1. Introduction: The Implications of Cognitive Psychology for Testing

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Introduction: The Implications of Cognitive Psychology for Testing

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The 1985 Buros-Nebraska Symposium was developed to address the broad issue of the influence of cognitive psychology on testing and measurement. In the planning process, four topics were formulated that we asked contributors to address. The following four issues provided the focus for the Symposium and hence for the present volume. We explore:

1. Cognitive psychology as a basis for questioning some of our assumptions about the nature of mental abilities;
2. The influence of cognitive psychology on test development;
3. Cognitive psychology influences on test validity;
4. Cognitive psychology as a means to provide a linkage between testing and measurement.

Each contributor, of course, responds to the four issues in a variety of ways and with differing emphases. Although examination of the chapters reveals all four issues are at least implicitly touched on, it is clear that issues one, two, and three were addressed most directly.

Why such a set of symposium themes? The explosive growth of cognitive psychology since 1950 has been widely noted. Cognitive psychologists claim a purview far beyond psychometric issues and take as their domain a rather breathtaking range of topics dealing with human behavior. For example, Donald Norman (1980) suggests the following range of topics as the domain for cognitive science: belief systems, consciousness, development, emotion, interaction, language, learning, memory, perception, performance, skill and thought. Psychometric theory and practice are now addressing the need to find methods for measuring increasingly varied and complex levels of behavior. The breadth...
of topics cognitive science sets out to address suggests its appropriateness as a source of information and data for examining such complex behaviors.

In 1984, Robert Sternberg (see Volume I of this series) briefly mentioned his sense that the boundaries between cognitive psychology and psychometrics are arbitrary and capricious. However, his description of the basic research strategy of the cognitive psychologist—intensive examination of performance on the particular task—suggests an important difference in perspective. It is this difference upon which the present volume capitalizes. Existing psychometric test development techniques are largely empirical, arising out of a history of test development dominated by correlational methods. These methods have led to heavy emphasis on description of tests by factor analytic techniques or examination of predictive validity. Factor analytic studies have resulted in clearer descriptions of the nature of test content and relationships among items within tests. Predictive validity studies provide an estimate of test value in predicting some external criterion. Neither perspective, however, provides information leading to clearer descriptions of the specific human behaviors upon which successful test performance is based.

In the same chapter Sternberg described the range of cognitive tasks studied by cognitive psychologists. He recognized that most of these tasks have not been used to predict conventional psychometric criteria such as grades. Nonetheless, substantial progress has been made in use of relatively novel tasks to predict general, as well as crystalized and fluid intelligence. This effort was only briefly addressed by Sternberg (1984). If a comprehensive picture of the contributions of cognitive psychology to the testing movement is to be understood and appreciated, a more substantial development of the four themes mentioned earlier must be provided.

At the same time that cognitive psychology has been expanding its contributions to issues close to those traditionally deemed psychometric, increasing demands have been placed upon the test movement to develop instruments that assess more complex levels of knowledge and performance. Glass (1986), in the second Buros Symposium volume, roundly criticized the current state of psychometric theory and practice. He asserted that beginning in about 1940 psychometrics began to move away from psychology and that by the 1960s, “... testing in psychology and education was severed from its roots in the study of human behavior” (p. 13). Others, (e.g., Glaser, 1981, and Hawkins, 1977) criticize extant tests for their lack of value in helping educators decide how children should be educated. Such criticisms, coupled with the press for increased sensitivity to assessment issues in testing groups such as ethnic minorities, women, and the varieties of disabled persons, lead to the realization that current psychometric theory and practice is inadequate to meet such varied demands. While Glass pressed the field of psychometrics to meet the challenge of psychoanalytic psychology, others, (Anastasi, 1967) have raised the issue more generally. Can testing methods be developed that appraise performance in such a way that test
givers may not only make selection decisions, but also acquire information basic to developing methods to help educators facilitate change in individuals and groups? Can cognitive psychologists provide descriptions of the structure of human information processing in ways that permit improved test construction as well as, ultimately, improved methods of education?

What is the current status of attempts to use "cognitive" tasks and cognitive research methods to assess performance in so-called "achievement" areas such as reading and writing? Are there upper limits to the information that these "new" methods can give us? Following the logic of Gene Glass, it seems clear that new conceptions of assessment are required, assessments that not only lead to improved selection decisions, but that also directly inform practice. Cognitive psychology may provide one source of ideas for these new assessment methods. However, differences in goals between psychometricians and cognitive psychologists may mask the significance of the information cognitive psychology can supply to performance appraisal. For example, concerns for selection and classification on the part of psychometricians may conflict with cognitive psychologist's desire to examine the processes humans use in responding to both simple and complex stimuli.

The present volume, then, represents an approach to measurement from a cognitive perspective. The rather varied chapters provide perspectives on the role cognitive psychology may play in developing means for both understanding and assessing human behavior. Taken together, they suggest the potential for fruitful collaborative work between psychometricians and cognitive psychologists.

OVERVIEW OF CHAPTERS

Part I: The Cognitive-Psychometric Connection

The boundaries between cognitive psychology and psychometrics are not clear. The three approaches taken by the chapter writers in this section demonstrate the fuzziness of the distinction. Hunt, as well as Glaser, Lesgold, and Lajoie address the distinction by directly examining potential situations where the measurement issues and cognitive issues impinge upon each other. Jensen, on the other hand, addresses a larger issue, the extent to which human performance may, or should be, explained at a physiological rather than a psychological level.

In the second chapter, the initial conference presentation, Professor Earl Hunt re-examines the issue Cronbach raised in his 1957 American Psychological Association presidential address: the need to unite experimental and correlational approaches to understand human behavior. Hunt's chapter, "Science, Technology, and Intelligence," demonstrates that at some levels such unification has already taken place, (i.e., some cognitive experimental approaches now are studying individual differences in process behaviors, while some individual dif-
ference approaches *are* concerned with process issues). At the same time, Hunt describes situations where the "costs," financial and otherwise, of measuring specific cognitive behaviors in situation specific settings may be higher than psychometric consumers are willing to pay. He also points out that current psychometric devices meet criteria of financial cost and prediction to certain settings, such as educational success, remarkably well.

Finally, Hunt rephrases the issue in a more complex way by questioning the appropriateness of a union of the two camps at a level where one might wish to "derive the dimensions of psychometric Euclidean representation of abilities from an underlying process theory." Hunt's question does not suggest that either approach is correct or incorrect, but rather that each was devised to answer different questions. Thus, the one approach deals with legitimate and important issues of prediction and classification while the other deals with the significant task of understanding cognitive performance in a wide variety of domains. In effect, Hunt seems to suggest a symbiotic relationship rather than a synthesis of approaches. This somewhat less positive view of the relationship between the two approaches is not shared by the writers of chapter three.

In chapter 3, "Toward a Cognitive Theory for the Measurement of Achievement," Professors Glaser, Lesgold, and Lajoie consider the division between psychometric and cognitive approaches from the perspective of the psychologically oriented practitioner-educator. They describe the strengths of the psychometric approach in areas of aptitude testing and selection, while stressing its weakness in providing an understanding of instructional and learning processes. Because typical achievement measures fail to provide an understanding of process, Glaser et al., report on progress in developing means for appraising knowledge structures and cognitive processes underlying differential performance in specific fields or domains of study.

Although admitting that knowledge of such structures and processes is limited, the authors assert that new perspectives in achievement testing will grow from the study of cognitive processes in learning and development examined in the context of instructional method. The use of the computer as a tool to provide intelligent, responsive tutoring systems illustrates, they believe, one technique that will not only gather psychometric data on learner behavior, but will also permit comparison of novice learner behavior to that of experts, thus permitting examination of process data. Knowledge obtained through use of computers to retain task processes permits assessment of present level attainment, and in addition, reveals forms of error, gaps in knowledge, etc., that require instructional attention.

The chapter concludes with identification of a set of dimensions that present components of achievement competency developed over time. The eight dimensions, knowledge organization and structure, depth of problem representation, quality of mental models, efficiency of procedures, automaticity, proceduralized
knowledge, and procedures for theory change and metacognitive skills, provide a fresh perspective from which to examine traditional achievement assessment. In contrast to Hunt, Glaser et al. express considerable optimism for the value of cognitive approaches in broadening the instrumentation through which achievement behaviors are assessed.

In chapter 4, "The $g$ Beyond Factor Analysis," Professor Jensen describes a process that may help us to understand cognitive and psychometric issues by considering them as subprocesses of a more fundamental process. He examines the problem of the basis of intelligent performance from examination of the $g$ factor derived from factor analyses of a wide variety of psychometric and cognitive tasks. In contrast to the preceding chapters, Jensen presents an argument for explanation of behavior at the level of biological rather than psychological constructs.

In a carefully developed argument, Jensen deals with three increasingly complex issues: (1) He attempts to demonstrate that $g$ is a stable entity and not a statistical artifact; (2) He builds a case that $g$ carries the bulk of the reliable variance in intelligence (and by extension in many other "cognitive" tasks) in a way suggesting a biological basis for $g$ leading him to conclude that the most viable explanation for $g$ will be found not in psychological but "... in genuinely physiological terms." This argument, whether in the final analysis correct or incorrect, formulates the issue of understanding intelligence in such a way that in the words of a reviewer, it "... will occupy researchers in intelligence for the next decade or longer." Clearly an argument leading to such a strongly biological conclusion will spark substantial interest to both psychometricians and cognitive theorists.

Part II. Cognitive Approaches to Psychometric Issues: Applications

Part II gives the reader a perspective on the success of current attempts to use cognitive approaches in understanding "standard" achievement areas such as reading and writing. The reader is invited to consider the adequacy of present explanations based on cognitive analyses for describing both process and outcome of such complex tasks as reading and writing. At the same time, one may reasonably question the applicability of existing cognitive research techniques to issues of understanding domains typically measured by conventional psychometric devices. The degree of care necessary to adapt cognitive techniques to the understanding of complex tasks is also delineated.

In chapter 5, "The Assessment of Cognitive Factors in Academic Abilities," Professors Benton and Kiewra list a series of interrelated cognitive factors that appear to contribute to successful scholastic achievement. These factors, declarative and procedural knowledge, control processes, and cognitive and meta-
cognitive strategies are assumed to underlie successful performance in subject domain areas such as reading, writing, mathematics, and science. Cognitive research in several domain areas is outlined in considerable detail. Research support for the usefulness of the cognitive perspective is described and an assessment of its present status is attempted.

Benton and Kiewra examine research and theory in the subject matter domains based in cognitive psychology. To the psychometrician, the extent and size of this literature may be surprising. Their review suggests a significant new direction in cognition is the study of complex processes necessary for success in domain specific areas. Such an examination seems fruitful not only in confirming cognitive principles derived from simpler and perhaps more artificial laboratory tasks, but in discovering additional principles growing out of the interactions observed when domain specific knowledge, such as skill in geometry, is acquired using more general cognitive skills.

Professor Ericsson’s chapter, “Theoretical Implications from Protocol Analysis on Testing and Measurement,” takes a technique associated with the study of complex problem solving, protocol analysis, and builds a careful, logical argument for the value of the technique in illuminating the nature of the problem-solving process. He documents the value of protocol analysis as a particularly useful technique to provide psychometricians with descriptions of the nature of the cognitive processes required for successful performance on a psychometric test. This information differs widely from that gained through examination of the psychometric structure of a test using statistical procedures such as factor analysis.

Ericsson’s descriptions of existing research and theory in protocol analysis provide convincing support for the value of verbal reports to the psychometrist. Analysis of the verbal reports made while carrying out such diverse activities as algebra, spatial ability, and digit-span memory tasks reveal the flexibility and usefulness of protocol analysis techniques in adding to our understanding of how subjects solve problems. Of equal importance, are the implications this approach has on test construction.

Part III. Methodological Issues

The last section of the volume reminds the reader of the gap between theory and practice. In both chapters, the writers raise, directly or indirectly, issues of methodology and definition. The optimism Glaser et al. express about the potential of studies of cognitive process to inform practice must be tempered by recognition of the need to find means to choose among the many competing models in cognitive psychology. Similarly, those cognitive or psychometric theorists who desire to understand cognitive behaviors that may underlie expression of some ability must have a very clear sense of how the ability is to be defined. Thus, if we wish to examine verbal ability, we need to determine
precisely what we mean by the term before we can hope to successfully discover underlying processes that lead to performance reflecting degrees of that ability.

The extensive research and theoretical activity occurring in cognitive psychology has resulted in the generation of a large number of competing models of cognitive structure and process. In chapter 7, "Structure and Process in Cognitive Psychology Using Multidimensional Scaling and Related Techniques," Professors Shoben and Ross present a rationale and a number of research examples suggesting the use of multidimensional scaling (MDS) as a method to provide a basis for choice among competing models. When a structure or model is assumed to vary across individuals, such methods of providing constraint in choice are valuable to psychometricians as well as to cognitive psychologists. As is the case when dealing with many methodological approaches, the method by no means provides final answers to the choices among structures cognitive psychologists face. Yet, Shoben and Ross nicely demonstrate the value of MDS techniques in providing as clear a set of constraints as is consistent with the level of development of cognitive psychology.

The final chapter in the volume, "New Perspectives in the Analysis of Abilities," returns to a somewhat more psychometric approach. Professor Carroll attacks the problem of definition of specific abilities by providing empirical data on a seemingly simple aptitude, human pitch discrimination. Carroll examined data on a large number of college students, looking particularly at differences between successful and less successful performance. His psychometric approach, examination of high and low scores, contrasts to the protocol approach described by Ericsson. Thus Carroll wishes to examine performance by analysis of scores of persons performing well or poorly on the pitch discrimination task. From Ericsson's perspective one might attempt to find a way to permit subjects carrying out pitch discrimination tasks to describe the process they use to make difficult pitch discriminations. His examination of high and low scores revealed the seemingly obvious finding that difficulty on the task was dependent upon the size of the pitch difference between two tones. High ability individuals have smaller pitch difference thresholds than less able persons.

Generalizing this finding to all aptitudes, Carroll argues that one definition of ability is the difference in individual thresholds of that ability. Carroll supports his case with several other examples. While he does not make the argument, a clear implication for the cognitive psychologist is the need to study the basis for the empirical finding. To what process(es) do we attribute the differential difficulty? Carroll provides an example of a Block Counting test used to study development of spatial ability. He identifies the chief source of difficulty as that of "visualization." A study (through protocol analysis) of the procedures subjects use to attempt that visualization might provide an interesting addition to Carroll's approach. Yet his argument is clear: In order to describe the process used in carrying out an act representative of some ability, the description is only useful if the ability is very clear and tightly described.
CONCLUDING COMMENTS

Demands by consumers for increasingly valid assessments of performance in a wide set of arenas pose a continuing challenge to test constructors. Some psychometricians argue that sophisticated measurement techniques have extracted as much useful information as exists from existing psychometric instruments. If these experts are correct, the demand for increased test validity cannot be met with existing instruments or measurement techniques.

Cognitive psychology appears to offer an attractive alternative to meet consumer demands. Cognitive theory has spawned a variety of theories of complex human intellective functioning moving beyond the study of purely laboratory tasks to the study of real world performance in activities that are significant to consumers. This volume demonstrates, we believe, the presence of a considerable body of theory and data about human cognitive processes valuable in meeting consumer concerns. Combined efforts of cognitive psychologists and psychometricians may well result not only in new tests and testing formats but substantially different conceptions of scoring and test use.

REFERENCES


