

AD-A076 601

ILLINOIS UNIV AT URBANA-CHAMPAIGN COMPUTER-BASED EDUC--ETC F/6 5/2
ANALYTICAL TEST THEORY MODEL FOR TIME AND SCORE.(U)

JUL 79 K TATSUOKA

N00014-78-C-0159

UNCLASSIFIED

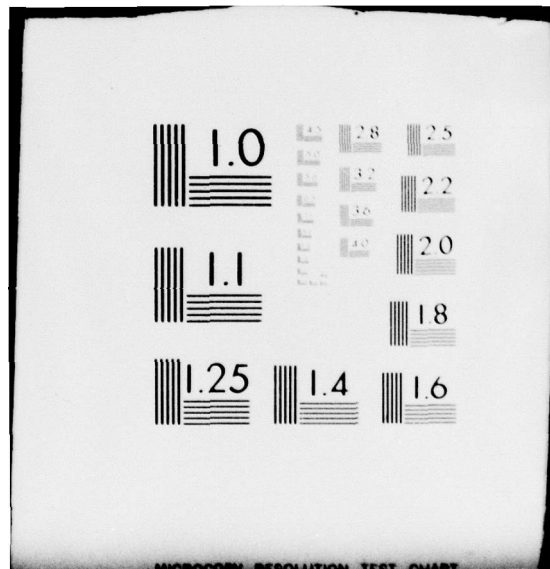
CERL-E-8

NL

| OF |
AD
A076601



END
DATE
FILMED
12-79
DDC

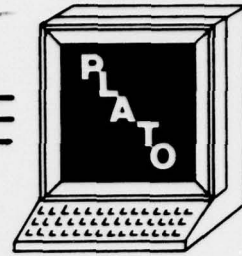


MICROCOPY RESOLUTION TEST CHART

LEVEL 12



Computer-based Education
Research Laboratory



AD A 076601

University of Illinois

Urbana Illinois

FINAL REPORT:
ANALYTICAL TEST THEORY MODEL
FOR TIME AND SCORE

KIKUMI TATSUOKA

DDC
R
NOV 14 1979
E

Approved for public release; distribution unlimited.
Reproduction in whole or in part permitted for any
purpose of the United States Government.

This research was sponsored by the Personnel and Training
Research Program, Psychological Sciences Division, Office
of Naval Research, under Contract No. N00014-78-C-0159.
Contract Authority Identification Number NR 150-415.

DDC FILE COPY

PEG PLATO®
Education
Group

CERL REPORT E-8

JULY 1979

79 11 13 031

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Analytical Test Theory Model for Time and Score		5. TYPE OF REPORT & PERIOD COVERED Final report
7. AUTHOR(s) Kikumi/Tatsuoka	8. CONTRACT OR GRANT NUMBER(s) N00014-78-C-0159	6. PERFORMING ORG. REPORT NUMBER CERL Report E-8
9. PERFORMING ORGANIZATION NAME AND ADDRESS Computer-based Education Research Laboratory University of Illinois Urbana, IL 61801	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61150C-RR042-04; RR0420401 NRI50-415	11. CONTROLLING OFFICE NAME AND ADDRESS Personnel and Training Research Programs Office of Naval Research (Code 458) Arlington, VA 22217
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	12/25	12. REPORT DATE July 1979
		13. NUMBER OF PAGES 53
		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) 16/RR04204		
18. SUPPLEMENTARY NOTES 14/ CERL-E-8		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) latent trait theory, diagnostic adaptive test, computer managed instructional system, information-processing skills, instructional method, achievement test, least-squares method, maximum likelihood method, latent response-time variable, conditional response rate for item and person		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) 1. The object of this study was to find a way to utilize response-time data in the scoring procedure of achievement testing. The empirical study of adaptive diagnostic testing and a computerized instructional system revealed that the differences in type of information-processing skill developed by different instructional backgrounds affect the		

408 130 gsu

learning of further instructional materials to a great extent. This fact urges us to tap what information-processing strategy was used to respond to a given problem, not only considering individual differences in ability or achievement level, derived solely from the performance scores. It was seen that there were response patterns which yielded the same achievement level θ but the answers were obtained by two different approaches. If these individual differences in information-processing skills would not be detected on a diagnostic test, then a proactive inhibition effect will cause a serious learning deficiency, even for many good students, upon studying further instructional materials.

2. A model useful in identifying discriminating items that are sensitive to differences in instructional method was developed. It also is helpful in identifying an individual's instructional background to a certain extent.

3. A method that estimates θ by regressing θ onto test-items was developed and compared with θ estimated by the maximum likelihood method. The new method provided as good θ as the traditionally established method did. This method is powerful when the number of subjects and test-items available are small. Also estimates are always obtainable, and moreover free from a choice of ordering test-items.

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DDC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification _____	
By _____	
Distribution/ _____	
Availability Codes	
Dist	Avail and/or special
A	

FINAL REPORT: ANALYTICAL TEST THEORY MODEL FOR TIME AND SCORE

Kikumi Tatsuoka

Computer-based Education Research Laboratory
University of Illinois at Urbana-Champaign

Approved for public release; distribution unlimited.
Reproduction in whole or in part permitted for any
purpose of the United States Government.

This research was sponsored by the Personnel and Training
Research Programs, Psychological Science Division, Office
of Naval Research, under Contract No. N00014-78-c-0159.
Contract Authority Identification Number, NR 150-415.

Final Report

July 1979

✓ This is the final report of a year-long project which explored psychometric properties of response-time data and developed a model in which response-time was incorporated in scoring achievement tests. Validation of the model with real data has not yet been done, though the foundation of the model is based on theoretical and empirical research conducted by the principal investigator and Maurice Tatsuoka in the past few years. Many studies related to response-time have been done by experimental psychologists and cognitive scientists since the early years of this century. They first tried to discover an empirical relationship between intelligence and reaction time (we call it response-time in this study) in the perceptual domain but the results from various studies were so diverse that convincing relations were not obtained. Due to recent technical advances in computer science, computerized testing allows for more accurate measurement and control of time data. Thus it enabled cognitive psychologists to provide a large amount of information about the relations between response-time and various types of stimuli. Moreover, many psychological studies pertinent to an information-processing view of mental abilities have indicated the existence of a series of cognitive processes which differ among individuals. The intention of the model is to try to quantify individual differences in information-processing skills in terms of a latent response-time variable (analogous to the ability variable in latent trait theory) which affects the time taken by an examinee to answer each of a given set of test items. We did not attempt to give a precise psychological meaning for this construct beyond saying that it may be regarded as a pervasive trait of individuals to be slow or quick in solving items of a certain domain. The scope of this study was summarized

7/21

in Technical Report No. 3, A Model for Incorporating Response-time Data in Scoring Achievement Tests.

The other object of the project was to apply adaptive testing techniques to the interactive mode of actual instructions and testing with computer-managed routing systems. The computer-based education system at the University of Illinois (PLATO) has been widely utilized in teaching many subject areas for the past several years. Computerized adaptive tests of signed-numbers operations for a junior high school, and of matrix algebra for the multivariate statistics courses in the Departments of Psychology and Educational Psychology at the University of Illinois, were implemented along with computer-managed routing systems by which each student was sent to the instructional unit corresponding to the level of achievement at which she/he stopped in the initial tests. Conventional posttests were administered at the end of instruction.

The practical use of adaptive diagnostic testing together with computerized instruction raised interesting questions and problems. Some of the findings in the empirical study were summarized in Technical Report No. 2, The Danger of Relying Solely on Diagnostic Adaptive Testing when Prior and Subsequent Instructional Methods are Different. The dimensionality of performance scores on the posttest for signed-numbers was far from satisfying unidimensionality, while the scores on the very same test obtained from the previous study--in which adaptive diagnostic testing was not used and hence students studied a whole series of instructional lessons--showed a strong tendency toward unidimensionality. A cluster analysis of the examinees' response patterns led us to find a group of students whose performance on the test was significantly different from the

others. Their scores on items prior to the stopping level of the individual diagnostic test were higher than those of most other students, while their scores on the subsequent items were as low as the poorest students' scores. We confirmed with their teachers that most of them were actually A-students. We also confirmed that the members of this group were taught signed-number addition operations by a teaching method different from that of subsequent instructional units, which teach subtraction operations. The procedures of information processing associated with these two instructional methods of performing arithmetic upon signed-numbers differ greatly. Fortunately, the response-time data that we observed gave us supplementary information which differentiates among individuals showing identical quality of performance. On the other hand, the traditional scoring procedure of latent trait theory, using performance scores, would not be capable of detecting the discrepancies associated with different information processes for arriving at the answer to a given item. The empirical study summarized in Technical Report No. 2 supports the notion of the new model introduced in Technical Report No. 3.

The first technical report, The Least Squares Estimation of Latent Trait Variables by a Hilbert Space Approach, describes the estimation method of the latent trait variable θ by regressing it on the predictor variables, the scores of all items used in an adaptive test. Latent trait theory has provided the only models that are applicable to assessing an individual student's ability level in an adaptive testing situation where each student takes a different set of items. The estimation of parameters of the latent trait theory models has been achieved iteratively by the maximum likelihood method. This method provides quite accurate values for

data generated by the Monte Carlo method, but it often fails to converge and cannot estimate the parameters for real data in which even a very few instances of certain kinds of unusual data are included; it also fails for either very high or very low θ values. This sensitivity is unfortunate, particularly when adaptive testing is used in practice, either as a diagnostic test or a posttest at the end of instruction. When diagnostic adaptive testing is used for routing each student to his/her most appropriate instructional unit in a series of lessons written on computer-based education systems, the problem of having nonconvergent θ values is severe. Some of our data showed about 10% of the students failing to obtain any fixed estimates of θ variable. The purpose of the study described in Technical Report No. 1 was to propose a new estimation method by which estimates of θ are always obtainable even for a small number of items. The results are compared with those obtained by the maximum likelihood method. It seems that the least squares multiple regression method is a useful alternative for providing estimation of θ when the other parameters, discriminating power and difficulty, are known.

ABSTRACTS OF RESEARCH REPORTS

TECHNICAL REPORT NO. 1

The Least-Squares Estimation of Latent Trait Variables by

A Hilbert Space Approach

This paper searched for a new method for estimating a given latent trait variable by the least squares approach. The beta weights are obtained recursively with the help of Fourier series and expressed as functions of item parameters of response curves. The values of the latent

trait variable estimated by this method and by the maximum likelihood method were compared using real data. The results were very close, and yet the values of the latent trait variable estimated by the multiple regression method were always obtainable. The maximum likelihood method, on the other hand, often fails to converge.

TECHNICAL REPORT NO. 2

The Danger of Relying Solely On Diagnostic Adaptive Testing
When Prior and Subsequent Instructional Methods are Different

A computerized diagnostic adaptive test for a series of pre-algebra signed-number lessons (which are also on the computer system) was programmed along with a computer-managed routing system by which each examinee was sent to the instructional unit corresponding to the level of skill at which she/he stopped in the initial test. Upon completion of the course a computerized conventional posttest was given to the examinees. The posttest scores were far from being unidimensional, while the pretest and posttest data obtained from a previous study, in which the pretest was a computerized conventional test and students were forced to go through all instructional units regardless of their achievement in the pretest, indicated a strong tendency to be unidimensional. The response patterns of the posttest in the present study showed a high error rate for the skills prior to stopping levels for one subgroup of examinees.

A cluster analysis was performed on the response patterns of the skills and four different groups were found. A discriminant analysis indicated significant differences among the four groups in response patterns of the skills in signed-number operations. After interviewing the teachers and several children, we came to the conclusion that it was the

difference between prior and current instructional methods that confused students and caused a mess in the posttest data. In other words, there was a proactive inhibition effect.

The scoring procedure of the adaptive testing did not consider individual differences in information-processing skills which were affected by the instructional method used in previous teaching. Thus, the students who were taught to perform the beginning part of a set of hierarchically ordered skills by instructional method A would very likely get confused in a lesson in which a different instructional method B was adopted. Consequently, quite a few peculiar response patterns were seen in the performance on the posttest. This fact cautions us that one should be careful not to rely solely on test results determined by performance scores on a diagnostic pretest when a computer-managed instructional system is to route each examinee to her/his initial level of instruction. It was suggested that we must somehow unravel what information-processing strategy was used and consider this knowledge simultaneously.

TECHNICAL REPORT NO. 3

A Model For Incorporating Response-Time Data In Scoring

Achievement Tests

The differences in type of information-processing skill developed by different instructional backgrounds affect, negatively or positively, the learning of further advanced instructional materials. That is, if prior and subsequent instructional methods are different, a proactive inhibition effect produces low achievement scores on a posttest. This fact poses a serious problem for routing of students to an instructional level on the sole basis of performance on a diagnostic adaptive test. It is essential

that we somehow unravel what information-processing strategy was used and consider this knowledge simultaneously.

Fortunately, response-time often provides supplementary information which differentiates among individuals showing identical quality of performance. A model that reflects this kind of information, obtainable from response-time scores, is formulated in a similar manner to latent trait theory and is discussed. This model is useful in identifying discriminating items that are sensitive to differences in instructional method. It also is helpful in identifying an individual's instructional background to a certain extent.

Distribution List

Navy

Dr. Ed Aiken
Navy Personnel R and D Center
San Diego, CA 92152

Dr. Jack R. Borsting
Provost and Academic Dean
U.S. Naval Postgraduate School
Monterey, CA 93940

Dr. Robert Breaux
Code N-71
NAVTRAEQUIPCEN
Orlando, FL 32813

Mr. Maurice Callahan
Pers 23a
Bureau of Naval Personnel
Washington, DC 20370

Dr. Richard Elster
Department of Administrative
Sciences
Naval Postgraduate School
Monterey, CA 93940

Dr. Pat Frederico
Navy Personnel R and D Center
San Diego, CA 92152

Dr. Paul Foley
Navy Personnel R and D Center
San Diego, CA 92152

Dr. John Ford
Navy Personnel R and D Center
San Diego, CA 92152

Capt. D.M. Gragg, MC, USN
Head, Section on Medical Education
Uniformed Services Univ. of the
Health Sciences
6917 Arlington Road
Bethesda, MD 20014

Dr. Norman J. Kerr
Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054

Dr. Leonard Kroeker
Navy Personnel R and D Center
San Diego, CA 92152

Chairman, Leadership and Law Dept.
Div. of Professional Development
U.S. Naval Academy
Annapolis, MD 21402

Dr. William L. Maloy
Principal Civilian Advisor for
Education and Training
Naval Training Command, Code 00A
Pensacola, FL 32508

CAPT Richard L. Martin
USS Francis Marion (LPA-249)
FPO New York, NY 09501

Dr. James McBride
Code 301
Navy Personnel R and D Center
San Diego, CA 92152

Dr. James McGrath
Navy Personnel R and D Center
Code 306
San Diego, CA 92152

Dr. William Montague
LRDC
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Commanding Officer
Naval Health Research
Center
ATTN: Library
San Diego, CA 92152

Naval Medical R&D Command
Code 44
National Naval Medical Center
Bethesda, MD 20014

Library
Navy Personnel R and D Center
San Diego, CA 92152

Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20390

Office of Civilian Personnel
(Code 26)
Dept. of the Navy
Washington, DC 20390

John Olsen
Chief of Naval Education and
Training Support
Pensacola, FL 32509

Psychologist
ONR Branch Office
495 Summer Street
Boston, MA 02210

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

Office of Naval Research
Code 200
Arlington, VA 22217

Code 436
Office of Naval Research
Arlington, VA 22217

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

Personnel & Training Research
Programs (Code 458)
Office of Naval Research
Arlington, VA 22217

Psychologist
Office of Naval Research Branch
223 Old Marylebone Road
London, NW, 15th England

Psychologist
ONR Branch Office
1030 East Green Street
Pasadena, CA 91101

Scientific Director
Office of Naval Research
Scientific Liaison Group/Tokyo
American Embassy
APO San Francisco, CA 96503

Office of the Chief of Naval Operations
Research, Development, and Studies Branch
(OP-102)
Washington, DC 20350

Scientific Advisor to the Chief of
Naval Personnel (Pers-Or)
Naval Bureau of Personnel
Room 4410, Arlington Annex
Washington, DC 20370

LT Frank C. Petho, MSC, USNR (Ph.d)
Code L51
Naval Aerospace Medical Research
Laboratory
Pensacola, FL 32508

Dr. Richard A. Pollak
Academic Computing Center
U.S. Naval Academy
Annapolis, MD 21402

Roger W. Remington, Ph.D.
Code L52
NAMRL
Pensacola, FL 32508

Dr. Bernard Rimland
Navy Personnel R&D Center
San Diego, CA 92152

Mr. Arnold Rubenstein
Naval Personnel Support Technology
Naval Material Command (O8T244)
Room 1044, Crystal Plaza #5
2221 Jefferson Davis Highway
Arlington, VA 20360

Dr. Worth Scanland
Chief of Naval Education and Training
Code N-5
NAS, Pensacola, FL 32508

A. A. Sjolhm
Tech. Support, Code 201
Navy Personnel R and D Center
San Diego, CA 92152

Mr. Robert Smith
Office of Chief of Naval Operations
OP-987E
Washington, DC 20350

Dr. Alfred F. Smode
Training Analysis and Evaluation
Group (TAEG)
Dept. of the Navy
Orlando, FL 32813

Dr. Richard Sorensen
Navy Personnel R and D Center
San Diego, CA 92152

CDR Charles J. Theisen, Jr., MSC,
USN
Head Human Factors Engineering Div.
Naval Air Development Center
Warminster, PA 18974

W. Gary Thomson
Naval Oceans Systems Center
Code 7132
San Diego, CA 92152

Dr. Ronald Weitzman
Department of Administrative
Sciences
U.S. Naval Postgraduate School
Monterey, CA 93940

Dr. Martin F. Wiskoff
Navy Personnel R and D Center
San Diego, CA 92152

Army

Technical Director
U. S. Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

HQ USAREUE & 7th Army
ODCSOPS
USAAREUE Director of GED
APO New York 09403

LCOL Gary Bloedorn
Training Effectiveness Analysis Division
US Army TRADOC Systems Analysis Activity
White Sands Missile Range, NM 88002

Dr. Ralph Dusek
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Beatrice J. Farr
Army Research Institute (PERI-OK)
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Myron Fischl
U.S. Army Research Institute for the
Social and Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Ed Johnson
U. S. Army Research Institute
5001 Eisenhower Blvd.
Alexandria, VA 22333

Dr. Michael Kaplan
U. S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Milton S. Katz
Individual Training and Skill
Evaluation Technical Area
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Milt Maier
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Harold F. O'Neil, Jr.
Attn: PERI-OK
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Robert Ross
U.S. Army Research Institute for the
Social and Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Robert Sasmor
U.S. Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Director, Training Development
U.S. Army Administration Center
ATTN: Dr. Sherrill
Ft. Benjamin Harrison, IN 46218

Dr. Frederick Steinheiser
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Joseph Ward
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Air Force

Air Force Human Resources Lab
AFHRL/PED
Brooks AFB, TX 78235

Air University Library
AUL/LSE 76/443
Maxwell AFB, AL 36112

Dr. Philip De Leo
AFHRL/TT
Lowry AFB, CO 80230

Dr. G. A. Eckstrand
AFHRL/AS
Wright-Patterson AFB, OH 45433

Dr. Genevieve Haddad
Program Manager
Life Sciences Directorate
AFOSR
Bolling AFB, DC 20332

CDR. Mercer
CNET Liaison Officer
ARGRL/Flying Training Div.
Williams AFB, AZ 85222

Dr. Ross L. Morgan (AFHRL/ASR)
Wright-Patterson AFB
Ohio 45433

Dr. Roger Pennell
AFHRL/TT
Lowry AFB, Co 80230

Personnel Analysis Division
HQ USAF/DPXXA
Washington, DC 20330

Research Branch
AFMPC/DPMYP
Randolph AFB, TX 78148

Dr. Malcolm Ree
AFHRL/PED
Brooks AFB, TX 78235

Dr. Marty Rockway (AFHRL/TT)
Lowry AFB
Colorado 80230

Jack A. Thorpe, Capt, USAF
Program Manager
Life Sciences Directorate
AFOSR
Bolling AFB, DC 20332

Brian K. Waters, LCOL, USAF
Air Univerity
Maxwell AFB
Montgomery, AL 36112

Marines

H. William Greenup
Education Advisor (E031)
Education Center, MCDEC
Quantico, VA 22134

Dr. A. L. Slafkosky
Scienfitic Advisor (Code RD-1)
HQ, U.S. Marine Corps
Washington, D.C. 20380

Coast Guard

Mr. Richard Lanterman
Psychological Research (G-P-1/62)
U.S. Coast Guard HQ
Washington, DC 20590

Dr. Thomas Warm
U.S. Coast Guard Institute
P.O. Substation 18
Oklahoma City, OK 73169

Other DoD

Dr. Stephan Andriole
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

Defense Documentation Center
Cameron Station, Bldg. 5
Alexandria, VA 22314
Attn: TC

Dr. Dexter Fletcher
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

Dr. William Graham
Testing Directorate
MEPCOM
Ft. Sheridan, IL 60037

Military Assistant for Training and
Personnel Technology
Office of the Under Secretary of
Defense for Research and Engineering
Room 3D129, The Pentagon
Washington, DC 20301

Major Wayne Sellman, USAF
Office of the Assistant Secretary
of Defence (MRA and L)
3B930 The Pentagon
Washington, DC 20301

Civil Government

Dr. Susan Chipman
Basic Skills Program
National Institute of Education
1200 19th Street NW
Washington, DC 20208

Dr. William Gorham, Director
Personnel R&D Center
Office of Personnel Management
1900 E Street NW
Washington, DC 20415

Dr. Joseph I. Lipson
Division of Science Education
Room W-638
National Science Foundation
Washington, DC 20550

Dr. John Mays
National Institute of Education
1200 19th Street NW
Washington, DC 20208

Dr. Arnold Melmed
National Institute of Education
1200 19th Street NW
Washington, DC 20208

Dr. Andrew B. Molnar
Science Education Dev.
and Research
National Science Foundation
Washington, DC 20550

Dr. Lalitha P. Sanathanan
Environmental Impact Studies Division
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

Dr. Jeffery Schiller
National Institute of Education
1200 19th St. NW
Washington, DC 20208

Dr. Thomas G. Sticht
Basic Skills Program
National Institute of Education
1200 19th Street NW
Washington, DC 20208

Dr. Vern W. Urry
Personnel R and D Center
U.S. Civil Service Commission
1900 E Street NW
Washington, DC 20415

Dr. Frank Withrow
U.S. Office of Education
400 6th Street SW
Washington, DC 20202

Dr. Joseph L. Young, Director
Memory and Cognitive Processes
National Science Foundation
Washington, DC 20550

Non Government

Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

Dr. Erling B. Anderson
University of Copenhagen
StuDiestraedt
Copenhagen
Denmark

Dr. John R. Anderson
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

Dr. Michael Atwood
Science Applications Institute
40 Denver Tech. Center West
7935 E. Prentice Avenue
Englewood, CO 80110

1 Psychological Research Unit
Dept. of Defence (Army Office)
Campbell Park Offices
Canberra ACT 2600, Australia

Dr. Alan Baddeley
Medical Research Council
Applied Research Council
15 Chaucer Road
Cambridge CB2 2EF
England

Dr. Patricia Baggett
Department of Psychology
University of Denver
University Park
Denver, CO 80208

Mr. Avron Barr
Department of Computer Science
Stanford University
Stanford, CA 94305

Dr. Isaac Bejar
Educational Testing Service
Princeton, NJ 08450

Dr. Warner Birice
Streitkaefteamt
Rosenberg 5300
Bonn, West Germany D-5300

Dr. R. Darrel Bock
Department of Education
University of Chicago
Chicago, IL 60637

Dr. Nicholas A. Bond
Dept. of Psychology
Sacramento State College
600 Jay Street
Sacramento, CA 95819

Dr. Lyle Bourne
Department of Psychology
University of Colorado
Boulder, CO 80302

Dr. David G. Bowers
Institute for Social Research
University of Michigan
Ann Arbor, MI 48106

Dr. Kenneth Bowles
Institute for Information Sciences
University of California at San Diego
La Jolla, CA 92037

Dr. Robert Brennan
American College Testing Programs
P.O. Box 168
Iowa City, IA 52240

Dr. John S. Brown
XEROX Palo Alto Research Center
3333 Coyote Road
Palo Alto, CA 94304

Dr. Bruce Buchanan
Department of Computer Science
Stanford University
Stanford, CA 94304

Dr. C. Victor Bunderson
Wicat Inc.
University Plaza, Suite 10
1160 So. State St.
Orem, UT 84057

Dr. John B. Carroll
Psychometric Lab
Univ. of No. Carolina
Davie Hall 013A
Chapel Hill, NC 27514

Charles Meyers Library
Livingston House
Livingston Road
Stratford
London E15 2LJ
England

Dr. Micheline Chi
Learning R&D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Dr. William Clancey
Department of Computer Science
Stanford University
Stanford, CA 94305

Dr. Kenneth E. Clark
College of Arts and Sciences
University of Rochester
River Campus Station
Rochester, NY 14627

Dr. Norman Cliff
Dept. of Psychology
Univ. of So. California
University Park
Los Angeles, CA 90007

Dr. William Coffman
Iowa Testing Programs
University of Iowa
Iowa City, IA 52242

Dr. Allan M. Collins
Bolt Beranek and Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Meredith Crawford
Department of Engineering
Administration
George Washington University
Suite 805
2101 L Street N. W.
Washington, DC 20037

Dr. Hans Cronbag
Education Research Center
University of Leyden
Boerhaavelaan 2
Leyden
The Netherlands

Major I.N. Evonic
Canadian Forces Pers. Applied
Research
1107 Avenue Road
Toronto, Ontario, Canada

Dr. Leonard Feldt
Lindquist Center for Measurement
University of Iowa
Iowa City, IA 52242

Dr. Richard L. Ferguson
The American College Testing Program
P.O. Box 168
Iowa City, IA 52240

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

Dr. Gerhardt Fischer
Liebigasse 5
Vienna 1010
Austria

Dr. Donald Fitzgerald
University of New England
Armidale, New South Wales 2351
Australia

Dr. Edwin A. Fleishman
Advanced Research Resources Organ.
Suite 900
4330 East West Highway
Washington, DC 20014

Dr. John B. Frederiksen
Bolt Beranek and Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Robert Glaser
LRDC
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Dr. Ira Goldstein
XEROX Palo Alto Research Center
3333 Coyote Road
Palo Alto, CA 94304

Dr. Ross Greene
Palo Alto, CA 94304
CTB/McGraw Hill
Del Monte Research Park
Monterey, CA 93940

Dr. James G. Greeno
LRDC
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Dr. Alan Gross
Center for Advanced Study in
Education
City University of New York
New York, NY 10036

Dr. Ron Hambleton
School of Education
University of Massachusetts
Amherst, MA 01002

Dr. Chester Harris
School of Education
University of California
Santa Barbara, CA 93106

Dr. Lloyd Humphreys
Department of Psychology
University of Illinois
Champaign, IL 61820

Library
HumRRO/Western Division
27857 Berwick Drive
Carmel, CA 93921

Dr. Steven Hunka
Department of Education
University of Alberta
Edmonton, Alberta
Canada

Dr. Earl Hunt
Dept. of Psychology
University of Washington
Seattle, WA 98105

Dr. Huynh Huynh
Department of Education
University of South Carolina
Columbia, SC 29208

Dr. Carl J. Jensema
Gallaudet College
Kendall Green
Washington, DC 20002

Dr. Arnold F. Kanarick
Honeywell, Inc.
2600 Ridgeway Pkwy
Minneapolis, MN 55413

Dr. John A. Keats
University of Newcastle
Newcastle, New South Wales
Australia

Mr. Marlin Kroger
1117 Via Goleta
Palos Verdes Estates, CA 90274

LCOL. C.R.J. Lafleur
 Personnel Applied Research
 National Defence HQS
 101 Colonel By Drive
 Ottawa, Canada K1A 0K2

Dr. Jill Larkin
 Department of Psychology
 Carnegie Mellon University
 Pittsburgh, PA 15213

Dr. Alan Lesgold
 Learning R&D Center
 University of Pittsburgh
 Pittsburgh, PA 15260

Dr. Michael Levine
 Department of Psychology
 University of Illinois
 Champaign, IL 61820

Faculteit Sociale Wetenschappen
 Rijksuniversiteit Groningen
 Oude Boteringestraat
 Groningen
 Netherlands

Dr. Robert Linn
 College of Education
 University of Illinois
 Urbana, IL 61801

Dr. Frederick M. Lord
 Educational Testing Service
 Princeton, NJ 08540

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

Dr. Gary Marco
 Educational Testing Service
 Princeton, NJ 08450

Dr. Scott Maxwell
 Department of Psychology
 University of Houston
 Houston, TX 77025

Dr. Sam Mayo
 Loyola University of Chicago
 Chicago, IL 60601

Dr. Mark Miller
 Systems and Information Sciences Lab.
 Central Research Laboratories
 Texas Instruments, Inc.
 Mail Station 5
 Post Office Box 5936
 Dallas, TX 75222

Dr. Richard B. Millward
 Dept. of Psychology
 Hunter Lab.
 Brown University
 Providence, RI 02912

Dr. Allen Munro
 Univ. of So. California
 Behavioral Technology Labs
 3717 South Hope Street
 Los Angeles, CA 90007

Dr. Donald A. Norman
 Dept. of Psychology C-009
 Univ. of California, San Diego
 La Jolla, CA 92093

Dr. Melvin R. Novick
 Iowa Testing programs
 University of Iowa
 Iowa City, IA 52242

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

Dr. Seymour A. Papert
 Massachusetts Institute of Technology
 Artificial Intelligence Lab.
 545 Technology Square
 Cambridge, MA 02139

Dr. James A. Paulson
Portland State University
P.O. Box 751
Portland, OR 97207

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

Dr. Steven M. Pine
4950 Douglas Avenue
Golden Valley, MN 55416

Dr. Peter Polson
Dept. of Psychology
University of Colorado
Boulder, CO 80302

Dr. Diane M. Ramsey-Klee
R-K Research and System Design
3947 Ridgmont Drive
Malibu, CA 90265

Min. Ret. M. Rauch
P II 4
Bundesministerium Der Verteidigung
Postfach 161
53 Bonn 1, Germany

Dr. Peter B. Read
Social Science Research Council
605 Third Avenue
New York, NY 10016

Dr. Mark D. Reckase
Educational Psychology Dept.
University of Missouri-Columbia
14 Hill Hall
Columbia, MO 65201

Dr. Fred Reif
SESAME
c/o Physics Department
University of California
Berkeley, CA 94720

Dr. Andrew M. Rose
American Institutes for Research
1055 Thomas Jefferson St. NW
Washington, DC 20007

Dr. Leonard L. Rosenbaum, Chairman
Department of Psychology
Montgomery College
Rockville, MD 20850

Dr. Ernst Z. Rothkopf
Bell Laboratories
600 Mountain Avenue
Murray Hill, NJ 07974

Dr. Donald Rubin
Educational Testing Services
Princeton, NJ 08450

Dr. Larry Rudner
Gallaudet College
Kendall Green
Washington, DC 20002

Dr. David Rumelhart
Center for Human Information Processing
Univ. of California, San Diego
La Jolla, CA 92093

Dr. J. Ryan
Department of Education
University of South Carolina
Columbia, SC 29208

Prof. Fumiko Samejima
Dept. of Psychology
University of Tennessee
Knoxville, TN 37916

Dr. Allen Schoenfeld
Department of Mathematics
Hamilton College
Clinton, NY 13323

Dr. Robert J. Seidel
Instructional Technology Group
HumRRO
300 N. Washington St.
Alexandria, VA 22314

Dr. Kazuo Shigemasu
University of Tohoku
Department of Educational Psychology
Kawauchi, Sendai 982
Japan

Dr. Edwin Shirkey
Department of Psychology
Florida Technological University
Orlando, FL 32816

Dr. Robert Smith
Department of Computer Science
Rutgers University
New Brunswick, NJ 08903

Dr. Richard Snow
School of Education
Stanford University
Stanford, CA 94305

Dr. Robert Sternberg
Dept. of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

Dr. Albert Stevens
Bolt Beranek and Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Patrick Suppes
Institute for Mathematical Studies in
the Social Services
Stanford University
Stanford, CA 94305

Dr. Hariharan Swaminathan
Laboratory of Psychometric and
Evaluation Research
School of Education
University of Massachusetts
Amherst, MA 01003

Dr. Brad Sympson
Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

Dr. Kikumi Tatsuoka
Computer-based Education Research
Laboratory
252 Engineering Research Laboratory
University of Illinois
Urbana, IL 61801

Dr. Maurice Tatsuoka
Department of Educational Psychology
University of Illinois
Champaign, IL 61801

Dr. David Thissen
Department of Psychology
University of Kansas
Lawrence, KS 66044

Dr. John Thomas
IBM Thomas J. Watson Research Center
P.O. Box 218
Yorktown Heights, NY 10598

Dr. Douglas Towne
Univ. of So. California
Behavioral Technology Labs
3717 Hope Street
Los Angeles, CA 90007

Dr. J. Uhlaner
Perceptrics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Howard Wainer
Bureau of Social Science Research
1990 M Street, N. W.
Washington, DC 20036

Dr. Thomas Wallsten
Psychometric Laboratory
Davie Hall 013A
University of North Carolina
Chapel Hill, NC 27514

Dr. Phyllis Weaver
Graduate School of Education
Harvard University
200 Larsen Hall, Appian Way
Cambridge, MA 02138

Dr. David J. Weiss
N660 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

Dr. Susan E. Whitely
Psychology Department
University of Kansas
Lawrence, Kansas 66044

Dr. Wolfgang Wildgrube
Streitkraefteamt
Rosenberg 5300
Bonn, West Germany D-5300

Dr. Robert Woud
School Examination Department
Universtiy of London
66-72 Gower Street
London WC1E 6EE
England

Dr. Karl Zinn
Center for Research on Learning
and Teaching
University of Michigan
Ann Arbor, MI 48104