Detecting Intersectional Differential Item Functioning: A Comparison of Two Methods

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Outline

- Background
- Methods
- Empirical study
- Discussions

Background

- Differential item functioning (DIF)
- Intersectionality
  - Acknowledges that most demographic factors do not function in isolation, but rather as interlinked phenomena that collectively shape complex social inequalities (Bauer et al., 2021; Grabe, 2020)
- Intersectional DIF
  - Not only incorporates multiple demographic variables in a single model but emphasizes the DIF effect that reflects the interactions of various identities rather than the mere additive effect

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Methods: Regularized DIF (reg-DIF) Method

$$P(y_{ij} \mid \theta_i) = \frac{1}{1 + \exp\left[-\left((a_j + \boldsymbol{X}_i^{\mathrm{T}}\boldsymbol{\gamma}_j)\theta_i + d_j + \boldsymbol{X}_i^{\mathrm{T}}\boldsymbol{\beta}_j\right)\right]}$$

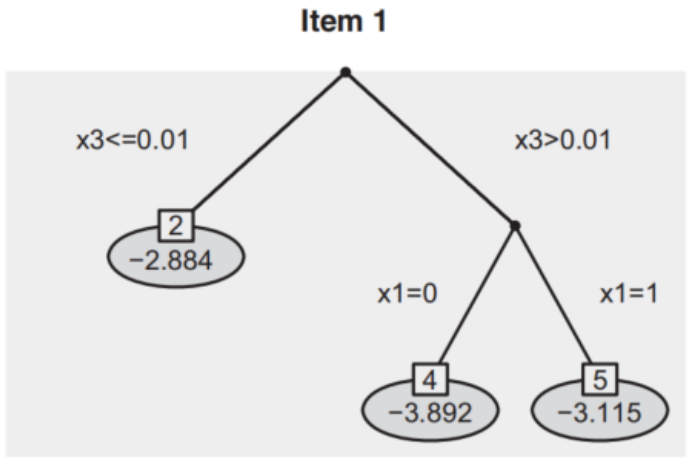
DIF parameters on which reg-DIF assign penalty

> The reg-DIF method incorporates regularization regression into the explanatory item response theory (EIRT).

Methods: Item-focused Tree (IFT) Method

$$\log\left[\frac{P(y_{ij}=1|S_i,\boldsymbol{X}_i)}{P(y_{ij}=0|S_i,\boldsymbol{X}_i)}\right] = \left[\Sigma_{k=1}^{K}\gamma_{jk}node_{jk}^{[U]}(\boldsymbol{X}_i)\right]S_i + \Sigma_{k=1}^{K}\beta_{jk}node_{jk}^{[NU]}(\boldsymbol{X}_i)$$

Non-Uniform DIF Uniform DIF



- The IFT method integrates the tree structure—binary recursive partitioning of the feature space—with logistic regression.

Intersectional DIF with reg-DIF and IFT

- reg-DIF: All the variables of interest are synthesized into a single grouping variable, within which each category corresponds to a unique combination of different demographic variables. Dummy coding is then applied to the synthesized variable and incorporated into the model.

- IFT: It can directly use the original demographic variables. The intersectional DIF is represented by the sequentially split nodes in the model.

Empirical Study

- Data is from the SCS1 assessment, an exam widely used for the undergraduate introductory programming course in computer science
- 259 students completed the test, and their demographics are as below

Table 1. Demographics for the 259 students that completed the relevant questions when attached to the end of SCS1.

Gender	n	Race/Ethnicity	n	Primary Language	n
Female	96	White/Caucasian	104	English	160
Male	159	Asian/Pacific Islander	117	Chinese	42
Other	4	Black	3	Korean	17
		Hispanic	6	Vietnamese	7
		Multiple	29	Spanish	4
				Other/(No answer)	29

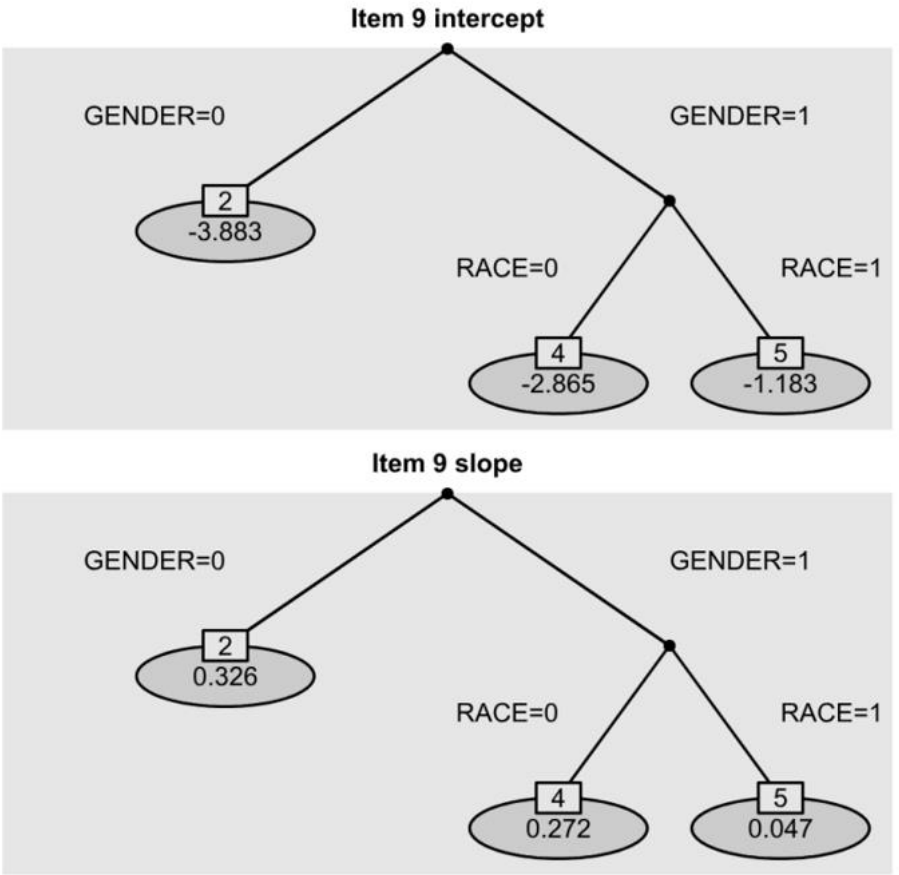
Results

Table 2. Intersectional DIF magnitude estimates.

	UDIF			U/NUDIF
Item with DIF	reg-DIF WMref	reg-DIF NFref	IFT	IFT
Item 8	$0.803^{(NM)}$	$0.801^{(NM)}$	-	-
Item 9	-	-	-	#
Item 13	$0.821^{(NM)}$	$0.820^{(NM)}$	-	-
Item 20	-	$0.793^{(WM)}$	-	-

Note: reg-DIF WMref refers to the reg-DIF method with white male as the reference, and reg-DIF NFref refers to the reg-DIF method with non-white female as the reference. The superscript on the magnitude denotes the focal group inducing DIF effect, with NM representing non-white male and WM denoting white male. # refers to the item detected with U/NUDIF, and it is illustrated in Figure 1.

Figure 1. Tree structure of item 9 under U/NUDIF detection by gender and race.



Note: GENDER=0 refers to males, GENDER=1 refers to females, RACE=0 refers to the white, RACE=1 refers to the non-white.

Thanks!
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