

# a single function version of makeVector and cachemean from the JHU Data Science Specialization on Coursera R Programming course

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available at [https://github.com/AlanBerger/R\\_Programming\\_GitHub\\_files](https://github.com/AlanBerger/R_Programming_GitHub_files)

## Motivation

The R Programming course in the Johns Hopkins University Data Science Specialization on Coursera (a 10 course sequence) covers many topics in the R Programming language, including *lexical scoping*. As part of a programming exercise involving lexical scoping, the pair of R functions, **makeVector** and **cachemean**, are made available to the class; they are publicly available within the **README.md** file in Professor Roger D. Peng's GitHub site: <https://github.com/rdpeng/ProgrammingAssignment2> A detailed description of how **makeVector** and **cachemean** work is available in an article by Leonard Greski at: [L\\_Greski\\_article](#)

A call to the **makeVector** function returns an R object that is a list of 4 functions, and also is a *function closure*, well described in Leonard Greski's article, but not referred to by that name. Function closures are also discussed in, for example, [AB\\_function\\_closure](#)

A good observation in the Discussion Forum in the JHU R Programming class noted that someone could “misuse” the **setmean** function provided by **makeVector**, replacing the current saved (*cached*) value of the mean of a given vector with an incorrect value.

The programming exercise involving **makeVector** and **cachemean** was focused on understanding lexical scoping, and not concerned at that point with producing “library quality” code that would “shield” the user from misadventure. However, I thought it an interesting exercise to write a single function that would retain the primary functionality of **makeVector** and **cachemean**, illustrate use of lexical scoping and the properties of a function closure, be simpler to use, and perhaps be a more concise demonstration of key concepts.

This function, **get\_and\_cache\_mean**, is provided below, along with sample runs. It is heavily commented, and uses long (one might say overly long) variable names to make it easier to follow.

## The get\_and\_cache\_mean function and example runs

The **get\_and\_cache\_mean** function has no argument. It codes for and returns the function **get\_the\_mean\_of\_v**

Since **get\_and\_cache\_mean** defines and returns the function **get\_the\_mean\_of\_v**, **get\_the\_mean\_of\_v** is also a *function closure* and has the capability of “retaining” variables in its parent environment, and accessing and modifying them (see the referenced articles above, or other sources on function closure). When **get\_the\_mean\_of\_v** is called,

its argument should be a non-empty numeric vector, call it `v`. `get_the_mean_of_v` calculates and returns the mean of `v`, and “stores” the calculated mean. The key point of this programming example is to use lexical scoping and the properties of a function closure so that if `get_the_mean_of_v` has been called before in the current R session, and the most recent call was with the same value of `v` as the present call, then `get_the_mean_of_v` will “fetch” the previously calculated value of the mean that was stored in the parent environment of `get_the_mean_of_v` (possible since `get_the_mean_of_v` is a function closure), rather than recalculating the mean.

If want to copy code, copy it from the Rmd (R Markdown) file, not the pdf file (copying code from a pdf file in GitHub might entrain formatting characters).

```
get_and_cache_mean <- function() {  
  # call it via:      get_the_mean_of_v <- get_and_cache_mean()  
  
  # get_and_cache_mean returns the function get_the_mean_of_v  
  # which will be a function of the argument v,  
  # and it will also be a function closure  
  
  m <- NULL # initialize the mean m of v to be NULL so  
  # know need to calculate it  
  v_for_which_calculated_the_mean <- NULL  
  # the v for which have calculated the mean, initially NULL  
  
  # define the function to be returned by get_and_cache_mean  
  
  get_the_mean_of_v <- function(v = numeric()) {  
    # calculate the mean of v, or when appropriate fetch and  
    # return the cached (saved) mean  
  
    # do some testing for whether the value that get_the_mean_of_v  
    # was called with is "admissible" for what get_the_mean_of_v  
    # is designed to do  
  
    if(is.numeric(v) == FALSE)  
      stop("the argument v of get_the_mean_of_v is not numeric")  
    if(is.vector(v) == FALSE)  
      stop("the argument v of get_the_mean_of_v is not a vector")  
    if(length(v) < 1) stop("length of v is < 1")  
    # note a variable that is a single value is, in R,  
    # a vector of length 1  
    # a matrix and a data frame are examples of R objects  
    # that are not vectors
```

```

    m_from_parent_envir <- m
#   use R's lexical scoping to acquire m

    v_from_parent_environment <- v_for_which_calculated_the_mean
#   use R's lexical scoping to acquire
#   v_for_which_calculated_the_mean

#   test whether there is a cached (saved) mean that is
#   appropriate to use

#   need to be VERY careful with any NULL values
#   use the is.null function to test a potential NULL value;
#   if have verified that
#   the value is not NULL,
#   then can do regular logical tests or arithmetic
#   on it (the length of the NULL R object is 0)
#
if(!is.null(m_from_parent_envir) && !is.null(v_from_parent_environment)) {
#   if got to here, neither is NULL, so have cached a mean
#
#   test whether the value of v used in the call to get_the_mean_of_v
#   is the one for which the cached mean has been calculated

    if(identical(v_from_parent_environment, v)) {
#       note for example c(1, 2, 3) is numeric while 1:3 is
#       the vector of integers c(1L, 2L, 3L) so they will not be
#       identical R objects
#       (even though their entries are equal numbers)

#       if pass the if test above, can use the cached (saved) mean

        message("getting cached value of the mean of v")
        return(m_from_parent_envir) # returns the cached mean
#       and exits the get_the_mean_of_v function

    } # closing brace for the if test immediately above
} # closing brace for the if test above that checks for NULL values

#   if got to here, need to calculate the mean of v
#   which is the v that is the argument of the current call
#   of get_the_mean_of_v

    v_for_which_calculated_the_mean <<- v
#       use the superassignment operator <<- to

```

```

#           update  v_for_which_calculated_the_mean
#           in the parent environment of  get_the_mean_of_v

#           the parent environment is a preserved version of
#           the "execution time" environment of
#           get_and_cache_mean

#           The R statement
#           get_the_mean_of_v <- get_and_cache_mean()
#           defines and returns the function  get_the_mean_of_v
#           and hence  get_the_mean_of_v
#           is also a "function closure"

#           As a crucial consequence of  get_the_mean_of_v  being a
#           function closure, the variables (R objects) m
#           and  v_for_which_calculated_the_mean
#           defined in the original call to  get_and_cache_mean
#           are preserved and available within the
#           parent environment of  get_the_mean_of_v
#           so available, if properly accessed, to
#           the function  get_the_mean_of_v

mean_of_v <- mean(v)  # note if v were v = numeric(),
#                     i.e., a numeric vector of length 0,
#                     its mean would be NaN
m <<- mean_of_v  # use the superassignment operator <<-
#               to cache the mean of v in the parent
#               environment of  get_the_mean_of_v

message("returning the calculated mean of v, NOT a cached value")
message("have now cached the mean of the current value of v")
return(mean_of_v)
}  # ending brace for the function  get_the_mean_of_v

}  # ending brace for the function  get_and_cache_mean

#####

# Now do some sample runs

get_the_mean_of_v <- get_and_cache_mean()
# get_the_mean_of_v  is a function and also is a function closure

v <- c(6, 7, 8)  # simple example

```

```
get_the_mean_of_v(v)
```

```
## returning the calculated mean of v, NOT a cached value
```

```
## have now cached the mean of the current value of v
```

```
## [1] 7
```

```
# check that the mean was cached in the previous
```

```
# call of get_the_mean_of_v
```

```
get_the_mean_of_v(v)
```

```
## getting cached value of the mean of v
```

```
## [1] 7
```

```
new_v <- c(1, 2, 3)
```

```
get_the_mean_of_v(new_v) # check works with new vector
```

```
## returning the calculated mean of v, NOT a cached value
```

```
## have now cached the mean of the current value of v
```

```
## [1] 2
```

```
get_the_mean_of_v(new_v) # again, check cached the mean
```

```
## getting cached value of the mean of v
```

```
## [1] 2
```

```
# note c(1, 2, 3) is numeric while 1:3 is
```

```
# the vector of integers c(1L, 2L, 3L) so they will not be
```

```
# identical R objects, and so
```

```
# get_the_mean_of_v will recalculate the mean in this case:
```

```
get_the_mean_of_v(1:3)
```

```
## returning the calculated mean of v, NOT a cached value
```

```
## have now cached the mean of the current value of v
```

```
## [1] 2
```

```
get_the_mean_of_v(1:3)  # again, check cached the mean
```

```
## getting cached value of the mean of v
```

```
## [1] 2
```

```
## the tests below will give errors and put the R session into Browse  
## (note they stop R Markdown)  
## exit Browse by hitting the Escape key
```

```
## get_the_mean_of_v("character string")  
# check non-numeric argument gets error
```

```
## matr <- matrix(1:12, 3, 4) # 3 row by 4 column matrix  
## get_the_mean_of_v(matr)  
# check argument that is not a vector gets error
```

```
## get_the_mean_of_v(numeric(0))  
# check argument that has length < 1 gets error
```

Hope this is helpful in understanding R's lexical scoping and how a function closure works.

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