

# Package ‘netmeta’

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**Title** Network Meta-Analysis using Frequentist Methods

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**Suggests** colorspace, rgl, hasseDiagram (>= 0.1.3), grid

**Imports** magic, MASS

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**URL** <https://github.com/guido-s/netmeta> <http://meta-analysis-with-r.org>

**Description** A comprehensive set of functions providing frequentist methods for network meta-analysis and supporting Schwarzer et al. (2015) <DOI:10.1007/978-3-319-21416-0>, Chapter 8 “Network Meta-Analysis”:  
- frequentist network meta-analysis following Rucker (2012) <DOI:10.1002/jrsm.1058>;  
- net heat plot and design-based decomposition of Cochran's Q according to Krahn et al. (2013) <DOI:10.1186/1471-2288-13-35>;  
- measures characterizing the flow of evidence between two treatments by König et al. (2013) <DOI:10.1002/sim.6001>;  
- ranking of treatments (frequentist analogue of SUCRA) according to Rucker & Schwarzer (2015) <DOI:10.1186/s12874-015-0060-8>;  
- partial order of treatment rankings ('poset') and Hasse diagram for 'poset' (Carlsen & Bruggemann, 2014) <DOI:10.1002/cem.2569>;  
- split direct and indirect evidence to check consistency (Dias et al., 2010) <DOI:10.1002/sim.3767>;  
- league table with network meta-analysis results;  
- automated drawing of network graphs described in Rucker & Schwarzer (2016) <DOI:10.1002/jrsm.1143>.

**License** GPL (>= 2)

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netmeta-package

*netmeta: Brief overview of methods and general hints*

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## Description

R package **netmeta** provides frequentist methods for network meta-analysis and supports Schwarzer et al. (2015), Chapter 8 on network meta-analysis <http://meta-analysis-with-r.org/>.

## Details

R package **netmeta** is an add-on package for **meta** providing the following meta-analysis methods:

- frequentist network meta-analysis (function `netmeta`) based on Rücker (2012);
- net heat plot (`netheat`) and design-based decomposition of Cochran's Q (`decomp.design`) described in Krahn et al. (2013);
- measures characterizing the flow of evidence between two treatments (`netmeasures`) described in König et al. (2013);
- ranking of treatments (`netrank`) based on frequentist analogue of SUCRA (Rücker & Schwarzer, 2015);
- partial order of treatment rankings (`netposet`, `plot.netposet`) and Hasse diagram (`hasse`) according to Carlsen & Bruggemann (2014);
- split direct and indirect evidence (`netsplit`) to check for consistency (Dias et al., 2010);
- league table with network meta-analysis results (`netleague`);
- automated drawing of network graphs (`netgraph`) described in Rücker & Schwarzer (2016).

Furthermore, functions and datasets from **netmeta** are utilised in Schwarzer et al. (2015), Chapter 8 "Network Meta-Analysis", <http://meta-analysis-with-r.org/>.

Type `help(package = "netmeta")` for a listing of R functions available in **netmeta**.

Type `citation("netmeta")` on how to cite **netmeta** in publications.

To report problems and bugs

- type `bug.report(package = "netmeta")` if you do not use RStudio,
- send an email to Guido Schwarzer <[sc@imbi.uni-freiburg.de](mailto:sc@imbi.uni-freiburg.de)> if you use RStudio.

The development version of **netmeta** is available on GitHub <https://github.com/guido-s/netmeta>.

## Author(s)

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## References

- Carlsen L, Bruggemann R (2014), Partial order methodology: a valuable tool in chemometrics. *Journal of Chemometrics*, **28**, 226–34, DOI:10.1002/cem.2569 .
- Dias S, Welton NJ, Caldwell DM, Ades AE (2010). Checking consistency in mixed treatment comparison meta-analysis. *Statistics in Medicine*, **29**, 932–44.
- König J, Krahn U, Binder H (2013). Visualizing the flow of evidence in network meta-analysis and characterizing mixed treatment comparisons. *Statistics in Medicine*, **32**(30), 5414–29.
- Krahn U, Binder H, König J (2013), A graphical tool for locating inconsistency in network meta-analyses. *BMC Medical Research Methodology*, **13**, 35.
- Rücker G (2012), Network meta-analysis, electrical networks and graph theory. *Research Synthesis Methods*, **3**, 312–24.

Rücker G & Schwarzer G (2015), Ranking treatments in frequentist network meta-analysis works without resampling methods. *BMC Medical Research Methodology*, **15**, 58, DOI:10.1186/s12874-015-0060-8 .

Rücker G & Schwarzer G (2016), Automated drawing of network plots in network meta-analysis. *Research Synthesis Methods*, **7**, 94–107.

Schwarzer G, Carpenter JR and Rücker G (2015), *Meta-Analysis with R (Use-R!)*. Springer International Publishing, Switzerland. <http://www.springer.com/gp/book/9783319214153>

---

as.data.frame.netmeta *Additional functions for objects of class netmeta*

---

### Description

The `as.data.frame` method returns a data frame containing information on individual studies, e.g., estimated treatment effect and its standard error.

### Usage

```
## S3 method for class 'netmeta'  
as.data.frame(x, row.names=NULL, optional=FALSE, details=FALSE, ...)
```

### Arguments

<code>x</code>	An object of class <code>netmeta</code> .
<code>row.names</code>	NULL or a character vector giving the row names for the data frame.
<code>optional</code>	A logical. If TRUE, setting row names and converting column names (to syntactic names) is optional.
<code>details</code>	A logical. If TRUE, additional variables of less interest are included in data frame.
<code>...</code>	Additional arguments.

### Value

A data frame is returned by the function `as.data.frame`.

### Author(s)

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### See Also

[netmeta](#)

**Examples**

```

data(Senn2013)

#
# Fixed effect model (default)
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD")

as.data.frame(net1)

as.data.frame(net1, details=TRUE)

```

decomp.design

*Design-based decomposition of Cochran's Q in network meta-analysis***Description**

This function performs a design-based decomposition of Cochran's Q for assessing the homogeneity in the whole network, the homogeneity within designs, and the homogeneity/consistency between designs. It allows also an assessment of the consistency assumption after detaching the effect of single designs.

**Usage**

```
decomp.design(x, tau.preset=x$tau.preset, warn=TRUE)
```

**Arguments**

x	An object of class netmeta.
tau.preset	An optional value for the square-root of the between-study variance $\tau^2$ (see Details).
warn	A logical indicating whether warnings should be printed.

**Details**

In the context of network meta-analysis and the assessment of the homogeneity and consistency assumption, a generalized Cochran's Q statistic for multivariate meta-analysis can be used as shown in Krahn et al. (2013). This Q statistic can be decomposed in a sum of within-design Q statistics and one between-designs Q statistic that incorporates the concept of design inconsistency, see Higgins et al. (2012).

For assessing the inconsistency in a random effects model, the between-designs Q statistic can be calculated based on a full design-by-treatment interaction random effects model (see Higgins et al., 2012). This Q statistic will be automatically given in the output ( $\tau^2$  estimated by the method of moments (see Jackson et al., 2012). Alternatively, the square-root of the between-study variance can be prespecified by argument tau.preset to obtain a between-designs Q statistic (in

`Q.inc.random`), its design-specific contributions `Q.inc.design.random.preset`) as well as residuals after detaching of single designs (`residuals.inc.detach.random.preset`).

Since an inconsistent treatment effect of one design can simultaneously inflate several residuals, Krahn et al. (2013) suggest for locating the inconsistency in a network to fit a set of extended models allowing for example for a deviating effect of each study design in turn. The recalculated between-designs Q statistics are given in list component `Q.inc.detach`. The change of the inconsistency contribution of single designs can be investigated in more detail by a net heat plot (see function [netheat](#)). Designs where only one treatment is involved in other designs of the network or where the removal of corresponding studies would lead to a splitting of the network do not contribute to the inconsistency assessment. These designs are not included in `Q.inc.detach`.

## Value

A list containing the following components:

<code>Q.decomp</code>	Data frame with Q statistics (variable Q) based on the fixed effects model to assess the homogeneity/consistency in the whole network, within designs, and between designs. Corresponding degrees of freedom (df) and p-values ( <code>p.val</code> ) are also given.
<code>Q.het.design</code>	Data frame with design-specific decomposition of the within-designs Q statistic (Q) of the fixed effects model, corresponding degrees of freedom (df) and p-values ( <code>p.val</code> ) are given.
<code>Q.inc.detach</code>	Data frame with between-designs Q statistics (Q) of the fixed effects model after detaching of single designs, corresponding degrees of freedom (df) and p-values ( <code>p.val</code> ) are given.
<code>Q.inc.design</code>	A named vector with contributions of single designs to the between design Q statistic given in <code>Q.decomp</code> .
<code>Q.inc.random</code>	Data frame with between-designs Q statistic (Q) based on a random effects model with square-root of between-study variance <code>tau.within</code> estimated embedded in a full design-by-treatment interaction model, corresponding degrees of freedom (df) and p-value ( <code>p.val</code> ).
<code>Q.inc.random.preset</code>	Data frame with between-designs Q statistic (Q) based on a random effects model with prespecified square-root of between-study variance <code>tau.preset</code> in the case if argument <code>tau.preset</code> is not NULL, corresponding degrees of freedom (df) and p-value ( <code>p.val</code> ).
<code>Q.inc.design.random.preset</code>	A named vector with contributions of single designs to the between design Q statistic based on a random effects model with prespecified square-root of between-study variance <code>tau.preset</code> in the case if argument <code>tau.preset</code> is given.
<code>residuals.inc.detach</code>	Matrix with residuals, i.e. design-specific direct estimates minus the corresponding network estimates after detaching the design of the column.
<code>residuals.inc.detach.random.preset</code>	Matrix with residuals analogous to <code>residuals.inc.detach</code> but based on a random effects model with prespecified square-root of between-study variance <code>tau.preset</code> in the case if argument <code>tau.preset</code> is not NULL.

call            Function call.  
version        Version of R package netmeta used to create object.

**Author(s)**

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**References**

Higgins JPT, Jackson D, Barrett JK, Lu G, Ades AE, White IR (2012), Consistency and inconsistency in network meta-analysis: concepts and models for multi-arm studies. *Research Synthesis Methods*, **3**(2), 98–110.

Krahn U, Binder H, König J (2013), A graphical tool for locating inconsistency in network meta-analyses. *BMC Medical Research Methodology*, **13**, 35.

Jackson D, White IR and Riley RD (2012), Quantifying the impact of between-study heterogeneity in multivariate meta-analyses. *Statistics in Medicine*, **31**(29), 3805–3820.

**See Also**

[netmeta](#), [netheat](#)

**Examples**

```
data(Senn2013)

#
# Generation of an object of class 'netmeta' with
# reference treatment 'plac', i.e. placebo
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD", reference="plac")

#
# Decomposition of Cochran's Q
#
decomp.design(net1)
```

---

dietaryfat

*Network meta-analysis of dietary fat*

---

**Description**

Network meta-analysis comparing the effects of two diets to control on mortality.

The data are rates, given as the number of deaths and person-years. These data are used as an example in the supplemental material of Dias S, Sutton AJ, Ades AE and Welton NJ (2013).

**Usage**

```
data(dietaryfat)
```

**Format**

A data frame with the following columns:

**treat1** Treatment 1

**treat2** Treatment 2

**treat3** Treatment 3

**years1** Person years arm 1

**years2** Person years arm 2

**years3** Person years arm 3

**d1** events (deaths) arm 1

**d2** events (deaths) arm 2

**d3** events (deaths) arm 3

**ID** Study ID

**Source**

Dias S, Sutton AJ, Ades AE and Welton NJ (2013). Evidence synthesis for decision making 2: A generalized linear modeling framework for pairwise and network meta-analysis of randomized controlled trials. *Medical Decision Making* **33**, 607–617.

**See Also**

[pairwise](#), [metainc](#), [netmeta](#), [netgraph](#)

**Examples**

```
data(dietaryfat)

# Transform data from arm-based format to contrast-based format
# Using incidence rate ratios (sm="IRR") as effect measure.
# Note, the argument 'sm' is not necessary as this is the default
# in R function metainc called internally
p1 <- pairwise(list(treat1, treat2, treat3),
               list(d1, d2, d3),
               time=list(years1, years2, years3),
               studlab=ID,
               data=dietaryfat, sm="IRR")

p1

# Conduct network meta-analysis:
net1 <- netmeta(p1)
summary(net1)

# Conduct network meta-analysis using incidence rate differences
```



```
# (sm="IRD").
p2 <- pairwise(list(treat1, treat2, treat3),
               list(d1, d2, d3),
               time=list(years1, years2, years3),
               studlab=ID,
               data=dietaryfat, sm="IRD")
net2 <- netmeta(p2)
summary(net2)

# Draw network graph
netgraph(net1, points=TRUE, cex.points=3, cex=1.25)
tname <- c("Control", "Diet", "Diet 2")
netgraph(net1, points=TRUE, cex.points=3, cex=1.25, labels=tname)
```

---

forest.netmeta	<i>Forest plot</i>
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---

## Description

Draws a forest plot in the active graphics window (using grid graphics system).

## Usage

```
## S3 method for class 'netmeta'
forest(x,
       pooled=ifelse(x$comb.random, "random", "fixed"),
       reference.group=x$reference.group,
       baseline.reference=x$baseline.reference,
       leftcols="studlab", leftlabs="Treatment",
       rightcols=c("effect", "ci"), rightlabs=NULL,
       digits=gs("digits.forest"), small.values="good", digits.Pscore=2,
       smlab=NULL,
       sortvar=x$seq, lab.NA=".", add.data,
       drop.reference.group = FALSE,
       ...)
```

## Arguments

x	An object of class netmeta.
reference.group	Reference group.
baseline.reference	A logical indicating whether results should be expressed as comparisons of other treatments versus the reference treatment (default) or vice versa.
pooled	A character string indicating whether results for the fixed effect ("fixed") or random effects model ("random") should be plotted. Can be abbreviated.
leftcols	A character vector specifying (additional) columns to be plotted on the left side of the forest plot or a logical value (see <a href="#">forest.meta</a> help page for details).

<code>leftlabs</code>	A character vector specifying labels for (additional) columns on left side of the forest plot (see <a href="#">forest.meta</a> help page for details).
<code>rightcols</code>	A character vector specifying (additional) columns to be plotted on the right side of the forest plot or a logical value (see <a href="#">forest.meta</a> help page for details).
<code>rightlabs</code>	A character vector specifying labels for (additional) columns on right side of the forest plot (see <a href="#">forest.meta</a> help page for details).
<code>digits</code>	Minimal number of significant digits for treatment effects and confidence intervals, see <code>print.default</code> .
<code>small.values</code>	A character string specifying whether small treatment effects indicate a beneficial ("good") or harmful ("bad") effect, can be abbreviated; see <a href="#">netrank</a> .
<code>digits.Pscore</code>	Minimal number of significant digits for P-score, see <a href="#">print.default</a> and <a href="#">netrank</a> .
<code>smlab</code>	A label printed at top of figure. By default, text indicating either fixed effect or random effects model is printed.
<code>sortvar</code>	An optional vector used to sort the individual studies (must be of same length as the total number of treatments).
<code>lab.NA</code>	A character string to label missing values.
<code>add.data</code>	An optional data frame with additional columns to print in forest plot (see Details).
<code>drop.reference.group</code>	A logical indicating whether the reference group should be printed in the forest plot.
<code>...</code>	Additional arguments for <a href="#">forest.meta</a> function.

## Details

A forest plot, also called confidence interval plot, is drawn in the active graphics window.

Argument `sortvar` can be either a numeric or character vector with length of number of treatments. If `sortvar` is numeric the [order](#) function is utilised internally to determine the order of values. If `sortvar` is character it must be a permutation of the treatment names. It is also possible to provide either `sortvar=Pscore`, `sortvar="Pscore"`, `sortvar=-Pscore` or `sortvar="-Pscore"` in order to sort treatments according to the ranking generated by [netrank](#) which is called internally. Similar expressions are possible to sort by treatment comparisons (`sortvar=TE`, etc.), standard error (`sortvar=seTE`), number of studies with direct treatment comparisons (`sortvar=k`), and direct evidence proportion (`sortvar=prop.direct`, see also [netmeasures](#)).

Argument `add.data` can be used to add additional columns to the forest plot. This argument must be a data frame with the same row names as the treatment effects matrices in R object `x`, i.e., `x$TE.fixed` or `x$TE.random`.

For more information see help page of [forest.meta](#) function.

## Author(s)

Guido Schwarzer <[sc@imbi.uni-freiburg.de](mailto:sc@imbi.uni-freiburg.de)>

## See Also

[forest.meta](#)

**Examples**

```
data(Senn2013)

## Not run:
#
# Fixed effect model (default)
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD")

forest(net1, ref="plac")

forest(net1, xlim=c(-1.5,1), ref="plac",
       xlab="HbA1c difference", rightcols=FALSE)

## End(Not run)

#
# Random effects effect model
#
net2 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD", comb.random=TRUE)

forest(net2, xlim=c(-1.5,1), ref="plac",
       xlab="HbA1c difference")

#
# Add column with P-Scores on right side of forest plot
#
forest(net2, xlim=c(-1.5,1), ref="plac",
       xlab="HbA1c difference",
       rightcols=c("effect", "ci", "Pscore"),
       rightlabs="P-Score",
       just.addcols="right")

## Not run:
#
# Add column with P-Scores on left side of forest plot
#
forest(net2, xlim=c(-1.5,1), ref="plac",
       xlab="HbA1c difference",
       leftcols=c("studlab", "Pscore"),
       leftlabs=c("Treatment", "P-Score"),
       just.addcols="right")

#
# Sort forest plot by descending P-Score
#
forest(net2, xlim=c(-1.5,1), ref="plac",
       xlab="HbA1c difference",
       rightcols=c("effect", "ci", "Pscore"),
       rightlabs="P-Score",
```

```

      just.addcols="right",
      sortvar=-Pscore)

#
# Drop reference group and sort by and print number of studies
# with direct treatment comparisons
#
forest(net2, xlim=c(-1.5,1), ref="plac",
       xlab="HbA1c difference",
       leftcols=c("studlab", "k"),
       leftlabs=c("Contrast\nto Placebo", "Direct\nComparisons"),
       sortvar=-k,
       drop=TRUE,
       smlab="Random Effects Model")

## End(Not run)

```

---

hasse

*Hasse diagram*


---

## Description

This function generates a Hasse diagram for a partial order of treatment ranks in a network meta-analysis.

## Usage

```

hasse(x,
      pooled=ifelse(x$comb.random, "random", "fixed"),
      newpage = TRUE)

```

## Arguments

x	An object of class <code>netposet</code> (mandatory).
pooled	A character string indicating whether Hasse diagram show be drawn for fixed effect ("fixed") or random effects model ("random"). Can be abbreviated.
newpage	A logical value indicating whether a new figure should be printed in an existing graphics window. Otherwise, the Hasse diagram is added to the existing figure.

## Details

Generate a Hasse diagram for a partial order of treatment ranks in a network meta-analysis (Carlsen and Bruggemann, 2014).

This R function is a wrapper function for R function `hasse` in R package **hasseDiagram** (Krzysztof Ciomek, <https://github.com/kciomek/hasseDiagram>), i.e., function `hasse` can only be used if R package **hasseDiagram** is installed.

**Author(s)**

Gerta Rücker <ruecker@imbi.uni-freiburg.de>, Guido Schwarzer <sc@imbi.uni-freiburg.de>

**References**

Carlsen L, Bruggemann R (2014), Partial order methodology: a valuable tool in chemometrics. *Journal of Chemometrics*, **28** 226–34, DOI:10.1002/cem.2569

**See Also**

[netmeta](#), [netposet](#)

**Examples**

```
# Use depression dataset
#
data(Linde2015)
#
# Define order of treatments
#
trts <- c("TCA", "SSRI", "SNRI", "NRI",
         "Low-dose SARI", "NaSSa", "rMAO-A", "Hypericum",
         "Placebo")
#
# Outcome labels
#
outcomes <- c("Early response", "Early remission")
#
# (1) Early response
#
p1 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(resp1, resp2, resp3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")
#
net1 <- netmeta(p1,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")
#
# (2) Early remission
#
p2 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(remi1, remi2, remi3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")
#
net2 <- netmeta(p2,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")
#
# Partial order of treatment rankings (all five outcomes)
#
```

```

po <- netposet(netrank(net1, small.values = "bad"),
              netrank(net2, small.values = "bad"),
              outcomes = outcomes)

#
# Hasse diagram
#
hasse(po)

```

---

Linde2015

*Network meta-analysis of treatments for depression*


---

### Description

Network meta-analysis of nine classes of antidepressants including placebo for the primary care setting; partly shown in Linde et al. (2015), supplementary Table 2.

### Usage

```
data(Linde2015)
```

### Format

A data frame with the following columns:

**id** Study ID

**author** First author

**year** Publication year

**treatment1** First treatment

**treatment2** Second treatment

**treatment3** Third treatment

**n1** Number of patients receiving first treatment

**resp1** Number of early responder (treatment 1)

**remi1** Number of early remissions (treatment 1)

**loss1** Number of patients loss to follow-up (treatment 1)

**loss.ae1** Number of patients loss to follow-up due to adverse events (treatment 1)

**ae1** Number of patients with adverse events (treatment 1)

**n2** Number of patients receiving second treatment

**resp2** Number of early responder (treatment 2)

**remi2** Number of early remissions (treatment 2)

**loss2** Number of patients loss to follow-up (treatment 2)

**loss.ae2** Number of patients loss to follow-up due to adverse events (treatment 2)

**ae2** Number of patients with adverse events (treatment 2)

**n3** Number of patients receiving third treatment  
**resp3** Number of early responder (treatment 3)  
**remi3** Number of early remissions (treatment 3)  
**loss3** Number of patients loss to follow-up (treatment 3)  
**loss.ae3** Number of patients loss to follow-up due to adverse events (treatment 3)  
**ae3** Number of patients with adverse events (treatment 3)

### Source

Linde K, Kriston L, Rucker G, et al. (2015). Efficacy and acceptability of pharmacological treatments for depressive disorders in primary care: Systematic review and network meta-analysis. *Annals of Family Medicine* **13**, 69–79.

### See Also

[pairwise](#), [metabin](#), [netmeta](#), [netposet](#)

### Examples

```
data(Linde2015)

# Transform data from arm-based format to contrast-based format
# Outcome: early response
p1 <- pairwise(list(treatment1, treatment2, treatment3),
               event = list(resp1, resp2, resp3),
               n = list(n1, n2, n3),
               studlab = id, data = Linde2015, sm = "OR")

# Define order of treatments
trts <- c("TCA", "SSRI", "SNRI", "NRI",
          "Low-dose SARI", "NaSSa", "rMAO-A", "Hypericum",
          "Placebo")

# Conduct network meta-analysis
net1 <- netmeta(p1, comb.fixed = FALSE, comb.random = TRUE,
               reference = "Placebo",
               seq = trts)
print(summary(net1), digits = 2)
```

**Description**

To determine the network structure and to test whether a given network is fully connected. Network information is provided as a triple of vectors `treat1`, `treat2`, and `studlab` where each row corresponds to an existing pairwise treatment comparison (`treat1`, `treat2`) in a study (`studlab`). The function calculates the number of subnetworks (connectivity components; value of 1 corresponds to a fully connected network) and the distance matrix (in block-diagonal form in the case of subnetworks).

**Usage**

```
netconnection(treat1, treat2, studlab, data = NULL, subset = NULL,
             title = "", warn = FALSE)
```

```
## S3 method for class 'netconnection'
print(x, digits = max(4, .Options$digits - 3), ...)
```

**Arguments**

<code>treat1</code>	Label/Number for first treatment.
<code>treat2</code>	Label/Number for second treatment.
<code>studlab</code>	An optional - but important! - vector with study labels (see Details).
<code>data</code>	An optional data frame containing the study information.
<code>subset</code>	An optional vector specifying a subset of studies to be used.
<code>title</code>	Title of meta-analysis / systematic review.
<code>warn</code>	A logical indicating whether warnings should be printed.
<code>x</code>	An object of class <code>netconnection</code> .
<code>digits</code>	Minimal number of significant digits, see <a href="#">print.default</a> .
<code>...</code>	Additional arguments (ignored at the moment)

**Value**

An object of class `netconnection` with corresponding `print` function. The object is a list containing the following components:

<code>treat1</code> , <code>treat2</code> , <code>studlab</code> , <code>title</code> , <code>warn</code>	As defined above.
<code>k</code>	Total number of studies.
<code>m</code>	Total number of pairwise comparisons.
<code>n</code>	Total number of treatments.
<code>n.subnets</code>	Number of subnetworks; equal to 1 for a fully connected network.
<code>D.matrix</code>	Distance matrix.
<code>A.matrix</code>	Adjacency matrix.
<code>L.matrix</code>	Laplace matrix.
<code>call</code>	Function call.
<code>version</code>	Version of R package <code>netmeta</code> used to create object.



**Author(s)**

Gerta Rücker <ruecker@imbi.uni-freiburg.de>, Guido Schwarzer <sc@imbi.uni-freiburg.de>

**See Also**

[netmeta](#), [netdistance](#)

**Examples**

```
data(Senn2013)

nc1 <- netconnection(treat1, treat2, studlab, data = Senn2013)
nc1

# Extract number of (sub)networks
nc1$n.subnets

# Extract distance matrix
nc1$D.matrix

# Conduct network meta-analysis (results not shown)
net1 <- netmeta(TE, seTE, treat1, treat2, studlab, data = Senn2013)

#
# Artificial example with two subnetworks
#
t1 <- c("G", "B", "B", "D", "A", "F")
t2 <- c("B", "C", "E", "E", "H", "A")
#
nc2 <- netconnection(t1, t2)
nc2

# Number of subnetworks
nc2$n.subnets

# Extract distance matrix
nc2$D.matrix

# Conduct network meta-analysis
# (results in an error message due to unconnected network)
try(net2 <- netmeta(1:6, 1:6, t1, t2, 1:6))

# Conduct network meta-analysis on first subnetwork
net2.1 <- netmeta(1:6, 1:6, t1, t2, 1:6,
                 subset = (t1 %in% c("A", "F", "H") & t2 %in% c("A", "F", "H")))

# Conduct network meta-analysis on first subnetwork
net2.2 <- netmeta(1:6, 1:6, t1, t2, 1:6,
                 subset = !(t1 %in% c("A", "F", "H") & t2 %in% c("A", "F", "H")))

summary(net2.1)
```

```
summary(net2.2)
```

---

netdistance

*Calculate distance matrix for an adjacency matrix*

---

### Description

Calculate distance matrix for an adjacency matrix based on distance algorithm by Müller et al. (1987).

### Usage

```
netdistance(x)
```

### Arguments

x                    Either a netmeta object or an adjacency matrix.

### Author(s)

Gerta Rücker <ruecker@imbi.uni-freiburg.de>

### References

Müller WR, Szymanski K, Knop JV, and Trinajstić N (1987). An algorithm for construction of the molecular distance matrix. *Journal of Computational Chemistry*, **8**, 170–173.

### See Also

[netmeta](#), [netconnection](#)

### Examples

```
data(Senn2013)

net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data = Senn2013, sm = "MD")

netdistance(net1)
netdistance(net1$A.matrix)
```

---

netgraph	<i>Network graph</i>
----------	----------------------

---

### Description

This function generates a graph of the evidence network.

### Usage

```
netgraph(x, seq = x$seq,
         labels = rownames(x$TE.fixed),
         cex = 1, col = "slateblue", offset = 0.0175, scale = 1.10,
         plastic, thickness, lwd = 5, lwd.min = lwd/2.5, lwd.max = lwd*4,
         dim = "2d",
         highlight = NULL, col.highlight = "red2", lwd.highlight = lwd,
         multiarm = any(x$narms > 2), col.multiarm = NULL,
         alpha.transparency = 0.5,
         points = FALSE, col.points = "red", cex.points = 1, pch.points = 20,
         number.of.studies = FALSE,
         cex.number.of.studies = cex,
         col.number.of.studies = "white",
         bg.number.of.studies = "black",
         start.layout = ifelse(dim == "2d", "circle", "eigen"),
         eig1 = 2, eig2 = 3, eig3 = 4,
         iterate, tol = 0.0001, maxit = 500, allfigures = FALSE,
         A.matrix = x$A.matrix, N.matrix = sign(A.matrix),
         D.matrix = netdistance(N.matrix),
         xpos = NULL, ypos = NULL, zpos = NULL,
         ...)
```

### Arguments

x	An object of class netmeta (mandatory).
seq	A character or numerical vector specifying the sequence of treatments arrangement (anticlockwise if start.layout = "circle").
labels	An optional vector with treatment labels.
cex	The magnification to be used for treatment labels.
col	Color of lines connecting treatments if argument plastic = FALSE.
offset	Distance between edges (i.e. treatments) in graph and treatment labels (value of 0.0175 corresponds to a difference of 1.75% of the range on x- and y-axis).
scale	Additional space added outside of edges (i.e. treatments). Increase this value for larger treatment labels (value of 1.10 corresponds to an additional space of 10% around the network graph).
plastic	A logical indicating whether the appearance of the comparisons should be in '3D look' (not to be confused with argument dim).

thickness	Either a character variable to determine the method to plot line widths (see Details) or a matrix of the same dimension and row and column names as argument <code>A.matrix</code> with information on line width.
lwd	A numeric for scaling the line width of comparisons.
lwd.max	Maximum line width in network graph. The connection with the largest value according to argument <code>thickness</code> will be set to this value.
lwd.min	Minimum line width in network graph. All connections with line widths below this values will be set to <code>lwd.min</code> .
dim	A character string indicating whether a 2- or 3-dimensional plot should be produced, either "2d" or "3d".
highlight	A character vector identifying comparisons that should be marked in the network graph, e.g. <code>highlight = "treat1:treat2"</code> .
col.highlight	Color for highlighting the comparisons given by <code>highlight</code> .
lwd.highlight	A numeric for the line width for highlighting the comparisons given by <code>highlight</code> .
multiarm	A logical indicating whether multi-arm studies should be marked in plot.
col.multiarm	Either a function from R library <code>colorspace</code> or <code>grDevice</code> to define colors for multi-arm studies or a character vector with colors to highlight multi-arm studies.
alpha.transparency	The alpha transparency of colors used to highlight multi-arm studies (0 means transparent and 1 means opaque).
points	A logical indicating whether points should be printed at nodes (i.e. treatments) of the network graph.
col.points, cex.points, pch.points	Corresponding color, size, type for points.
number.of.studies	A logical indicating whether number of studies should be added to network graph.
cex.number.of.studies	The magnification to be used for number of studies.
col.number.of.studies	Color for number of studies.
bg.number.of.studies	Color for shadow around number of studies.
start.layout	A character string indicating which starting layout is used if <code>iterate = TRUE</code> . If "circle" (default), the iteration starts with a circular ordering of the vertices; if "eigen", eigenvectors of the Laplacian matrix are used, calculated via generic function <code>eigen</code> (spectral decomposition); if "prcomp", eigenvectors of the Laplacian matrix are calculated via generic function <code>prcomp</code> (principal component analysis); if "random", a random layout is used, drawn from a bivariate normal.
eig1	A numeric indicating which eigenvector is used as x coordinate if <code>start = "eigen"</code> or "prcomp" and <code>iterate = TRUE</code> . Default is 2, the eigenvector to the second-smallest eigenvalue of the Laplacian matrix.

eig2	A numeric indicating which eigenvector is used as y-coordinate if <code>start = "eigen"</code> or <code>"prcomp"</code> and <code>iterate = TRUE</code> . Default is 3, the eigenvector to the third-smallest eigenvalue of the Laplacian matrix.
eig3	A numeric indicating which eigenvector is used as z-coordinate if <code>start = "eigen"</code> or <code>"prcomp"</code> and <code>iterate = TRUE</code> . Default is 4, the eigenvector to the fourth-smallest eigenvalue of the Laplacian matrix.
iterate	A logical indicating whether the stress majorization algorithm is carried out for optimization of the layout.
tol	A numeric for the tolerance for convergence if <code>iterate = TRUE</code> .
maxit	An integer defining the maximum number of iteration steps if <code>iterate = TRUE</code> .
allfigures	A logical indicating whether all iteration steps are shown if <code>iterate = TRUE</code> . May slow down calculations if set to <code>TRUE</code> (especially if <code>plastic = TRUE</code> ).
A.matrix	Adjacency matrix ( $nxn$ ) characterizing the structure of the network graph. Row and column names must be the same set of values as provided by argument <code>seq</code> .
N.matrix	Neighborhood matrix ( $nxn$ ) replacing A.matrix if <code>neighborhood</code> is to be specified differently from node adjacency in the network graph, for example content-based. Row and column names must be the same set of values as provided by argument <code>seq</code> .
D.matrix	Distance matrix ( $nxn$ ) replacing A.matrix and N.matrix if distances should be provided directly. Row and column names must be the same set of values as provided by argument <code>seq</code> .
xpos	Vector ( $n$ ) of x coordinates.
ypos	Vector ( $n$ ) of y coordinates.
zpos	Vector ( $n$ ) of z coordinates.
...	Additional graphical arguments.

## Details

The network is laid out in the plane, where the nodes in the graph layout correspond to the treatments and edges display the observed treatment comparisons. For the default setting, nodes are placed on a circle. Other starting layouts are "eigen", "prcomp", and "random" (Rücker & Schwarzer 2015). If `iterate = TRUE`, the layout is further optimized using the stress majorization algorithm. This algorithm specifies an 'ideal' distance (e.g., the graph distance) between two nodes in the plane. In the optimal layout, these distances are best approximated in the sense of least squares. Starting from an initial layout, the optimum is approximated in an iterative process called stress majorization (Kamada and Kawai 1989, Michailidis and de Leeuw 2001, Hu 2012). The starting layout can be chosen as a circle or coming from eigenvectors of the Laplacian matrix (corresponding to Hall's algorithm, Hall 1970), calculated in different ways, or random. Moreover, it can be chosen whether the iteration steps are shown (argument `allfigures = TRUE`).

Argument `thickness` providing the line width of the nodes (comparisons) can be a matrix of the same dimension as argument `A.matrix` or any of the following character variables:

- Same line width (argument `lwd`) for all comparisons (`thickness = "equal"`)
- Proportional to number of studies comparing two treatments (`thickness = "number.of.studies"`)
- Proportional to inverse standard error of fixed effect model comparing two treatments (`thickness = "se.fixed"`)

- Proportional to inverse standard error of random effects model comparing two treatments (thickness = "se.random")
- Weight from fixed effect model comparing two treatments (thickness = "w.fixed")
- Weight from random effects model comparing two treatments (thickness = "w.random")

Only evidence from direct treatment comparisons is considered to determine the line width if argument thickness is equal to any but the first method. By default, thickness = "se.fixed" is used if start.layout = "circle", iterate = FALSE, and plastic = TRUE. Otherwise, the same line width is used.

Further, a couple of graphical parameters can be specified, such as color and appearance of the edges (treatments) and the nodes (comparisons), whether special comparisons should be highlighted and whether multi-arm studies should be indicated as colored polygons. By default, if R package colospace is available the `sequential_hcl` function is used to highlight multi-arm studies; otherwise the `rainbow` is used.

In order to generate 3-D plots (argument dim = "3d"), R package `rgl` is necessary. Note, under macOS the X.Org X Window System must be available (see <https://www.xquartz.org>).

### Author(s)

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### References

- Hall, K.M. (1970). An r-dimensional quadratic placement algorithm. *Management Science*, **17**, 219–229.
- Hu, Y. (2012). *Combinatorial Scientific Computing*, Chapter Algorithms for Visualizing Large Networks, pages 525–549. Chapman and Hall/CRC Computational Science.
- Kamada, T. and Kawai, S. (1989). An algorithm for drawing general undirected graphs. *Information Processing Letters*, **31**(1), 7–15.
- Krahn U, Binder H, König J (2013), A graphical tool for locating inconsistency in network meta-analyses. *BMC Medical Research Methodology*, **13**, 35.
- Michailidis, G. and de Leeuw, J. (2001). Data visualization through graph drawing. *Computational Statistics*, **16**(3), 435–450.
- Rücker G & Schwarzer G (2016), Automated drawing of network plots in network meta-analysis. *Research Synthesis Methods*, **7**, 94–107.

### See Also

[netmeta](#)

### Examples

```
data(Senn2013)

# Generation of an object of class 'netmeta' with reference treatment 'plac'
#
```

```
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data = Senn2013, sm = "MD", reference = "plac")

# Network graph with default settings
#
netgraph(net1)

# Network graph with specified order of the treatments and one
# highlighted comparison
#
trts <- c("plac", "benf", "mig1", "acar", "sulf",
          "metf", "rosi", "piog", "sita", "vild")
netgraph(net1, highlight = "rosi:plac", seq = trts)

# Same network graph using argument 'seq' in netmeta function
#
net2 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data = Senn2013, sm = "MD", reference = "plac",
               seq = trts)
netgraph(net2, highlight = "rosi:plac")

# Network graph optimized, starting from a circle, with multi-arm
# study colored
#
netgraph(net1, start = "circle", iterate = TRUE, col.multiarm = "purple")

# Network graph optimized, starting from a circle, with multi-arm
# study colored and all intermediate iteration steps visible
#
## Not run: netgraph(net1, start = "circle", iterate = TRUE, col.multiarm = "purple",
##               allfigures = TRUE)
## End(Not run)

# Network graph optimized, starting from Laplacian eigenvectors, with
# multi-arm study colored
#
netgraph(net1, start = "eigen", col.multiarm = "purple")

# Network graph optimized, starting from different Laplacian
# eigenvectors, with multi-arm study colored
#
netgraph(net1, start = "prcomp", col.multiarm = "purple")

# Network graph optimized, starting from random initial layout, with
# multi-arm study colored
#
netgraph(net1, start = "random", col.multiarm = "purple")

# Network graph without plastic look and one highlighted comparison
#
netgraph(net1, plastic = FALSE, highlight = "rosi:plac")

# Network graph without plastic look and comparisons with same
```

```

# thickness
netgraph(net1, plastic = FALSE, thickness = FALSE)

# Network graph with changed labels and specified order of the
# treatments
#
netgraph(net1, seq = c(1, 3, 5, 2, 9, 4, 7, 6, 8, 10),
         labels = LETTERS[1:10])

## Not run:
# Network graph in 3-D (opens a new device, where you may rotate and
# zoom the plot using the mouse / the mouse wheel).
# The rgl package must be installed for 3-D plots.
#
netgraph(net1, dim = "3d")

## End(Not run)

```

---

netheat

*Net heat plot*


---

## Description

This function creates a net heat plot, a graphical tool for locating inconsistency in network meta-analyses.

## Usage

```
netheat(x, random=FALSE, tau.preset=NULL, showall=FALSE, ...)
```

## Arguments

x	An object of class netmeta.
random	A logical indicating whether the net heat plot should be based on a random effects model.
tau.preset	An optional value for the square-root of the between-study variance $\tau^2$ for a random effects model on which the net heat plot will be based.
showall	A logical indicating whether results should be shown for all designs or only a sensible subset, see Details.
...	Additional arguments.

## Details

The net heat plot is a matrix visualization proposed by Krahn et al. (2013) that highlights hot spots of inconsistency between specific direct evidence in the whole network and renders transparent possible drivers.

In this plot, the area of a gray square displays the contribution of the direct estimate of one design in the column to a network estimate in a row. In combination, the colors show the detailed change



in inconsistency when relaxing the assumption of consistency for the effects of single designs. The colors on the diagonal represent the inconsistency contribution of the corresponding design. The colors on the off-diagonal are associated with the change in inconsistency between direct and indirect evidence in a network estimate in the row after relaxing the consistency assumption for the effect of one design in the column. Cool colors indicate an increase and warm colors a decrease: the stronger the intensity of the color, the greater the difference between the inconsistency before and after the detachment. So, a blue colored element indicates that the evidence of the design in the column supports the evidence in the row. A clustering procedure is applied to the heat matrix in order to find warm colored hot spots of inconsistency. In the case that the colors of a column corresponding to design  $d$  are identical to the colors on the diagonal, the detaching of the effect of design  $d$  dissolves the total inconsistency in the network.

The pairwise contrasts corresponding to designs of three- or multi-arm studies are marked by ' \_ ' following the treatments of the design.

By default (`showall=FALSE`), designs where only one treatment is involved in other designs of the network or where the removal of corresponding studies would lead to a splitting of the network do not contribute to the inconsistency assessment and are not incorporated into the net heat plot.

In the case of `random=TRUE`, the net heat plot is based on a random effects model generalised for multivariate meta-analysis in which the between-study variance  $\tau^2$  is estimated by the method of moments (see Jackson et al., 2012) and embedded in a full design-by-treatment interaction model (see Higgins et al., 2012).

### Author(s)

Ulrike Krahn <ulrike.krahn@bayer.com>

### References

Krahn U, Binder H, König J (2013), A graphical tool for locating inconsistency in network meta-analyses. *BMC Medical Research Methodology*, **13**, 35.

Jackson D, White IR and Riley RD (2012), Quantifying the impact of between-study heterogeneity in multivariate meta-analyses. *Statistics in Medicine*, **31**(29), 3805–3820.

Higgins JPT, Jackson D, Barrett JK, Lu G, Ades AE, White IR (2012), Consistency and inconsistency in network meta-analysis: concepts and models for multi-arm studies. *Research Synthesis Methods*, **3**, 98–110.

### See Also

[netmeta](#)

### Examples

```
data(Senn2013)

#
# Generation of an object of class 'netmeta' with
# reference treatment 'plac', i.e. placebo
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
```

```

data=Senn2013, sm="MD", reference="plac")

#
# Generate a net heat plot based on a fixed effects model
#
netheat(net1)

#
# Generate a net heat plot based on a random effects model
#
netheat(net1, random=TRUE)

```

---

netleague

---

*Print league table for network meta-analysis results*


---

## Description

A league table is a square matrix showing all pairwise comparisons in a network meta-analysis. Typically, both treatment estimates and confidence intervals are shown.

## Usage

```

netleague(x, y,
          comb.fixed = x$comb.fixed, comb.random = x$comb.random,
          seq = x$seq, ci = TRUE, backtransf = TRUE,
          digits = gs("digits"))

```

## Arguments

x	An object of class netmeta (mandatory).
y	An object of class netmeta (optional).
comb.fixed	A logical indicating whether a league table for fixed effect meta-analyses should be printed.
comb.random	A logical indicating whether a league table for random effects meta-analyses should be printed.
seq	A character or numerical vector specifying the sequence of treatments in rows and columns of a league table.
ci	A logical indicating whether confidence intervals should be shown.
backtransf	A logical indicating whether printed results should be back transformed. If backtransf=TRUE, results for sm="OR" are printed as odds ratios rather than log odds ratios, for example.
digits	Minimal number of significant digits, see print.default.

## Details

If argument `y` is not provided, the league table contains the same information in the lower and upper triangle, i.e., treatment comparisons and confidence intervals for network meta-analysis object `x`.

If argument `y` is provided, the league table contains information on treatment comparisons from network meta-analysis object `x` in the lower triangle and from network meta-analysis object `y` in the upper triangle.

R function [netrank](#) can be used to change the order of rows and columns in the league table (see examples).

## Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>, Gerta Rücker <ruecker@imbi.uni-freiburg.de>

## See Also

[netmeta](#), [netposet](#), [netrank](#)

## Examples

```
# Network meta-analysis of count mortality statistics
#
data(Woods2010)

p0 <- pairwise(treatment, event = r, n = N,
               studlab = author, data = Woods2010, sm = "OR")
net0 <- netmeta(p0)

cilayout(bracket = "(", separator = " - ")
oldopts <- options(width = 100)

# League table for fixed effect model
#
netleague(net0, digits = 2)

# League table for fixed effect and random effects model
#
netleague(net0, comb.random = TRUE, digits = 2)

# Change order of treatments according to treatment ranking
#
netleague(net0, comb.random = TRUE, digits = 2,
          seq = netrank(net0))
#
print(netrank(net0), comb.random = TRUE)

# Use depression dataset
#
data(Linde2015)
cilayout()
#
```

```

# Define order of treatments
#
trts <- c("TCA", "SSRI", "SNRI", "NRI",
          "Low-dose SARI", "NaSSa", "rMAO-A", "Hypericum",
          "Placebo")
#
# Outcome labels
#
outcomes <- c("Early response", "Early remission")
#
# (1) Early response
#
p1 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(resp1, resp2, resp3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")
#
net1 <- netmeta(p1,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")
#
# (2) Early remission
#
p2 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(remi1, remi2, remi3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")
#
net2 <- netmeta(p2,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")

options(width = 200)
netleague(net1, digits = 2)

netleague(net1, digits = 2, ci = FALSE)
netleague(net2, digits = 2, ci = FALSE)
netleague(net1, net2, digits = 2, ci = FALSE)

netleague(net1, net2, seq = netrank(net1, small = "bad"), ci = FALSE)
netleague(net1, net2, seq = netrank(net2, small = "bad"), ci = FALSE)

print(netrank(net1, small = "bad"), comb.random = TRUE)
print(netrank(net2, small = "bad"), comb.random = TRUE)

options(oldopts)

## Not run:
# Generate a partial order of treatment rankings
#
np <- netposet(net1, net2, outcomes = outcomes, small.values = rep("bad",2))
hasse(np)

```

```
plot(np)

## End(Not run)
```

---

netmeasures

*Measures for characterizing a network meta-analysis*


---

## Description

This function provides measures for quantifying the direct evidence proportion, the mean path length and the minimal parallelism (the latter on aggregated and study level) of mixed treatment comparisons (network estimates) as well as the evidence flow per design, see König et al. (2013). These measures support the critical evaluation of the network meta-analysis results by rendering transparent the process of data pooling.

## Usage

```
netmeasures(x,
            random = x$comb.random | !missing(tau.preset),
            tau.preset = x$tau.preset, warn = TRUE)
```

## Arguments

x	An object of class netmeta.
random	A logical indicating whether random effects model should be used to calculate network measures.
tau.preset	An optional value for the square-root of the between-study variance $\tau^2$ .
warn	A logical indicating whether warnings should be printed.

## Details

The direct evidence proportion gives the absolute contribution of direct effect estimates combined for two-arm and multi-arm studies to one network estimate.

Concerning indirectness, comparisons with a mean path length beyond two should be interpreted with particular caution, as more than two direct comparisons have to be combined serially on average.

Large indices of parallelism, either on study-level or on aggregated level, can be considered as supporting the validity of a network meta-analysis if there is only a small amount of heterogeneity.

The network estimates for two treatments are linear combinations of direct effect estimates comparing these or other treatments. The linear coefficients can be seen as the generalization of weights known from classical meta-analysis. These coefficients are given in the projection matrix  $H$  of the underlying model. For multi-arm studies, the coefficients depend on the choice of the study-specific baseline treatment, but the absolute flow of evidence can be made explicit for each design as shown in König et al. (2013) and is given in  $H.tilde$ .

All measures are calculated based on the fixed effects meta-analysis by default. In the case that in function netmeta the argument `comb.random=TRUE`, all measures are calculated for a random

effects model. The value of the square-root of the between-study variance  $\tau^2$  can also be pre-specified by argument `tau.preset` in function `netmeta`.

### Value

A list containing the following components:

<code>proportion</code>	A named vector of the direct evidence proportion of each network estimate.
<code>meanpath</code>	A named vector of the mean path length of each network estimate.
<code>minpar</code>	A named vector of the minimal parallelism on aggregated level of each network estimate.
<code>minpar.study</code>	A named vector of the minimal parallelism on study level of each network estimate.
<code>H.tilde</code>	Design-based hat matrix with information on absolute evidence flow per design. The number of rows is equal to the number of possible pairwise treatment comparisons and the number of columns is equal to the number of designs.

### Author(s)

Ulrike Krahn <ulrike.krahn@bayer.com>, Jochem König <koenigjo@uni-mainz.de>

### References

König J, Krahn U, Binder H (2013). Visualizing the flow of evidence in network meta-analysis and characterizing mixed treatment comparisons. *Statistics in Medicine*, **32**(30), 5414–29.

### See Also

[netmeta](#)

### Examples

```
data(Senn2013)

#
# Generation of an object of class 'netmeta' with
# reference treatment 'plac', i.e. placebo based
# on a fixed effects model
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD", reference="plac")

#
# Calculate measures based on a fixed effects model
#
nm1 <- netmeasures(net1)

#
# Plot of minimal parallelism versus mean path length
#
```

```

plot(nm1$meanpath, nm1$minpar, pch="",
     xlab="Mean path length", ylab="Minimal parallelism")
text(nm1$meanpath, nm1$minpar, names(nm1$meanpath), cex=0.8)

# Generation of an object of class 'netmeta' with
# reference treatment 'plac' based on a random
# effects model
#
net2 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD", reference="plac", comb.random=TRUE)

#
# Calculate measures based on a random effects model
#
nm2 <- netmeasures(net2)

```

---

netmeta

*Network meta-analysis using graph-theoretical method*


---

## Description

Network meta-analysis is a generalisation of pairwise meta-analysis that compares all pairs of treatments within a number of treatments for the same condition. The graph-theoretical method for analysis of network meta-analyses uses graph-theoretical methods that were originally developed in electrical network theory. It has been found to be equivalent to the frequentist approach to network meta-analysis (Rücker, 2012).

## Usage

```

netmeta(TE, seTE, treat1, treat2, studlab, data=NULL, subset=NULL,
        sm, level=0.95, level.comb=0.95,
        comb.fixed=TRUE, comb.random=!is.null(tau.preset),
        prediction=FALSE, level.predict=0.95,
        reference.group="", baseline.reference=TRUE,
        all.treatments=NULL, seq=NULL, tau.preset=NULL,
        tol.multiarm = 0.0005, details.chkmultiarm = FALSE,
        sep.trts=":", title="", warn=TRUE)

```

## Arguments

TE	Estimate of treatment effect, i.e. difference between first and second treatment (e.g. log odds ratio, mean difference, or log hazard ratio).
seTE	Standard error of treatment estimate.
treat1	Label/Number for first treatment.
treat2	Label/Number for second treatment.
studlab	An optional - but important! - vector with study labels (see Details).
data	An optional data frame containing the study information.

<code>subset</code>	An optional vector specifying a subset of studies to be used.
<code>sm</code>	A character string indicating underlying summary measure, e.g., "RD", "RR", "OR", "ASD", "HR", "MD", "SMD", or "ROM".
<code>level</code>	The level used to calculate confidence intervals for individual comparisons.
<code>level.comb</code>	The level used to calculate confidence intervals for pooled estimates.
<code>comb.fixed</code>	A logical indicating whether a fixed effect meta-analysis should be conducted.
<code>comb.random</code>	A logical indicating whether a random effects meta-analysis should be conducted.
<code>prediction</code>	A logical indicating whether prediction intervals should be printed.
<code>level.predict</code>	The level used to calculate prediction intervals for a new study.
<code>reference.group</code>	Reference group.
<code>baseline.reference</code>	A logical indicating whether results should be expressed as comparisons of other treatments versus the reference treatment (default) or vice versa. This argument is only considered if <code>reference.group</code> has been specified.
<code>all.treatments</code>	A logical or value "NULL". If TRUE, matrices with all treatment effects, and confidence limits will be printed.
<code>seq</code>	A character or numerical vector specifying the sequence of treatments in print-outs.
<code>tau.preset</code>	An optional value for the square-root of the between-study variance $\tau^2$ .
<code>tol.multiarm</code>	A numeric for the tolerance for consistency of treatment estimates and corresponding variances in multi-arm studies which are consistent by design.
<code>details.chkmultiarm</code>	A logical indicating whether treatment estimates and / or variances of multi-arm studies with inconsistent results or negative multi-arm variances should be printed.
<code>sep.trts</code>	A character used in comparison names as separator between treatment labels.
<code>title</code>	Title of meta-analysis / systematic review.
<code>warn</code>	A logical indicating whether warnings should be printed (e.g., if studies are excluded from meta-analysis due to zero standard errors).

## Details

Network meta-analysis using R package **netmeta** is described in detail in Schwarzer et al. (2015), Chapter 8.

Let  $n$  be the number of different treatments (nodes, vertices) in a network and let  $m$  be the number of existing comparisons (edges) between the treatments. If there are only two-arm studies,  $m$  is the number of studies. Let  $TE$  and  $seTE$  be the vectors of observed effects and their standard errors. Let  $W$  be the  $m \times m$  diagonal matrix that contains the inverse variance  $1/seTE^2$ .

The given comparisons define the network structure. Therefrom an  $m \times n$  design matrix  $B$  (edge-vertex incidence matrix) is formed; for more precise information, see Rucker (2012). Moreover, the  $n \times n$  Laplacian matrix  $L$  and its Moore-Penrose pseudoinverse  $L^+$  are calculated (both matrices



play an important role in graph theory and electrical network theory). Using these matrices, the variances based on both direct and indirect comparisons can be estimated. Moreover, the hat matrix  $H$  can be estimated by  $H = \mathbf{B}\mathbf{L} + \mathbf{B}^t\mathbf{W} = \mathbf{B}(\mathbf{B}^t\mathbf{W}\mathbf{B})^{-1} + \mathbf{B}^t\mathbf{W}$  and finally consistent treatment effects can be estimated by applying the hat matrix to the observed (potentially inconsistent) effects.  $H$  is a projection matrix which maps the observed effects onto the consistent  $(n-1)$ -dimensional subspace. This is the Aitken estimator (Senn et al., 2013). As in pairwise meta-analysis, the  $Q$  statistic measures the deviation from consistency.  $Q$  can be separated into parts for each pairwise meta-analysis and a part for remaining inconsistency between comparisons.

Often multi-arm studies are included in a network meta-analysis. In multi-arm studies, the treatment effects on different comparisons are not independent, but correlated. This is accounted for by reweighting all comparisons of each multi-arm study. The method is described in R ucker (2012) and R ucker and Schwarzer (2014).

Comparisons belonging to multi-arm studies are identified by identical study labels (argument `studlab`). It is therefore important to use identical study labels for all comparisons belonging to the same multi-arm study, e.g., study label "Willms1999" for the three-arm study in the data example (Senn et al., 2013). The function `netmeta` then automatically accounts for within-study correlation by reweighting all comparisons of each multi-arm study.

Data entry for this function is in *contrast-based* format, that is, data are given as contrasts (differences) between two treatments (argument `TE`) with standard error (argument `seTE`). In principle, meta-analysis functions from R package `meta`, e.g. `metabin` for binary outcomes or `metacont` for continuous outcomes, can be used to calculate treatment effects separately for each treatment comparison which is a rather tedious enterprise. If data are provided in *arm-based* format, that is, data are given for each treatment arm separately (e.g. number of events and participants for binary outcomes), a much more convenient way to transform data into contrast-based form is available. Function `pairwise` can automatically transform data with binary outcomes (using the `metabin` function from R package `meta`), continuous outcomes (`metacont` function), incidence rates (`metainc` function), and generic outcomes (`metagen` function). Additional arguments of these functions can be provided, e.g., to calculate Hedges'  $g$  or Cohen's  $d$  for continuous outcomes (see help page of function `pairwise`).

Note, all pairwise comparisons must be provided for a multi-arm study. Consider a multi-arm study of  $p$  treatments with known variances. For this study, treatment effects and standard errors must be provided for each of  $p(p-1)/2$  possible comparisons. For instance, a three-arm study contributes three pairwise comparisons, a four-arm study even six pairwise comparisons. Function `pairwise` automatically calculates all pairwise comparisons for multi-arm studies.

A simple random effects model assuming that a constant heterogeneity variance is added to each comparison of the network can be defined via a generalised methods of moments estimate of the between-studies variance  $\tau^2$  (Jackson et al., 2012). This is added to the observed sampling variance  $seTE^2$  of each comparison in the network (before appropriate adjustment for multi-arm studies). Then, as in standard pairwise meta-analysis, the procedure is repeated with the resulting enlarged standard errors.

Names of treatment comparisons are created by concatenating treatment labels of pairwise comparisons using `sep.trts` as separator (see `paste`). These comparison names are used in the covariance matrices `Cov.fixed` and `Cov.random` and in some R functions, e.g. `decomp.design`. By default, a colon is used as the separator. If any treatment label contains a colon the following characters are used as separator (in consecutive order): "-", "\_", "/", "+", ".". If all of these characters are used in treatment labels, a corresponding error message is printed asking the user to specify a different separator.

**Value**

An object of class `netmeta` with corresponding `print`, `summary`, `forest`, and `netrank` function. The object is a list containing the following components:

`TE`, `seTE`, `studlab`, `treat1`, `treat2`, `sm`, `level`, `level.comb`  
As defined above.

`comb.fixed`, `comb.random`, `seq`, `tau.preset`, `title`, `warn`  
As defined above.

`seTE.adj` Standard error of treatment estimate, adjusted for multi-arm studies.

`reference.group`  
The name of the reference group, if specified, otherwise `c("")`.

`all.treatments` A logical or value "NULL". If TRUE, matrices with all treatment effects, and confidence limits will be printed.

`studies` Study labels coerced into a factor with its levels sorted alphabetically.

`narms` Number of arms for each study.

`TE.nma.fixed`, `TE.nma.random`  
A vector of length  $m$  of consistent treatment effects estimated by network meta-analysis (nma) (fixed effect / random effects model).

`seTE.nma.fixed`, `seTE.nma.random`  
A vector of length  $m$  of effective standard errors estimated by network meta-analysis (fixed effect / random effects model).

`lower.nma.fixed`, `lower.nma.random`  
A vector of length  $m$  of lower confidence interval limits for consistent treatment effects estimated by network meta-analysis (fixed effect / random effects model).

`upper.nma.fixed`, `upper.nma.random`  
A vector of length  $m$  of upper confidence interval limits for the consistent treatment effects estimated by network meta-analysis (fixed effect / random effects model).

`leverage.fixed` A vector of length  $m$  of leverages, interpretable as factors by which variances are reduced using information from the whole network.

`w.fixed`, `w.random`  
A vector of length  $m$  of weights of individual studies (fixed effect / random effects model).

`TE.fixed`, `TE.random`  
 $n \times n$  matrix with estimated overall treatment effects (fixed effect / random effects model).

`seTE.fixed`, `seTE.random`  
 $n \times n$  matrix with standard errors (fixed effect / random effects model).

`lower.fixed`, `upper.fixed`, `lower.random`, `upper.random`  
 $n \times n$  matrices with lower and upper confidence interval limits (fixed effect / random effects model).

`zval.fixed`, `pval.fixed`, `zval.random`, `pval.random`  
 $n \times n$  matrices with z-value and p-value for test of overall treatment effect (fixed effect / random effects model).

TE.direct.fixed, TE.direct.random	$n \times n$ matrix with estimated treatment effects from direct evidence (fixed effect / random effects model).
seTE.direct.fixed, seTE.direct.random	$n \times n$ matrix with estimated standard errors from direct evidence (fixed effect / random effects model).
lower.direct.fixed, upper.direct.fixed, lower.direct.random, upper.direct.random	$n \times n$ matrices with lower and upper confidence interval limits from direct evidence (fixed effect / random effects model).
zval.direct.fixed, pval.direct.fixed, zval.direct.random, pval.direct.random	$n \times n$ matrices with z-value and p-value for test of overall treatment effect from direct evidence (fixed effect / random effects model).
TE.indirect.fixed, TE.indirect.random	$n \times n$ matrix with estimated treatment effects from indirect evidence (fixed effect / random effects model).
seTE.indirect.fixed, seTE.indirect.random	$n \times n$ matrix with estimated standard errors from indirect evidence (fixed effect / random effects model).
lower.indirect.fixed, upper.indirect.fixed, lower.indirect.random, upper.indirect.random	$n \times n$ matrices with lower and upper confidence interval limits from indirect evidence (fixed effect / random effects model).
zval.indirect.fixed, pval.indirect.fixed, zval.indirect.random, pval.indirect.random	$n \times n$ matrices with z-value and p-value for test of overall treatment effect from indirect evidence (fixed effect / random effects model).
prop.direct.fixed, prop.direct.random	A named vector of the direct evidence proportion of each network estimate. (fixed effect / random effects model).
Q.fixed	A vector of length $m$ of contributions to total heterogeneity / inconsistency statistic.
k	Total number of studies.
m	Total number of pairwise comparisons.
n	Total number of treatments.
d	Total number of designs.
Q	Overall heterogeneity / inconsistency statistic.
df.Q	Degrees of freedom for test of heterogeneity / inconsistency.
pval.Q	P-value for test of heterogeneity / inconsistency.
I <sup>2</sup>	I-squared.
tau	Square-root of between-study variance.
Q.heterogeneity	Overall heterogeneity statistic.
df.Q.heterogeneity	Degrees of freedom for test of overall heterogeneity.
pval.Q.heterogeneity	P-value for test of overall heterogeneity.

Q.inconsistency	Overall inconsistency statistic.
df.Q.inconsistency	Degrees of freedom for test of overall inconsistency.
pval.Q.inconsistency	P-value for test of overall inconsistency.
A.matrix	Adjacency matrix ( $nxn$ ).
B.matrix	Edge-vertex incidence matrix ( $mxn$ ).
L.matrix	Laplacian matrix ( $nxn$ ).
Lplus.matrix	Moore-Penrose pseudoinverse of the Laplacian matrix ( $nxn$ ).
Q.matrix	Matrix of heterogeneity statistics for pairwise meta-analyses, where direct comparisons exist ( $nxn$ ).
G.matrix	Matrix with variances and covariances of comparisons ( $mxm$ ). G is defined as <b>BL+B<sup>t</sup></b> .
H.matrix	Hat matrix ( $mxm$ ), defined as <b>H=GW=BL+B<sup>t</sup>W</b> .
Cov.fixed	Variance-covariance matrix (fixed effect model)
Cov.random	Variance-covariance matrix (random effects model)
Q.decomp	Data frame with columns 'treat1', 'treat2', 'Q', 'df' and 'pval.Q', providing heterogeneity statistics for each pairwise meta-analysis of direct comparisons.
P.fixed, P.random	$nxn$ matrix with direct evidence proportions (fixed effect / random effects model).
call	Function call.
version	Version of R package netmeta used to create object.

### Author(s)

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### References

- Jackson D, White IR and Riley RD (2012), Quantifying the impact of between-study heterogeneity in multivariate meta-analyses. *Statistics in Medicine*, **31**(29), 3805–3820.
- Rucker G (2012), Network meta-analysis, electrical networks and graph theory. *Research Synthesis Methods*, **3**, 312–24.
- Rucker G and Schwarzer G (2014), Reduce dimension or reduce weights? Comparing two approaches to multi-arm studies in network meta-analysis. *Statistics in Medicine*, **33**, 4353–4369.
- Schwarzer G, Carpenter JR and Rucker G (2015), *Meta-Analysis with R (Use-R!)*. Springer International Publishing, Switzerland
- Senn S, Gavini F, Magrez D, and Scheen A (2013), Issues in performing a network meta-analysis. *Statistical Methods in Medical Research*, **22**(2), 169–189. First published online 2012 Jan 3.

### See Also

[pairwise](#), [forest.netmeta](#), [netrank](#), [metagen](#)

**Examples**

```

data(Senn2013)

#
# Fixed effect model (default)
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD")
net1
net1$Q.decomp

#
# Comparison with reference group
#
print(net1, reference="plac")

#
# Random effects model
#
net2 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD", comb.random=TRUE)
net2

#
# Change printing order of treatments (placebo first)
#
trts <- c("plac", "acar", "benf", "metf", "mig1", "piog",
          "rosi", "sita", "sulf", "vild")
net3 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD",
               seq=trts)
print(summary(net3), digits=2)

```

---

netposet

*Partial order of treatments in network meta-analysis*


---

**Description**

Partial order of treatments in network meta-analysis. The set of treatments in a network is called a partially ordered set (in short, a *poset*), if different outcomes provide different treatment ranking lists.

**Usage**

```

netposet(..., outcomes, treatments, small.values,
         comb.fixed, comb.random)

## S3 method for class 'netposet'
print(x,

```

```
pooled=ifelse(x$comb.random, "random", "fixed"),
...)
```

### Arguments

...	See details.
outcomes	A character vector with outcome names.
treatments	A character vector with treatment names.
small.values	See details.
comb.fixed	A logical indicating whether to show results for fixed effect model.
comb.random	A logical indicating whether to show results for random effects model.
x	An object of class netposet.
pooled	A character string indicating whether Hasse diagram should be drawn for fixed effect ("fixed") or random effects model ("random"). Can be abbreviated.

### Details

In network meta-analysis, frequently different outcomes are considered which may each provide a different ordering of treatments. The concept of a partially ordered set (in short, a *poset*, Carlsen and Bruggemann, 2014) of treatments can be used to gain further insights in situations with apparently conflicting orderings.

In function `netposet`, argument `...` can be any of the following:

- arbitrary number of `netrank` objects providing P-scores;
- arbitrary number of `netmeta` objects;
- single ranking matrix with each column providing P-scores (Rücker and Schwarzer 2015) or SUCRA values (Salanti et al. 2011) for an outcome and rows corresponding to treatments.

Note, albeit in general a ranking matrix is not constrained to have values between 0 and 1, `netposet` stops with an error in this case as this function expects a matrix with P-scores or SUCRA values.

Argument `outcomes` can be used to label outcomes. If argument `outcomes` is missing,

- column names of the ranking matrix are used as outcome labels (if first argument is a ranking matrix and column names are available);
- capital letters 'A', 'B', ... are used as outcome labels and a corresponding warning is printed.

Argument `treatments` can be used to provide treatment labels if the first argument is a ranking matrix. If argument `treatment` is missing,

- row names of the ranking matrix are used as treatment labels (if available);
- letters 'a', 'b', ... are used as treatment labels and a corresponding warning is printed.

If argument `...` consists of `netmeta` objects, `netrank` is called internally to calculate P-scores. In this case, argument `small.values` can be used to specify for each outcome whether small values are good or bad; see `netrank`. This argument is ignored for a ranking matrix and `netrank` objects.

Arguments `comb.fixed` and `comb.random` can be used to define whether results should be printed and plotted for fixed effect and / or random effects model. If `netmeta` and `netrank` objects are

provided in argument `...`, values for `comb.fixed` and `comb.random` within these objects are considered; if these values are not unique, argument `comb.fixed` and / or `comb.random` are set to `TRUE`.

In function `print.netposet`, argument `...` is passed on to the printing function.

## Value

An object of class `netposet` with corresponding `print`, `plot`, and `hasse` function. The object is a list containing the following components:

<code>P.fixed</code>	Ranking matrix with rows corresponding to treatments and columns corresponding to outcomes (fixed effect model).
<code>M0.fixed</code>	Hasse matrix skipping unnecessary paths (fixed effect model).
<code>M.fixed</code>	"Full" Hasse matrix (fixed effect model).
<code>O.fixed</code>	Matrix with information about partial ordering (fixed effect model).
<code>P.random</code>	Ranking matrix with rows corresponding to treatments and columns corresponding to outcomes (random effects model).
<code>M0.random</code>	Hasse matrix skipping unnecessary paths (random effects model).
<code>M.random</code>	"Full" Hasse matrix (random effects model).
<code>O.random</code>	Matrix with information about partial ordering (random effects model).
<code>small.values</code> , <code>comb.fixed</code> , <code>comb.random</code>	As defined above.
<code>call</code>	Function call.
<code>version</code>	Version of R package <code>netmeta</code> used to create object.

## Author(s)

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## References

Carlsen L, Bruggemann R (2014), Partial order methodology: a valuable tool in chemometrics. *Journal of Chemometrics*, **28**, 226–34, DOI:10.1002/cem.2569 .

Rucker G & Schwarzer G (2015), Ranking treatments in frequentist network meta-analysis works without resampling methods. *BMC Medical Research Methodology*, **15**, 58, DOI:10.1186/s12874-015-0060-8 .

Salanti G, Ades AE, Ioannidis JP (2011). Graphical methods and numerical summaries for presenting results from multiple-treatment meta-analysis: an overview and tutorial. *Journal of Clinical Epidemiology*, **64**(2), 163–171.

## See Also

[netmeta](#), [netrank](#), [hasse](#), [plot.netposet](#)

**Examples**

```

# Use depression dataset
#
data(Linde2015)
#
# Define order of treatments
#
trts <- c("TCA", "SSRI", "SNRI", "NRI",
          "Low-dose SARI", "NaSSa", "rMAO-A", "Hypericum",
          "Placebo")

#
# Outcome labels
#
outcomes <- c("Early response", "Early remission")
#
# (1) Early response
#
p1 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(resp1, resp2, resp3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")

#
net1 <- netmeta(p1,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")

#
# (2) Early remission
#
p2 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(remi1, remi2, remi3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")

#
net2 <- netmeta(p2,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")

#
# Partial order of treatment rankings (all five outcomes)
#
po <- netposet(netrank(net1, small.values = "bad"),
              netrank(net2, small.values = "bad"),
              outcomes = outcomes)

#
# Hasse diagram
#
hasse(po)

## Not run:
#
# Outcome labels
#

```



```

outcomes <- c("Early response", "Early remission",
             "Lost to follow-up", "Lost to follow-up due to AEs",
             "Adverse events (AEs)")

#
# (3) Loss to follow-up
#
p3 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(loss1, loss2, loss3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")

#
net3 <- netmeta(p3,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")

#
# (4) Loss to follow-up due to adverse events
#
p4 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(loss.ae1, loss.ae2, loss.ae3),
              n = list(n1, n2, n3),
              studlab = id, data = subset(Linde2015, id != 55),
              sm = "OR")

#
net4 <- netmeta(p4,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")

#
# (5) Adverse events
#
p5 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(ae1, ae2, ae3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")

#
net5 <- netmeta(p5,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")

#
# Partial order of treatment rankings (all five outcomes)
#
po.ranks <- netposet(netrank(net1, small.values = "bad"),
                   netrank(net2, small.values = "bad"),
                   netrank(net3, small.values = "good"),
                   netrank(net4, small.values = "good"),
                   netrank(net5, small.values = "good"),
                   outcomes = outcomes)

#
# Same result
#
po.nets <- netposet(net1, net2, net3, net4, net5,
                  small.values = c("bad", "bad", "good", "good", "good"),
                  outcomes = outcomes)

#

```

```

all.equal(po.ranks, po.nets)
#
# Print matrix with P-scores (random effects model)
#
po.nets$P.random
#
# Hasse diagram for all outcomes (random effects model)
#
hasse(po.ranks)
#
# Hasse diagram for outcomes early response and early remission
#
po12 <- netposet(netrank(net1, small.values = "bad"),
                 netrank(net2, small.values = "bad"),
                 outcomes = outcomes[1:2])

hasse(po12)
#
# Scatter plot
#
oldpar <- par(pty = "s")
plot(po12)
par(oldpar)

## End(Not run)

# Example using ranking matrix with P-scores
#
# Ribassin-Majed L, Marguet S, Lee A.W., et al. (2017),
# What is the best treatment of locally advanced nasopharyngeal
# carcinoma? An individual patient data network meta-analysis.
# Journal of Clinical Oncology.
# 35, 498-505, DOI:10.1200/JCO.2016.67.4119
#
outcomes <- c("OS", "PFS", "LC", "DC")
treatments <- c("RT", "IC-RT", "IC-CRT", "CRT",
               "CRT-AC", "RT-AC", "IC-RT-AC")
#
# P-scores (from Table 1)
#
pscore.os <- c(15, 33, 63, 70, 96, 28, 45) / 100
pscore.pfs <- c( 4, 46, 79, 52, 94, 36, 39) / 100
pscore.lc <- c( 9, 27, 47, 37, 82, 58, 90) / 100
pscore.dc <- c(16, 76, 95, 48, 72, 32, 10) / 100
#
pscore.matrix <- data.frame(pscore.os, pscore.pfs, pscore.lc, pscore.dc)
rownames(pscore.matrix) <- treatments
colnames(pscore.matrix) <- outcomes
pscore.matrix
#
po <- netposet(pscore.matrix)
po12 <- netposet(pscore.matrix[, 1:2])
po

```

```

po12
#
hasse(po)
hasse(po12)
#
oldpar <- par(pty = "s")
plot(po12)
par(oldpar)

```

---

netrank

*Frequentist method to rank treatments in network*


---

## Description

Ranking treatments in frequentist network meta-analysis without resampling methods.

## Usage

```

netrank(x, small.values="good")

## S3 method for class 'netrank'
print(x,
      comb.fixed = x$x$comb.fixed, comb.random = x$x$comb.random,
      sort=TRUE, digits=max(4, .Options$digits - 3), ...)

```

## Arguments

<code>x</code>	An object of class <code>netmeta</code> ( <code>netrank</code> function) or <code>netrank</code> ( <code>print</code> function).
<code>comb.fixed</code>	A logical indicating whether to print P-scores for fixed effect model.
<code>comb.random</code>	A logical indicating whether to print P-scores for random effects model.
<code>small.values</code>	A character string specifying whether small treatment effects indicate a beneficial ("good") or harmful ("bad") effect, can be abbreviated.
<code>sort</code>	A logical indicating whether printout should be sorted by decreasing P-score.
<code>digits</code>	Minimal number of significant digits, see <a href="#">print.default</a> .
<code>...</code>	Additional arguments passed on to <a href="#">print.data.frame</a> function (used internally).

## Details

Treatments are ranked based on a network meta-analysis. Ranking is performed by P-scores. P-scores are based solely on the point estimates and standard errors of the network estimates. They measure the extent of certainty that a treatment is better than another treatment, averaged over all competing treatments (Rücker and Schwarzer 2015).

The P-score of treatment  $i$  is defined as the mean of all  $1 - P[j]$  where  $P[j]$  denotes the one-sided P-value of accepting the alternative hypothesis that treatment  $i$  is better than one of the competing treatments  $j$ . Thus, if treatment  $i$  is better than many other treatments, many of these P-values will

be small and the P-score will be large. Vice versa, if treatment  $i$  is worse than most other treatments, the P-score is small.

The P-score of treatment  $i$  can be interpreted as the mean extent of certainty that treatment  $i$  is better than another treatment. This interpretation is comparable to that of the Surface Under the Cumulative Ranking curve (SUCRA) which is the rank of treatment  $i$  within the range of treatments, measured on a scale from 0 (worst) to 1 (best) (Salanti et al. 2011).

## Value

An object of class `netrank` with corresponding `print` function. The object is a list containing the following components:

<code>Pscore.fixed</code>	A named numeric vector with P-scores for fixed effect model.
<code>Pmatrix.fixed</code>	Numeric matrix based on pairwise one-sided p-values for fixed effect model.
<code>Pscore.random</code>	A named numeric vector with P-scores for random effects model.
<code>Pmatrix.random</code>	Numeric matrix based on pairwise one-sided p-values of random effects model.
<code>small.values, x</code>	As defined above.
<code>version</code>	Version of R package <code>netmeta</code> used to create object.

## Author(s)

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## References

Rücker G & Schwarzer G (2015), Ranking treatments in frequentist network meta-analysis works without resampling methods. *BMC Medical Research Methodology*, **15**, 58, DOI:10.1186/s12874-015-0060-8 .

Salanti G, Ades AE, Ioannidis JP (2011). Graphical methods and numerical summaries for presenting results from multiple-treatment meta-analysis: an overview and tutorial. *Journal of Clinical Epidemiology*, **64**(2), 163–171.

## See Also

[netmeta](#)

## Examples

```
data(Senn2013)

net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD")
net2 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD",
               comb.fixed=FALSE, comb.random=TRUE)
net3 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD",
```

```

comb.random=TRUE)

nr1 <- netrank(net1)
nr1
print(nr1, sort=FALSE)

nr2 <- netrank(net2)
nr2
print(nr2, sort=FALSE)

nr3 <- netrank(net3)
nr3
print(nr3, sort="fixed")
print(nr3, sort=FALSE)

```

---

netsplit

*Split direct and indirect evidence in network meta-analysis*

---

### Description

Split contribution of direct and indirect evidence in network meta-analysis.

### Usage

```

netsplit(x)

## S3 method for class 'netsplit'
print(x,
      comb.fixed = x$comb.fixed,
      comb.random = x$comb.random,
      showall = TRUE,
      overall = TRUE,
      ci = FALSE,
      test = TRUE,
      digits = gs("digits"),
      digits.zval = gs("digits.zval"),
      digits.pval = gs("digits.pval"),
      text.NA = ".", backtransf = TRUE,
      ...)

```

### Arguments

x	An object of class netmeta or netsplit.
comb.fixed	A logical indicating whether results for fixed effect model should be printed.
comb.random	A logical indicating whether results for random effects model should be printed.
showall	A logical indicating whether all comparisons (default) or only comparisons contributing both direct and indirect evidence should be printed.

<code>overall</code>	A logical indicating whether estimates from network meta-analysis should be printed in addition to direct and indirect estimates.
<code>ci</code>	A logical indicating whether confidence intervals should be printed in addition to treatment estimates.
<code>test</code>	A logical indicating whether results of a test comparing direct and indirect estimates should be printed.
<code>digits</code>	Minimal number of significant digits, see <code>print.default</code> .
<code>digits.zval</code>	Minimal number of significant digits for z-value of test of agreement between direct and indirect evidence, see <code>print.default</code> .
<code>digits.pval</code>	Minimal number of significant digits for p-value of test of agreement between direct and indirect evidence, see <code>print.default</code> .
<code>backtransf</code>	A logical indicating whether printed results should be back transformed. For example, if <code>backtransf=TRUE</code> , results for <code>sm="OR"</code> are printed as odds ratios rather than log odds ratios.
<code>text.NA</code>	A character string specifying text printed for missing values.
<code>...</code>	Additional arguments (ignored at the moment)

## Details

Direct and indirect treatment estimates are calculated in `netmeta`. This function combines and prints these estimates in a user-friendly way.

A comparison of direct and indirect treatment estimates can serve as check for consistency of network meta-analysis (Dias et al., 2010).

## Value

An object of class `netsplit` with corresponding print function. The object is a list containing the following components:

<code>comb.fixed</code> , <code>comb.random</code>	As defined above.
<code>comparison</code>	A vector with treatment comparisons.
<code>prop.fixed</code> , <code>prop.random</code>	A vector with direct evidence proportions (fixed effect / random effects model).
<code>fixed</code> , <code>random</code>	Results of network meta-analysis (fixed effect / random effects model), i.e., list with vectors <code>TE</code> , <code>seTE</code> , <code>lower</code> , <code>upper</code> , <code>z</code> , and <code>p</code> .
<code>direct.fixed</code> , <code>direct.random</code>	Network meta-analysis results based on direct evidence (fixed effect / random effects model), i.e., list with vectors <code>TE</code> , <code>seTE</code> , <code>lower</code> , <code>upper</code> , <code>z</code> , and <code>p</code> .
<code>indirect.fixed</code> , <code>indirect.random</code>	Network meta-analysis results based on indirect evidence (fixed effect / random effects model), i.e., list with vectors <code>TE</code> , <code>seTE</code> , <code>lower</code> , <code>upper</code> , <code>z</code> , and <code>p</code> .
<code>compare.fixed</code> , <code>compare.random</code>	Comparison of direct and indirect evidence in network meta-analysis (fixed effect / random effects model), i.e., list with vectors <code>TE</code> , <code>seTE</code> , <code>lower</code> , <code>upper</code> , <code>z</code> , and <code>p</code> .

sm	A character string indicating underlying summary measure
level.comb	The level used to calculate confidence intervals for pooled estimates.
version	Version of R package netmeta used to create object.

**Author(s)**

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**References**

Dias S, Welton NJ, Caldwell DM, Ades AE (2010). Checking consistency in mixed treatment comparison meta-analysis. *Statistics in Medicine*, **29**, 932–44.

Puhan MA, Schünemann HJ, Murad MH, et al. (2014). A GRADE working group approach for rating the quality of treatment effect estimates from network meta-analysis. *British Medical Journal*, **349**, g5630

**See Also**

[netmeta](#), [netmeasures](#)

**Examples**

```
data(Woods2010)
#
p1 <- pairwise(treatment, event = r, n = N,
               studlab = author, data = Woods2010, sm = "OR")
#
net1 <- netmeta(p1)
#
print(netsplit(net1), digits = 2)
print(netsplit(net1), digits = 2,
      backtransf = FALSE, comb.random = TRUE)

data(Senn2013)
#
net2 <- netmeta(TE, seTE, treat1, treat2, studlab, data = Senn2013,
               comb.random = TRUE)
#
print(netsplit(net2), digits = 2)
# Layout of Puhan et al. (2014), Table 1
print(netsplit(net2), digits = 2, ci = TRUE, test = FALSE)
```

**Description**

This function transforms data that are given in an arm-based format (e.g. input format for WinBUGS) to a contrast-based format that is needed as input to R function `netmeta`. The function can transform data with binary, continuous, or generic outcomes as well as incidence rates from arm-based to contrast-based format.

**Usage**

```
pairwise(treat, event, n, mean, sd, TE, seTE, time,
         data=NULL, studlab,
         incr=0.5, allincr=FALSE, addincr=FALSE, allstudies=FALSE,
         ...)
```

**Arguments**

<code>treat</code>	A list or vector with treatment information for individual treatment arms (see Details).
<code>event</code>	A list or vector with information on number of events for individual treatment arms (see Details).
<code>n</code>	A list or vector with information on number of observations for individual treatment arms (see Details).
<code>mean</code>	A list or vector with estimated means for individual treatment arms (see Details).
<code>sd</code>	A list or vector with information on the standard deviation for individual treatment arms (see Details).
<code>TE</code>	A list or vector with estimated treatment effects for individual treatment arms (see Details).
<code>seTE</code>	A list or vector with standard errors of estimated treatment effect for individual treatment arms (see Details).
<code>time</code>	A list or vector with information on person time at risk for individual treatment arms (see Details).
<code>data</code>	An optional data frame containing the study information.
<code>studlab</code>	A vector with study labels (optional).
<code>incr</code>	A numerical value which is added to each cell frequency for studies with a zero cell count.
<code>allincr</code>	A logical indicating if <code>incr</code> is added to each cell frequency of all studies if at least one study has a zero cell count. If <code>FALSE</code> (default), <code>incr</code> is added only to each cell frequency of studies with a zero cell count.
<code>addincr</code>	A logical indicating if <code>incr</code> is added to each cell frequency of all studies irrespective of zero cell counts.
<code>allstudies</code>	A logical indicating if studies with zero or all events in two treatment arms are to be included in the meta-analysis (applies only if <code>sm</code> is equal to "RR" or "OR").
<code>...</code>	Additional arguments passed-through to the functions to calculate effects.



## Details

R function `netmeta` expects data in a *contrast-based format*, where each row corresponds to a comparison of two treatments and contains a measure of the treatment effect comparing two treatments with standard error, labels for the two treatments and an optional study label. In contrast-based format, a three-arm study contributes three rows with treatment comparison and corresponding standard error for pairwise comparison  $A$  vs  $B$ ,  $A$  vs  $C$ , and  $B$  vs  $C$  whereas a four-arm study contributes six rows / pairwise comparisons:  $A$  vs  $B$ ,  $A$  vs  $C$ ,  $\dots$ ,  $C$  vs  $D$ .

Other programs for network meta-analysis in WinBUGS and Stata require data in an *arm-based format*, i.e. treatment estimate for each treatment arm instead of a difference of two treatments. This format consists of one data row per study, containing treatment and other necessary information for all study arms. For example, a four-arm study contributes one row with four treatment estimates and corresponding standard errors for treatments  $A$ ,  $B$ ,  $C$ , and  $D$ . Another possible arm-based format is a long format where each row corresponds to a single study arm. Accordingly, in the long format a study contributes as many rows as treatments considered in the study.

The `pairwise` function transforms data given in arm-based format into the contrast-based format which consists of *pairwise* comparisons and is needed as input to the `netmeta` function.

The `pairwise` function can transform data with binary outcomes (using the `metabin` function from R package `meta`), continuous outcomes (`metacont` function), incidence rates (`metainc` function), and generic outcomes (`metagen` function). Depending on the outcome, the following arguments are mandatory:

- `treat`, event, n (see `metabin`)
- `treat`, n, mean, sd (see `metacont`)
- `treat`, event, time (see `metainc`)
- `treat`, TE, seTE (see `metagen`)

Argument `treat` is mandatory to identify the individual treatments. The other arguments contain outcome specific data. These arguments must be either lists (one-row-per-study) or vectors (long format, i.e. multiple-rows-per-study) of the same length.

For the one-row-per-study format, each list consists of as many vectors of the same length as the multi-arm study with the largest number of treatments. If a single multi-arm study has five arms, five vectors have to be provided for each lists. Two-arm studies have entries with NA for the third and subsequent vectors. Each list entry is a vector with information for each individual study; i.e. the length of this vector corresponds to the total number of studies incorporated in the network meta-analysis. Typically, list elements are part of a data frame (argument `data`, optional); see Examples. An optional vector with study labels can be provided which can be part of the data frame.

In the long format, argument `studlab` is mandatory to identify rows contributing to individual studies.

Additional arguments for these functions can be provided using argument `'...'`. The following is a list of some important arguments:

Argument	Description	R function
<code>sm</code>	Summary measure	<code>metabin</code> , <code>metacont</code> , <code>metainc</code> , <code>metagen</code>
<code>method</code>	Meta-analysis method	<code>metabin</code> , <code>metainc</code>
<code>method.tau</code>	Estimation of between-study variance	<code>metabin</code> , <code>metacont</code> , <code>metainc</code> , <code>metagen</code>
<code>method.smd</code>	Standardised mean difference	<code>metacont</code>

More information on these as well as other arguments is given in the help pages of R functions [metabin](#), [metacont](#), [metainc](#), and [metagen](#), respectively.

The value of `pairwise` is a data frame with as many rows as there are pairwise comparisons. For each study with  $p$  treatments,  $p*(p-1)/2$  contrasts are generated. Each row contains the treatment effect (TE), its standard error (seTE), the treatments compared ((`treat1`), (`treat2`)) and the study label ((`studlab`)). Further columns are added according to type of data.

### Value

A data frame with the following columns

TE	Treatment estimate comparing treatment 'treat1' and 'treat2'.
seTE	Standard error of treatment estimate.
studlab	Study labels.
treat1	First treatment in comparison.
treat2	Second treatment in comparison.
event1	Number of events for first treatment arm (for <code>metabin</code> and <code>metainc</code> ).
event2	Number of events for second treatment arm (for <code>metabin</code> and <code>metainc</code> ).
n1	Number of observations for first treatment arm (for <code>metabin</code> and <code>metacont</code> ).
n2	Number of observations for second treatment arm (for <code>metabin</code> and <code>metacont</code> ).
mean1	Estimated mean for first treatment arm (for <code>metacont</code> ).
mean2	Estimated mean for second treatment arm (for <code>metacont</code> ).
sd1	Standard deviation for first treatment arm (for <code>metacont</code> ).
sd2	Standard deviation for second treatment arm (for <code>metacont</code> ).
TE1	Estimated treatment effect for first treatment arm (for <code>metagen</code> ).
TE2	Estimated treatment effect for second treatment arm (for <code>metagen</code> ).
seTE1	Standard error of estimated treatment effect for first treatment arm (for <code>metagen</code> ).
seTE2	Standard error of estimated treatment effect for second treatment arm (for <code>metagen</code> ).
time1	Person time at risk for first treatment arm (for <code>metainc</code> ).
time2	Person time at risk for second treatment arm (for <code>metainc</code> ).

### Author(s)

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### See Also

[netmeta](#), [metacont](#), [metagen](#), [metabin](#), [metainc](#), [netgraph](#)

**Examples**

```

#
# Example using continuous outcomes (internal call of function metacont)
#
data(parkinson)
# Transform data from arm-based format to contrast-based format
p1 <- pairwise(list(Treatment1, Treatment2, Treatment3),
               n=list(n1, n2, n3),
               mean=list(y1, y2, y3),
               sd=list(sd1, sd2, sd3),
               data=parkinson, studlab=Study)

p1

# Conduct network meta-analysis
net1 <- netmeta(p1)
net1

# Draw network graphs
netgraph(net1, points=TRUE, cex.points=3, cex=1.5,
         thickness="se.fixed")
netgraph(net1, points=TRUE, cex.points=3, cex = 1.5,
         plastic=TRUE, thickness="se.fixed",
         iterate=TRUE)
netgraph(net1, points=TRUE, cex.points=3, cex = 1.5,
         plastic=TRUE, thickness="se.fixed",
         iterate=TRUE, start="eigen")

#
# Example using generic outcomes (internal call of function metagen)
#
# Calculate standard error for means y1, y2, y3
parkinson$se1 <- with(parkinson, sqrt(sd1^2/n1))
parkinson$se2 <- with(parkinson, sqrt(sd2^2/n2))
parkinson$se3 <- with(parkinson, sqrt(sd3^2/n3))
# Transform data from arm-based format to contrast-based format using
# means and standard errors (note, argument 'sm' has to be used to
# specify that argument 'TE' is a mean difference)
p2 <- pairwise(list(Treatment1, Treatment2, Treatment3),
               TE=list(y1, y2, y3),
               seTE=list(se1, se2, se3),
               data=parkinson, studlab=Study,
               sm="MD")

p2

# Compare pairwise objects p1 (based on continuous outcomes) and p2
# (based on generic outcomes)
all.equal(p1[, c("TE", "seTE", "studlab", "treat1", "treat2")],
         p2[, c("TE", "seTE", "studlab", "treat1", "treat2")])

# Same result as network meta-analysis based on continuous outcomes
# (object net1)

```

```

## Not run: net2 <- netmeta(p2)
net2
## End(Not run)

#
# Example with binary data
#
data(smokingcessation)
# Transform data from arm-based format to contrast-based format
# (internal call of metabin function). Argument 'sm' has to be used for
# odds ratio as risk ratio (sm="RR") is default of metabin function.
p3 <- pairwise(list(treat1, treat2, treat3),
               list(event1, event2, event3),
               list(n1, n2, n3),
               data=smokingcessation,
               sm="OR")

p3

# Conduct network meta-analysis
net3 <- netmeta(p3)
net3

#
# Example with incidence rates
#
data(dietaryfat)

# Transform data from arm-based format to contrast-based format
p4 <- pairwise(list(treat1, treat2, treat3),
               list(d1, d2, d3),
               time=list(years1, years2, years3),
               studlab=ID,
               data=dietaryfat)

p4

# Conduct network meta-analysis using incidence rate ratios (sm="IRR").
# Note, the argument 'sm' is not necessary as this is the default in R
# function metainc called internally
net4 <- netmeta(p4, sm="IRR")
summary(net4)

#
# Example with long data format
#
data(Woods2010)

# Transform data from long arm-based format to contrast-based format
# Argument 'sm' has to be used for odds ratio as summary measure; by
# default the risk ratio is used in the metabin function called
# internally.
p5 <- pairwise(treatment, event=r, n=N,
               studlab=author, data=Woods2010, sm="OR")

```

```
p5  
  
# Conduct network meta-analysis  
net5 <- netmeta(p5)  
net5
```

---

parkinson

*Network meta-analysis of treatments for Parkinson's disease*

---

### Description

Network meta-analysis comparing the effects of a number of treatments for Parkinson's disease.

The data are the mean lost work-time reduction in patients given dopamine agonists as adjunct therapy in Parkinson's disease. The data are given as sample size, mean and standard deviation in each trial arm. Treatments are placebo, coded 1, and four active drugs coded 2 to 5. These data are used as an example in the supplemental material of Dias et al. (2013).

### Usage

```
data(parkinson)
```

### Format

A data frame with the following columns:

**Study** Study label

**Treatment1** Treatment 1

**y1** Treatment effect arm 1

**sd1** Standard deviation arm 1

**n1** Sample size arm 1

**Treatment2** Treatment 2

**y2** Treatment effect arm 2

**sd2** Standard deviation arm 2

**n2** Sample size arm 2

**Treatment3** Treatment 3

**y3** Treatment effect arm 3

**sd3** Standard deviation arm 3

**n3** Sample size arm 3

### Source

Dias S, Sutton AJ, Ades AE and Welton NJ (2013). Evidence synthesis for decision making 2: A generalized linear modeling framework for pairwise and network meta-analysis of randomized controlled trials. *Medical Decision Making* **33**, 607–617.

**See Also**

[pairwise](#), [metacont](#), [netmeta](#), [netgraph](#)

**Examples**

```
data(parkinson)

# Transform data from arm-based format to contrast-based format
p1 <- pairwise(list(Treatment1, Treatment2, Treatment3),
               n=list(n1, n2, n3),
               mean=list(y1, y2, y3),
               sd=list(sd1, sd2, sd3),
               data=parkinson, studlab=Study)

p1

# Conduct network meta-analysis
net1 <- netmeta(p1)
net1

# Draw network graphs
netgraph(net1, points=TRUE, cex.points=3, cex=1.5,
         thickness="se.fixed")
netgraph(net1, points=TRUE, cex.points=3, cex = 1.5,
         plastic=TRUE, thickness="se.fixed",
         iterate=TRUE)
netgraph(net1, points=TRUE, cex.points=3, cex = 1.5,
         plastic=TRUE, thickness="se.fixed",
         iterate=TRUE, start="eigen")
```

---

plot.netposet

*Scatter plot or biplot showing partially order of treatment ranks*

---

**Description**

This function generates a scatter plot or biplot of P-scores with an overlay describing partial order of treatment ranks.

**Usage**

```
## S3 method for class 'netposet'
plot(x,
     plottype = "scatter",
     pooled=ifelse(x$comb.random, "random", "fixed"),
     dim = "2d",
     sel.x = 1, sel.y = 2, sel.z = 3,
     cex = 1, col = "black",
     cex.text = cex, col.text = col,
     adj.x = 0, adj.y = 1,
     offset.x = 0.005, offset.y = -0.005,
```

```

pch = NULL, cex.points = cex, col.points = col,
col.lines = "black", lty.lines = 1, lwd.lines = 1,
arrows = FALSE,
length = 0.05,
grid = TRUE,
col.grid = "gray", lty.grid = 2, lwd.grid = 1,
...)
```

## Arguments

x	An object of class <code>netmeta</code> (mandatory).
plottype	A character string indicating whether a scatter plot or biplot should be produced, either "scatter" or "biplot". Can be abbreviated.
pooled	A character string indicating whether scatter plot should be drawn for fixed effect ("fixed") or random effects model ("random"). Can be abbreviated.
dim	A character string indicating whether a 2- or 3-dimensional plot should be produced, either "2d" or "3d". Can be abbreviated.
sel.x	A numeric specifying number of outcome to use for the x-axis in a scatterplot (argument is not considered for a biplot).
sel.y	A numeric specifying number of outcome to use for the y-axis in a scatterplot (argument is not considered for a biplot).
sel.z	A numeric specifying number of outcome to use for the z-axis in a scatterplot (argument is not considered for a biplot).
cex	The magnification to be used for treatment labels and points.
col	Colour(s) of treatment labels and points.
cex.text	The magnification to be used for treatment labels.
col.text	Colour(s) of treatment labels.
adj.x	Value(s) in [0, 1] to specify adjustment of treatment labels on x-axis (only considered in 2-D plots); see <a href="#">text</a> .
adj.y	Value(s) in [0, 1] to specify adjustment of treatment labels on y-axis (only considered in 2-D plots); see <a href="#">text</a> .
offset.x	Offset(s) of treatment labels on x-axis (only considered in 2-D plots).
offset.y	Offset(s) of treatment labels on y-axis (only considered in 2-D plots).
pch	Plot symbol(s) for points; no points printed if equal to NULL.
cex.points	Magnification(s) to be used for points.
col.points	Colour(s) of points.
col.lines	Line colour.
lty.lines	Line type.
lwd.lines	Line width.
arrows	A logical indicating whether arrows should be printed (only considered in 2-D plots).
length	Length of arrows; see <a href="#">arrows</a> .

grid	A logical indicating whether grid lines should be added to plot.
col.grid	Colour of grid lines.
lty.grid	Line type of grid lines.
lwd.grid	Line width of grid lines.
...	Additional graphical arguments.

### Details

By default (arguments `plottype="scatter"` and `dim="2d"`), a scatter plot is created showing P-scores (see [netrank](#)) for the first two outcomes considered in the generation of a partially ordered set of treatment ranks (using [netposet](#)). In addition to the P-scores, the partially order of treatment ranks is shown as lines connecting treatments which is analogous to a Hasse diagram. If argument `dim="3d"`, a 3-D scatter plot is generated showing P-scores for the first three outcomes.

To overcome the restriction of two or three dimension, a biplot (Gabriel, 1971) can be generated using argument `plottype="biplot"`. This is essentially a scatter plot using the first two (`dim="2d"`) or three (`dim="3d"`) components in a principal components analysis (using [prcomp](#)). Note, if only two / three outcomes are considered in a `netposet` object, a 2-D / 3-D scatter plot is generated instead of a biplot as a principal component analysis is superfluous in such a situation.

Arguments `sel.x` and `sel.y` can be used to select different outcomes to show on x- and y-axis in a 2-D scatter plot; argument `sel.z` can be used accordingly in a 3-D scatter plot. These arguments are ignored for a biplot.

Note, in order to generate 3-D plots (argument `dim="3d"`), R package `rgl` is necessary. Note, under macOS the X.Org X Window System must be available (see <https://www.xquartz.org>).

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### References

- Carlsen L, Bruggemann R (2014), Partial order methodology: a valuable tool in chemometrics. *Journal of Chemometrics*, **28** 226–34, DOI:10.1002/cem.2569
- Gabriel KR (1971), The biplot graphic display of matrices with application to principal component analysis. *Biometrika*, **58** 453–67

### See Also

[netmeta](#), [netrank](#), [netposet](#), [hasse](#)

### Examples

```
# Use depression dataset
#
data(Linde2015)
#
# Define order of treatments
#
trts <- c("TCA", "SSRI", "SNRI", "NRI",
```



```
      "Low-dose SARI", "NaSSa", "rMAO-A", "Hypericum",
      "Placebo")
#
# Outcome labels
#
outcomes <- c("Early response", "Early remission")
#
# (1) Early response
#
p1 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(resp1, resp2, resp3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")
#
net1 <- netmeta(p1,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")
#
# (2) Early remission
#
p2 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(remi1, remi2, remi3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")
#
net2 <- netmeta(p2,
               comb.fixed = FALSE, comb.random = TRUE,
               seq = trts, ref = "Placebo")
#
# Partial order of treatment rankings
#
po2 <- netposet(netrank(net1, small.values = "bad"),
               netrank(net2, small.values = "bad"),
               outcomes = outcomes)
#
# Scatter plot
#
plot(po2)
#
# Same scatter plot as only two outcomes considered in netposet()
#
plot(po2, "biplot")

#
# Consider three outcomes
#
#
# Outcome labels
#
outcomes <- c("Early response", "Early remission", "Lost to follow-up")
#
# (3) Loss to follow-up
#
```

```

p3 <- pairwise(treat = list(treatment1, treatment2, treatment3),
              event = list(loss1, loss2, loss3),
              n = list(n1, n2, n3),
              studlab = id, data = Linde2015, sm = "OR")
#
net3 <- netmeta(p3,
              comb.fixed = FALSE, comb.random = TRUE,
              seq = trts, ref = "Placebo")
#
# Partial order of treatment rankings (with three outcomes)
#
po3 <- netposet(netrank(net1, small.values = "bad"),
              netrank(net2, small.values = "bad"),
              netrank(net3, small.values = "good"),
              outcomes = outcomes)
#
# Hasse diagram
#
hasse(po3)
#
# Scatter plot
#
plot(po3)
#
# Biplot (reverse limits of y-axis as biplot is upside down)
#
plot(po3, "bi", xlim = c(-1, 1.7), ylim = c(2.5, -2.5))

```

---

print.decomp.design    *Print method for objects of class decomp.design*

---

## Description

Print and summary method for objects of class decomp.design.

## Usage

```
## S3 method for class 'decomp.design'
print(x, digits=2, showall=FALSE, ...)
```

## Arguments

x	An object of class decomp.design.
digits	Minimal number of significant digits for Q statistics, see print.default.
showall	A logical indicating whether results should be shown for all designs or only designs contributing to chi-squared statistics (default).
...	Additional arguments (ignored at the moment).

**Author(s)**

Guido Schwarzer <sc@imbi.uni-freiburg.de>, Ulrike Krahn <ulrike.krahn@bayer.com>

**See Also**

[decomp.design](#)

**Examples**

```
data(Senn2013)

net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD")
print(decomp.design(net1))
```

---

print.netmeta

*Print and summary method for objects of class netmeta*

---

**Description**

Print and summary method for objects of class netmeta.

**Usage**

```
## S3 method for class 'netmeta'
print(x, sortvar,
      comb.fixed=x$comb.fixed, comb.random=x$comb.random,
      prediction=x$prediction,
      reference.group=x$reference.group,
      baseline.reference=x$baseline.reference,
      all.treatments=x$all.treatments,
      details=TRUE, ma=TRUE, logscale=FALSE,
      digits=max(4, .Options$digits - 3), ...)

## S3 method for class 'netmeta'
summary(object,
        comb.fixed=object$comb.fixed, comb.random=object$comb.random,
        prediction=object$prediction,
        reference.group=object$reference.group,
        baseline.reference=object$baseline.reference,
        all.treatments=object$all.treatments,
        warn=object$warn, ...)

## S3 method for class 'summary.netmeta'
print(x, comb.fixed=x$comb.fixed, comb.random=x$comb.random,
      prediction=x$prediction,
      reference.group=x$reference.group,
```

```
baseline.reference=x$baseline.reference,
all.treatments=x$all.treatments,
logscale=FALSE, header=TRUE, digits=max(3, .Options$digits - 3), ...)
```

### Arguments

<code>x</code>	An object of class <code>netmeta</code> or <code>summary.netmeta</code> .
<code>object</code>	An object of class <code>netmeta</code> .
<code>sortvar</code>	An optional vector used to sort individual studies (must be of same length as <code>x\$TE</code> ).
<code>comb.fixed</code>	A logical indicating whether a fixed effect meta-analysis should be conducted.
<code>comb.random</code>	A logical indicating whether a random effects meta-analysis should be conducted.
<code>prediction</code>	A logical indicating whether prediction intervals should be printed.
<code>reference.group</code>	Reference group.
<code>baseline.reference</code>	A logical indicating whether results should be expressed as comparisons of other treatments versus the reference treatment (default) or vice versa. This argument is only considered if <code>reference.group</code> has been specified.
<code>all.treatments</code>	A logical or value "NULL". If TRUE, matrices with all treatment effects, and confidence limits will be printed.
<code>details</code>	A logical indicating whether further details for individual studies should be printed.
<code>ma</code>	A logical indicating whether summary results of meta-analysis should be printed.
<code>logscale</code>	A logical indicating whether results for summary measures 'RR', 'OR', 'HR', or 'PLN' will be printed on logarithmic scale.
<code>header</code>	A logical indicating whether information on title of meta-analysis, comparison and outcome should be printed at the beginning of the printout.
<code>digits</code>	Minimal number of significant digits, see <code>print.default</code> .
<code>warn</code>	A logical indicating whether the use of <code>summary.meta</code> in connection with <code>metacum</code> or <code>metainf</code> should result in a warning.
<code>...</code>	Additional arguments.

### Value

A list is returned by the function `summary.netmeta` with the following elements:

<code>comparison</code>	Results for pairwise comparisons (a list with elements <code>TE</code> , <code>seTE</code> , <code>lower</code> , <code>upper</code> , <code>z</code> , <code>p</code> , <code>level</code> , <code>df</code> , <code>studlab</code> , <code>treat1</code> , <code>treat2</code> ).
<code>comparison.nma.fixed</code>	Results for pairwise comparisons based on fixed effect model (a list with elements <code>TE</code> , <code>seTE</code> , <code>lower</code> , <code>upper</code> , <code>z</code> , <code>p</code> , <code>level</code> , <code>df</code> , <code>studlab</code> , <code>treat1</code> , <code>treat2</code> , <code>leverage</code> ).

comparison.nma.random	Results for pairwise comparisons based on random effects model (a list with elements TE, seTE, lower, upper, z, p, level, df, studlab, treat1, treat2).
fixed	Results for fixed effect model (a list with elements TE, seTE, lower, upper, z, p, level, df).
random	Results for random effects model (a list with elements TE, seTE, lower, upper, z, p, level, df).
studies	Study labels coerced into a factor with its levels sorted alphabetically.
narms	Number of arms for each study.
k	Total number of studies.
m	Total number of pairwise comparisons.
n	Total number of treatments.
Q	Overall heterogeneity / inconsistency statistic.
df.Q	Degrees of freedom for test of heterogeneity / inconsistency.
pval.Q	P-value for test of heterogeneity / inconsistency.
I2	I-squared.
tau	Square-root of between-study variance.
Q.heterogeneity	Overall heterogeneity statistic.
df.Q.heterogeneity	Degrees of freedom for test of overall heterogeneity.
pval.Q.heterogeneity	P-value for test of overall heterogeneity.
Q.inconsistency	Overall inconsistency statistic.
df.Q.inconsistency	Degrees of freedom for test of overall inconsistency.
pval.Q.inconsistency	P-value for test of overall inconsistency.
sm	A character string indicating underlying summary measure.
ci.lab	Label for confidence interval.
comb.fixed	A logical indicating whether result for fixed effect meta-analysis should be printed.
comb.random	A logical indicating whether result for random effects meta-analysis should be printed.
prediction	A logical indicating whether prediction intervals should be printed.
seq	A character specifying the sequence of treatments.
all.treatments	A logical or value "NULL". If TRUE, matrices with all treatment effects, and confidence limits will be printed.
reference.group	Reference group.

`all.treatments` A logical or value "NULL". If TRUE, matrices with all treatment effects, and confidence limits will be printed.

`title` Title of meta-analysis / systematic review.

`call` Function call.

`version` Version of R package netmeta used to create object.

**Author(s)**

Guido Schwarzer <sc@imbi.uni-freiburg.de>

**See Also**

[netmeta](#)

**Examples**

```
data(Senn2013)

#
# Fixed effect model (default)
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD")
print(net1, ref="plac", digits=3)
summary(net1)

#
# Random effects model
#
net2 <- netmeta(TE, seTE, treat1, treat2, studlab,
               data=Senn2013, sm="MD", comb.random=TRUE)
print(net2, ref="plac", digits=3)
summary(net2)
```

---

Senn2013

*Network meta-analysis in diabetes*

---

**Description**

Network meta-analysis in diabetes comparing effects of a number of drugs on the HbA1c value.

These data are used as an example in Senn et al. (2013) and have been preprocessed for use in R package netmeta.

**Usage**

```
data(Senn2013)
```

**Format**

A data frame with the following columns:

**TE** Treatment effect  
**seTE** Standard error of treatment effect  
**treat1** Treatment 1  
**treat2** Treatment 2  
**studlab** Study label

**Details**

Treatment labels have been abbreviated:

- acar = Acarbose
- benf = Benfluorex
- metf = Metformin
- migl = Miglitol
- piog = Pioglitazone
- plac = Placebo
- rosi = Rosiglitazone
- sita = Sitagliptin
- sulf = Sulfonylurea
- vild = Vildagliptin

**Source**

Senn S, Gavini F, Magrez D, and Scheen A (2013). Issues in performing a network meta-analysis. *Statistical Methods in Medical Research*, **22**(2), 169–189. First published online 2012 Jan 3.

**See Also**

[netmeta](#)

**Examples**

```
data(Senn2013)

#
# Fixed effect model (default)
#
net1 <- netmeta(TE, seTE, treat1, treat2, studlab, data=Senn2013)
net1
net1$Q.decomp

#
# Forest plot
```

```
#
forest(net1, ref="plac")

## Not run:
#
# Comparison with reference group
#
netmeta(TE, seTE, treat1, treat2, studlab, data=Senn2013,
        reference="plac")

#
# Random effects model
#
net2 <- netmeta(TE, seTE, treat1, treat2, studlab, data=Senn2013,
               comb.random = TRUE)
net2
forest(net2, ref="plac")

## End(Not run)
```

---

smokingcessation

*Network meta-analysis of interventions for smoking cessation*

---

## Description

Network meta-analysis comparing the effects of a number of interventions for smoking cessation. These data are used as an example in Dias et al. (2013), page 651.

## Usage

```
data(smokingcessation)
```

## Format

A data frame with the following columns:

**event1** Number of events in arm 1  
**n1** Number of observations in arm 1  
**event2** Number of events in arm 2  
**n2** Number of observations in arm 2  
**event3** Number of events in arm 3  
**n3** Number of observations in arm 3  
**treat1** Treatment 1  
**treat2** Treatment 2  
**treat3** Treatment 3



**Source**

Dias S, Welton NJ, Sutton AJ, Caldwell DM, Lu G and Ades AE (2013). Evidence Synthesis for Decision Making 4: Inconsistency in networks of evidence based on randomized controlled trials. *Medical Decision Making* **33**, 641–656.

**See Also**

[pairwise](#), [metabin](#), [netmeta](#), [netgraph](#)

**Examples**

```
data(smokingcessation)

# Transform data from arm-based format to contrast-based format
# Argument 'sm' has to be used for odds ratio as summary measure; by
# default the risk ratio is used in the metabin function called
# internally.
p1 <- pairwise(list(treat1, treat2, treat3),
               event=list(event1, event2, event3),
               n=list(n1, n2, n3),
               data=smokingcessation,
               sm="OR")

p1

# Conduct network meta-analysis
net1 <- netmeta(p1)
net1

# Draw network graph
netgraph(net1, points=TRUE, cex.points=3, cex=1.25)
tname <- c("No intervention", "Self-help", "Individual counselling", "Group
counselling")
netgraph(net1, points=TRUE, cex.points=3, cex=1.25, labels=tname)
```

---

Woods2010

*Count statistics of survival data*


---

**Description**

Count mortality statistics in randomised controlled trials of treatments for chronic obstructive pulmonary disease (Woods et al. (2010), Table 1).

**Usage**

```
data(Woods2010)
```

**Format**

A data frame with the following columns:

**author** First author / study name

**treatment** Treatment

**r** Number of deaths in treatment arm

**N** Number of patients in treatment arm

**Source**

Woods BS, Hawkins N, Scott DA (2010). Network meta-analysis on the log-hazard scale, combining count and hazard ratio statistics accounting for multi-arm trials: A tutorial. *BMC Medical Research Methodology* **10**, 54.

**See Also**

[pairwise](#), [metabin](#), [netmeta](#)

**Examples**

```
data(Woods2010)

# Transform data from long arm-based format to contrast-based format
# Argument 'sm' has to be used for odds ratio as summary measure; by
# default the risk ratio is used in the metabin function called
# internally.
p1 <- pairwise(treatment, event = r, n = N,
               studlab = author, data = Woods2010, sm = "OR")
p1

# Conduct network meta-analysis
net1 <- netmeta(p1)
net1

## Not run:
# Show forest plot
forest(net1, ref = "Placebo", drop = TRUE,
       leftlabs = "Contrast to Placebo")

## End(Not run)
```

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