Evaluation of Psychometric Properties and Differential Item Functioning of the Dental Anxiety Inventory (DAI-36) Questionnaire using Iterative Hybrid Ordinal Logistic Regression

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Research Article

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Abstract

**Background:** Dental anxiety is a major dental problem. The difference of dental anxiety between groups may be reflect of the perception of individual of the items of questionnaire at the same level of the underlying dental anxiety. The propose of this study was to assess whether the Dental Anxiety Inventory (DAI-36) showed differential item functioning (DIF) by gender, age and education levels.

**Methods:** By an iterative hybrid ordinal logistic regression model, we assessed measurement equivalence of DAI-36 items across gender, education, and age groups. All analysis was run by lordif package in R3.1.3 software for 950 participants.

**Results:** The chi-square statistics declared 7, 7, and 4 non-uniform DIF items, and 2, 5, and 4 uniform DIF items across gender, education, and age groups, respectively. $\Delta R^2$ was always lower than 0.07 in all uniform and non-uniform DIF items. However, $\Delta \beta_1$ revealed significant uniform DIF in items 1 and 8 across gender ($\Delta \beta_1$ (item 1)=0.0137, $\Delta \beta_1$ (item 8)=0.0124) and items 22 and 27 across age categories ($\Delta \beta_1$ (item 22)=0.0110, $\Delta \beta_1$ (item 27)=0.0136).

**Conclusions:** DIF items had no large magnitude or cancel out each other, so statements phrased in DAI-36 questionnaire have equivalent meaning across respondents, regardless of their gender, education, and age groups.

Introduction

Dental anxiety is an aversive emotional state of apprehension and significant issue in pediatric and even adulthood (1, 2). Approximately 50% of children and 11–46% of adults experienced dental anxiety in different studies report (1–6).

Dental anxiety leading to lack of patient management, extended duration of dental appointments, increase dental care costs, and avoidance of dental treatment (1, 2, 4, 7). Avoidance of dental treatment causes poor oral health that impacts oral health–related quality of life negatively (1, 8).

There are different psychometric properties instruments for assessing dental anxiety such as the Dental Anxiety Inventory (DAI), the Dental Anxiety Scale (DAS), the Dental Fear Survey (DFS), the Modified Dental Anxiety Scale (MDAS), the State–Trait Anxiety Inventory scale (STAIC) for Children, Abeer Children Dental Anxiety Scale (ACDAS) and the others (1, 3, 5, 9). DAI-36 questionnaire is a one the more comprehensive tools which considers the range of dental anxiety and the multifaceted nature of dental anxiety (9, 10).

According to the literature, different factors associated with dental anxiety. Gender, age and the level of education were the significant factors on dental anxiety (1, 4, 5, 11). Women had more dental anxiety than men (4, 11, 12) also, with increasing age, dental anxiety decreased (1, 11). The level of education was not significant factor on dental anxiety (4, 5, 12). The difference of dental anxiety between groups may be reflect of the perception of individual of the items of questionnaire at the same level of the...
underlying dental anxiety. So, it is important to use valid psychometric properties tools to collect information with high quality (5). Traditional validation procedures have been applied on instruments such as criterion, structure, convergent and discriminant (5, 9–11). Deferential item functioning (DIF) is an alternative and complementary validation approach to explore the psychometric properties of instruments.

Construct-related validity as well as valid interpretation of group differences is important before making comparisons among individuals or groups by any psychological test (13). But these types of validity will be a threat when statements phrased in DAI-36 questionnaire have inequivalent meaning across respondents, regardless of their group membership. Therefore, the present study evaluated DIF items of DAI-36 across gender, age and level of education by the hybrid ordinal logistic regression (OLR/IRT) model.

**Material And Methods**

To evaluate dental anxiety, the code of ethics (Ir.bums.REC.1398.296) was obtained from Birjand University of Medical Sciences Ethics Committee. Then, we divided each of the cities of Birjand, Mashhad, and Shiraz into 4 geographical districts. And 80 households were randomly selected in each district and two randomly selected family members (one male and one female) were asked to complete the DAI-36 questionnaire and the initial information checklist (including age, education, and gender). Participants received explanations about the research and signed informed consent forms. The questionnaire for illiterate subjects was completed through interviews by interviewer. Finally, 10 incomplete questionnaires were excluded before data analysis. The Dental Anxiety Inventory was included 36 items on a 5-point scale that people rates their dental anxiety from 1 (totally untrue) to 5 (completely true) (14). High correlation between the DAI and Corah's Dental Anxiety Scale (DAS) supported convergent validity. The original DAI version also had discriminant validity, because of nonsignificant correlation with variables such as extroversion and small positive correlations with scales for neuroticism, anxiety, and fear. Marlies’ study also supported the construct validity of the DAI. The Persian version had also high internal consistency (Cronbach’s alpha = 0.94 and $r_{split-half} =0.95$) (15).

**Data analysis**

The ordinal logistic regression model (OLR) determined uniform and non-uniform DIF by comparing Models 1 and 2 and Models 2 and 3, respectively (16).
\logit [P(Y \leq k|g, \theta)] = \beta_{0k} + \beta_1 \theta + \beta_2 g \quad k = 0, 1, \ldots, m-1 \quad \text{(Model 1)}

\logit [P(Y \leq k|g, \theta)] = \beta_{0k} + \beta_1 \theta + \beta_2 g + \beta_3 \theta g \quad k = 0, 1, \ldots, m-1 \quad \text{(Model 3)}

In these formulas, \( m \), \( \theta \), and \( g \) were assumed to be the number of domains, ability score, and grouping variable, respectively. To adjusted the effect of biased item on DIF detection, an iterative hybrid ordinal logistic regression incorporates the Rasch trait score rather than the sum of score ability and using an iterative procedure to detect DIF items, as described previously (17).

In large sample size studies, the statistically significant \( \chi^2 \) test without using parallel DIF effect size measures might be misleading (18). So, we used Crane, van Belle and Larson criterion (CvBL) as uniform DIF effect size measure and McFadden pseudo R-square (\( \Delta R^2 \)) as both uniform and non-uniform DIF effect size measures (19, 20). McFadden pseudo-\( R^2 \) more than 0.070, and CvBL more than 0.01 considered large DIF measure in present article. So we focused on declaring the DIF items of the DAI-36 by the lordif package in R3.1.3 software (17). Finally, comparing between groups were analyzed by T-test and Mann-Whitney U test with and without DIF items.

**Results**

In this study, 950 of the respondents answer Dental Anxiety Inventory (492 male and 458 female). The mean ± SD ages of male and females were 33.1 ± 11.63 and 28.74 ± 9.28 years, respectively. Most of the participants were nongovernment employees (30.3% students, 28% government employee, and 41.7% nongovernment employee), lived in the city (80%), and had not academic degree (54.5%). In Table 1, the Confirmatory Factor Analysis (CFA) indices were reported for total DAI-36 score and each gender, education, and age category separately. As Table 1 clearly shows, Cronbach’s alpha, coefficient omega, and the Standardized Root Mean Squared Residuals (SRMR) were in acceptable range. But all other CFA indices with the exception of total Root Mean Squared Error of Approximate (RMSEA) were out of recommended range by Hu and Bentler (21, 22).
Table 1

The results of validity and reliability in each demographic factor category separately.

|                | Alpha<sup>a</sup> | Omega<sup>b</sup> | RMSEA<sup>c</sup> | SRMR<sup>d</sup> | CFI<sup>e</sup> | TLI<sup>f</sup> |
|----------------|-------------------|-------------------|-------------------|-----------------|-----------------|-----------------|
| **Gender**     |                   |                   |                   |                 |                 |                 |
| Male           | 0.97*             | 0.97*             | 0.066             | 0.052*          | 0.876           | 0.868           |
| Female         | 0.97*             | 0.97*             | 0.068             | 0.051*          | 0.871           | 0.863           |
| **Education**  |                   |                   |                   |                 |                 |                 |
| Non-academic   | 0.96*             | 0.98*             | 0.077             | 0.058*          | 0.830           | 0.820           |
| Academic       | 0.97*             | 0.98*             | 0.073             | 0.056*          | 0.859           | 0.851           |
| **Age**        |                   |                   |                   |                 |                 |                 |
| < 30           | 0.97*             | 0.98*             | 0.092             | 0.070*          | 0.786           | 0.773           |
| ≥ 30           | 0.97*             | 0.98*             | 0.086             | 0.063*          | 0.812           | 0.801           |
| **Total**      | 0.97*             | 0.97*             | 0.060<sup>+</sup> | 0.039*          | 0.899           | 0.893           |

* model fit indices acceptable range Hu and Bentler

<sup>a</sup> Cronbach’s alpha coefficient

<sup>b</sup> Guttman's Lambda 6 reliability

<sup>c</sup> Root Mean Squared Error of Approximate (RMSEA)

<sup>d</sup> Standardized Root Mean Squared Residual (SRMR)

<sup>e</sup> Comparative Fit Index (CFI)

<sup>f</sup> Tucker-Lewis Index (TLI)

**DIF analysis**

DIF analysis is provided across gender, education, and age groups in Tables 2. As the table clearly shows, the chi-square statistics declare 7, 7, and 4 non-uniform DIF items across these factors, respectively. But, $\Delta R^2$ was always lower than 0.008. The chi-square statistics also reported significant uniform DIF in items 1 and 8 across gender categories, items 9, 15, 20, 21, and 34 across education categories and items 22, 27, and 36 across age categories. However, none of $\Delta R_1$ was large ($\Delta R_1 \leq 0.48$). $\Delta \beta_1$ was significant in uniform DIF items across gender ($\Delta \beta_1$(item 1) = 0.0137, $\Delta \beta_1$(item 8) = 0.0124) and items 22 and 27 across age categories ($\Delta \beta_1$(item 22) = 0.0110, $\Delta \beta_1$(item 27) = 0.0136).
Table 2
The results of the hybrid OLR/IRT DIF analysis on the Dental Anxiety Inventory (DAI).

|                       | Non-uniform |       |       |       |       |
|-----------------------|-------------|-------|-------|-------|-------|
|                       | $\chi^2$(P) | $\Delta R_2$ | $\chi^2$(P) | $\Delta R_1$ | $\Delta \beta_1$ |
| **Gender**            |             |       |       |       |       |
| 1. I become nervous when the dentist invites me to sit down in the chair. | 0.351 (0.5534) | 0.0001 | 8.239 (0.0041*) | 0.0029 | 0.0137*
| 3. When I'm on my way to the dentist and thinking about the anaesthetic, I would rather go back. | 6.784 (0.0092*) | 0.0025 | 2.024 (0.1548) | 0.0007 | 0.0073
| 8. I already feel uncomfortable at home when I think that the dentist will make a remark about my teeth. | 0.394 (0.5303) | 0.0001 | 6.224 (0.0126*) | 0.0023 | 0.0124*
| 12. When I think of the moment when the dentist blows air into a cavity, I would like to cancel the appointment. | 6.582 (0.0103*) | 0.0024 | 0.4335 (0.5103) | 0.0002 | 0.0046
| 15. On my way to the dentist, I feel nervous when I know my teeth will be scaled. | 7.247 (0.0071*) | 0.0027 | 0.319 (0.5720) | 0.0001 | 0.0043
| 22. In the waiting room, I sweat or freeze when I think of sitting down in the dentist's chair. | 5.017 (0.0251*) | 0.0018 | 1.01 (0.3152) | 0.0004 | 0.0052
| 27. On my way to the dentist, I get anxious at the thought that she/he will have to drill. | 6.989 (0.0082*) | 0.0025 | 0.098 (0.7537) | 0.0000 | 0.0021
| 34. When I'm waiting for the dentist's assistant to call me in, I try to think of something else. | 4.762 (0.0291*) | 0.0018 | 2.701 (0.1003) | 0.0010 | 0.0127
| 36. I sleep badly the night before I have to have a tooth extracted. | 15.138 (0.0001*) | 0.0054 | 1.863 (0.1723) | 0.0007 | 0.0120
| **Education**         |             |       |       |       |       |
| 3. When I'm on my way to the dentist and thinking about the anaesthetic, I would rather go back. | 5.238 (0.0221*) | 0.0019 | 0.023 (0.8784) | 0.0000 | 0.0004
| 8. I already feel uncomfortable at home when I think that the dentist will make a remark about my teeth. | 5.360 (0.0206*) | 0.0020 | 1.064 (0.3023) | 0.0004 | 0.0014
| 9. When the dentist is about to give me an anaesthetic, I cling to the arms of the chair. | 0.102 (0.7500) | 0.0000 | 5.577 (0.0182*) | 0.0020 | 0.0078
|   | Non-uniform |   | Uniform |   |   |   |   |   |   |
|---|-------------|---|---------|---|---|---|---|---|---|
|   | $\chi^2(P)$ | $\Delta R_2$ | $\chi^2(P)$ | $\Delta R_1$ | $\Delta \beta_1$ |
| 10. | I become afraid in the waiting room when I hear sounds coming from the dentist's surgery. | 7.0102 (0.0077*) | 0.0025 | 1.789 (0.1810) | 0.0006 | 0.0016 |
| 14. | I want to walk out of the waiting room the moment I think the dentist will not explain what she/he is going to do in my mouth. | 6.371 (0.0116*) | 0.0023 | 0.202 (0.6531) | 0.0001 | 0.0011 |
| 15. | On my way to the dentist, I feel nervous when I know my teeth will be scaled. | 12.532 (0.0004*) | 0.0048 | 6.013 (0.0142*) | 0.0023 | 0.0076 |
| 20. | Before going to the dentist, I get palpitations when I think of how the dentist will be displeased at my teeth. | 2.188 (0.1391) | 0.0008 | 5.586 (0.0181*) | 0.0020 | 0.0097 |
| 21. | As soon as the dentist gets his/her needle ready for the anaesthetic, I shut my eyes tight. | 0.494 (0.4820) | 0.0002 | 4.774 (0.0289*) | 0.0017 | 0.0083 |
| 34. | When I'm waiting for the dentist's assistant to call me in, I try to think of something else. | 1.371 (0.2417) | 0.0005 | 5.636 (0.0176*) | 0.0021 | 0.0019 |
| 35. | On my way to the dentist, the idea of being in the chair already makes me nervous. | 4.750 (0.0293*) | 0.0018 | 0.397 (0.5285) | 0.0001 | 0.0018 |
| 36. | I sleep badly the night before I have to have a tooth extracted. | 5.511 (0.0189*) | 0.0019 | 1.054 (0.3047) | 0.0004 | 0.0020 |

**Age**

|   |   |   |   |   |
|---|---|---|---|---|
| 2. | I need to go to the toilet more often when I sit in the waiting room thinking that the dentist will say my teeth look bad. | 4.923 (0.0265*) | 0.0018 | 13.070 (0.0003*) | 0.0048 | 0.0042 |
| 11. | On my way to the dentist, I sweat or freeze at the thought that the dentist will say I brush my teeth badly. | 15.138 (0.0001*) | 0.0071 | 0.670 (0.4130) | 0.0002 | 0.0040 |
| 22. | In the waiting room, I sweat or freeze when I think of sitting down in the dentist's chair. | 0.282 (0.5952) | 0.0001 | 5.447 (0.0196*) | 0.0020 | 0.0110* |
| 26. | In the waiting room, I feel nervous at the thought that the dentist will say my teeth are badly brushed. | 5.596 (0.0180*) | 0.0020 | 0.735 (0.3913) | 0.0003 | 0.0042 |
|   | Non-uniform | uniform |
|---|-------------|---------|
| 27. | On my way to the dentist, I get anxious at the thought that she/he will have to drill. | $\chi^2(P) = 0.053$ (0.8187) | $\Delta R_2 = 0.0000$ | $\chi^2(P) = 7.033$ (0.0080*) | $\Delta R_1 = 0.0025$ | $\Delta \beta_1 = 0.0136*$ |
| 29. | When I am sitting in the dentist's chair not knowing what is going on in my mouth, I break into a cold sweat. | $\chi^2(P) = 15.138$ (0.0001*) | $\Delta R_2 = 0.0063$ | $\chi^2(P) = 0.065$ (0.7993) | $\Delta R_1 = 0.0000$ | $\Delta \beta_1 = 0.0006$ |
| 36. | I sleep badly the night before I have to have a tooth extracted. | $\chi^2(P) = 2.193$ (0.1386) | $\Delta R_2 = 0.0008$ | $\chi^2(P) = 4.168$ (0.0412*) | $\Delta R_1 = 0.0015$ | $\Delta \beta_1 = 0.0083$ |

* items showing uniform or non-uniform DIF; P: p-value of Chi-square statistic; 

$\chi^2$: the value of the difference in -2 log likelihood of models with and without group variable G for uniform DIF and models with and without interaction $\theta G$ for non-uniform DIF 

$\Delta \beta_1$: Crane van Belle and Larson criterion or $|\beta_1 (\text{Model without } G) - \beta_1 (\text{Model with } G)|/\beta_1 (\text{Model without } G)$

$\Delta R_1 = 1 - \ln[L(\text{Model with } G)]/\ln[L(\text{Model without } G)]$; $\Delta R_2 = 1 - \ln[L(\text{Model with } G)]/\ln[L(\text{Model without } G)]$

Figure 1 shows additive or cancel out effect of uniform DIF items in all study variables. For comfortable imaging, test characteristic curve were presented in separate line for each variable (Fig. 1). In first row, uniform DIF items show additive effect across gender groups. However, items 1 and 8 had not important effect in valid interpretation of group differences according to very small $\Delta R_1$ in Table 2. In academic degree status, items 34 and 9 cancel out each other, but items 15, 20 and 21 go in one direction. But small DIF magnitude in both $\Delta R_1$ and $\Delta \beta_1$ cannot change group comparison between people with and without academic degree. In third row of Fig. 1, only non-significant item 2 is in the opposite direction of items 22, 27, and 36, but this additive effect was not important in assessing age groups difference because of very small $\Delta R_1$ (range 0.0015–0.0025).

To assess whether uniform DIF items affected valid interpretation of group differences, gender, education and age groups were compared in Table 3. With and without uniform DIF items, the difference between male and female was not significant as well as group difference of academic and non-academic people. About age groups, older people also scores DAI-36 higher than younger ones with and without uniform DIF items (p-value ≤ 0.001). And these findings approve result of Fig. 1 and Table 2.
Table 3
The results of comparing group differences with and without uniform DIF items

|                          | Total score |                      | Total score corrected for DIF |                      |
|--------------------------|-------------|-----------------------|------------------------------|----------------------|
|                          | Mean (SD)   | P-value\(^{+}\)       | Mean (SD)                    | P-value\(^{+}\)      |
| **Gender\(^{a}\)**      |             |                       |                              |                      |
| Male                     | 2.765 (0.745) | 0.269                 | 2.759 (0.745)               | 0.318                |
| Female                   | 2.712 (0.725) |                       | 2.711 (0.725)               |                      |
| **Education\(^{b}\)**   |             |                       |                              |                      |
| Non-academic             | 2.700 (0.719) | 0.070\(^{#}\)        | 2.684 (0.726)               | 0.108                |
| Academic                 | 2.787 (0.753) |                       | 2.770 (0.756)               |                      |
| **Age\(^{c}\)**         |             |                       |                              |                      |
| < 30                     | 2.603 (0.707) | \(< 0.001\)          | 2.609 (0.715)               | \(< 0.001\)         |
| ≥ 30                     | 2.906 (0.736) |                       | 2.913 (0.730)               |                      |

\(^{#}\) P-value of independent samples T test

\(^{+}\) P-value of Mann-Whitney U test

\(^{a}\) Total score after removing uniform DIF items 1 and 8

\(^{a}\) Total score after removing uniform DIF items 9, 15, 20, 21, and 34

\(^{c}\) Total score after removing uniform DIF items 2, 22, 27, and 36

**Discussion**

The purpose of this study was to evaluate the psychometric properties of the DAI-36 questionnaire by hybrid ordinal logistic regression (OLR/IRT) model and assess whether perceive the meaning of items in the DAI-36 questionnaire differently across gender, age and education categories.

Gender DIF analysis identified two significant uniform DIF items. This two uniform DIF items indicated females often overestimate dental anxiety than males. Regarding in items 1 and 8 of the questionnaire “I become nervous when the dentist invites me to sit down in the chair” and “I already feel uncomfortable at home when I think that the dentist will make a remark about my teeth”, in several culture, females were over-represented in physiological conditions involving anxiety, worry and fear (9, 23) This could possibly be explained by the fact that although females are more sensitive about oral health but caries tooth loss were slightly more prevalent among them (24), and they had phobia prior to dental treatment of local anaesthetic injection and tooth drilled, also they reported lower pain thresholds (1).

Gender was not a significant factor on dental anxiety in present of DIF items. To handle DIF items, there are different approaches (25) that delete items approach was used in this study, after removing two uniform DIF items, the mean dental anxiety of females and males still was not significant difference. In some previous researches, females had more dental anxiety than males (4, 6, 9, 11, 12, 26), whereas in
some studies, total score of dental anxiety was not statistically significant difference between female and males that is in line with this study (1, 5, 27).

Education DIF analysis identified five significant uniform DIF items. Items 9, 20 and 21 of the questionnaire were additive uniform DIF. Although academic group overestimate dental anxiety than non-academic but these DIF magnitude were small so perceive the meaning of these items between academic and non-academic groups consistently. The total score of DAI-36 questionnaire was not statistically significant difference between academic and non-academic groups. However, after removing uniform DIF items, the mean dental anxiety of academic and non-academic was not significant difference. This is in accordance with previous results showing level of education was not significant factor on dental anxiety (4, 5, 27–29).

This study revealed that individual with age > 30 and age < 30 respond differently to 4 items in the DAI-36 questionnaire. The considerable uniform DIF magnitude was found in items 22 and 27 of the questionnaire. The individual > 30 years old overestimate dental anxiety than < 30 years old. Regarding in item 22 of the questionnaire “In the waiting room, I sweat or freeze when I think of sitting down in the dentist’s chair.”, this could possibly be explained that with increasing age compatibility is decreased and older may be have some disabilities so they reported more their anxiety of the time length of the waiting room. In a study, about 17% of adult reported exacerbated dental anxiety in the waiting room of a clinic (12).

In item 27 of the questionnaire “On my way to the dentist, I get anxious at the thought that she/he will have to drill”, it was found that older possibility concerned about many and large dental problems therefore they had more reported phobia of tooth drilled. Age was the significant factors on dental anxiety with and without DIF items, the individual greater than 30 years old had more dental anxiety than individual less than 30 years old. This could possibly be explained by older patients had referred a dentist with a bad dental experience commonly therefore their dental anxiety was higher than younger. Similar studies showed dental anxiety in patients in the 35 to 49 year was the highest (30) and in adults 31–35 years was high and decreased after 60 years old (31). In some previous studies, younger age group had the highest dental anxiety scores than older age group (11, 32) that this finding contradictory with our study.

Finally, this is the first study to evaluate DIF items of DAI-36 questionnaire across gender, age and level of education using hybrid ordinal logistic regression (OLR/IRT) model. So, other studies in different cultures can help us to insure good validity of this questions for different translations.

Conclusions

In conclusion, our study revealed some items in the DAI-36 questionnaire did not function in a similar way across females and males and different level of age. The validation of the questionnaire was not affected by uniform DIF items. The management of the patients’ dental anxiety is important because lead to avoidance of dental treatment, therefore may be causes poor oral health and oral health–related
quality of life. Moreover, professionals and clinicians should be cautious about ensure the comfortable of patient for dental proceed especially in older persons.

Declarations

Ethics approval and consent to participate

This article had ethics code IR.BUMS.REC.1398.296 and approved from Birjand University of Medical Sciences Ethics Committee. All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all subjects and for illiterate subject, informed consent was obtained from legally representative or caregivers.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no conflict of interest.

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Author’s contributions

Dr. Elahe Allahyari: Concept, design, literature search, data collection and analysis, manuscript writing. Dr. Narges Roustaei: Literature search, statistical analysis, manuscripts preparing, manuscript editing and review. All authors read and approved the final manuscript.

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**Figures**

![Test characteristic curve of DIF items for gender, education, and age groups](image)

**Figure 1**

Test characteristic curve of DIF items for gender (male (solid line), female (dashed line)), education (non-academic (solid line), academic (dashed line)), and age (<30 (solid line), ≥30 (dashed line)) groups according to the hybrid OLR/IRT.