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Testing for Differential Item Functioning in Performance Assessments

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Background: Performance assessment (I)

- Performance assessments often require test takers to create answers or products that demonstrate their knowledge and skills (Rudner & Boston, 1994).

Background: Performance assessment (II)

Features of Performance Assessment

- Authentic
- Intended to assess higher level (cognitive) skills
- Likely use open-ended tasks
- Each task may require a relatively long time to complete
  - Number of tasks is small
- Performance is often evaluated by multiple raters using scoring rubrics
  - Test scores may be on a continuous scale

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Background: Differential Item Functioning (DIF) I

- Motivated by fairness issues in testing
- Can also be used in
  - Quality assurance; e.g., drift analysis
  - Establishing measurement invariance to allow group comparison
  - Investigating comparability of different versions of a measure; e.g., translation effect

Background: Differential Item Functioning (DIF) II

Many DIF methods have focused on dichotomously scored items or polytomously scored items with few possible scoring categories

Background: Differential Item Functioning (DIF) III

Logistic regression method:

Item Score = Total Score (A) + Grouping (G) + Interaction (A x G)

Proxy for Ability Uniform DIF Non-Uniform DIF

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Challenges of DIF Investigation in Performance Assessment

Lack of internal variable for ability approximation

Item Score = Ability (A) + Grouping (G) + Interaction (A x G)

- **First challenge**: There is no well defined ability approximation variable because performance assessments are typically short with 1 or 2 tasks.
- Researchers have used external variables to approximate ability scores (e.g., the total score of other related subjects).
- It is also possible to match the two groups: e.g., covariance adjustment, exact matching, and propensity score matching.

Challenges of DIF Investigation in Performance Assessment

Continuous ratings

Item Score = Ability (A) + Grouping (G) + Interaction (A x G)

- **Second challenge**: There is no clear guideline for DIF analysis based on <u>matched data with continuous item scores</u>.
- For DIF analysis with covariance adjustment, linear regression can be applied.
- However, for exact matching or propensity score matching, we have not found any published studies providing statistical solutions or guidance.

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Research Purpose (Propensity Score DIF for Performance Assessment)

Extends on the current literature of DIF investigation in performance assessments—(multiple) matching of other, correlated, sub-scales or tests.

Describes a propensity score DIF method that handles continuous scores in cases that lack well-defined ability approximation variables.

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Demonstration

- Investigates DIF due to different levels of education in a writing task.
- Our example uses 1450 test takers’ data from a high-stakes English writing test which consisting of two tasks.

Participants

1450 Adult test takers

21% were females

A wide variety of language backgrounds

Education level:

- 487 below undergraduate level (coded 1);
- 963 undergraduate level or above (coded 0).

Measure:

- A measure of functional English language proficiency in: reading, listening, speaking, and writing.

Focus is on: Writing Test with two tasks

- Task 1 Email & Task 2 Response to a survey question
- Each task score is a continuous variable which can theoretically be any numerical value between 0 and 12.
- In the past we have used linear regression DIF with reading and listening scores as multiple covariates matching (Chen, Lam, & Zumbo, 2016).

Analysis

A 2-step modeling approach

Step-1. Propensity score matching

- Selecting covariates
- Estimating propensity score and matching

Step-2. DIF analysis with mixed effects regression models

Step-1. Propensity score matching: Selecting covariates

- Employment: student, construction & factory, store & restaurant, office, or unemployed
- Daily use of English:
  - Speaking: grocery shopping, talk to friends/coworker/family, meeting, chat online
  - Listening: watching TV and video
  - Reading: read books/reports/news, online social media
  - Writing: write email/assignment/reports/business correspondence
- Language background: first language, year of learning English, year living in English speaking countries
- Test taking experience: repeater

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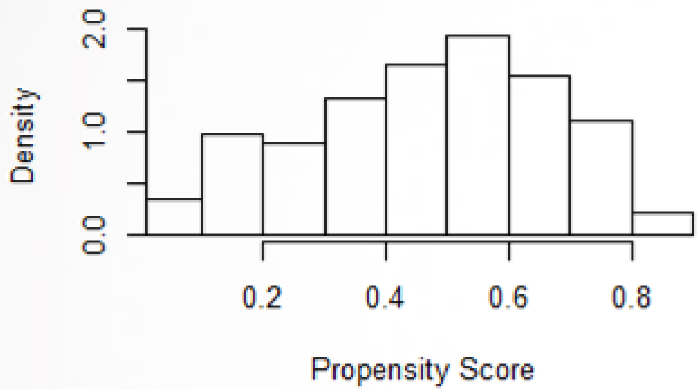
Results: Step-1. Propensity score matching

Optimal Pair Matching

Raw below Undergraduate



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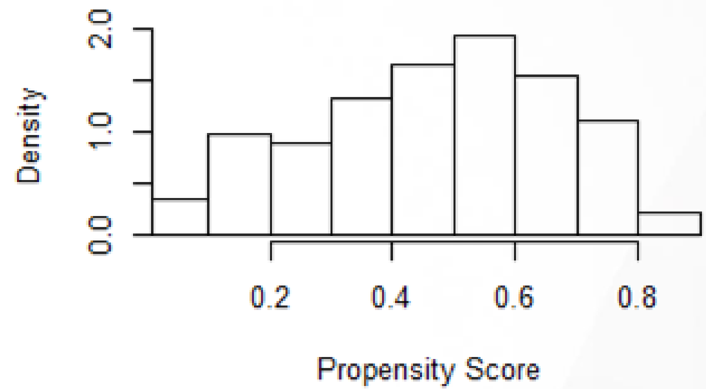

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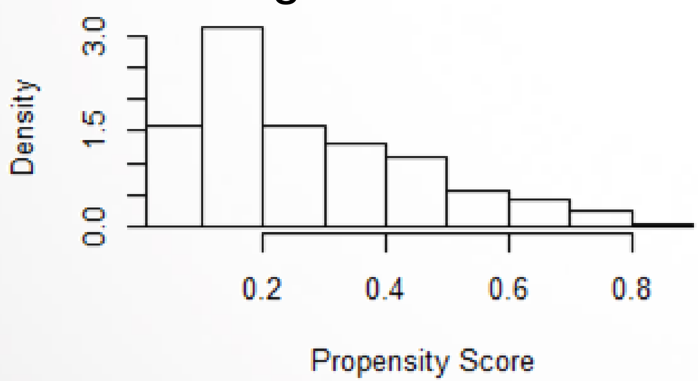

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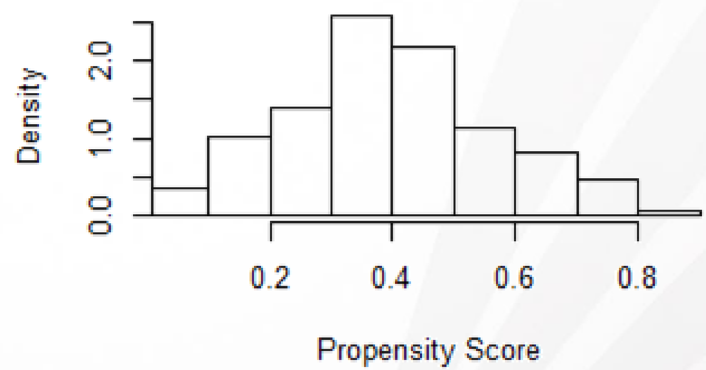

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Results: Step-1. Propensity score matching

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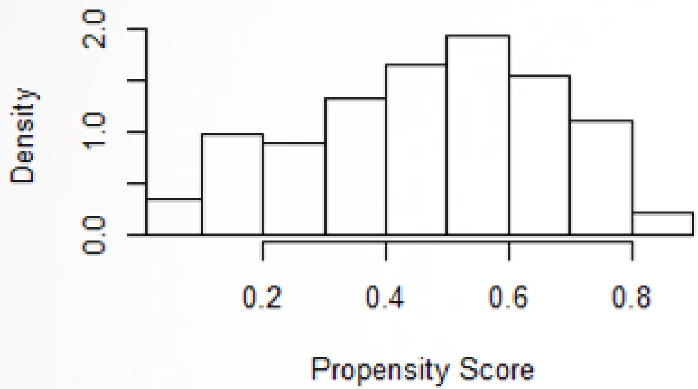

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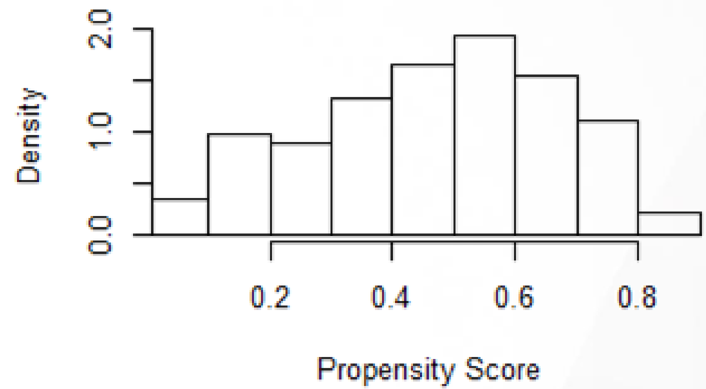

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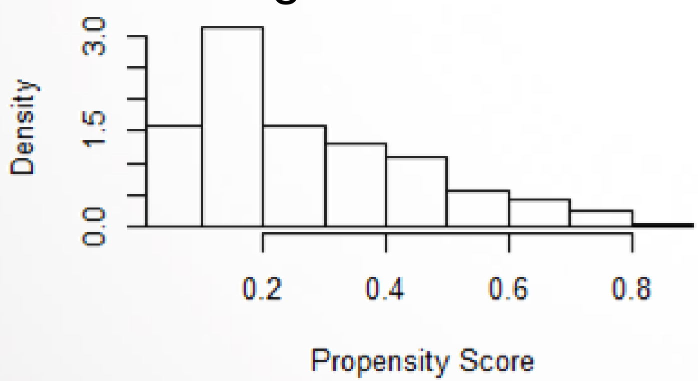

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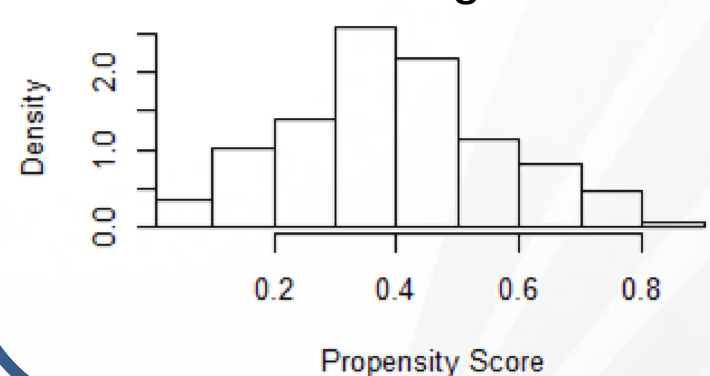

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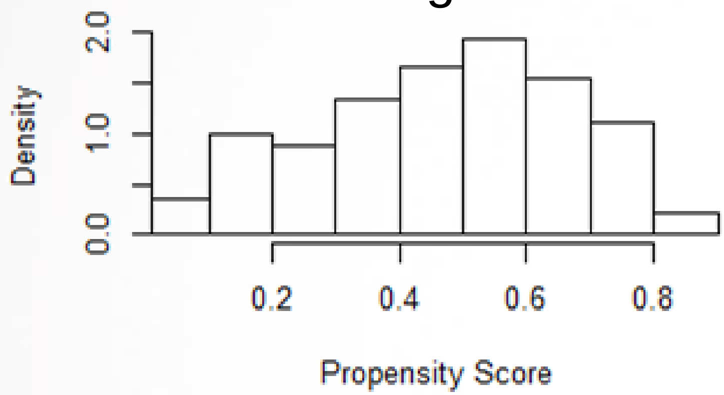
Results: Step-1. Propensity score matching

Optimal full matching: 1 to multiple, multiple to 1

Raw below Undergraduate



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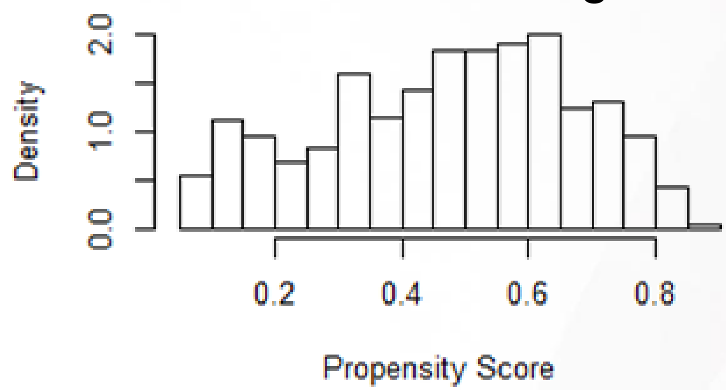

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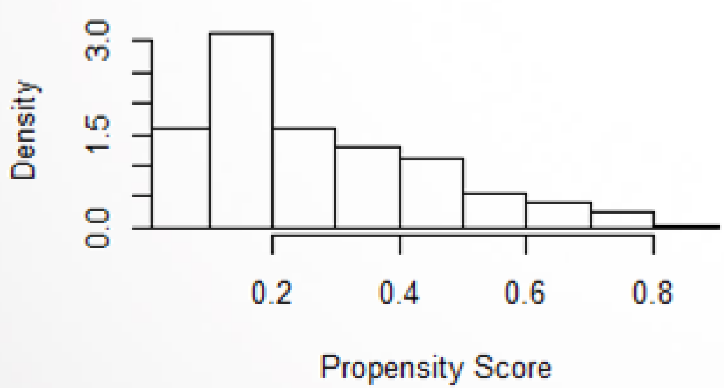

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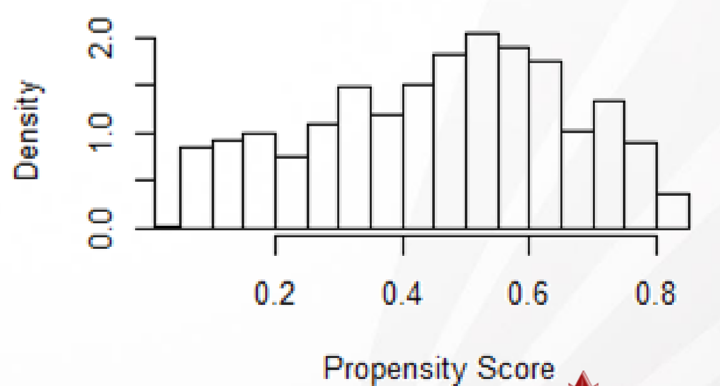

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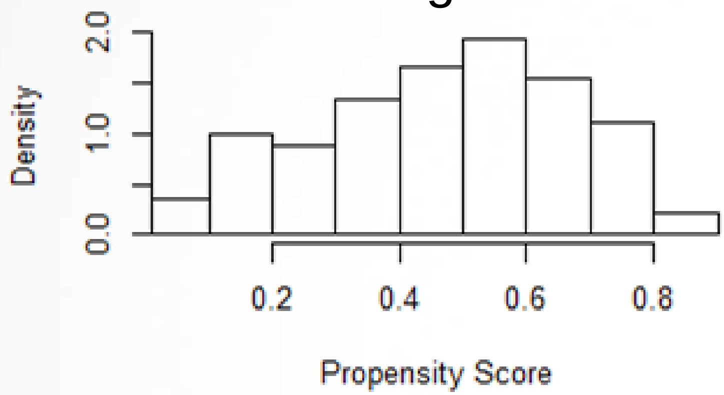

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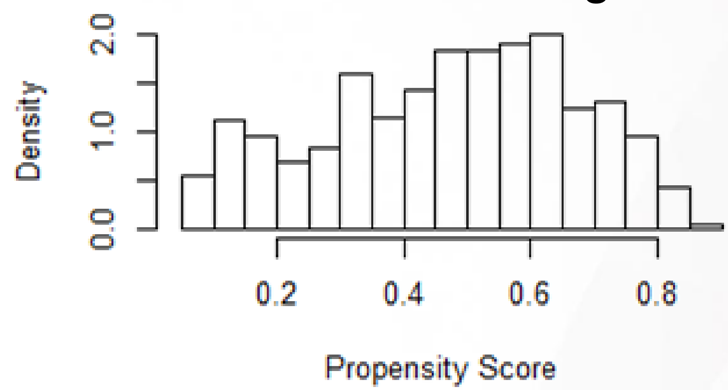

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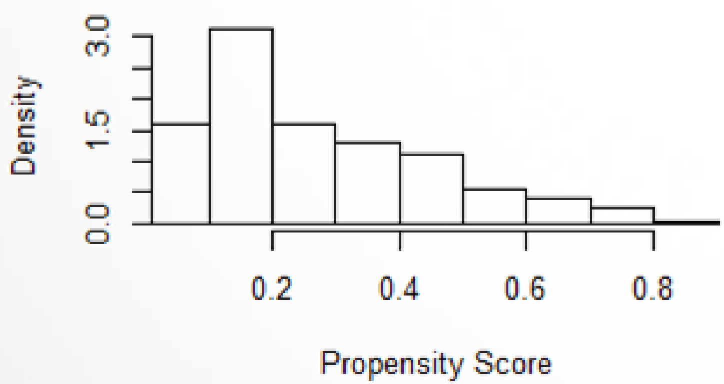

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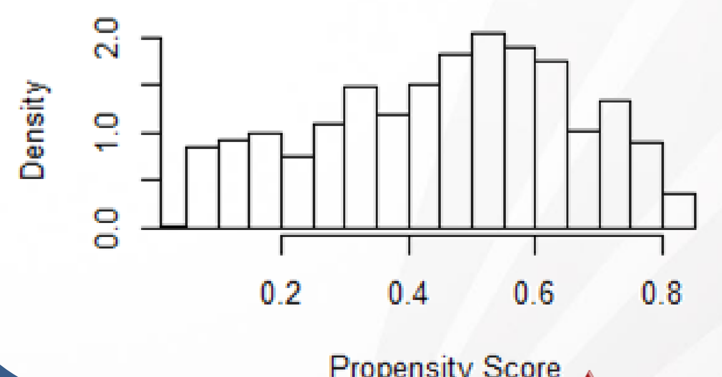

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Results: Step-2. DIF analysis using linear mixed effects regression model

Based on matched dataset (Optimal full matching)

Regression model for DIF investigation:

Item Score = Total Score (A) + Grouping (G) + Interaction (A x G)

Proxy for Ability   Uniform DIF   Non-Uniform DIF

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Results: Step-2. DIF analysis using linear mixed effects regression model

Based on matched dataset (Optimal full matching)

ICC=0.26

Fixed effects:

	Estimate	S.E.	df	t value	Pr(>|t|)
Intercept	6.686	0.070	458	95.267	< .001***
A	0.074	0.003	1263	25.943	< .001***
Education	-0.303	0.071	1250	-4.276	< .001***
A * Edu	**-0.018**	**0.005**	**1381**	**-3.805**	**< .001*** **

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This graph is prepared for illustration purpose only. Coefficients of fixed effects were used, while random effects were ignored.

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2 df likelihood ratio test for DIF detection

Compare two nested models:

- Model 0:

  WritingTask ~ A + u_{0j} + e_{ij}
- Model 2:

  WritingTask ~ A + Edu + interaction(A * Edu) + u_{0j}+ e_{ij}

Note: A: proxy for ability; Edu: education

	df	AIC	BIC	logLik	Deviance	Chi-square (2df)
Model 0	4	4867.1	4888.3	-2429.6	4859.1	
Model 2	6	4841.5	4873.2	-2414.8	4829.5	29.592***

***: p<.001

Summary

Building on previous work (e.g., Chen et al., 2016; Liu et al., 2016; Swaminathan & Rogers, 1990; Zumbo, 2008), a method to test DIF for a continuously scored writing test with only two prompts on each test form is proposed and demonstrated with real test data.

Discussion: Regression Methods for DIF Investigation

- Directly modeling continuous data; without shifting to probabilities of specific score categories.
- Cluster effect of matched data has been accounted for in mixed effects model.
- Regression-type models are flexible. Both uniform and non-uniform DIF effect can be modeled.
- Propensity score matching allows a large number of covariates to be included to approximate randomized experimental design; Avoid problems with many covariates in the final DIF analysis.

Future Directions

- Sensitivity and accuracy of this proposed method still need to be tested.
- Additional studies would be useful for considering how these results compare to those obtained from other testing programs and different DIF detection approaches.

Thank You

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Selected Reference

- Chen, M. Y., Lam, W., & Zumbo, B. D. (2016). *Testing for differential item functioning with no internal matching variable and continuous item ratings*. Poster presented at the Language Testing Research Colloquium. Palermo, Italy.
- Liu, Y., Zumbo, B. D., Gustafson, P., Huang, Y., Kroc, E., & Wu, A. D. (2016). Investigating causal DIF via propensity score methods. *Practical Assessment, Research & Evaluation, 21*(13). Available online: http://pareonline.net/getvn.asp?v=21&n=13.
- Swaminathan, H., & Rogers, H. J. (1990). Detecting differential item functioning using logistic regression procedures. *Journal of Educational measurement, 27*(4), 361-370.
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