Psychology 405: Psychometric Theory
Scale Construction

William Revelle

Department of Psychology
Northwestern University
Evanston, Illinois USA

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Outline

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 or 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.

Scale construction: A 10 steps program (continued)

4. 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).
   - my.data <- read.file() #go find the file on your computer
   - my.data <- read.file(myfile) #if you have the file name some
   - my.data <- read.clipboard() #if you have already copied the data to the clipboard
5. Run basic descriptive statistics to do one more check for errors. Graphically check as well.
   - describe(my.data)
   - pairs.panels(my.data)
6. Form the variance/covariance matrix from the items and examine the dimensionality of the resulting space.

Scale construction: A 10 steps program (continued)

7. Apply various data reduction techniques (factor analysis, principal components analysis, cluster analysis).
   - `fa`
   - `irt.fa` # if you have polytomous or dichotomous items
   - `principal`
   - `iclust`
8. Form composite scales of the selected items. Check these scales for various measures of internal consistency.
   - `make.keys`
   - `scoreItems`
   - `bestScales` (For empirical scale construction)
9. Discriminant validity requires that the scales not correlate with other, unrelated traits.
10. 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, 12 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 80 items into one questionnaire with 20 items believed to measure each of the constructs. An additional four items were the simple stem: "I think I am ... ".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 110 participants assessed on 89 items (the 84 self report items and the 4 peer ratings + Gender).

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. Unfortunately, given that the server is now an https server, it is necessary to read the data using a browser and then copy to the clipboard.

```
prq.data.name <-  "http://personality-project.org/revelle/syllabi/371/prq.data"
prq.dictionary <- "http://personality-project.org/revelle/syllabi/371/prq.labels"
prq.data <- read.table(prq.data.name,header=TRUE)
pro <- read.clipboard.tab()
prq.dictionary <- read.clipboard.tab()
dim(prq.data)
names(prq.data)
```

```
> dim(prq)
[1] 110  89
names(prq)
 [1] "Q1"  "Q2"  "Q3"  "Q4"  "Q5"  "Q6"  "Q7"  "Q8"  "Q9"  "Q10" "Q11" "Q12" "Q13" "Q14" "Q15" "Q16"
[17] "Q17" "Q18" "Q19" "Q20" "Q21" "Q22" "Q23" "Q24" "Q25" "Q26" "Q27" "Q28" "Q29" "Q30" "Q31" "Q32"
[33] "Q33" "Q34" "Q35" "Q36" "Q37" "Q38" "Q39" "Q40" "Q41" "Q42" "Q43" "Q44" "Q45" "Q46" "Q47" "Q48"
[49] "Q49" "Q50" "Q51" "Q52" "Q53" "Q54" "Q55" "Q56" "Q57" "Q58" "Q59" "Q60" "Q61" "Q62" "Q63" "Q64"
[65] "Q65" "Q66" "Q67" "Q68" "Q69" "Q70" "Q71" "Q72" "Q73" "Q74" "Q75" "Q76" "Q77" "Q78" "Q79" "Q80"
[81] "Q81" "Q82" "Q83" "Q84" "N"   "A"   "S"   "I"   "G"
```

Data checking

Always check the data first. Use the `describe` function.

```
> describe(prq)
```

	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
Q1	1	110	2.26	1.16	2.0	2.14	1.48	1	6	5	0.87	0.49	0.11
Q2	2	110	3.94	1.50	4.0	4.00	1.48	1	6	5	-0.34	-0.97	0.14
Q3	3	110	4.42	1.28	5.0	4.55	1.48	1	6	5	-0.65	-0.26	0.12
Q4	4	110	3.85	1.24	4.0	3.85	1.48	1	6	5	-0.04	-0.83	0.12
Q5	5	110	4.22	1.30	4.0	4.32	1.48	1	6	5	-0.43	-0.27	0.12
Q6	6	110	3.19	1.71	3.0	3.11	1.48	1	6	5	0.20	-1.20	0.16
Q7	7	110	3.62	1.31	4.0	3.58	1.48	1	6	5	0.07	-0.79	0.13
Q8	8	110	4.49	1.27	5.0	4.61	1.48	1	6	5	-0.73	0.24	0.12
...													
Q78	78	110	4.29	1.29	4.5	4.42	0.74	1	6	5	-0.75	0.09	0.12
Q79	79	110	3.95	1.28	4.0	3.99	1.48	1	6	5	-0.41	-0.39	0.12
Q80	80	110	3.01	1.44	3.0	2.93	1.48	1	6	5	0.39	-0.69	0.14
Q81	81	110	4.90	1.10	5.0	5.05	1.48	1	6	5	-1.03	0.98	0.10
Q82	82	110	3.25	1.53	3.0	3.23	1.48	1	6	5	-0.02	-0.98	0.15
Q83	83	110	4.27	1.24	4.0	4.35	1.48	1	6	5	-0.38	-0.39	0.12
Q84	84	110	3.08	1.40	3.0	3.02	1.48	1	6	5	0.36	-0.67	0.13
N	85	110	6.15	2.09	6.0	6.23	1.48	1	10	9	-0.29	-0.12	0.20
A	86	110	5.15	2.07	5.0	5.12	2.22	1	10	9	0.18	-0.64	0.20
S	87	110	5.64	2.10	6.0	5.60	2.97	2	10	8	0.07	-0.93	0.20
I	88	110	4.32	2.00	4.0	4.16	1.48	1	9	8	0.53	-0.36	0.19
G	89	110	1.58	0.50	2.0	1.60	0.00	1	2	1	-0.33	-1.91	0.05

Data checking

In doing this, we discovered (on the first pass through the data) that one of the variables had a range of 46 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. However, if we copy the data file to the clipboard and then use the `read.clipboard.tab` function, this solves that problem. 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 `scoreItems` 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.

Making up the scoring keys

```
> nach <-  c(-1,  5,  9, 13, 17, 21, 25, 29, -33, 37, 41, 45, 49, 53, 57, 61, 65, 69, 73, -77, 81)
> anx <- c(2,  6, -10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58, 62, 66, -70, -74, -78, 82)
> soc <- c( 3,  7, 11, -15, -19, 23, -27, 31, 35, 39, -43, 47, 51, 55, 59, 63, 67, 71, 75, 79, 83)
> imp <- c(4,  -8, 12, -16, 20, -24, -28, 32, 36, 40, 44, 48, 52, 56, 60, 64, -68, -72, -76, 80, 84)
> prq.keys <- make.keys(prq,list(nach=nach,anx=anx,soc=soc,imp=imp,PeerNach=85,
              PeerAnx=86,  PeerSoc=87,PeerImp=88,gender=89))
```

By having the scoring key information in this form, we can always reproduce it.

We can also save it using dput

But the keys.list format is easiest to use.

Saving the prq.keys so that we can use them later if we need to do so.

dput(prq.keys)

```
dput(prq.keys)
structure(c(-1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, 0,
1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1,
0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, 0, 1, 0, 0, 0, -1,
0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
-1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1,
0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, 0, -1,
0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0,
0, 1, 0, 0, 0, -1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0,
0, -1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0,
0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, 0, 1, 0,
0, 0, -1, 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, 1, 0,
0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0,
0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0,
0, -1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
```

A keys matrix

```
> prq.keys
```

	nach	anx	soc	imp	PeerNach	PeerAnx	PeerSoc	PeerImp	gender
Q1	-1	0	0	0	0	0	0	0	0
Q2	0	1	0	0	0	0	0	0	0
Q3	0	0	1	0	0	0	0	0	0
Q4	0	0	0	1	0	0	0	0	0
Q5	1	0	0	0	0	0	0	0	0
Q6	0	1	0	0	0	0	0	0	0
Q7	0	0	1	0	0	0	0	0	0
Q8	0	0	0	-1	0	0	0	0	0
...									
Q81	1	0	0	0	0	0	0	0	0
Q82	0	1	0	0	0	0	0	0	0
Q83	0	0	1	0	0	0	0	0	0
Q84	0	0	0	1	0	0	0	0	0
N	0	0	0	0	1	0	0	0	0
A	0	0	0	0	0	1	0	0	0
S	0	0	0	0	0	0	1	0	0
I	0	0	0	0	0	0	0	1	0
G	0	0	0	0	0	0	0	0	1

Score the items

We use the `scoreItems` 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 (based upon the correlations of the items - with SAPA data this will differ from correlating 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 scoreItems

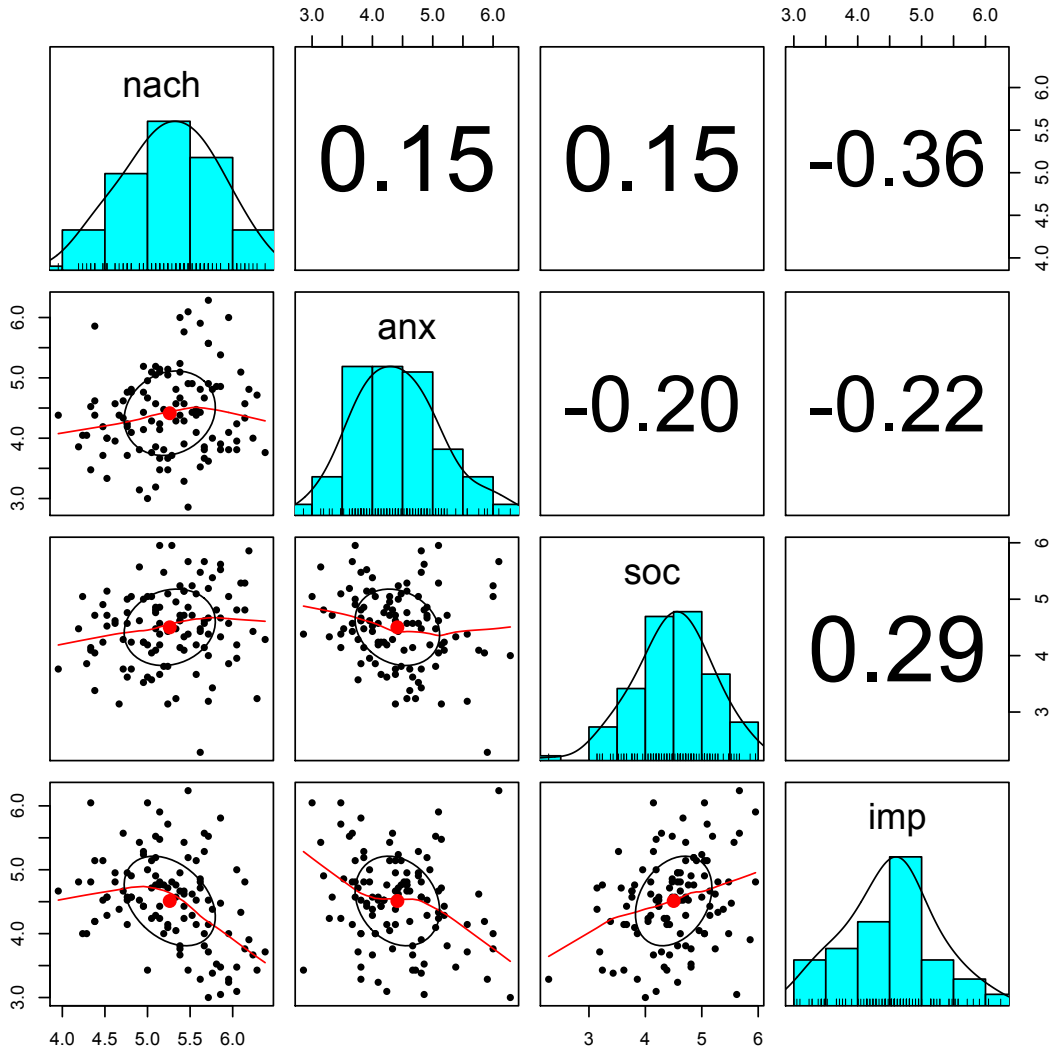
```
> prq.scores <- scoreItems(prq.keys,prq)
> prq.scores

(Unstandardized) Alpha:
      nach  anx  soc  imp PeerNach PeerAnx PeerSoc PeerImp gender
alpha  0.8 0.85 0.85 0.86        1       1       1       1      1

Standard errors of unstandardized Alpha:
       nach   anx   soc   imp PeerNach PeerAnx PeerSoc PeerImp gender
ASE   0.033 0.027 0.026 0.026      NaN     NaN     NaN     NaN    NaN

Average item correlation:
          nach  anx  soc  imp PeerNach PeerAnx PeerSoc PeerImp gender
average.r 0.16 0.21 0.22 0.22      NaN     NaN     NaN     NaN    NaN

 Guttman 6* reliability:
         nach  anx  soc  imp PeerNach PeerAnx PeerSoc PeerImp gender
Lambda.6 0.98 0.98 0.98 0.98     0.85    0.88     0.9     0.9   0.88

Signal/Noise based upon av.r :
             nach anx soc imp PeerNach PeerAnx PeerSoc PeerImp gender
Signal/Noise  4.1 5.6 5.8 5.9      NaN     NaN     NaN     NaN    NaN
```

Show more of the output

```
> item.scores

Scale intercorrelations corrected for attenuation
 raw correlations below the diagonal, alpha on the diagonal
 corrected correlations above the diagonal:
           nach    anx    soc   imp PeerNach PeerAnx PeerSoc PeerImp gender
nach      0.803  0.178  0.182 -0.43    0.476   0.033   0.186  -0.041  0.149
anx       0.146  0.847 -0.231 -0.25    0.105   0.382  -0.192  -0.246  0.456
soc       0.151 -0.197  0.853  0.34   -0.161  -0.174   0.459   0.258  0.050
imp      -0.356 -0.217  0.294  0.86   -0.414  -0.331   0.135   0.477 -0.175
PeerNach  0.427  0.096 -0.149 -0.38    1.000   0.259   0.315  -0.016 -0.096
PeerAnx   0.029  0.351 -0.161 -0.31    0.259   1.000  -0.135  -0.161  0.028
PeerSoc   0.167 -0.176  0.424  0.12    0.315  -0.135   1.000   0.542 -0.024
PeerImp  -0.037 -0.227  0.238  0.44   -0.016  -0.161   0.542   1.000 -0.198
gender    0.134  0.419  0.046 -0.16   -0.096   0.028  -0.024  -0.198  1.000

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

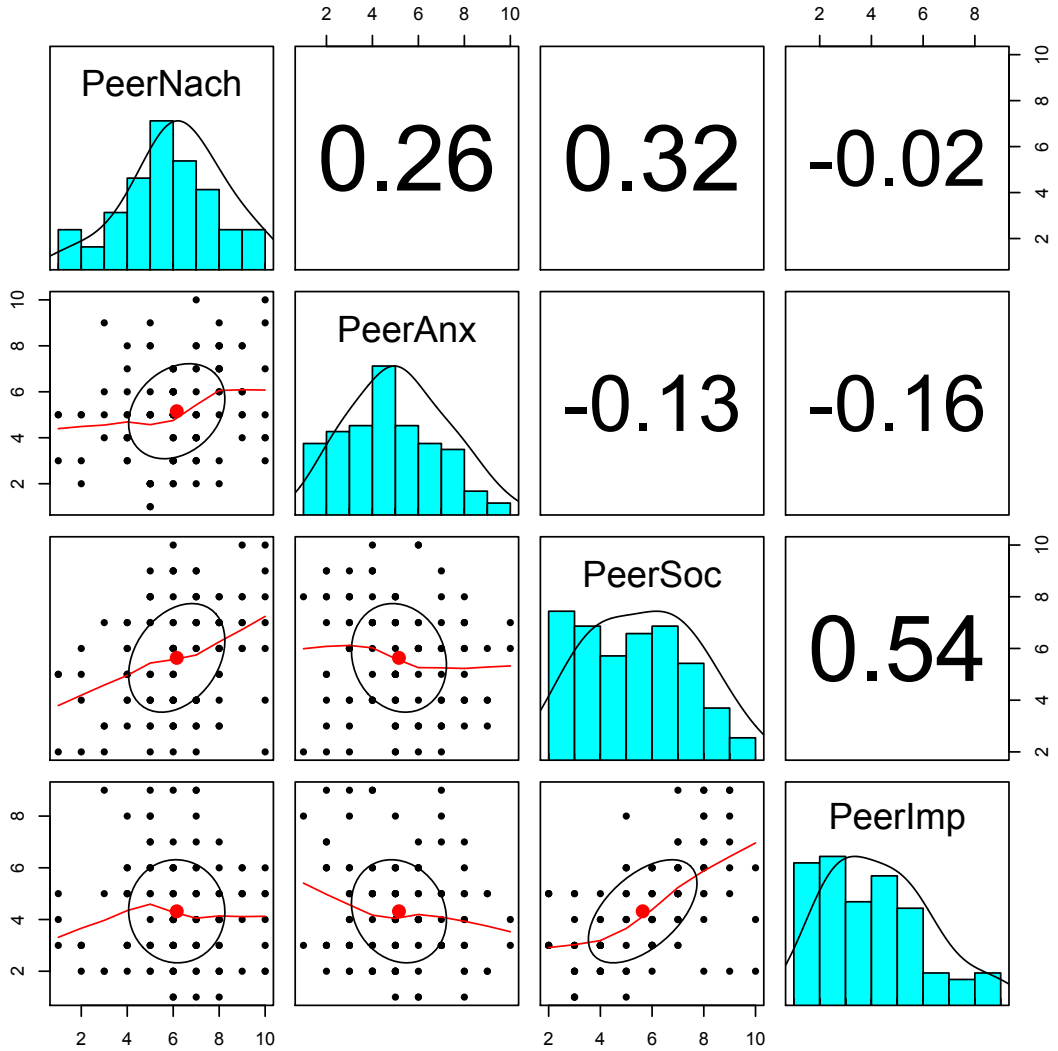
Display the four self report dimensions

pairs.panels(prq.scores$scores[,1:4]) # note that scores is an object in prq.scores



Show the peer rating structure

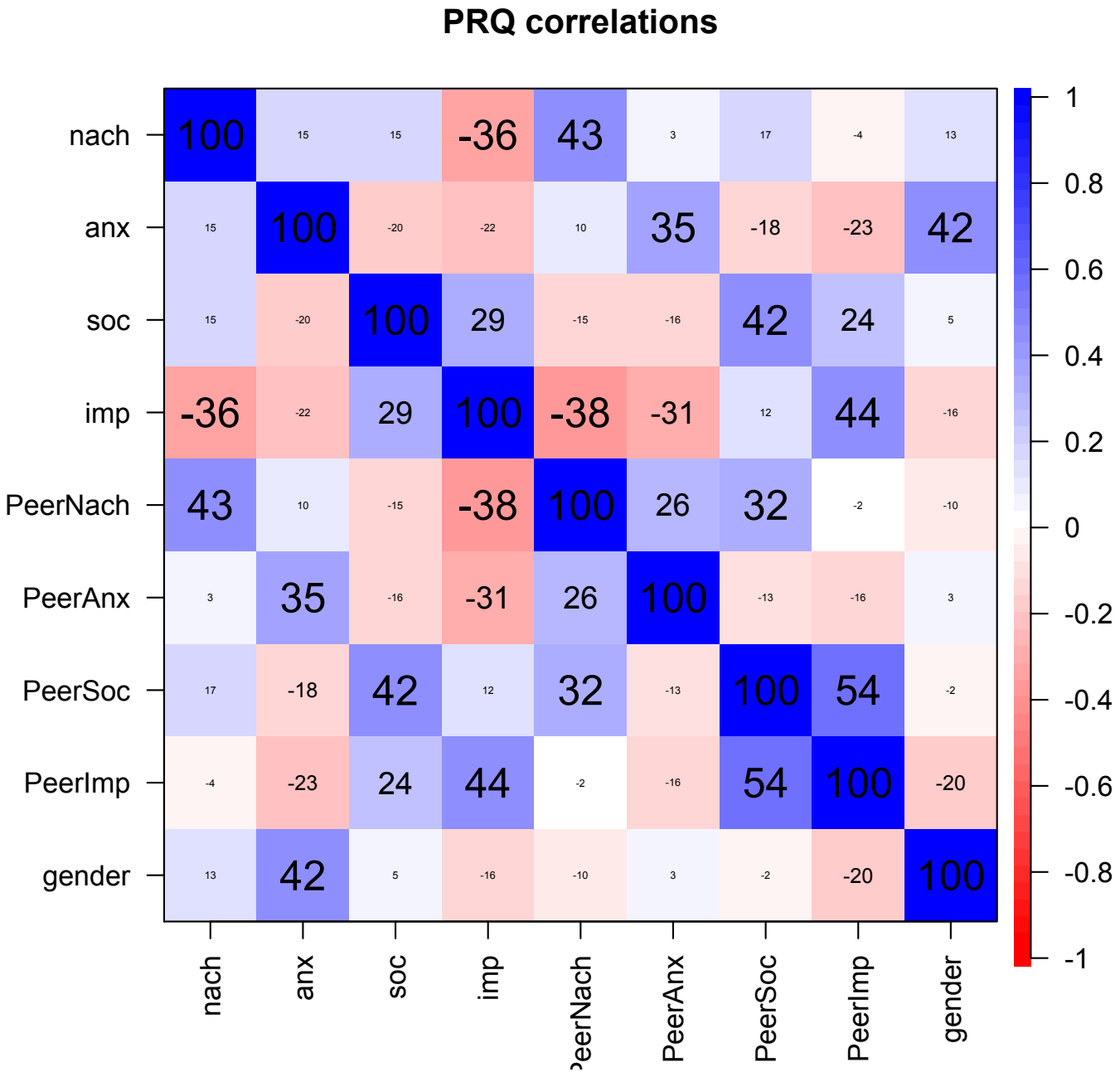
pairs.panels(prq.scores$scores[,5:8])



The Multi-Trait- Multi- Method Matrix

1. Correlations within method combine trait and method variance
   - What is the structure of NASI within self report
   - What is the structure of NASI within peer report
2. Correlations across method show trait variance
   - Do the self report dimensions match the peer ratings?
   - Note the correlations of gender differ between self and peer report. What could account for this difference?

Show the MMTM matrix graphically – cor.ci(prq.scores$scores)



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

$$R \approx FF' + U^2 \tag{1}$$

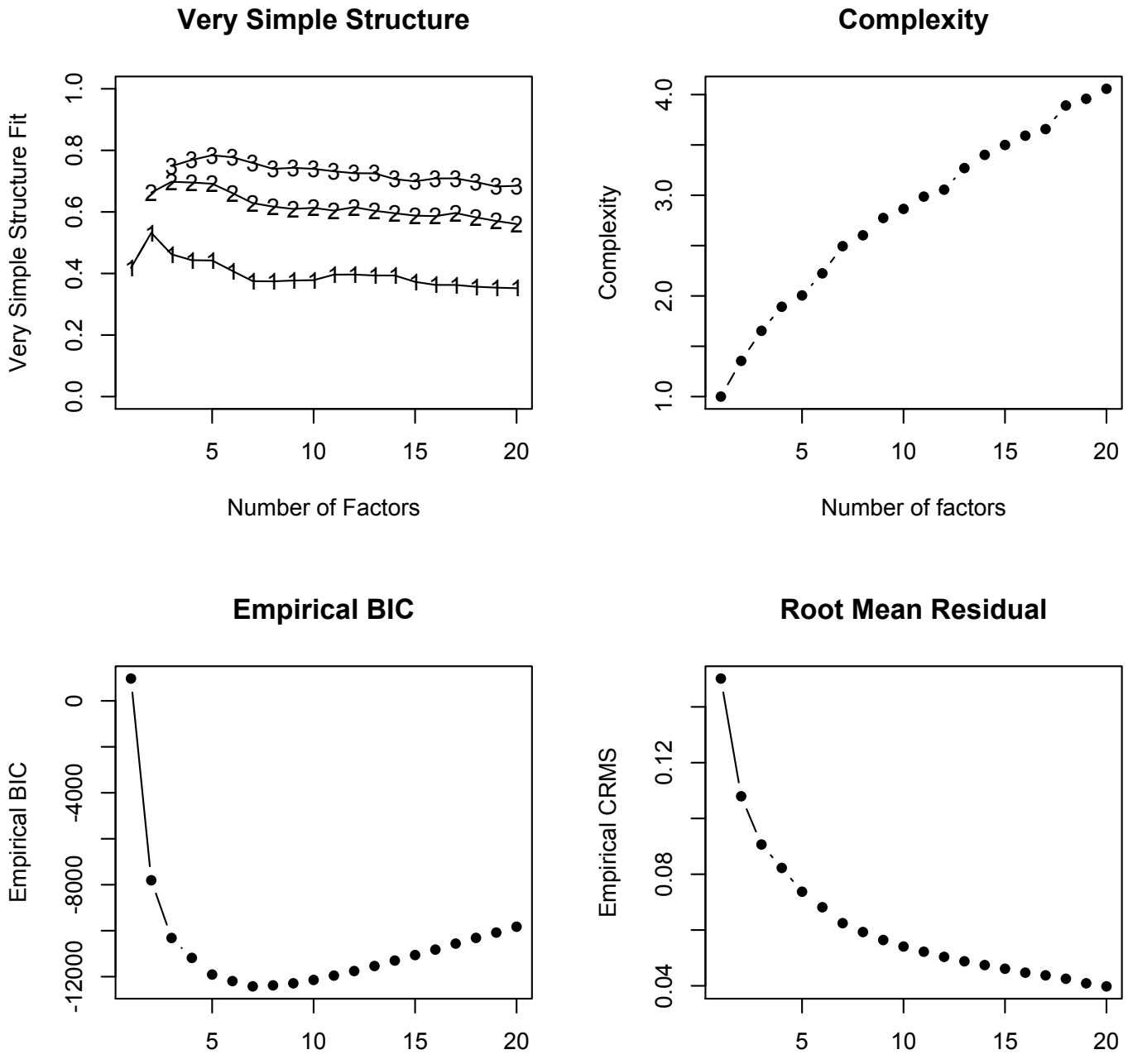
or

$$R \approx CC' \tag{2}$$

Factor analysis of PRQ

1. We need more people than items to make the matrix invertible
2. Can be solved in either case by using minimum residuals (OLS)
3. Can be solved by the `fa` function using minres option
4. How many factors to extract is a perpetual problem.
   - nfactors(prq)
   - Use VSS 2 (complexity 1) or 3 (complexity 2)
   - Use MAPS 9
   - Empirical BIC 3 factors
5. Theory says 4

VSS of prq


Very Simple Structure
Very Simple Structure Fit
Number of Factors
Complexity
Complexity
Number of factors
Empirical BIC
Empirical BIC
Root Mean Residual
Empirical CRMS

Find a 4 factor as well as a 4 component solution – very similar

```
f4 <- fa(prq,4)
p4 <- principal(prq,4)
> factor.congruence(f4,p4)
```

```
      RC1   RC2   RC4   RC3
MR1  0.97  0.08 -0.22  0.28
MR2  0.11  0.99  0.19 -0.17
MR3 -0.35  0.21  0.98 -0.07
MR4  0.02 -0.12 -0.15  0.97
```

Summary of the 4 factor solution

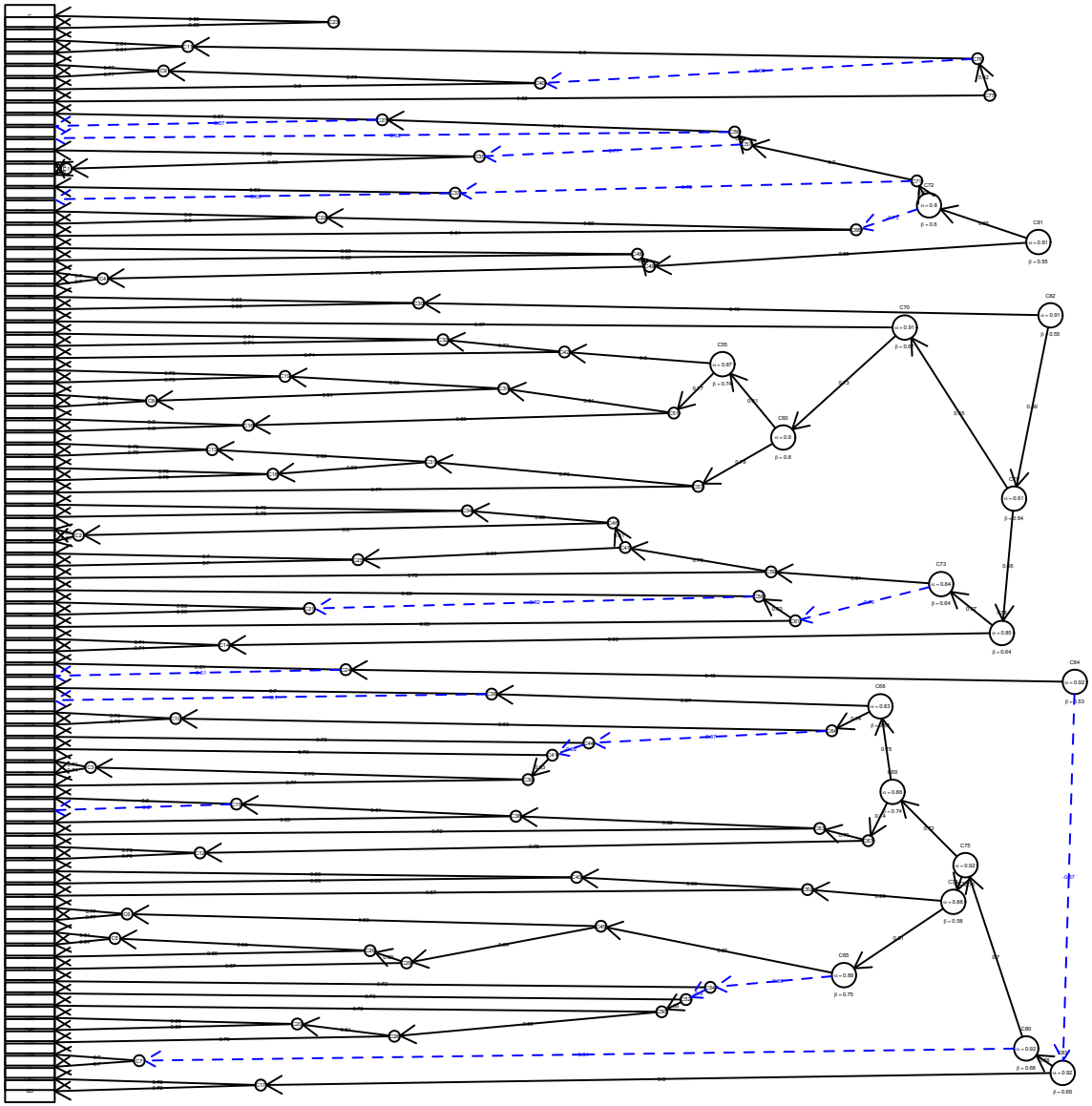
```
> summary(f4)


Factor analysis with Call: fa(r = prq, 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  65.08
The number of observations was  110  with Chi Square =  4935.07  with prob <  5e-48

The root mean square of the residuals (RMSA) is  0.08
The df corrected root mean square of the residuals is  0.08

Tucker Lewis Index of factoring reliability =  0.54
RMSEA index =  0.095  and the 90 % confidence intervals are  0.055 0.063
BIC =  -11826.85
 With factor correlations of
      MR1   MR2   MR3   MR4
MR1  1.00  0.11 -0.24  0.14
MR2  0.11  1.00  0.14 -0.15
MR3 -0.24  0.14  1.00 -0.06
MR4  0.14 -0.15 -0.06  1.00
```

Also try a cluster analysis

```
> ic <-  iclust(prq)
> summary(ic)

ICLUST (Item Cluster Analysis)Call: iclust(r.mat = prq)
ICLUST

Purified Alpha:
 C84  C82  C81  C77  C23
0.93 0.91 0.80 0.73 0.51

 Guttman Lambda6*
 C84  C82  C81  C77  C23
0.99 0.99 0.97 0.96 0.91

Original Beta:
 C84  C82  C81  C77  C23
0.53 0.55 0.55 0.39 0.51

Cluster size:
C84 C82 C81 C77 C23
 36  28  16   7   2

Purified scale intercorrelations
 reliabilities on diagonal
 correlations corrected for attenuation above diagonal:
       C84  C82     C81     C77   C23
C84  0.925 0.18  0.0559  0.3261 -0.34
C82  0.164 0.91  0.3016  0.2529  0.23
C81  0.048 0.26  0.8029 -0.0045 -0.33
C77  0.267 0.21 -0.0034  0.7271  0.10
```

The cluster solution

ICLUST



Compare the solutions

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

	MR1	MR2	MR3	MR4	RC1	RC2	RC4	RC3	C84	C82	C81	C77	C23
MR1	1.00	0.05	-0.17	0.07	0.97	0.08	-0.22	0.28	-0.86	0.01	0.07	-0.34	0.43
MR2	0.05	1.00	0.11	-0.07	0.11	0.99	0.19	-0.17	0.01	0.87	0.32	0.20	0.39
MR3	-0.17	0.11	1.00	-0.06	-0.35	0.21	0.98	-0.07	0.60	0.52	0.03	0.63	-0.08
MR4	0.07	-0.07	-0.06	1.00	0.02	-0.12	-0.15	0.97	-0.28	-0.31	-0.93	0.04	0.54
RC1	0.97	0.11	-0.35	0.02	1.00	0.12	-0.36	0.22	-0.91	0.00	0.12	-0.49	0.40
RC2	0.08	0.99	0.21	-0.12	0.12	1.00	0.26	-0.19	0.03	0.91	0.37	0.30	0.41
RC4	-0.22	0.19	0.98	-0.15	-0.36	0.26	1.00	-0.18	0.65	0.59	0.10	0.55	-0.14
RC3	0.28	-0.17	-0.07	0.97	0.22	-0.19	-0.18	1.00	-0.44	-0.36	-0.90	0.00	0.58
C84	-0.86	0.01	0.60	-0.28	-0.91	0.03	0.65	-0.44	1.00	0.27	0.14	0.52	-0.48
C82	0.01	0.87	0.52	-0.31	0.00	0.91	0.59	-0.36	0.27	1.00	0.47	0.38	0.19
C81	0.07	0.32	0.03	-0.93	0.12	0.37	0.10	-0.90	0.14	0.47	1.00	0.04	-0.31
C77	-0.34	0.20	0.63	0.04	-0.49	0.30	0.55	0.00	0.52	0.38	0.04	1.00	0.00
C23	0.43	0.39	-0.08	0.54	0.40	0.41	-0.14	0.58	-0.48	0.19	-0.31	0.00	1.00

```
>
```

Combine the factor scores with the empirical scores

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

	MR1	MR2	MR3	MR4	nach	anx	soc	imp	PrNch	PrAnx	PerSc	PrIm
MR1	1.00											
MR2	0.11	1.00										
MR3	-0.24	0.14	1.00									
MR4	0.14	-0.16	-0.06	1.00								
nach	0.89	0.25	-0.36	-0.06	1.00							
anx	0.32	-0.16	-0.17	0.91	0.15	1.00						
soc	0.06	0.91	0.27	-0.13	0.15	-0.20	1.00					
imp	-0.34	0.27	0.90	-0.16	-0.36	-0.22	0.29	1.00				
PeerNach	0.49	-0.14	-0.33	-0.06	0.43	0.10	-0.15	-0.38	1.00			
PeerAnx	0.16	-0.15	-0.27	0.41	0.03	0.35	-0.16	-0.31	0.26	1.00		
PeerSoc	0.19	0.41	0.17	-0.25	0.17	-0.18	0.42	0.12	0.32	-0.13	1.00	
PeerImp	0.00	0.22	0.47	-0.30	-0.04	-0.23	0.24	0.44	-0.02	-0.16	0.54	1.0
gender	0.21	0.09	-0.19	0.46	0.13	0.42	0.05	-0.16	-0.10	0.03	-0.02	-0.2

Compare original, factors and clusters

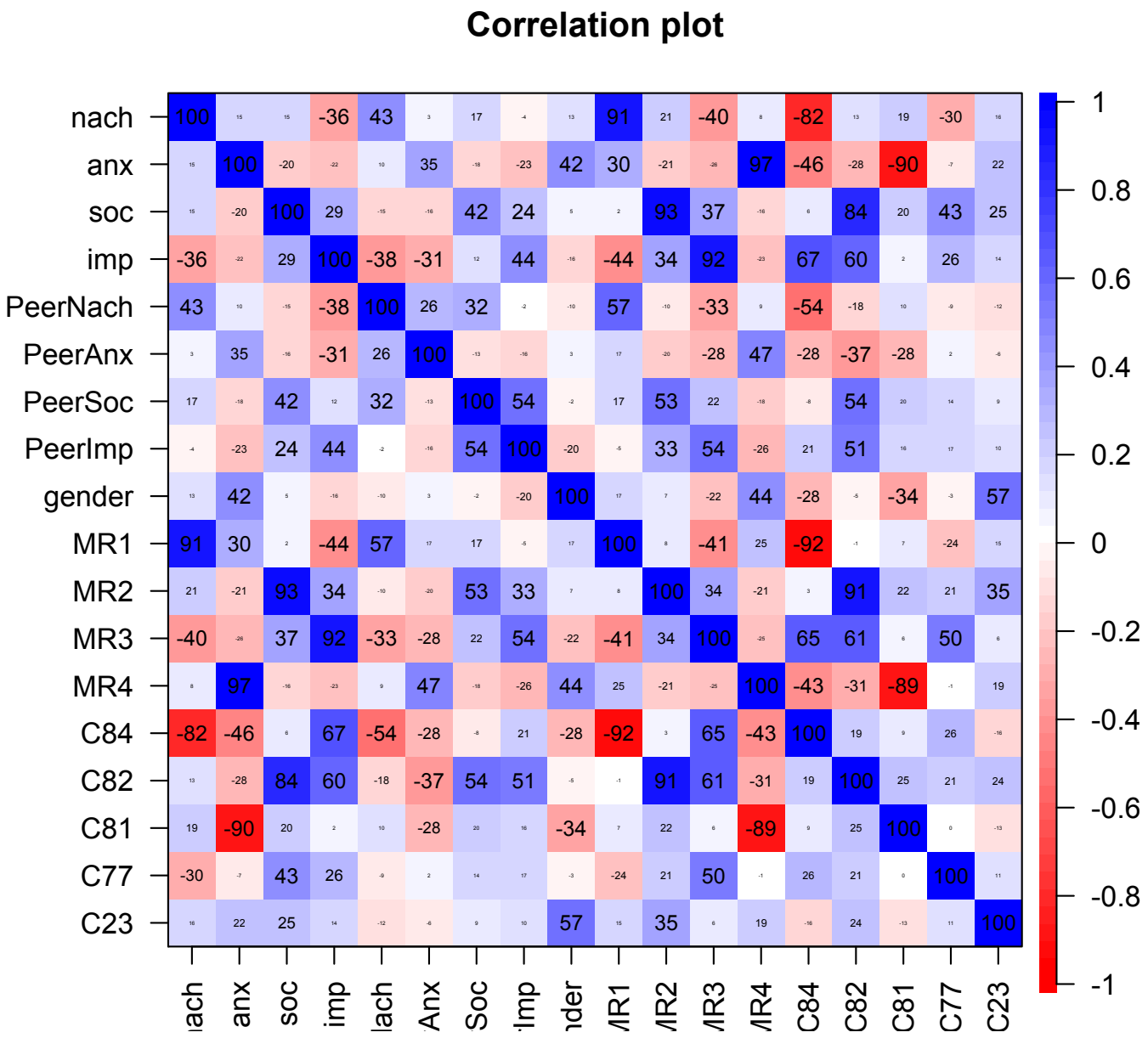
```
> fkeys <- factor2cluster(f4)
> ckeys <- cluster2keys(ic)
> all.keys <- cbind(prq.keys,fkeys,ckeys)
> all.scores <- scoreItems(all.keys,prq)
> lowerMat(all.scores$cor)
```

Coefficients and bootstrapped confidence intervals

	nach	anx	soc	imp	PrNch	PrAnx	PerSc	PrImp	gendr	MR1	MR2	MR3	MR4	C84
nach	1.00													
anx	0.15	1.00												
soc	0.15	-0.20	1.00											
imp	-0.36	-0.22	0.29	1.00										
PeerNach	0.43	0.10	-0.15	-0.38	1.00									
PeerAnx	0.03	0.35	-0.16	-0.31	0.26	1.00								
PeerSoc	0.17	-0.18	0.42	0.12	0.32	-0.13	1.00							
PeerImp	-0.04	-0.23	0.24	0.44	-0.02	-0.16	0.54	1.00						
gender	0.13	0.42	0.05	-0.16	-0.10	0.03	-0.02	-0.20	1.00					
MR1	0.91	0.30	0.02	-0.44	0.57	0.17	0.17	-0.05	0.17	1.00				
MR2	0.21	-0.21	0.93	0.34	-0.10	-0.20	0.53	0.33	0.07	0.08	1.00			
MR3	-0.40	-0.26	0.37	0.92	-0.33	-0.28	0.22	0.54	-0.22	-0.41	0.34	1.00		
MR4	0.08	0.97	-0.16	-0.23	0.09	0.47	-0.18	-0.26	0.44	0.25	-0.21	-0.25	1.00	
C84	-0.82	-0.46	0.06	0.67	-0.54	-0.28	-0.08	0.21	-0.28	-0.92	0.03	0.65	-0.43	1.00
C82	0.13	-0.28	0.84	0.60	-0.18	-0.37	0.54	0.51	-0.05	-0.01	0.91	0.61	-0.31	0.19
C81	0.19	-0.90	0.20	0.02	0.10	-0.28	0.20	0.16	-0.34	0.07	0.22	0.06	-0.89	0.09
C77	-0.30	-0.07	0.43	0.26	-0.09	0.02	0.14	0.17	-0.03	-0.24	0.21	0.50	-0.01	0.26
C23	0.16	0.22	0.25	0.14	-0.12	-0.06	0.09	0.10	0.57	0.15	0.35	0.06	0.19	-0.16

	C82	C81	C77	C23
C82	1.00			
C81	0.25	1.00		
C77	0.21	0.00	1.00	
C23	0.24	-0.13	0.11	1.00

The correlations between rational keying, peer ratings factors and clusters



Best items sorted by factor loading Factor 1

```
> fa.lookup(f4,prq.dictionary)
```

	MR1	MR2	MR3	MR4	com	h2	content
Q25	0.87	-0.02	-0.04	-0.02	1.01	0.76	I am goal oriented
Q73	0.81	0.01	0.00	-0.01	1.00	0.65	Success motivates me
Q61	0.79	-0.05	-0.04	0.12	1.06	0.68	I set goals for myself
Q17	0.77	-0.01	0.06	-0.01	1.01	0.58	I strive to be the best
Q37	0.65	0.07	-0.11	-0.04	1.09	0.47	I push myself to succeed
Q53	0.60	0.04	0.17	-0.07	1.20	0.35	I am a competitive person
Q62	0.58	-0.05	0.09	0.29	1.55	0.46	I feel uncomfortable when I do not have control over a situation
Q57	0.57	0.09	-0.23	-0.04	1.39	0.45	I am a motivated person
Q29	0.53	-0.23	0.13	0.25	1.94	0.40	I get upset when I lose or do poorly
Q33	0.51	-0.18	0.03	0.38	2.13	0.48	I am afraid of failure
Q76	0.51	0.03	-0.29	-0.18	1.89	0.41	When I start a task I always finish it
Q21	0.51	0.13	0.04	-0.44	2.12	0.43	I am not afraid of difficult tasks
Q42	0.49	-0.20	0.07	0.27	1.97	0.37	I have trouble letting go of things
N	0.48	-0.19	-0.20	-0.17	1.96	0.33	Nach
Q65	0.48	0.16	0.00	0.12	1.34	0.29	The reward often justifies the effort.
Q45	0.44	0.23	0.03	0.05	1.54	0.27	I feel accomplished when I reach my goals
Q81	0.43	0.20	-0.30	-0.04	2.30	0.37	I believe that if something is worth doing, it is worth doing well.
Q13	0.39	0.14	-0.03	-0.29	2.16	0.25	I like challenging tasks
Q68	0.38	0.15	-0.26	0.01	2.13	0.28	I know what I am doing next week
Q36	-0.32	0.15	0.26	0.06	2.48	0.22	I sometimes switch goals with no real reason
Q5	0.32	-0.16	-0.05	0.11	1.80	0.16	It is important for me to outperform my peers
Q66	0.29	0.19	-0.20	-0.27	3.58	0.25	I feel like I have control over my life
Q9	0.24	0.14	-0.07	0.01	1.82	0.09	I would prefer a moderately difficult task over an easy or hard one

Factor 2

Q83	0.06	0.83	0.00	0.11	1.05	0.69	I am a very sociable person.
Q47	-0.07	0.78	0.07	0.05	1.04	0.61	I like to meet new people.
Q55	-0.10	0.76	-0.08	0.01	1.06	0.56	I can easily hold a conversation with a stranger.
Q35	-0.02	0.73	-0.15	0.02	1.09	0.52	I find it easy to make new friends.
Q51	-0.01	0.69	0.27	0.03	1.30	0.60	I like to be around groups of people.
Q79	0.00	0.66	-0.06	-0.34	1.50	0.62	I am relaxed and confident around others.
Q31	-0.17	0.65	-0.14	-0.25	1.55	0.54	I am relaxed when meeting new people.
Q39	0.00	0.65	-0.14	-0.10	1.14	0.45	Expressing myself to others comes naturally.
Q67	0.13	0.64	0.19	0.21	1.49	0.51	I often crave interaction with other people.
Q3	0.00	0.62	-0.21	-0.05	1.23	0.40	I say hello to acquaintances on the street.
Q11	0.14	0.59	0.16	0.03	1.29	0.42	I am talkative.
Q71	-0.02	0.58	0.27	0.14	1.55	0.45	I prefer interacting with others to spending time by myself.
Q75	-0.16	0.43	0.17	0.04	1.63	0.26	I prefer working with others to working alone.
Q59	0.30	0.38	0.15	0.08	2.32	0.28	I am often the first person to speak during a conversation.
S	0.22	0.33	0.17	-0.22	3.13	0.26	Sociability
Q60	0.15	0.30	0.14	0.21	2.81	0.17	When shopping I find my spending money on things I never planned to
Q80	-0.16	0.28	0.25	-0.25	3.57	0.30	I like not knowing what comes next
Q64	0.01	0.21	0.06	-0.18	2.16	0.10	Do you often switch lanes when you are driving?

Factor 3

Q84	0.17	0.12	0.73	0.00	1.17	0.55	I am an impulsive person.
Q72	0.19	0.19	-0.64	-0.07	1.40	0.51	I think before I act
Q41	0.18	0.16	-0.63	-0.03	1.31	0.48	I consider myself to be a perfectionist
Q32	-0.22	-0.01	0.62	0.13	1.34	0.50	I often act without thinking
Q4	0.16	0.37	0.62	-0.06	1.79	0.58	I like to do things spur of the moment
Q44	0.29	-0.10	0.57	-0.17	1.77	0.35	I want to try sky-diving
Q16	0.14	0.20	-0.56	0.02	1.38	0.38	I plan out my actions in detail
Q20	0.10	0.34	0.52	-0.04	1.82	0.44	I like making decisions on the spur of the moment
Q34	0.21	-0.07	-0.51	0.30	2.08	0.50	Others would describe me as uptight or high strung
Q48	0.02	0.24	0.50	-0.05	1.47	0.35	I find myself doing things I had not planned to do that day
Q24	0.27	0.24	-0.50	0.02	2.05	0.43	I consider all of my options before making a decision
Q40	0.09	0.25	0.49	-0.22	2.00	0.40	I like to take risks
Q56	-0.17	0.21	0.49	0.03	1.65	0.36	Do you go on unplanned trips or excursions
I	0.13	0.10	0.47	-0.27	1.89	0.32	Impulsivity
Q8	0.30	0.07	-0.45	-0.06	1.84	0.36	I like to plan out my day
Q28	0.00	-0.05	-0.42	0.02	1.03	0.19	I analyze my thoughts before saying them out loud?
Q63	-0.05	0.38	0.41	0.06	2.07	0.36	I enjoy being in a crowded area.
Q52	0.08	0.26	0.39	-0.18	2.28	0.30	I enjoy surprises?
Q69	-0.09	-0.12	0.39	-0.04	1.32	0.19	I frequently cheat to succeed
Q12	-0.31	-0.17	0.39	-0.10	2.51	0.35	I rarely plan for the future
Q43	-0.12	0.17	0.39	0.21	2.21	0.25	I would prefer to have many friends rather than a few close ones.
Q23	0.12	0.00	0.32	-0.01	1.29	0.10	I like to be the center of attention.
Q1	-0.26	0.01	0.31	0.20	2.71	0.22	I give up easily
Q15	0.14	-0.04	-0.21	-0.14	2.65	0.09	I like quiet time alone.
Q27	0.17	-0.15	-0.19	0.12	3.62	0.13	I need time to recharge after spending time with others.

Factor 4

Q2	0.08	0.13	-0.06	0.70	1.11	0.52	I have difficulty stopping myself from worrying
Q22	0.14	-0.03	-0.03	0.68	1.09	0.52	I often feel nervous or on edge
Q30	0.03	0.10	-0.15	0.63	1.18	0.42	Sometimes, I am so worried, I can not focus
Q6	-0.05	0.05	0.21	0.53	1.34	0.30	I often fidget or bite my nails
Q54	0.06	-0.05	-0.06	0.51	1.08	0.30	I often feel threatened or judged by other people
Q70	0.31	0.27	0.08	-0.50	2.37	0.44	I am confident in my abilities
Q50	-0.21	0.17	0.19	0.48	2.00	0.30	I have trouble concentrating on difficult tasks
G	0.09	0.18	-0.16	0.47	1.64	0.28	Gender
Q26	0.38	-0.09	0.15	0.44	2.30	0.38	I often worry that my life will not turn out as planned
Q18	0.39	0.05	-0.37	0.42	3.00	0.60	I often fret over details for future plans
Q14	0.17	-0.10	0.21	0.42	1.97	0.26	I anticipate the worst outcome of a situation
Q78	0.19	0.14	0.02	-0.42	1.63	0.23	I usually think things will work out
Q58	0.21	0.25	-0.34	0.42	3.16	0.43	I overthink details
Q74	0.20	0.05	-0.09	-0.40	1.66	0.20	I work well under pressure
Q77	0.34	-0.12	-0.09	0.38	2.32	0.35	Avoiding failure motivates me
Q82	-0.16	0.31	0.07	0.38	2.43	0.22	I am more emotional than my friends
A	0.07	-0.07	-0.22	0.37	1.81	0.23	Anxiety
Q10	-0.31	0.19	0.17	-0.35	3.08	0.36	It is easy for me to relax
Q46	-0.04	-0.05	-0.20	0.32	1.75	0.15	I get nervous before speaking in public
Q49	0.15	0.25	-0.06	-0.31	2.49	0.20	Failure is a sign to try again
Q38	0.22	-0.06	-0.02	0.27	2.03	0.15	I often feel restlessness or insomnia
Q7	0.12	0.16	0.12	0.25	2.69	0.11	Many of my goals involve other people.

Show the items for the clusters

fa.lookup(ic,prq.dictonary)

	C84	C82	C81	C77	C23	content scal
Q25	-0.77	-0.01	0.09	-0.13	0.19	I am goal oriented
Q61	-0.75	-0.06	-0.04	-0.14	0.24	I set goals for myself
Q73	-0.71	0.05	0.06	-0.23	0.24	Success motivates me
Q18	-0.70	-0.20	-0.34	-0.21	0.33	I often fret over details for future plans
Q17	-0.66	0.07	0.10	-0.02	0.18	I strive to be the best
Q57	-0.63	-0.02	0.14	-0.20	0.13	I am a motivated person
Q37	-0.63	0.05	0.07	-0.27	0.01	I push myself to succeed
Q76	-0.61	0.00	0.22	-0.03	0.13	When I start a task I always finish it
Q34	-0.58	-0.37	-0.20	-0.07	0.32	Others would describe me as uptight or high strung
Q62	-0.58	-0.05	-0.21	-0.02	0.26	I feel uncomfortable when I do not have control over a situation
Q33	-0.55	-0.22	-0.28	-0.03	0.22	I am afraid of failure
Q12	0.54	0.02	0.00	0.19	-0.25	I rarely plan for the future
Q81	-0.54	0.08	0.02	-0.39	0.16	I believe that if something is worth doing, it is worth doing well.
Q72	-0.54	-0.11	0.06	-0.20	0.07	I think before I act
Q32	0.54	0.27	-0.12	0.33	0.09	I often act without thinking
Q24	-0.53	-0.03	0.07	-0.26	0.08	I consider all of my options before making a decision
Q8	-0.53	-0.09	0.10	-0.18	0.29	I like to plan out my day
Q41	-0.53	-0.14	0.12	-0.18	0.24	I consider myself to be a perfectionist
N	-0.52	-0.18	0.12	-0.09	-0.13	Nach
Q58	-0.51	-0.05	-0.28	-0.36	0.25	I overthink details
Q68	-0.51	0.01	0.15	-0.13	0.17	I know what I am doing next week
Q10	0.50	0.33	0.35	-0.04	-0.15	It is easy for me to relax
Q42	-0.50	-0.18	-0.28	-0.09	0.08	I have trouble letting go of things
Q16	-0.49	-0.07	0.03	-0.29	0.13	I plan out my actions in detail
Q65	-0.48	0.13	0.05	-0.07	0.32	The reward often justifies the effort.
Q77	-0.48	-0.26	-0.22	-0.02	0.20	Avoiding failure motivates me
Q29	-0.47	-0.21	-0.19	-0.01	0.13	I get upset when I lose or do poorly
Q36	0.46	0.20	-0.08	0.11	0.00	I sometimes switch goals with no real reason
Q56	0.46	0.37	0.01	0.21	-0.06	Do you go on unplanned trips or excursions

Cluster 2

IQ83	-0.12	0.71	0.08	0.07	0.24	I am a very sociable person.
Q47	0.05	0.70	0.15	0.17	0.15	I like to meet new people.
Q51	0.16	0.70	0.13	0.30	0.25	I like to be around groups of people.
Q4	0.25	0.66	0.08	0.02	0.02	I like to do things spur of the moment
Q79	0.04	0.66	0.40	-0.08	0.03	I am relaxed and confident around others.
Q55	0.02	0.65	0.10	0.00	0.13	I can easily hold a conversation with a stranger.
Q31	0.09	0.62	0.31	0.14	0.01	I am relaxed when meeting new people.
Q11	-0.04	0.62	0.17	0.21	0.27	I am talkative.
Q35	-0.08	0.59	0.09	-0.03	0.03	I find it easy to make new friends.
Q20	0.22	0.58	0.06	0.10	0.08	I like making decisions on the spur of the moment
Q71	0.10	0.58	0.08	0.45	0.13	I prefer interacting with others to spending time by myself.
Q40	0.24	0.58	0.15	0.23	-0.06	I like to take risks
Q67	-0.08	0.56	0.05	0.18	0.29	I often crave interaction with other people.
Q39	-0.07	0.55	0.25	0.02	0.04	Expressing myself to others comes naturally.
Q84	0.28	0.53	-0.04	0.16	0.16	I am an impulsive person.
Q52	0.17	0.53	0.13	0.00	-0.13	I enjoy surprises?
Q63	0.23	0.52	0.06	0.38	0.07	I enjoy being in a crowded area.
S	-0.07	0.50	0.20	0.14	0.05	Sociability
Q48	0.28	0.49	0.05	0.09	0.05	I find myself doing things I had not planned to do that day
Q3	-0.12	0.48	0.17	-0.12	0.10	I say hello to acquaintances on the street.
Q80	0.36	0.47	0.19	0.01	-0.13	I like not knowing what comes next
I	0.21	0.46	0.15	0.18	-0.01	Impulsivity
Q75	0.22	0.46	0.07	0.25	0.18	I prefer working with others to working alone.
Q59	-0.23	0.44	0.07	0.35	0.19	I am often the first person to speak during a conversation.
Q64	0.06	0.36	0.14	0.04	0.15	Do you often switch lanes when you are driving?
Q49	-0.08	0.34	0.28	-0.12	0.10	Failure is a sign to try again
A	-0.28	-0.34	-0.27	0.02	-0.03	Anxiety
Q44	0.12	0.30	0.10	0.06	0.03	I want to try sky-diving

Cluster 3

Q2	-0.31	-0.11	-0.66	-0.06	0.24	I have difficulty stopping myself from worrying
Q22	-0.32	-0.21	-0.65	0.05	0.19	I often feel nervous or on edge
Q30	-0.31	-0.14	-0.63	-0.10	0.27	Sometimes, I am so worried, I can not focus
Q70	-0.10	0.39	0.62	0.03	-0.16	I am confident in my abilities
Q78	-0.02	0.22	0.56	0.01	0.10	I usually think things will work out
Q6	0.03	-0.01	-0.52	0.01	0.22	I often fidget or bite my nails
Q21	-0.30	0.26	0.51	0.00	0.00	I am not afraid of difficult tasks
Q54	-0.24	-0.23	-0.49	-0.04	0.14	I often feel threatened or judged by other people
Q74	-0.11	0.10	0.48	-0.23	-0.07	I work well under pressure
Q14	-0.13	-0.07	-0.47	-0.07	-0.09	I anticipate the worst outcome of a situation
Q50	0.15	0.14	-0.47	0.14	0.39	I have trouble concentrating on difficult tasks
Q66	-0.30	0.14	0.45	-0.01	0.03	I feel like I have control over my life
Q46	-0.14	-0.20	-0.41	-0.17	0.26	I get nervous before speaking in public
Q13	-0.24	0.20	0.38	-0.08	0.13	I like challenging tasks
Q38	-0.28	-0.09	-0.34	-0.05	0.14	I often feel restlessness or insomnia
Q82	0.09	0.16	-0.29	0.03	0.07	I am more emotional than my friends

Cluster 4

Q15	-0.17	-0.08	0.00	-0.72	-0.06	I like quiet time alone.
Q43	0.26	0.23	-0.08	0.69	0.16	I would prefer to have many friends rather than a few close ones.
Q19	-0.21	0.04	0.04	-0.68	-0.07	I can have fun alone.
Q27	-0.27	-0.25	-0.17	-0.65	0.10	I need time to recharge after spending time with others.
Q69	0.31	0.09	0.01	0.55	-0.06	I frequently cheat to succeed
Q23	0.06	0.15	0.06	0.53	0.00	I like to be the center of attention.
Q7	-0.12	0.12	-0.15	0.39	0.14	Many of my goals involve other people.

Cluster 5

```
G   -0.28 -0.04 -0.32 -0.03  0.78                                                                  Gender
Q60 -0.10  0.29 -0.03  0.13  0.78 When shopping I find my spending money on things I never planned to
```

Empirical scale construction

1. Identify those items that most correlate with the criteria
   - Form item composites based upon those items
2. `best.scales` will do this
   - bs <- best.scales(prq,c("N","A","I","S"),dictionary=prq.dictionary)

Empirical 1

```
The items most correlated with the criteria yield r's of
  correlation n.items
N        0.58       9
A        0.55      10
I        0.53       9
S        0.48       8

The best items, their correlations and content  are
$N
        N                                                content scale
Q25  0.42                                 I am goal oriented     N
Q73  0.41                                Success motivates me    N
Q76  0.38             When I start a task I always finish it     I
Q72  0.37                                 I think before I act    I
Q82 -0.37               I am more emotional than my friends      A
Q17  0.35                               I strive to be the best    N
Q34  0.35 Others would describe me as uptight or high strung     A
Q61  0.34                                I set goals for myself    N
Q10 -0.32                          It is easy for me to relax     A
```

Empirical 2

```
$A
        A                                                        content scale
Q22  0.35                                  I often feel nervous or on edge     A
Q40 -0.33                                               I like to take risks     I
Q34  0.33                 Others would describe me as uptight or high strung     A
Q58  0.32                                             I overthink details     A
Q18  0.31                       I often fret over details for future plans     A
Q2   0.31                  I have difficulty stopping myself from worrying     A
Q84 -0.31                                        I am an impulsive person.     I
Q33  0.30                                           I am afraid of failure     N
Q49 -0.29                                    Failure is a sign to try again     N
Q62  0.29 I feel uncomfortable when I do not have control over a situation     A
```

Empirical 3

```
$I
        I                                                    content scale
Q84  0.41                                    I am an impulsive person.     I
Q4   0.37                         I like to do things spur of the moment     I
Q44  0.36                                     I want to try sky-diving     I
Q40  0.36                                         I like to take risks     I
Q48  0.34 I find myself doing things I had not planned to do that day     I
Q32  0.33                                   I often act without thinking     I
Q52  0.31                                          I enjoy surprises?     I
Q20  0.31            I like making decisions on the spur of the moment     I
Q77 -0.29                                  Avoiding failure motivates me     N
```

Empirical 4

```
$S
       S                                      content scale
Q79 0.42 I am relaxed and confident around others.     S
Q31 0.36     I am relaxed when meeting new people.     S
Q47 0.34                I like to meet new people.     S
Q11 0.33                           I am talkative.     S
Q35 0.33       I find it easy to make new friends.     S
Q51 0.33     I like to be around groups of people.     S
Q52 0.30                         I enjoy surprises?     I
Q83 0.30              I am a very sociable person.     S
```

Multiple ways to construct scales

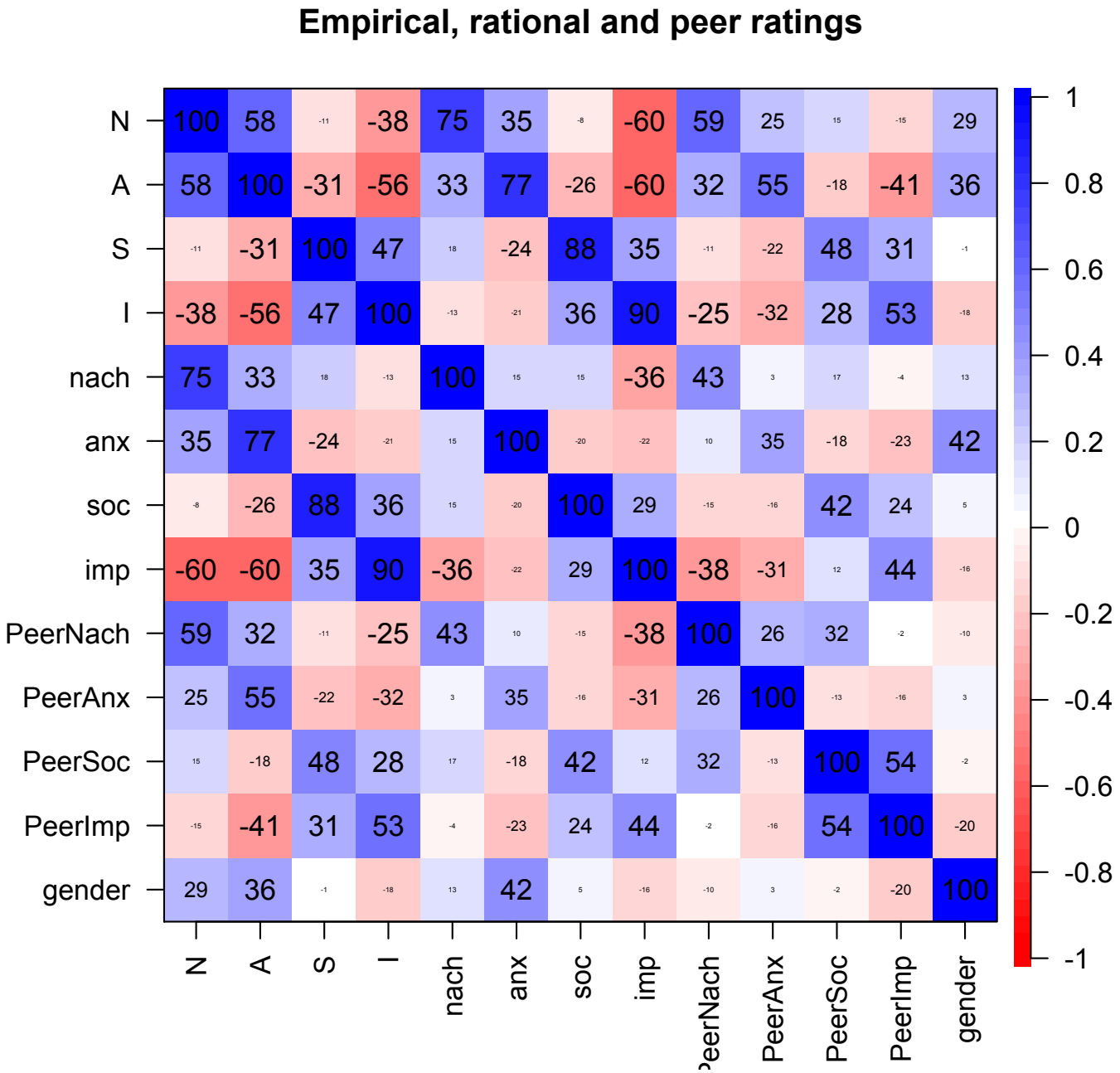
1. Rational/Theoretical
   - Learn Theory
   - Write good items
2. Homogeneous keying
   - Write good items
   - Factor/Cluster analyze
3. Empirical Keys
   - Write good items
   - Select those items that correlate with the criteria

Reliability of various ways of scoring

```
>  mixed.key <- cbind(bs$key,prq.keys)
> mixed <- scoreItems(mixed.key,prq)
> mixed
```

```
> mixed
Call: scoreItems(keys = mixed.key, items = prq)

(Unstandardized) Alpha:
        N    A    S    I nach  anx  soc  imp PeerNach PeerAnx PeerSoc PeerImp gender
alpha 0.8 0.77 0.86 0.82  0.8 0.85 0.85 0.86        1       1       1       1      1

Standard errors of unstandardized Alpha:
          N     A     S     I  nach   anx   soc   imp PeerNach PeerAnx PeerSoc PeerImp gender
ASE   0.044 0.046 0.038 0.041 0.033 0.027 0.026 0.026      NaN      NaN      NaN      NaN    NaN

Average item correlation:
            N    A    S    I nach  anx  soc  imp PeerNach PeerAnx PeerSoc PeerImp gender
average.r 0.3 0.25 0.42 0.34 0.16 0.21 0.22 0.22      NaN      NaN      NaN      NaN    NaN

 Guttman 6* reliability:
            N    A    S    I nach  anx  soc  imp PeerNach PeerAnx PeerSoc PeerImp gender
Lambda.6 0.98 0.97 0.98 0.98 0.98 0.98 0.98 0.98     0.85    0.88     0.9     0.9   0.88

Signal/Noise based upon av.r :
               N   A   S   I nach anx soc imp PeerNach PeerAnx PeerSoc PeerImp gender
Signal/Noise 3.9 3.4 5.9 4.5  4.1 5.6 5.8 5.9      NaN      NaN      NaN      NaN    NaN
```

Show the MMTM matrix graphically – cor.ci(mixed$scores)



10 steps: Reprise

1. Specify your theory of relevant constructs
2. Define the population of interest
3. Give items to engaged subjects
4. Enter the data (carefully)
5. Descriptives to double check data entry and subject engagement
6. Find the variance/covariance matrix
7. Reduce its dimensionality through FA, PC, or clustering
8. Score composites (classical or IRT based)
9. Discriminant validity versus other constructs
10. Convergent validity with similar constructs and different methods

Methods of scale construction

1. Empirical
   - MMPI
   - Strong Vocational Interest Blank
2. Rational
   - California Psychological Inventory
3. Theoretical
   - Measures of Need Achievement (e.g., Jackson PI)
4. Homegeneous keying
   - Eysenck Personality Inventory
   - NEO
   - BFI
   - TIPI

Empirical

1. Ask items that discriminate known groups
   - People in general versus specific group
   - Choose items that are maximally independent and that have highest validities
2. Example:
   - MMPI
   - Strong-Campbell
   - sex and ethnic differences in personality and music
3. Problem:
   - What is the meaning of the scale?
   - Need to develop new scale for every new group

Sex differences at item level

Item	effect size
Get overwhelmed by emotions.	0.59
Sympathize with others' feelings.	0.45
Worry about things.	0.43
Feel others' emotions.	0.39
Get stressed out easily.	0.51
Have a soft heart.	0.38
Panic easily	0.50
Inquire about others' well-being.	0.41
Get upset by unpleasant thoughts that come into my mind.	0.38
Get upset easily.	0.37
Am indifferent to the feelings of others.	-0.33
Am not interested in other people's problems.	-0.33
Feel little concern for others.	-0.35
Am not easily bothered by things	-0.35
Love to help others.	0.34
Am not really interested in others.	-0.32
Think of others first.	0.30
Take offense easily.	0.29
Take time out for others.	0.33

Sex differences and music preference

effect size	Item
0.9	Broadway Musicals (e.g. Rent, Cats, Phantom of the Opera)
0.68	Top 40/Pop Vocal Music (e.g. Kelly Clarkson, Madonna, The Black Eyed Peas)
0.65	Broadway, Movie and TV Soundtrack Music in General
0.59	Contemporary Rhythm and Blues (e. g. Whitney Houston, Usher, Alicia Keys)
0.59	Modern Country Music (e.g. Garth Brooks, Dixie Chicks, Tim McGraw)
0.37	Country Music in General
0.37	Movie Soundtracks (e.g. Starwars, Good Will Hunting, Garden State)
0.36	Top 40 Music/Pop in General
0.32	Pop Rock (e.g. Maroon 5, Counting Crows, John Mayer)
0.31	Modern Religious Music (e.g. 4Him, Casting Crowns)
0.3	Soul Rock (e.g. Stevie Wonder, Earth Wind and Fire)
-0.3	Acid Rock (e.g. Pink Floyd, The Doors, Jefferson Airplane)
-0.4	Heavy Metal (e.g. Metallica, Marilyn Manson, System of a Down)

Ethnic differences and music preference

effect size	Item
1.26	Acid Rock (e.g. Pink Floyd, The Doors, Jefferson Airplane)
1	Alternative (e.g. Pearl Jam, Incubus, Radiohead)
0.97	Electronic Music in General
0.91	Rock Music In General
0.87	Jam Bands (e.g. The Grateful Dead, Phish, String Cheese Incident)
0.87	Classic Rock (e.g. The Beatles, The Rolling Stones, Led Zeppelin)
0.85	Country Rock (e.g. The Allman Brothers, Lynyrd Skynyrd)
0.61	Electronic Dance Music (e.g. DJ Tiesto, Paul Van Dyk, Keoki)
0.59	Folk Music in General (e.g. Bob Dylan, Iron and Wine, Simon and Garfunkel)
0.57	Pop Rock (e.g. Maroon 5, Counting Crows, John Mayer)
0.56	Country Music in General
0.51	Bluegrass (e.g. Alison Krauss, Lester Flatt, Nickel Creek)
-0.56	Contemporary Rhythm and Blues (e. g. Whitney Houston, Usher, Alicia Keys)
-0.6	Blues in General (e.g. Ray Charles, Stevie Ray Vaughn, B.B. King)
-0.63	Instrumental Hip-Hop (e.g. DJ Hi-Tek, RJD2, Prefuse 73)
-0.64	Gospel Soul (e.g. Aretha Franklin, Solomon Burke)
-0.67	Soul in General (e.g. Otis Redding, Marvin Gaye)
-0.84	Religious Music in General
-1.04	Soul Rock (e.g. Stevie Wonder, Earth Wind and Fire)
-1.11	Rhythm and Blues in General
-1.43	Religious Gospel (e.g. Andre Crouch, Gospel Quartet)

Rational Keying

1. Ask items with direct content relevance
2. Example: California Psychological Inventory
3. Problems
   - Not all items predict in obvious way
   - Need evidence for validity
   - Easy to fake

Theoretical Keying

1. Ask items with theoretical relevance
2. Example: Jackson Personality Research Form
3. Problems:
    - Theoretical circularity
    - Need evidence for validity

Homogeneous Keying

1. Select items to represent single domain
2. Exclude items based upon internal consistency
3. Examples:
   - 16PF
   - EPI/EPQ,
   - NEO/NEO-PIR
4. Problems
   - Garbage In, Garbage Out
   - Need evidence for validity

Methods of Homogeneous keying

1. Cluster analysis (e.g. `iclust`)
2. Principal Components analysis (e.g., `pca`)
3. Factor analysis (e.g., `fa`)

The Hase and Goldberg and Goldberg studies

1. Hase and Goldberg: a direct comparison of different techniques
   - Differential validity of scale construction
   - Factor analytic
   - Empirical Group discrimination
   - Intuitive theoretical
   - Intuitive rational
   - Stylistic-psychometric
   - Random
2. 200 University Freshman women
3. CPI items and 13 criteria

Hase and Goldberg: 13 criteria

1. Sorority Membership
2. An experimental measure of conformity
3. Peer ratings of
   - Dominance
   - Sociability
   - Responsibility
   - Psychological Mindedness
   - Femininity
4. Peer ratings of how well known the person is
5. Average number of dates per month
6. College Grade Point Average
7. College Achievement relative to ability
8. College Major
9. College Droput

Does it make a difference?

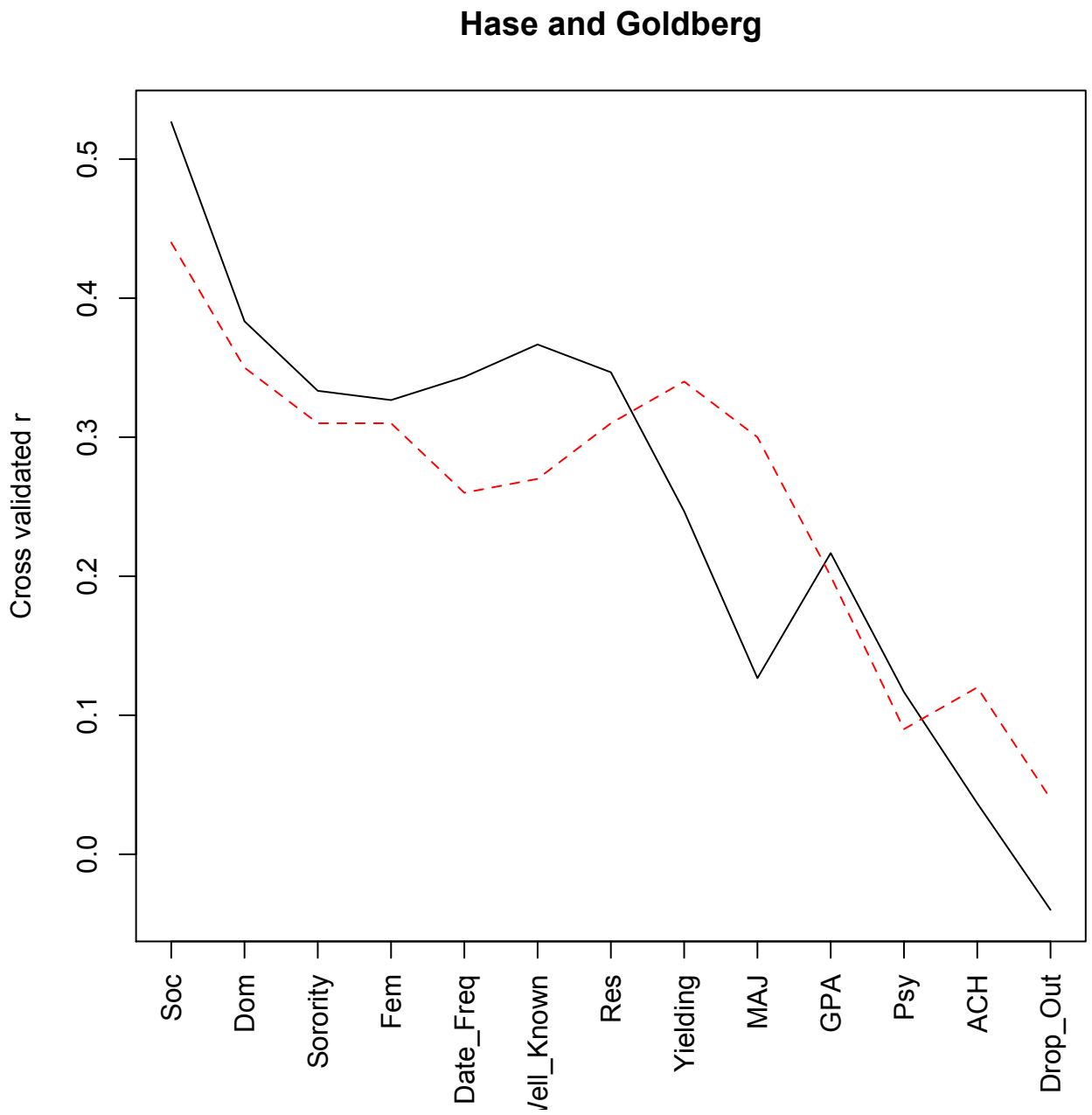
1. Hase and Goldberg (Hase & Goldberg, 1967) No
2. Goldberg (1972) YES

Hase and Goldberg; mean values)

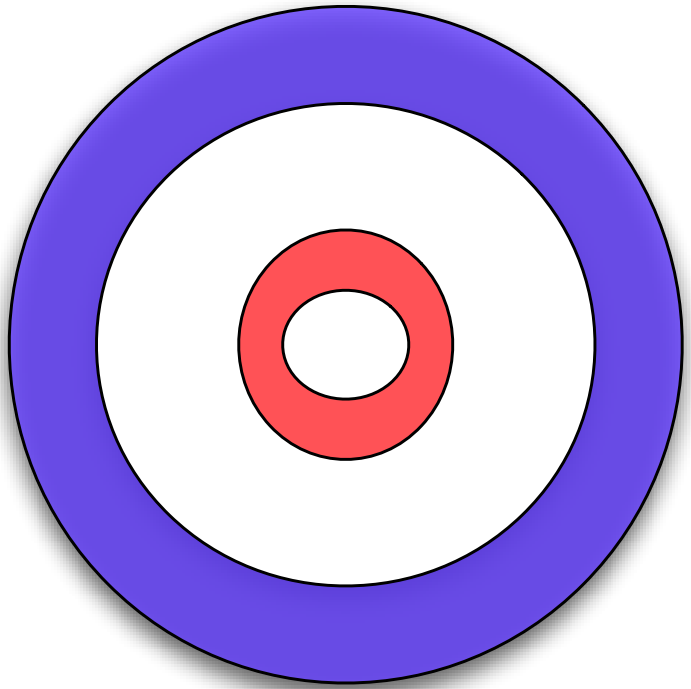
Original Hase and Goldberg showed no difference between methods, except that stylistic and random were much worse.

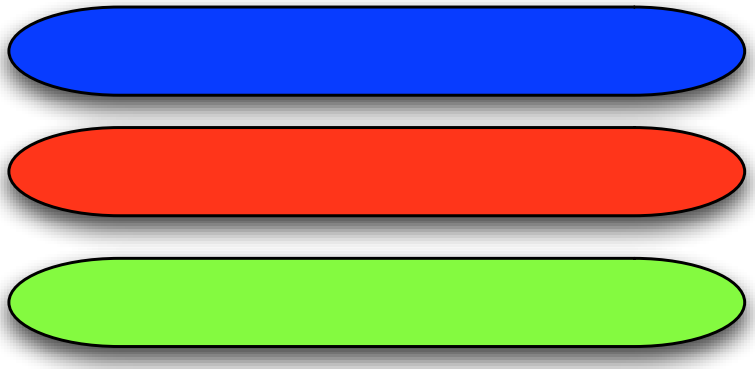
	var	n	mean	sd	median	trimmed	mad	min	max	range	se
Factor	1	13	0.25	0.18	0.27	0.25	0.13	-0.05	0.57	0.62	0.05
Theoretical	2	13	0.25	0.16	0.26	0.25	0.18	0.01	0.52	0.51	0.04
Rational	3	13	0.26	0.16	0.32	0.27	0.09	-0.08	0.49	0.57	0.04
Empirical	4	13	0.26	0.11	0.30	0.26	0.06	0.04	0.44	0.40	0.03
Stylistic	5	13	0.13	0.12	0.11	0.13	0.12	-0.07	0.35	0.42	0.03
Random	6	13	0.10	0.12	0.11	0.10	0.13	-0.08	0.30	0.38	0.03

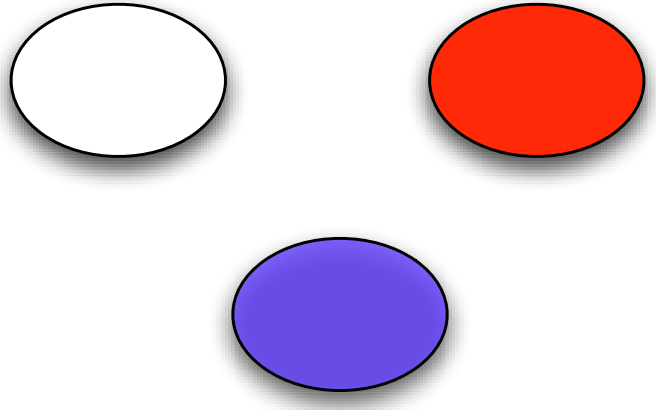
Prediction depends upon criteria: Goldberg: 72



What is a cluster?



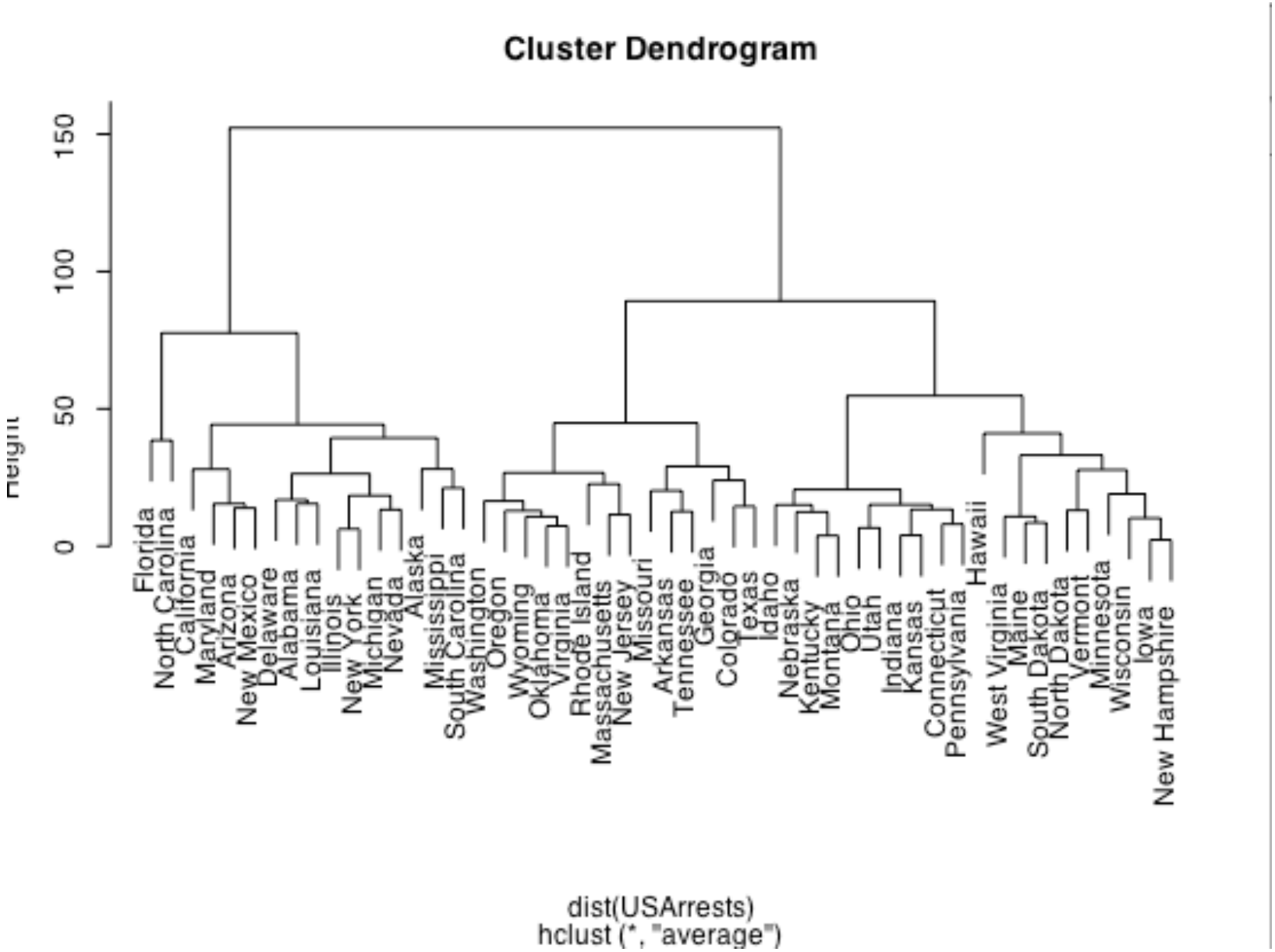




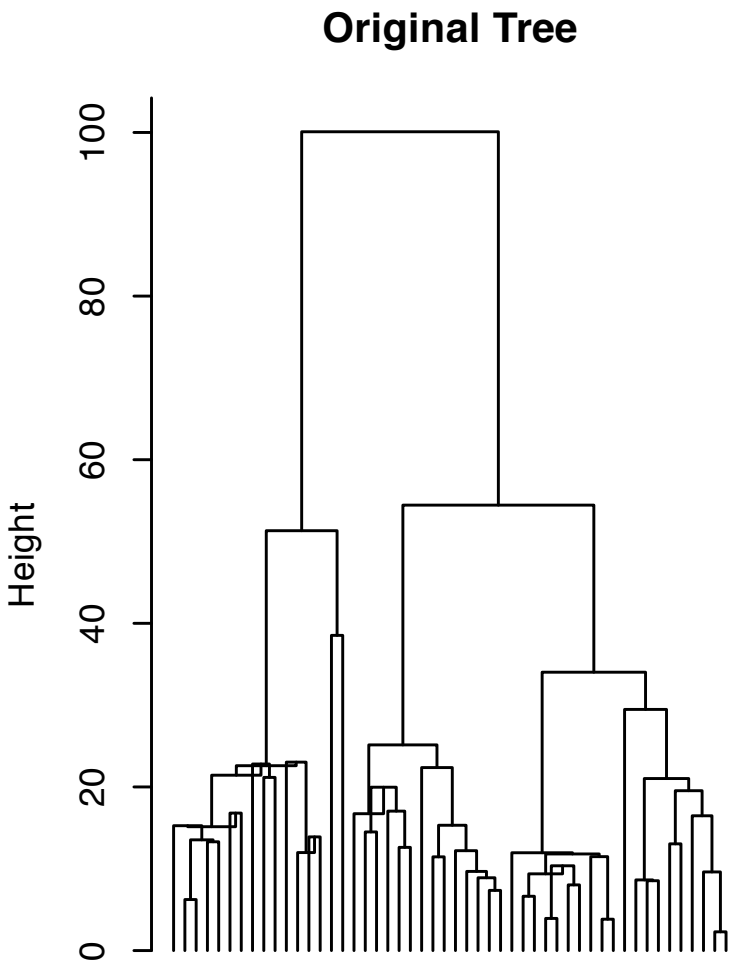
Clustering rules

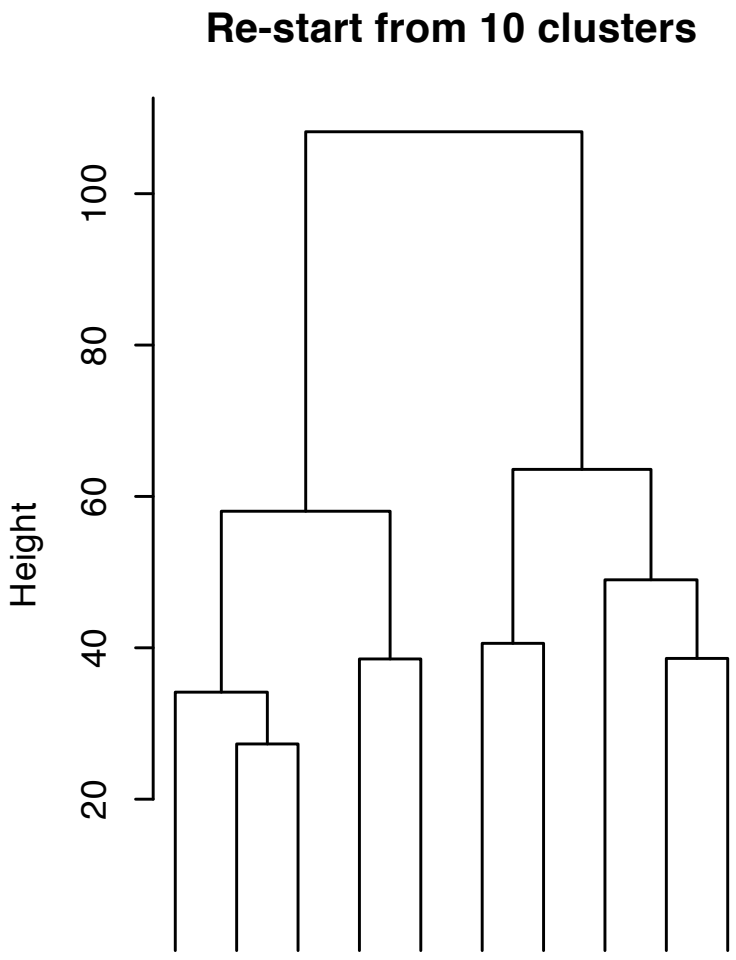
- Distance:
  - Nearest neighbor
  - Farthest neighbor
  - Centroid distance
- Methods
  - Hierarchical
    - Agglomerative
    - Divisive
  - non-hierarchical

Hierarchical Clustering

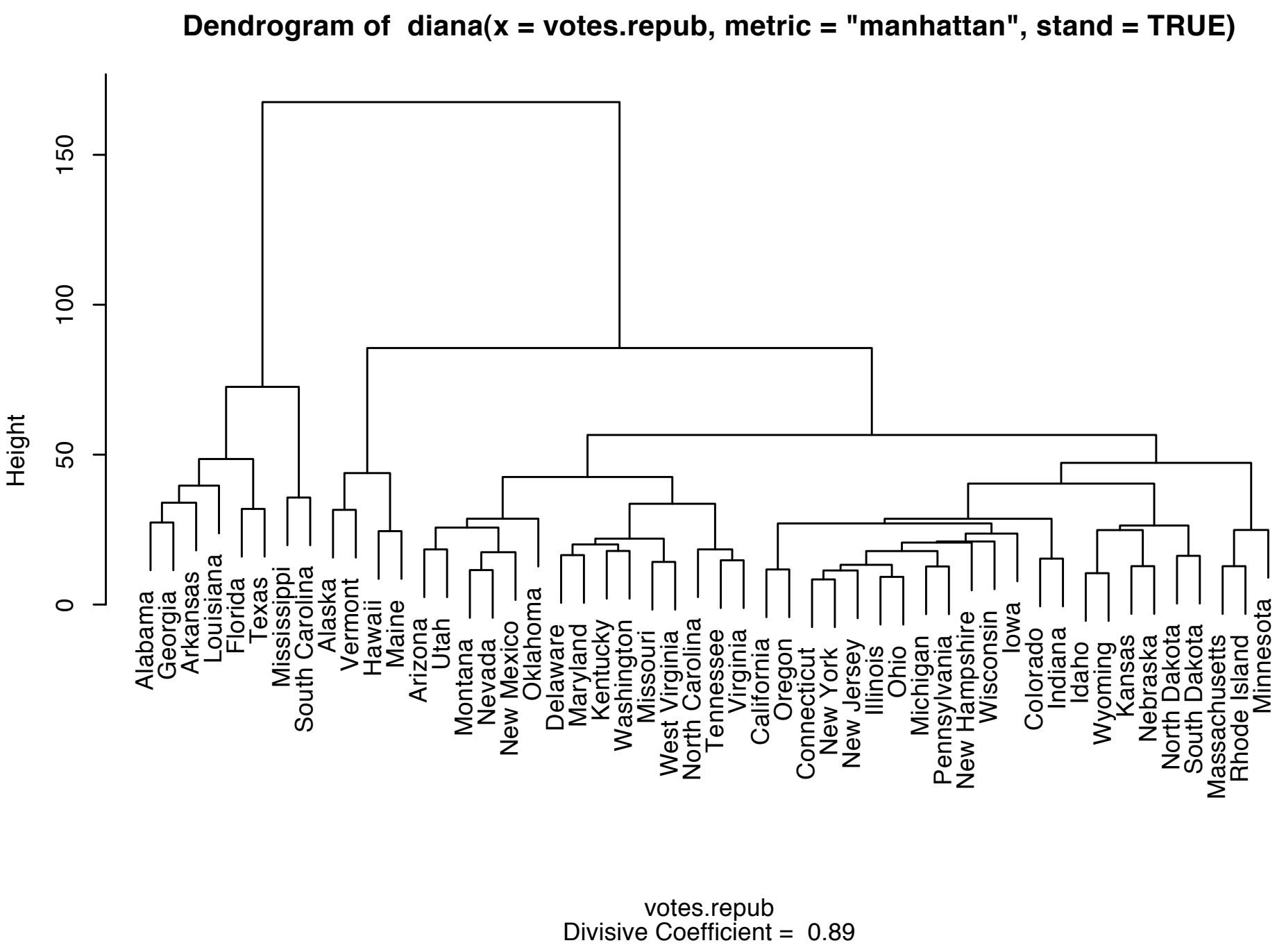


More clustering





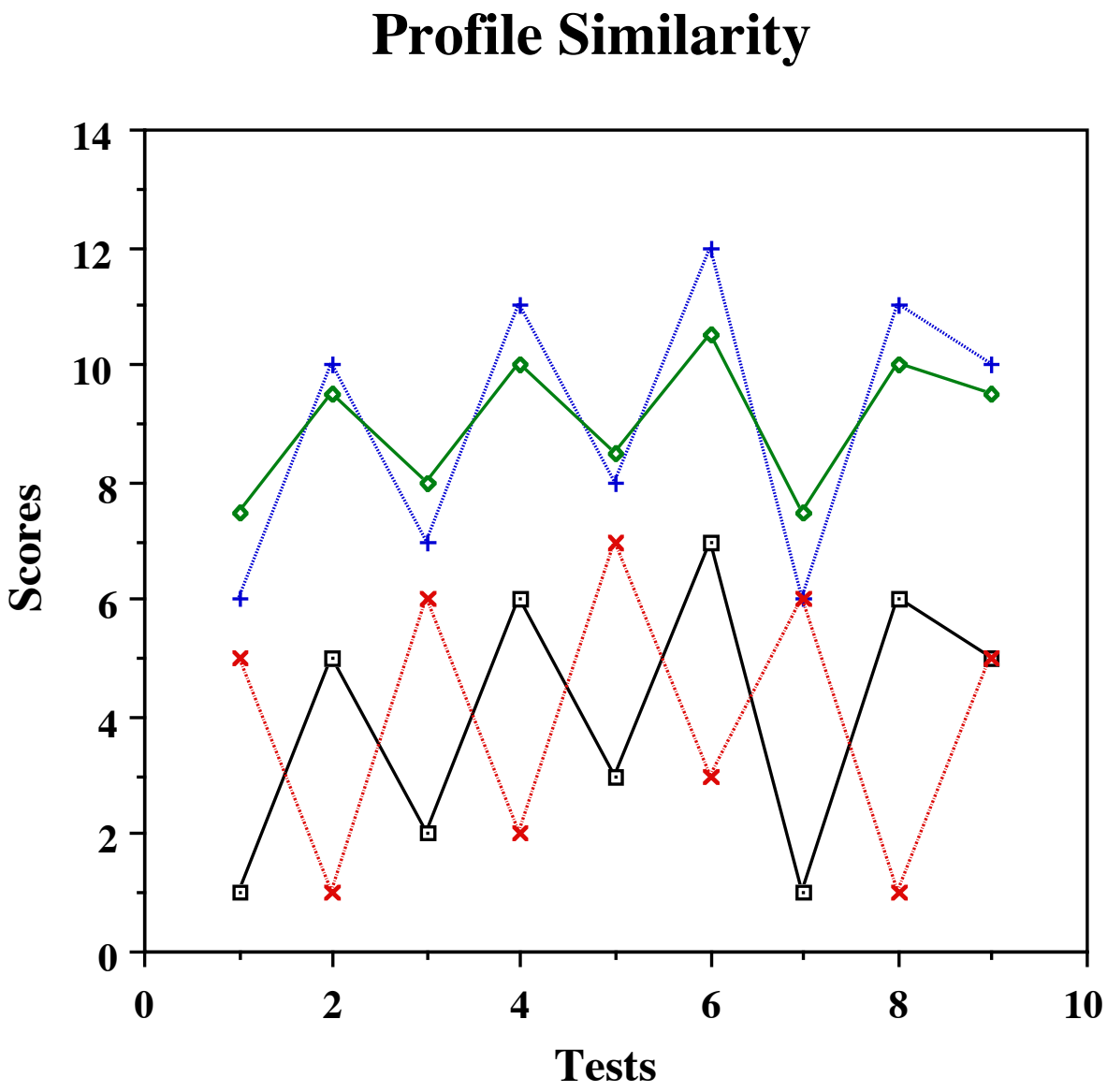
Clusters of voting behavior



Clustering Issues

- Cluster Objects/people
  - similarities or distances?
    - what distance metric
  - can objects be reversed? (not usually)
- Cluster items (unusual, but see ICLUST)
  - items can be reversed (-happy)
  - results are similar to factor analysis
- Stopping rules for cluster
  - number of cluster problem

Measuring similarity



Similarity and distance

Questions:

Given a set of scores on multiple tests (a subject profile), how should we measure the similarity between different profiles? What does it mean to have a similar profile?

What metric to use?

Minkowski Distances = $\sqrt[r]{\sum (X_i - Y_i)^r}$

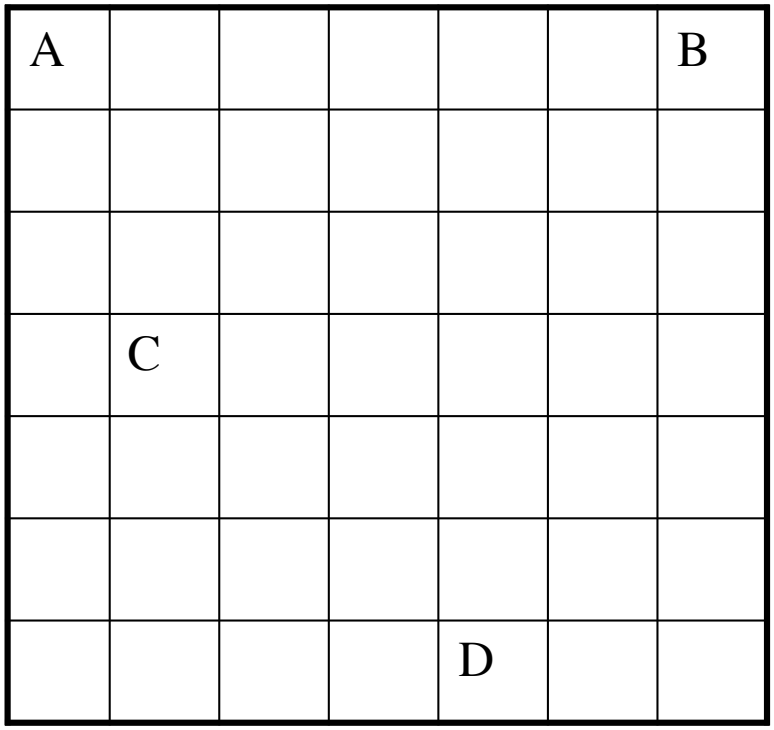
r=1 city block metric ==> all distances equally important (no diagonals)

r=2 Euclidean metric ==> diagonals are shorter than sums

r>2 non-Euclidean ==> emphasizes biggest differences

r=∞ non-Euclidean ==> distance = biggest difference

Consider different metrics



	X	Y
A	1	7
B	7	7
C	2	4
D	5	1

Min

	A	B	C	D
A				
B	0			
C	1	3		
D	4	2	3	

Euclidean

	A	B	C	D
A				
B	6			
C	3.2	5.8		
D	7.2	6.3	4.2	

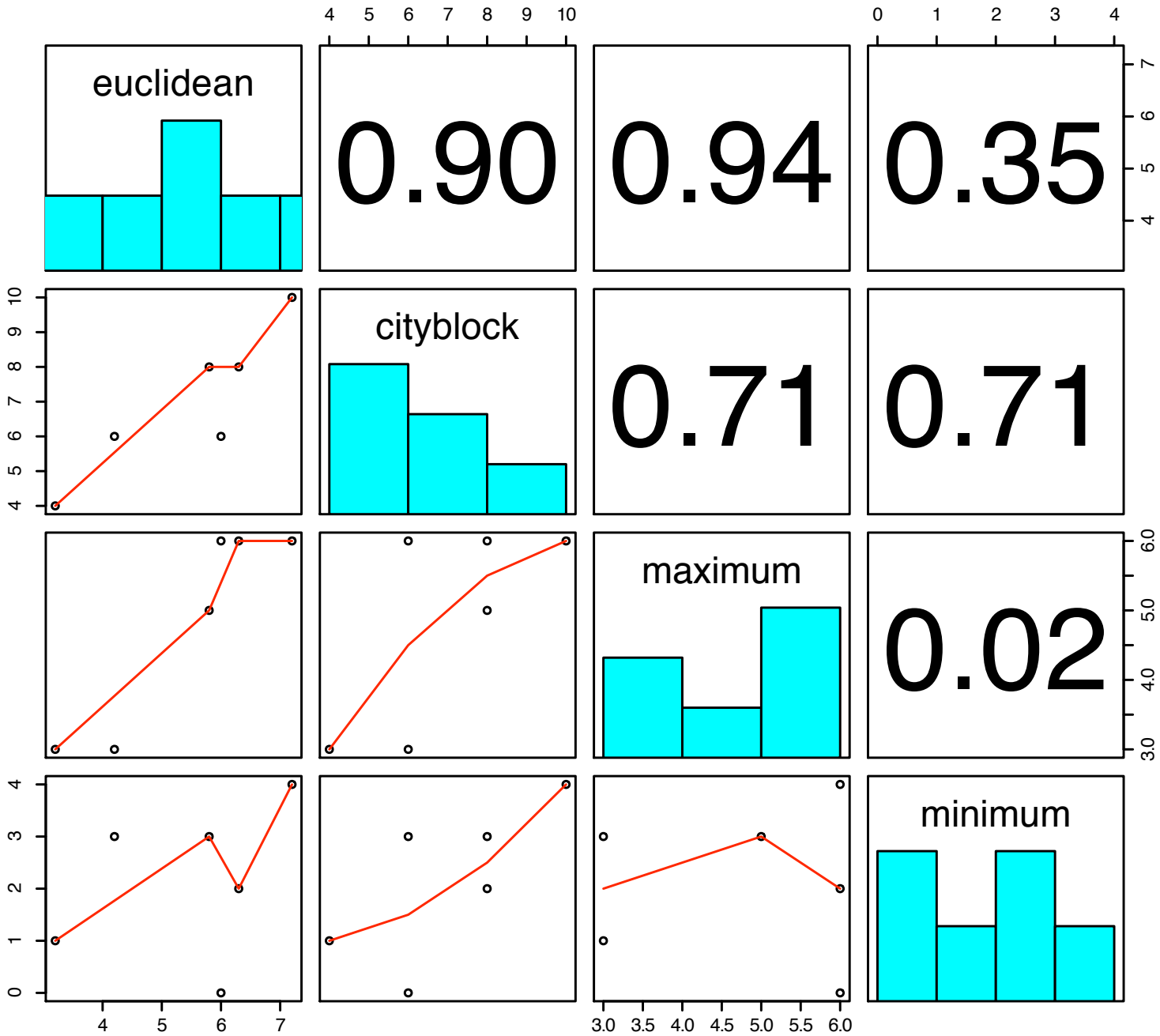
City block

	A	B	C	D
A				
B	6			
C	4	8		
D	10	8	6	

Max

	A	B	C	D
A				
B	6			
C	3	5		
D	6	6	3	

A comparison of metrics



Similarity and correlation

$$D = \sqrt{\sum(X_i - Y_i)^2}$$

let M_X= mean X M_y=mean Y $L=M_X-M_y$

$x=X-M_X$ $y=Y-M_y$

$$D = \sqrt{\sum(X_i - Y_i)^2} = \sqrt{\sum\{(X_i - M_X) - (Y_i - M_y) + L\}^2}$$

$$D = \sqrt{\sum(x-y+L)^2} \Rightarrow D = \sqrt{Var_X + Var_y - 2Cov_{xy} + L^2}$$

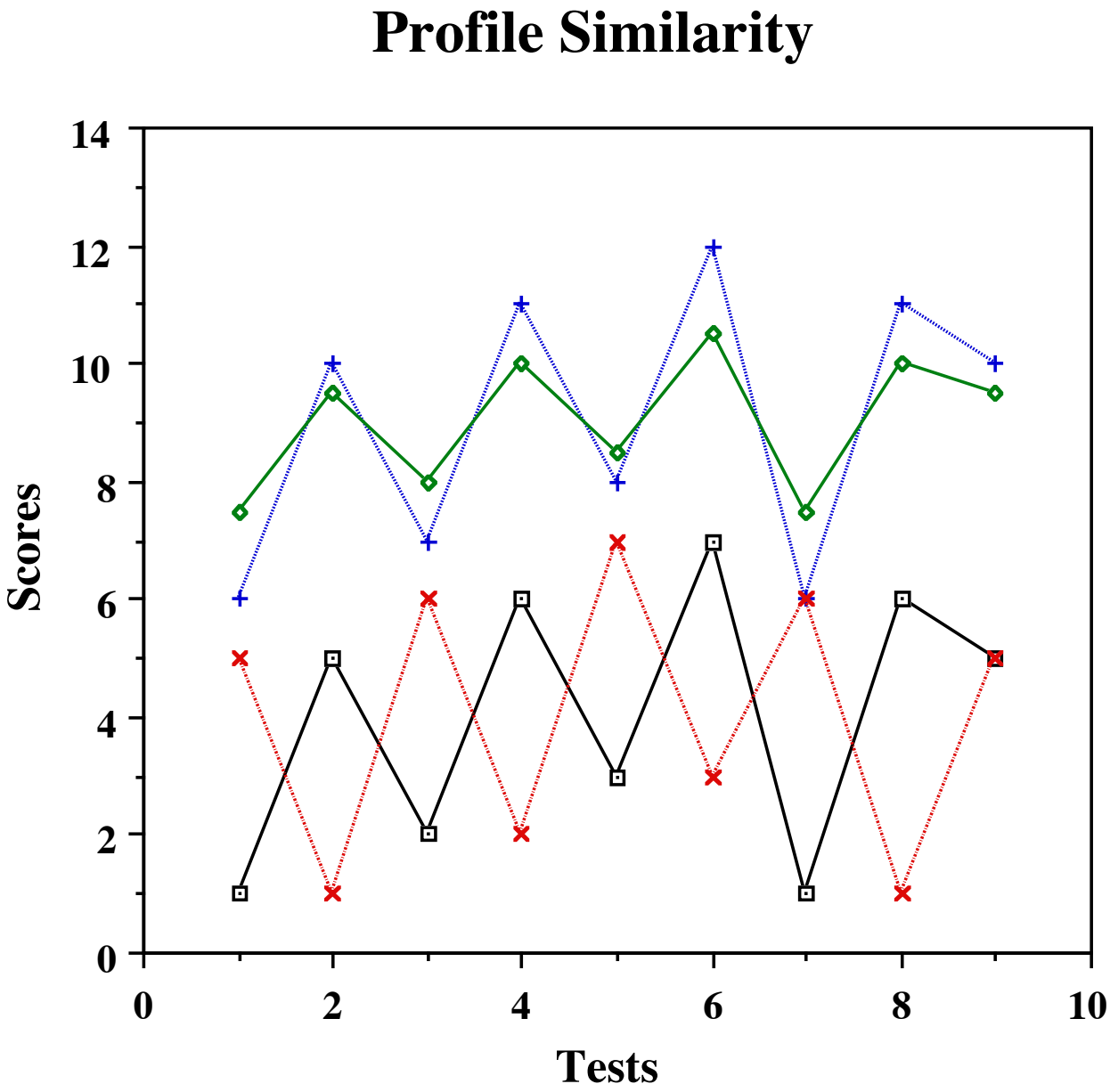
Distance is a function of differences of Level, Scatter, and Pattern

Level ==>	**differences of means**	$L^2=(M_X-M_y)^2$
Scatter ==>	**Variances**	$Var_X + Var_y$
Pattern ==>	**Covariance**	$2Cov_{xy}$

If variables are standardized (means set to zero and variances to 1) then distance is a function of the correlation between the two profiles.

$$D^2 = 2\,(1- r_{xy})$$

Similarity



City blocks vs. Euclid

```
MATRIX  OF  CITY  BLOCK  DISTANCES
                X               Y               Z               W
    X           0.000
    Y           3.778           0.000
    Z           5.000           5.000           0.000
    W           5.000           5.000           1.000
0.000
(W  and  Z  are  most  similar,  followed  by  X  and  Y)

  MATRIX  OF  NORMALIZED  EUCLIDEAN  DISTANCES

                X               Y               Z               W

   X            0.000
   Y            4.028           0.000
   Z            5.000           6.420           0.000
   W            5.115           5.855           1.080
0.000
(W  and  Z  are  most  similar,  followed  by  X  and  Y)
```

Covariance and Correlation

COVARIANCE MATRIX

	X	Y	Z	W
X	5.250			
Y	-3.875	5.250		
Z	5.250	-3.875	5.250	
W	2.625	-1.938	2.625	1.313

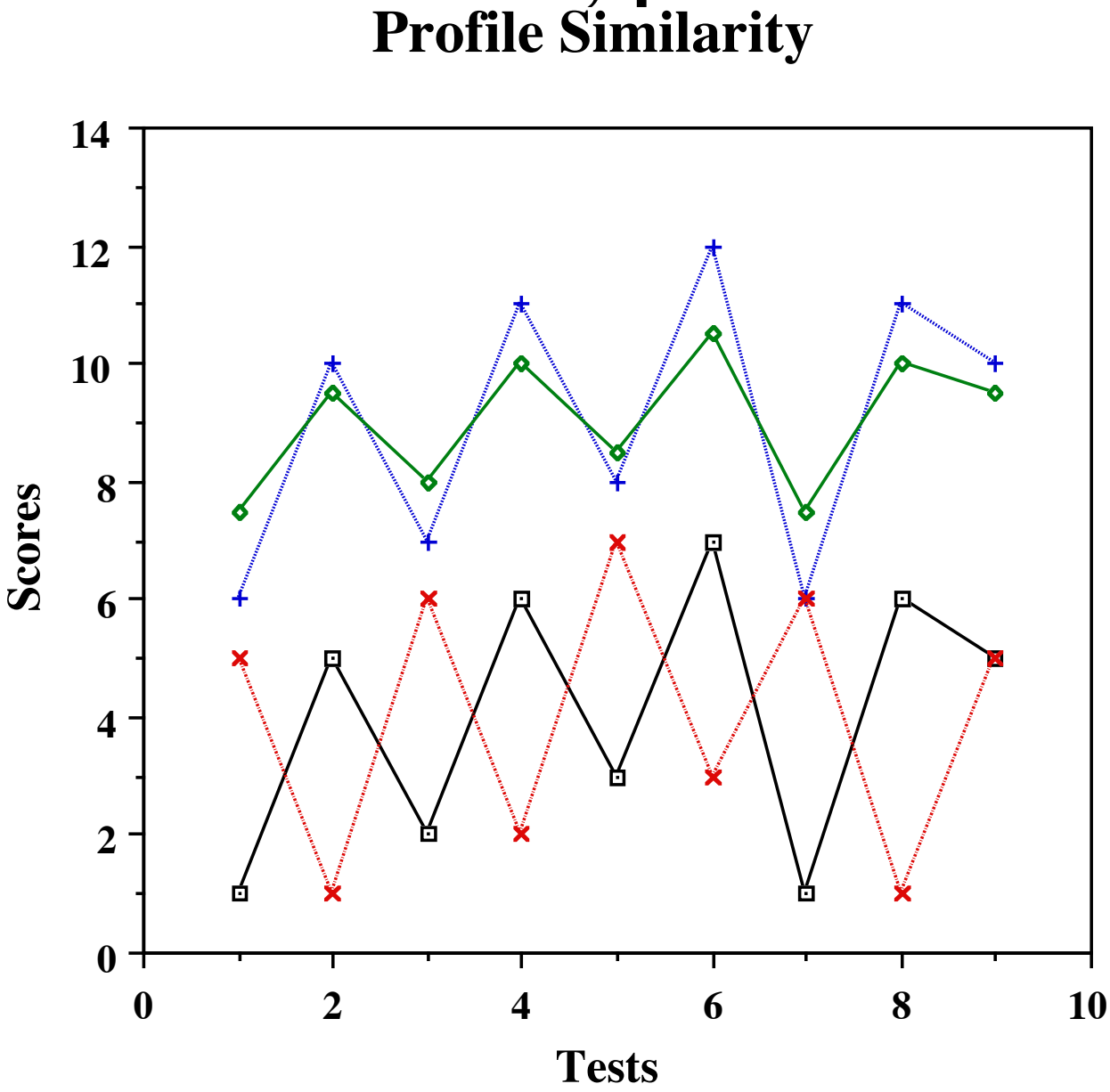
(X and W are most similar, X is negatively related to Y)

PEARSON CORRELATION MATRIX

	X	Y	Z	W
X	1.000			
Y	-0.738	1.000		
Z	1.000	-0.738	1.000	
W	1.000	-0.738	1.000	1.000

(X is identical to W and Z, negatively related to Y)

Similarity of Profiles: Level, scatter, pattern



Sources of Data

- Self Report
  - Direct subjective
    - empirical scales: MMPI/Strong-Campbell
    - factorial scales: EPI/16PF/NEOPI-R
    - rational scales: PRF
  - Indirect/projective (access to subconscious?)
    - TAT
    - Rorschach
  - Indirect/objective
    - Cattell objective test battery
    - Implicit Attitudes Test (RT measures)
    - Emotional "Stroop"
  - Indirect/other
    a) Kelly Construct Repetory Grid
    a) Carroll INDSCAL

George Kelly and the theory of Personal Constructs

- Man as scientist:
  - "each man contemplates in his own personal way the stream of events upon which he finds himself so swiftly borne"

  - "Man looks at his world through transparent patterns or templates which he creates and then attempts to fit over the realities of which the world is composed. The fit is not always very good. Yet without such patterns the world appears to be such an undifferentiated homogeneity that man is unable to make any sense out of it. Even a poor fit is more helpful to him than nothing at all.

George Kelly and the theory of Personal Constructs

- Fundamental postulate:
  - "A person's processes are psychological channelized by the ways in which he anticipates events."
- Measurement:
  - The role construct repertory test (REP test).
- Analysis:
  - What are the fundamental constructs with which one views the world? This can be the entire set of constructs elicited by the REP test, or some clustering or grouping of these constructs.

Kelly Rep Test

self	O		O				
lover	O						
mother		O					
father				O			
sib	O						
teacher			O				
Best friend		O		O			
Boss			O				
coworker		O		O			
construct							

REP test: complications

- Completely idiosyncratic. There is no concern with any fundamental dimensions. However, it is possible to apply same group space and still detect individual construct dimensions
- But consider a similar model: individuals as having unique distortions of shared space. The INDSCAL and ALSCAL algorithms are available to solve for joint and individual spaces.

Multidimensional Scaling

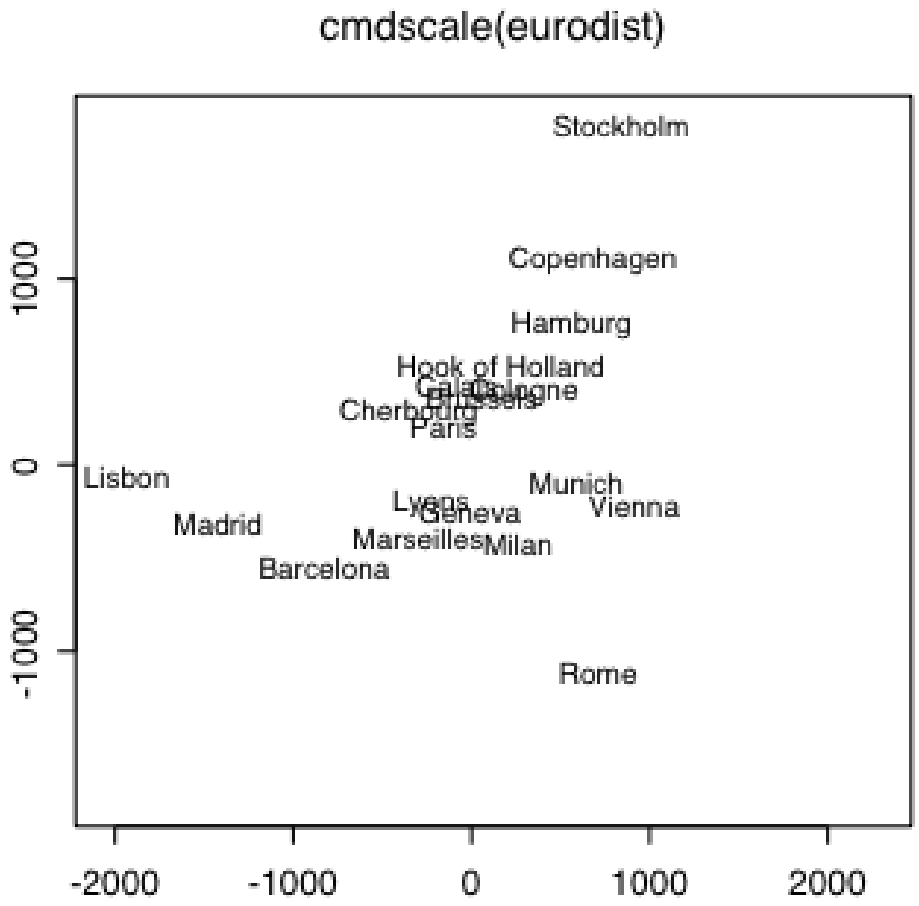
- Application of metric or non-metric scaling
- Metric scaling:
  - Find dimensional representation of observed distances (e.g., latitude and longitude)
  - Strong assumption of data and metric
- Non-metric scaling
  - Scaling to minimize a criterion insensitive to ordinal transformations

Distances between cities

	Athen	Barcelona	Brussels	Calais	Cherburg	Cologne	Copenhage	Geneva	Gilbralter	Hamburg
Barcelona	3313									
Brussels	2963	1318								
Calais	3175	1326	204							
Cherbourg	3339	1294	583	460						
Cologne	2762	1498	206	409	785					
Copenhagen	3276	2218	966	1136	1545	760				
Geneva	2610	803	677	747	853	1662	1418			
Gibralta	4485	1172	2256	2224	2047	2436	3196	1975		
Hamburg	2977	2018	597	714	1115	460	460	1118	2897	
Hook of Holkan	3030	1490	172	330	731	269	269	895	2428	550

What is the best representation of these distances in a two dimensional space?

Scaling of European Cities

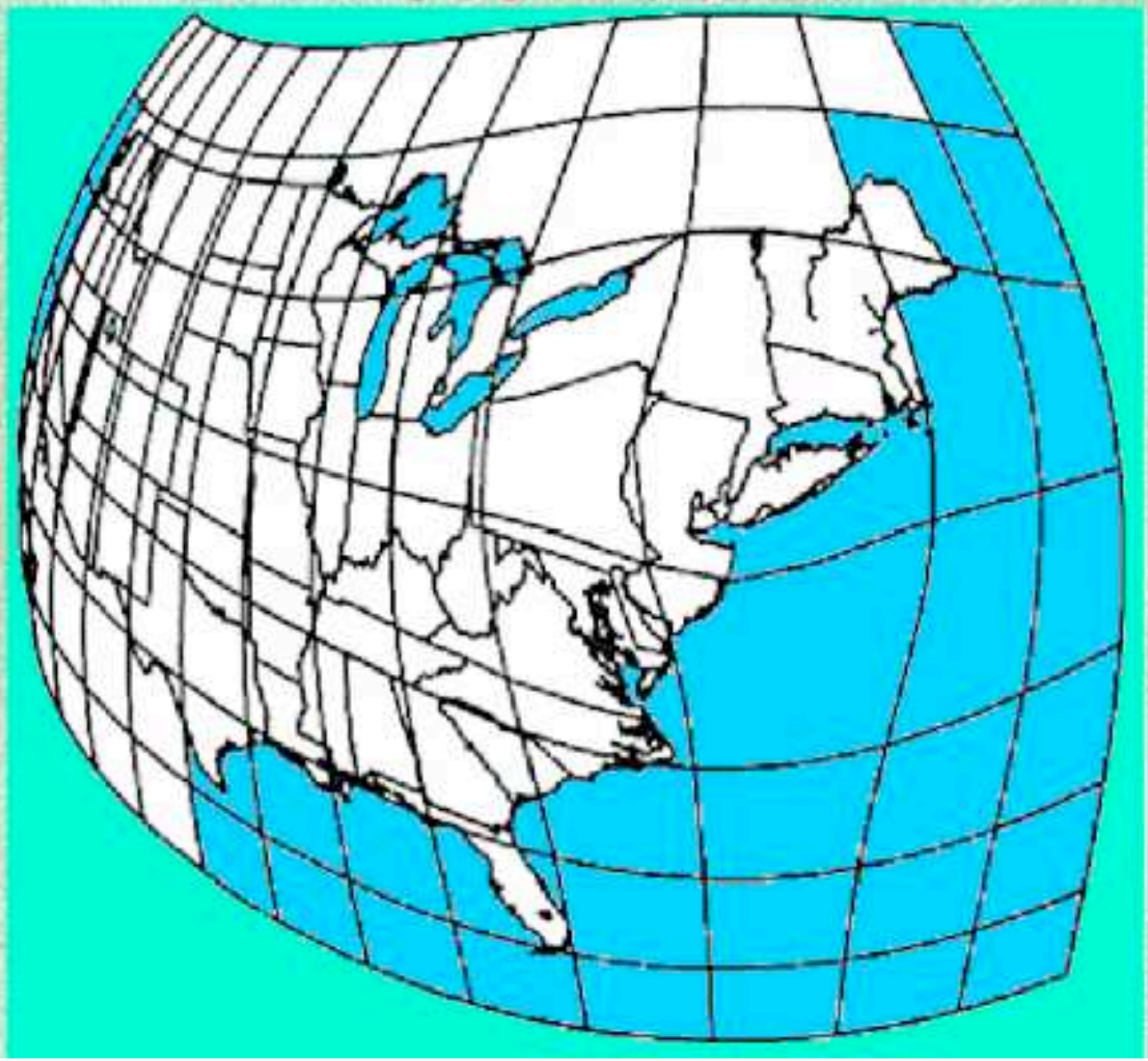


Individual Differences in MDS INDSCAL

- Consider individual differences in MDS
  - Each individual applies a unique weighting to the MDS dimensions
- Solve for Group space as well as individual weights to be applied to the group space

A New Yorker's View

Square root azimuthal projection, with obvious distortion




THE
NEW YORKER
PACIFIC OCEAN
HUDSON RIVER
10TH AVE
9TH AVE

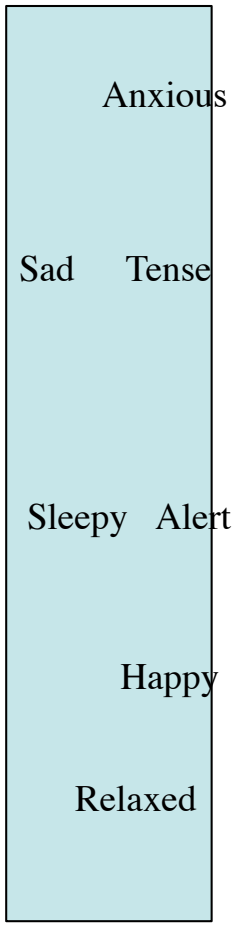
THE GERMAN HEALTH CARE SYSTEM

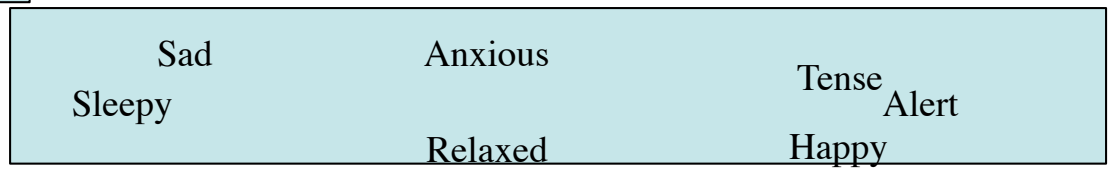
INDSCAL

- Consider a set of points X_i with a corresponding set of distances in K dimensional space:
  - $D_{ij} = (\sum (x_{ik} - x_{jk})^2)^{.5} \quad (k=1 \ldots K)$
- Consider individuals 1 .. n who differ in the relative importance (weight) they place on the dimensions $w_{k.}$
- Then, the distances for individual$_l$ are
  - $D_{ijl} = (\sum \{w_{lk} * (x_{ik} - x_{jk})\}^2)^{.5} \quad (k=1 \ldots K)$

Carroll IndScal model
Individual Differences in MDS

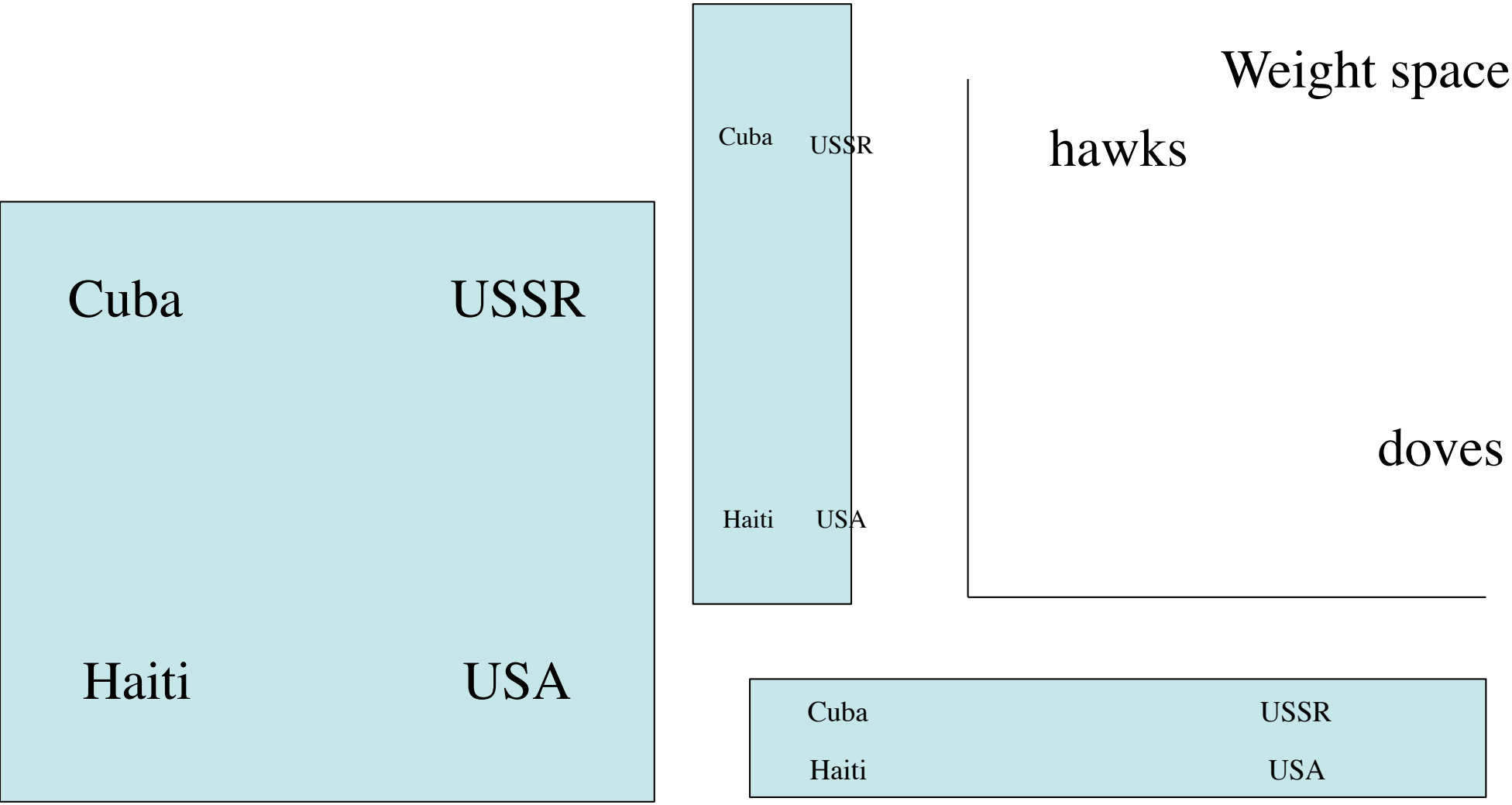
Group Space



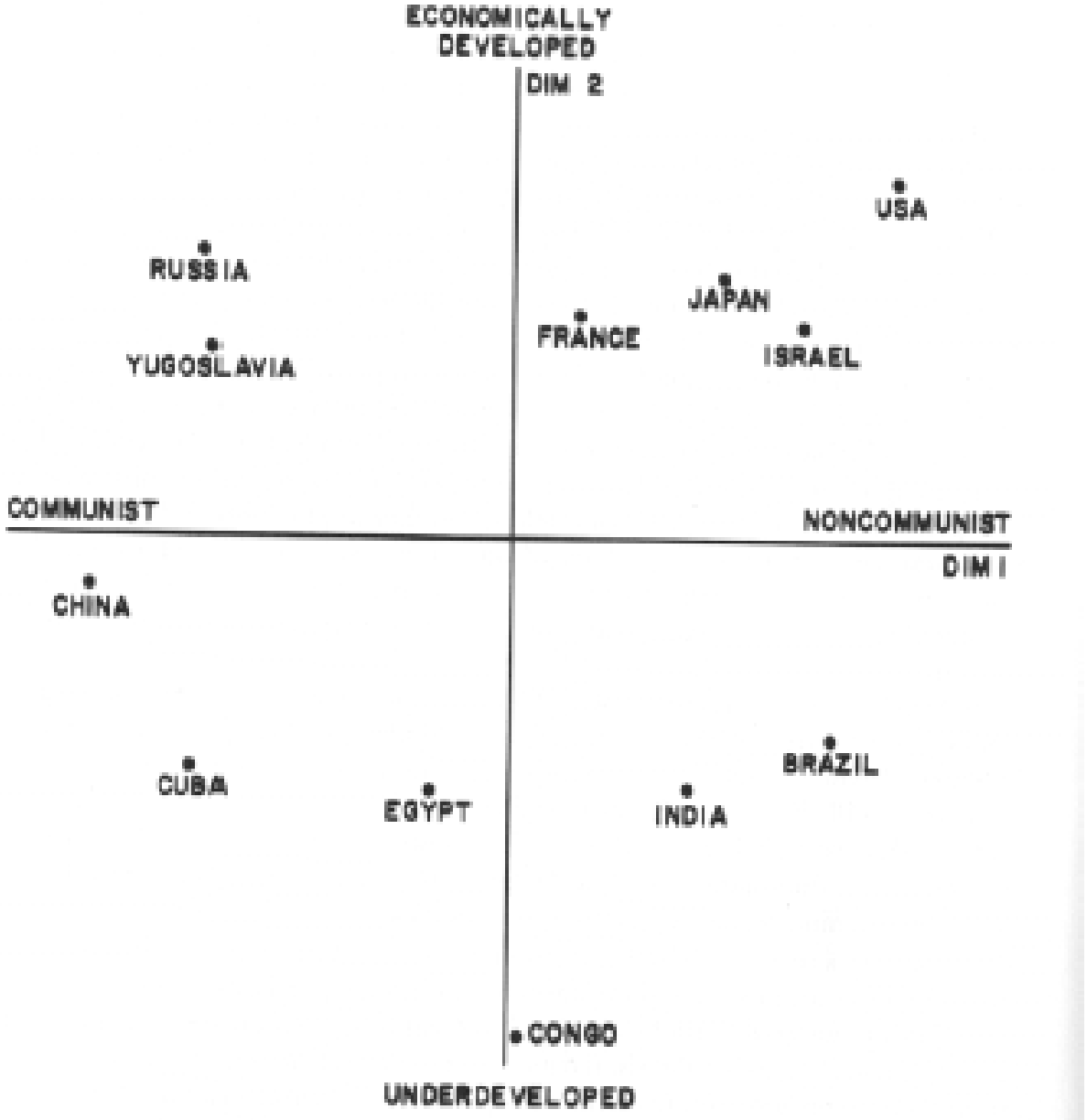


Individual Spaces as
Distortions of group space

Representation of Countries and attitudes towards Vietnam



INDSCAL- Wish data of countries



from J.D. Carroll and M. Wish, 2002

Weight space - Wish data

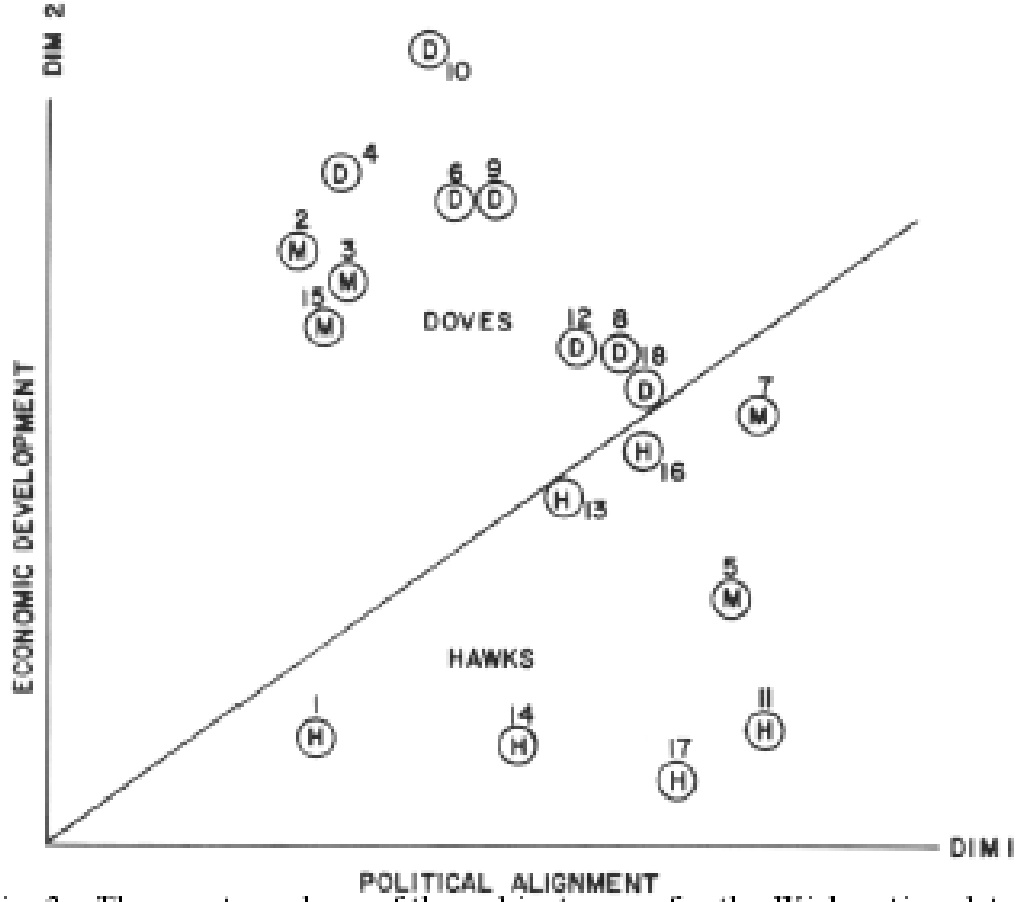


Fig. 3. The one-two plane of the subject space for the Wish nation data. *D*, *H* and M stand for "dove," "hawk," and "moderate" (as determined by subjects' self-report) vis-a-vis attitudes on Vietnam War. Forty-five-degree line divides "doves" from "hawks," with "moderates" on both sides.

Sources of Data

- Structured interviews (e.g., SCID)
- Other ratings
  - Peer ratings
  - supervisory ratings
  - subordinate ratings
- archival/unobtrusive measures
  - unobtrusive measures
  - historical record
    - GPA
    - Publications
    - Citations
    - Neuropsychological
      a) neurometrics
      b) "lie detection"

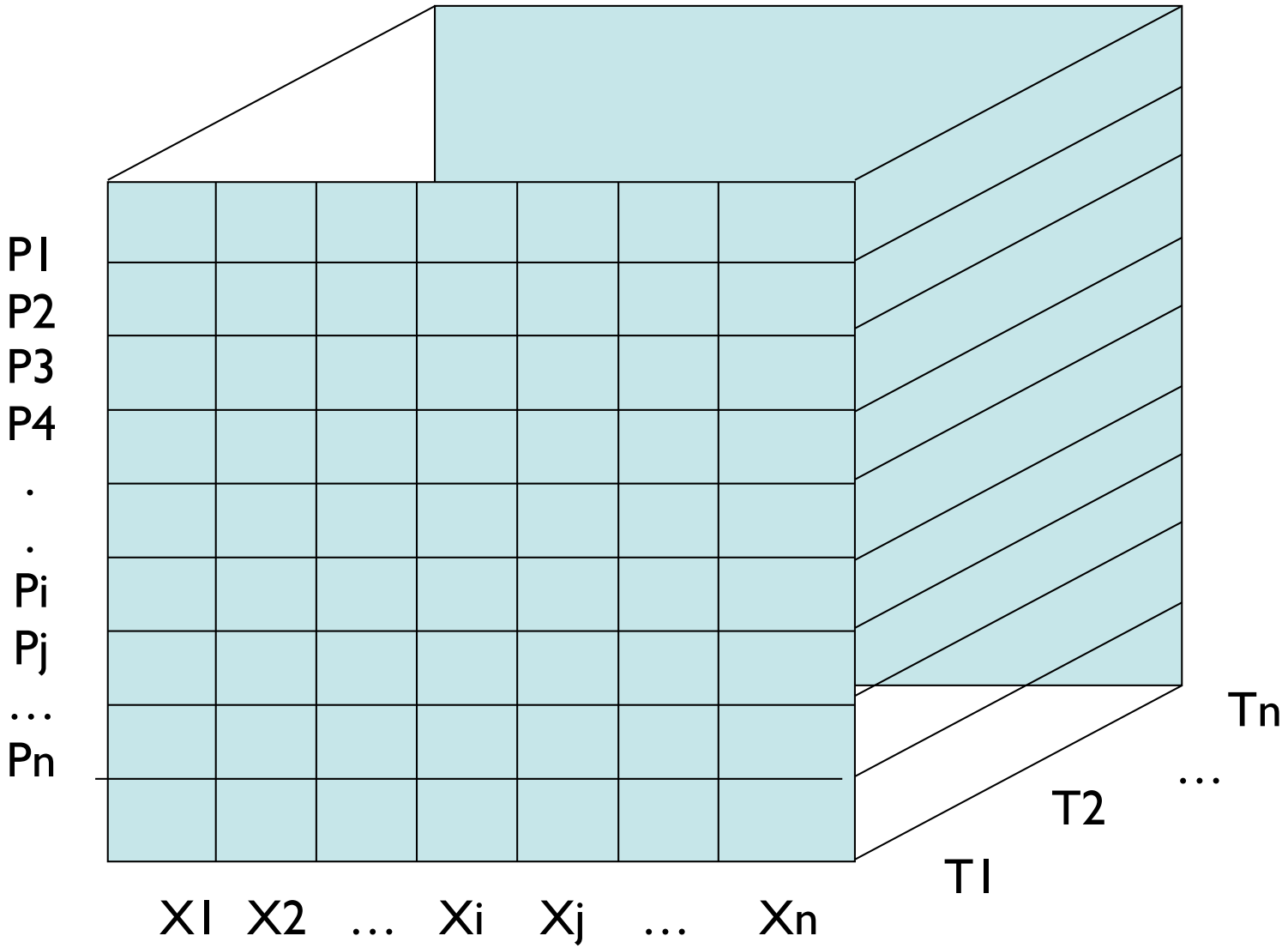
Sources of Data

- Performance tests
  - OSS stress tests
  - New faculty job talks
  - Clinical graduate applicant interviews
  - Internships
  - Probationary Periods
- Web based instrumentation
  - self report
  - indirect (IAT)

The data box

Multiple ways of assessment

The data box: measurement across time, situations, items, and people



Cattell's data box

Integrating People, Variables, and Occasions

- Person x Variables
  - Variables over People, fixed Occasion (R)
  - People over Variables, fixed Occasion (Q)
- Person x Occasions
  - Occasions over People, fixed Variable (S)
  - People over Occasions, fixed Variable (T)
- Variables x Occasions
  - Variables over Occasions, fixed People (O)
  - Occasions over Variables, fixed People (P)

Cattell, R.B (1978) The scientific use of factor analysis. p 323

Traditional measures

- Individuals across items
  - correlations of items taken over people to identify dimensions of items which are in turn used to describe dimensions of individual differences
    - Ability
    - Non-cognitive measures of individual differences
      - stable: trait
      - unstable: state
- INDSCAL type comparisons of differences in structure of items across people
- 3 Mode Factor Analysis

Other ways of measurement

- Example of measurement of the structure of mood
  - between subjects
  - within subjects

Introversion/Extraversion as one dimension of affect/behavior space

- Personality trait description
  - Introversion/Extraversion
  - Neuroticism Stability
- Affective Space
  - Positive Affect
  - Negative Affect
- Behavior
  - Activation and Approach
  - Inhibition and Avoidance

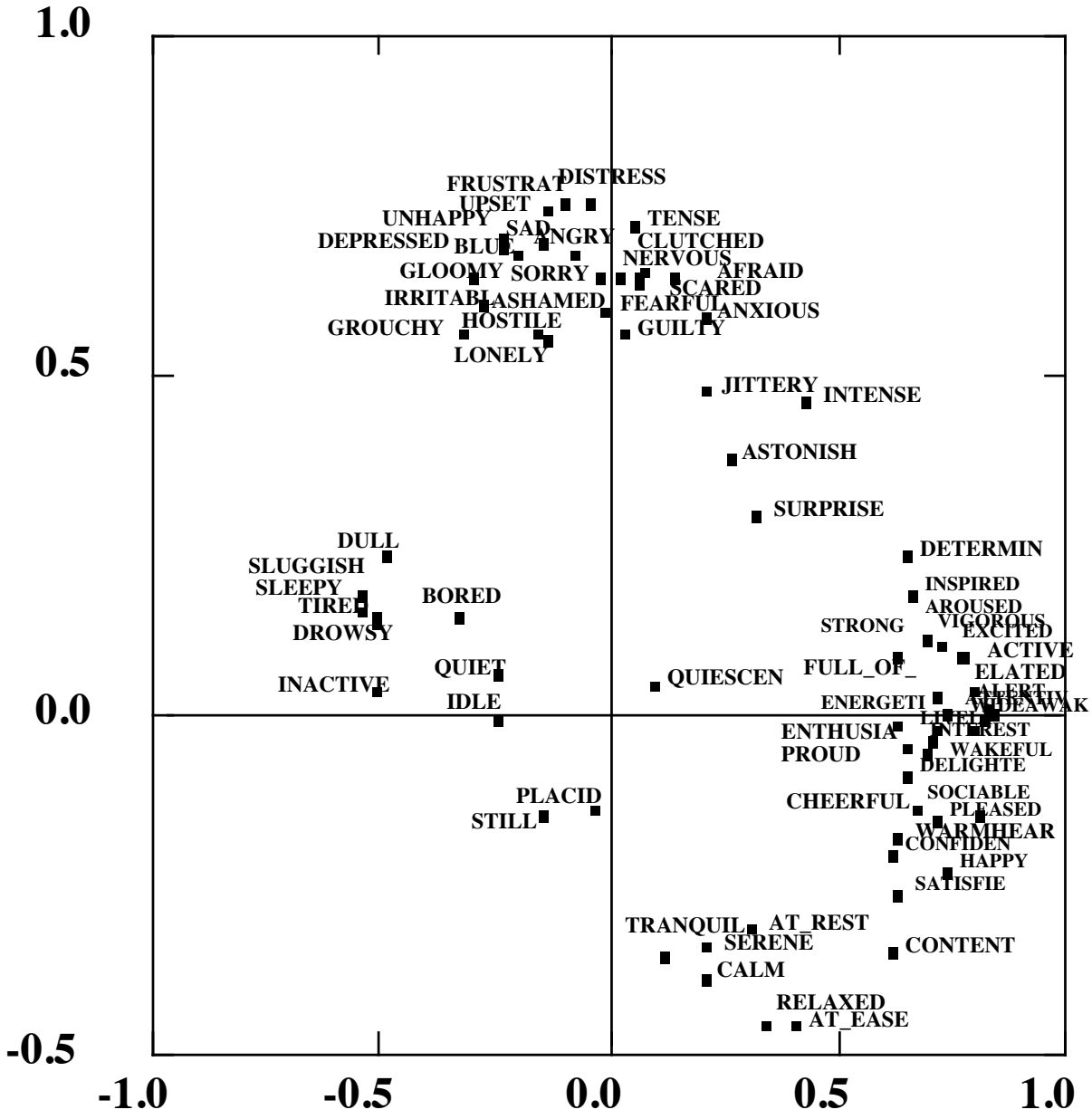
Personality and Emotions

- Standard model
  - Dimensional model of personality
    - Particularly Extraversion and Neuroticism
  - Dimensional model of emotions
    - Positive Affect and Negative Affect
  - Dimensional congruence
    - Extraversion and Positive Affectivity
    - Neuroticism and Negative Affectivity

Measuring the dimensions of affect

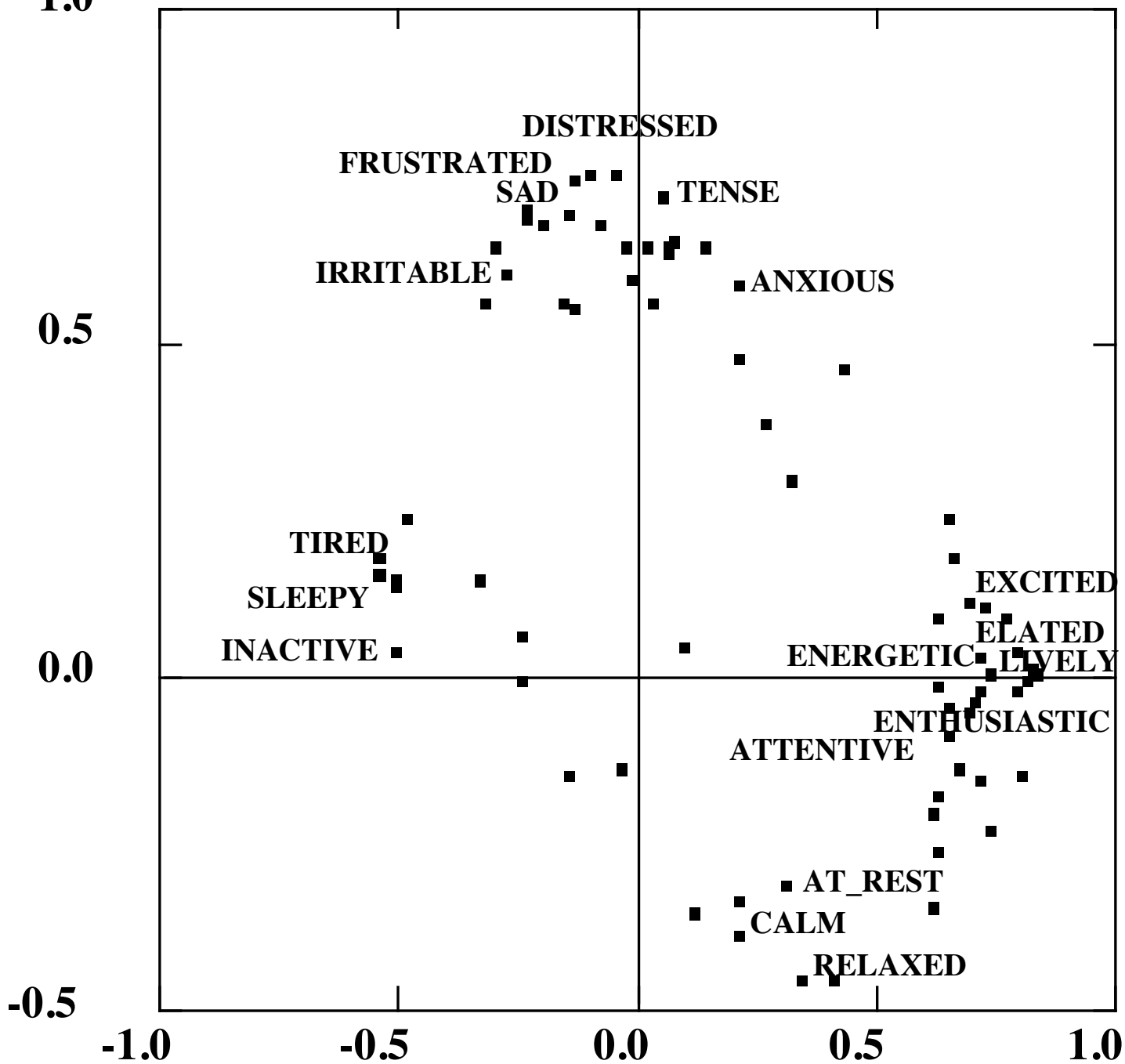
- Motivational state questionnaire (MSQ)
  - 70-72 items given as part of multiple studies on personality and cognitive performance
  - Items taken from
    - Thayer's Activation-Deactivation Adjective Checklist (ADACL)
    - Watson and Clark Positive Affect Negative Affect Scale (PANAS)
    - Larsen and Diener adjective circumplex
  - MSQ given before and after various mood manipulations
    - Structural data is from before
- Structural results based upon factor analyses of correlation matrix to best summarize data

2 Dimensions of Affect



Energetic Arousal/Positive Affect

2 Dimensions of Affect



Representative MSQ items (arranged by angular location)

Item	EA-PA	TA-NA	Angle
energetic	**0.8**	0.0	1
elated	**0.7**	0.0	2
excited	**0.8**	0.1	6
anxious	0.2	**0.6**	70
tense	0.1	**0.7**	85
distressed	0.0	**0.8**	93
frustrated	-0.1	**0.8**	98
sad	-0.1	**0.7**	101
irritable	-0.3	**0.6**	114
sleepy	**-0.5**	0.1	164
tired	**-0.5**	0.2	164
inactive	**-0.5**	0.0	177
calm	0.2	**-0.4**	298
relaxed	0.4	**-0.5**	307
at ease	0.4	**-0.5**	312
attentive	**0.7**	0.0	357
enthusiastic	**0.8**	0.0	358
lively	**0.9**	0.0	360

Personality and Emotions

- Standard model
  - Dimensional model of Personality
    - Behavioral Activation/Approach <-> Extraversion
    - Behavioral Inhibition <-> Neuroticism
  - Dimensional model of Emotions
    - Positive Affect
    - Negative Affect
    - Arousal?
  - Dimensional congruence
    - Extraversion, Approach, and Positive Affectivity
    - Neuroticism, Inhibition, and Negative Affectivity

Personality measurement: snapshot or movie?

- Cross sectional measurement of a person is similar to a photograph-- a snapshot of a person at an instant.
- Appropriate measurement requires the integration of affect, behavior, and cognition across time.

Personality and affect: within subject measurements

- High frequency sampling: the example of body temperature

- Low frequency sampling: palm pilot sampling of affect

Within subject diary studies-1

- Very High Frequency (continuous) measurements
  - Physiological assays
    - Cortisol
    - Body temperature <--
      - Core body temperature collected for ≈ 2 weeks
      - Data taken by aggregating subjects from multiple studies conducted by Eastman and Baehr on phase shifting by light and exercise

Within subject diary studies-2

- Measures
  - Check lists
  - Rating scales
- High frequency sampling <--
  - Multiple samples per day
- Low frequency sampling
  - Once a day
  - Sometimes at different times

High frequency measures of affect

- Measures taken every 3 hours during waking day for 6-14 days
- Paper and pencil mood ratings
  - Short form of the MSQ -- Visual Analog Scale
  - Sampled every 3 hours
- Portable computer (Palm) mood ratings <--
  - Short form of the MSQ
  - Sampled every 3 hours

Goldberg, L. R. (1972). Parameters of personality inventory construction and utilization: A comparison of prediction strategies and tactics. *Multivariate Behavioral Research Monographs. No 72-2*, *7*.

Hase, H. D. & Goldberg, L. R. (1967). Comparative validity of different strategies of constructing personality inventory scales. *Psychological Bulletin*, *67*(4), 231–248.