wam package: computing Word association measure

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October 28, 2015

Abstract

Contents

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1 Introduction: Indicators of word association

```
> library(wam);
```

1.1 Introduction

This package contains various functions for computing word association measure as well as a high level function for conveniently applying these functions on all the lexical types of a corpora.

Word association can serve two goals: analyzing the association strength between a word and a subcorpora or analyzing the association strength between two words. The two are modelized with the same quantitative framework: association between two words is simply the association between a word and the subcorpus made of all its cooccurrences with the other word.

1.2 Value

All association measure functions are prefixed with "wam." and return a numeric vector indicating the association strengh between the word(s) under scrutiny and subcorpus/ora.

These association measures, unless otherwise stated in the help pages of the functions, are positive when the word is over-represented ("attracted"), and negative when the word is under-represented.

In absolute value, the more the word is over-representend or under-represented, the more the association measure givien is high.

1.3 Arguments

All association measure functions have the following signature: (N, n, K, k), where:

1. N is the total size of the corpora
2. n is the size of the subcorpora
3. K is the total frequency of the form under scrutiny in the corpora
4. k is the sub-frequency of the form under scrutinty in the subcorpora

This can be easily turn into the "contingency table" representation used in some presentation (according to Stefan Evert UCS documentation) :

	word	$\neg word$	T
subcorpus	11	12	R1
$\neg subcorpus$	21	22	R2
Totals	C1	C2	N

where :

- N = total words in corpus (or subcorpus or restriction, but they are not implemented yet)
- C1 = frequency of the collocate in the whole corpus
- C2 = frequency of words that aren't the collocate in the corpus
- R1 = total words in window
- R2 = total words outside of window
- 11 = how many of collocate there are in the window
- 12 = how many words other than the collocate there are in the window (calculated from row total)
- 21 = how many of collocate there are outside the window
- 22 = how many words other than the collocate there are outside the window

Conversion from N, n, K, k notation :

	word	$\neg word$	T
subcorpus	k	$n-k$	n
$\neg subcorpus$	$K-k$	$N-K-(n-k)$	$N-n$
Totals	K	$N-K$	N

Conversion to N, n, K, k notation :

- $N = N$
- $n = O11 + O12$
- $K = O11 + O21$
- $k = O11$

  See the functions make.contingency and make.list for an easy way of doing these conversions.

1.4 Recycling arguments

For all functions arguments are recycled.

2 The indicators

2.1 Introduction

All word association functions will be illustrated with data from the robespierre dataset. We will consider the subfrequency of the lexical types *peuple* in a subcorpora containing the fourth discourse by Robespierre. Is this type over- or under-represented in this discouse, according to its frequency in the corpus of all the discourses?

```
> data(robespierre, package="wam")
> head(robespierre)
```

```
  types parts   k     N    K    n
1    de    D1 464 61449 3173 8395
2    la    D1 365 61449 2788 8395
3   les    D1 281 61449 2123 8395
4    et    D1 227 61449 1708 8395
5    le    D1 200 61449 1351 8395
6     l    D1 188 61449 1287 8395
```

```
> peuple_D4 <- robespierre[robespierre$types=="peuple" & robespierre$parts == "D4",]
> peuple_D4
```

```
     types parts  k     N   K    n
495 peuple    D4 14 61449 296 6903
```

```
> N <- peuple_D4$N
> n <- peuple_D4$n
> K <- peuple_D4$K
> k <- peuple_D4$k
```

A graph of the function is provided for all the possible values of k. The interval of the possible value of K is $[0, min(k, n)]$. (it is not possible to have more occurrences of the lexical type than the size of the subcorpus or more than the total frequency of the type in the whole corpus).

```
> maxk <- min(K,n)
> maxk
```

```
[1] 296
```

```
> allk <- 0:maxk
```

The expected subfrequency of ”peuple” in the subcorpus D4 (the fourth discourse by Robespierre) is: $K \times n/N$.

```
> expected = round(K * n / N)
> expected
```

```
[1] 33
```

A form is over-used (attracted) if the subfrequency k in the subcorpus is greater than the expected expected frequency and under-used otherwise. Here, the form *peuple* is under-represented.

2.2 Log-likelihood

See Dunning 1993.

```
> wam.loglikelihood(N, n, K, k);
```

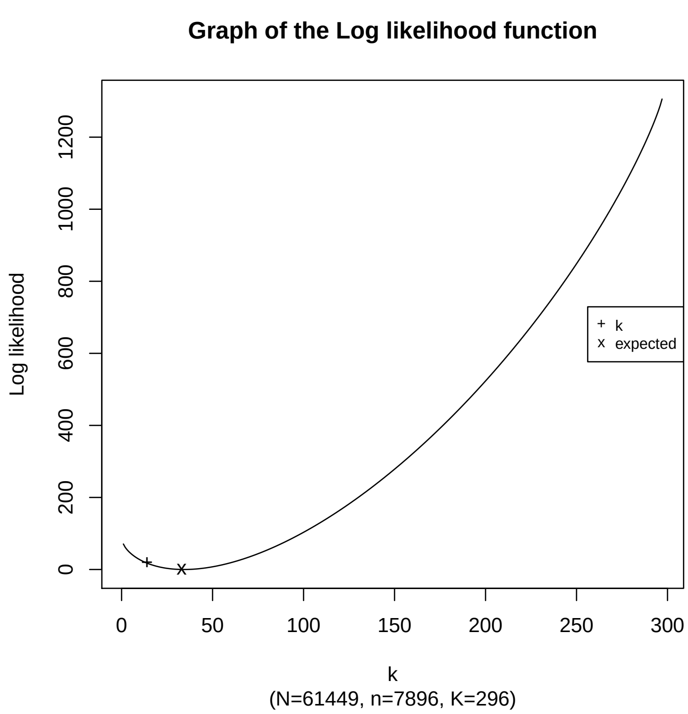
```
[1] 15.7202
```

```
> wam.loglikelihood(N, n, K, expected);
```

```
[1] 0.002162702
```

Graph of the function :

```
> plot(wam.loglikelihood(N, n, K, allk),
+      type="l", xlab="k", ylab="Log likelihood",
+           main="Graph of the Log likelihood function",
+           sub="(N=61449, n=7896, K=296)")
> points(k, wam.loglikelihood(N, n, K, k), pch="+")
> points(expected, wam.loglikelihood(N, n, K, expected), pch="x")
> legend("right",legend=c("k","expected"), pch=c("+","x"), cex=0.75)
```



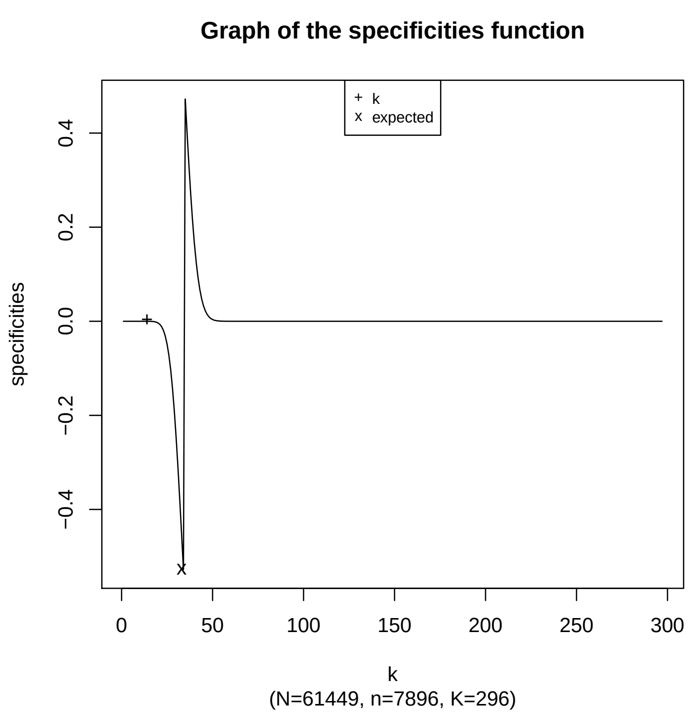
2.3 Specificities

See Lafon 1980.

```
> wam.specificities(N, n, K, k, method="base");

[1] -6.693709e-05

> wam.specificities(N, n, K, expected, method="base");

[1] -0.5276713
```

Graph of the function:

```
> plot(wam.specificities(N, n, K, allk, method="base"),
+       type="l", xlab="k", ylab="specificities",
+            main="Graph of the specificities function",
+            sub="(N=61449, n=7896, K=296)")
> points(k, wam.specificities(N, n, K, k, method="base"), pch="+")
> points(expected, wam.specificities(N, n, K, expected, method="base"), pch="x")
> legend("top",legend=c("k","expected"), pch=c("+","x"), cex=0.75)
```



2.3.1 Analysis of the specificities indicator : Standard indicator (method="base")

The presentation below follows (Lafon, 1980).

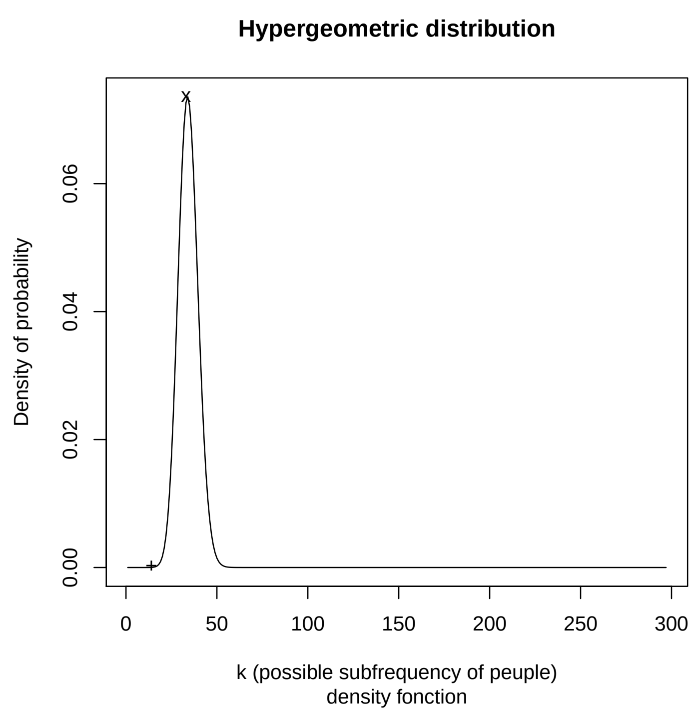
The specificities indicator is based on the hypergeometric distribution. This distribution give the probability associated with a drawing without replacement.

For all the possible subfrequencys of *peuple* in the fourth discourses we can compute the density of probability in the hypergeometric distribution. The graph contains also the observed frequency as well as the mode. The mode is the closest positive integers to the expected frequency.

```
> mode <- floor((n+1)*(K+1)/(N+2));
> mode
```

```
[1] 33
```

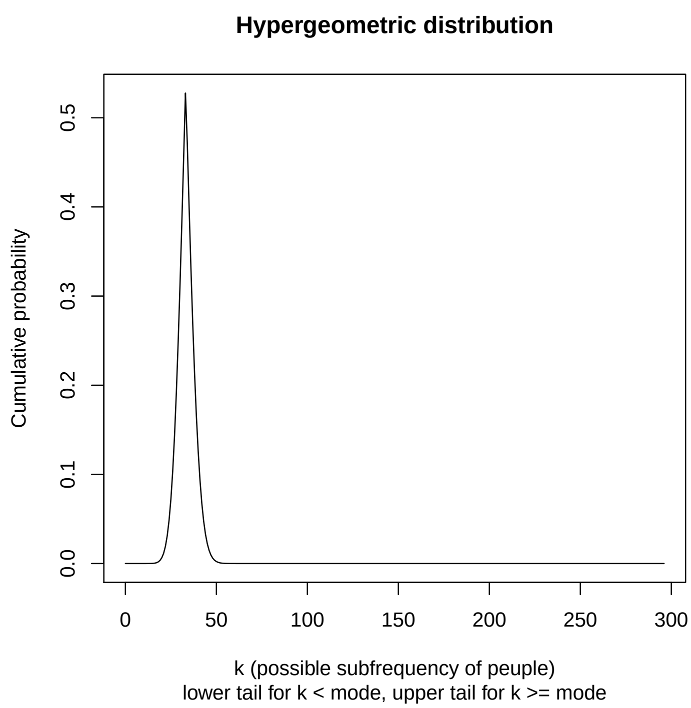
```
> plot(dhyper(allk, K, N-K, n),
+ type="l", xlab="k (possible subfrequency of peuple)", ylab="Density of probability",
+ main="Hypergeometric distribution", sub="density fonction")
> points(k, dhyper(k, K, N-K, n), pch="+")
> points(mode, dhyper(mode, K, N-K, n), pch="x")
```



If the observed frequency is less than the expected frequency, we compute the sum of the probability for a frequency lesser or equal to the observed frequency ($Prob(X \leq k)$) – that is, the cumulative probability.

If the observed frequency is greater than the expected frequency, we compute the sum of the probability for a frequency greater to the observed frequency ($Prob(X > k)$) (Lafon 1980 : 141) – that is, the cumulative probability for the upper tail of the distribution.

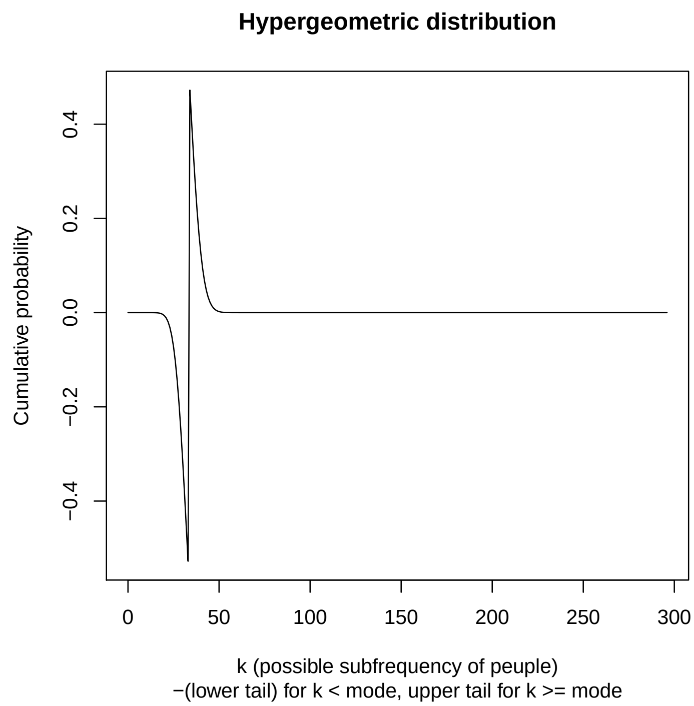
```
> y <- ifelse(allk <= mode, phyper(allk, K, N-K, n),
+                           phyper(allk-1, K, N-K, n, lower.tail=FALSE))
> plot(allk, y,
+         type="l", xlab="k (possible subfrequency of peuple)",
+         ylab="Cumulative probability",
+         main="Hypergeometric distribution",
+         sub="lower tail for k < mode, upper tail for k >= mode")
```



We add a sign: negative if the frequency is lower than expected, positive if it is greater.

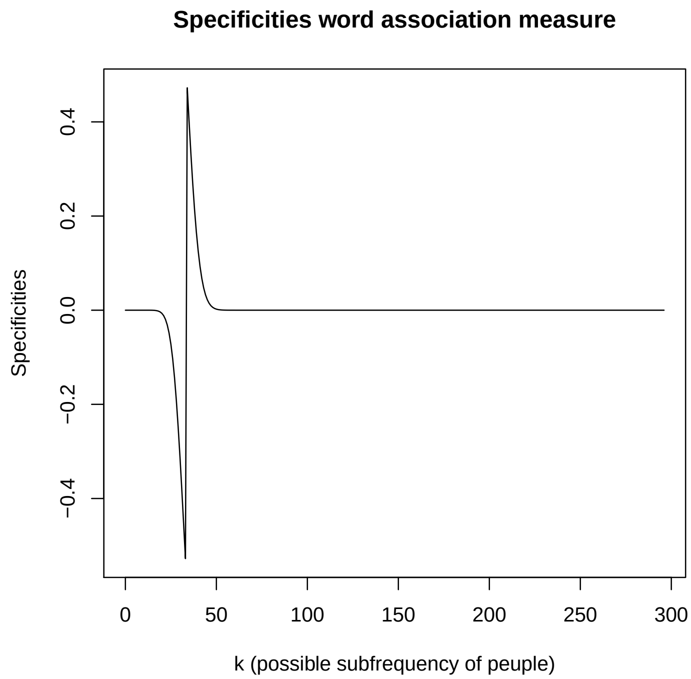
```
> y <- ifelse(allk <= mode, phyper(allk, K, N-K, n),
+                        phyper(allk-1, K, N-K, n, lower.tail=FALSE))
> y <- ifelse(allk <= mode, -y, y);
```

```
> plot(allk, y,
+         type="l", xlab="k (possible subfrequency of peuple)",
+         ylab="Cumulative probability",
+         main="Hypergeometric distribution",
+         sub="-(lower tail) for k < mode, upper tail for k >= mode")
```



It is the standard Specificities function (Lafon 1980), as implemented in the function wam.specificities with method="base" :

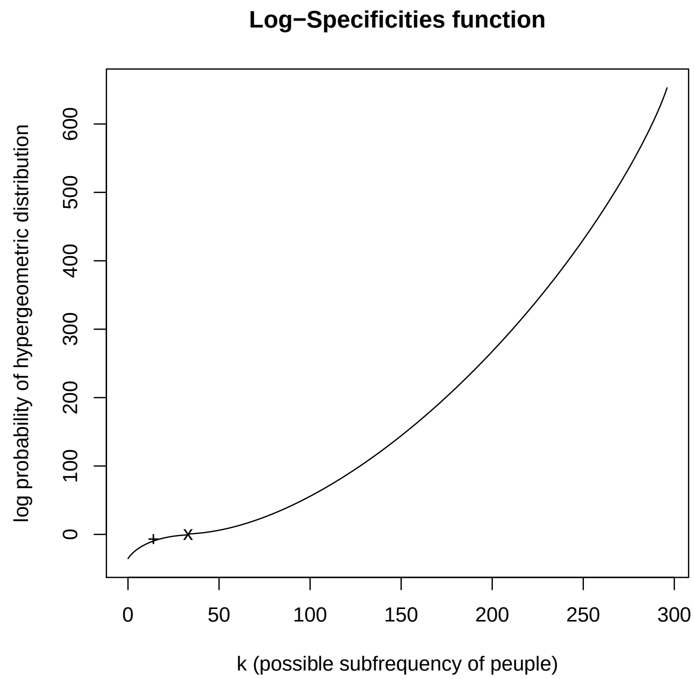
```
> plot(allk, wam.specificities(N, n, K, allk, method="base"),
+         type="l", xlab="k (possible subfrequency of peuple)",
+         ylab="Specificities",
+         main="Specificities word association measure")
```



2.3.2 Analysis of the specificities indicator : log (method="log")

In order to ease the reading, log are used:

```
> y <- ifelse(allk <= mode, phyper(allk, K, N-K, n, log.p=TRUE),
+                           phyper(allk-1, K, N-K, n, lower.tail=FALSE, log.p=TRUE))
> y <- ifelse(allk <= mode, -abs(y), abs(y));
> plot(allk, y,
+          type="l", xlab="k (possible subfrequency of peuple)",
+          ylab="log probability of hypergeometric distribution",
+          main="Log-Specificities function");
> points(k, phyper(k, K, N-K, n, log.p=TRUE), , pch="+")
> points(mode, phyper(mode, K, N-K, n, log.p=TRUE), pch="x")
```



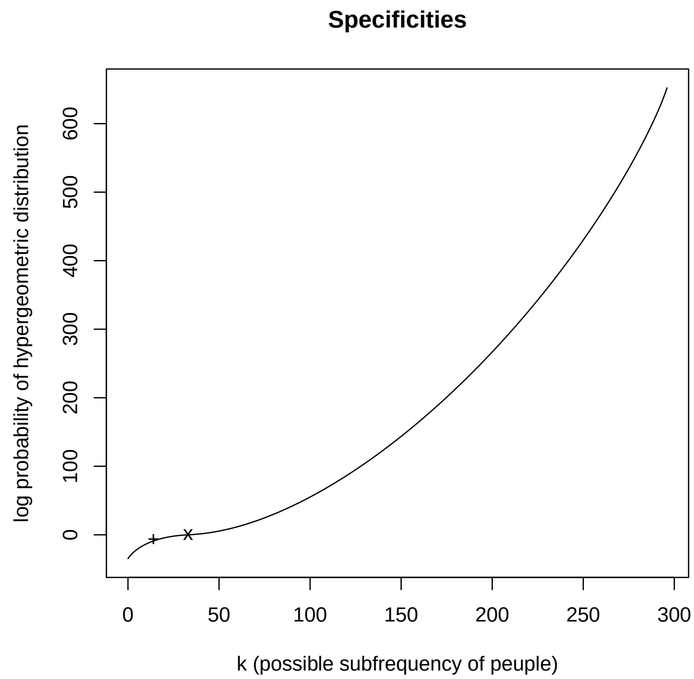
Another issue is that the mode is different from 0:

```
> phyper(mode, K, N-K, n, log.p=TRUE)
```

```
[1] -0.6392818
```

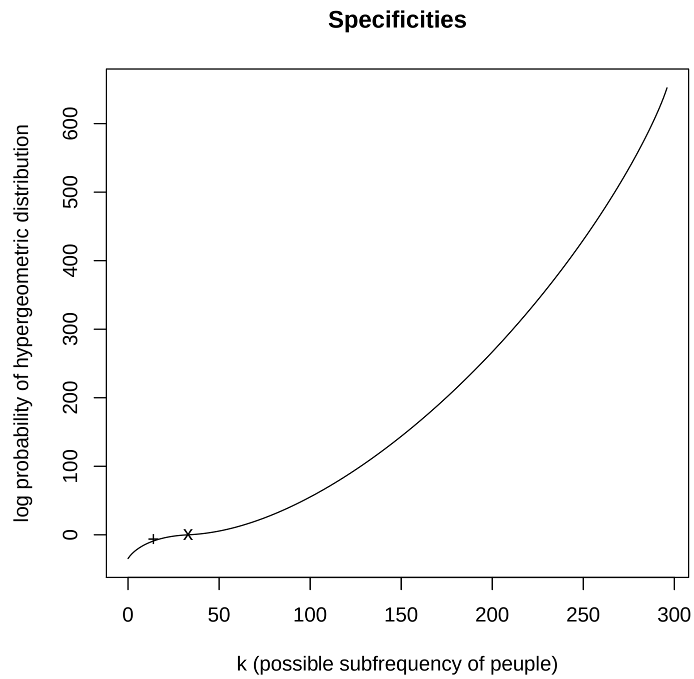
in order to have $mode = 0$, the value of the mode is substracted from all values:

```
> y <- ifelse(allk <= mode, phyper(allk, K, N-K, n, log.p=TRUE),
+                          phyper(allk-1, K, N-K, n, lower.tail=FALSE, log.p=TRUE))
> cdmo <- phyper(mode, K, N-K, n, log.p=TRUE);
> y <- ifelse(allk <= mode, -abs(cdmo-y), abs(cdmo-y));
> plot(allk, y,
+         type="l", xlab="k (possible subfrequency of peuple)",
+         ylab="log probability of hypergeometric distribution",
+         main="Specificities")
> points(k, wam.specificities(N, n, K, k, method="log"), pch="+")
> points(mode, wam.specificities(N, n, K, mode, method="log"), pch="x")
```



That is the wam.specificities function with method="log":

```
> plot(allk, wam.specificities(N, n, K, allk, method="log"),
+         type="l", xlab="k (possible subfrequency of peuple)",
+         ylab="log probability of hypergeometric distribution",
+         main="Specificities")
> points(k, wam.specificities(N, n, K, k, method="log"), pch="+")
> points(mode, wam.specificities(N, n, K, mode, method="log"), pch="x")
```



where the mode is 0 :

```
> wam.specificities(N, n, K, mode, method="log");
```

```
[1] 0
```

2.4 z

```
> wam.z(N, n, K, k);
```

```
[1] -3.338591
```

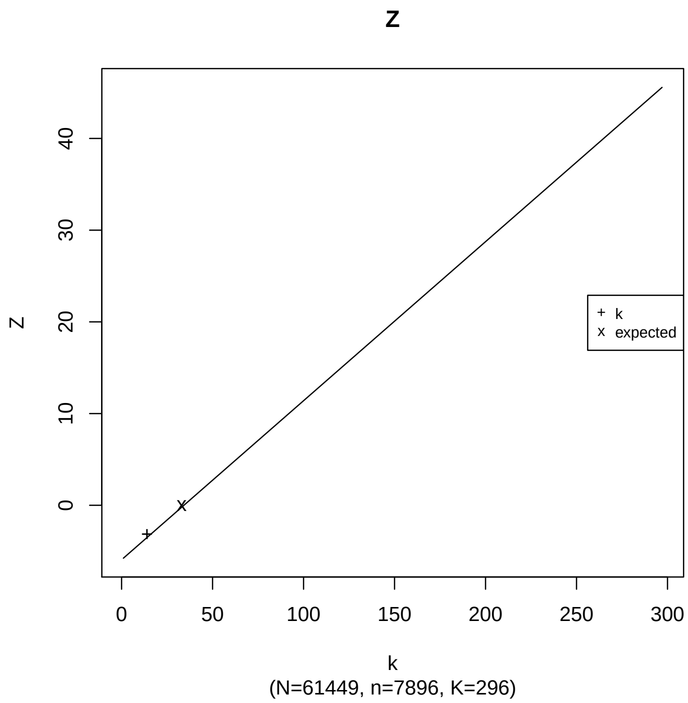
```
> wam.z(N, n, K, mode);
```

```
[1] -0.04366125
```

Graph of the function :

```
> plot(wam.z(N, n, K, allk),
+      type="l", xlab="k", ylab="Z",
+           main="Z",
+           sub="(N=61449, n=7896, K=296)")
> points(k, wam.z(N, n, K, k), pch="+")
```

```
> points(mode, wam.z(N, n, K, mode), pch="x")
> legend("right",legend=c("k","expected"), pch=c("+","x"), cex=0.75)
```



2.5 t

```
> wam.t(N, n, K, k);
```

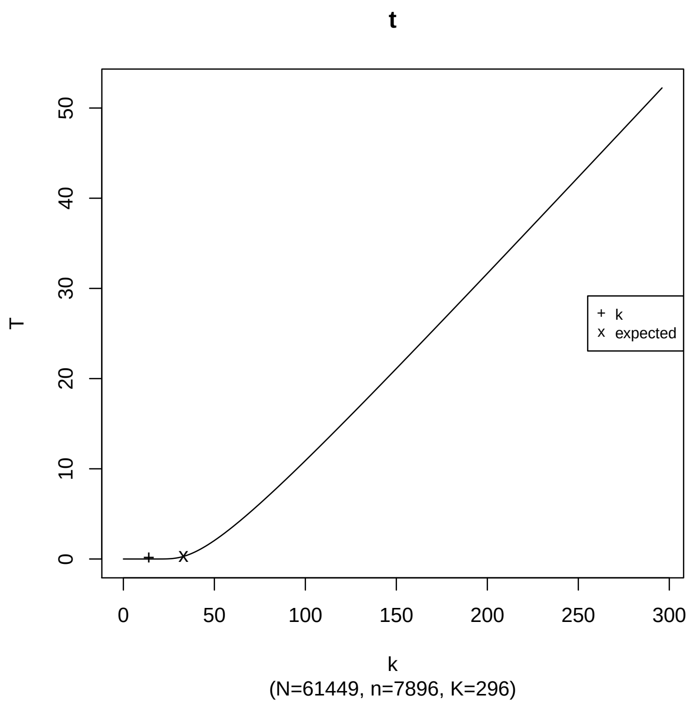
```
[1] 5.801351e-08
```

```
> wam.t(N, n, K, mode);
```

```
[1] 0.2861072
```

Graph of the function :

```
> plot(allk, wam.t(N, n, K, allk),
+       type="l", xlab="k", ylab="T",
+           main="t",
+           sub="(N=61449, n=7896, K=296)")
> points(k, wam.t(N, n, K, k), pch="+")
> points(mode, wam.t(N, n, K, mode), pch="x")
> legend("right",legend=c("k","expected"), pch=c("+","x"), cex=0.75)
```



2.6 chisq

```
> wam.chisq(N, n, K, k);
```

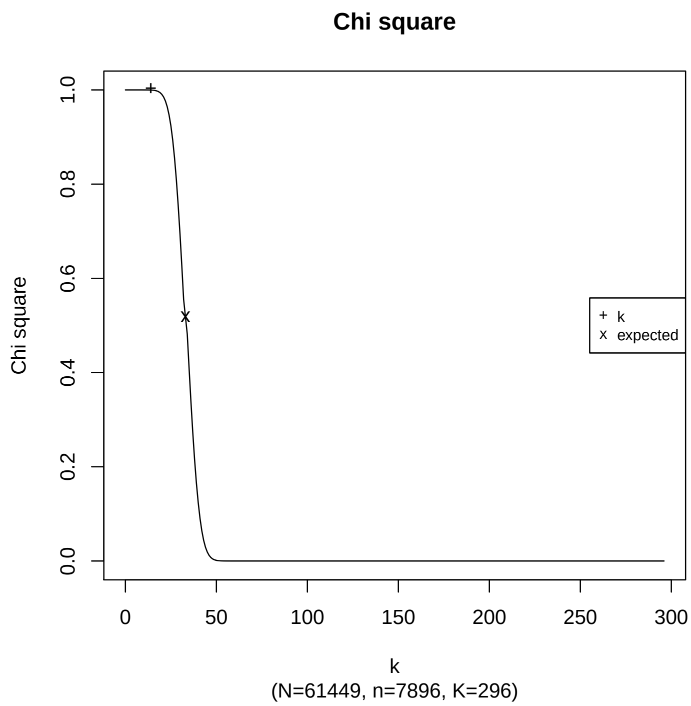
```
[1] 0.9997298
```

```
> wam.chisq(N, n, K, mode);
```

```
[1] 0.5182654
```

Graph of the function :

```
> plot(allk, wam.chisq(N, n, K, allk),
+       type="l", xlab="k", ylab="Chi square",
+            main="Chi square",
+            sub="(N=61449, n=7896, K=296)")
> points(k, wam.chisq(N, n, K, k), pch="+")
> points(mode, wam.chisq(N, n, K, mode), pch="x")
> legend("right",legend=c("k","expected"), pch=c("+","x"), cex=0.75)
```



2.7 fisher

```
> wam.fisher(N, n, K, k);
```

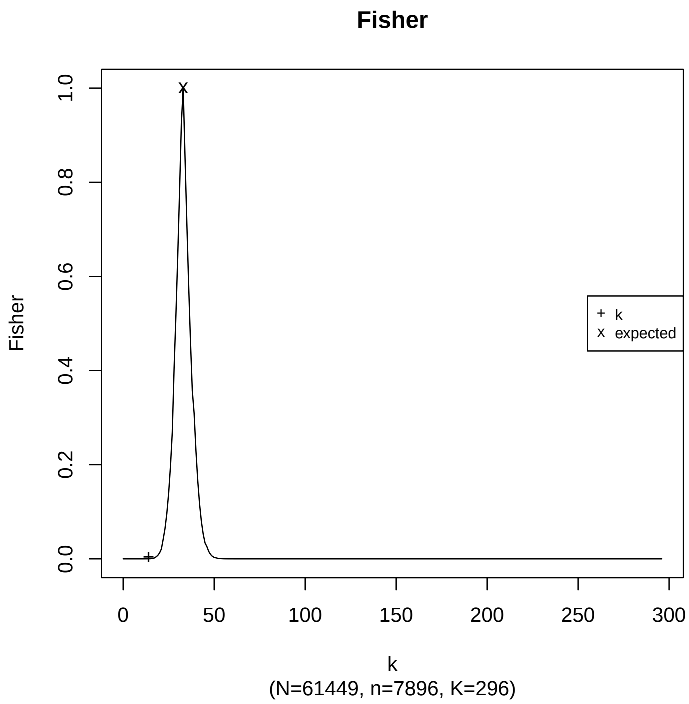
```
[1] 0.0001353407
```

```
> wam.fisher(N, n, K, expected);
```

```
[1] 1
```

Graph of the function :

```
> plot(allk, wam.fisher(N, n, K, allk),
+      type="l", xlab="k", ylab="Fisher",
+           main="Fisher",
+           sub="(N=61449, n=7896, K=296)")
> points(k, wam.fisher(N, n, K, k), pch="+")
> points(expected, wam.fisher(N, n, K, expected), pch="x")
> legend("right",legend=c("k","expected"), pch=c("+","x"), cex=0.75)
```



3 High level interface

The function *wam* provide a more high level interface to the actual functions.

This function allows for computing several indicators at the same time.

It takes also as argument the subcorpus name and lexical types.

```
> rm(list=ls())
> data(robespierre, package="wam")
> attach(robespierre)
> wam.res <- wam(N, n, K, k, measure=c("loglikelihood", "specificities"),
+ types=types, parts=parts)
```

function allows for retrieving the basic information (see the manual page for WordAssociation):

```
> head(k(wam.res));
```

```
[1] 464 365 281 227 200 188
```

```
> head(association(wam.res));
```

```
     loglikelihood specificities
[1,]     2.5758482     2.1848933
[2,]     0.8133694    -0.9840740
[3,]     0.3408187    -0.5627793
[4,]     0.2069236    -0.3991217
[5,]     1.4940429     1.4588965
[6,]     0.9787803     1.0712966
```

```
> indicator.name(wam.res)
```

```
[1] "loglikelihood" "specificities"
```

The print function allows for an easy to use reading of the results. See :

```
> wam.res <- wam(N, n, K, k, measure=c("loglikelihood", "specificities"),
+ types=types, parts=parts)
> print(wam.res, from=1, to=10, parts="D4");
```

```
Printing association measure for 1 part(s); from: 1 to: 10
Corpus size: 61449
Sorted by: loglikelihood
-----------------------------------------------------------------------------
word                | sub freq | tot freq |   loglikelihood |   specificities
-----------------------------------------------------------------------------
.............................................................................
Part name: D4
Part size: 6903 tokens.
Positive specificities printed: 10
Negative specificities printed: 0
bourdon             |       20 |       20 |           87.50 |           43.25
nous                |        3 |      430 |           79.45 |          -40.51
vous                |        6 |      424 |           63.13 |          -32.58
salut               |       33 |       91 |           39.00 |           21.12
comité             |       35 |      103 |           37.31 |           20.20
fabre               |       13 |       19 |           34.59 |           18.43
convention          |       37 |      126 |           30.52 |           16.88
public              |       32 |      108 |           26.84 |           14.98
ils                 |       21 |      419 |           20.14 |          -11.35
il                  |      105 |      605 |           20.12 |           11.70
```

4 Bibliographie

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