World Health Organization

Multidimensionality

Rasch Technical Training 8

Carolina Fellinghauer : fellinghauerc@who.int

Multidimensionality

The Rasch model assumes that a questionnaire measures only one single latent trait or construct.

In presence of multidimensionality, the scale measures different aspects of a construct and single interval scaled sum score is not meaningful anymore.

Standardised Residuals

The analysis for multidimensionality searches the standardised residuals for patterns indicating items loading strongly on different dimensions.

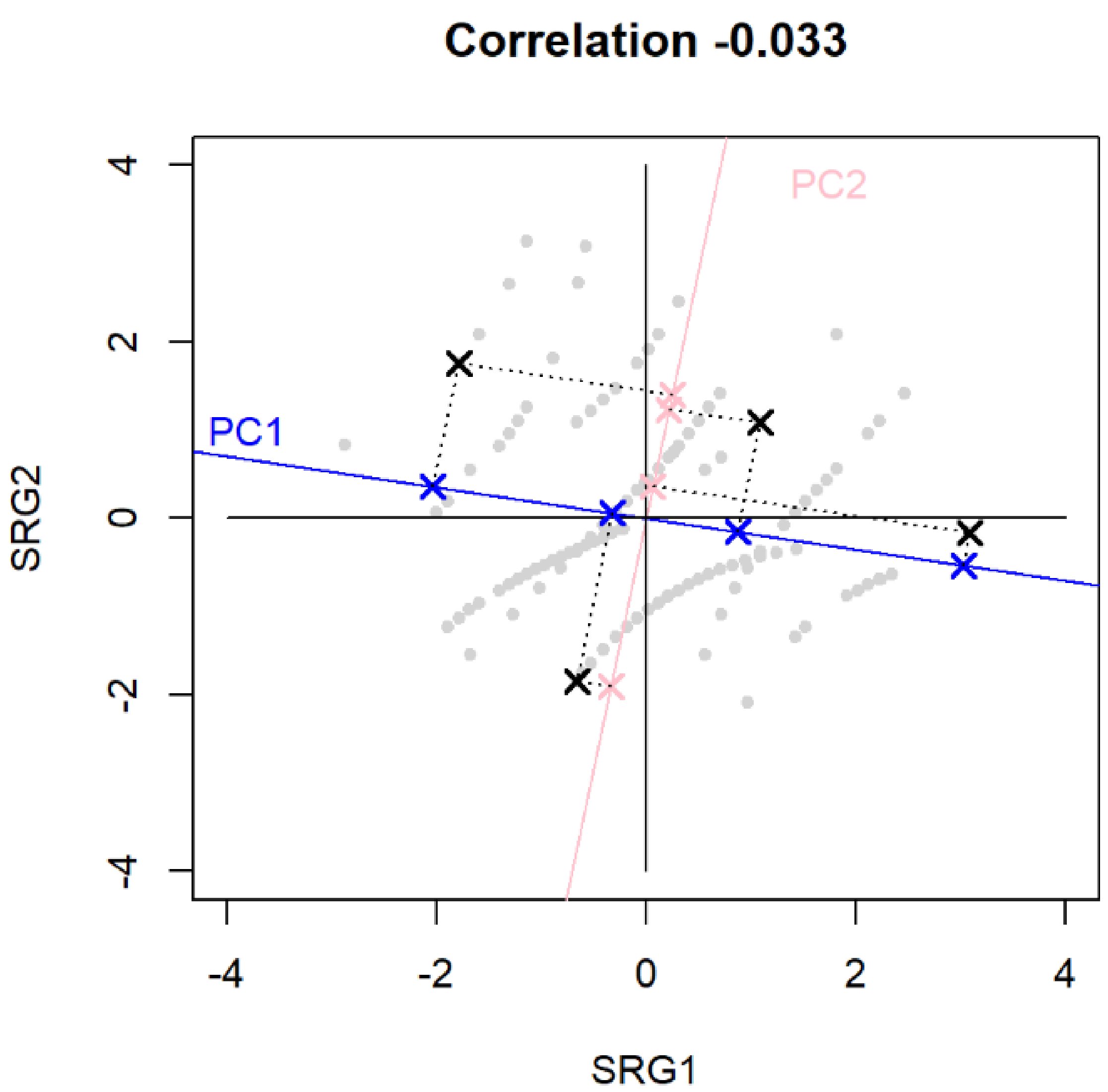
The method to analysis the standardised residuals is called principal component analysis (PCA).

Principal Component Analysis (PCA)

- is a dimensionality reduction technique
- allow to identify clusters of similar variables.
- needs no distributional assumptions.
- is an exploratory method bases on singular value decomposition (SVC) or eigendecomposition.

Central idea: reduce the dimensionality of a dataset, while preserving as much ‘variability’ (i.e. statistical information) as possible, i.e. through maximizing the variance in each dimension.

Principal Components

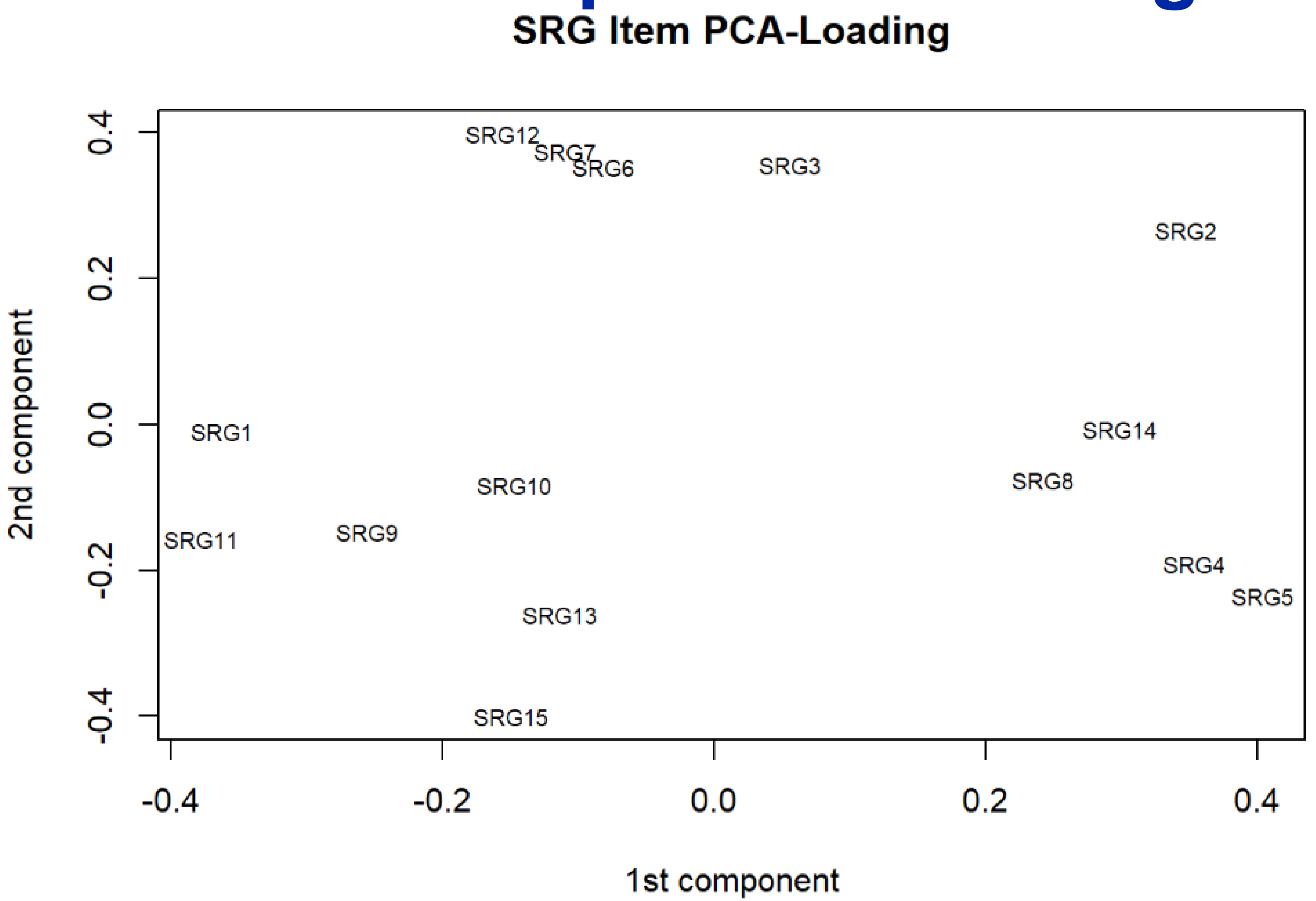


Component loading Matrix (or eigenvector)

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
SRG1	-0.362	-0.010	-0.085	0.092	-0.276	0.529	-0.399	0.082	-0.021	0.116
SRG2	0.348	0.266	-0.099	0.123	-0.307	0.374	0.004	0.231	-0.202	0.227
SRG3	0.056	0.356	0.359	-0.245	0.286	0.172	0.050	-0.185	0.208	0.183
SRG4	0.354	-0.191	0.038	-0.418	0.244	0.268	0.123	-0.133	0.115	-0.091
SRG5	0.404	-0.236	-0.207	0.117	0.170	-0.005	-0.261	0.246	0.058	-0.491
SRG6	-0.082	0.352	-0.096	0.398	0.387	0.067	0.219	-0.272	-0.128	0.060
SRG7	-0.110	0.374	0.090	-0.162	0.240	-0.316	-0.400	0.417	-0.137	-0.086
SRG8	0.242	-0.076	-0.263	0.436	0.002	-0.332	-0.159	-0.155	0.411	0.394
SRG9	-0.256	-0.148	-0.296	-0.249	0.072	-0.165	-0.353	-0.524	-0.340	0.006
SRG10	-0.147	-0.083	-0.443	-0.045	0.135	-0.039	0.550	0.283	-0.359	0.050
SRG11	-0.378	-0.157	-0.182	-0.281	-0.065	-0.033	0.170	0.226	0.572	0.141
SRG12	-0.155	0.399	0.029	0.090	-0.392	-0.207	0.194	-0.117	0.189	-0.551
SRG13	-0.114	-0.261	0.500	0.146	0.064	-0.277	0.021	0.284	-0.196	0.259
SRG14	0.299	-0.006	0.094	-0.282	-0.514	-0.304	0.106	-0.165	-0.215	0.176
SRG15	-0.150	-0.400	0.382	0.318	-0.046	0.151	0.129	-0.168	-0.063	-0.249

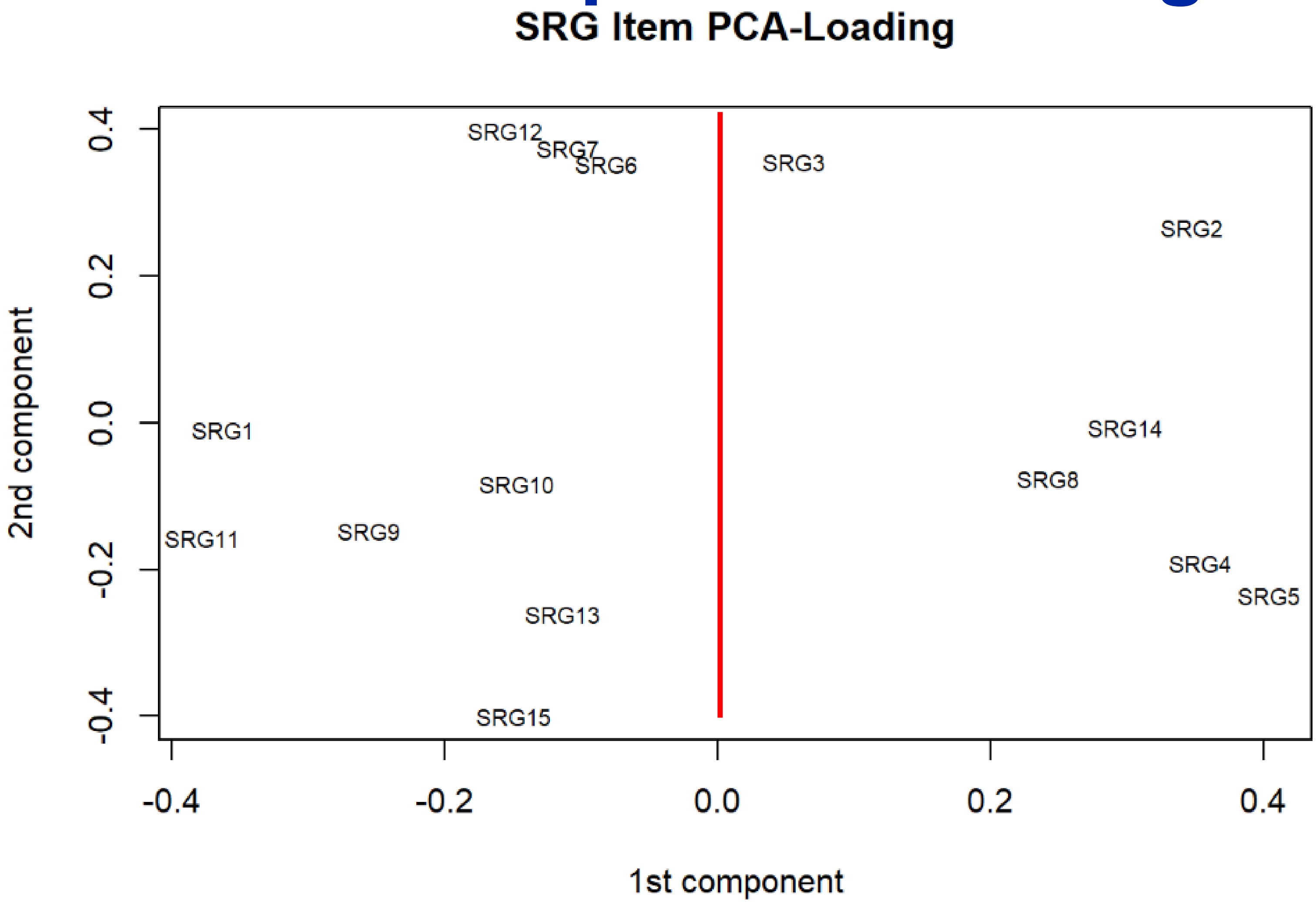
The residual matrix is factorized into several component matrices, including eigenvectors or component loading matrix.
Component loading matrix has as many columns and rows as items in the scale (here column 11 to 15 are not shown.)
PC1 explains most of the variability in the residuals, it is the most important. PC2 explains what is left unexplained from PC1 etc… etc…

PCA: Component Loading



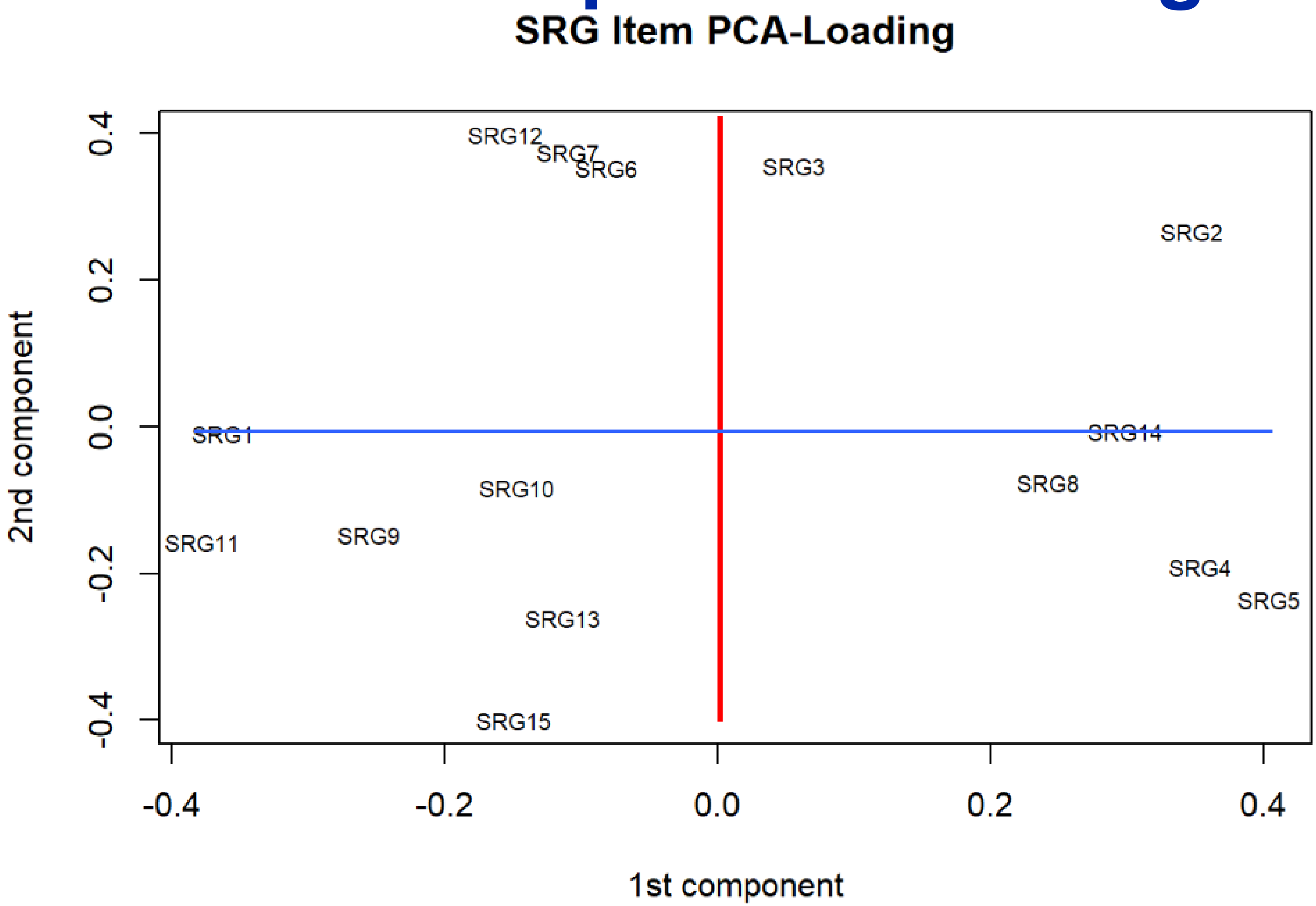
The first 2 columns of the component loading matrix provide the x and y coordinates for the plot above.

PCA: Component Loading



The opposition on the x-axis is the most important.

PCA: Component Loading



The opposition on the x-axis is the most important.

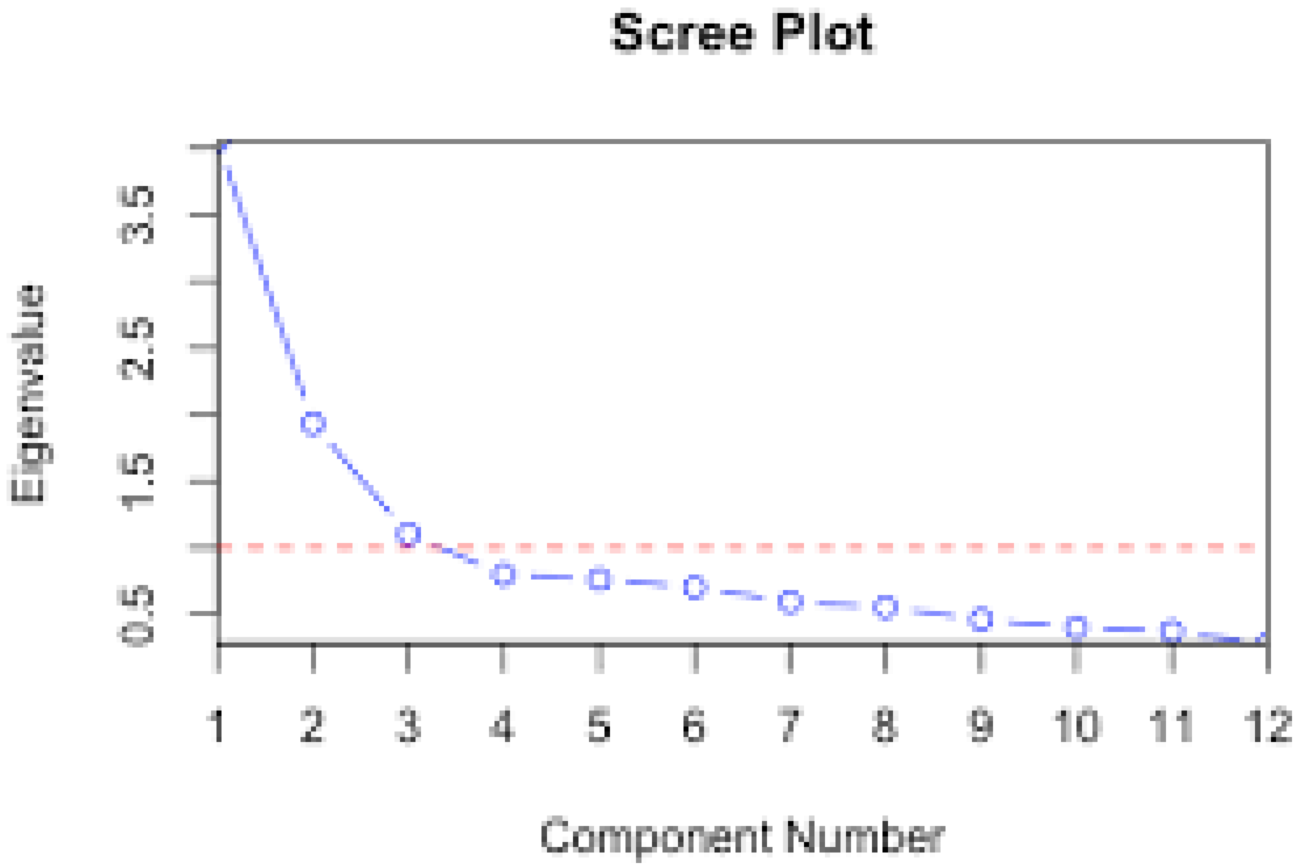
Eigenvalues

- The component loadings do not allow to determine if the display is unidimensional or indicative of multidimensionality.
- The eigenvalue vector allows to determine if a set of items is unidimensional or multidimensional.
- Diverse rules are available to interpret the eigenvalue vector.
  - the first eigenvalue should not be too large, at least < 2
  - the second eigenvalue should be < 1.4
  - Analysis of a screeplot to determine the number of dimensions – number of components left of the elbow

Eigenvalues

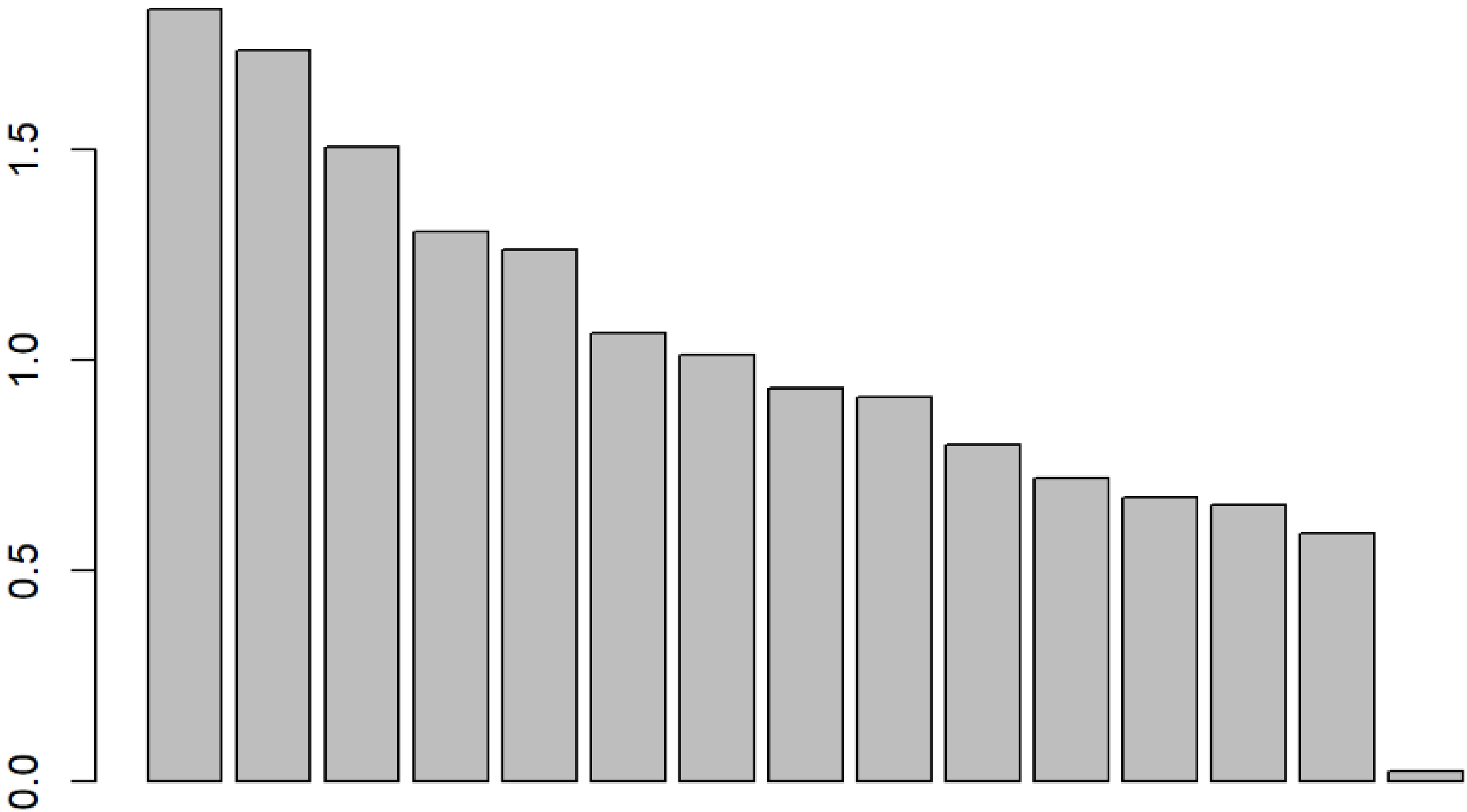
	Eigen.Value.srg	Perc.Eigen.srg	Cum.Perc.Eigen.srg
[1,]	1.83099421	12.2066281	12.20663
[2,]	1.73230689	11.5487126	23.75534
[3,]	1.50419437	10.0279625	33.78330
[4,]	1.30228213	8.6818809	42.46518
[5,]	1.26171263	8.4114175	50.87660
[6,]	1.06130819	7.0753879	57.95199
[7,]	1.01239306	6.7492871	64.70128
[8,]	0.93249940	6.2166627	70.91794
[9,]	0.91122070	6.0748047	76.99274
[10,]	0.79821304	5.3214203	82.31416
[11,]	0.71759422	4.7839615	87.09813
[12,]	0.67182066	4.4788044	91.57693
[13,]	0.65289308	4.3526205	95.92955
[14,]	0.58717403	3.9144936	99.84404
[15,]	0.02339337	0.1559558	100.00000

Eigenvalues and Screeplot



To determine the number of dimensions a rule is to determine where the elbow is…
This figure shows about 2 to 3 dimensions left of the line break..

Eigenvalues and Screeplot



To determine the number of dimensions a rule is to determine where the elbow is…
This figure based on SRG does not indicate any strong change in direction.

Let's go to R-Studio

Open the R-Script TT8_Rscript.r that you find in Github.

Exercise

Using the MDS Data :

a. compute eigenvalues and

b. draw a scree plot which shows the proportion of variation that each PC accounts for.

c. Is it unidimensional?

Based on the proportion of variance that the 3 first PC explain:

d. Draw a 2-dimensional or a 3-dimensional PC loading plot. What do you observe?