ABILITIES, MOTIVATION & METHODOLOGY

The Minnesota Symposium on Learning and Individual Differences

edited by

Ruth Kanfer Phillip L. Ackerman Robert Cudeck

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The Minnesota Symposium
on Learning and Individual Differences

To

Fred and Ruby
(R.K.)

Leonard and Sally Ann
(P.L.A.)

Trisha
(R.C.)

List of Contributors

Phillip L. Ackerman
Department of Psychology
University of Minnesota

Jack A. Adams
Department of Psychology
University of Illinois at Urbana-Champaign

K. A. Brookhuis
Institute for Experimental Psychology
University of Groningen

John B. Carroll
Department of Psychology
University of North Carolina at Chapel Hill

Robert Cudeck
Department of Psychology
University of Minnesota

Jan-Eric Gustafsson
Department of Education
University of Göteborg

Earl B. Hunt
Department of Psychology
University of Washington

James J. Jenkins
Department of Psychology
University of South Florida

Ruth Kanfer
Department of Psychology
University of Minnesota

Uwe Kleinbeck
Department of Psychology
Bergische University

Kristina Kraska
Department of Psychology
University of Osnabrück

Julius Kuhl
Department of Psychology
University of Osnabrück

Patrick C. Kyllonen
Air Force Human Resources
Laboratory
Brooks Air Force Base

David F. Lohman
College of Education
The University of Iowa

J. J. McArdle
Department of Psychology
University of Virginia

William E. Montague
Training Technology Department
Navy Personnel Research &
Development Center

Gijsbertus Mulder
Institute for Experimental Psychology
University of Groningen

L. J. M. Mulder
Institute for Experimental Psychology
University of Groningen

J. Bruce Overmier
Center for Research in Learning,
Perception, and Cognition
University of Minnesota

James W. Pellegrino
Department of Education
University of California, Santa
Barbara

Hans-Henning Quast
Department of Psychology
Bergische University

William Revelle
Department of Psychology
Northwestern University

Ronald Schwarz
Department of Psychology
Bergische University

H. G. O. M. Smid
Institute for Experimental Psychology
University of Groningen

Richard E. Snow
School of Education
Stanford University

A. A. Wijers
Institute for Experimental Psychology
University of Groningen

Dan J. Woltz
Air Force Human Resources
Laboratory
Brooks Air Force Base

Penny Yee
Department of Psychology
University of Washington

Preface

The challenge to the unification of experimental and differential disciplines of psychology is nowhere more salient than in the field of learning and individual differences. Diverse developments in ability research, in motivation research, and in the derivations of new methodological techniques have too often proceeded on parallel courses. In the past 3 years, discussions among the editors of this volume and our discussions with several other concerned scientists gradually led to the notion that communication across domains could be vastly improved through intensive interaction between researchers. With the encouragement of Professor J. Bruce Overmier, the Director of the University of Minnesota Center for Research in Learning, Perception, and Cognition, and the enthusiastic support of Dr. Barbara McDonald at the U.S. Navy Personnel Research and Development Center, plans were made to convene a symposium where researchers with varied perspectives on learning and individual differences could share their respective theories and empirical research in an environment that would foster critically needed cross-fertilization and integration.

On April 14, 1988, 16 distinguished scholars from Europe, Scandinavia, and the United States, serving as participants and discussants, and over 60 local, national, and international observers gathered in Minneapolis, Minnesota for a 2½-day symposium on ability, motivation, and methodology concerns relating to learning and individual differences. Prior to the symposium, the participants had prepared and circulated advance papers that concerned several facets of the topic. The symposium was devoted to the reading and discussion of these papers. Following the conference, the participants were given a chance to finalize their papers for inclusion in this volume. In addition, we compiled and edited transcriptions of the spontaneous discussions among the participants and observers

recorded during the conference. This volume represents an amalgamation of these two sources. Each chapter contains the final text produced by the participants and their collaborators, immediately followed by edited discussions concerning each chapter. The resulting product provides a vivid point and counterpoint when paradigms clash, and lively illustrations of how researchers successfully struggle to make needed points of contact across disciplines.

This volume is organized into five parts, each dealing with a major theme of the conference. Part I represents the opening session of the conference. The chapters in this section provide an orientation to the treatment of learning and individual differences from three major perspectives: experimental psychology (Adams), motivational psychology (Kleinbeck), and differential/methodological psychology (Carroll). The panoramic approach taken in these chapters provides the context for consideration of theoretical and empirical developments described in later chapters. Specifically, each chapter, and the discussions following the chapters, highlights controversy and consensus surrounding interdisciplinary approaches to learning and individual differences. These issues reappear throughout the remainder of the chapters.

In chapter 1, Jack Adams reviews several fundamental issues of learning and individual differences. He moves from a description of enduring questions in learning and variability research from the early 1900s to ability-performance research from the 1950s, and concludes with a look at current problems and challenges for integration of experimental and differential psychologies in the 1990s. The discussion following Adams' chapter directly pits the experimental and correlational approaches against one another and sets the stage for several interactions that can be found throughout this volume.

Uwe Kleinbeck and his colleagues Hans-Henning Quast and Ronald Schwarz (chap. 2) discuss motivational and volitional concepts from a dual-task perspective. These authors introduce many information processing concepts and experimental procedures used in the investigation of volitional processes. Kleinbeck and his colleagues illustrate the potential advantages of coordinating motivational and information processing frameworks in the context of empirical studies in cognition and motivation.

In chapter 3, Jack Carroll offers a critical overview of the cognitive/intellectual ability domain from a factor-analytic perspective. In this chapter, Carroll describes the results of an ongoing project aimed at integrating several decades of inquiry into the structure and development of individual differences in abilities. He provides a valuable overview of the corpus of factor analytic ability research, and presents a map of well-defined and well-replicated abilities representing the cumulative accomplishments of ability theory, empirical data, and quantitative methodological advances.

Part II of this volume continues and expands the discussion of quantitative methodology and applications to learning and individual differences. In chapter 4, Jack McArdle presents a mathematical and empirical tour of a multivariate

experimental approach and its implications for the study learning and individual differences. Specifically, McArdle describes a unique framework for considering growth functions (for groups, for individuals, and for several different variables) that is based on developments in structural equation modeling.

Another important methodological issue in the design and evaluation of experiments on information processing constructs pertains to the choice of meaningful and appropriate performance measures. In chapter 5, Dave Lohman presents a compelling set of arguments and evidence for a reconsideration of *speed* and *accuracy* constructs as they affect the adequacy of performance measures. In addition, Lohman describes a set of experimental procedures that may be used to efficiently derive speed-accuracy tradeoff functions for information processing tasks. As indicated in Lohman's chapter, this perspective has direct implications for discovering individual differences constructs that pertain to sex differences in spatial abilities and to cognitive style issues.

The section on methodological developments concludes with a commentary by Bob Cudeck (chap. 6). In this chapter, Cudeck presents a factor analytic framework that abstracts the context of the earlier chapters, and draws together a number of related issues raised by Carroll, McArdle, and Lohman.

Part III of this book is devoted primarily to developments in the cognitive ability domain. The first chapter in this section (chap. 7) describes the efforts of Jim Pellegrino, Buz Hunt, and Penny Yee in their search for *information coordination abilities*. Pellegrino and his colleagues focus on dynamic spatial abilities and describe the development of new procedures to assess and model a class of abilities that influence efficient performance of multiple-interrelated tasks. In a notable departure from classic dual-task investigations, these authors demonstrate how the boundaries of contemporary ability theory can be expanded with a transition from classic paper and pencil testing to the use of microcomputer technology.

In chapter 8, Jan-Eric Gustafsson discusses issues involved in integration of hierarchical factor analysis/structural equation techniques with aptitude-treatment interaction (ATI) investigations. Gustafsson describes the results of a series of ATI studies using sophisticated hierarchical factor analytic procedures. His findings indicate that important ATIs can be revealed from educational-instructional manipulations, when attention is accorded to the structure of higher-order intellectual abilities.

Another modern approach, emphasizing the unification of cognitive ability and information-processing perspectives in skill acquisition, is provided by Pat Kyllonen and Dan Woltz (chap. 9). Kyllonen and Woltz propose the use of a four-source framework for determining individual differences in skill and knowledge acquisition. These four sources of general cognitive factors include *knowledge, skills, processing capacity,* and *processing speed.* They describe ongoing investigations on these sources of individual differences at the Air Force Human Resources Laboratory—Learning Abilities Measurement Program. Fi-

nally, they indicate how these concepts fit within modern theories of cognitive abilities and theories of skill acquisition.

Part III concludes with commentary by Phil Ackerman (chap. 10). Ackerman discusses the historical context of ability research concerned with individual differences in learning and the points of contact between differential and information processing approaches to common issues. He indicates several ways that contemporary developments in the cognitive ability domain contribute to the interdisciplinary enterprise and identifies promising developments described in previous chapters. In addition, Ackerman relates a number of issues raised in this section to methodological and substantive issues raised elsewhere in this volume.

Part IV addresses the impact of non-cognitive, personal constructs (personality and conation) on learning and performance. In chapter 11, Bill Revelle provides a broad overview of the relations between individual differences in personality, the conative construct of arousal, and information processing components involved in learning. Revelle's conceptual and empirical organization of information processing components and tasks further draws together cognitive and non-cognitive perspectives in a way that suggests when and how conative and personality variables affect learning.

Julius Kuhl and his colleague Kristina Kraska (chap. 12) discuss the structure of self-regulation and individual differences in the development and use of metamotivational strategies. In the model proposed by these authors, volitional processes are described within an information-processing framework that includes affective responses. Kuhl and Kraska report evidence indicating the developmental course of metamotivational knowledge and they discuss the impact of metamotivational knowledge on performance in conflict situations. Their results provide an intriguing opportunity for reconsideration of the relations between metamotivational knowledge and individual differences in cognitive abilities.

Part IV concludes with a commentary by Ruth Kanfer (chap. 13). In this chapter, Kanfer discusses the import of the newer conative approaches in the broader context of motivational psychology, and in the study of individual differences in learning. This commentary attempts to clarify the boundaries of non-cognitive concepts, such as personality, volition, and motivation, as they are applied to the learning domain. Kanfer derives implications of recent advances in the non-cognitive domains that further unify cognitive ability, personality, and motivation streams of research; and she presents a research agenda for research programs aimed at integrating the non-cognitive and cognitive, information processing domains.

Part V contains chapters from the closing session of the conference. The chapters in this section represent both retrospective and forward-looking views of individual differences and learning. One very promising perspective stems from recent developments in psychophysiological research. In chapter 14, Bert Mulder and his colleagues (chap. 14) describe a program of research that concen-

trates on identification of brain and peripheral psychophysiological correlates of computational processes such as encoding and cognitive resource allocation. Mulder and his colleagues review a program of research concerning the mapping of task information processing demands to corresponding brain and behavioral variables. This approach, fusing advanced electrophysiological techniques with more traditional behavioral measures in an experimental paradigm, provides a wealth of new opportunities for identification and organization of individual difference constructs that affect learning.

In chapter 15, Dick Snow provides an analytical overview of past developments and present trends in research on cognitive-conative aptitude interactions. Adopting an aptitude-treatment interaction perspective, Snow relates previous research on cognitive-aptitude treatment interactions to the cognitive aptitude construct domain. Snow concentrates on the neglected research domain that includes conative-aptitudes as elements of ATIs. He describes several recent studies that provide promising directions for future ATI research. Based on this overview, Snow suggests an integrative ATI framework that coordinates cognitive and conative domains.

In the final chapter of this volume (chap. 16), Jim Jenkins gives closing comments on the conference and addresses several of the larger issues facing researchers (of all perspectives) concerned with the study of learning and individual differences. Jenkins responds to the long-standing concern over the relative efficacy of experimental versus correlational approaches by vividly describing how both approaches are necessary, and neither approach is alone sufficient, for continuing progress in learning and individual differences. Jenkins identifies and illustrates the importance of several specific cautions for each approach, and argues in favor of a more thoughtful delineation of one's objectives in the conduct of both types of research.

The successful completion of a project such as this one is due to the labors of many individuals and organizations. We are grateful for the financial support that allowed The Minnesota Symposium on Learning and Individual Differences to come about. Funds for the symposium were provided by the U.S. Office of Naval Research (ONR) Cognitive Science Program and the Navy Personnel Research and Development Center (NPRDC), and by several organizations at the University of Minnesota, including the Graduate School, College of Liberal Arts, Department of Professional Development, and Continuing Education and Extension. We also want to acknowledge the moral and scientific support provided by the Center for Research in Learning, Perception, and Cognition (CRLPC)—an interdisciplinary unit at the University that provides an ideal environment for scientific interchange across areas. Many individuals in these organizations were especially helpful to the project. We especially wish to acknowledge Dr. Barbara McDonald at NPRDC, Dr. Susan Chipman, the Cognitive Science Program Manager at ONR, Professor J. Bruce Overmier of the

CRLPC, and Ms. Lyn Diaz from the Department of Professional Development. Most of all, we thank the participants in the symposium, who provided thoughtful and incisive discussion throughout the conference, much of which we have recorded in this volume.

Ruth Kanfer
Phillip L. Ackerman
Robert Cudeck

Prolegomenon

J. Bruce Overmier
University of Minnesota

William E. Montague
Navy Personnel Research & Development Center

James J. Jenkins
University of South Florida

A little over 30 years ago Lee Cronbach published a seminal article in which he challenged psychologists to *integrate* the two disjoint disciplines of differential and experimental psychology. Cronbach specifically called for the study of the interactions between individual differences variables (aptitudes) and experimental manipulations (or treatments). Such interactions have become generically known to differential, educational, industrial/organizational, personality, and experimental psychologists as aptitude-treatment interactions. Following the appearance of Cronbach's article, several researchers turned their attention to this area. Some of the most significant discussions emerging from this area have pertained to the study of *individual differences in learning*.

The task at hand has not been an easy one, though. An early conference in 1965 on these issues held at the University of Pittsburgh (R. M. Gagné, Editor, *Learning and Individual Differences*. Columbus, Ohio: Charles E. Merrill) paved the way for later advances in research in this area, and anticipated many subsequent developments in the information processing approach to human abilities. Other conferences have looked specifically at relevant methodological issues, such as the one at the University of Wisconsin in 1962 (C. W. Harris, Editor, *Problems in Measuring Change*, Madison, Wisconsin: University of Wisconsin).

Although there has been substantial growth during the past decade in research concerned with ability, motivation, and methodological approaches to learning and individual differences, much of this research has developed along parallel tracks, with too limited interaction between researchers who investigate related topics. However, guided by contemporary theories of cognition from the mid-1970s, many productive research programs have been initiated in psychol-

ogy and related fields (namely, experimental-cognitive psychology, differential psychology, curriculum and instruction, organizational behavior, industrial training, and so on). The commonality of underlying theories and the further common ground of methodological tools for assessing individual differences in change and growth, illustrate the potential for bringing these related areas together. Clearly, there are theoretical, methodological, and practical benefits to be gained by studying, discussing, and attempting to integrate these varied developments. The purpose of this book is to move toward realization of these benefits by directing researchers to consider their findings in the larger domain of learning and individual differences.

There has also been increasing recognition of how an integrative focus might benefit those persons involved with instruction and training. An abiding concern among organizational personnel is the development of appropriate instructional technologies for persons of differing ability levels and profiles. Aptitude-treatment interaction frameworks provide a common ground for linking theoretical advances with development of efficient innovations in instructional technologies.

The continuing need for knowledge that can be applied to real-world settings provides basic research efforts with a powerful set of motives and a general sense of the directions and objectives that such research should strive to address. In the U.S. Navy, for example, over 7,000 different courses are taught each year to about 900,000 students. In this setting, theory-based knowledge about the influence of particular types of instruction on individuals of differing abilities is of critical importance. Such knowledge may have far-reaching implications for organizations that build and implement instructional programs affecting large numbers of people. The chapters of this book describe research efforts informed by developments in methodology, and in substantive theories. Particular attention is directed toward the study of interdependencies among ability and motivational aspects of the learning process. The text and interspersed discussions provide promising avenues for understanding and effectively managing aptitude differences in diverse learning environments.

The conference that spawned the chapters and discussion in this volume was enormously intellectually stimulating. The resulting product could not have been accomplished without careful attention to the academic orientation and diverse mixture of participants. In particular, we wish to thank Drs. Ackerman, Kanfer, and Cudeck for bringing these participants and areas of inquiry together, and for providing an ideal setting for the interchange of ideas and data. If we could be assured that every conference would be as well-organized, comfortable, and provocative as this one, we would volunteer to go to conferences all the time.

On a personal note, the conference from which this volume emerged has special meaning for one of us (Jim Jenkins), who spent 34 years on the psychology faculty at the University of Minnesota. The Graduate School's co-sponsorship of this event, held as part of the celebration of the centennial of the Graduate School at the University of Minnesota, reflects a continuing commit-

ment to facilitating and promoting psychological research. The Graduate School at the University of Minnesota is not a passive collection of administrators and it is not simply another organization for pushing paper around. The Graduate School is a dynamic force that plays a very important role in the lives of many graduate students and faculty members at the University. The importance of the Graduate School in furthering research is perhaps best illustrated by Jim's early experience at Minnesota.

Thirty eight years ago, Jim and several other members of the Department of Psychology applied for and received unique support—a grant from a federal agency! This sounds routine now, but at the time few psychology researchers had ever held such a grant. (One must remember that this was in the ancient days before federal grants had such an important role in supporting academic research.) Jim's grant was for basic research on language processes under the Office of Naval Research, which was then laying the groundwork for the National Science Foundation. No one knew quite how to handle this new development. The problem was solved by channeling everything through the Graduate School. The Graduate School did all the paperwork and showed Jim and his colleagues how to manage the grant. Furthermore, the Graduate School supported Jim and several of the younger faculty members in summer sessions so that they could prepare publications and technical reports that would carry the fruits of their research to the field at-large. These efforts finally resulted in the Center for Research in Human Learning (now called the Center for Research in Learning, Perception, and Cognition), which itself was seeded in part by the Graduate School and now by the College of Liberal Arts.

This kind of support does not happen automatically; as faculty from many universities can testify, it is not by any means a simple consequence of having a graduate school. These benefits can only flow from organizations that deeply understand academic values and goals and from those that have the maturity, the resources and the good will towards the graduate students and the faculty that has been true at the University of Minnesota. As the chapters in this volume attest, long-standing commitments by several other organizational units and agencies, in particular, the University of Minnesota College of Liberal Arts and the Center for Research in Learning, Perception, and Cognition, the U.S. Office of Naval Research, and the Navy Personnel Research and Development Center, foster the conditions that make it possible for researchers to develop an integrative and cumulative perspective on topics as central to the field of psychology as learning and individual differences.

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