

# Package ‘qch’

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**Title** Query Composed Hypotheses

**Version** 1.0.0

**Description** Provides functions for the joint analysis of  $K$  sets of  $p$ -values obtained for a same list of items. This joint analysis is performed by querying a composed hypothesis, i.e. an arbitrary complex combination of simple hypotheses, as described in Mary-Huard et al. (2021) <arXiv:2104.14601>. The null distribution corresponding to the composed hypothesis of interest is obtained by fitting non-parametric mixtures models (one for each of the simple hypothesis of the complex combination). Type I error rate control is achieved through Bayesian False Discovery Rate control. The 3 main functions of the package `GetHinfo()`, `qch.fit()` and `qch.test()` correspond to the 3 steps for querying a composed hypothesis (composed  $H_0/H_1$  formulation, inferring the null distribution and testing the null hypothesis).

**License** GPL-3

**Depends** R (>= 2.10)

**Imports** graphics, ks, mclust, stats

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.1.1

**NeedsCompilation** no

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FastKerFdr	<i>FastKerFdr</i>
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### Description

FastKerFdr

### Usage

FastKerFdr(Pval, p0 = NULL, plotting = FALSE, NbKnot = 1e+05, tol = 1e-05)

### Arguments

Pval	a vector of p-values (corresponding to a p-value serie)
p0	a priori proportion of H0 hypotheses
plotting	boolean, should some diagnostic graphs be plotted. Default is FALSE.
NbKnot	The (maximum) number of knot for the kde procedure. Default is 1e5
tol	a tolerance value for convergence. Default is 1e-5

### Value

A list of 3 objects. Object p0 is an estimate of the proportion of H0 hypotheses., tau is the vector of H1 posteriors. fl is a numeric vector, each coordinate  $i$  corresponding to the evaluation of the H1 density at point  $p_i$ , where  $p_i$  is the  $i$ th p-value in Pval.

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GetHinfo	<i>Generate H0/H1 configurations and specify the ones corresponding to the composed H1</i>
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### Description

Generate H0/H1 configurations and specify the ones corresponding to the composed H1

### Usage

GetHinfo(Q, AtLeast, Consecutive = FALSE)

**Arguments**

Q	number of test series to be combined
AtLeast	How many H1 hypotheses at least for the item to be of interest ?
Consecutive	Should the significant test series be consecutive ? Default=FALSE

**Value**

A list of two objects 'Hconfig' and 'Hconfig.H1'. Hconfig is the list of all possible combination of H0 and H1 hypotheses among Q hypotheses tested. Hconfig.H1 is the vector of components of Hconfig that correspond to the 'AtLeast' specification.

**See Also**

[GetHinfoEqual\(\)](#)

**Examples**

```
GetHinfo(4,2)
```

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GetHinfoEqual	<i>Generate H0/H1 configurations and specify the ones corresponding to the composed H1</i>
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**Description**

Generate H0/H1 configurations and specify the ones corresponding to the composed H1

**Usage**

```
GetHinfoEqual(Q, Equal, Consecutive = FALSE)
```

**Arguments**

Q	number of test series to be combined
Equal	How many H1 hypotheses exactly for the item to be of interest ?
Consecutive	Should the significant test series be consecutive ? Default=FALSE

**Value**

A list of two objects 'Hconfig' and 'Hconfig.H1'. Hconfig is the list of all possible combination of H0 and H1 hypotheses among Q hypotheses tested. Hconfig.H1 is the vector of components of Hconfig that correspond to the 'Equal' specification.

**See Also**

[GetHinfo\(\)](#)

**Examples**

```
GetHinfoEqual(4,2)
```

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PvalSets

*Synthetic example to illustrate the main qch functions*

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**Description**

PvalSets is a data.frame with 10,000 rows and 3 columns. Each row corresponds to an item, columns 'Pval1' and 'Pval2' each correspond to a test serie over the items, and column 'Class' provides the truth, i.e. if item  $i$  belongs to class 1 then the H0 hypothesis is true for the 2 tests, if item  $i$  belongs to class 2 (resp. 3) then the H0 hypothesis is true for the first (resp. second) test only, and if item  $i$  belongs to class 4 then both H0 hypotheses are false (for the first and the second test).

**Usage**

```
PvalSets
```

**Format**

```
A data.frame
```

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qch.fit

*Infer Hconfig posteriors*

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**Description**

Infer Hconfig posteriors

**Usage**

```
qch.fit(pValMat, Hconfig, plotting = FALSE)
```

**Arguments**

pValMat            a matrix of p-values, each column corresponding to a p-value serie.  
Hconfig            an Hconfig list as generated by the [GetHinfo\(\)](#) function.  
plotting           a boolean. Should some diagnostic graphs be plotted ? Default is FALSE.

**Value**

A list of 2 objects 'prior' and 'posterior'. Object 'prior' is a vector of estimated prior probabilities for each of the H-configurations. Object 'posterior' is a matrix providing for each item (in row) its posterior probability to belong to each of the H-configurations (in columns).

**Examples**

```

data(PvalSets)
PvalMat <- as.matrix(PvalSets[,-3])
## Build the Hconfig objects
Q <- 2
AtLeast <- 2
Hconfig <- GetHinfo(Q,AtLeast)$Hconfig

## Run the function
res.fit <- qch.fit(PvalMat,Hconfig)

## Display the prior of each class of items
res.fit$prior

## Display the first posteriors
head(res.fit$posterior)

```

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qch.test

*Perform composed hypothesis testing with FDR control*


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**Description**

Perform composed hypothesis testing with FDR control

**Usage**

```
qch.test(posterior, Hconfig.H1, Alpha = 0.05)
```

**Arguments**

posterior	a matrix of posterior probabilities for each item to belong the different H-configurations, as provided by the <code>qch.fit()</code> function.
Hconfig.H1	a list of H1 config, as created by the <code>GetHinfo()</code> function.
Alpha	the nominal Type I error rate for FDR control.

**Value**

A list of 2 objects 'Rejection' and 'lFDR'. Object 'Rejection' is a vector providing for each item the result of the composed hypothesis test, after multiple testing correction. Object 'lFDR' is a vector providing for each item its local FDR estimate.

**Examples**

```

data(PvalSets)
PvalMat <- as.matrix(PvalSets[,-3])
Truth <- PvalSets[,3]

## Build the Hconfig objects

```

```
Q <- 2
AtLeast <- 2
Hconfig <- GetHinfo(Q,AtLeast)$Hconfig
Hconfig.H1 <- GetHinfo(Q,AtLeast)$Hconfig.H1

## Infer the posteriors
res.fit <- qch.fit(PvalMat,Hconfig)

## Run the test procedure with FDR control
res.test <- qch.test(res.fit$posterior,Hconfig.H1)
table(res.test$Rejection,Truth==4)
```

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