Elements of R usage

A. Blejec

andrej.blejec@nib.si

Nacionalni inštitut za biologijo
in
Univerza v Ljubljani
BF Oddelek za biologijo

July 31, 2010

Links

R project home page

http://www.r-project.org

Nearest repository **CRAN** (Austria)

http://cran.at.r-project.org/

Newest R version on **CRAN** (Austria)

http://cran.at.r-project.org/bin/windows/base/release.htm

Tinn-R GUI/Editor

http://www.sciviews.org/Tinn-R/

WinEdt - ASCII editor (shareware)

http://www.winedt.com/

R materials on my web page

http://ablejec.nib.si/R in http://ablejec.nib.si/ITAP

My e-mail address

andrej.blejec@nib.si

Elementary arithmetic

Operators: + − / * ^

```
> 2+3 # calculate 2+3, everything after # is a comment
[1] 5
> 2*3 # arithmetics in R: + - * /
[1] 6
> 2^3 # power
[1] 8
> sqrt(4) # Functions have arguments in brackets ()
[1] 2
> # sqrt(-4)     # kar tako ne bo šlo :
> sqrt(as.complex(-4))     # R knows complex numbers
[1] 0+2i
> sqrt(-4+0i) # same as above
[1] 0+2i
```

Rounding

```
> x <- 7/6
> round(x)
[1] 1
> round(x,3)
[1] 1.167
> floor(x)
[1] 1
> ceiling(x)
[1] 2
> format(1/2,nsmall=3)
[1] "0.500"
```

Some constants

`pi`	π
`NA`	Missing value (Not Available)
`NaN`	"not a number"
`Inf`	infinite (`1/0`)
`NULL`	empty, null value
`letters`	lower case characters
`LETTERS`	upper case characters

Functions: `is.something` in `as.something`

```
> is.na(111)
[1] FALSE
> is.numeric(111)
[1] TRUE
> as.character(111)
[1] "111"
> (x <- c(1,2,NA,NULL,5,"bla"))  # forced characters!!
[1] "1"   "2"   NA    "5"   "bla"
> is.null(x)
[1] FALSE
> is.na(x)
[1] FALSE FALSE  TRUE FALSE FALSE
```

Results can be saved as named objects

```
> x <- 2+2
> y <- 2^3
> x
[1] 4
> y
[1] 8
> ime <- x  # R is case sensitive
> IME <- y
> ls()      # list of objects
[1] "ime" "IME" "x"   "y"
```

Logical values and operators

```
> x<y      # "logical"
[1] TRUE
> x>=20    # comparison operators: < <= > >= == !=
[1] FALSE
> x!=y     # x not equal y
[1] TRUE
> z <- T   # logical constants T in F
> z
[1] TRUE
```

It is advisable to use words `TRUE` in `FALSE`

Types: numeric, logical, character, factor, ordered

```
> is.character("Text")
[1] TRUE
> is.numeric(x<y)
[1] FALSE
> as.numeric(x<y)
[1] 1
> as.character(x<y)
[1] "TRUE"
> library(chron)     # library of date functions
> apropos("date")    # speaking about date :)
 [1] "-.Date"                    "[.Date"
 [3] "[[.Date"                   "[<-.Date"
 [5] "+.Date"                    "as.character.Date"
 [7] "as.data.frame.Date"        "as.Date"
 [9] "as.Date.character"         "as.Date.date"
[11] "as.Date.dates"             "as.Date.default"
```

vector

Function combine `c(...)` combines values into a vector:

```
> c(1,2,3,10,20,4)          # values combined

[1]  1  2  3 10 20  4

> x <- c(1,2,3,10,20,4)     # vector saved to x
> x                         # type values in x

[1]  1  2  3 10 20  4

> print(x)                  # same as above,

[1]  1  2  3 10 20  4

> length(x)                 # vectors have length: n of el

[1] 6
```

Vector arithmetics

R uses arithmetic component by component

```
> y <- c(3, 4, 5, 11, 12, 13)    # še en vektor
> x
[1]  1  2  3 10 20  4
> y
[1]  3  4  5 11 12 13
> x + y                          # sum
[1]  4  6  8 21 32 17
> x * y                          # and product by components
[1]   3   8  15 110 240  52
> round(sqrt(x),2)               # functions work on component
[1] 1.00 1.41 1.73 3.16 4.47 2.00
> x < y                          # so do comparisons
[1]  TRUE  TRUE  TRUE  TRUE FALSE  TRUE
```

Reuse of short operands

If operands have different lengths, shorter one is reused.

```
> x
[1]  1  2  3 10 20  4
> x * 2              # multiply by constant
[1]  2  4  6 20 40  8
> x * c(2, -2)       # if there is not enough values, shor
[1]   2  -4   6 -20  40  -8
> rep(c(2, -2), 3) # like this
[1]  2 -2  2 -2  2 -2
```

If length of longer is not a multiple of the shorter one, we get a (**warning**)

Sequence of numbers: seq

```
> args(seq.default)          # function arguments
function (from = 1, to = 1, by = ((to - from)/(length.ou
    length.out = NULL, along.with = NULL, ...)
NULL
> 1:6                        # sequence of numbers (by = 1)
[1] 1 2 3 4 5 6
> 6:1                        # decreasing (by = -1)
[1] 6 5 4 3 2 1
> seq(1, 6, 2)               # by = 2
[1] 1 3 5
> seq(6, 1, -2)              # by = -2
[1] 6 4 2
> seq(1, 6, length=3)        # known length
[1] 1.0 3.5 6.0
```

Repeating values: `rep`

```
> rep(2,6)
[1] 2 2 2 2 2 2
> rep(c(1,2),times=3)
[1] 1 2 1 2 1 2
> rep(c(1,2),each=3)
[1] 1 1 1 2 2 2
> rep(c(1,2),length=6)
[1] 1 2 1 2 1 2
> expand.grid(1:2,1:3)
  Var1 Var2
1    1    1
2    2    1
3    1    2
4    2    2
5    1    3
6    2    3
```

Element selection

```
> (x <- c(1,2,3,1,2,4))
[1] 1 2 3 1 2 4
> x[4]          # fourth element
[1] 1
> x[3:5]        # 3., 4. in 5. element
[1] 3 1 2
> x[c(1,4,2)] # mixed positions :-)
[1] 1 1 2
> x[-1]         # don't use the first one
[1] 2 3 1 2 4
```

Changing values to selected elements

```
> x
[1] 1 2 3 1 2 4
> x[4] <- 40                    # only one element
> x
[1]  1  2  3 40  2  4
> x[3:5] <- c(33,44,55); x      # 3. do 5. element; izpis
[1]  1  2 33 44 55  4
> x[c(1,4,2)] <- 11             # replace selected values wi
> x
[1] 11 11 33 11 55  4
> x[-1] <- 22                   # change all but the first e
> x
[1] 11 22 22 22 22 22
```

Logical operations and selection

```
> x <- c(2, 6, 3, 10,  1,  2)
> y <- c(3, 4, 5, 11, 12, 13)
> x>5
[1] FALSE  TRUE FALSE  TRUE FALSE FALSE
> which(x>5)
[1] 2 4
> y[x>5]      # elements of y, corresponding to values o
[1]  4 11
```

Logical operators: `&` (and) `|` (or) in `!` (not)

```
> (x>3)|(y<2) # logical operations with vectors
[1] FALSE  TRUE FALSE  TRUE FALSE FALSE
```

Manual data typing

Finnish the entry of data with Enter in an empty line

```
z <- scan()
11
22
33
44
55
66
  <Enter>
```

```
> (z <- c(11,22,33,44,55,66)) # print assigned value not
[1] 11 22 33 44 55 66
> y
[1]  3  4  5 11 12 13
> x
[1]  2  6  3 10  1  2
```

Vector binding

```
> cbind(x,y,z)     # vectors bind as columns (c)
      x  y  z
[1,]  2  3 11
[2,]  6  4 22
[3,]  3  5 33
[4,] 10 11 44
[5,]  1 12 55
[6,]  2 13 66
> rbind(x,y,z)     # or as rows (r)
  [,1] [,2] [,3] [,4] [,5] [,6]
x    2    6    3   10    1    2
y    3    4    5   11   12   13
z   11   22   33   44   55   66
```

matrix and transpose

t(...) matrix transpose (exchange row and column indices)

```
> u <- cbind(x,y,z)
> dim(u)              # u has two dimesions (6 rows, 3 colum

[1] 6 3

> is.matrix(u)      # u is a matrix

[1] TRUE

> t(u)

  [,1] [,2] [,3] [,4] [,5] [,6]
x    2    6    3   10    1    2
y    3    4    5   11   12   13
z   11   22   33   44   55   66
```

Reshaping vector into matrix

```
> c(x,y,z)     # one long vector
 [1]  2  6  3 10  1  2  3  4  5 11 12 13 11 22 33 44 55
[18] 66

> matrix(c(x,y,z),ncol=3) # is now a matrix with 3 colum
     [,1] [,2] [,3]
[1,]    2    3   11
[2,]    6    4   22
[3,]    3    5   33
[4,]   10   11   44
[5,]    1   12   55
[6,]    2   13   66
```

Reshaping vector into matrix

```
> matrix(c(x,y,z),nrow=6) # 6 rows
     [,1] [,2] [,3]
[1,]    2    3   11
[2,]    6    4   22
[3,]    3    5   33
[4,]   10   11   44
[5,]    1   12   55
[6,]    2   13   66
> matrix(c(x,y,z),nrow=6,byrow=T) # Fill matrix by rows
     [,1] [,2] [,3]
[1,]    2    6    3
[2,]   10    1    2
[3,]    3    4    5
[4,]   11   12   13
[5,]   11   22   33
[6,]   44   55   66
```

data.frame - main stat data structure

```
> data.frame(x,y,z)    # similar as cbind
   x  y  z
1  2  3 11
2  6  4 22
3  3  5 33
4 10 11 44
5  1 12 55
6  2 13 66

> cbind(x,y,z)
      x  y  z
[1,]  2  3 11
[2,]  6  4 22
[3,]  3  5 33
[4,] 10 11 44
[5,]  1 12 55
[6,]  2 13 66

> names(cbind(x,y,z)) # cbind drops the names
NULL
```

Variable names (column names)

```
> v <- data.frame(x=x,drugi=y,z=z)     # data frame
> dimnames(v) # dimension names

[[1]]
[1] "1" "2" "3" "4" "5" "6"

[[2]]
[1] "x"     "drugi" "z"

> names(v)     # column names (variable names)

[1] "x"     "drugi" "z"

> dimnames(v)[[2]] # column names

[1] "x"     "drugi" "z"
```

read.table: read data as data.frame

```
> dbmi <- read.table("..\\data\\bmi.txt",header=T)
> head(dbmi)   # show first few lines
  id spol lroj starost visina teza
1  1    Z 1941      19  165.0 48.8
2  2    Z 1941      18  155.7 48.9
3  3    Z 1941      19  153.6 55.5
4  4    Z 1941      18  163.4 69.7
5  5    Z 1941      19  164.7 60.8
6  6    Z 1941      19  163.6 58.6
```

The richest structure: `list`

```
> w <- list("Mixed components",1:3,dva=x,mat=u)   # short
> w

[[1]]
[1] "Mixed components"

[[2]]
[1] 1 2 3

$dva
[1]  2  6  3 10  1  2

$mat
      x  y  z
[1,]  2  3 11
[2,]  6  4 22
[3,]  3  5 33
[4,] 10 11 44
[5,]  1 12 55
[6,]  2 13 66
```

`list`: component selection

Selection by position `[[...]]`

```
> w[[3]]
[1]  2  6  3 10  1  2
```

or name (`$`)

```
> w$dva
[1]  2  6  3 10  1  2
```

`list`: component selection

Also possible: `[...]`

SIngle brackets return component as `list`:

```
> w[3]

$dva
[1]  2  6  3 10  1  2

> mode(w[3]);mean(w[3])

[1] "list"

[1] NA


> w[[3]]

[1]  2  6  3 10  1  2

> mode(w[[3]]);mean(w[[3]])

[1] "numeric"

[1] 4
```

Sample selection

```
> N <- dim(dbmi)[1]
> n <- 20
> (select <- sample(1:N,n))

 [1]  166  277 1005   49  673  417  855 1115  576 1418
[11]  225  483  115  211  578  465  863  610  947  265

> data <- dbmi[select,]
> dimnames(data)

[[1]]
 [1] "166"  "277"  "1005" "49"   "673"  "417"  "855"
 [8] "1115" "576"  "1418" "225"  "483"  "115"  "211"
[15] "578"  "465"  "863"  "610"  "947"  "265"

[[2]]
[1] "id"      "spol"    "lroj"    "starost" "visina"
[6] "teza"

> dimnames(data)[[1]] <- 1:n
```

New variable

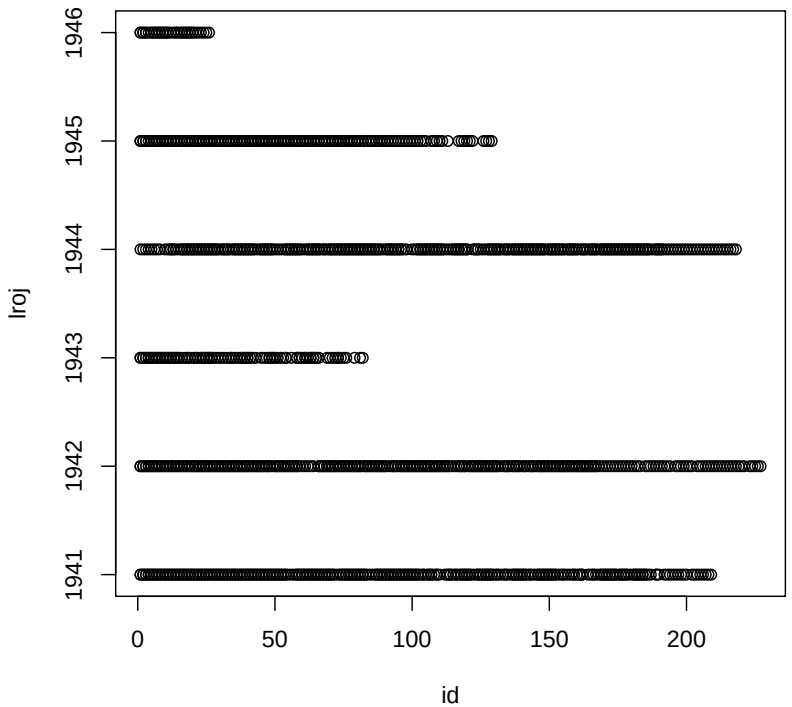
```
> attach(data)
> bmi <- teza/(visina/100)^2 # teza = weight, visina = h
> data <- cbind(data,bmi)    # new variable bmi added to
```

Sample

	id	spol	lroj	starost	visina	teza	bmi
1	183	Z	1941	19	157.0	55.6	22.55670
2	111	Z	1942	19	162.2	55.2	20.98154
3	137	M	1942	19	171.4	59.3	20.18520
4	49	Z	1941	20	170.1	65.4	22.60316
5	113	Z	1945	20	155.0	50.7	21.10302
6	41	Z	1944	20	166.3	61.1	22.09310
7	175	M	1941	19	181.5	66.2	20.09577
8	27	M	1943	20	169.5	73.0	25.40876
9	10	Z	1945	20	161.5	56.5	21.66224
10	20	M	1946	18	177.4	72.0	22.87838
11	55	Z	1942	19	166.3	53.2	19.23655
12	120	Z	1944	19	173.4	59.0	19.62248
13	126	Z	1941	19	149.9	60.5	26.92478
14	40	Z	1942	18	163.4	55.8	20.89922
15	12	Z	1945	19	167.0	53.8	19.29076
16	101	Z	1944	20	169.5	61.5	21.40601
17	185	M	1941	19	184.1	79.7	23.51531
18	46	Z	1945	20	152.8	46.7	20.00185
19	72	M	1942	19	169.8	63.5	22.02411
20	99	Z	1942	19	155.5	58.1	24.02787

`id` is repeated within a year

```
> plot(dbmi[,c("id","lroj")])
```



Light (teza)

```
> which(teza<60)

 [1]  1  2  3  5  9 11 12 14 15 18 20

> data[teza<60,]

    id spol lroj starost visina teza      bmi
1  183    Z 1941       19  157.0 55.6 22.55670
2  111    Z 1942       19  162.2 55.2 20.98154
3  137    M 1942       19  171.4 59.3 20.18520
5  113    Z 1945       20  155.0 50.7 21.10302
9   10    Z 1945       20  161.5 56.5 21.66224
11  55    Z 1942       19  166.3 53.2 19.23655
12 120    Z 1944       19  173.4 59.0 19.62248
14  40    Z 1942       18  163.4 55.8 20.89922
15  12    Z 1945       19  167.0 53.8 19.29076
18  46    Z 1945       20  152.8 46.7 20.00185
20  99    Z 1942       19  155.5 58.1 24.02787
```

Types of returned values

- single values
- `vector`
- `matrix`
- `list`

Posamezne vrednosti

Results of elementary functions are single values

```
> x <- visina <- rnorm(20,170,8)
> xBar <- mean(x)
> xBar
```

```
[1] 171.2762
```

```
> str(xBar)
```

```
 num 171
```

Intermediate results can be used in the analysis

```
> x-xBar
```

```
 [1]  15.16655001   6.00565072  -4.34805674
 [4]   8.65181935   0.30278832  -8.96655844
 [7]  13.29657158 -13.45650231   0.06145109
[10] -11.77971669   4.63303367  -0.86156690
[13]  -5.26933163   5.28075710  -5.62170120
[16]  -1.28649033   0.98040813   0.74958449
[19]  -4.44928166   0.91059145
```

vector

```
> xq <- quantile(x,seq(0,1,.25))
> xq
      0%       25%       50%       75%      100%
157.8197 166.6219 171.4584 176.0712 186.4428

> str(xq)
 Named num [1:5] 158 167 171 176 186
 - attr(*, "names")= chr [1:5] "0%" "25%" "50%" "75%" ..

> length(xq)
[1] 5
```

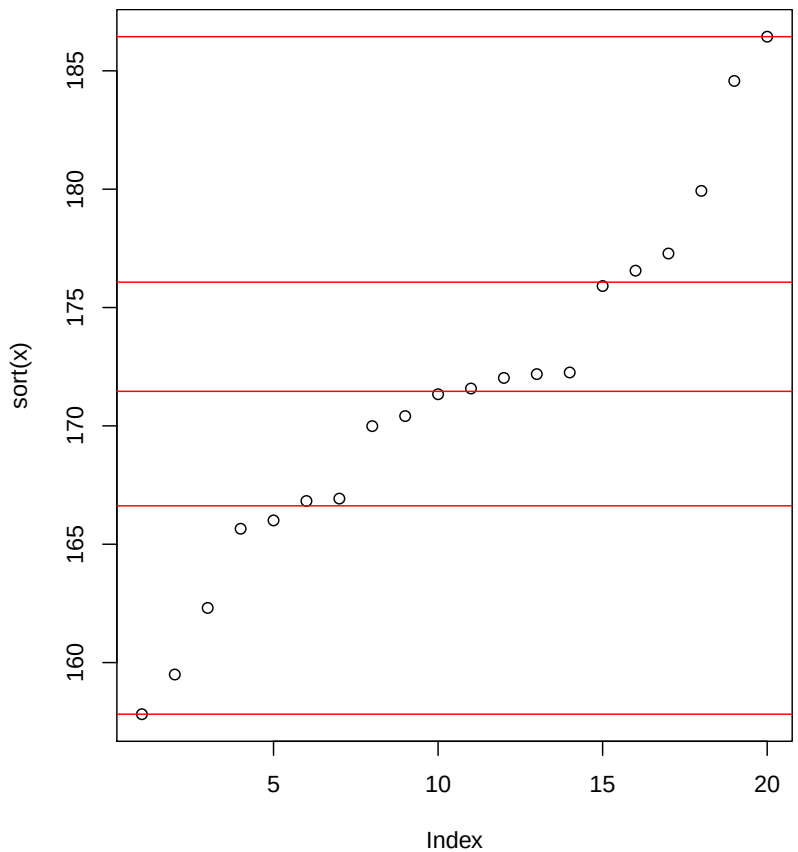
Selection of elements

Individual elements can be selected by vector of indices insquare brackets `[...]`

```
> xq[2]    # second element
     25%
166.6219
> xq[2:4] # elements 2, 3, 4 (quartiles)
     25%      50%      75%
166.6219 171.4584 176.0712
> xq[-1]   # no minimum
     25%      50%      75%     100%
166.6219 171.4584 176.0712 186.4428
```

Cutting numerical variables

```
> par(mar=c(4,4,0,2))
> plot(sort(x))
> abline(h=xq,col="red")
```



Vector use

Distribute values into classes **xq**

```
> xClass <- cut(x,xq)
> xClass
 [1] (176,186] (176,186] (167,171] (176,186] (171,176]
 [6] (158,167] (176,186] <NA>      (167,171] (158,167]
[11] (171,176] (167,171] (158,167] (176,186] (158,167]
[16] (167,171] (171,176] (171,176] (167,171] (171,176]
Levels: (158,167] (167,171] (171,176] (176,186]

> str(xClass)
 Factor w/ 4 levels "(158,167]","(167,171]",..: 4 4 2 4

> as.numeric(xClass)
 [1]  4  4  2  4  3  1  4 NA  2  1  3  2  1  4  1  2  3
[18]  3  2  3
```

Frequency table

```
> tabela <- table(xClass,spol)
> dim(tabela)
```

```
[1] 4 2
```

```
> tabela
```

```
            spol
xClass       M Z
  (158,167] 1 3
  (167,171] 2 3
  (171,176] 1 4
  (176,186] 1 4
```

Rectangular structures

- `matrix` – 2 dimensions
- `array` – 3 or more than dimensions
- `data.frame`

All elements of the same type (numbers, characters, logical), in `data.frame` columns can be of different type.

`data.frame` classical structure of stat data:
cases (units) in rows, variables in columns (same length!)

Selection from rectangular structures

Values are extracted referencing rows and columns

```
> tabela[3:4, 1]

(171,176] (176,186]
        1         1

> tabela[ -4, ]    # skip row no 4

            spol
xClass       M Z
  (158,167] 1 3
  (167,171] 2 3
  (171,176] 1 4

> tabela[ , 2]     # just column 2

(158,167] (167,171] (171,176] (176,186]
        3         3         4         4
```

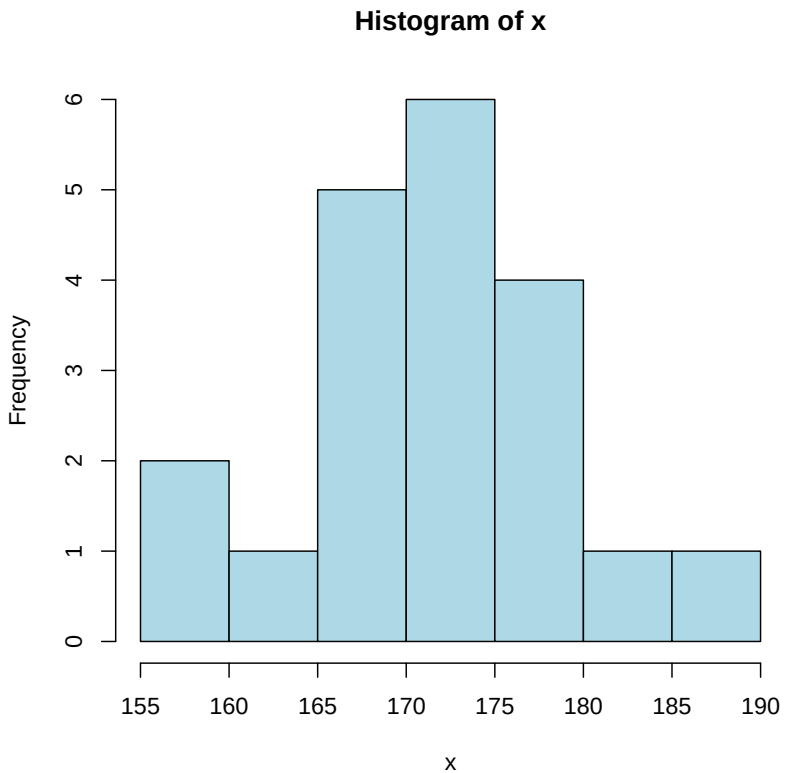
array

```
> array(letters,c(2,3,2))

, , 1

     [,1] [,2] [,3]
[1,] "a"  "c"  "e"
[2,] "b"  "d"  "f"

, , 2

     [,1] [,2] [,3]
[1,] "g"  "i"  "k"
[2,] "h"  "j"  "l"
```

list

Function **hist** returns useful information about the histogram.

```
> desc <- hist(x,col="lightblue")
```



Structure `list`

Returned values have a list structure. Why?

```
> names(desc)
```

```
[1] "breaks"      "counts"      "intensities"
[4] "density"     "mids"        "xname"
[7] "equidist"
```

```
> str(desc)
```

```
List of 7
 $ breaks     : num [1:8] 155 160 165 170 175 180 185 19
 $ counts     : int [1:7] 2 1 5 6 4 1 1
 $ intensities: num [1:7] 0.02 0.01 0.05 0.06 0.04 ...
 $ density    : num [1:7] 0.02 0.01 0.05 0.06 0.04 ...
 $ mids       : num [1:7] 158 162 168 172 178 ...
 $ xname      : chr "x"
 $ equidist   : logi TRUE
 - attr(*, "class")= chr "histogram"
```

Elements of `list`

```
> names(desc)
[1] "breaks"      "counts"      "intensities"
[4] "density"     "mids"        "xname"
[7] "equidist"
```

Select list component: referenced by name

```
> desc$counts
[1] 2 1 5 6 4 1 1
```

Select list component: referenced by component number

```
> desc[[2]]
[1] 2 1 5 6 4 1 1
```

Histogram with added polygon

Object **desc** has details needed for plotting (**class:histogram**)

```
> plot(desc,col="lightblue",main="Dopolnjen histogram")
> points(desc$mids,desc$counts,pch=16,col="red",cex=2)
> lines(desc$mids,desc$counts,col="blue",lwd=3,lty=2)
```