

# Package ‘matrixStrucTest’

July 18, 2019

**Version** 1.0.0

**Date** 2019-07-14

**Title** Tests of Matrix Structure for Construct Validation

**Description** Tests for block-diagonal structure in symmetric matrices (e.g. correlation matrices) under the null hypothesis of exchangeable off-diagonal elements. As described in Segal et al. (2019), these tests can be useful for construct validation either by themselves or as a complement to confirmatory factor analysis. Monte Carlo methods are used to approximate the permutation p-value with Hubert's Gamma (Hubert, 1976) and a t-statistic. This package also implements the chi-squared statistic described by Steiger (1980). Please see Segal, et al. (2019) <doi:10.1007/s11336-018-9647-4> for more information.

**Depends** R (>= 3.1)

**Suggests** ggplot2, reshape2

**Author** Brian D. Segal [aut, cre]

**Maintainer** Brian D. Segal <bdsegal@umich.edu>

**License** GPL (>= 3)

**URL** <https://github.com/bdsegal/matrixStrucTest>

**LazyData** true

**RoxygenNote** 6.1.1

**NeedsCompilation** no

**Repository** CRAN

**Date/Publication** 2019-07-18 06:35:48 UTC

## R topics documented:

big5	2
deltaSub	4
makeGroupList	4
matrixStrucTest	5
matrixStrucTestSub	7
multiSub	8
prepBoxPlots	8

print.mst . . . . .	10
sigmaRhoFun . . . . .	10
sigmaZFun . . . . .	11
X2Fun . . . . .	11

big5

*Big Five personality questionnaire***Description**

A dataset containing answers to a Big Five Personality Test conducted by <http://personality-testing.info>. These data were collected (c. 2012) through an interactive online personality test. The test was constructed with items from the International Personality Item Pool. Participants were informed that their responses would be recorded and used for research at the beginning of the test and asked to confirm their consent at the end of the test. The items were rated on a five point scale where 1=Disagree, 3=Neutral, 5=Agree. All were presented on one page in the order E1, N1, A1, C1, O1, E2,...

**Usage**

big5

**Format**

A data frame with 19,719 rows of 57 variables:

**race** 1=Mixed Race, 2=Arctic (Siberian, Eskimo), 3=Caucasian (European), 4=Caucasian (Indian), 5=Caucasian (Middle East), 6=Caucasian (North African, Other), 7=Indigenous Australian, 8=Native American, 9=North East Asian (Mongol, Tibetan, Korean Japanese, etc), 10=Pacific (Polynesian, Micronesian, etc), 11=South East Asian (Chinese, Thai, Malay, Filipino, etc), 12=West African, Bushmen, Ethiopian, 13=Other

**age** Entered as text (individuals reporting age < 13 were not recorded)

**engnat** Response to "is English your native language?". 1=yes, 2=no

**gender** 1=Male, 2=Female, 3=Other

**hand** "What hand do you use to write with?". 1=Right, 2=Left, 3=Both

**country** The participant's technical location. ISO country code

**source** How the participant came to the test. Based on HTTP Referer. 1=from another page on the test website, 2=from google, 3=from facebook, 4=from any url with ".edu" in its domain name, 6=other source, or HTTP Referer not provided

**E1** I am the life of the party.

**E2** I don't talk a lot.

**E3** I feel comfortable around people.

**E4** I keep in the background.

**E5** I start conversations.

**E6** I have little to say.

- E7 I talk to a lot of different people at parties.
- E8 I don't like to draw attention to myself.
- E9 I don't mind being the center of attention.
- E10 I am quiet around strangers.
- N1 I get stressed out easily.
- N2 I am relaxed most of the time.
- N3 I worry about things.
- N4 I seldom feel blue.
- N5 I am easily disturbed.
- N6 I get upset easily.
- N7 I change my mood a lot.
- N8 I have frequent mood swings.
- N9 I get irritated easily.
- N10 I often feel blue.
- A1 I feel little concern for others.
- A2 I am interested in people.
- A3 I insult people.
- A4 I sympathize with others' feelings.
- A5 I am not interested in other people's problems.
- A6 I have a soft heart.
- A7 I am not really interested in others.
- A8 I take time out for others.
- A9 I feel others' emotions.
- A10 I make people feel at ease.
- C1 I am always prepared.
- C2 I leave my belongings around.
- C3 I pay attention to details.
- C4 I make a mess of things.
- C5 I get chores done right away.
- C6 I often forget to put things back in their proper place.
- C7 I like order.
- C8 I shirk my duties.
- C9 I follow a schedule.
- C10 I am exacting in my work.
- O1 I have a rich vocabulary.
- O2 I have difficulty understanding abstract ideas.
- O3 I have a vivid imagination.

- O4** I am not interested in abstract ideas.
- O5** I have excellent ideas.
- O6** I do not have a good imagination.
- O7** I am quick to understand things.
- O8** I use difficult words.
- O9** I spend time reflecting on things.
- O10** I am full of ideas.

### Details

This dataset is for demonstration purposes only. Please see <http://personality-testing.info/privacypolicy.html> and <http://personality-testing.info/about> for more information.

### Source

[http://personality-testing.info/\\_rawdata/](http://personality-testing.info/_rawdata/)

---

deltaSub

*Sub-routine to create Delta matrix*

---

### Description

This sub-routine outputs 1 if *i* and *j* are in at least one group together, and 0 otherwise, and is called by `matrixStrucTest` and `prepBoxPlots`.

### Usage

```
deltaSub(i, j, group_list)
```

### Arguments

<code>i</code>	First index
<code>j</code>	Second index
<code>group_list</code>	List of indices for each block

---

makeGroupList	<i>Convert character string in lavaan syntax into a list of indices</i>
---------------	---

---

**Description**

This sub-routine is called by `matrixStrucTest` and `prepBoxPlots`.

**Usage**

```
makeGroupList(groups, A)
```

**Arguments**

<code>groups</code>	Character string in lavaan syntax specifying groups
<code>A</code>	A Distance or similarity matrix. Must have column names

**Value**

`group_list` List of column indices of A corresponding to each group

---

<code>matrixStrucTest</code>	<i>Permutation p-values for Gamma and t-statistics</i>
------------------------------	--

---

**Description**

This function computes permutation p-values for Hubert's Gamma and t-statistics for both overall and block-specific tests.

**Usage**

```
matrixStrucTest(A, group_list = NULL, groups = NULL, B = 1000,
  absolute = TRUE)
```

**Arguments**

<code>A</code>	Distance or similarity matrix, e.g. correlation
<code>group_list</code>	List of column indices of A for each group. Either <code>groups</code> or <code>group_list</code> but not both must be supplied.
<code>groups</code>	CFA model in lavaan syntax. Either <code>groups</code> or <code>group_list</code> but not both must be supplied.
<code>B</code>	Number of Monte Carlo resamples (defaults to B=1000)
<code>absolute</code>	Use the absolute values of A (defaults to TRUE)

**Value**

pt\_overall\_one\_sided: Overall one-sided p-value using t statistic  
 pt\_overall\_two\_sided: Overall two-sided p-value using t statistic  
 pt\_multi\_one\_sided: Block-specific one-sided p-values using t statistic  
 pt\_multi\_two\_sided: Block-specific two-sided p-values using t statistic  
 t0 Observed overall: t statistic  
 t0k: Observed block-specific t statistic  
 t\_overall: Vector of overall t statistics from permuted A  
 t\_max\_one\_sided: Vector of max t statistics from permuted A (one-sided)  
 t\_max\_two\_sided: Vector of max t statistics from permuted A (two-sided)  
 pG\_overall\_one\_sided: Overall one-sided p-value using Hubert's Gamma  
 pG\_overall\_two\_sided: Overall two-sided p-value using Hubert's Gamma  
 pG\_multi\_one\_sided: Block-specific one-sided p-values using Hubert's Gamma  
 pG\_multi\_two\_sided: Block-specific two-sided p-values using Hubert's Gamma  
 Gamma0: Observed overall Hubert's Gamma  
 Gamma0k: Observed block-specific Hubert's Gamma  
 Gamma\_overall: Vector of Hubert's Gamma statistics from permuted A  
 Gamma\_max\_one\_sided: Vector of max Hubert's Gamma statistics from permuted A (one-sided)  
 Gamma\_max\_two\_sided: Vector of max Hubert's Gamma statistics from permuted A (two-sided)  
 B: number of Monte Carlo resamples  
 group\_list: List of column/row indices corresponding to each group

**Examples**

```

# example for matrixStrucTest package
library(matrixStrucTest)
data("big5")

# get column numbers for questionnaire items
items <- grep("[0-9]", colnames(big5))

# compute Spearman's correlation matrix
A <- cor(big5[, items], use = "complete.obs", method = "spearman")

# specify the groups
groups <- "extrovert ~ E1 + E2 + E3 + E4 + E5 + E6 + E7 + E8 + E9 + E10
          neurotic ~ N1 + N2 + N3 + N4 + N5 + N6 + N7 + N8 + N9 + N10
          agreeable ~ A1 + A2 + A3 + A4 + A5 + A6 + A7 + A8 + A9 + A10
          conscientious ~ C1 + C2 + C3 + C4 + C5 + C6 + C7 + C8 + C9 + C10
          open ~ O1 + O2 + O3 + O4 + O5 + O6 + O7 + O8 + O9 + O10"

# compute permutation p-values
# Note: Using small B for fast checking on CRAN. Set B >= 1000 in practice.
result <- matrixStrucTest(A = A, groups = groups, B = 100, absolute = TRUE)

```

```

# Note: two-sided p-values from Hubert's Gamma printed by default
#       other results available by directing accessing them from the
#       returned object
result

# Alternative approach for specifying the groups as a list of column/row indices
extrovert <- grep("E", colnames(A))
neurotic <- grep("N", colnames(A))
agreeable <- grep("A", colnames(A))
conscientious <- grep("C", colnames(A))
open <- grep("O", colnames(A))

# put blocks/groups in list
group_list <- list(extrovert = extrovert,
                  neurotic = neurotic,
                  agreeable = agreeable,
                  conscientious = conscientious,
                  open = open)

# Note: Using small B for fast checking on CRAN. Set B >= 1000 in practice.
result <- matrixStrucTest(A = A, group_list = group_list, B = 100, absolute = TRUE)

# Note: two-sided p-values from Hubert's Gamma printed by default
#       other results available by directing accessing them from the
#       returned object
result

# Visualize groups
library(ggplot2)
library(reshape2)

ord <- unlist(result$group_list)
diag(A) <- NA # remove diagonals from color scale
Am <- melt(A[ord, ord])
names(Am) <- c("x", "y", "value")
Am$y <- factor(Am$y, levels = rev(levels(Am$y)))

ggplot(aes(x = x, y = y, fill = abs(value)), data = Am)+
  geom_tile()+
  theme_bw(18)+
  scale_fill_gradient2(space="Lab", name="abs(Cor)", lim = c(0, 1))+
  labs(x = "", y = "")+
  theme(axis.text.x = element_text(angle = 90, vjust = .35, hjust=1))

```

---

matrixStrucTestSub *Compute Gamma and t-statistics for a single permutation*

---

## Description

This sub-routine is called by `matrixStrucTest` and `prepBoxPlots`.

**Usage**

```
matrixStrucTestSub(A, group_list_ord, Delta, multi_group_ind, A_upper_ind,
K)
```

**Arguments**

A	Distance or similarity matrix, e.g. correlation
group_list_ord	List of groupings for ordered matrix A
Delta	Delta matrix
multi_group_ind	List of indicator matrices for membership in block k test
A_upper_ind	indicator matrix for upper triangular elements
K	Total number of hypothesized blocks

**Value**

Gamma\_overall: Overall Hubert's Gamma  
Gamma\_multi: Block-specific Hubert's Gamma  
t\_overall: Overall t-statistic (unequal variance)  
t\_multi: Block-specific t-statistics  
Ak\_list: List of values in A used for each block-specific test  
Deltak\_list: List of values in Delta used for each block-specific test  
A\_upper: Upper triangular elements of A (used for box plot function)  
Delta\_upper: Upper triangular elements of Delta (used for box plot function)

---

multiSub

---

*Sub-routine to create Delta matrix for block-specific tests*


---

**Description**

This sub-routine outputs TRUE if either *i* or *j* are in *group*, FALSE otherwise, and is called by `matrixStrucTest` and `prepBoxPlots`.

**Usage**

```
multiSub(i, j, group)
```

**Arguments**

<i>i</i>	First index
<i>j</i>	Second index
<i>group</i>	Indices for items in group



---

```
prepBoxPlots          Prepare data for box plots
```

---

### Description

This function prepares the data for making box plots.

### Usage

```
prepBoxPlots(A, groups = NULL, group_list = NULL, absolute = TRUE)
```

### Arguments

A	Distance or similarity matrix, e.g. correlation
groups	CFA model in lavaan syntax. Either groups or group_list but not both must be supplied.
group_list	List of groupings. Either groups or group_list but not both must be supplied.
absolute	Use the absolute values of A (defaults to TRUE)

### Value

multi: data frame for making box plots for block-specific tests

overall: data frame for making box plots for overall test

### Examples

```
library(matrixStrucTest)
library(ggplot2)

data("big5")

# get column numbers for questionnaire items
items <- grep("[0-9]", colnames(big5))

# compute Spearman's correlation matrix
A <- cor(big5[, items], use = "complete.obs", method = "spearman")

groups <- "extrovert ~ E1 + E2 + E3 + E4 + E5 + E6 + E7 + E8 + E9 + E10
          neurotic ~ N1 + N2 + N3 + N4 + N5 + N6 + N7 + N8 + N9 + N10
          agreeable ~ A1 + A2 + A3 + A4 + A5 + A6 + A7 + A8 + A9 + A10
          conscientious ~ C1 + C2 + C3 + C4 + C5 + C6 + C7 + C8 + C9 + C10
          open ~ O1 + O2 + O3 + O4 + O5 + O6 + O7 + O8 + O9 + O10"

# Make box plots contrasting within and between group correlations
box <- prepBoxPlots(A = A, groups = groups, absolute = TRUE)

ggplot(aes(x = as.factor(delta), y = a), data = box$overall)+
```

```

geom_boxplot()+
theme_bw(22)+
labs(x = expression(Delta), y="|a|")

dev.new(width = 12, height = 5)
ggplot(aes(x = as.factor(delta), y = a), data = box$multi)+
  geom_boxplot()+
  facet_grid(~block)+
  theme_bw(22)+
  labs(x = expression(Delta), y = "|a|")

```

---

```
print.mst          Print results from matrixStrucTest
```

---

### Description

This function prints results from an object returned by `matrixStrucTest`.

### Usage

```
## S3 method for class 'mst'
print(x, ...)
```

### Arguments

<code>x</code>	Output from <code>matrixStrucTest</code>
<code>...</code>	Further arguments passed to <code>print</code>

---

```
sigmaRhoFun          Sub-routine to compute OLS estimates of covariance between correlations
```

---

### Description

This sub-routine is called by `X2fun`.

### Usage

```
sigmaRhoFun(j, k, h, m, A)
```

### Arguments

<code>j</code>	First index
<code>k</code>	Second index
<code>h</code>	Third index
<code>m</code>	Fourth index
<code>A</code>	Correlation matrix

---

sigmaZFun	<i>Sub-routine to get covariance of z-transformed variables</i>
-----------	---

---

**Description**

This sub-routine is called by X2fun.

**Usage**

```
sigmaZFun(s, t, index, A, Sigma)
```

**Arguments**

s	First index
t	Second index
index	Matrix with two columns with index pairs given by rows
A	Correlation matrix
Sigma	Variance-covariances of correlation matrix A

---

X2Fun	<i>Goodness-of-fit chi-squared statistic described by Steiger (1980).</i>
-------	---

---

**Description**

This function computed the goodness-of-fit chi-squared statistic described by Steiger (1980). Reference: Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. Psychological Bulletin, 87(2) 245-251.

**Usage**

```
X2Fun(data, group_list, corMethod = "spearman")
```

**Arguments**

data	Data frame
group_list	List of column indices of A for each group
corMethod	Type of correlations; passed to cor()