# Package 'SSRA'

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**Type** Package

**Title** Sakai Sequential Relation Analysis

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**Author** Takuya Yanagida [cre, aut],
Keiko Sakai [aut]

**Maintainer** Takuya Yanagida <takuya.yanagida@univie.ac.at>

**Description**
Takeya Semantic Structure Analysis (TSSA) and Sakai Sequential Relation Analysis (SSRA) for polytomous items for examining whether each pair of items has a sequential or equal relation. Package includes functions for generating a sequential relation table and a treegram to visualize sequential or equal relations between pairs of items.

**License** GPL-3

**LazyLoad** yes

**LazyData** true

**Imports** shape, stringr

**Depends** R (>= 3.2.0)

**RoxygenNote** 5.0.1

**NeedsCompilation** no

**Repository** CRAN

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## R topics documented:

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`exdat` *Example data based on Takeya (1991)*

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## Description

A dataset containing 10 observations on 5 items.

## Usage

```
exdat
```

## Format

A data frame with 10 rows and 5 variables

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`plot.ssra` *Plot ssra*

---

## Description

Function for plotting the ssra object

## Usage

```
## S3 method for class 'ssra'
plot(x, r.crt = NULL, r.sig = TRUE, d.sq = NULL,
  m.sig = TRUE, sig.col = TRUE,
  col = c("red2", "green4", "blue3", "black"),
  pch = c(1, 2, 0, 4), mar = c(3.5, 3.5, 1.5, 1), ...)
```

## Arguments

| | |
|---|---|
| `x` | requires the return object from the SSRA function |
| `r.crt` | minimal absolute correlation to be judged 'sequential' |
| `r.sig` | plot statistically significant correlations |
| `d.sq` | minimal effect size Cohen's d to be judged 'sequential' |
| `m.sig` | plot statistically significant mean difference |
| `sig.col` | significance in different colors |
| `col` | color code or name |
| `pch` | plotting character |
| `mar` | number of lines of margin to be specified on the four sides of the plot |
| `...` | further arguments passed to or from other methods |

## Details

Using this function, all item pairs are plotted on a graph by their correlation coefficients and their mean differences (Cohen's d). This graph is useful for defining (or changing) criteria regarding correlation coefficient and mean difference to judge whether an item pair is 'sequential' or 'equal'.

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

SSRA, treegram, scatterplot

## Examples

```
# Example data based on Takeya (1991)

# Sakai Sequential Relation Analysis
# ordering assesed according to the correlation coefficient and mean difference
exdat.ssra <- SSRA(exdat, output = FALSE)
plot(exdat.ssra)
```

---

# print.ssra *Sakai Sequential Relation Analysis Print*

---

## Description

print function for the ssra object

## Usage

```
## S3 method for class 'ssra'
print(x, digits = 3, ...)
```

## Arguments

| | |
|---|---|
| x | requires the result object of hssr function |
| digits | integer indicating the number of decimal places to be used |
| ... | further arguments passed to or from other methods |

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

seqtable

## Examples

```
# Example data based on Takeya (1991)

# Sakai Sequential Relation Analysis
# ordering assesed according to the correlation coefficient and mean difference
exdat.ssra <- SSRA(exdat, output = FALSE)
print(exdat.ssra)
```

---

# print.tssa *Semantric Structure Analysis Print*

---

## Description

`print` function for the `tssa` object

## Usage

```
## S3 method for class 'tssa'
print(x, digits = 3, ...)
```

## Arguments

| | |
|---|---|
| `x` | requires the result object of hssr function |
| `digits` | integer indicating the number of decimal places to be used |
| `...` | further arguments passed to or from other methods |

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

seqtable

## Examples

```
# Example data based on Takeya (1991)

# Takeya Semantic Structure Analysis
# ordering assesed according to the ordering coefficient
exdat.tssa <- TSSA(exdat, m = 5, output = FALSE)
print(exdat.tssa)

# Takeya Semantic Structure Analysis including statistical testing
# ordering assesed according to the ordering coefficient and statistical significance
exdat.tssa <- TSSA(exdat, m = 5, sig = TRUE, output = FALSE)
print(exdat.tssa)
```

---

# scatterplot *Scatterplot Matrices*

---

## Description

This function produces a scatterplot matrix

## Usage

```
scatterplot(data, select = NULL, type = c("jitter", "size", "count", "sun"))
```

## Arguments

| | |
|---|---|
| data | a data frame |
| select | select items to be plotted |
| type | type of plot, i.e., 'jitter', 'size', 'count', and 'sun' |

## Details

Using a scatterplot matrix, an overview of the answer patterns for the pairs of items can be taken.

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

TSSA, SSRA

## Examples

```
# Example data based on Takeya (1991)

# Select items to be plotted
scatterplot(exdat, select = c("Item2", "Item3", "Item4"))

# Scatterplot matrix: jitter
scatterplot(exdat)

# Scatterplot matrix: size
scatterplot(exdat, type = "size")

# Scatterplot matrix: count
scatterplot(exdat, type = "count")

# Scatterplot matrix: sun
scatterplot(exdat, type = "sun")
```

---

`seqtable` *Sequential Relation Table*

---

## Description

This function builds a table for the tssa and ssra object used to create a treegram

## Usage

```
seqtable(object, order = c("no", "decreasing", "increasing"),
  digits = 3, output = TRUE)
```

## Arguments

| | |
|---|---|
| `object` | requires the return object from the TSSA or SSRA function |
| `order` | sort by item mean of j? |
| `digits` | integer indicating the number of decimal places to be used |
| `output` | print result table? |

## Details

In this table, we can see how many 'sequential' or 'equal' relations each of items has with the other items.

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

TSSA, SSRA, treegram, summary.seqtable

## Examples

```
# Example data based on Takeya (1991)

# Takeya Semantic Structure Analysis
# ordering assesed according to the correlation coefficient and mean difference
exdat.tssa <- TSSA(exdat, m = 5, output = FALSE)
seqtable(exdat.tssa)

# Sakai Sequential Relation Analysis
# ordering assesed according to the correlation coefficient and mean difference
exdat.ssra <- SSRA(exdat, output = FALSE)
seqtable(exdat.ssra)
```

---

# SSRA *Sakai Sequential Relation Analysis*

---

## Description

This function conducts Sakai Sequential Relation Analysis (SSRA) based on Sakai 2016.

## Usage

```
SSRA(dat, r.crt = 0.3, mu.sq = 0, mu.eq = Inf, d.sq = 0.2, d.eq = 0.2,
  pairwise = TRUE, method = c("pearson", "kendall", "spearman"), alpha = 0.05,
  p.adjust.method = c("holm", "hochberg", "hommel",
                      "bonferroni", "BH", "BY", "fdr", "none"),
  digits = 3, vnames = TRUE, order = c("no", "decreasing", "increasing"),
  exclude = TRUE, output = TRUE)
```

## Arguments

| | |
|---|---|
| dat | requires a data frame with polytomous data |
| r.crt | correlation coefficient criterion to be judged 'sequential' or 'equivalent |
| mu.sq | Absolute mean difference criterion to be judged 'sequential' |
| mu.eq | maximal absolute mean difference to be judged 'equivalent' |
| d.sq | effect size for mean difference criterion to be judged 'sequential' |
| d.eq | maximal effect size Cohen's d to be judged 'equivalent' |

| | |
|---|---|
| pairwise | pairwise deletion of missing data, if pairwise = FALSE listwise deletion is applied |
| method | character string indicating which correlation coefficient to be used, 'pearson' = Pearson's product moment correlation coefficien 'spearman' = Spearman's rho statistic 'kendall' = Kendall's tau (default) |
| alpha | significance level |
| p.adjust.method | p-value correction method for multiple comparisons, see: ?p.adjust (default = holm) |
| digits | integer indicating the number of decimal places to be used |
| vnames | use variable names for labeling? |
| order | sort by item mean of j and k? |
| exclude | exclude paths with no relationship? |
| output | print result table? |

## Details

In Sakai Sequential Relation Analysis (SSRA), a pair of items is judged 'sequential', if there is a higher correlation and a bigger mean difference than defined criterions between the two items. If there is a higher correlation and a smaller mean difference than defined criterions between the two items, the relation of the two items is judged 'equal'.

## Value

Returns an object of class ssra, to be used for the seqtable function. The object is a list with following entries: 'dat' (data frame), 'call" (function call), 'args' (specification of arguments), 'time' (time of analysis), 'R' (R version), 'package' (package version), and 'restab' (result table). The 'restab' entry has following entries:

| | |
|---|---|
| j | item j |
| k | item k |
| n | sample size |
| j.mean | mean of item j |
| j.sd | standard deviation of item j |
| k.mean | mean of item k |
| k.sd | standard deviation of item k |
| r | correlation coefficient |
| r.t | test statistic of the statistical significanc test for the correlation coefficient |
| r.p | statistical significance value of the correlation |
| r.sig | statistical significance of the correlation (0 = not significant / 1 = significant) |
| r.crt | correlation criterion for judging 'sequential' or 'equal': 'r.p < alpha' and 'r > r.crt' (0 = no / 1 = yes) |
| m.diff | mean difference |
| sd.diff | standard deviation difference |
| m.diff.eff | effect size Cohen's d for dependent samples |
| m.t | test statistic of the statistical significanc test for mean difference |
| m.p | statistical significance value of the mean difference |
| m.sig | statistical significance of the mean difference (0 = not significant / 1 = significant) |

| | |
|---|---|
| m.crt.sq | mean difference criteria for judging 'sequential': 'm.diff.p < alpha', 'm.diff > mu.sq' and 'm.diff.eff > d.sq' (0 |
| m.crt.eq | mean difference criteria for judging 'equivalence': statistical significant and 'm <= mu.eq' 'd <= d.sq' (0 = no |
| seq | sequential relation of item pairs ("+","-", "") |
| eq | equivalence of item pairs ("=" or "") |
| order | order structure of item pairs ("=", "+","-") |

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

seqtable, TSSA, plot.ssra, scatterplot

## Examples

```
# Example data based on Takeya (1991)

# Sakai Sequential Relation Analysis
# ordering assesed according to the correlation coefficient and mean difference
SSRA(exdat)
```

---

# summary.seqtable *Sequential Relationship Table Summary*

---

## Description

summary function for the seqtab object

## Usage

```
## S3 method for class 'seqtable'
summary(object, exclude = TRUE, ...)
```

## Arguments

| | |
|---|---|
| object | requires the result object of seqtable function |
| exclude | exclude lower-order paths (i.e., paths included in higher order paths)? |
| ... | additional arguments affecting the summary produced |

## Details

Summary function for the seqtab object.

In this function, the number of the sequences is counted. 'Sequence' means a range of items with sequential relations. Sequences are classified in their length and are counted.

## Value

| | |
|---|---|
| `rel` | relationship: sq = sequential / eq = equal |
| `var` | variables involved in the sequential/equal paths |

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

SSRA, TSSA

## Examples

```
# Example data based on Takeya (1991)

# Sakai Sequential Relation Analysis
# ordering assesed according to the correlation coefficient and mean difference
exdat.ssra <- SSRA(exdat, output = FALSE)
exdat.seqtab<- seqtable(exdat.ssra, output = FALSE)
summary(exdat.seqtab)
```

---

# treegram *Treegram*

---

## Description

This function draws a treegram for the Takeya Semantic Structure Analysis (TSSA) and Sakai Sequential Relation Analysis (SSRA)

## Usage

```
treegram(object, select = NULL, pos = NULL, col = NULL,
  mai = c(0.2, 0, 0.2, 0.2), print.pos = TRUE, cex.text = 0.95,
  x.factor = 1.7, x.digits = 0, y.digits = 2, y.intersp = 1.45,
  cex.legend = 0.9)
```

## Arguments

| | |
|---|---|
| object | requires the result object of seqtab function |
| select | select items to be plotted |
| pos | position of items on the x-axis |
| col | color code or name for paths |
| mai | numeric vector of the form c(bottom, left, top, right) which gives the margin size specified in inches |
| print.pos | display x/y-position as legend |
| cex.text | text expansion factor relative to current par("cex") |
| x.factor | shift factor of legend position |
| x.digits | decimal places of x-position |
| y.digits | decimal places of y-position |
| y.intersp | legend character interspacing factor for vertical (y) line distances |
| cex.legend | legend character expansion factor relative to current par("cex) |

## Details

An item with lower item mean is located above, and an item with higher item mean is placed below in a treegram. An arrow is drawn between two items in sequential relation, namely, from the item with higher item mean to the item with lower item mean. And two items in equal relation are linked by a dashed line.

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at>, Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

seqtable

## Examples

```
# Example data based on Takeya (1991)

# Sakai Sequential Relation Analysis
# ordering assesed according to the correlation coefficient and mean difference
exdat.ssra <- SSRA(exdat, output = FALSE)
exdat.seqtab <- seqtable(exdat.ssra, output = FALSE)
treegram(exdat.seqtab)

# Select items to be plotted
exdat.ssra <- SSRA(exdat, output = FALSE)
exdat.seqtab <- seqtable(exdat.ssra, output = FALSE)
treegram(exdat.seqtab, select = c("Item2", "Item3", "Item4"))

# Define position for each item on the x-axis
exdat.ssra <- SSRA(exdat, output = FALSE)
exdat.seqtab <- seqtable(exdat.ssra, output = FALSE)
treegram(exdat.seqtab, pos = c(Item5 = 1, Item4 = 3,
                               Item3 = 5, Item2 = 2, Item1 = 4))

# Change colors for each path of an item
exdat.ssra <- SSRA(exdat, output = FALSE)
exdat.seqtab <- seqtable(exdat.ssra, output = FALSE)
treegram(exdat.seqtab,
         col = c(Item5 = "red3", Item4 = "blue3",
                 Item3 = "gray99", Item2 = "darkgreen", Item1 = "darkorange2"))
```

---

TSSA *Takeya Semantic Structure Analysis*

---

## Description

This function conducts Takeya Semantic Structure Analysis (TSSA) for polytomous items based on Takeya 1991.

## Usage

```
TSSA(dat, m, crit = 0.93, pairwise = TRUE, sig = FALSE, exact = TRUE, alpha = 0.05,
  p.adjust.method = c("holm", "hochberg", "hommel",
                      "bonferroni", "BH", "BY", "fdr", "none"),
  digits = 3, vnames = TRUE, order = c("no", "decreasing", "increasing"),
  exclude = TRUE, output = TRUE)
```

## Arguments

| | |
|---|---|
| dat | requires a data frame with polytomous data, all items need to have the same numbers of response categories |
| m | requires the number of item response categories |

| | |
|---|---|
| crit | criteria for ordering coefficient |
| pairwise | pairwise deletion of missing data, if pairwise = FALSE listwise deletion if applied |
| sig | if sig = TRUE, ordering will be assesed according to ordering coefficient and statistical significance |
| exact | if exact = TRUE, exact binomial test will be applied otherwise single-sample proportion test will be applied |
| alpha | significance level |
| p.adjust.method | p-value correction method for multiple comparisons, see: ?p.adjust (default = holm) |
| digits | integer indicating the number of decimal places to be used |
| vnames | use variable names for labeling? |
| order | sort by item mean of j and k? |
| exclude | exclude paths with no relationship? |
| output | print result table? |

## Details

In Takeya Semantic Structure Analysis (TSSA), a pair of items (e.g., Item1 and Item2) is judged 'sequential', if exceptional answer patterns are less than a defined criterion. If we suppose Item1 to be the item with higher item mean than Item2 (i.e., 'Item1 -> Item2' in the treegram), 'exceptional answer patter' means that somone gets a lower score on Item1 and a higher score on Item2. If this kind of sequential relation is bi-directional (i.e., not only 'Item1 -> Item2' but also 'Item2 -> Item1'), the relation of the two items is judged 'equal'.

## Value

Returns an object of class `tssa`, to be used for the `seqtable` function. The object is a list with following entries: 'dat' (data frame), 'call" (function call), 'args' (specification of arguments), 'time' (time of analysis), 'R' (R version), 'package' (package version), and 'restab' (result table). The 'restab' entry has following entries:

| | |
|---|---|
| j | item j |
| k | item k |
| n | sample size |
| j.mean | mean of item j |
| j.sd | standard devication of item j |
| k.mean | mean of item k |
| k.sd | standard devication of item k |
| c.jk | ordering coefficient j -> k |
| p.jk | p-value j -> k (available if `sig = TRUE`) |
| sig.jk | statistical significane p-value j -> k (0 = no / 1 = yes; available if sig = TRUE) |
| c.kj | ordering coefficient k -> j |
| p.kj | p-value k -> j (0 = no / 1 = yes; available if `sig = TRUE`) |
| sig.kj | statistical significane p-value k -> j (available if `sig = TRUE`) |

| | |
|---|---|
| crt.jk | ordering j -> k |
| crt.kj | ordering k -> j |
| order | order structure of item pairs ("=", "+","-") |

## Author(s)

Takuya Yanagida <takuya.yanagida@univie.ac.at> Keiko Sakai <keiko.sakai@oit.ac.jp>

## References

Takeya, M. (1991). *A new test theory: Structural analyses for educational information*. Tokyo: Waseda University Press.

## See Also

SSRA, seqtable, scatterplot

## Examples

```
# Example data based on Takeya (1991)

# Takeya Semantic Structure Analysis
# ordering assesed according to the ordering coefficient
TSSA(exdat, m = 5)

# Takeya Semantic Structure Analysis including statistical testing
# ordering assesed according to the ordering coefficient and statistical significance
TSSA(exdat, m = 5, sig = TRUE)
```

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