

Multi-Stage Computerized Adaptive Testing with Uniform Item Exposure

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Today's Talk

- ▶ MFS and uMFS
- ▶ Optimization
- ▶ Stages and Levels

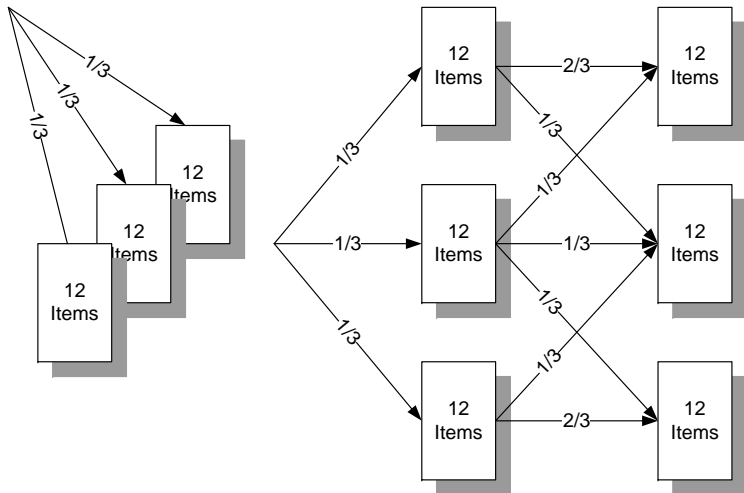
CAT Designs

- ▶ “Typical” CAT
 - ▶ Item by item adaptation
 - ▶ Exposure control (on the fly)
 - ▶ Content control (on the fly)
- ▶ Multi-Form Structure (MFS) CAT
 - ▶ Block by block adaptation
 - ▶ Pre-assembled blocks
 - ▶ Content specifications met in assembly
 - ▶ Human review of forms

Uniform Multi-From Structure (uMFS) CAT

- ▶ uMFS CAT allows us to:
 - ▶ Have uniform item exposure by construction, controlling “absolute exposure for expected candidate volumes”
- ▶ CAST, BMAT (Luecht and colleagues)

A 3-stage, 3-level uMFS CAT



Goals for uMFS CAT (Objective Function)

1. Small average error variance ($1 - \rho$)
2. Uniform accuracy of theta measurement
3. Routing stage blocks equivalent
4. Branching fractions as specified

Optimization

- ▶ Given a set of items, how do we assign items to bins?
- ▶ Threshold accepting (TA)
 - ▶ Randomly assign items to bins
 - ▶ Swap item pairs in canonical order
 - ▶ Accept all swaps that lower objective function or increase it less than current threshold, reject all others
 - ▶ Run until no further improvement possible

How many stages, How many levels?

A very general question one might entertain at this point is: What uMFS structure is best? How many stages? How many levels?

To examine this question we examined a number of different uMFS “shapes”:

- ▶ Levels: 2,3,4
- ▶ Stages: 1,2,3,4,6,9

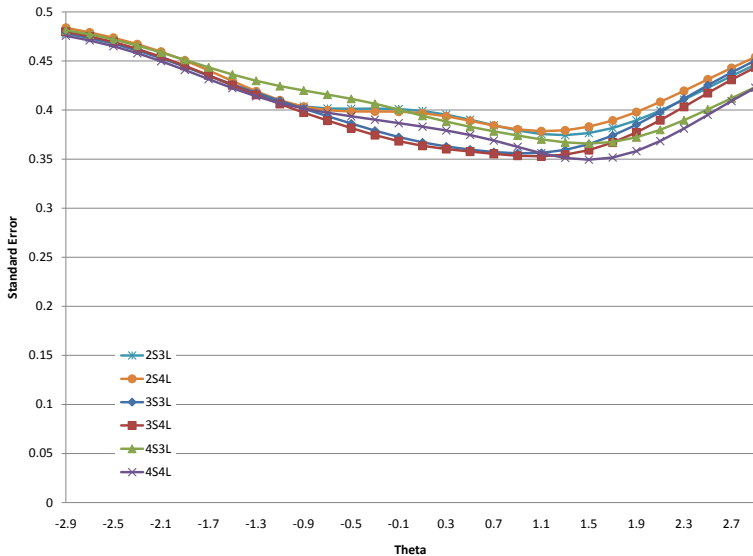
Simulation Conditions

- ▶ Each examinee would see 36 items
- ▶ $\hat{\theta}$ based on pattern of summed scores
- ▶ Item parameters drawn from
 - ▶ $\log(a) \sim N(-0.3, 0.3)$
 - ▶ $b \sim N(0.2, 1.2)$
 - ▶ $\text{logit}(c) \sim N(-1.4, 0.5)$
- ▶ For each condition two sets of items, two shuffles per item set

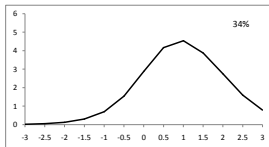
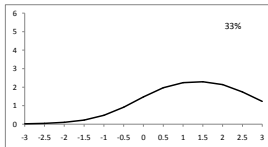
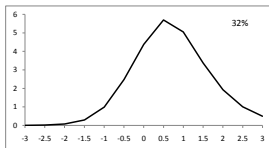
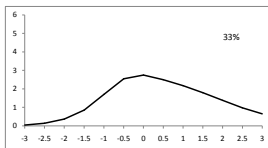
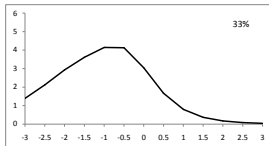
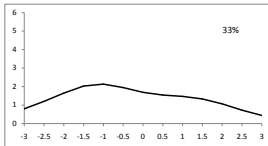
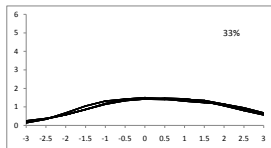
Simulation Results - Reliability

Levels	Stages					
	1	2	3	4	6	9
2	0.806	0.838	0.840	0.840	0.839	-
3	0.820	0.841	0.854	0.856	0.855	0.853
4	0.815	0.829	0.840	0.850	0.853	0.854

Comparing 3- and 4-level standard errors



Block Information Functions



The uMFS CAT

The uMFS CAT has several advantages:

- ▶ The uMFS CAT has all the benefits of the MFS CAT
- ▶ In addition:
 - ▶ Content control accomplished in assembly
 - ▶ Exposure control accomplished in assembly

The 3-stage, 3-level uMFS CAT

The 3-stage, 3-level uMFS CAT adds:

- ▶ Appreciable improvement over non-adaptive test
- ▶ Ability to correct initial misrouting
- ▶ 21 possible pathways through test
- ▶ Compromise between complexity and parsimony

The End

Thank you.

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