Detecting DIF between Conventional and Computerized Adaptive Testing: A Monte Carlo Study

Barth B. Riley

Chestnut Health Systems

Adam C. Carle

University of Cincinnati

Introduction

- Instruments are being transitioned from paper-and-pencil (P&P) to computerized adaptive modes of administration.
- Problems arise when item parameters used by CAT are estimated from P&P.
- Mode effects can diminish measurement reliability and validity and increase error in trait estimates (Pommerich, 2007).

Problem

- Differential item functioning (DIF) refers to differences in level of item endorsement between two or more groups after controlling for differences in ability.
- Most DIF methods are designed for use *within* mode but not *between* mode of administration.
- Differences in level of missing item responses between modes.

Purpose and Rationale

- *Develop and evaluate approaches to assessing item-level mode effects*.
- Bayesian methods can provide more accurate results compared to conventional approaches.
  - Take into account uncertainty in trait and item parameter estimates.

DIF Procedure

1. Estimate θ using item response data pooled across administration modes (CAT and P&P).
2. Using θ_i obtained in Step 1, estimate the posterior distributions of mode-specific item parameters.
3. For each item common across modes, assess the difference in the posterior distributions of the item parameters (i.e., between βj^{CAT} and $\beta j^{P\&P}$).

Comparing Posterior Distributions

- Two approaches.
  - Modified robust *Z* statistic (Huynh & Meyer, 2010).
  - 95% Credible Interval for mean difference between β_j^{CAT} and $\beta_j^{P\&P}$.

Modified Robust Z

$$Robust\ Z_j = \frac{Med(\beta_j^{CAT} - \beta_j^{P\&P})}{0.74(IQR[\beta_j^{CAT} - \beta_j^{P\&P}])}$$

- *Med* = median of the differences in the CAT and P&P item parameters based on their posterior distributions.
- *IQR* = interquartile range of the difference.

Priors and Generated Parameters

Parameter	**Prior**	**Generated**
Discrimination	*LN*(0.0,0.5)	1PLM: 1.0 2PLM: *LN*(0.0,0.5)
Difficulty	*Normal*(0.0,2.0)	Uniform(-3.0,3.0)
Ability	*Normal*(0.0,1.0)	*Normal*(0.0,1.0)

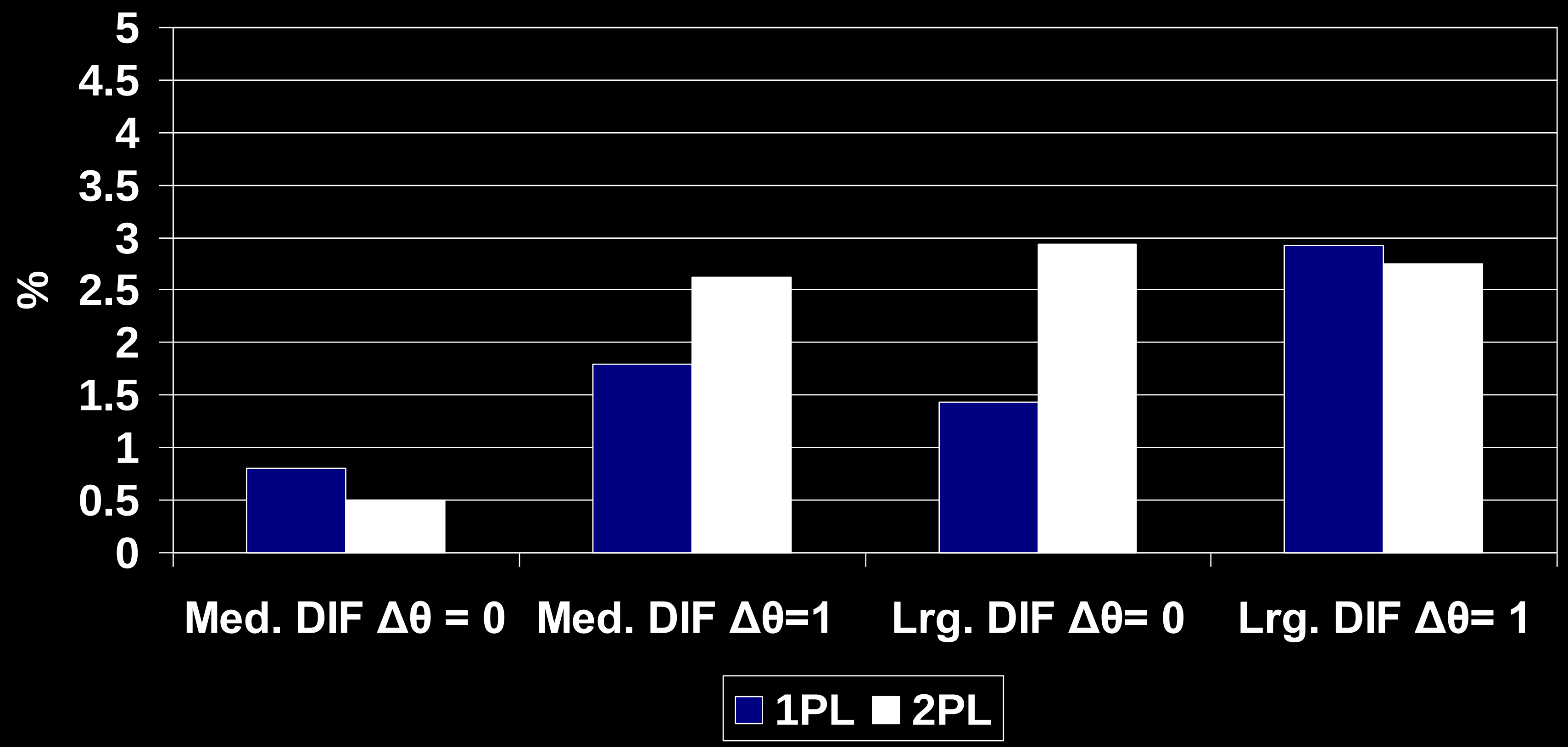
Monte Carlo Study

- Two sets of P&P item parameters generated using previous criteria fitting one- (1PLM) and two-parameter (2PLM) IRT models.
- Item response data generated using each set of parameters.
- Parameters then estimated using maximum likelihood (Mplus).

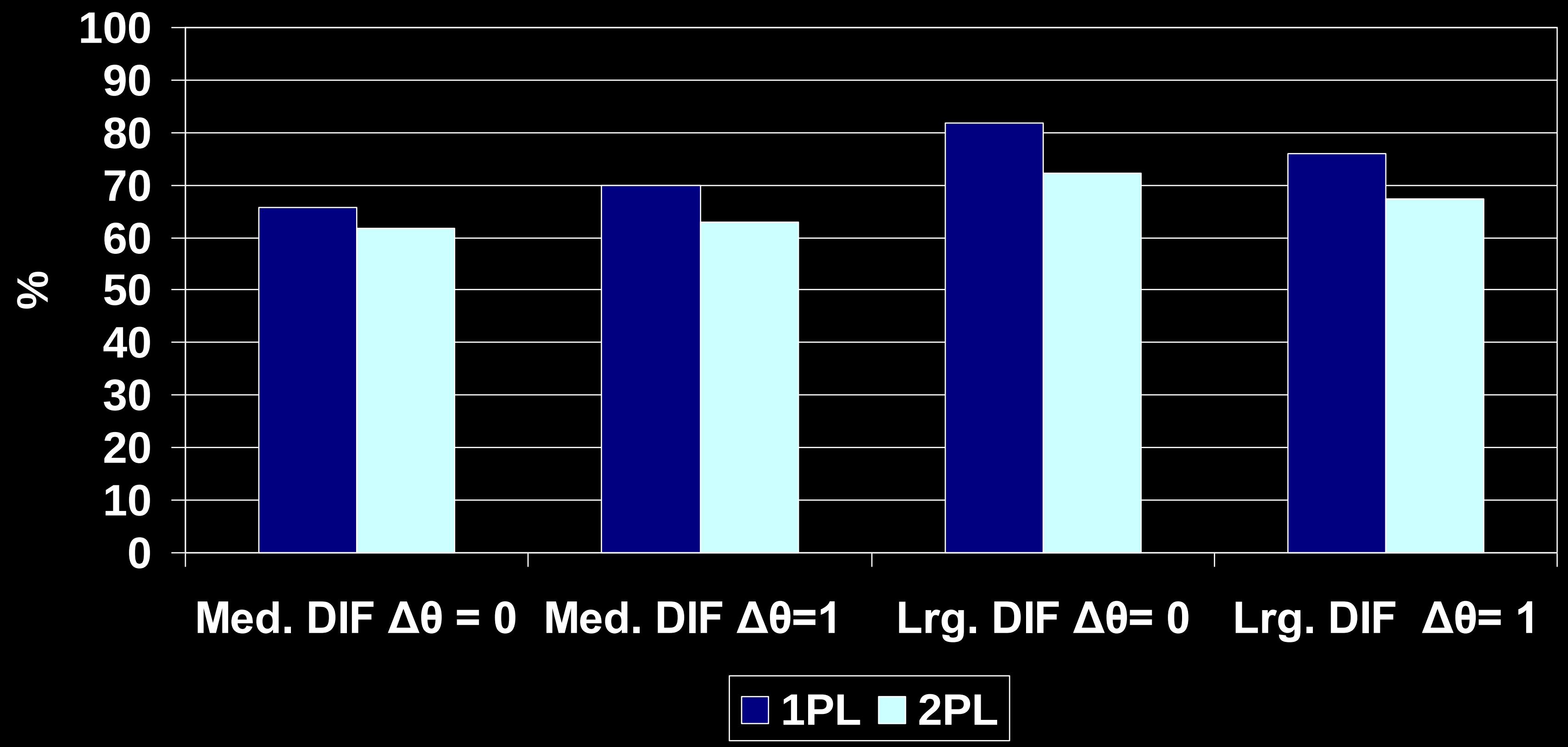
Monte Carlo Study cont.

- CAT item response data were generated using the following variables:
  - % of DIF items (10% vs. 30%).
  - Magnitude of DIF $|\beta_j^{CAT} - \beta_j^{P\&P}| = 0.42$ vs. 0.63.
  - Mean difference in θ between CAT and P&P samples (0 vs. 1 logit).
  - Direction of DIF was randomized.
  - 10 datasets generated per condition.
- CAT simulations: Firestar 1.33 (Choi, 2009).
- Bayesian Analysis: WinBUGS 1.43 (Spiegelhalter et al., 2007).
- Sample Size:
  - P&P Data: N = 1,000.
  - CAT Data: N = 3,000.

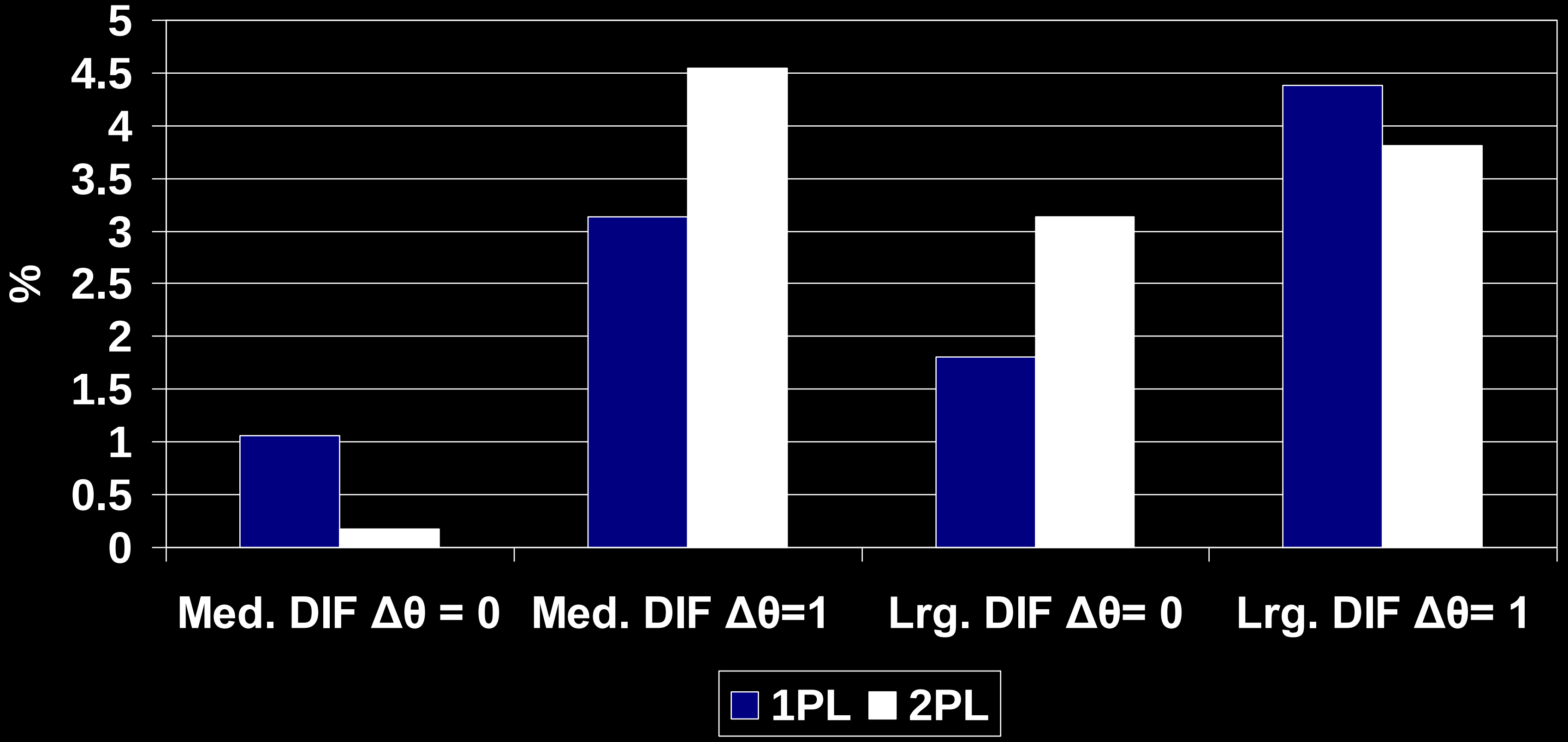
Robust Z: False Positive Rate



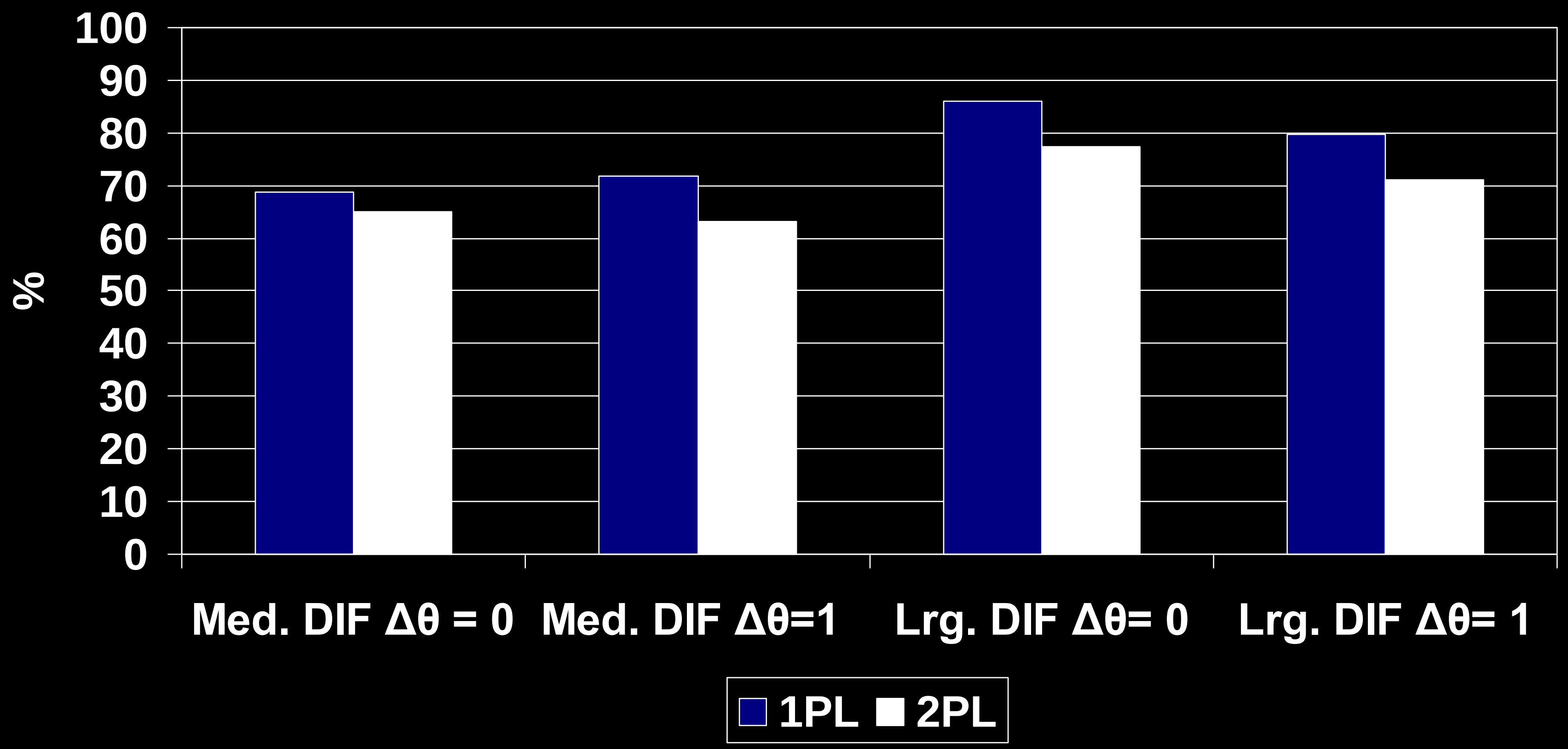
Robust Z: True Positive Rate



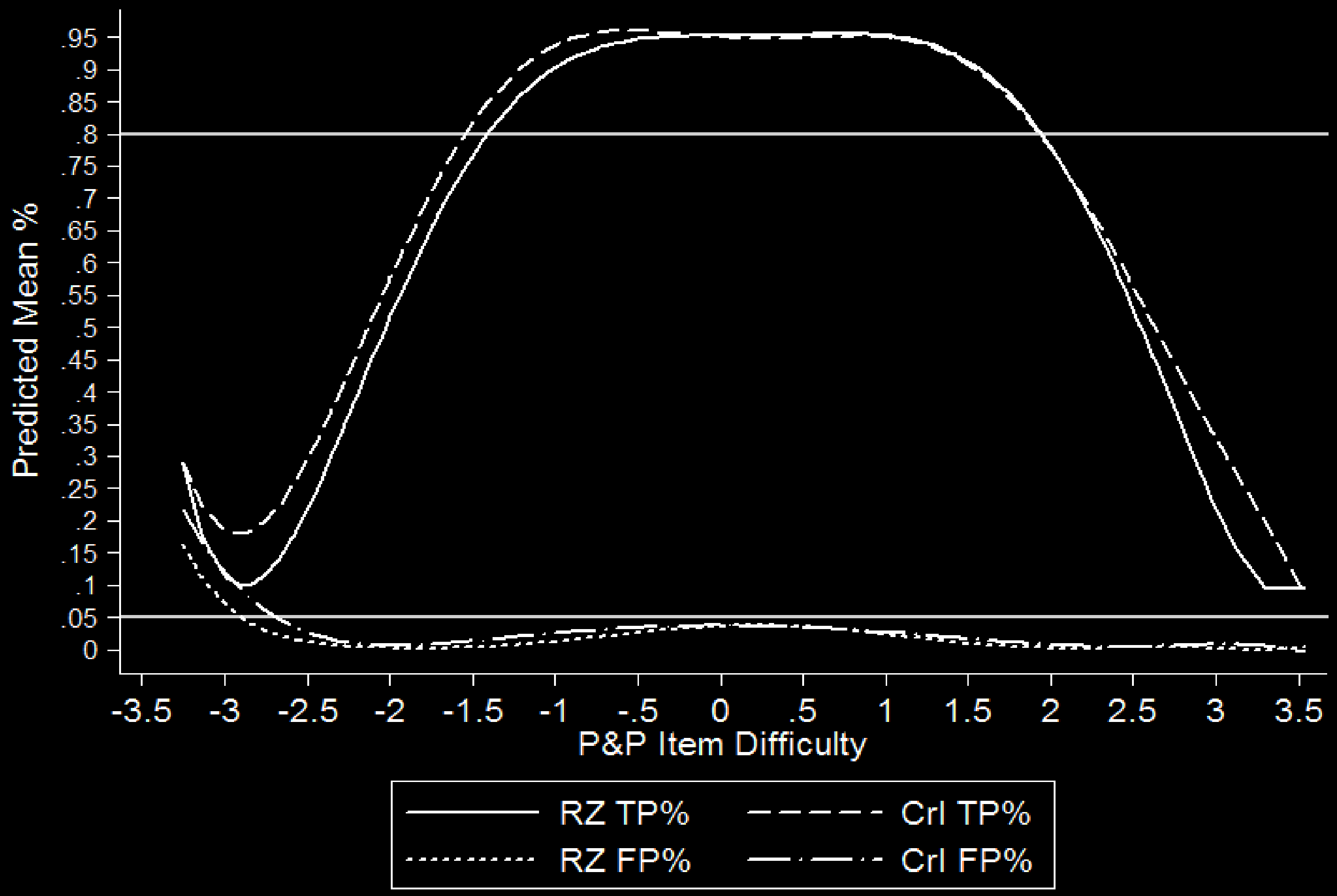
CrI: False Positive Rate



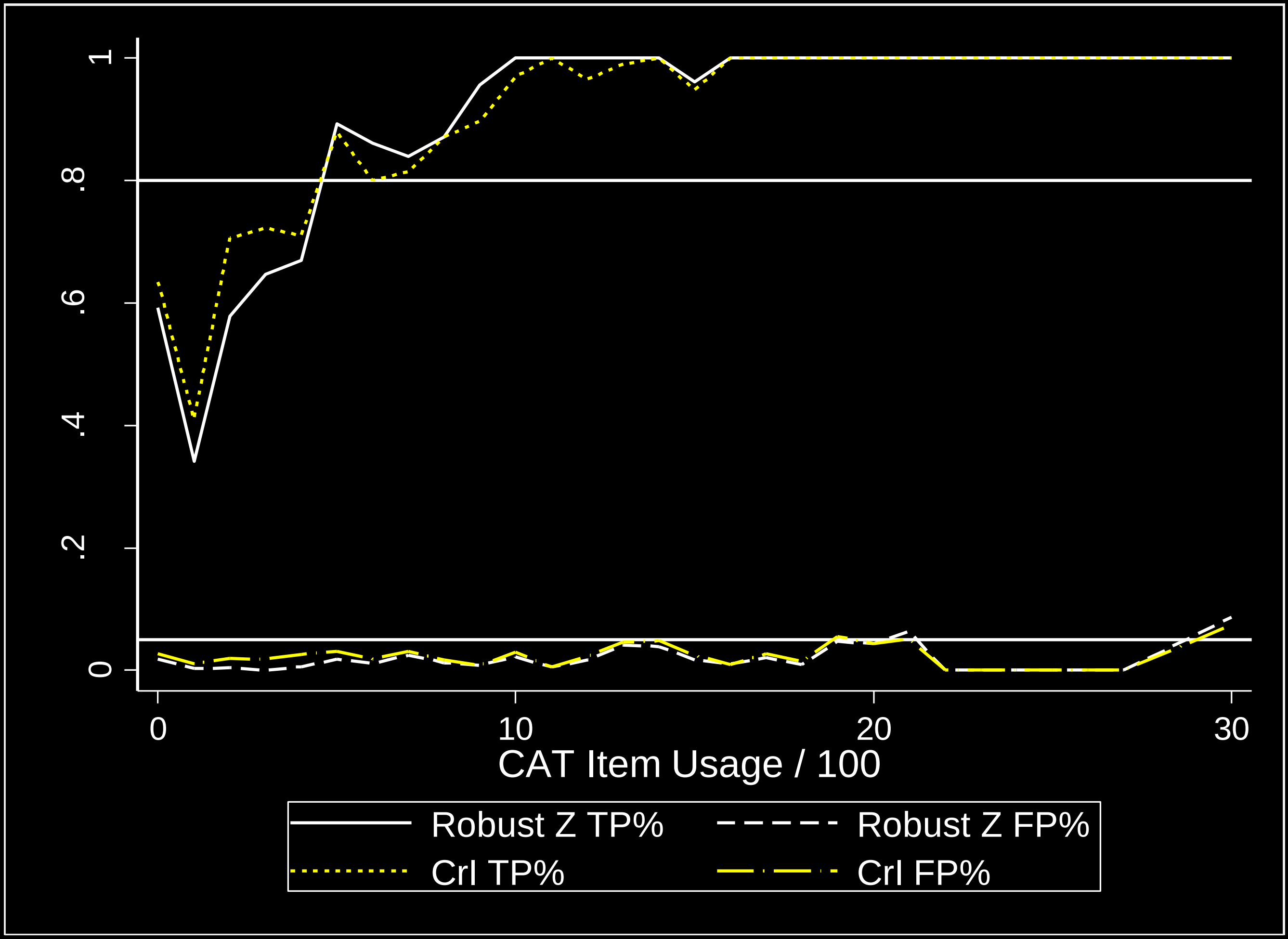
CrI: True Positive Rate



Performance by Item Difficulty



True & False Positive Rates by CAT Item Usage



Conclusions

- Both procedures evidenced adequate control of false positive DIF results.
  - Exception: low difficulty items (< -2.5 logits).
  - Not significantly affected by % of DIF items.
  - Was affected by mean trait level difference.
- *CrI* evidenced slightly higher power to detect DIF, but also higher false positive rate.

Conclusions cont.

- Power to detect DIF varied considerably, and was affected by several factors, including:
  - Item usage.
  - DIF size.
  - IRT model.
  - Mean difference in trait estimates.
  - Item difficulty.

Future Research

- Test robustness of procedures to data that do not conform to prior assumptions.
  - Skewed ability and item parameter distributions.
- Detecting non-uniform DIF.

References

Choi SW: **Firestar: Computerized adaptive testing simulation program for polytomous IRT models**. *Applied Psychological Measurement* 2009, **33**(8):644-645.

Huynh H, Meyer P: **Use of robust z in detecting unstable items in item response theory models**. In *Practical Assessment Research & Evaluation. Volume 15*. 2010.

Pommerich M: **The effect of using item parameters calibrated from paper administrations in computer adaptive test administrations**. *Journal of Technology, Learning, and Assessment* 2007, **5**(7):1-29.

Spiegelhalter D, Thomas A, Best N, Lunn D: *WinBUGS version 1.4. 3 user manual*. Cambridge, United Kingdom: MRC Biostatistics Unit; 2007.

Thank You

For more information, please contact:

Barth Riley

bbriley@chestnut.org