Toward the Integration of Cognitive Diagnosis,
Diagnostic Item Analysis, and
Internet-Based Instruction

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A Triangular Model of Education and Psychology

Testing and Measurement

Cognition ⟶⟵ Instruction

Implications of the Triangular Model

Testing should inform both cognitive diagnosis and instructional practice.

Cognitive research should inform the both test construction and analysis and instructional practice.

Instructional science should inform cognitive research and test construction.

Cognitive Diagnosis: Purpose

- A major purpose of cognitive diagnosis is understanding how participants think when they respond to test items and understanding why they make their errors that they make to the test items.

Cognitive Diagnosis: Requirement

- A requirement of cognitive diagnosis is that cognitive research be done on
  - how students think when they answer test items and
  - why participants make their errors that they do when answering test items.

Cognitive Diagnosis: Consequence

- A consequence of cognitive diagnosis is to provide the empirical basis for
  - the construction of test items including item distractors and
  - the interpretation of item responses.

Cognitive Diagnosis: Prospects

- There has been much cognitive research on lower-level cognitive functioning as would occur in reading and arithmetic. For example,

- http://dibels.uoregon.edu/measures/orf.php

- There is a strong need for cognitive research on higher-level cognitive functioning as would occur in critical thinking and problem solving and intermediate and advanced levels in mathematics and science.

Diagnostic Item Analysis: Purpose

- A major purpose of diagnostic item analysis is the extraction of as much useful information as possible from an examination of participant responses to test items.

Diagnostic Item Analysis: Requirement

Two requirements of diagnostic item analysis are

- research on how to select highly diagnostic test items and
- research on how to analyze test item responses to provide cognitive interpretations and instructional implications of item responses.

Diagnostic Item Analysis: Central Aspect

- Progress in diagnostic item analysis requires greater attention to the test item and the quest for highly diagnostic items.
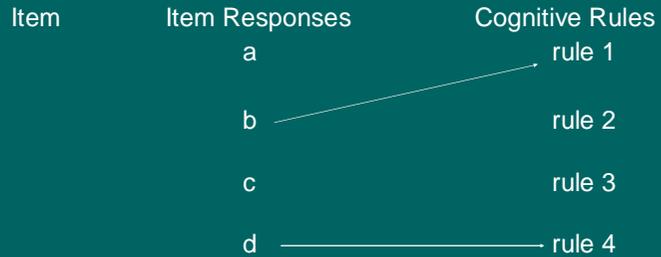- Highly diagnostic tests require highly diagnostic test items.

Diagnostic Item Analysis: A Useful Tool

- One useful tool in diagnostic item analysis is the item digraph.
- Diagnostic item analysis from the dense item perspective is one approach to diagnostic item analysis that makes judicious usage of the item digraph.

Item Digraph for a Semi-Dense Item, a Highly Diagnostic Test Item

Item	Item Responses	Cognitive Rules
	a —————————→	rule 1
	b —————————→	rule 2
	c —————————→	rule 3
	d —————————→	rule 4

Item Digraph for a Defective Diagnostic Test Item: A Lack of Response Interpretability

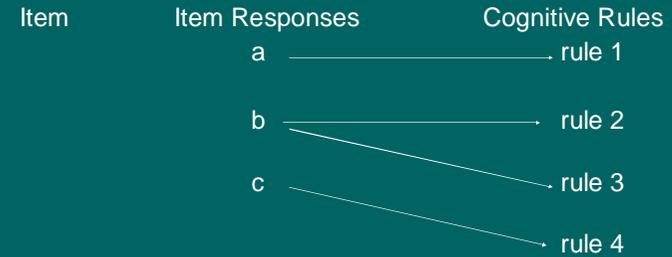Item   Item Responses   Cognitive Rules
                    a   rule 1

                    b   rule 2

                    c   rule 3

                    d   rule 4

The rule set for this item does not permit the interpretation of all of the responses to the item

Item Digraph for a Defective Diagnostic Test Item: A Lack of Response Discrimination

Item   Item Responses   Cognitive Rules
                    a   rule 1

                    b   rule 2

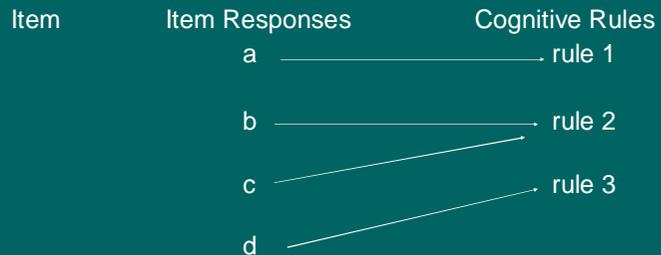   c   rule 3

                                                rule 4

Response b does not discriminate between rules 2 and 3.

Item Digraph for a Defective Diagnostic Test Item: A Lack of Rule Discrimination

Item   Item Responses   Cognitive Rules
                    a   rule 1

                    b   rule 2

   c   rule 3

                    d

Rule 2 does not discriminate between responses b and c.

Item Digraph for a Defective Diagnostic Test Item: A Lack of Rule Set Usage

Item   Item Responses   Cognitive Rules
                    a   rule 1

                    b   rule 2

                    c   rule 3
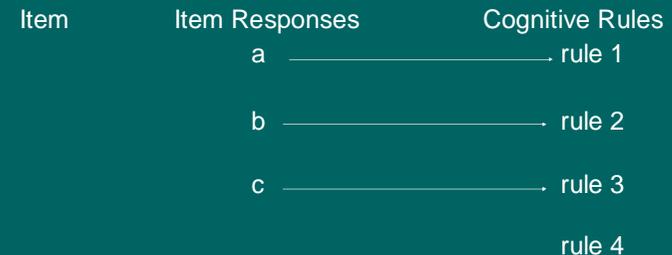
                                                rule 4

Rule 4 is a superfluous rule in the rule set for the item.

Item Digraph for a Semi-Dense Item, a Highly Diagnostic Test Item

Item   Item Responses   Cognitive Rules

a → rule 1

b → rule 2

c → rule 3

d → rule 4
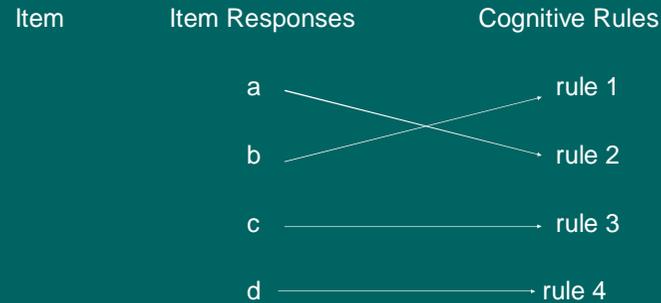
Diagnostic Item Analysis: Challenge

A main challenge for diagnostic item analysis is the determination of methods of analysis of item response data that permit the user to infer the rules used by participants when responding to test items, even though the test items may lack properties of highly diagnostic test items.

Internet-Based Instruction: Purpose

- One purpose of internet-based instruction is to make available high-quality instruction to practically anyone in the world

Internet-Based Instruction: Requirement

- One requirement of internet-based instruction is the judicious usage of technological advances and contemporary ideas and research findings in cognition, measurement, and instructional science.
- It is doubtful whether teachers uniformly throughout the world can diagnose student errors and prescribe correctives.

Internet-Based Instruction: Consequence

- Internet-based instruction is inevitable if there continues to be a shortage of high-quality teachers who can serve as instructors, coaches, and tutors.

Internet-Based Instruction: Prospects

- The prospects for Internet-based instruction are very bright, given the need for high-quality, effective instruction is enormous and the shortage of high-quality teachers.

Internet-Based Instruction: Challenge

- The challenge for Internet-based instruction is to coordinate advances in diagnostic testing, cognitive science, and instructional science.