

# Package ‘Harman’

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**Type** Package

**Title** The removal of batch effects from datasets using a PCA and constrained optimisation based technique

**Version** 1.2.0

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**Description** Harman is a PCA and constrained optimisation based technique that maximises the removal of batch effects from datasets, with the constraint that the probability of overcorrection (i.e. removing genuine biological signal along with batch noise) is kept to a fraction which is set by the end-user.

**NeedsCompilation** yes

**Suggests** HarmanData, BiocGenerics, BiocStyle, knitr, rmarkdown, RUnit, RColorBrewer, bladderbatch, limma, minfi, lumi, msmsEDA, affydata, minfiData, sva

**Depends** R (>= 3.3)

**Imports** Rcpp (>= 0.11.2), graphics, stats

**LinkingTo** Rcpp

**License** GPL-3 + file LICENCE

**LazyData** true

**biocViews** BatchEffect, Microarray, MultipleComparison, PrincipalComponent, Normalization, Preprocessing, DNAMethylation, Transcription, Software, StatisticalMethod

**VignetteBuilder** knitr

**URL** <http://www.bioinformatics.csiro.au/harman/>

**BugReports** <https://github.com/JasonR055/Harman/issues>

**RoxygenNote** 5.0.1

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arrowPlot	<i>PCA before and after arrow plot for harman results</i>
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### Description

Generates an arrow plot for an instance of `harmanresults`. The tail of the arrow is the starting point (original) in principle coordinates, while the arrow head is the new point (corrected) in principle coordinates. It can be observed that on principle components that have undergone correction (`codeharmanresults$stats$correction < 1.0`), the samples within a batch will be coordinately moved towards 0 on that principle component.

### Usage

```
arrowPlot(harmanresults, pc_x = 1, pc_y = 2, colBy = "batch",
          palette = "rainbow", col, length = 0.1, legend = TRUE, ...)
```

### Arguments

<code>harmanresults</code>	an instance of <code>harmanresults</code> .
<code>pc_x</code>	integer, principle component for the plot x dimension.
<code>pc_y</code>	integer, principle component for the plot y dimension.
<code>colBy</code>	string, colour the points by the experimental or batch variable; legal values are <code>expt</code> and <code>batch</code> . The palette function specified in <code>palette</code> is used. This parameter is overridden by <code>col</code> .
<code>palette</code>	string, the function to call to create a vector of contiguous colours with the levels of factor in <code>colBy</code> steps.
<code>col</code> ,	colour vector for the points. This parameter overrides <code>palette</code> .
<code>length</code>	length of the <code>arrow</code> heads, default is 0.1.
<code>legend</code>	logical, whether to display a legend on the plot
<code>...</code>	further arguments passed to or from other methods.

**Details**

Generates a Principle Component plot for an instance of `harmanresults`. If a vector of colours is supplied via the `col` argument, then a legend will not be drawn.

**Value**

None

**See Also**

[harmanresults](#) [plot.harmanresults](#)

**Examples**

```
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
arrowPlot(olf.harman, pc_x=2, pc_y=3, length=0.2)
```

---

callHarman

*Wrapper function to call the shared C/C++ library code*

---

**Description**

This wrapper should probably not be addressed directly except for debugging. Instead use [harman](#). Input of PCA scores and the experiment structure (treatments and batches) and returns a batch corrected version of the PCA scores matrix

**Usage**

```
.callHarman(pc_data_scores, group, limit, numrepeats, randseed, forceRand,
  printInfo)
```

**Arguments**

<code>pc_data_scores</code>	2D NumericMatrix of PCA scores data (from the <code>prcomp</code> \$ <code>x</code> slot), rows = samples, cols = PC scores
<code>group</code>	The structure of the experiment, consisting of batch numbers and treatment numbers forming 2 rows or columns ( <code>HarmanMain</code> works out which). Each entry for a sample describes what batch it came from and what treatment it was given. Has to be integer formatted data.
<code>limit</code>	A double precision value indicating the limit of confidence in which to stop removing a batch effect
<code>numrepeats</code>	The number of repeats in which to run the simulated batch mean distribution estimator. Probably should be greater than 100,000.
<code>randseed</code>	Random seed to pass to the random number generator (0 for use default from system time)
<code>forceRand</code>	Force algorithm
<code>printInfo</code>	Print update information to screen

**Value**

```
SEXP R list: scores.corrected = harman_res_list["corrected_scores"]
correction = harman_res_list["correction"]
confidence = harman_res_list["confidence"]
```

**Note**

A data matrix with samples in columns must be transposed before PCA analysis and these scores in turn are tweaked a little before handing over to `.callHarman`. See the example below.

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detachHarman	<i>Detach the Harman package and its shared C/C++ library code</i>
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---

**Description**

A helper function that can be called if `harman` had to be aborted.

**Usage**

```
detachHarman()
```

**Value**

None

---

harman	<i>Harman batch correction method</i>
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---

**Description**

Harman is a PCA and constrained optimisation based technique that maximises the removal of batch effects from datasets, with the constraint that the probability of overcorrection (i.e. removing genuine biological signal along with batch noise) is kept to a fraction which is set by the end-user (Oytam et al, 2016; <http://dx.doi.org/10.1186/s12859-016-1212-5>).

Harman expects unbounded data, so for example, with HumanMethylation450 arrays do not use the Beta statistic (with values constrained between 0 and 1), instead use the logit transformed M-values.

**Usage**

```
harman(datamatrix, expt, batch, limit = 0.95, numrepeats = 100000L,
       randseed, forceRand = FALSE, printInfo = FALSE)
```

## Arguments

<code>datamatrix</code>	matrix or <code>data.frame</code> , the data values to correct with samples in columns and data values in rows. Internally, a <code>data.frame</code> will be coerced to a matrix. Matrices need to be of type <code>integer</code> or <code>double</code> .
<code>expt</code>	vector or factor with the experimental variable of interest (variance to be kept).
<code>batch</code>	vector or factor with the batch variable (variance to be removed).
<code>limit</code>	numeric, confidence limit. Indicates the limit of confidence in which to stop removing a batch effect. Must be between 0 and 1.
<code>numrepeats</code>	integer, the number of repeats in which to run the simulated batch mean distribution estimator using the random selection algorithm. (N.B. 32 bit Windows versions may have an upper limit of 300000 before catastrophic failure)
<code>randseed</code>	integer, the seed for random number generation.
<code>forceRand</code>	logical, to enforce Harman to use a random selection algorithm to compute corrections. Force the simulated mean code to use random selection of scores to create the simulated batch mean (rather than full explicit calculation from all permutations).
<code>printInfo</code>	logical, whether to print information during computation or not.

## Details

The `datamatrix` needs to be of type `integer` or `numeric`, or alternatively a `data.frame` that can be coerced into one using `as.matrix`. The matrix is to be constructed with data values (typically microarray probes or sequencing counts) in rows and samples in columns, much like the ‘`assayData`’ slot in the canonical Bioconductor `eSet` object, or any object which inherits from it. The data should have normalisation and any other global adjustment for noise reduction (such as background correction) applied prior to using Harman. For converge, the number of simulations, `numrepeats` parameter should probably be at least 100,000. The underlying principle of Harman rests upon PCA, which is a parametric technique. This implies Harman should be optimal when the data is normally distributed. However, PCA is known to be rather robust to very non-normal data.

## Value

A `harmanresults` S3 object.

## References

Oytam et al (2016) BMC Bioinformatics 17:1. DOI: 10.1186/s12859-016-1212-5

## See Also

[harman](#), [reconstructData](#), [pcaPlot](#), [arrowPlot](#)

## Examples

```
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
plot(olf.harman)
olf.data.corrected <- reconstructData(olf.harman)
```

```
## Reading from a csv file
datafile <- system.file("extdata", "NPM_data_first_1000_rows.csv.gz",
package="Harman")
infofile <- system.file("extdata", "NPM_info.csv.gz", package="Harman")
datamatrix <- read.table(datafile, header=TRUE, sep=",", row.names="probeID")
batches <- read.table(infofile, header=TRUE, sep=",", row.names="Sample")
res <- harman(datamatrix, expt=batches$Treatment, batch=batches$Batch)
arrowPlot(res, 1, 3)
```

---

harmanresults

*Harman results object*


---

## Description

The S3 object returned after running [harman](#).

## Details

`harmanresults` is the S3 object used to store the results from [harman](#). This object may be presented to summary and data exploration functions such as [plot.harmanresults](#) and [summary.harmanresults](#) as well as the [reconstructData](#) function which creates a corrected matrix of data with the batch effect removed.

## Slots

`factors` A data.frame of the expt and batch vectors.

`parameters` The harman runtime parameters. See [harman](#) for details.

`stats` Confidence intervals and the degree of correction for each principal component.

`center` The centering vector returned by [prcomp](#) with `center=TRUE`.

`rotation` The matrix of eigenvectors (by column) returned from [prcomp](#).

`original` The original PC scores returned by [prcomp](#).

`corrected` The harman corrected PC scores.

## See Also

[harman](#), [reconstructData](#), [pcaPlot](#), [arrowPlot](#)

## Examples

```
## HarmanResults
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(as.matrix(olf.data), expt, batch)
plot(olf.harman)
summary(olf.harman)
pcaPlot(olf.harman, pc_x=2, pc_y=3)
pcaPlot(olf.harman, pc_x=2, pc_y=3, colBy='expt', pch=1)
olf.data.corrected <- reconstructData(olf.harman)
```

---

harmanScores	<i>A Principal components prcomp function tweaked for Harman</i>
--------------	--

---

**Description**

A tweaking of `stats::prcomp` such that for the `svd`, the transpose of `u` is used instead of `v` when the number of assays is less than the number of samples.

**Usage**

```
harmanScores(x)
```

**Arguments**

`x` matrix, data matrix of values to perform PCA on.

**Value**

scores, a `prcomp`-like object with rotation, scores and the center values. The scores are corrected, but all three are needed later to reconstruct the data.

---

pcaPlot	<i>PCA plot for harman results</i>
---------	------------------------------------

---

**Description**

Generates a Principle Component plot for an instance of [harmanresults](#).

**Usage**

```
pcaPlot(harmanresults, pc_x = 1, pc_y = 2, this = "corrected",
        colBy = "batch", pchBy = "expt", palette = "rainbow", legend = TRUE,
        col, pch, ...)
```

**Arguments**

<code>harmanresults</code>	An instance of <code>harmanresults</code> .
<code>pc_x</code>	integer, principle component for the plot x dimension.
<code>pc_y</code>	integer, principle component for the plot y dimension.
<code>this</code>	string, legal values are <code>original</code> or <code>corrected</code> .
<code>colBy</code>	string, colour the points by the experimental or batch variable; legal values are <code>expt</code> and <code>batch</code> . The palette function specified in <code>palette</code> is used. This parameter is overridden by <code>col</code> .
<code>pchBy</code>	string, point-type by the experimental or batch variable; legal values are <code>expt</code> and <code>batch</code> . This parameter is overridden by <code>pch</code> .
<code>palette</code>	string, the function to call to create a vector of contiguous colours with the levels of factor in <code>colBy</code> steps.
<code>legend</code>	logical, whether to display a legend on the plot.

col,	colour vector for the points. This parameter overrides colBy and palette.
pch,	integer vector giving the point type. This parameter overrides pchBy.
...	further arguments passed to or from other methods.

### Details

If a vector of colours is supplied via the col argument, then a legend will not be drawn.

### Value

None

### See Also

[harmanresults](#) [plot.harmanresults](#)

### Examples

```
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(as.matrix(olf.data), expt, batch)
pcaPlot(olf.harman)
pcaPlot(olf.harman, colBy='expt')
pcaPlot(olf.harman, pc_x=2, pc_y=3, this='original', pch=17)
```

---

plot.harmanresults     *Plot method for harman*

---

### Description

Plot method for instances of [harmanresults](#).

### Usage

```
## S3 method for class 'harmanresults'
plot(x, ...)
```

### Arguments

x	An instance of harmanresults.
...	further plotting parameters.

### Value

None

### See Also

[harmanresults](#) [pcaPlot](#)



**Examples**

```
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
plot(olf.harman)
```

prcompPlot

*PCA plot***Description**

Generates a Principle Component plot for data.frames, matrices, or a pre-made [prcomp](#) object.

**Usage**

```
prcompPlot(object, pc_x = 1, pc_y = 2, scale = FALSE, colFactor = NULL,
           pchFactor = NULL, palette = "rainbow", legend = TRUE, ...)
```

**Arguments**

object	data.frame, matrix or prcomp object.
pc_x	integer, principle component for the plot x dimension.
pc_y	integer, principle component for the plot y dimension.
scale	logical, whether to scale to unit variance before PCA.
colFactor	factor or vector, colour the points by this factor, default is NULL.
pchFactor	factor or vector, point-type by this factor, default is NULL.
palette	string, the function to call to create a vector of contiguous colours with <code>levels(colFactor)</code> steps.
legend	logical, whether to display a legend on the plot.
...	further arguments passed to or from other methods.

**Details**

A data.frame object will be coerced internally to a matrix. Matrices must be of type double or integer. The prcompPlot function will then perform a principle component analysis on the data prior to plotting. The function is call is `prcomp(t(object), retx=TRUE, center=TRUE, scale.=scale)`. Instead of specifying a data.frame or matrix, a pre-made prcomp object can be given to prcompPlot. In this case, care should be taken in setting the appropriate value of scale.. If a vector is given to colFactor or pchFactor, they will be coerced internally to factors.

For the default NULL values of colFactor and pchFactor, all colours will be black and circles the point type, respectively.

**Value**

None

**See Also**

[prcomp rainbow](#)

**Examples**

```
library(HarmanData)
data(IMR90)
expt <- imr90.info$Treatment
batch <- imr90.info$Batch
prcompPlot(imr90.data, colFactor=expt)
pca <- prcomp(t(imr90.data), scale.=TRUE)
prcompPlot(pca, 1, 3, colFactor=batch, pchFactor=expt, palette='topo.colors',
main='IMR90 PCA plot of Dim 1 and 3')
```

---

```
print.summary.harmanresults
```

*Printing Harmanresults summaries.*

---

**Description**

Print method for `summary.harmanresults`.

**Usage**

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

**Arguments**

`x` an object of class `summary.harmanresults`, usually, a result of a call to `summary.harmanresults`.  
`...` further parameters.

**Value**

Prints summary information from an object of class `summary.harmanresults`.

---

```
reconstructData
```

*Reconstruct corrected data from Harman results*

---

**Description**

Method which reverts the PCA factorisation for instances of `harmanresults`. This allows the original or corrected data to be returned back from the PCA domain into the original data domain.

**Usage**

```
reconstructData(object, this = "corrected")
```

**Arguments**

object            An instance of harmanresults.  
this              string, legal values are original or corrected.

**Value**

matrix of data

**See Also**

[harman](#) [harmanresults](#)

**Examples**

```
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
olf.data.corrected <- reconstructData(olf.harman)
```

---

shiftBetas

*Shift beta values from 0 and 1 to avoid infinite M values*

---

**Description**

A convenience function for methylation data.

**Usage**

```
shiftBetas(betas, shiftBy = 1e-04)
```

**Arguments**

betas            matrix, beta values.  
shiftBy         numeric, the amount to shift values of 0 and 1 by.

**Value**

None

**Examples**

```
betas <- seq(0, 1, by=0.05)
range(betas)
newBetas <- shiftBetas(betas, shiftBy=1e-4)
newBetas
range(newBetas)
```

summary.harmanresults *Summarizing harman results.*

---

**Description**

Summary method for class [harmanresults](#).

**Usage**

```
## S3 method for class 'harmanresults'  
summary(object, ...)
```

**Arguments**

object	An object of class harmanresults.
...	further parameters.

**Value**

Returns an object of class summary.harmanresults.

**See Also**

[harmanresults](#)

**Examples**

```
library(HarmanData)  
data(OLF)  
expt <- olf.info$Treatment  
batch <- olf.info$Batch  
olf.harman <- harman(olf.data, expt, batch)  
summary(olf.harman)
```

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