Estimating theta using existing item parameters with flexMIRT® software

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flexMIRT®, the "most advanced IRT software available" (Cai, 2013; Houts & Cai, 2013): https://www.vpgcentral.com/software/irt-software/, can be used to estimate theta using existing item parameters. This memo briefly summarizes what is needed to use this software to estimate theta.

The Appendix provides example input files needed to estimate theta for the PROMIS GI reflux scale (Spiegel et al., 2014):

- *reflux13-prm.txt* (item names, number of response options, item parameters)
- *reflux13.dat* (data analyzed)
- *flexMIRTscoring_reflux13.flexmirt* (specifications for scoring)
- *flexMIRTscoring_reflux13-ssc.txt* (IRT output)
- *flexMIRTscoring_reflux13-sco.txt* (z-score output)

The GI reflux scale has 13 items and was calibrated using a graded response model. The *reflux13-prm.txt* file provides the number of response categories and the item parameters (threshold parameters followed by the discrimination parameter). The raw data input file (*reflux13.dat*) begins with the ID (flexMIRT can only accommodate a single ID variable so one might wish to do something analogous to what we did—that is, combine ID with event code--to uniquely identify a case), followed by responses to the 13 items (note that -9 is used to denote missing data). Raw data needs to begin with "0" to represent the lowest response category. The *flexMIRTscoring_reflux13.flexmirt* file indicates the location of the raw data input file and provides instructions on how to score the data. IRT output is provided in

flexMIRTscoring_reflux13-ssc.txt and the theta estimates are given in *flexMIRTscoring_reflux13-sco.txt*. The sco.txt file includes the ID, theta, and the standard error of theta. Note that theta is output as a z-score. If you want to express the score on a T-score metric you need to transform it linearly using: T = 50 + (z-score *10).

References

Cai, L. (2013). flexMIRT® version 2: Flexible multilevel multidimensional item analysis and test scoring [Computer software]. Chapel Hill, NC: Vector Psychometric Group.

Houts, C. R., & Cai, L. (2013). flexMIRT® user's manual version 2: Flexible multilevel multidimensional item analysis and test scoring. Chapel Hill, NC: Vector Psychometric Group.

Spiegel, B., Hays, R. D., Bolus, R., Melmed, G. Y., Chang, L., Whiteman, C., Khanna, P. P., Paz, S. H., Hays, T., Reise, S., & Khanna, D. (2014). Development of the NIH Patient Reported Outcomes Measurement Information System (PROMIS®) Gastrointestinal Symptom Scales. American Journal of Gastroenterology. 109(11), 1804-14.

Appendix

reflux13-prm.txt

```
1       GISX02  1       1       2       5       0.2819  1.0126  1.7374  2.1730  2.7323
1       GISX03  1       1       2       5       -1.2538 1.4683  2.5384  3.3943  1.3433
1       GISX09  1       1       2       5       0.1641  0.9542  1.8650  2.6277  3.72
1       GISX10  1       1       2       5       -0.2183 1.0840  2.0188  2.6815  1.3281
1       GISX11  1       1       2       5       0.3131  1.1842  1.8511  2.2681  3.1623
1       GISX12  1       1       2       5       0.0948  1.0709  2.2040  3.3646  1.4578
1       GISX14  1       1       2       5       -1.0782 0.7093  2.0314  2.7013  1.3419
1       GISX21  1       1       2       5       0.0958  0.7960  1.6433  2.5443  2.868
1       GISX22  1       1       2       4       -2.6726 -0.6899 1.5410  0.7529
1       GISX24  1       1       2       5       0.3428  1.2668  1.9401  2.5744  1.969
1       GISX25  1       1       2       5       -0.4166 1.7500  3.5979  5.3608  0.9021
1       GISX28  1       1       2       5       0.3049  1.0086  1.9555  2.5836  1.9526
1       GISX30  1       1       2       5       -0.3474 1.1196  2.0808  2.9458  1.511
0       Group1  1       1       0       0       1
```

Commented [d1]: 1 = row provides item information
0 = row provides group information

Commented [d2]: Variable name.

Commented [d3]: 1st group.

Commented [d4]: 1 latent variable.

Commented [d5]: 1 = 3PL, 2 = graded response, 3 = nominal model

Commented [d6]: 5 response categories

Commented [d7]: Item intercepts by default, but "SlopeThreshold" option in "flexMIRTscoring_reflux13.fliexmirt" file below specificies thresholds instead. So these are thresholds.

Commented [d8]: Item discrimination.

Commented [d9]: Group label.

Commented [d10]: 1st group.

Commented [d11]: 1 latent variable

Commented [d12]: 0 = normal prior, 1 = empirical histogram

Commented [d13]: latent variable mean.

Commented [d14]: Latent variable SD.

reflux13.dat (example data input)

```
001-026-09 3 1 3 3 1 3 4 3 1 1 0 3 -9
001-028-05 -9 2 3 3 -9 2 0 1 0 0 0 0 -9
```

flexMIRTscoring_reflux13.flexmirt

```
<Project>
  Title = "GI Reflux";
  Description = "PROMIS GI Reflux Scale";
<Options>
  Mode = Scoring;
  ReadPRMFile = "C:\PROMIS_GI\flexmirt\reflux13-prm.txt";
  Score = EAP;
  SlopeThreshold = Yes;
  saveSCO=YES;
<Groups>
  %Group1%
  File = "C:\PROMIS_GI\flexmirt\reflux13.dat";
  Varnames = ID,GISX02,GISX03,GISX09,GISX10,
  GISX11,GISX12,GISX14,GISX21,GISX22,
  GISX24,GISX25,GISX28,GISX30;
  Select = GISX02,GISX03,GISX09,GISX10,
  GISX11,GISX12,GISX14,GISX21,GISX22,
  GISX24,GISX25,GISX28,GISX30;
  CaseID = ID;
  N = 88;
<Constraints>
```

flexMIRTscoring_reflux13-ssc.txt

```
flexMIRT(R) Engine Version 3.03 (64-bit)
Flexible Multilevel Multidimensional Item Response Modeling and Test Scoring
(C) 2013-2015 Vector Psychometric Group, LLC., Chapel Hill, NC, USA

GI Reflux
PROMIS GI Reflux Scale

Summary of the Data and Dimensions
   Missing data code        -9
     Number of Items        13
     Number of Cases        88
 # Latent Dimensions         1

Item  Categories       Model
   1           5      Graded
   2           5      Graded
   3           5      Graded
   4           5      Graded
   5           5      Graded
   6           5      Graded
   7           5      Graded
   8           5      Graded
   9           4      Graded
  10           5      Graded
  11           5      Graded
  12           5      Graded
  13           5      Graded

Scoring Control Values
Response pattern EAPs are computed

Miscellaneous Control Values

Output Files
Text results and control parameters: flexMIRTscoring_reflux13-ssc.txt
Text scale score file: flexMIRTscoring_reflux13-sco.txt

GI Reflux
PROMIS GI Reflux Scale

Graded Items for Group 1: Group1
    Item       a     c 1     c 2     c 3     c 4
       1    2.73   -0.77   -2.77   -4.75   -5.94
       2    1.34    1.68   -1.97   -3.41   -4.56
       3    3.72   -0.61   -3.55   -6.94   -9.78
       4    1.33    0.29   -1.44   -2.68   -3.56
       5    3.16   -0.99   -3.74   -5.85   -7.17
       6    1.46   -0.14   -1.56   -3.21   -4.90
       7    1.34    1.45   -0.95   -2.73   -3.62
       8    2.87   -0.27   -2.28   -4.71   -7.30
       9    0.75    2.01    0.52   -1.16
      10    1.97   -0.67   -2.49   -3.82   -5.07
      11    0.90    0.38   -1.58   -3.25   -4.84
      12    1.95   -0.60   -1.97   -3.82   -5.04
      13    1.51    0.52   -1.69   -3.14   -4.45

Graded Items for Group 1: Group1
    Item       a     b 1     b 2     b 3     b 4
       1    2.73    0.28    1.01    1.74    2.17
       2    1.34   -1.25    1.47    2.54    3.39
       3    3.72    0.16    0.95    1.87    2.63
       4    1.33   -0.22    1.08    2.02    2.68
       5    3.16    0.31    1.18    1.85    2.27
       6    1.46    0.09    1.07    2.20    3.36
       7    1.34   -1.08    0.71    2.03    2.70
       8    2.87    0.10    0.80    1.64    2.54
       9    0.75   -2.67   -0.69    1.54
      10    1.97    0.34    1.27    1.94    2.57
      11    0.90   -0.42    1.75    3.60    5.36
      12    1.95    0.30    1.01    1.96    2.58
      13    1.51   -0.35    1.12    2.08    2.95

GI Reflux
```

Commented [d15]: http://www.healthmeasures.net/resource-center/measurement-science/item-response-theory

Commented [d16]: Intercepts
c= --a*b

Commented [d17]: thresholds
b=- c/a

PROMIS GI Reflux Scale

Group Parameter Estimates:

Group	Label	mu	s2	sd
1	Group1	0.00	1.00	1.00

GI Reflux
PROMIS GI Reflux Scale

Item Information Function Values at 15 Values of theta from -2.80 to 2.80 for Group 1: Group1

		Theta:														
Item	Label	-2.8	-2.4	-2.0	-1.6	-1.2	-0.8	-0.4	-0.0	0.4	0.8	1.2	1.6	2.0	2.4	2.8
1	GISX02	0.00	0.00	0.01	0.04	0.13	0.35	0.87	1.65	2.11	2.19	2.21	2.24	2.24	1.78	0.97
2	GISX03	0.18	0.26	0.36	0.43	0.46	0.44	0.40	0.37	0.38	0.43	0.49	0.53	0.55	0.56	0.56
3	GISX09	0.00	0.00	0.00	0.02	0.09	0.36	1.35	3.20	3.53	3.64	3.34	3.30	3.69	3.58	3.17
4	GISX10	0.05	0.09	0.14	0.21	0.30	0.39	0.47	0.51	0.53	0.54	0.55	0.55	0.55	0.53	0.49
5	GISX11	0.00	0.00	0.01	0.02	0.08	0.28	0.86	1.99	2.67	2.59	2.85	2.91	3.03	2.55	1.33
6	GISX12	0.03	0.05	0.09	0.15	0.24	0.36	0.48	0.58	0.63	0.65	0.65	0.65	0.65	0.65	0.64
7	GISX14	0.15	0.22	0.32	0.41	0.47	0.49	0.50	0.50	0.52	0.53	0.54	0.55	0.55	0.54	0.50
8	GISX21	0.00	0.01	0.02	0.06	0.19	0.54	1.30	2.13	2.37	2.38	2.26	2.32	2.21	2.22	1.83
9	GISX22	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.15	0.13	0.12
10	GISX24	0.01	0.02	0.04	0.08	0.17	0.33	0.60	0.89	1.09	1.15	1.19	1.21	1.21	1.16	0.98
11	GISX25	0.08	0.10	0.13	0.16	0.18	0.21	0.22	0.23	0.24	0.24	0.24	0.24	0.25	0.25	0.25
12	GISX28	0.01	0.02	0.04	0.09	0.18	0.36	0.62	0.91	1.10	1.16	1.16	1.15	1.17	1.13	0.97
13	GISX30	0.05	0.09	0.16	0.26	0.39	0.52	0.61	0.64	0.65	0.67	0.69	0.70	0.71	0.70	0.67
Test Information:		1.72	2.04	2.48	3.11	4.06	5.82	9.44	14.78	16.99	17.35	17.33	17.53	17.96	16.78	13.47
Expected s.e.:		0.76	0.70	0.63	0.57	0.50	0.41	0.33	0.26	0.24	0.24	0.24	0.24	0.24	0.24	0.27

Marginal reliability for response pattern scores: 0.88

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flexMIRTscoring_reflux13-sco.txt (example data output)

```
  1       1 001-026-09      1.682786     0.251195
  1       2 001-028-05      0.654112     0.364532
  1       3 001-029-05      1.876118     0.256452
  1       4 001-029-06      1.465449     0.268183
  1       5 001-030-05      1.376503     0.249393
  1       6 001-030-06      0.996224     0.310618
  1       7 002-002-05      0.320123     0.237148
  1       8 002-002-06      0.515149     0.244667
  1       9 002-003-05      0.841432     0.243315
  1      10 002-004-05      0.979630     0.243255

Columns:
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Note that in this example:

Column	Variable
3	Group #
10-11	Observation #
13-19	ID
21-22	Event Code
29-36	z-score
42-49	SE of z-score

The event codes are shown below.

event	redcap_event_name
01	SIBO Baseline (Arm 3: SIBO)
02	SIBO 4 week Follow up (Arm 3: SIBO)
03	Constipation Baseline (Arm 4: Constipation)
04	Constipation 12 week Follow Up (Arm 4: Constipation)
05	GERD Baseline (Arm 1: GERD)
06	GERD 4 week Follow Up (Arm 1: GERD)
07	FI Baseline (Arm 5: Fecal Incontinence (FI))
09	Gastroparesis Baseline (Arm 2: Gastroparesis)
10	Gastroparesis 4 week Follow up (Arm 2: Gastroparesis)

Commented [d18]: Note that the contents of the file are above. The columns are shown so the reader can see the location of the elements of the output.