Evaluating Multi-Item Scales Using Item-Scale Correlations and Confirmatory Factor Analysis

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Drew Cobb Room 131/Broxton 2nd Floor Conference Room

http://gim.med.ucla.edu/FacultyPages/Hays/

Development and Evaluation of PROMIS GI Distress Scale (n = 574)

- Dinesh Khanna and Brennan Spiegel, PIs
- Irritable Bowel Syndrome, Irritable Bowel Disease, Scleroderma
- 61% female; median age = 48 (18-85 yr. range)
- Some college = median educational level
- Race/ethnicity
  - 13% Hispanic
  - 17% non-Hispanic black
  - 12% non-Hispanic Asian
  - 5% non-Hispanic other

8 Hypothesized Scales (101 items)

1. Gastroesphageal reflux (29 items)
2. Disrupted swallowing (7 items)
3. Diarrhea (7 items)
4. Bowel incontinence/soilage (4 items)
5. Nausea and vomiting (13 items)
6. Constipation (15 items)
7. Belly pain (8 items)
8. Gas/bloat/flatulence (18 items)

Gastroesphageal Reflux (29 items)

In the past 7 days …

- How often did you have regurgitation—that is, food or liquid coming back up into your throat or mouth without vomiting?
  - Never
  - One day
  - 2-6 days
  - Once a day
  - More than once a day

Disrupted swallowing (7 items)

In the past 7 days …

- How often did food get stuck in your throat when you were eating?
  - Never
  - Rarely
  - Sometimes
  - Often
  - Always

Diarrhea (7 items)

In the past 7 days …

- How many days did you have loose or watery stools?
  - No days
  - 1 day
  - 2 days
  - 3-5 days
  - 6-7 days

Bowel incontinence (4 items)

In the past 7 days …

- How often did you have bowel incontinence—that is, have an accident because you could not make it to the bathroom in time?
  - No days
  - 1 day
  - 2-3 days
  - 4-5 days
  - 6-7 days

Nausea and vomiting (13 items)

In the past 7 days …

- How often did you have nausea—that is, a feeling like you could vomit?
  - Never
  - Rarely
  - Sometimes
  - Often
  - Always

Constipation (14 items)

In the past 7 days …

- How often did you strain while trying to have bowel movements?
  - Never
  - Rarely
  - Sometimes
  - Often
  - Always

Belly pain (8 items)

In the past 7 days …

- How often did you have belly pain?
  - Never
  - Rarely
  - Sometimes
  - Often
  - Always

Gas/bloat/flatulence (18 items)

In the past 7 days …

- How often did you feel bloated?
  - Never
  - Rarely
  - Sometimes
  - Often
  - Always

Problematic Item*

Constipation (Gisx62)

In the last 7 days …

How often did you have a bowel movement?

- Never {3}
- One day {2}
- 2-6 days {1}
- Once a day {1}
- More than once a day {1}

Problematic Item #2

Gastroesphageal Reflux (Gisx22)

In the last 7 days …

How often did you burp?

- Never {1}
- One day {2}
- 2-6 days {3}
- Once a day {3}
- More than once a day {4}

Problematic Item #3

Gas/Bloat/Flatulence (Gisx105)

In the last 7 days …

How often did you pass gas?

- Never {1}
- Rarely (only once or twice a day) {2}
- About every 3-4 hours {3}
- About every 2 hours {4}
- About every hour {4}

Internal Consistency Reliability for 8 Scales (101 items)

Scale	Number of items	Alpha
Gastroesphageal Reflux	29	0.94
Disrupted swallowing	7	0.90
Diarrhea	7	0.89
Bowel incontinence	4	0.87
Nausea/vomiting	13	0.93
Constipation	14	0.93
Belly pain	8	0.93
Gas/bloat	18	0.96

Reliability Standards:

0.70 or above for group comparisons; 0.90 for individual assessment

How often did you have a bowel movement? did not go with *Constipation* scale.

Item-scale correlation matrix

	Depress	Anxiety	Anger
Item #1	0.80*	0.20	0.20
Item #2	0.80*	0.20	0.20
Item #3	0.80*	0.20	0.20
Item #4	0.20	0.80*	0.20
Item #5	0.20	0.80*	0.20
Item #6	0.20	0.80*	0.20
Item #7	0.20	0.20	0.80*
Item #8	0.20	0.20	0.80*
Item #9	0.20	0.20	0.80*

*Item-scale correlation, corrected for overlap.

16

Item-scale correlation matrix

	Depress	Anxiety	Anger
Item #1	0.50*	0.50	0.50
Item #2	0.50*	0.50	0.50
Item #3	0.50*	0.50	0.50
Item #4	0.50	0.50*	0.50
Item #5	0.50	0.50*	0.50
Item #6	0.50	0.50*	0.50
Item #7	0.50	0.50	0.50*
Item #8	0.50	0.50	0.50*
Item #9	0.50	0.50	0.50*

*Item-scale correlation, corrected for overlap.

17

MULTI -- MULTITRAIT SCALING PROGRAM: gisx105rec item-scale correlations based on separate MULTI.
SAMPSIZE = 573 SEOFCORR = 0.04

item	Gastro	Disrup	Diarr	Bowel	Nause	Consti	Belly	Gas
gisx2	0.70*	0.50	0.18	0.15	0.52	0.23	0.30	0.29
gisx3	0.59*	0.40	0.18	0.17	0.55	0.19	0.31	0.29
gisx4	0.63*	0.49	0.14	0.15	0.50	0.17	0.22	0.22
gisx5	0.65*	0.52	0.11	0.18	0.39	0.20	0.22	0.22
gisx6	0.71*	0.52	0.20	0.17	0.55	0.19	0.27	0.31
gisx7	0.66*	0.48	0.12	0.19	0.42	0.17	0.18	0.20
gisx8	0.74*	0.54	0.19	0.18	0.54	0.24	0.28	0.31
gisx9	0.75*	0.59	0.21	0.17	0.54	0.30	0.31	0.30
gisx10	0.51*	0.42	0.16	0.13	0.33	0.19	0.20	0.14
gisx11	0.68*	0.51	0.11	0.11	0.41	0.22	0.23	0.26
gisx12	0.42*	0.31	0.09	0.11	0.35	0.25	0.21	0.18
gisx13	0.71*	0.55	0.15	0.12	0.40	0.27	0.28	0.31
gisx14	0.65*	0.48	0.13	0.12	0.38	0.26	0.30	0.31
gisx15	0.72*	0.52	0.15	0.15	0.45	0.30	0.34	0.39
gisx16	0.74*	0.51	0.14	0.15	0.44	0.28	0.35	0.36
gisx17	0.56*	0.43	0.07	0.05	0.35	0.26	0.21	0.31
gisx18	0.70*	0.50	0.11	0.11	0.40	0.28	0.25	0.35
gisx19	0.71*	0.50	0.14	0.16	0.40	0.28	0.31	0.37
gisx20	0.44*	0.25	0.12	0.07	0.25	0.11	0.21	0.24
gisx21	0.74*	0.60	0.15	0.16	0.40	0.21	0.30	0.32
gi22rec	0.30*	0.22	0.09	0.05	0.19	0.11	0.12	0.19
gisx23	0.57*	0.39	0.14	0.13	0.39	0.23	0.20	0.31
gisx24	0.59*	0.43	0.14	0.07	0.44	0.31	0.23	0.34
gisx25	0.41*	0.29	0.12	0.19	0.26	0.19	0.15	0.19
gisx26	0.42*	0.29	0.17	0.15	0.36	0.20	0.15	0.19
gisx27	0.46*	0.28	0.11	0.11	0.31	0.19	0.16	0.20
gisx28	0.63*	0.64	0.11	0.13	0.36	0.28	0.25	0.28
gisx29	0.62*	0.62	0.18	0.20	0.42	0.27	0.23	0.27
gisx30	0.63*	0.63	0.14	0.13	0.39	0.27	0.24	0.27
gisx31	0.59	0.71*	0.13	0.18	0.37	0.26	0.18	0.19
gisx32	0.60	0.80*	0.14	0.24	0.38	0.27	0.18	0.25
gisx33	0.68	0.68*	0.14	0.18	0.41	0.32	0.29	0.29
gisx34	0.60	0.81*	0.15	0.26	0.37	0.25	0.18	0.23
gisx35	0.56	0.74*	0.13	0.26	0.35	0.22	0.17	0.25
gisx36	0.56	0.70*	0.09	0.19	0.31	0.24	0.18	0.21
gisx37	0.48	0.62*	0.09	0.19	0.32	0.24	0.16	0.23
gisx38	0.06	0.02	0.69*	0.34	0.20	0.04	0.26	0.18
gisx39	0.06	0.05	0.63*	0.39	0.20	0.11	0.24	0.17
gisx40	0.23	0.14	0.84*	0.46	0.37	0.22	0.40	0.33
gisx41	0.20	0.13	0.83*	0.40	0.34	0.21	0.37	0.31
gisx42	0.20	0.17	0.71*	0.51	0.26	0.20	0.32	0.27
gisx43	0.26	0.20	0.82*	0.47	0.33	0.28	0.38	0.36
gisx44	0.23	0.19	0.80*	0.44	0.32	0.29	0.37	0.34
gisx45	0.13	0.19	0.42	0.76*	0.22	0.10	0.08	0.12
gisx46	0.15	0.23	0.46	0.84*	0.20	0.10	0.04	0.11
gisx47	0.13	0.21	0.41	0.80*	0.17	0.07	0.03	0.09
gisx48	0.28	0.28	0.49	0.60*	0.28	0.19	0.19	0.27

item	Gastro	Disrup	Diarr	Bowel	Nause	Consti	Belly	Gas
gisx49	0.52	0.39	0.30	0.19	0.79*	0.31	0.46	0.37
gisx50	0.51	0.35	0.30	0.16	0.84*	0.32	0.48	0.38
gisx51	0.53	0.35	0.31	0.16	0.82*	0.32	0.49	0.36
gisx52	0.45	0.37	0.23	0.17	0.73*	0.27	0.33	0.31
gisx53	0.52	0.36	0.35	0.16	0.84*	0.35	0.46	0.41
gisx54	0.52	0.35	0.32	0.15	0.84*	0.34	0.49	0.40
gisx55	0.39	0.34	0.31	0.25	0.52*	0.28	0.35	0.30
gisx56	0.40	0.32	0.19	0.21	0.59*	0.21	0.25	0.18
gisx57	0.43	0.34	0.21	0.22	0.63*	0.26	0.26	0.23
gisx58	0.46	0.37	0.20	0.21	0.63*	0.26	0.29	0.25
gisx59	0.47	0.29	0.16	0.18	0.62*	0.15	0.26	0.21
gisx60	0.49	0.31	0.22	0.21	0.67*	0.18	0.28	0.25
gisx61	0.41	0.26	0.21	0.21	0.61*	0.11	0.24	0.23
gisx63	0.22	0.19	-.04	-.00	0.13	0.44*	0.17	0.21
gisx64	0.31	0.29	0.02	0.01	0.22	0.66*	0.32	0.38
gisx65	0.24	0.24	0.09	0.05	0.25	0.74*	0.32	0.35
gisx66	0.25	0.25	0.08	0.04	0.25	0.78*	0.33	0.35
gisx67	0.23	0.22	0.14	0.05	0.25	0.82*	0.37	0.40
gisx68	0.28	0.26	0.21	0.11	0.26	0.79*	0.34	0.37
gisx69	0.29	0.27	0.23	0.09	0.27	0.78*	0.38	0.37
gisx70	0.31	0.25	0.24	0.12	0.30	0.79*	0.39	0.39
gisx71	0.28	0.26	0.24	0.08	0.27	0.82*	0.37	0.37
gisx72	0.24	0.22	0.30	0.16	0.27	0.63*	0.42	0.44
gisx73	0.24	0.17	0.36	0.15	0.31	0.68*	0.45	0.50
gisx74	0.27	0.30	0.17	0.25	0.25	0.43*	0.18	0.23
gisx75	0.24	0.17	0.20	0.21	0.29	0.48*	0.25	0.24
gisx76	0.25	0.18	0.21	0.16	0.30	0.53*	0.26	0.31
gisx77	0.34	0.23	0.35	0.09	0.42	0.41	0.89*	0.55
gisx78	0.25	0.15	0.31	0.09	0.39	0.33	0.81*	0.49
gisx79	0.36	0.21	0.37	0.08	0.45	0.39	0.87*	0.53
gisx80	0.37	0.23	0.35	0.06	0.46	0.43	0.89*	0.52
gi8189ct	0.31	0.21	0.29	0.04	0.33	0.31	0.72*	0.49
gisx90	0.35	0.21	0.44	0.14	0.48	0.43	0.84*	0.57
gisx91	0.35	0.22	0.39	0.10	0.46	0.47	0.89*	0.58
gisx92	0.37	0.24	0.36	0.11	0.46	0.41	0.83*	0.61
gisx93	0.39	0.30	0.24	0.17	0.32	0.39	0.53	0.82*
gisx94	0.38	0.28	0.24	0.17	0.34	0.38	0.52	0.84*
gisx95	0.37	0.26	0.24	0.15	0.34	0.36	0.51	0.84*
gisx96	0.41	0.28	0.30	0.17	0.41	0.41	0.57	0.81*
gisx97	0.38	0.28	0.24	0.11	0.37	0.42	0.54	0.85*
gisx98	0.31	0.23	0.27	0.14	0.31	0.41	0.53	0.82*
gisx99	0.37	0.26	0.26	0.15	0.35	0.41	0.52	0.88*
gisx100	0.34	0.23	0.23	0.10	0.32	0.41	0.53	0.86*
gisx101	0.38	0.27	0.24	0.10	0.36	0.43	0.55	0.87*
gisx102	0.25	0.23	0.14	0.05	0.26	0.34	0.39	0.65*
gisx103	0.38	0.26	0.26	0.14	0.35	0.43	0.53	0.85*
gisx104	0.38	0.26	0.22	0.08	0.33	0.43	0.51	0.87*
gisx106	0.30	0.18	0.34	0.22	0.25	0.36	0.32	0.56*
gisx107	0.30	0.17	0.35	0.21	0.23	0.40	0.34	0.55*
gisx108	0.21	0.09	0.35	0.11	0.27	0.24	0.42	0.48*
gisx109	0.21	0.11	0.34	0.09	0.28	0.29	0.43	0.49*
gisx110	0.29	0.17	0.33	0.14	0.31	0.37	0.44	0.61*
gi105rec	**0.18**	**0.07**	**0.19**	**0.05**	**0.10**	**0.25**	**0.24**	**0.39***

Summary of Item-Scale Correlations

- Gisx22 (burp) correlates only 0.30 with *Gastroesphageal Reflux* scale
- Gisx33 (pain in chest when swallowing food) correlates as highly with *Gastroesphageal Reflux* as with *Disrupted swallowing* scale
- Three items correlate as highly with *Disrupted Swallowing* as with *Gastroesphageal Reflux* scale:
  - Gisx28 (lump in throat frequency)
  - Gisx29 (lump in throat interfere)
  - Gisx30 (lump in throat bother)

Confirmatory Factor Analysis

	Depress	Anxiety	Anger
Item #1	0.80*	0.00	0.00
Item #2	0.80*	0.00	0.00
Item #3	0.80*	0.00	0.00
Item #4	0.00	0.80*	0.00
Item #5	0.00	0.80*	0.00
Item #6	0.00	0.80*	0.00
Item #7	0.00	0.00	0.80*
Item #8	0.00	0.00	0.80*
Item #9	0.00	0.00	0.80*

*Factor loading.

21

Confirmatory Factor Analysis

- Eight-factor categorical model fit the data well (CFI=0.952 and RMSEA=0.049).
- Lower loadings on *Gastroesphageal Reflux* for:
  - Gisx22 (burp frequency): 0.377
  - Gisx20 (pain behind breastbone): 0.391
- Secondary loadings on *Gas* for:
  - GIsx48 (thought gas but liquid; BI): 0.222
  - GIsx72 (unfinished frequency; Con.): 0.224
  - GIsx73 (feeling unfinished bother; Con.): 0.265

22

Correlated Residuals

- **r = 0.58** (Gas/bloat/flatulence)
  - GI108 (freq. gurgling in belly) with GI109 (freq. gurgling when not hungry)
- **r = 0.53** (Constipation)
  - GI75 (freq. pain in anus) with GI76 (bother pain in anus)
- **r = 0.50** (Gas/bloat/flatulence)
  - GI106 (gas interference) with GI107 (gas bother)

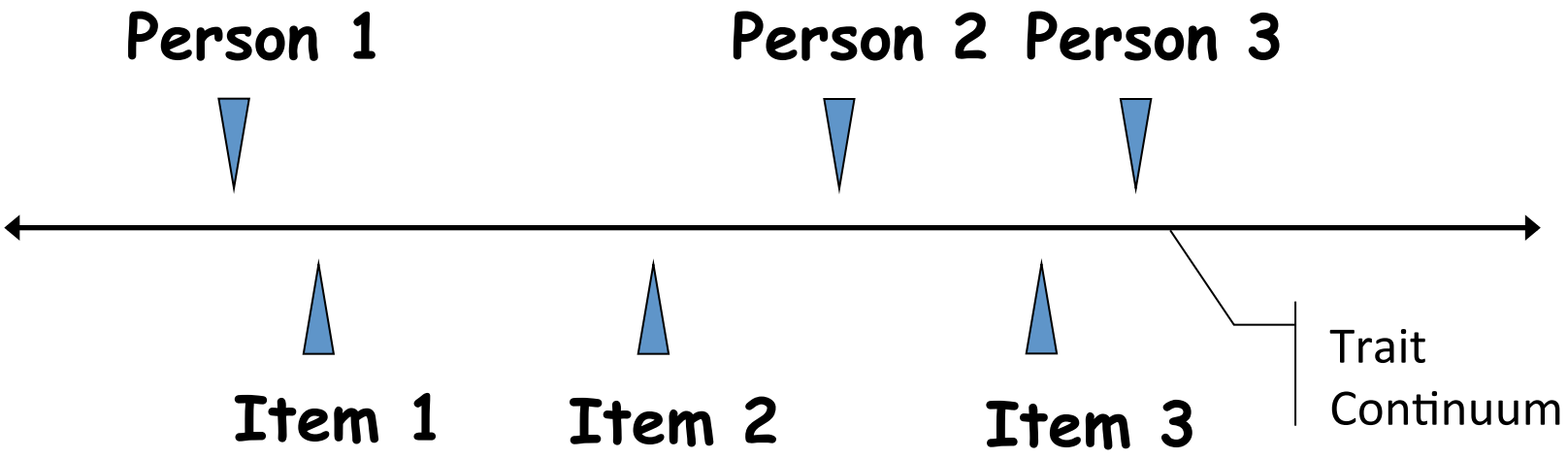
Item Response Theory (IRT)

IRT models the relationship between a person's response Y_i to the question (i) and his or her level of the latent construct θ being measured by positing

$$\Pr(Y_i \geq k) = \frac{1}{1 + \exp(-a_i\theta + b_{ik})}$$

b_{ik} estimates how difficult it is for the item (i) to have a score of k or more and the discrimination parameter a_i estimates the discriminatory power of the item.

Item Responses and Trait Levels



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Bowel Incontinence Items

- How often did you soil or dirty your underwear before getting to a bathroom?
- How often did you have bowel incontinence—that is, have an accident because you could not make it to the bathroom in time?
- How often did you leak stool or soil your underwear?
- How often did you think you were going to pass gas, but stool or liquid came out instead?

Graded Response Model Parameters (Incontinence)

Item	Slope	Threshold 1	Threshold 2	Threshold 3	Threshold 4
Gisx46	11.4	0.7	1.3	1.7	2.1
Gisx45	5.0	0.9	1.5	1.9	2.4
Gisx47	4.8	0.7	1.2	1.7	2.1
Gisx48	2.0	0.1	1.0	2.0	3.1

1. How often did you soil or dirty your underwear before getting to a bathroom?
2. How often did you have bowel incontinence—that is, have an accident because you could not make it to the bathroom in time?
3. How often did you leak stool or soil your underwear?

[**No days; 1 day; 2-3 days; 4-5 days; 6-7 days**]

4. How often did you think you were going to pass gas, but stool or liquid came out instead?

[**Never; Rarely; Sometimes; Often; Always**]

Questions?

Coefficient Alpha Formula is Two-Way Fixed Model Below

Model	Reliability	Intraclass Correlation
One-way	$\frac{MS_{BMS} - MS_{WMS}}{MS_{BMS}}$	$\frac{MS_{BMS} - MS_{WMS}}{MS_{BMS} + (k-1)MS_{WMS}}$
Two-way fixed	$\frac{MS_{BMS} - MS_{EMS}}{MS_{BMS}}$	$\frac{MS_{BMS} - MS_{EMS}}{MS_{BMS} + (k-1)MS_{EMS}}$
Two-way random	$\frac{N(MS_{BMS} - MS_{EMS})}{NMS_{BMS} + MS_{JMS} - MS_{EMS}}$	$\frac{MS_{BMS} - MS_{EMS}}{MS_{BMS} + (k-1)MS_{EMS} + k(MS_{JMS} - MS_{EMS})/N}$

BMS = Between Ratee Mean Square
WMS = Within Mean Square
JMS = Item or Rater Mean Square
EMS = Ratee x Item (Rater) Mean Square

N = n of ratees
k = n of replicates

29

Confirmatory Factor Analysis Fit Indices

- Normed fit index: $\dfrac{\chi^2_{null} - \chi^2_{model}}{\chi^2_{null}}$

- Non-normed fit index: $\dfrac{\frac{\chi^2_{null}}{df_{null}} - \frac{\chi^2_{model}}{df_{model}}}{\left[\frac{\chi^2_{null}}{df_{null}} - 1\right]}$

- Comparative fit index: $1 - \left[\dfrac{\chi^2_{model} - df_{model}}{\chi^2_{null} - df_{null}}\right]$

RMSEA = SQRT (λ^2 – df)/SQRT (df (N – 1))