. AUTHOR(s) ⑩ Charles Lewis Melvin R. Novick		6. PERFORMING ORG. REPORT NUMBER Technical Report No. 78-2
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Iowa Iowa Testing Programs Iowa City, IA 52242		8. CONTRACT OR GRANT NUMBER(s) ⑮ NDDC 14-77-C-0428
11. CONTROLLING OFFICE NAME AND ADDRESS Personnel and Training Research Programs Office of Naval Research (Code 458) Arlington, VA		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 6115 3N; RR 042-04; RRO42-04-01; NR 150-404
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) ⑪ 1 Jun 78		12. REPORT DATE June 1, 1978
⑫ 9p.		13. NUMBER OF PAGES 7
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release, distribution unlimited. ⑭ TR-78-2		15. SECURITY CLASS. (of this report) Unclassified
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) ⑯ RR 04204 / ⑰ RR 0420401		16a. DECLASSIFICATION/DOWNGRADING SCHEDULE
18. SUPPLEMENTARY NOTES ① Technical Rept. Oct 77-May 78		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Applied statistical decision theory; Bayesian decision theory; Conditional expected utility; Bayesian decision making.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) SEE BACK OF SHEET		

78 - 8 08 086  
440 844

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 68 IS OBSOLETE  
S/N 0102-014-6001

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

BLOCK 20:

A useful and comprehensive framework for applied statistical decision theory has been provided by Raiffa and Schlaifer (1961). More recently, Luce and Krantz (1971) gain an axiomatic treatment of what they called conditional expected utility. Specifically, probability, utility, and the expression of preference in terms of conditional expected utility were all developed from a set of non-numerical axioms about preference orderings. It is the purpose of this note to investigate the connections between the systems of Luce and Krantz and Raiffa and Schlaifer, primarily through a translation of Raiffa and Schlaifer's terminology into that of Luce and Krantz.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

A NOTE RELATING TWO DECISION SYSTEMS

Charles Lewis  
University of Illinois

ABSTRACT

A useful and comprehensive framework for applied statistical decision theory has been provided by Raiffa and Schlaifer (1961). More recently, Luce and Krantz (1971) gain an axiomatic treatment of what they called conditional expected utility. Specifically, probability, utility, and the expression of preference in terms of conditional expected utility were all developed from a set of non-numerical axioms about preference orderings. It is the purpose of this note to investigate the connections between the systems of Luce and Krantz and Raiffa and Schlaifer, primarily through a translation of Raiffa and Schlaifer's terminology into that of Luce and Krantz.

ADMISSION for		
RTS	White Section	<input checked="" type="checkbox"/>
RS	Self Section	<input type="checkbox"/>
ADVANCED		<input type="checkbox"/>
JUSTIFICATION.....		
BY		
DISTRIBUTION AVAILABILITY CODES		
Dist.	AVAIL.	and or SPECIAL
A		

A NOTE RELATING TO THE THEORY OF DECISIONS

Thomas Lewis  
University of Illinois

ABSTRACT

A useful and comprehensive framework for applied statistical decision theory has been provided by E. L. Lehmann and J. H. Neyman (1937). More recently, James and Stein (1961) have shown that the usual unbiased estimator of a normal mean is inadmissible under squared error loss. Stein's paradoxical result has led to a new class of estimators known as "shrinkage" estimators. In this note, we discuss the relationship between the James-Stein estimator and the Bayes estimator of a normal mean with respect to a loss function which is a sum of squared errors. It is shown that the James-Stein estimator is a Bayes estimator with respect to a normal prior distribution. This result is extended to the case of a normal distribution with unknown variance. The relationship between the James-Stein estimator and the Bayes estimator is also discussed in the context of a normal distribution with unknown mean and variance. Finally, the relationship between the James-Stein estimator and the Bayes estimator is discussed in the context of a normal distribution with unknown mean and unknown variance.

Author	Thomas Lewis
Title	A Note Relating to the Theory of Decisions
Journal	
Volume	
Number	
Year	
Pages	
Abstract	

## A NOTE RELATING TWO DECISION SYSTEMS<sup>\*</sup>

Charles Lewis  
University of Illinois

Raiffa and Schlaifer (1961; henceforth referred to as RS) provided a useful and comprehensive framework for applied statistical decision theory. More recently, Luce and Krantz (1971; henceforth referred to as LK) gave an axiomatic treatment of what they called conditional expected utility. Specifically, probability, utility, and the expression of preference in terms of conditional expected utility were all developed from a set of non-numerical axioms about preference orderings. There is a detailed description of the LK system in Krantz, et al. (1971, pp. 369-420), at the end of which an interest is expressed in possible connections with the RS framework. It is the purpose of this note to investigate these connections, primarily through a translation of RS terms into those of LK.

A brief outline of the elements of statistical decision-making as provided by RS (pp. 3-15) is in order. There are four sets and two functions to consider at the outset. The sets are acts,  $A = \{a\}$ ; states,  $\theta = \{\theta\}$ ; experiments,  $E = \{e\}$ ; and samples or observations  $Z = \{z\}$ . The first function is  $u$ , with  $u(e, z, a, \theta)$  a real number representing the utility of the consequence of conducting experiment  $e$ , observing  $z$ , and

---

\*The research reported herein was supported in part by ONR grant #N00014-77-C-0428. The opinions expressed are solely those of the author and do not reflect the opinions or policies of the supporting institution.

selecting act  $a$  when  $\theta$  is the true state of the world. The second function (or family of functions),  $P_{\theta, z|e}$ , which for each  $e \in E$  assigns a probability measure to  $\theta \times Z$ , referred to as the possibility space. The conditional probability notation used here is not strictly appropriate, since  $e$  is not a subset of  $\theta \times Z$ . It will be useful to remedy this as follows: Let  $Z_e$  be the sample space associated with experiment  $e$  and let  $Z$  be the disjoint union of all the  $Z_e$  such that  $e \in E$ :

$$Z = \bigcup_{e \in E} Z_e .$$

Then the possibility space may be rewritten as

$$\theta \times Z = \theta \times \bigcup Z_e = \bigcup (\theta \times Z_e) .$$

If  $\theta \times Z_e$  is identified with  $e$ , then conditioning on  $e$  becomes a formal possibility. This leaves open the question of a probability measure on  $E$  itself, but it is not an important question since only the conditional measures will be of interest. More generally, most details concerning the probability measure on  $\theta \times Z$  are left unspecified.

The RS system is applied to decision problems at three primary levels. Given the choice of  $e$  and the observation of  $z \in Z_e$ , preferences among acts are specified in terms of conditional expected utilities

$$E[u(e, z, a, \theta) | z] \tag{1}$$

where, to be more precise, the conditioning is taking place on the set  $\theta \times \{z\} \subseteq e$ .

The next level of decision-making requires the introduction of decision functions

$$d: Z_e \rightarrow A ,$$

which describe the choice of an act given the outcome of experiment  $e$ .

With  $e$  fixed,  $d$  should be chosen to maximize

$$E[u(e, z, d(z), \theta) | e] \quad (2)$$

Such a function may be constructed by choosing, for each  $z \in Z_a$ , an act  $a$  which maximizes (1). As demonstrated in RS (p. 15), this process defines a  $d$  which maximizes (2). This is described as establishing the equivalence of extensive and normal forms of analysis.

Finally, the decision maker may consider the choice of  $e$ . Here one should select the experiment whose maximal value for (2) is greatest. This is rephrased in RS as choosing the strategy  $(e, d)$  which maximizes (2).

Now consider the LK system, as described by Krantz, et al. (1971). It is more formal as regards probabilities than is the RS framework in that an algebra of subsets (A) of a set X is explicitly introduced. These subsets "represent chance events to which probabilities ultimately will be assigned," (p. 372). A set C of consequences (c) is also introduced. Then, for non-null events A (those which will be given non-zero probabilities), a decision conditional on A is defined as a function

$$f_A: A \rightarrow C$$

which assigns a consequence to each element of the event A. For events A and B with no elements in common and conditional decisions  $f_A$  and  $g_B$  the decision  $f_A \cup g_B$  is defined for each element in  $A \cup B$ . Specifically, this function assigns a consequence using  $f_A$  if the element is in A and using  $g_B$  if the element is in B.

Axioms are introduced which allow the development of a probability measure on the algebra of events and a utility function which assigns a real valued utility to each decision in  $D$ , the set of all conditional decisions under consideration. These utilities preserve the preference ordering which is assumed to exist on  $D$ . Moreover, they are compatible with the probability measure in the sense that

$$u(f_A \cup g_B) = u(f_A)P(A|A \cup B) + u(g_B)P(B|A \cup B) ,$$

thus assigning a conditional expected utility to the composite decision based on the utilities of the component decisions. Clearly, more general expectations than the preceding will be assumed to be appropriate even though, strictly speaking, the LK development does not justify their use.

For the translation, begin by identifying  $X$  with  $\Theta \times Z$ . In each system it is the relevant subsets of these sets to which probabilities are assigned. Next, let  $C$  be identified with  $Re$ . Since the RS system includes no separately identified consequences, it seems easiest to think of these directly as utilities. The most elementary level of decision in the RS system may be represented in LK terms by defining

$$f_{a,z} : \Theta \times \{z\} \rightarrow Re$$

as

$$f_{a,z}(\theta, z) = u(e, z, a, \theta)$$

for fixed  $z \in Z_e$ . Here the decision to choose act  $a$ , given result  $z$  of experiment  $e$ , produces a consequence  $u(e, z, a, \theta)$  for each state  $\theta \in \Theta$ . The decision  $f_{a,z}$  may actually be thought of as a union of even more

elementary decisions, each of which assigns a utility to a single point  $(\theta, z)$ . In this spirit, the utility of  $f_{a,z}$  may be expressed as an expectation:

$$u(f_{a,z}) = E[u(e, z, a, \theta) | \theta \times \{z\}] \quad (3)$$

Thus a representation of (1) has been provided in the LK system. Note that the expectation in (3) is being taken, in effect, over the posterior distribution of  $\theta$  given  $z$ .

To deal with the next level of decision for RS, namely a choice among decision rules, define the conditional decision

$$g_{d,e} = \bigcup_{z \in Z_e} f_{d(z),z}$$

on the set  $e = \theta \times Z_e$ . Once again, the utility of the composite decision can be represented as the conditional expected utility of its components:

$$u(g_{d,e}) = E[u(f_{d(z),z}) | e] \quad .$$

Here expectation is with respect to the prior predictive distribution of  $z$ .

Using (3), this can be rewritten as

$$u(g_{d,e}) = E[u(e, z, a, \theta) | e] \quad , \quad (4)$$

which is the counterpart of (2) in the RS system.

Finally, the choice of a strategy  $(e, d)$  may be simply described as selection of the conditional decision  $(g, d, e)$  whose utility is maximal across all  $e \in E$ . With this basis, both extensive and normal form analyses are simply explicated in the LK system, always using the principle that the utilities of decisions reflect preference orderings. To be more ex-

plicit, normal form analysis directly considers a choice among the decisions  $g_{d,e}$ . Extensive form, on the other hand, begins with a choice among  $f_{a,z}$  for each  $z \in Z_e$ .

An immediate conceptual advantage of this treatment over that given in RS is that all levels of analysis take place on the same basic entities, namely conditional decisions.

#### References

- Krantz, D.H., Luce, R.D., Suppes, P., & Tversky, A. Foundations of Measurement, Volume 1: Additive and Polynomial Representation, New York: Academic Press, 1971.
- Luce, R.D., and Krantz, D.H., "Conditional Expected Utility," *Econometrika*, 1971, 39, 253-271.
- Raiffa, H., and Schlaifer, R., Applied Statistical Decision Theory, Boston: Harvard Business School, 1961.

Navy

- 4 DR. JACK ADAMS  
OFFICE OF NAVAL RESEARCH BRANCH  
223 OLD MARYLEBONE ROAD  
LONDON, NW, 15TH ENGLAND
- 1 Dr. Jack R. Borsting  
Provost & Academic Dean  
U.S. Naval Postgraduate School  
Monterey, CA 93940
- 1 Dept. of the Navy  
CHNAVMAT (NMAT 034D)  
Washington, DC 20350
- 1 Chief of Naval Education and  
Training Support )-(01A)  
Pensacola, FL 32509
- 1 Dr. Charles E. Davis  
ONR Branch Office  
536 S. Clark Street  
Chicago, IL 60505
- 5 Dr. Marshall J. Farr, Director  
Personnel & Training Research Programs  
Office of Naval Research (Code 458)  
Arlington, VA 22217
- 1 DR. PAT FEDERICO  
NAVY PERSONNEL R&D CENTER  
SAN DIEGO, CA 92152
- 1 CDR John Ferguson, MSC, USN  
Naval Medical R&D Command (Code 44)  
National Naval Medical Center  
Bethesda, MD 20014
- 1 Dr. John Ford  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 Dr. Eugene E. Gloye  
ONR Branch Office  
1030 East Green Street  
Pasadena, CA 91101

Navy

- 1 CDR Robert S. Kennedy  
Naval Aerospace Medical and  
Research Lab  
Box 29407  
New Orleans, LA 70189
- 1 Dr. Norman J. Kerr  
Chief of Naval Technical Training  
Naval Air Station Memphis (75)  
Millington, TN 38054
- 1 Dr. Leonard Krockner  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 Dr. James Lester  
ONR Branch Office  
495 Summer Street  
Boston, MA 02210
- 1 Dr. William L. Maloy  
Principal Civilian Advisor for  
Education and Training  
Naval Training Command, Code 00A  
Pensacola, FL 32508
- 1 Dr. James McBride  
Code 301  
Navy Personnel R&D Center  
San Diego, CA 92152
- 2 Dr. James McGrath  
Navy Personnel R&D Center  
Code 306  
San Diego, CA 92152
- 1 DR. WILLIAM MONTAGUE  
NAVY PERSONNEL R & D CENTER  
SAN DIEGO, CA 92152
- 1 Commanding Officer  
Naval Health Research  
Center  
Attn: Library  
San Diego, CA 92152

^L

Navy

Navy

- 1 CDR PAUL NELSON  
NAVAL MEDICAL R& D COMMAND  
CODE 44  
NATIONAL NAVAL MEDICAL CENTER  
BETHESDA, MD 20014
- 1 DR. RICHARD J. NIEHAUS  
CODE 301  
OFFICE OF CIVILIAN PERSONNEL  
NAVY DEPT  
WASHINGTON, DC 20390
- 1 Library  
Navy Personnel R&D Center  
San Diego, CA 92152
- 6 Commanding Officer  
Naval Research Laboratory  
Code 2627  
Washington, DC 20390
- 1 OFFICE OF CIVILIAN PERSONNEL  
(CODE 26)  
DEPT. OF THE NAVY  
WASHINGTON, DC 20390
- 1 JOHN OLSEN  
CHIEF OF NAVAL EDUCATION &  
TRAINING SUPPORT  
PENSACOLA, FL 32509
- 1 Office of Naval Research  
Code 200  
Arlington, VA 22217
- 1 Scientific Director  
Office of Naval Research  
Scientific Liaison Group/Tokyo  
American Embassy  
APO San Francisco, CA 96503
- 1 SCIENTIFIC ADVISOR TO THE CHIEF  
OF NAVAL PERSONNEL  
NAVAL PUREAU OF PERSONNEL (PERS OR)  
RM. 4410, ARLINGTON ANNEX  
WASHINGTON, DC 20370

- 1 DR. RICHARD A. POLLAK  
ACADEMIC COMPUTING CENTER  
U.S. NAVAL ACADEMY  
ANNAPOLIS, MD 21402
- 1 Mr. Arnold I. Rubinstein  
Human Resoureces Program Manager  
Naval Material Command (0344)  
Room 1044, Crystal Plaza #5  
Washington, DC 20360
- 1 A. A. SJOHOLM  
TECH. SUPPORT, CODE 201  
NAVY PERSONNEL R& D CENTER  
SAN DIEGO, CA 92152
- 1 Mr. Robert Smith  
Office of Chief of Naval Operations  
OP-987E  
Washington, DC 20350
- 1 Dr. Alfred F. Smode  
Training Analysis & Evaluation Group  
(TAEG)  
Dept. of the Navy  
Orlando, FL 32813
- 1 DR. H.M. WEST III  
DEPUTY ADCNO FOR CIVILIAN PLANNING  
AND PROGRAMMING  
RM. 2625, ARLINGTON ANNEX  
WASHINGTON, DC 20370
- 1 DR. MARTIN F. WISKOFF  
NAVY PERSONNEL R& D CENTER  
SAN DIEGO, CA 92152

**THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDQ**

Army	Air Force
1 HQ USAREUE & 7th Army ODCSOPS USAAAREUE Director of GED APO New York 09402	1 Air Force Human Resources Lab AFHRL/PED Brooks AFB, TX 78235
1 DR. RALPH CANTER U.S. ARMY RESEARCH INSTITUTE 5001 EISENHOWER AVENUE ALEXANDRIA, VA 22333	1 Air University Library AUL/LSE 76/443 Maxwell AFB, AL 36112
1 DR. RALPH DUSEK U.S. ARMY RESEARCH INSTITUTE 5001 EISENHOWER AVENUE ALEXANDRIA, VA 22333	1 Dr. Alfred R. Fregly AFOSR/NL, Bldg. 410 Bolling AFB, DC 20332
1 Dr. Milton S. Katz Individual Training & Skill Evaluation Technical Area U.S. Army Research Institute 5001 Eisenhower Avenue Alexandria, VA 22333	1 Dr. Ross L. Morgan (AFHRL/ASR) Wright -Patterson AFB Ohio 45433
1 Dr. Harold F. O'Neil, Jr. ATIN: PERI-OK 5001 EISENHOWER AVENUE ALEXANDRIA, VA 22333	1 Personnel Analysis Division HQ USAF/DPXXA Washington, DC 20330
1 DR. JAMES L. RANEY U.S. ARMY RESEARCH INSTITUTE 5001 EISENHOWER AVENUE ALEXANDRIA, VA 22333	1 Research Branch AFMPC/DPMYP Randolph AFB, TX 78148
1 Director, Training Development U.S. Army Administration Center ATTN: Dr. Sherrill Ft. Benjamin Harrison, IN 46218	1 Dr. Marty Rockway (AFHRL/TT) Lowry AFB Colorado 80230
1 Dr. Joseph Ward U.S. Army Research Institute 5001 Eisenhower Avenue Alexandria, VA 22333	1 Major Wayne S. Sellman Chief, Personnel Testing AFMPC/DPMYPT Randolph AFB, TX 78148

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC

## Marines

- 1 Director, Office of Manpower Utilization 1  
HQ, Marine Corps (MPU)  
ECE, Bldg. 2009  
Quantico, VA 22134
- 1 DR. A.L. SLAFKOSKY  
SCIENTIFIC ADVISOR (CODE RD-1)  
HQ, U.S. MARINE CORPS  
WASHINGTON, DC 20380

## Other DoD

- Dr. Stephen Andriole  
ADVANCED RESEARCH PROJECTS AGENCY  
1400 WILSON BLVD.  
ARLINGTON, VA 22209
- 12 Defense Documentation Center  
Cameron Station, Bldg. 5  
Alexandria, VA 22314  
Attn: TC
- 1 Dr. Dexter Fletcher  
ADVANCED RESEARCH PROJECTS AGENCY  
1400 WILSON BLVD.  
ARLINGTON, VA 22209
- 1 Military Assistant for Human Resources  
Office of the Director of Defense  
Research & Engineering  
Room 3D129, the Pentagon  
Washington, DC 20301
- 1 Director, Research & Data  
OSD/MRA&L (Rm. 3E919)  
The Pentagon  
Washington, DC 20301
- 1 Mr. Fredrick W. Suffa  
MPP (A&R)  
2E269  
Pentagon  
Washington, D.C. 20301

^L

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDG

## Civil Govt

- 1 Dr. Susan Chipman  
Basic Skills Program  
National Institute of Education  
1200 19th Street NW  
Washington, DC 20208
- 1 Dr. William Gorham, Director  
Personnel R&D Center  
U.S. Civil Service Commission  
1900 E Street NW  
Washington, DC 20415
- 1 Dr. Vern W. Urry  
Personnel R&D Center  
U.S. Civil Service Commission  
1900 E Street NW  
Washington, DC 20415
- 1 C.S. WINIEWICZ  
U.S. CIVIL SERVICE COMMISSION  
REGIONAL PSYCHOLOGIST  
230 S. DEARBORN STREET  
CHICAGO, IL 60604
- 1 Dr. Joseph L. Young, Director  
Memory & Cognitive Processes  
National Science Foundation  
Washington, DC 20550

## Non Govt

- 1 PROF. EARL A. ALLUISI  
DEPT. OF PSYCHOLOGY  
CODE 287  
OLD DOMINION UNIVERSITY  
NORFOLK, VA 23508
- 1 Dr. John R. Anderson  
Dept. of Psychology  
Yale University  
New Haven, CT 06520
- 1 1 psychological research unit  
Dept. of Defense (Army Office)  
Campbell Park Offices  
Canberra ACT 2600, Australia
- 1 MR. SAMUEL PALL  
EDUCATIONAL TESTING SERVICE  
PRINCETON, NJ 08540
- 1 Dr. Nicholas A. Bond  
Dept. of Psychology  
Sacramento State College  
600 Jay Street  
Sacramento, CA 95819
- 1 Dr. David G. Bowers  
Institute for Social Research  
University of Michigan  
Ann Arbor, MI 48106
- 1 Dr. John Seeley Brown  
Eolt Beranek & Newman, Inc.  
50 Moulton Street  
Cambridge, MA 02138
- 1 Dr. John P. Carroll  
Psychometric Lab  
Univ. of No. Carolina  
Davie Hall 013A  
Chapel Hill, NC 27514
- 1 Dr. William Chase  
Department of Psychology  
Carnegie Mellon University  
Pittsburgh, PA 15213

L

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC

## Non Govt

- 1 Dr. Kenneth E. Clark  
College of Arts & Sciences  
University of Rochester  
River Campus Station  
Rochester, NY 14627
- 1 Dr. Norman Cliff  
Dept. of Psychology  
Univ. of So. California  
University Park  
Los Angeles, CA 90007
- 1 Dr. Allan M. Collins  
Bolt Beranek & Newman, Inc.  
50 Moulton Street  
Cambridge, Ma 02138
- 1 Dr. Meredith Crawford  
5605 Montgomery Street  
Chevy Chase, MD 20015
- 1 DR. RENE V. DAWIS  
DEPT. OF PSYCHOLOGY  
UNIV. OF MINNESOTA  
75 E. RIVER RD.  
MINNEAPOLIS, MN 55455
- 1 Dr. Marvin D. Dunnette  
N492 Elliott Hall  
Dept. of Psychology  
Univ. of Minnesota  
Minneapolis, MN 55455
- 1 MAJOR I. N. EVONIC  
CANADIAN FORCES PERS. APPLIED RESEARCH  
1107 AVENUE ROAD  
TORONTO, ONTARIO, CANADA
- 1 Dr. Richard L. Ferguson  
The American College Testing Program  
P.O. Box 163  
Iowa City, IA 52240
- 1 Dr. Victor Fields  
Dept. of Psychology  
Montgomery College  
Rockville, MD 20850

## Non Govt

- 1 Dr. Edwin A. Fleishman  
Advanced Research Resources Organ.  
8555 Sixteenth Street  
Silver Spring, MD 20910
- 1 Dr. John R. Frederiksen  
Bolt Beranek & Newman  
50 Moulton Street  
Cambridge, MA 02138
- 1 DR. ROBERT GLASER  
LRDC  
UNIVERSITY OF PITTSBURGH  
3939 O'HARA STREET  
PITTSBURGH, PA 15213
- 1 DR. JAMES G. GREENO  
LRDC  
UNIVERSITY OF PITTSBURGH  
3939 O'HARA STREET  
PITTSBURGH, PA 15213
- 1 Dr. Ron Hambleton  
School of Education  
University of Massachusetts  
Amherst, MA 01002
- 1 Dr. Richard S. Hatch  
Decision Systems Assoc., Inc.  
350 Fortune Terrace  
Rockville, MD 20854
- 1 Library  
HumRRO/Western Division  
27857 Berwick Drive  
Carmel, CA 93921
- 1 Dr. Earl Hunt  
Dept. of Psychology  
University of Washington  
Seattle, WA 98105
- 1 Mr. Gary Irving  
Data Sciences Division  
Technology Services Corporation  
2811 Wilshire Blvd.  
Santa Monica CA 90403

## Non Govt

- 1 DR. LAWRENCE F. JOHNSON  
LAWRENCE JOHNSON & ASSOC., INC.  
SUITE 502  
2001 S STREET NW  
WASHINGTON, DC 20009
- 1 Dr. Ezra S. Krendel  
Wharton School, DH/DC  
University of Pennsylvania  
Philadelphia, PA 19174
- 1 Mr. Marlin Kroger  
1117 Via Goleta  
Palos Verdes Estates, CA 90274
- 1 LCOL. C.R.J. LAFLEUR  
PERSONNEL APPLIED RESEARCH  
NATIONAL DEFENSE HQS  
101 COLONEL BY DRIVE  
OTTAWA, CANADA K1A 0K2
- 1 Dr. Frederick M. Lord  
Educational Testing Service  
Princeton, NJ 08540
- 1 Dr. Robert R. Mackie  
Human Factors Research, Inc.  
6780 Cortona Drive  
Santa Barbara Research Pk.  
Goleta, CA 93017
- 1 Dr. Donald A Norman  
Dept. of Psychology C-009  
Univ. of California, San Diego  
La Jolla, CA 92093
- 1 Dr. Jesse Orlansky  
Institute for Defense Analysis  
400 Army Navy Drive  
Arlington, VA 22202
- 1 Dr. Seymour A. Papert  
Massachusetts Institute of Technology  
Artificial Intelligence Lab  
545 Technology Square  
Cambridge, MA 02139

## Non Govt

- 1 MR. LUIGI PETRULLO  
2431 N. EDGEWOOD STREET  
ARLINGTON, VA 22207
- 1 DR. STEVEN M. PINE  
N660 ELLIOTT HALL  
UNIVERSITY OF MINNESOTA  
75 E. RIVER ROAD  
MINNEAPOLIS, MN 55455
- 1 DR. PETER POLSON  
DEPT. OF PSYCHOLOGY  
UNIVERSITY OF COLORADO  
BOULDER, CO 80502
- 1 MIN. RET. M. RAUCH  
P II 4  
EUNDESMINISTERIUM DER VERTEIDIGUNG  
POSTFACH 161  
53 BONN 1, GERMANY
- 1 Dr. Mark D. Reekase  
Educational Psychology Dept.  
University of Missouri-Columbia  
12 Hill Hall  
Columbia, MO 65201
- 1 Dr. Joseph W. Rigney  
Univ. of So. California  
Behavioral Technology Labs  
3717 South Hope Street  
Los Angeles, CA 90007
- 1 Dr. Andrew M. Rose  
American Institutes for Research  
1055 Thomas Jefferson St. NW  
Washington, DC 20007
- 1 Dr. Leonard L. Rosenbaum, Chairman  
Department of Psychology  
Montgomery College  
Rockville, MD 20850
- 1 Dr. Ernst Z. Rothkopf  
Bell Laboratories  
600 Mountain Avenue  
Murray Hill, NJ 07974

L

## Non Govt

- 1 PROF. FUMIKO SAMEJIMA  
DEPT. OF PSYCHOLOGY  
UNIVERSITY OF TENNESSEE  
KNOXVILLE, TN 37916
- 1 DR. WALTER SCHNEIDER  
DEPT. OF PSYCHOLOGY  
UNIVERSITY OF ILLINOIS  
CHAMPAIGN, IL 61820
- 1 DR. ROBERT J. SEIDEL  
INSTRUCTIONAL TECHNOLOGY GROUP  
HUMERO  
300 N. WASHINGTON ST.  
ALEXANDRIA, VA 22314
- 1 Dr. Richard Snow  
School of Education  
Stanford University  
Stanford, CA 94305
- 1 Dr. Robert Sternberg  
Dept. of Psychology  
Yale University  
Box 11A, Yale Station  
New Haven, CT 06520
- 1 DR. ALBERT STEVENS  
EOLT BERANEK & NEWMAN, INC.  
50 MOULTON STREET  
CAMBRIDGE, MA 02138
- 1 DR. PATRICK SUPPES  
INSTITUTE FOR MATHEMATICAL STUDIES IN  
THE SOCIAL SCIENCES  
STANFORD UNIVERSITY  
STANFORD, CA 94305
- 1 Dr. Kikumi Tatsuoka  
Computer Based Education Research  
Laboratory  
252 Engineering Research Laboratory  
University of Illinois  
Urbana, IL 61801
- 1 DR. PERRY THORNDYKE  
THE RAND CORPORATION  
1700 MAIN STREET  
SANTA MONICA, CA 90406

## Non Govt

- 1 DR. THOMAS WALLSTEN  
PSYCHOMETRIC LABORATORY  
DAVIE HALL 013A  
UNIVERSITY OF NORTH CAROLINA  
CHAPEL HILL, NC 27514
- 1 Dr. Claire E. Weinstein  
Educational Psychology Dept.  
Univ. of Texas at Austin  
Austin, TX 78712
- 1 Dr. David J. Weiss  
N660 Elliott Hall  
University of Minnesota  
75 E. River Road  
Minneapolis, MN 55455
- 1 DR. SUSAN E. WHITELY  
PSYCHOLOGY DEPARTMENT  
UNIVERSITY OF KANSAS  
LAWRENCE, KANSAS 66044

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDG