Tutorial for Chapter 12: Assessing Unidimensionality of the BLOT

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# Preliminary steps before you can run the multidimensionality analysis of the BLOT data

1. Create a folder called “dimension\_analysis” on your desktop, for example. Download the data set BLOT.csv and the R code Chapter\_12\_eRm.R from the website and save both in *that* folder. This folder will serve as your working directory containing all files you need to conduct the analysis and to store optional output (i.e., code, data, and figures). If the R code and the .csv files are not in the same folder, you will not be able to load the data using the code below.
2. Open the file Chapter\_12\_eRm.R in RStudio by clicking on the file. This will open the file in RStudio.
3. Go to “Session” “Set Working Directory” “To Source File Location”. This defines the folder you named above as your working directory in which you are currently working and where R expects all data sets to be.

You are now ready to run the multidimensionality analysis of the BLOT data from ARM4 Chapter 12. Please use the following instructions and explanations of the R code.

# Multidimensionality

# Installing the required packages for this analysis.   
# This is only required once.   
# Uncomment the code below to run the install.packages function.  
# install.packages(c("eRm", "dplyr", "ggplot2", "pairwise", "TAM", "psych"))  
  
# Load the packages required for the analysis  
library(eRm)  
library(dplyr)  
library(pairwise)

As always, let’s first load our data in using the read.csv function.

# Reading in the comma-seperated data set  
df <- read.csv("BLOT.csv", header = FALSE, sep = ";")

Before we can assess the dimensionality of the BLOT Rasch residuals we need to preprocess it. Just as in the eRm previous tutorials, the following lines of code define column names of the data frame and finally create an object called “blot\_items” containing the BLOT items we need for the Rasch analysis. Each BLOT item is represented by a column. Each participant has their own row.

# Defining the name of the first column of the data frame called "df"  
colnames(df)[1] <- c("id")   
# Defining the names of the columns referring to the items  
colnames(df)[2:49] <- paste("Blot", (1:48), sep="\_")   
# Selecting only the BLOT items  
blot\_items <- dplyr::select(df, Blot\_1:Blot\_35)

## PCA of residuals

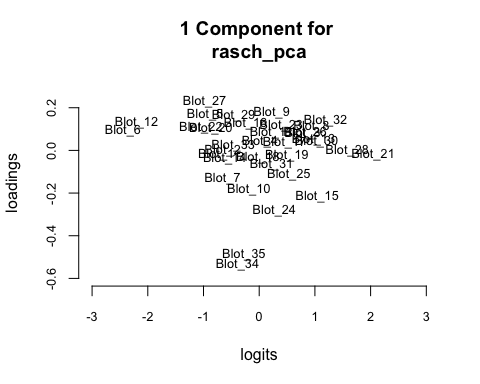
The Rasch model assumes that the data are unidimensional. There are several ways of assessing multidimensionality; here we will show how to perform a principal components analysis (PCA) on residuals from the Rasch analysis.

Conceptually, the purpose of the residual PCA is to determine if the items are related above and beyond what the Rasch model expects. Residuals are “leftover” unexplained variance after using a model. In practice, all models have residuals. Most statistical methods assume (or, require) that all residuals are independent and random. That is, anything the model doesn’t explain is just noise and there is no pattern to it. A pattern or relationship in the residuals suggests that there is another dimension that is influencing our data. If this influence is large, it can invalidate the results of our model.

By running a PCA on the residuals we ask: After we run the Rasch model, is there a pattern in the unexplained variance? We want that answer to be “no.”

Previously, we have use the *eRm* package to fit Rasch models, but *eRm* does not have a PCA function. Instead, we are going to use the *pairwise* package. The *pairwise* functions will not accept *eRm* objects, so we’ll obtain item and person parameters using the *pairwise* functions. First we will calculate item parameters using the pers function and person parameters pair functions. Then we can use these person parameters in the rfa function to perform the PCA.

# Calculate Rasch item paramters using the "pairwise" package  
pair\_rasch\_blot <- pair(blot\_items)  
# Obtain person parameters using the "pairwise" package functions  
pers <- pers(pair\_rasch\_blot)  
# Perform the PCA  
rasch\_pca <- rfa(pers)  
plot(rasch\_pca, com = 1)



The figure shows the factor loading plot of the BLOT items after the primary Rasch dimension has been extracted and residualized from the items. This map plots the item measure (Rasch estimate in logits) against the PCA factor loading of its residual, based on the standardized residual of each item from the Rasch dimension. Thus, items that have substantial correlations unexplained by the primary Rasch measure have factor loadings that are greater in magnitude, irrespective of sign. Items without significant correlation to this nuisance dimension will have factor loadings of approximately zero. Most of our items have loadings between -0.2 and +0.2, which is fairly small.

The vertical spread of these items helps diagnose whether these items are clustered at particular levels of the measure (e.g., clustered as more or less difficult). Items “BLOT\_34” and “BLOT\_35” seem to be slightly separated from the rest of the items, suggesting that their item responses are also dependent on a second dimension besides the primary Rasch measure.

Before one interprets the loading plot, one should check the size of the eigenvalue of the first principal component. An eigenvalue informs us about the amount of systematic variance in our standardized item response residuals. Now, keep in mind that standardized residuals have a variance of unity and a mean of zero. So, an eigenvalue of the first principal component of, say, four, would imply that this component explains the residual variance of four items. Or, in other words, the principal component aggregates the residual variance of four items. Aggregating the residual variance of more than one item is only possible if items still share variance after the first Rasch dimension has been extracted, that is, if some items are still correlated. If, on the other hand, there were only random noise, the eigenvalue of the first principal component would be close to unity. A small eigenvalue of the first principal component, usually smaller than 2.0, indicates that the residuals are merely random noise. A larger (usually more than 2.0) eigenvalue, on the other hand, implies that there is probably a “second dimension” besides the primary Rasch dimension.

So, let us now check the size of the first principal component of the standardized Rasch residuals. We can get this information from the previously run Rasch residual PCA from by calling a summary of the results stored in the object rasch\_pca as follows:

summary(rasch\_pca)

## Principal Components over items of Rasch Residuals:

## $eigen.values  
## [1] 2.31319869 2.09458745 1.83867863 1.80651707 1.72659479 1.64376186  
## [7] 1.61911534 1.50409281 1.40231166 1.31364591 1.23457198 1.18064351  
## [13] 1.10322411 1.06795046 1.04928376 1.01644124 0.95305291 0.93347998  
## [19] 0.90007646 0.87257764 0.77865838 0.74042844 0.72907372 0.66297320  
## [25] 0.63047338 0.57625946 0.53958913 0.50936286 0.50079582 0.44706485  
## [31] 0.39905657 0.38282758 0.27224050 0.22099974 0.03639012  
##   
## $loadings  
## Comp.01 Comp.02 Comp.03 Comp.04 Comp.05  
## Blot\_1 -0.0195538509 -0.30255942 0.062320248 0.187152533 -0.312272031  
## Blot\_2 0.0007647666 -0.29382986 0.223636505 0.147832672 -0.340157959  
## Blot\_3 0.0786282392 -0.05161894 -0.056705710 -0.019144082 0.300742507  
## Blot\_4 0.0424372601 0.16746880 0.173659163 -0.188206186 0.149897273  
## Blot\_5 0.1714009238 -0.12970674 0.030384858 -0.063458308 0.205368361  
## Blot\_6 0.0926734410 0.14144214 0.179711785 -0.038011790 -0.028201702  
## Blot\_7 -0.1286606992 0.32199594 -0.054443755 -0.041477406 -0.069816226  
## Blot\_8 0.1134469951 0.18886013 0.324884436 0.112638360 0.165993688  
## Blot\_9 0.1773322742 -0.08040125 0.345941562 -0.074710883 0.087532294  
## Blot\_10 -0.1797005985 0.10921675 0.091806389 -0.165468598 0.183863208  
## Blot\_11 0.0850638249 0.06352485 0.016479975 -0.202769001 -0.063310156  
## Blot\_12 0.1344563170 0.06597658 -0.020740937 0.249204867 0.165324360  
## Blot\_13 0.0520587119 -0.14920063 -0.254237685 -0.180188083 -0.034362428  
## Blot\_14 -0.0387506328 -0.01808373 0.029484907 -0.278302275 -0.021252223  
## Blot\_15 -0.2162113305 -0.20500653 -0.053595764 0.098265229 0.097579163  
## Blot\_16 0.1293642353 -0.05523366 -0.166143512 -0.177999244 0.164928286  
## Blot\_17 0.0376022976 -0.24235014 0.367235659 0.026536766 0.258785327  
## Blot\_18 -0.0296732461 -0.21561039 0.130530742 0.153330767 0.086036684  
## Blot\_19 -0.0241864616 -0.01417021 -0.049892729 -0.022453234 -0.116335548  
## Blot\_20 0.1050152661 -0.06997873 -0.204724544 0.230468057 0.075368390  
## Blot\_21 -0.0162507417 -0.14875215 -0.305272345 -0.253814334 -0.037725518  
## Blot\_22 0.1098988669 0.20173104 -0.095931473 0.040626560 0.087802629  
## Blot\_23 0.1190683175 -0.07992629 0.208444169 0.034680615 -0.025146526  
## Blot\_24 -0.2797556255 0.05702436 0.102956444 0.106941717 0.056791140  
## Blot\_25 -0.1098957484 0.17554944 -0.093809729 0.009746983 -0.066228309  
## Blot\_26 0.0873751294 0.18875255 -0.032987527 0.305520604 -0.267430603  
## Blot\_27 0.2327769537 0.01278818 -0.259405974 0.226351463 0.241363895  
## Blot\_28 0.0020090215 0.29629512 0.051703546 -0.080397035 -0.227932596  
## Blot\_29 0.1669593477 -0.10190095 -0.150635463 0.337704746 0.009400299  
## Blot\_30 0.0447022407 -0.24293880 -0.246222731 -0.167305914 -0.100371681  
## Blot\_31 -0.0663434000 0.16129795 0.003632823 -0.098258496 -0.058620685  
## Blot\_32 0.1433805221 0.28295777 -0.069827580 0.277173130 -0.125284698  
## Blot\_33 0.0258822151 -0.07514497 0.154397124 -0.124578121 -0.367228360  
## Blot\_34 -0.5333840728 -0.04814224 -0.026978054 0.126869822 0.078042893  
## Blot\_35 -0.4846685096 0.01241122 -0.028951627 0.179440313 0.156095651  
## Comp.06 Comp.07 Comp.08 Comp.09 Comp.10  
## Blot\_1 -0.074552556 -0.219595996 -0.099720312 -0.084401032 -0.040154341  
## Blot\_2 -0.121665197 -0.103988575 -0.162488170 -0.116588907 -0.108905727  
## Blot\_3 -0.190789950 -0.057114943 -0.123120632 -0.528607444 -0.141713434  
## Blot\_4 0.166312365 -0.204482304 -0.375388236 0.129670569 0.113708953  
## Blot\_5 -0.297290881 -0.036256017 -0.190656586 -0.043432026 0.229972694  
## Blot\_6 0.326038447 -0.240278980 -0.149270187 0.286706415 -0.180697879  
## Blot\_7 -0.081203959 0.193775413 -0.262772331 -0.196642685 0.059045185  
## Blot\_8 -0.185897219 -0.111106208 -0.028253237 0.107587956 -0.174129898  
## Blot\_9 0.283669605 -0.137521757 0.187814074 -0.171459043 0.131254485  
## Blot\_10 0.050663857 0.088103665 0.004024910 -0.195866596 -0.369876582  
## Blot\_11 -0.281690200 -0.184349014 0.401411009 -0.067690851 -0.018716307  
## Blot\_12 -0.185511938 -0.153535130 -0.056515522 0.319394232 -0.259804995  
## Blot\_13 0.031208331 0.037212385 -0.191713585 0.078545048 -0.323018490  
## Blot\_14 0.150656113 0.021428600 0.372006510 -0.146137375 -0.184142140  
## Blot\_15 0.143479504 -0.127654213 0.014023948 -0.061174061 0.329500967  
## Blot\_16 -0.043014262 0.239519706 0.114572353 0.130917033 0.178483456  
## Blot\_17 -0.013161948 0.197756477 0.065732162 0.146997508 -0.020501059  
## Blot\_18 0.040268951 0.231690872 -0.140135965 0.057745376 0.070304026  
## Blot\_19 -0.056701464 0.346199378 0.273861987 0.395596440 -0.065209528  
## Blot\_20 0.141780861 -0.014733817 0.109681648 -0.185071225 -0.306934251  
## Blot\_21 0.265117884 -0.233625636 -0.062268487 0.113298882 -0.057022134  
## Blot\_22 0.034569596 0.128079909 -0.174870427 0.094090979 -0.093055840  
## Blot\_23 0.174224993 0.425301818 -0.023136490 -0.091072936 0.090977353  
## Blot\_24 -0.016982400 -0.240611352 0.149400991 0.160812530 0.094998989  
## Blot\_25 0.245759072 0.041845970 -0.102761887 -0.132196754 0.209344888  
## Blot\_26 0.013878157 0.242218409 -0.102309596 -0.065829512 -0.118047557  
## Blot\_27 -0.185289789 -0.130949065 0.112097023 0.027997457 0.149338349  
## Blot\_28 -0.120175719 -0.012641855 0.008043241 -0.031477591 0.172485640  
## Blot\_29 0.229703392 0.001683808 0.081819512 0.007331644 0.151259174  
## Blot\_30 -0.124385876 -0.005815168 -0.166730995 0.133961404 0.036942799  
## Blot\_31 -0.245844481 -0.037103823 -0.021505341 0.053903279 0.224828258  
## Blot\_32 0.125182611 -0.146431279 0.226502927 -0.082709493 0.040789244  
## Blot\_33 -0.206733368 -0.017038891 0.022061273 0.010756432 -0.052906836  
## Blot\_34 0.002234129 -0.039143570 0.002769971 0.045511164 -0.006222393  
## Blot\_35 -0.114655838 0.046679501 0.047997726 0.029945569 -0.107062991  
## Comp.11 Comp.12 Comp.13 Comp.14 Comp.15  
## Blot\_1 0.082148381 -0.18094078 -0.019601593 -0.212265858 4.629587e-02  
## Blot\_2 -0.129122049 -0.09355379 0.201625591 0.127156818 1.786533e-01  
## Blot\_3 -0.115453023 0.08642171 0.076151934 -0.098999813 -1.756275e-02  
## Blot\_4 -0.147409818 0.10508584 0.063294767 -0.121431630 6.670634e-02  
## Blot\_5 0.182737915 -0.15333491 0.035305656 -0.092187350 -2.624025e-01  
## Blot\_6 -0.073136139 0.08473087 -0.053395300 0.071487125 7.215238e-02  
## Blot\_7 0.041202729 -0.04980007 0.138975896 -0.141346216 4.593130e-02  
## Blot\_8 -0.050712834 -0.01264613 -0.327537952 -0.249401633 -1.342021e-01  
## Blot\_9 0.121260729 0.13597606 -0.073925570 0.210652414 -5.769775e-02  
## Blot\_10 0.283637563 0.00321999 0.140085640 0.080782902 5.393994e-02  
## Blot\_11 0.069735034 -0.03713037 0.233475345 0.123751364 -7.487284e-02  
## Blot\_12 0.115463364 -0.09769823 0.112780452 0.117692473 1.869432e-01  
## Blot\_13 0.078041809 0.16983018 -0.104222760 0.102896165 -4.457163e-01  
## Blot\_14 -0.036598969 -0.24380712 -0.203304472 -0.233733770 2.441770e-01  
## Blot\_15 0.191160738 0.30420719 0.235117343 -0.117334936 2.690830e-01  
## Blot\_16 -0.152361355 0.08736352 0.001946312 0.157968048 1.096669e-01  
## Blot\_17 0.109093964 0.01688570 0.202446909 -0.029598168 -1.088108e-02  
## Blot\_18 -0.476629601 -0.16813488 0.136452698 -0.014051536 -3.242334e-02  
## Blot\_19 -0.021838160 -0.01092121 0.261404380 -0.272556835 -5.877404e-02  
## Blot\_20 -0.175158157 -0.01507247 -0.031775549 0.003243649 2.730618e-01  
## Blot\_21 -0.086031856 -0.10828668 0.163570630 -0.229524491 -1.583691e-01  
## Blot\_22 0.160715128 -0.08061801 0.227115436 0.335409708 3.126677e-01  
## Blot\_23 -0.035704574 -0.06837053 -0.324669347 0.072111273 2.255631e-05  
## Blot\_24 0.117545049 -0.31923100 -0.004734486 -0.022791404 -6.193282e-02  
## Blot\_25 -0.009606168 -0.47081966 0.103232494 0.273670080 -1.959154e-01  
## Blot\_26 0.257583147 0.03516924 -0.021053210 -0.214003867 -8.259523e-02  
## Blot\_27 -0.206870200 -0.03400282 -0.044331735 0.046660550 -3.485289e-02  
## Blot\_28 -0.169446508 0.37915805 0.063336105 -0.220493875 1.255241e-01  
## Blot\_29 0.386562472 0.18461304 -0.069936504 -0.025366493 -1.120743e-01  
## Blot\_30 0.060820068 0.01928834 -0.397648134 0.087724028 3.217034e-01  
## Blot\_31 0.157345814 -0.17325513 -0.278183227 0.083947466 1.966306e-01  
## Blot\_32 -0.250832928 0.04591482 -0.001280722 0.118452474 -1.389772e-01  
## Blot\_33 -0.060420043 0.22146302 0.054766904 0.393570955 -1.439608e-01  
## Blot\_34 -0.069030288 0.10566579 -0.183993404 0.101700415 -1.016723e-01  
## Blot\_35 -0.110665830 0.20114317 -0.107788558 0.148372372 -6.600200e-02  
## Comp.16 Comp.17 Comp.18 Comp.19 Comp.20  
## Blot\_1 0.300548406 0.1012325565 0.3140128691 0.017562921 -0.03590990  
## Blot\_2 -0.059419923 -0.1299313561 0.1083939900 -0.036873928 -0.03404288  
## Blot\_3 -0.007772428 -0.0852507828 -0.0003296581 -0.219565038 -0.04700913  
## Blot\_4 0.253622536 0.0874909309 -0.1093572971 -0.085973359 0.12636292  
## Blot\_5 -0.138135153 -0.2531299276 -0.0301647496 0.294264545 -0.06202345  
## Blot\_6 -0.222449864 -0.3410742555 0.1882047437 -0.051393605 -0.01051743  
## Blot\_7 -0.135176166 0.0123614382 -0.1073008586 -0.470477450 0.15346679  
## Blot\_8 -0.004278741 -0.0826918438 0.0535408819 0.091598881 0.33233524  
## Blot\_9 -0.109266667 0.1188551348 -0.0141972242 -0.284933012 -0.13545987  
## Blot\_10 -0.176879106 -0.0198222841 -0.0584087419 0.447671117 -0.15043510  
## Blot\_11 0.150560293 -0.1608423607 0.0058391708 -0.146449161 0.08549714  
## Blot\_12 -0.084218928 -0.0942652165 -0.1723244429 -0.106173818 -0.41139823  
## Blot\_13 0.031230903 0.3239814216 0.0766425218 -0.094025925 -0.07899049  
## Blot\_14 0.213116837 -0.0378055033 -0.1151697399 -0.060045964 -0.17750950  
## Blot\_15 -0.212116284 -0.0710839781 -0.1261245949 0.037413525 0.10780026  
## Blot\_16 0.100433382 -0.4221108948 0.4777469584 -0.054356727 0.03226085  
## Blot\_17 0.115648584 0.2353487074 0.1432234805 -0.113039024 -0.07000109  
## Blot\_18 -0.121325524 0.1100721253 -0.1419159357 0.063864815 -0.16717182  
## Blot\_19 -0.201851211 0.0663280641 -0.0659550462 -0.098916783 0.10143234  
## Blot\_20 -0.228193969 0.1129739862 0.1104244561 0.164765272 0.42925623  
## Blot\_21 -0.058089753 -0.0585305997 0.0342708457 0.058203822 0.03582576  
## Blot\_22 0.407604110 0.1839548237 0.0452513984 0.066326603 0.16189475  
## Blot\_23 0.083146803 -0.0921641340 -0.1667962082 0.121909665 0.06620432  
## Blot\_24 0.102043860 -0.0009347401 -0.2359221062 0.008722449 0.21618430  
## Blot\_25 0.016471313 -0.1001893575 0.0503612550 0.109392732 -0.04568848  
## Blot\_26 0.052925219 -0.2815260806 0.0213362889 -0.129335803 -0.08941458  
## Blot\_27 0.107186941 0.1250030233 -0.1120973605 0.031472584 0.03979326  
## Blot\_28 0.176882958 0.1224537994 0.0451946739 0.397308063 -0.27640167  
## Blot\_29 0.105046408 0.0052358205 -0.0003039468 0.041018700 0.05884968  
## Blot\_30 -0.007061464 -0.1058719277 -0.3728350144 -0.091788801 -0.10483843  
## Blot\_31 -0.416882629 0.3776752909 0.3810936143 -0.033538828 -0.04383238  
## Blot\_32 -0.115302276 0.0666719140 -0.0652228965 -0.032359422 -0.24485182  
## Blot\_33 -0.058572300 -0.0320182062 -0.2510193932 0.094981240 0.30970256  
## Blot\_34 0.105860890 -0.0433030464 0.1204041677 -0.072482670 -0.07965495  
## Blot\_35 0.118442501 -0.1417295027 0.0533528670 -0.045108640 -0.02842822  
## Comp.21 Comp.22 Comp.23 Comp.24 Comp.25  
## Blot\_1 0.079479149 -0.147195257 0.016369140 0.011606100 -0.1355005973  
## Blot\_2 0.063644312 -0.049533544 0.019050889 0.041766519 -0.0003623822  
## Blot\_3 -0.243605215 0.097825783 -0.108195061 -0.034002118 0.0929810089  
## Blot\_4 -0.082980938 -0.103120373 0.214412277 -0.048412402 0.1766838252  
## Blot\_5 0.004002266 -0.013163796 -0.046896270 0.430067772 0.0949685279  
## Blot\_6 -0.022117288 0.057423114 -0.085647887 0.113095553 -0.3275404804  
## Blot\_7 0.147266337 -0.102406751 -0.049221815 0.012942049 -0.2576967191  
## Blot\_8 0.089564974 0.122598206 0.158511713 0.064345850 0.0771034053  
## Blot\_9 0.009499228 -0.021364244 0.027173327 0.144700221 -0.1657162581  
## Blot\_10 0.040599616 -0.019323302 -0.036563857 -0.181890827 -0.1708883589  
## Blot\_11 0.419948775 0.076729812 0.229744267 -0.059047602 0.0281702523  
## Blot\_12 0.074659550 -0.184954510 0.138094895 -0.119466231 0.0498881347  
## Blot\_13 0.134932308 -0.270582330 -0.134292529 0.192804525 -0.0973940630  
## Blot\_14 -0.151454934 0.139989879 0.005430841 0.266890103 -0.1172020864  
## Blot\_15 0.178530366 -0.113399071 0.005420628 0.083184867 0.0390824031  
## Blot\_16 -0.089278689 -0.168133927 -0.249359586 -0.054664659 -0.0146765388  
## Blot\_17 -0.313054841 -0.050841446 0.016658629 -0.278022003 0.1579239994  
## Blot\_18 0.145386816 0.390385517 -0.118573922 0.115912633 -0.1863150055  
## Blot\_19 -0.108564159 -0.089380263 0.193449737 0.237985605 -0.0011588736  
## Blot\_20 -0.089786854 -0.228518370 0.106417684 0.091517814 0.0938976359  
## Blot\_21 0.128266328 0.314247435 -0.049850289 -0.396157252 0.1452800501  
## Blot\_22 0.138359266 0.287159557 -0.163770741 0.289097656 0.0920418737  
## Blot\_23 0.440247220 -0.220178737 -0.020948009 -0.267181191 0.0701035192  
## Blot\_24 -0.129049717 -0.211926355 -0.588805308 -0.054707817 -0.0763656983  
## Blot\_25 -0.271083324 -0.161899874 0.437471200 0.010762965 -0.0274727640  
## Blot\_26 -0.164134274 0.136258043 -0.098994757 -0.158952560 0.0303317436  
## Blot\_27 -0.041409046 -0.060793706 0.086228021 -0.213103490 -0.5309851226  
## Blot\_28 -0.075706985 -0.134767562 -0.013324512 0.015411903 -0.1465107803  
## Blot\_29 -0.076168644 0.315599087 0.110447467 0.032190306 -0.1259620309  
## Blot\_30 -0.148312215 0.004283391 0.077808087 0.003434145 0.1043308831  
## Blot\_31 0.007779968 0.222619308 -0.021200003 -0.138355007 0.0356725804  
## Blot\_32 0.039097794 -0.038237892 -0.224812246 0.075273890 0.4526577930  
## Blot\_33 -0.322475496 0.151186501 -0.035885023 -0.100003726 -0.0547415213  
## Blot\_34 0.016948500 0.010084451 0.112605484 0.154563118 0.1177850680  
## Blot\_35 0.044011046 0.147600709 0.137403568 -0.032412021 -0.0673551353  
## Comp.26 Comp.27 Comp.28 Comp.29 Comp.30  
## Blot\_1 -0.001397789 -0.01516215 0.111362457 0.031161589 0.304395545  
## Blot\_2 0.369172561 -0.01345779 -0.255699658 -0.001963927 -0.221818019  
## Blot\_3 0.134690248 -0.20603366 0.093220639 0.292314109 -0.102938206  
## Blot\_4 0.194357301 0.09649645 -0.296575256 -0.404661034 -0.022081561  
## Blot\_5 -0.071289923 -0.14496952 -0.010145126 -0.272960853 0.290325236  
## Blot\_6 -0.064313772 -0.16288977 0.087620329 0.062752550 0.074641782  
## Blot\_7 0.011207936 0.23586569 0.062812923 0.036676952 0.405930304  
## Blot\_8 0.050298219 0.17700353 0.135406399 0.289213207 -0.181624731  
## Blot\_9 -0.180256009 -0.22542415 -0.180027051 0.052033111 0.083384866  
## Blot\_10 0.202008832 0.11539758 -0.300663622 0.013010710 0.095945836  
## Blot\_11 -0.271939920 0.12753929 -0.197906695 -0.023779051 -0.070621153  
## Blot\_12 -0.002215676 0.12944485 0.277401704 -0.027594138 0.090137462  
## Blot\_13 -0.017859158 0.13580108 0.086866114 -0.087417628 -0.278944404  
## Blot\_14 0.167107340 0.11346100 0.258849908 -0.311363399 -0.021215141  
## Blot\_15 0.010604484 0.03117089 0.344756109 -0.077911727 -0.304519151  
## Blot\_16 0.108240070 0.26890928 -0.048466690 -0.005084986 0.011644600  
## Blot\_17 -0.189005466 0.05892334 0.093750835 -0.005886435 0.143481540  
## Blot\_18 -0.238034731 0.29215472 -0.088132600 -0.020540896 -0.083741527  
## Blot\_19 0.255734964 -0.29584356 -0.145743853 0.149053212 0.034321562  
## Blot\_20 -0.337707188 0.05260785 -0.115548943 -0.172354668 0.165754011  
## Blot\_21 -0.026591642 -0.17903413 0.080686743 0.056646003 0.187889589  
## Blot\_22 -0.003697449 -0.25440564 0.083686188 0.108023284 0.003496497  
## Blot\_23 0.131391946 -0.22283207 0.135338609 -0.009777082 0.092351065  
## Blot\_24 -0.063581641 0.03127329 -0.145265207 0.080371299 -0.096613964  
## Blot\_25 -0.080717793 0.05777590 0.150558890 0.169103051 -0.175100791  
## Blot\_26 -0.288991877 -0.16912318 -0.156198077 -0.325526417 -0.274809752  
## Blot\_27 0.175441051 -0.26203965 -0.073685002 -0.148376001 -0.034568603  
## Blot\_28 -0.216715131 -0.01019213 0.016578388 0.201471406 0.037337539  
## Blot\_29 0.250962762 0.37918941 -0.126678100 0.111405561 0.144429622  
## Blot\_30 -0.173577132 0.03876955 -0.251708917 0.242821731 0.050211389  
## Blot\_31 0.082369728 -0.04616252 0.006127992 -0.168885890 -0.085024672  
## Blot\_32 0.206406160 0.07690856 -0.013939445 -0.049574270 0.181090037  
## Blot\_33 0.064186607 0.05450555 0.292490892 -0.150744895 0.183261686  
## Blot\_34 0.004184798 -0.10702590 -0.175367469 0.103173286 0.200879730  
## Blot\_35 -0.017891566 -0.12871722 0.089630150 -0.254556396 0.059076245  
## Comp.31 Comp.32 Comp.33 Comp.34 Comp.35  
## Blot\_1 -0.054829807 0.3273951253 0.360817374 0.104138918 -0.08428514  
## Blot\_2 0.191554595 -0.2620354926 -0.333163191 0.003930641 -0.15405367  
## Blot\_3 -0.385013204 0.0018208737 0.098280525 0.018173193 -0.18538372  
## Blot\_4 -0.180083914 0.0237045041 0.175471843 0.011436305 -0.13583991  
## Blot\_5 0.026314288 -0.0582660809 -0.137416744 0.007903291 -0.10698275  
## Blot\_6 -0.297102020 0.2592173131 -0.261631593 -0.018786413 -0.05193626  
## Blot\_7 0.176808531 -0.0230092133 -0.148778812 -0.023636733 -0.11381401  
## Blot\_8 0.339569535 0.0340451321 0.078851597 -0.040915770 -0.21410441  
## Blot\_9 0.280265992 -0.2242525987 0.311788843 0.080886319 -0.16753100  
## Blot\_10 0.112885974 0.2495393726 0.157401148 -0.030444548 -0.11286421  
## Blot\_11 -0.252469754 0.1425089847 -0.106569701 -0.056132765 -0.17925335  
## Blot\_12 -0.085028636 -0.3176635845 0.218938489 -0.084248408 -0.07095619  
## Blot\_13 -0.021801531 0.0069287577 -0.084054536 -0.019743628 -0.26330431  
## Blot\_14 0.032678624 -0.0586272655 -0.113960415 -0.125482474 -0.15819178  
## Blot\_15 0.089613072 0.2221353988 0.055528214 -0.124534024 -0.20579630  
## Blot\_16 0.128399514 -0.0443145594 0.233541082 -0.024157191 -0.14937461  
## Blot\_17 0.082428194 0.1902941230 -0.408447121 -0.060000544 -0.15944514  
## Blot\_18 -0.111138108 0.0726290889 0.194054250 -0.047569583 -0.12899086  
## Blot\_19 -0.120083750 0.0483044590 0.177159099 0.086963938 -0.20133152  
## Blot\_20 -0.075283523 -0.1637300672 -0.029990181 -0.009968596 -0.13420325  
## Blot\_21 0.212432923 -0.2266660096 -0.003137066 -0.030290974 -0.25787094  
## Blot\_22 0.105170419 0.0249902476 0.010700986 -0.032790294 -0.13926546  
## Blot\_23 -0.253193496 -0.0674570492 -0.048618695 -0.043523046 -0.20239866  
## Blot\_24 -0.144898037 -0.1463769257 0.001238802 0.085049751 -0.19023992  
## Blot\_25 0.008294813 0.0449805356 0.001633004 0.043579344 -0.22247467  
## Blot\_26 0.087038614 0.0548222216 0.120043753 -0.171553733 -0.14623794  
## Blot\_27 0.185464083 0.1660762258 -0.109300156 -0.203666617 -0.08050014  
## Blot\_28 -0.051366939 -0.2462592648 -0.115270998 0.015662596 -0.26524134  
## Blot\_29 -0.253671750 -0.1828221165 -0.117728373 0.059921831 -0.13744842  
## Blot\_30 0.104016153 0.2509997911 -0.071211133 0.118665365 -0.21494078  
## Blot\_31 -0.182842028 -0.0305875310 0.027259392 -0.016394001 -0.21816904  
## Blot\_32 0.122233315 0.3427603325 -0.070743232 0.056598278 -0.18707961  
## Blot\_33 -0.040285462 -0.0008831842 0.192368432 -0.166633445 -0.11329626  
## Blot\_34 -0.040743702 -0.0658317378 0.004084477 -0.650665607 -0.05950787  
## Blot\_35 0.061257457 -0.0411913703 -0.055788897 0.605067673 -0.17601858  
##   
## $variance.proportion  
## [1] 0.066091391 0.059845356 0.052533675 0.051614773 0.049331280 0.046964624  
## [7] 0.046260438 0.042974080 0.040066047 0.037532740 0.035273485 0.033732672  
## [13] 0.031520689 0.030512870 0.029979536 0.029041178 0.027230083 0.026670856  
## [19] 0.025716470 0.024930790 0.022247382 0.021155098 0.020830678 0.018942091  
## [25] 0.018013525 0.016464556 0.015416832 0.014553225 0.014308452 0.012773281  
## [31] 0.011401616 0.010937931 0.007778300 0.006314278 0.001039718  
##   
## $variance.total  
## [1] 35  
##   
## $transposed  
## [1] FALSE

The eigenvalue of the first PCA is the first entry of $eigen.values, its proportion of explained variance the first entry of $variance.proportion. The remaining parts of the output can be ignored for the moment. The eigenvalues of the first and second PCAs were 2.3 and 2.1 respectively, which indicates the possibility of multidimensionality. As already mentioned in the interpretation of the Figure above, items “BLOT\_34” and “BLOT\_35” seem to share another second dimension and therefore show a lack of local independence. To furthermore check for possible local dependence of items, and of these two items in particular, we can use Yen’s (1984) statistic as implemented in pairwise. is a correlation between item response residuals also accounting for non-linear relationships between the partialled-out primary Rasch dimension and item responses.

We can get descriptive statistics as well as the three largest response residual correlations in terms of absolute value of with the following code.

# This line estimates Q3 for each item and stores the results as an object  
yen\_q3 <- q3(pers)   
# Estimated Yen's Q3, rounded to 2 decimal spaces  
round(yen\_q3[["resid\_cor"]][["cor"]],2)

## Blot\_1 Blot\_2 Blot\_3 Blot\_4 Blot\_5 Blot\_6 Blot\_7 Blot\_8 Blot\_9 Blot\_10  
## Blot\_1 NA 0.42 -0.06 -0.11 0.02 -0.06 -0.14 -0.05 -0.06 -0.20  
## Blot\_2 0.42 NA 0.01 -0.08 0.00 0.02 -0.10 -0.07 0.02 -0.08  
## Blot\_3 -0.06 0.01 NA -0.01 0.16 -0.16 0.09 0.03 0.02 0.08  
## Blot\_4 -0.11 -0.08 -0.01 NA 0.00 0.23 0.10 0.14 0.06 -0.04  
## Blot\_5 0.02 0.00 0.16 0.00 NA -0.11 -0.09 0.11 -0.01 -0.01  
## Blot\_6 -0.06 0.02 -0.16 0.23 -0.11 NA -0.06 0.16 0.20 0.02  
## Blot\_7 -0.14 -0.10 0.09 0.10 -0.09 -0.06 NA -0.03 -0.15 0.06  
## Blot\_8 -0.05 -0.07 0.03 0.14 0.11 0.16 -0.03 NA 0.01 -0.02  
## Blot\_9 -0.06 0.02 0.02 0.06 -0.01 0.20 -0.15 0.01 NA -0.03  
## Blot\_10 -0.20 -0.08 0.08 -0.04 -0.01 0.02 0.06 -0.02 -0.03 NA  
## Blot\_11 -0.01 -0.01 0.00 -0.11 0.04 -0.12 -0.04 0.03 0.07 -0.01  
## Blot\_12 -0.03 0.03 -0.02 -0.01 0.07 0.13 -0.07 0.12 -0.10 0.01  
## Blot\_13 0.04 -0.09 0.00 -0.04 0.01 -0.03 -0.05 -0.15 -0.07 0.02  
## Blot\_14 0.00 -0.11 0.01 -0.06 -0.16 -0.03 -0.09 -0.06 0.10 0.11  
## Blot\_15 0.03 0.04 -0.03 -0.02 0.00 -0.06 -0.03 -0.23 0.05 0.00  
## Blot\_16 -0.18 -0.12 0.02 -0.07 0.08 0.02 -0.07 -0.13 -0.08 -0.11  
## Blot\_17 0.05 0.03 0.03 0.04 0.05 -0.09 -0.20 0.07 0.22 0.04  
## Blot\_18 0.00 0.17 0.00 -0.05 0.04 -0.04 -0.05 -0.04 -0.04 -0.10  
## Blot\_19 -0.13 -0.06 -0.25 -0.18 -0.08 -0.07 0.02 -0.07 -0.17 -0.06  
## Blot\_20 0.03 0.01 0.10 -0.15 -0.13 0.00 -0.10 -0.01 -0.05 0.01  
## Blot\_21 0.04 -0.09 -0.04 0.07 -0.05 0.11 -0.12 -0.23 -0.12 -0.03  
## Blot\_22 -0.11 -0.11 -0.04 0.10 -0.05 0.02 0.09 -0.05 -0.11 0.04  
## Blot\_23 -0.04 0.01 -0.11 -0.06 -0.02 -0.06 -0.02 0.04 0.13 -0.01  
## Blot\_24 0.05 -0.06 -0.16 -0.01 -0.05 0.00 0.00 0.05 -0.06 0.03  
## Blot\_25 -0.06 -0.08 -0.11 0.03 -0.04 0.01 0.13 -0.18 -0.05 0.03  
## Blot\_26 0.05 0.02 -0.05 -0.15 -0.06 0.03 0.19 0.02 -0.14 -0.05  
## Blot\_27 -0.03 -0.14 0.14 -0.04 0.11 -0.13 -0.12 0.04 -0.05 -0.21  
## Blot\_28 -0.03 -0.10 -0.10 0.11 -0.10 0.00 0.08 0.01 -0.10 0.00  
## Blot\_29 0.09 -0.09 -0.08 -0.13 0.00 -0.03 -0.16 -0.05 0.11 -0.12  
## Blot\_30 0.04 0.03 -0.03 -0.04 0.06 -0.09 -0.10 -0.18 -0.12 -0.15  
## Blot\_31 -0.04 -0.07 -0.11 -0.07 0.03 -0.05 0.12 0.04 -0.06 0.00  
## Blot\_32 -0.11 -0.07 -0.04 -0.06 -0.16 0.07 -0.02 0.02 0.07 -0.15  
## Blot\_33 0.02 0.24 -0.09 -0.07 -0.02 0.00 -0.05 -0.03 0.01 -0.05  
## Blot\_34 0.06 -0.01 -0.06 -0.06 -0.17 -0.08 0.02 -0.07 -0.14 0.08  
## Blot\_35 -0.06 -0.06 0.00 -0.11 -0.17 -0.10 0.05 -0.01 -0.22 0.13  
## Blot\_11 Blot\_12 Blot\_13 Blot\_14 Blot\_15 Blot\_16 Blot\_17 Blot\_18 Blot\_19  
## Blot\_1 -0.01 -0.03 0.04 0.00 0.03 -0.18 0.05 0.00 -0.13  
## Blot\_2 -0.01 0.03 -0.09 -0.11 0.04 -0.12 0.03 0.17 -0.06  
## Blot\_3 0.00 -0.02 0.00 0.01 -0.03 0.02 0.03 0.00 -0.25  
## Blot\_4 -0.11 -0.01 -0.04 -0.06 -0.02 -0.07 0.04 -0.05 -0.18  
## Blot\_5 0.04 0.07 0.01 -0.16 0.00 0.08 0.05 0.04 -0.08  
## Blot\_6 -0.12 0.13 -0.03 -0.03 -0.06 0.02 -0.09 -0.04 -0.07  
## Blot\_7 -0.04 -0.07 -0.05 -0.09 -0.03 -0.07 -0.20 -0.05 0.02  
## Blot\_8 0.03 0.12 -0.15 -0.06 -0.23 -0.13 0.07 -0.04 -0.07  
## Blot\_9 0.07 -0.10 -0.07 0.10 0.05 -0.08 0.22 -0.04 -0.17  
## Blot\_10 -0.01 0.01 0.02 0.11 0.00 -0.11 0.04 -0.10 -0.06  
## Blot\_11 NA 0.03 -0.09 0.11 -0.10 0.06 -0.08 -0.21 0.02  
## Blot\_12 0.03 NA -0.02 -0.15 -0.08 -0.07 0.08 -0.03 0.01  
## Blot\_13 -0.09 -0.02 NA -0.09 -0.15 0.01 -0.07 -0.07 0.00  
## Blot\_14 0.11 -0.15 -0.09 NA -0.11 0.01 -0.03 -0.07 0.05  
## Blot\_15 -0.10 -0.08 -0.15 -0.11 NA -0.06 0.01 -0.01 -0.04  
## Blot\_16 0.06 -0.07 0.01 0.01 -0.06 NA 0.07 -0.02 0.06  
## Blot\_17 -0.08 0.08 -0.07 -0.03 0.01 0.07 NA 0.18 0.12  
## Blot\_18 -0.21 -0.03 -0.07 -0.07 -0.01 -0.02 0.18 NA 0.05  
## Blot\_19 0.02 0.01 0.00 0.05 -0.04 0.06 0.12 0.05 NA  
## Blot\_20 -0.10 0.03 0.01 0.00 0.03 -0.01 -0.08 0.02 -0.02  
## Blot\_21 0.00 -0.12 0.16 0.06 0.06 0.00 -0.17 -0.02 -0.02  
## Blot\_22 -0.02 0.12 -0.01 -0.08 -0.13 0.05 -0.03 -0.05 -0.06  
## Blot\_23 -0.15 -0.14 -0.06 0.02 -0.09 0.06 0.10 0.15 -0.01  
## Blot\_24 0.00 0.02 -0.18 0.03 0.09 -0.17 0.01 -0.06 -0.04  
## Blot\_25 -0.10 -0.10 -0.11 -0.01 -0.08 -0.05 -0.16 -0.02 -0.09  
## Blot\_26 -0.12 0.06 -0.07 -0.11 -0.15 -0.09 -0.09 -0.09 0.06  
## Blot\_27 0.05 0.20 -0.03 -0.13 -0.07 0.10 -0.09 0.03 -0.05  
## Blot\_28 0.03 -0.10 -0.14 -0.03 -0.06 -0.03 -0.17 -0.11 -0.01  
## Blot\_29 -0.12 0.03 0.00 -0.12 0.15 -0.02 0.00 -0.07 -0.03  
## Blot\_30 -0.09 0.06 0.12 0.05 0.01 0.06 -0.14 -0.04 -0.05  
## Blot\_31 0.00 -0.02 -0.10 -0.06 -0.07 -0.03 -0.08 -0.12 -0.04  
## Blot\_32 0.02 0.11 -0.12 -0.06 -0.13 -0.08 -0.24 -0.04 -0.06  
## Blot\_33 0.13 -0.12 0.03 -0.08 -0.11 -0.08 -0.01 -0.05 0.02  
## Blot\_34 -0.14 -0.10 -0.01 -0.05 0.18 -0.10 -0.04 0.04 -0.02  
## Blot\_35 -0.07 0.00 -0.07 -0.05 0.16 -0.05 -0.01 0.07 -0.03  
## Blot\_20 Blot\_21 Blot\_22 Blot\_23 Blot\_24 Blot\_25 Blot\_26 Blot\_27 Blot\_28  
## Blot\_1 0.03 0.04 -0.11 -0.04 0.05 -0.06 0.05 -0.03 -0.03  
## Blot\_2 0.01 -0.09 -0.11 0.01 -0.06 -0.08 0.02 -0.14 -0.10  
## Blot\_3 0.10 -0.04 -0.04 -0.11 -0.16 -0.11 -0.05 0.14 -0.10  
## Blot\_4 -0.15 0.07 0.10 -0.06 -0.01 0.03 -0.15 -0.04 0.11  
## Blot\_5 -0.13 -0.05 -0.05 -0.02 -0.05 -0.04 -0.06 0.11 -0.10  
## Blot\_6 0.00 0.11 0.02 -0.06 0.00 0.01 0.03 -0.13 0.00  
## Blot\_7 -0.10 -0.12 0.09 -0.02 0.00 0.13 0.19 -0.12 0.08  
## Blot\_8 -0.01 -0.23 -0.05 0.04 0.05 -0.18 0.02 0.04 0.01  
## Blot\_9 -0.05 -0.12 -0.11 0.13 -0.06 -0.05 -0.14 -0.05 -0.10  
## Blot\_10 0.01 -0.03 0.04 -0.01 0.03 0.03 -0.05 -0.21 0.00  
## Blot\_11 -0.10 0.00 -0.02 -0.15 0.00 -0.10 -0.12 0.05 0.03  
## Blot\_12 0.03 -0.12 0.12 -0.14 0.02 -0.10 0.06 0.20 -0.10  
## Blot\_13 0.01 0.16 -0.01 -0.06 -0.18 -0.11 -0.07 -0.03 -0.14  
## Blot\_14 0.00 0.06 -0.08 0.02 0.03 -0.01 -0.11 -0.13 -0.03  
## Blot\_15 0.03 0.06 -0.13 -0.09 0.09 -0.08 -0.15 -0.07 -0.06  
## Blot\_16 -0.01 0.00 0.05 0.06 -0.17 -0.05 -0.09 0.10 -0.03  
## Blot\_17 -0.08 -0.17 -0.03 0.10 0.01 -0.16 -0.09 -0.09 -0.17  
## Blot\_18 0.02 -0.02 -0.05 0.15 -0.06 -0.02 -0.09 0.03 -0.11  
## Blot\_19 -0.02 -0.02 -0.06 -0.01 -0.04 -0.09 0.06 -0.05 -0.01  
## Blot\_20 NA 0.01 0.03 -0.02 -0.11 -0.03 0.01 0.16 -0.15  
## Blot\_21 0.01 NA -0.10 -0.19 -0.04 0.03 -0.16 -0.03 -0.15  
## Blot\_22 0.03 -0.10 NA -0.01 -0.06 0.05 0.07 0.04 0.00  
## Blot\_23 -0.02 -0.19 -0.01 NA -0.15 0.00 0.08 -0.09 -0.09  
## Blot\_24 -0.11 -0.04 -0.06 -0.15 NA 0.06 -0.09 -0.02 -0.11  
## Blot\_25 -0.03 0.03 0.05 0.00 0.06 NA 0.03 -0.05 -0.07  
## Blot\_26 0.01 -0.16 0.07 0.08 -0.09 0.03 NA -0.08 0.08  
## Blot\_27 0.16 -0.03 0.04 -0.09 -0.02 -0.05 -0.08 NA -0.03  
## Blot\_28 -0.15 -0.15 0.00 -0.09 -0.11 -0.07 0.08 -0.03 NA  
## Blot\_29 0.09 -0.01 0.06 0.03 -0.09 -0.02 0.20 0.16 -0.14  
## Blot\_30 -0.02 0.09 -0.05 0.00 -0.11 -0.13 -0.08 0.03 -0.11  
## Blot\_31 -0.11 -0.11 -0.01 -0.12 0.02 0.01 -0.07 -0.03 0.05  
## Blot\_32 0.11 -0.08 0.00 -0.05 0.00 0.07 0.13 0.15 0.13  
## Blot\_33 -0.10 -0.09 -0.07 -0.02 -0.03 -0.08 -0.02 -0.12 0.08  
## Blot\_34 -0.08 -0.04 -0.13 -0.13 0.25 0.08 -0.12 -0.18 -0.06  
## Blot\_35 -0.05 -0.12 -0.07 -0.11 0.16 -0.02 -0.02 -0.04 -0.05  
## Blot\_29 Blot\_30 Blot\_31 Blot\_32 Blot\_33 Blot\_34 Blot\_35  
## Blot\_1 0.09 0.04 -0.04 -0.11 0.02 0.06 -0.06  
## Blot\_2 -0.09 0.03 -0.07 -0.07 0.24 -0.01 -0.06  
## Blot\_3 -0.08 -0.03 -0.11 -0.04 -0.09 -0.06 0.00  
## Blot\_4 -0.13 -0.04 -0.07 -0.06 -0.07 -0.06 -0.11  
## Blot\_5 0.00 0.06 0.03 -0.16 -0.02 -0.17 -0.17  
## Blot\_6 -0.03 -0.09 -0.05 0.07 0.00 -0.08 -0.10  
## Blot\_7 -0.16 -0.10 0.12 -0.02 -0.05 0.02 0.05  
## Blot\_8 -0.05 -0.18 0.04 0.02 -0.03 -0.07 -0.01  
## Blot\_9 0.11 -0.12 -0.06 0.07 0.01 -0.14 -0.22  
## Blot\_10 -0.12 -0.15 0.00 -0.15 -0.05 0.08 0.13  
## Blot\_11 -0.12 -0.09 0.00 0.02 0.13 -0.14 -0.07  
## Blot\_12 0.03 0.06 -0.02 0.11 -0.12 -0.10 0.00  
## Blot\_13 0.00 0.12 -0.10 -0.12 0.03 -0.01 -0.07  
## Blot\_14 -0.12 0.05 -0.06 -0.06 -0.08 -0.05 -0.05  
## Blot\_15 0.15 0.01 -0.07 -0.13 -0.11 0.18 0.16  
## Blot\_16 -0.02 0.06 -0.03 -0.08 -0.08 -0.10 -0.05  
## Blot\_17 0.00 -0.14 -0.08 -0.24 -0.01 -0.04 -0.01  
## Blot\_18 -0.07 -0.04 -0.12 -0.04 -0.05 0.04 0.07  
## Blot\_19 -0.03 -0.05 -0.04 -0.06 0.02 -0.02 -0.03  
## Blot\_20 0.09 -0.02 -0.11 0.11 -0.10 -0.08 -0.05  
## Blot\_21 -0.01 0.09 -0.11 -0.08 -0.09 -0.04 -0.12  
## Blot\_22 0.06 -0.05 -0.01 0.00 -0.07 -0.13 -0.07  
## Blot\_23 0.03 0.00 -0.12 -0.05 -0.02 -0.13 -0.11  
## Blot\_24 -0.09 -0.11 0.02 0.00 -0.03 0.25 0.16  
## Blot\_25 -0.02 -0.13 0.01 0.07 -0.08 0.08 -0.02  
## Blot\_26 0.20 -0.08 -0.07 0.13 -0.02 -0.12 -0.02  
## Blot\_27 0.16 0.03 -0.03 0.15 -0.12 -0.18 -0.04  
## Blot\_28 -0.14 -0.11 0.05 0.13 0.08 -0.06 -0.05  
## Blot\_29 NA -0.01 -0.13 0.10 -0.09 -0.08 -0.11  
## Blot\_30 -0.01 NA 0.03 -0.23 0.09 -0.01 -0.10  
## Blot\_31 -0.13 0.03 NA -0.03 -0.01 0.02 -0.03  
## Blot\_32 0.10 -0.23 -0.03 NA -0.03 -0.08 -0.10  
## Blot\_33 -0.09 0.09 -0.01 -0.03 NA -0.11 -0.02  
## Blot\_34 -0.08 -0.01 0.02 -0.08 -0.11 NA 0.68  
## Blot\_35 -0.11 -0.10 -0.03 -0.10 -0.02 0.68 NA

As indicated, Yen’s between “BLOT\_34” and “BLOT\_35” turns out to be .68, strongly suggesting a violation of local independence. Thus, whether a participant can successfully answer “BLOT\_35” depends, to some extent, upon that participant’s responses to “preceding items”BLOT\_34", implying a logical dependency between these items.

As an aside, between “BLOT\_1” and “BLOT\_2” turned out to be .42. Given the explanations provided in chapter 12: “Items #1 and #2 … introductory questions which refer to Bill and Tom playing on a see-saw in order to make it work. The second of those questions asks: What is another way that Bill and Tom can get the see-saw to work?”, therefore reveals a logical dependency between these items resulting in a noticeable response residual correlation.

### References

Yen, W. M. (1984). Effects of Local Item Dependence on the Fit and Equating Performance of the Three-Parameter Logistic Model. *Applied Psychological Measurement, 8*(2), 125–145. <https://doi.org/10.1177/01466216840>