Steps towards scale construction

A demonstration

Preliminary steps

Score the scales

Determining how many constructs are in a set of items

Score the alternative solutions

Show the items

Psychology 405: Psychometric Theory

Scale Construction: an example

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Outline

1. Steps towards scale construction
2. A demonstration
3. Preliminary steps
   - Data checking
4. Score the scales
5. Determining how many constructs are in a set of items
6. Scoring the alternative solutions
7. Show the items
Scale construction: A 10 steps program

1. Personality scales are not created in a theoretical vacuum. Perhaps the most important step in developing a new scale is a consideration of what is the construct of interest. What is it, what are manifestations of it, what is it not, and what should it not relate to.

2. Then, what is the population of interest? Are they young old, highly literate, or somewhat challenged by literacy. Write items suitable for the population of interest.

3. Give the items to the participants. Make sure that they are engaged in the task.
To analyze the data, it is necessary to enter the data into a machine readable form.

- This is a source of error. Double check for data entry errors.
- Double entry (two different people enter the data and then the two files are automatically compared) is recommended.
- Even better is automatic data entry (but then you need to check and double check the program).

```r
my.data <- read.table(myfile)
my.data <- read.clipboard()
```

Run basic descriptive statistics to do one more check for errors. Graphically check as well.

- `describe()`
- `pairs.panels()`

Form the variance/covariance matrix from the items and examine the dimensionality of the resulting space.
Apply various data reduction techniques (factor analysis, principal components analysis, cluster analysis).

- `fa`
- `principal`
- `iclust`

Form composite scales of the selected items. Check these scales for various measures of internal consistency.

- `make.keys`
- `score.items`

Discriminant validity requires that the scales not correlate with other, unrelated traits.

Convergent validity requires that the scale do correlate with other, alternative measures of the same trait.
Basic item development

As a demonstration of scale construction and validation, consider the following problem. N self-report items are given to a number of people. This inventory has is composed of subsets of items that measure believed to measure different traits. In addition, each subject is rated by a friend on those same traits. There are several questions we can ask of these data:

1. Do the items form reliable scales?
2. What are the correlations of these scales?
3. Do the scales correlate with the peer ratings?
4. Can we empirically find a better structure of the items?
5. Do these revised scales show greater independence, reliability, and validity?
Item writing

To show the procedures, 14 students in a personality research course spent several weeks learning about each of four personality dimensions. Each student then wrote five items to assess each of four constructs.

1. Need for Achievement
2. Anxiety
3. Sociability
4. Impulsivity

As a group they examined all of the items and formed the best 84 items into one questionnaire with 21 items believed to measure each of the constructs. They administered this questionnaire to approximately ten friends each whom they also rated on these four constructs. Thus, we have a data set of about 140 participants assessed on 88 items (the 84 self report items and the 4 peer ratings). These four sets of items can be seen as samples from four domains.
Initial data reading

The data, item labels, and scoring keys are saved on a web server. They may be accessed by the `read.table(file.name)` command. We then use the `dim` command to find out the dimensions of the data file as well as the `names` command to find out what the names are.

```r
prq.data.name <- "http://personality-project.org/revelle/syllabi/301/prq.data"
prq.keys.name <- "http://personality-project.org/revelle/syllabi/301/prq.keys"
prq.labels.name <- "http://personality-project.org/revelle/syllabi/301/prq.labels"
prq.data <- read.table(prq.data.name, header=TRUE)
prq.keys <- read.table(prq.keys.name, header=TRUE)
prq.labels <- read.table(prq.labels.name, header=TRUE)
dim(prq.data)
names(prq.data)
#only 75 subjects!
[1] 75 91
> names(prq.data)
[1] "Exp"    "Subject" "NeedAch" "Anxiety" "Sociability" "Impulsivity"
[7] "Gender" "q1"    "q2"    "q3"    "q4"    "q5"
[13] "q6"    "q7"    "q8"    "q9"    "q10"   "q11"
[19] "q12"   "q13"   "q14"   "q15"   "q16"   "q17"
[25] "q18"   "q19"   "q20"   "q21"   "q22"   "q23"
[31] "q24"   "q25"   "q26"   "q27"   "q28"   "q29"
[37] "q30"   "q31"   "q32"   "q33"   "q34"   "q35"
...[85] "q78"   "q79"   "q80"   "q81"   "q82"   "q83"
[91] "q84"
```
Data checking

The first two variables are not particularly interesting, so we create a new data.frame without them. Then find the descriptive statistics of the data in order to make sure that the data were entered correctly.

```r
> prq.items <- prq.data[,,-c(1:2)]
> describe(prq.items)
```

<table>
<thead>
<tr>
<th>var</th>
<th>n</th>
<th>mean</th>
<th>sd</th>
<th>median</th>
<th>trimmed</th>
<th>mad</th>
<th>min</th>
<th>max</th>
<th>range</th>
<th>skew</th>
<th>kurtosis</th>
<th>se</th>
</tr>
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<tbody>
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<td>NeedAch</td>
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<td>6.39</td>
<td>6.48</td>
<td>1.48</td>
<td>2</td>
<td>10</td>
<td>8</td>
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<td>-0.64</td>
<td></td>
<td>0.22</td>
</tr>
<tr>
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<td>2</td>
<td>75</td>
<td>5.24</td>
<td>5.21</td>
<td>2.97</td>
<td>1</td>
<td>10</td>
<td>9</td>
<td>0.09</td>
<td>-1.18</td>
<td></td>
<td>0.26</td>
</tr>
<tr>
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<td>6.31</td>
<td>1.48</td>
<td>1</td>
<td>9</td>
<td>8</td>
<td>-0.69</td>
<td>-0.60</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Impulsivity</td>
<td>4</td>
<td>75</td>
<td>5.16</td>
<td>5.20</td>
<td>2.97</td>
<td>1</td>
<td>9</td>
<td>8</td>
<td>-0.13</td>
<td>-1.32</td>
<td></td>
<td>0.27</td>
</tr>
<tr>
<td>Gender</td>
<td>5</td>
<td>74</td>
<td>1.51</td>
<td>1.52</td>
<td>0.00</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>-0.05</td>
<td>-2.02</td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>q1</td>
<td>6</td>
<td>75</td>
<td>4.27</td>
<td>4.34</td>
<td>1.48</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>-0.52</td>
<td>-0.08</td>
<td></td>
<td>0.13</td>
</tr>
<tr>
<td>q2</td>
<td>7</td>
<td>75</td>
<td>3.37</td>
<td>3.33</td>
<td>1.48</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>0.21</td>
<td>-0.73</td>
<td></td>
<td>0.16</td>
</tr>
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<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q82</td>
<td>87</td>
<td>75</td>
<td>3.84</td>
<td>3.92</td>
<td>1.48</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>-0.39</td>
<td>-0.74</td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>q83</td>
<td>88</td>
<td>75</td>
<td>4.08</td>
<td>4.10</td>
<td>1.48</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>-0.35</td>
<td>-1.06</td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td>q84</td>
<td>89</td>
<td>75</td>
<td>3.89</td>
<td>3.92</td>
<td>1.48</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>-0.32</td>
<td>-0.80</td>
<td></td>
<td>0.15</td>
</tr>
</tbody>
</table>
Data checking

In doing this, we discovered (on the first pass through the data) that one of the variables had a range of 32 rather than the 6 that was appropriate. Correcting the data, we can start over again. Even with well meaning, careful data entry, mistakes will happen in data entry. It is recommended that data be entered twice and then compared using software that compares the two files line by line and entry by entry. In all cases, make sure to describe the data and check that the ranges are appropriate for the data. Thus, the data were edited and the prior steps were done again until there were no incorrectly entered subjects. One error that makes data checking complicated is a blank field in Excel is read improperly. Using NA to specify not available is better. Note that the describe output shows that some variables do not have as many subjects as others.
Score the scales

1. Forming scale scores as linear sums (or averages) of the items is easy to do in R.

2. One technique (not recommended) is to do a series of recodings, creating new variables for each scale.

3. A simpler technique, using the `score.items` function from the `psych` package does this for all scales defined in a matrix of keys (the keys matrix).

4. This is essentially a matrix of -1, 0, and 1s where 0 means don’t include the item in the scale, and a 1 means to include it. -1 means to reverse key the item.
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Show the items

A keys matrix

```r
> prq.keys

   PNach PAnx PSoc PImp G Nach Anx Soc Imp
   1     1   0   0   0   0   0   0   0   0
   2     0   1   0   0   0   0   0   0   0
   3     0   0   1   0   0   0   0   0   0
   4     0   0   0   1   0   0   0   0   0
   5     0   0   0   0   1   0   0   0   0
   6     0   0   0   0   0   1   0   0   0
   7     0   0   0   0   0   0   1   0   0
   8     0   0   0   0   0   0   0   1   0
   9     0   0   0   0   0   0   0   0   -1
...  84     0   0   0   0   0   0   0   -1   0
  85     0   0   0   0   0   0   0   0   1
  86     0   0   0   0   0   1   0   0   0
  87     0   0   0   0   0   0   1   0   0
  88     0   0   0   0   0   0   0   1   0
  89     0   0   0   0   0   0   0   0   1
```
Making a keys matrix

Although it is possible to make up a keys matrix in Excel and copy it into R, it is easier to use the `make.keys` function.

```r
my.keys <- make.keys(nvars=89,keys.list=list(Pnach=1,PAnx=2,PSoc=3,PImp=4,G=5, Nach=c(6,10,14,18),Anx=c(7,11,15,19),Soc=c(8,12,-16,20),Imp=c(-9,13,-17,21)))
> my.keys

     Pnach  PAnx  PSoc  PImp  G  Nach  Anx  Soc  Imp
[1,]   1     0     0     0     0    0    0    0    0
[2,]   0     1     0     0     0    0    0    0    0
[3,]   0     0     1     0     0    0    0    0    0
[4,]   0     0     0     1     0    0    0    0    0
[5,]   0     0     0     0     1    0    0    0    0
[6,]   0     0     0     0     0    1    0    0    0
[7,]   0     0     0     0     0    0    1    0    0
[8,]   0     0     0     0     0    0    0    1    0
[9,]   0     0     0     0     0    0    0    0    -1
[10,]  0     0     0     0     0    0    1    0    0
[11,]  0     0     0     0     0    1    0    0    0
[12,]  0     0     0     0     0    0    1    0    0
[13,]  0     0     0     0     0    0    0    1    0
[14,]  0     0     0     0     0    1    0    0    0
[15,]  0     0     0     0     0    0    1    0    0
[16,]  0     0     0     0     0    0    0    -1    0
[17,]  0     0     0     0     0    0    0    0    -1
[18,]  0     0     0     0     0    0    1    0    0
[19,]  0     0     0     0     0    1    0    0    0
[20,]  0     0     0     0     0    0    1    0    0
[21,]  0     0     0     0     0    0    0    1    0
...
```
Score the items

We use the `score.items` function.

We first do this just for the items. The `item.scores` is a list of multiple values:

1. **scores** – the actual scores for each subject
2. **missing** – where there any missing values for any subject?
3. **alpha** – coefficient alpha for each scale
4. **av.r** – the average r within each scale
5. **n.items** – how many items in each scale?
6. **item.cor** – the correlation of each item with each scale
7. **cor** – the correlation matrix of the scales
8. **corrected** – the raw correlations of the scales (below the diagonal), the alpha reliabilities (on the diagonal), and the intercorrelations corrected for unreliability (above the diagonal).
Using `score.items`

```r
> tem.scores <- score.items(prq.keys[,6:9], prq.items)
> print(item.scores$corrected)
> round(item.scores$corrected, 2)

> print(item.scores$corrected)

<table>
<thead>
<tr>
<th></th>
<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nach</td>
<td>0.83928271</td>
<td>0.08193167</td>
<td>0.2755535</td>
<td>-0.22602236</td>
</tr>
<tr>
<td>Anx</td>
<td>0.06805717</td>
<td>0.82212135</td>
<td>-0.2545185</td>
<td>0.09498796</td>
</tr>
<tr>
<td>Soc</td>
<td>0.23857492</td>
<td>-0.21809815</td>
<td>0.8931604</td>
<td>0.44321814</td>
</tr>
<tr>
<td>Imp</td>
<td>-0.19259110</td>
<td>0.08010640</td>
<td>0.3895946</td>
<td>0.86509005</td>
</tr>
</tbody>
</table>

#rounding to 2 decimal places is nicer

<table>
<thead>
<tr>
<th></th>
<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nach</td>
<td>0.84</td>
<td>0.08</td>
<td>0.28</td>
<td>-0.23</td>
</tr>
<tr>
<td>Anx</td>
<td>0.07</td>
<td>0.82</td>
<td>-0.25</td>
<td>0.09</td>
</tr>
<tr>
<td>Soc</td>
<td>0.24</td>
<td>-0.22</td>
<td>0.89</td>
<td>0.44</td>
</tr>
<tr>
<td>Imp</td>
<td>-0.19</td>
<td>0.08</td>
<td>0.39</td>
<td>0.87</td>
</tr>
</tbody>
</table>
```
Show more of the output

```r
> item.scores
Call: score.items(keys = prq.keys[, 6:9], items = prq.items)
(Unstandardized) Alpha:
    Nach    Anx    Soc    Imp
alpha  0.84  0.82  0.89  0.87
Average item correlation:
    Nach    Anx    Soc    Imp
average.r  0.2  0.18  0.28  0.23

Guttman 6* reliability:
    Nach    Anx    Soc    Imp
Lambda.6  0.93  0.89  0.93  0.92

Scale intercorrelations corrected for attenuation
raw correlations below the diagonal, alpha on the diagonal
corrected correlations above the diagonal:
    Nach    Anx    Soc    Imp
Nach  0.839  0.082  0.28 -0.226
Anx   0.068  0.822 -0.25  0.095
Soc   0.239 -0.218  0.89  0.443
Imp  -0.193  0.080  0.39  0.865

In order to see the item by scale loadings and frequency counts of the data
print with the short option = FALSE
```
Display the four self report dimensions

```r
pairs.panels(item.scores$scores) # note that scores are not shown in output
```

![Scatter plots and histograms for the four self-report dimensions: Nach, Anx, Soc, Imp.](image)

- **Nach**: Scores range from 0.07 to 0.24, with a slight right skew.
- **Anx**: Scores range from -0.22 to 0.08, with a slight left skew.
- **Soc**: Scores range from 0.39 to 6.5, showing a strong positive correlation.
- **Imp**: Scores range from 3.5 to 6.5, with a consistent distribution and no outliers.

The data visualization includes box plots and scatter plots for each dimension, highlighting the distribution and relationships between the scores.
Show the peer rating structure

pairs.panels(prq.data[,3:7])
### Score the peer ratings and the scales

```r
mmtm <- score.items(prq.keys, prq.items)

> mmtm
Call: score.items(keys = prq.keys, items = prq.items)

(Unstandardized) Alpha:

<table>
<thead>
<tr>
<th></th>
<th>PNach</th>
<th>PAnx</th>
<th>PSoc</th>
<th>PImp</th>
<th>G</th>
<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.84</td>
<td>0.82</td>
<td>0.89</td>
<td>0.87</td>
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</tbody>
</table>

Average item correlation:

<table>
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<th>PNach</th>
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<th>PImp</th>
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<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
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</thead>
<tbody>
<tr>
<td>average.r</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>0.2</td>
<td>0.18</td>
<td>0.28</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Guttman 6* reliability:

<table>
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<tr>
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<th>PImp</th>
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<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
</tr>
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<tbody>
<tr>
<td>Lambda.6</td>
<td>0.27</td>
<td>0.19</td>
<td>0.22</td>
<td>0.18</td>
<td>4</td>
<td>0.93</td>
<td>0.89</td>
<td>0.93</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Scale intercorrelations corrected for attenuation

raw correlations below the diagonal, alpha on the diagonal

<table>
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<tr>
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<th>PNach</th>
<th>PAnx</th>
<th>PSoc</th>
<th>PImp</th>
<th>G</th>
<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
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<td>corrected correlations above the diagonal:</td>
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<table>
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<th>PSoc</th>
<th>PImp</th>
<th>G</th>
<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNach</td>
<td>1.0000</td>
<td>0.207</td>
<td>-0.077</td>
<td>-0.304</td>
<td>-0.0011</td>
<td>0.1993</td>
<td>0.098</td>
<td>-0.0041</td>
<td>-0.311</td>
</tr>
<tr>
<td>PAnx</td>
<td>0.2068</td>
<td>1.000</td>
<td>-0.102</td>
<td>-0.030</td>
<td>0.3733</td>
<td>-0.0065</td>
<td>0.659</td>
<td>-0.2173</td>
<td>0.059</td>
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<tr>
<td>PSoc</td>
<td>-0.0767</td>
<td>-0.102</td>
<td>1.000</td>
<td>0.293</td>
<td>0.0919</td>
<td>-0.1555</td>
<td>-0.175</td>
<td>0.6014</td>
<td>0.372</td>
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<tr>
<td>PImp</td>
<td>-0.3041</td>
<td>-0.030</td>
<td>0.293</td>
<td>1.000</td>
<td>0.0545</td>
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<tr>
<td>G</td>
<td>-0.0011</td>
<td>0.373</td>
<td>0.092</td>
<td>0.054</td>
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<td>0.0241</td>
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<td>-0.229</td>
<td>-0.0792</td>
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<td>0.082</td>
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<td>-0.226</td>
</tr>
<tr>
<td>Anx</td>
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<td>-0.159</td>
<td>0.146</td>
<td>0.1901</td>
<td>0.0681</td>
<td>0.822</td>
<td>-0.2545</td>
<td>0.095</td>
</tr>
<tr>
<td>Soc</td>
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<td>0.0228</td>
<td>0.2386</td>
<td>-0.218</td>
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<td>0.055</td>
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<td>-0.1926</td>
<td>0.080</td>
<td>0.3896</td>
<td>0.865</td>
</tr>
</tbody>
</table>

In order to see the item by scale loadings and frequency counts of the data print with the short option = FALSE.
Show the MMTM matrix graphically
Steps towards scale construction A demonstration

Preliminary steps Score the scales Determining how many constructs are in a set of items Scoring the alternative solutions Show the items

Factor Analysis

The items analysed were meant to represent four constructs. Given the previous analysis, they probably do. But what if we did not know how many separate dimensions were in the data? Is it possible to find out? Three alternative procedure address this question.

1. Principal components analysis
2. Factor analysis
3. Cluster analysis

All three of these procedures are attempting to approximate the nvar * nvar correlation matrix $R$ with a matrix of lesser rank, one that is nvar * nf. That is, can we find a Factor (Component or Cluster) such that

$$ R \approx FF' + U^2 \quad (1) $$
Factor analysis of PRQ

1. More items than people makes the matrix not invertible
2. Can be solved by the `fa` function using minres option
3. How many factors to extract?
   - VSS(prq.items)
   - Use VSS 3 (complexity 1) or 4 (complexity 2)
   - Use MAPS 8
4. Theory says 4
Steps towards scale construction

A demonstration

Preliminary steps

Score the scales

Determining how many constructs are in a set of items

Score the alternative solutions

Show the items

VSS of prq
Find a 4 factor as well as a 4 component solution

```r
f4 <- fa(prq.items, 4)
p4 <- principal(prq.items, 4)
summary(f4)
```

```r
> summary(f4)

Factor analysis with Call: fa(r = prq.items, nfactors = 4)

Test of the hypothesis that 4 factors are sufficient.
The degrees of freedom for the model is 3566 and the objective function was 523.91
The number of observations was 75 with Chi Square = 21393.03 with prob < 0

The root mean square of the residuals (RMSA) is 0.07
The df corrected root mean square of the residuals is 0.1

Tucker Lewis Index of factoring reliability = NaN
RMSEA index = 0.365 and the 90 % confidence intervals are 0.255 0.262
BIC = 5996.86

With factor correlations of

<table>
<thead>
<tr>
<th></th>
<th>MR1</th>
<th>MR2</th>
<th>MR4</th>
<th>MR3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR1</td>
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<td>-0.03</td>
<td>1.00</td>
<td>0.02</td>
</tr>
<tr>
<td>MR3</td>
<td>-0.16</td>
<td>-0.03</td>
<td>0.02</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Also try a cluster analysis

```r
> ic <- ICLUST(prq.items, labels=strtrim(prq.labels[,2],20))
> summary(ic)

ICLUST (Item Cluster Analysis)
Call: ICLUST(r.mat = prq.items, labels = strtrim(prq.labels[, 2], 20))
ICLUST

Purified Alpha:
C83  C82  C85  C81
0.92  0.89  0.87  0.54

Guttman Lambda6*
C83  C82  C85  C81
  1   1   1   1

Original Beta:
C83  C82  C85  C81
0.58  0.47  0.48  0.40

Cluster size:
C83  C82  C85  C81
  40  25  20   4

Purified scale intercorrelations
reliabilities on diagonal
correlations corrected for attenuation above diagonal:

C83  C82  C85  C81
C83  0.920 -0.0312  0.1818  0.11
C82  0.028  0.8922 -0.0036  0.18
C85  0.162 -0.0032  0.8679  0.20
C81  0.074  0.1280  0.1386  0.54
```
## Compare the solutions

```r
> factor.congruence(list(f4,p4,ic))
```

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<tr>
<th></th>
<th>MR1</th>
<th>MR2</th>
<th>MR4</th>
<th>MR3</th>
<th>PC1</th>
<th>PC2</th>
<th>PC4</th>
<th>PC3</th>
<th>C83</th>
<th>C82</th>
<th>C85</th>
<th>C81</th>
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<td>-0.06</td>
<td>0.17</td>
<td>-0.54</td>
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<tr>
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<td>0.00</td>
<td>0.02</td>
<td>1.00</td>
<td>-0.19</td>
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<td>1.00</td>
<td>0.19</td>
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<td>1.00</td>
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<td>0.99</td>
<td>-0.01</td>
<td>0.28</td>
<td>-0.07</td>
<td>1.00</td>
<td>0.02</td>
<td>-0.70</td>
<td>-0.08</td>
<td>0.10</td>
<td>-0.52</td>
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<td>0.95</td>
<td>0.41</td>
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<td>-0.08</td>
<td>-0.07</td>
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<td>-0.09</td>
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<td>0.41</td>
<td>0.13</td>
<td>0.28</td>
<td>0.19</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Combine the factor scores with the empirical scores

```r
> scores.df <- data.frame(f4$scores, item.scores$scores)
> lowerCor(scores.df)
```

<table>
<thead>
<tr>
<th></th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>Nach</th>
<th>Anx</th>
<th>Soc</th>
<th>Imp</th>
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<td>0.08</td>
<td>0.39</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Compare original, factors and clusters

```r
> fkeys <- factor2cluster(f4)
> ckeys <- cluster2keys(ic)
> all.keys <- cbind(prq.keys,fkeys,ckeys)
> all.scores <- score.items(all.keys,prq.items)
> lowerMat(all.scores$cor)
```

<table>
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<tr>
<th></th>
<th>PNach</th>
<th>PAnx</th>
<th>PSoc</th>
<th>PImp</th>
<th>G</th>
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<th>Imp</th>
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<th>MR2</th>
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</tr>
</tbody>
</table>

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ICLUST output

> print(ic, sort=TRUE, labels=prq.labels)

ICLUST (Item Cluster Analysis)
Call: ICLUST(r.mat = prq.items, labels = strtrim(prq.labels[, 2], 20))

Purified Alpha:
   C83  C82  C85  C81
0.92  0.89  0.87  0.54

G6* reliability:
   C83  C82  C85  C81
0.84  0.97  0.96  1.00

Original Beta:
   C83  C82  C85  C81
0.58  0.47  0.48  0.40

Cluster size:
C83  C82  C85  C81
40   25   20   4
## Cluster 1

### Item by Cluster Structure matrix: Sorted by loading

<table>
<thead>
<tr>
<th>Item</th>
<th>Cluster</th>
<th>Content</th>
<th>C83</th>
<th>C82</th>
<th>C85</th>
<th>C81</th>
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</thead>
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<td>I have a large soci</td>
<td>-0.71</td>
<td>-0.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>q83</td>
<td>88</td>
<td>I am a very sociable</td>
<td>-0.64</td>
<td>0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>q67</td>
<td>72</td>
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<td>q59</td>
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<td>A good night for me</td>
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</table>
### Cluster 2

| q81 | NeedAch | 1 | I believe that if so | 2 | 0.74 |
| q17 | NeedAch | 22 | I have high standard | 2 | 0.72 |
| q33 | NeedAch | 38 | I find myself needing | 2 | 0.69 |
| q4 | NeedAch | 9 | I am thoughtful and | 2 | 0.63 |
| q41 | NeedAch | 46 | I always make sure | 2 | 0.63 |
| q25 | NeedAch | 30 | If I fail, I keep trying | 2 | 0.62 |
| q13 | NeedAch | 18 | I like to go the extra mile | 2 | 0.61 |
| q1 | NeedAch | 6 | I love to seek out | 2 | 0.60 |
| q77 | NeedAch | 82 | I always see projects | 2 | 0.60 |
| q61 | NeedAch | 66 | I experience great | 2 | 0.60 |
| q49 | NeedAch | 54 | The joy of success | 2 | 0.59 |
| q60 | NeedAch | 65 | I stay on task until | 2 | 0.58 |
| q45 | NeedAch | 50 | I prefer challenging | 2 | 0.55 |
| q73 | NeedAch | 78 | I set long term and | 2 | 0.51 |
| q12 | NeedAch | 17 | I weigh all the options | 2 | 0.50 |
| q57 | NeedAch | 62 | I always reach the | 2 | 0.49 |
| q78 | NeedAch | 83 | I tend to back away | 2 | -0.47 |
| q37 | NeedAch | 42 | I get bored if a task | 2 | 0.46 |
| q58 | NeedAch | 63 | I prefer to work in | 2 | 0.46 |
| q27 | NeedAch | 32 | I tend to enjoy smaller | 2 | 0.41 |
| q5 | NeedAch | 10 | Personal satisfaction | 2 | 0.35 |
| q21 | NeedAch | 26 | I am a perfectionist | 2 | 0.35 |
| q65 | NeedAch | 70 | I tend to have trouble | 2 | -0.32 |
| q75 | NeedAch | 80 | I work better when | 2 | |
| q29 | NeedAch | 34 | I seek the enjoyment | 2 | |
Cluster 3

<table>
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<tr>
<th>Q</th>
<th>Statement</th>
<th>Construct</th>
<th>Score 1</th>
<th>Score 2</th>
<th>Score 3</th>
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<tr>
<td>q6</td>
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<td>0.56</td>
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<tr>
<td>q22</td>
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<tr>
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<td>q62</td>
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<td>0.52</td>
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<tr>
<td>q70</td>
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<tr>
<td>q74</td>
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<td>59 I feel tension in my</td>
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<tr>
<td>q38</td>
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<tr>
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<td>19 Measures of skill or</td>
<td>Anxiety</td>
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<td>0.42</td>
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<tr>
<td>q10</td>
<td>15 I am easily bothered</td>
<td>Gender</td>
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<td>0.31</td>
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</tbody>
</table>
Cluster 4

| q72 | 77  | I always stick to p | 4 | 0.72 |
| q64 | 69  | I dislike changing  | 4 | 0.69 |
| q82 | 87  | I am more emotional | 4 | 0.63 |
| q9  | 14  | I am a good multi t | 4 | 0.31 | 0.55 |
Show the items for the factors

```r
> rownames(f4$loadings) <- strtrim(prq.labels[,2],20)
> print(f4,sort=TRUE)
```

Factor Analysis using method = minres
Call: fa(r = prq.items, nfactors = 4)

<table>
<thead>
<tr>
<th>Item Description</th>
<th>MR1</th>
<th>MR2</th>
<th>MR4</th>
<th>MR3</th>
<th>h2</th>
<th>u2</th>
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<tr>
<td>I have a large soci</td>
<td>0.79</td>
<td>0.02</td>
<td>0.06</td>
<td>-0.13</td>
<td>0.696</td>
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</tr>
<tr>
<td>I like to meet new</td>
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<td>-0.16</td>
<td>0.15</td>
<td>0.607</td>
<td>0.39</td>
</tr>
<tr>
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<td>0.02</td>
<td>0.09</td>
<td>0.644</td>
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<td>-0.01</td>
<td>0.14</td>
<td>0.531</td>
<td>0.47</td>
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<td>0.14</td>
<td>0.10</td>
<td>-0.09</td>
<td>0.596</td>
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<td>-0.04</td>
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<td>I am happier when I</td>
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<td>0.15</td>
<td>0.08</td>
<td>0.575</td>
<td>0.42</td>
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<tr>
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<td>-0.09</td>
<td>-0.15</td>
<td>0.13</td>
<td>0.487</td>
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<tr>
<td>I often and activel</td>
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<td>0.01</td>
<td>0.18</td>
<td>0.23</td>
<td>0.400</td>
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<td>I can easily start</td>
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<tr>
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<tr>
<td>When given the choi</td>
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<td>0.01</td>
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<tr>
<td>I enjoy being alone</td>
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<td>I dont understand h</td>
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<td>-0.07</td>
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<td>-0.06</td>
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<td>-0.22</td>
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## Factor 2

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<td>0.12 0.75 0.14 0.03 0.619 0.38</td>
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<tr>
<td>I have high standards</td>
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<td>I find myself needing help</td>
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<td>0.17 0.65 0.08 0.07 0.487 0.51</td>
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<td>I like to go the extra</td>
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<td>0.12 0.65 -0.10 0.04 0.457 0.54</td>
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<td>I stay on task until the end</td>
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<td>I always make sure</td>
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<td>0.10 0.61 -0.04 -0.03 0.403 0.60</td>
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<tr>
<td>I always see projects</td>
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</tr>
<tr>
<td>I am thoughtful and</td>
<td>9</td>
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<tr>
<td>The joy of success</td>
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<td>0.20 0.57 0.06 0.06 0.393 0.61</td>
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<td>I set long term and</td>
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<td>-0.19 0.56 0.17 -0.02 0.336 0.66</td>
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<td>I love to seek out</td>
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<td>I weigh all the options</td>
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### Factor 3

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<th>Score 4</th>
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<td>0.72</td>
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<td>I often regret decisions</td>
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<td>I indulge in my desires</td>
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<td>0.14</td>
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<td>0.373</td>
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<td>I always stick to plans</td>
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<td>I always think before</td>
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<td>I sometimes look back</td>
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<td>I tend to act on my decisions</td>
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<td>I plan my activities</td>
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<td>I often say the first</td>
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<td>I feel tension in my</td>
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<td>0.33</td>
<td>0.24</td>
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### Factor 4

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<th>Item</th>
<th>Score</th>
<th>Factor Loadings</th>
<th>Reliability Coefficients</th>
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<td>I don't handle stress</td>
<td>11</td>
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<tr>
<td>Even trivial problems</td>
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<td>-0.15</td>
<td>0.67 0.506 0.49</td>
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<tr>
<td>Even in non stressful situations</td>
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<td>I worry about what</td>
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<td>I get nervous very easily</td>
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<tr>
<td>I am easily bothered</td>
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<td>A small unpleasant</td>
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<td>I feel stressed when</td>
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<td>I have a hard time feeling</td>
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<td>I often feel anxious</td>
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<td>I am more emotional</td>
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<td>I often feel tense</td>
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<tr>
<td>I dislike changing</td>
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<tr>
<td>I rarely feel tense</td>
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<td>I tend to talk a lot</td>
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<tr>
<td>I tend to dwell on</td>
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<tr>
<td>I bounce back quick</td>
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<td>0.23</td>
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<td>I'll spend time talking</td>
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<td>Measures of skill or</td>
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