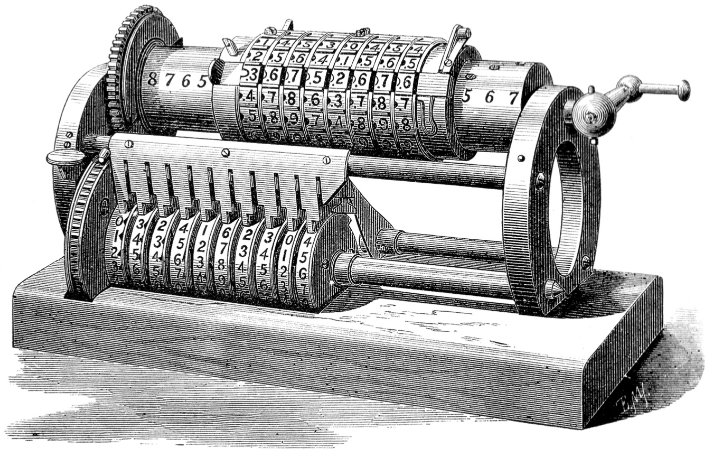
Programming in R

Binder
Herrmann



2020-12-28

Dev Track
Programming Style

Programming Style

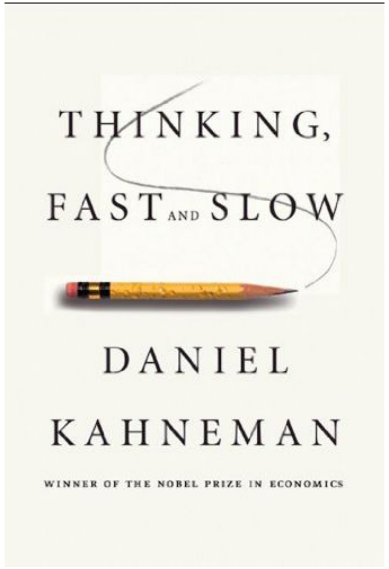
- We not only want to teach you R itself, but also how to write software well.
- **Programming Style**: Suppose you know what sequence of commands you want R to execute.
  - How should you write these commands down?
  - What formatting do you use?
  - How do you break your code up into functions?
  - How do you name these functions?

Programming Style

- The program you write will not only be read by your computer, but also by humans:
    - Other people. Even if you are not (planning to) collaborate with others, eventually you will.
        - (Unlike some physical tasks, programming naturally lends itself to division of labour. When you build a chair for yourself and your friend also wants a chair, you have to put in the same effort again. When you write a program to do your data analysis for your thesis, and your friend wants to do the same analysis, then he can just copy your code... and you better hope you wrote the program in an understandable way!)
    - The future "you".
        - Look at your calendar from a year ago and try to remember what you meant with all the different one-word entries you wrote down in a hurry.
        - Future you from a long enough time is essentially a stranger who will hate you if they can't read your code.
- Adapt your code to be readable and easily adaptable!

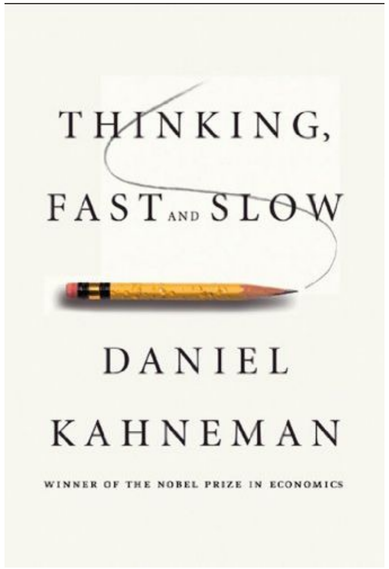
A Short Detour to Human Psychology

- Kahneman: Thinking, Fast and Slow
  - "System 1": emotional, stereotypic, unconscious, going by first appearances, fast, automatic
  - "System 2": logical, calculating, conscious effort, slow, effortful



A Short Detour to Human Psychology

- Kahneman: Thinking, Fast and Slow
  - "System 1": emotional, stereotypic, unconscious, going by first appearances, fast, automatic
  - "System 2": **logical, calculating**, conscious effort, slow, effortful
- Computers do "System 2"!
  - does not care about what your code "looks like"
  - there is no ambiguity, just does the calculation

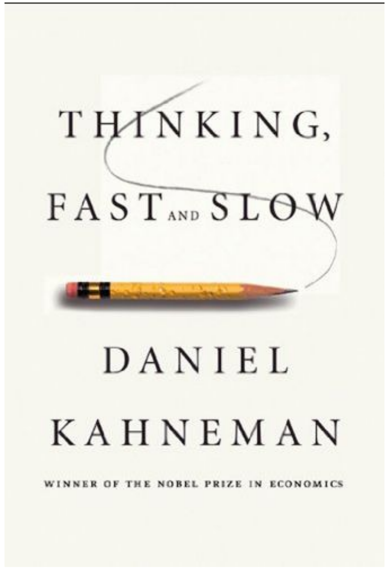


A Short Detour to Human Psychology

- Kahneman: Thinking, Fast and Slow
    - "System 1": emotional, stereotypic, unconscious, going by first appearances, fast, automatic
    - "System 2": **logical, calculating**, conscious effort, slow, effortful
- Computers do "System 2"!
    - does not care about what your code "looks like"
    - there is no ambiguity, just does the calculation

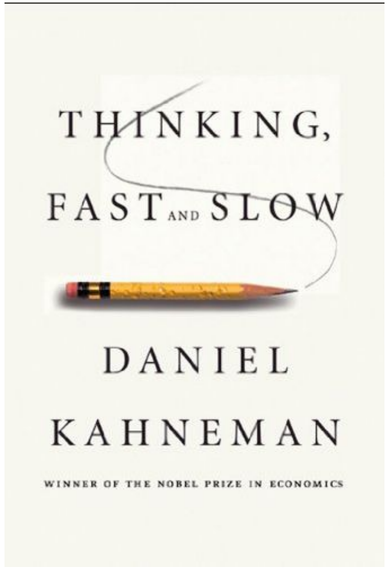
Computers have no problems with this:

```
f <- (function(f) (function(x) f(x(x)))(function(x) f(x(x))))(
  function(x) function(n) if (n < 1) 1 else n * x(n - 1))
```



A Short Detour to Human Psychology

- Kahneman: Thinking, Fast and Slow
  - "System 1": emotional, stereotypic, unconscious, going by first appearances, **fast, automatic**
  - "System 2": logical, calculating, conscious effort, slow, effortful
- Computers do "System 2"!
  - does not care about what your code "looks like"
  - there is no ambiguity, just does the calculation
- Humans prefer "System 1"!
  - judge by appearances and familiarity

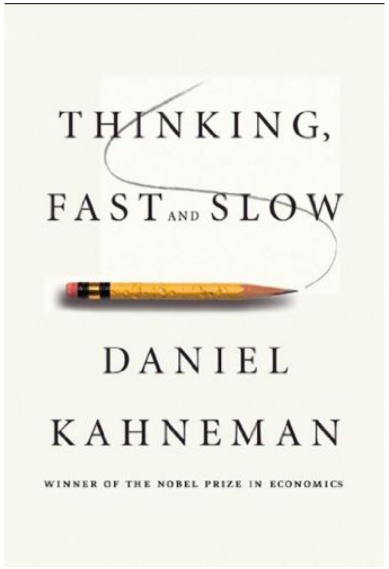


A Short Detour to Human Psychology

- Kahneman: Thinking, Fast and Slow
  - "System 1": emotional, stereotypic, unconscious, going by first appearances, **fast, automatic**
  - "System 2": logical, calculating, conscious effort, slow, effortful
- Computers do "System 2"!
  - does not care about what your code "looks like"
  - there is no ambiguity, just does the calculation
- Humans prefer "System 1"!
  - judge by appearances and familiarity

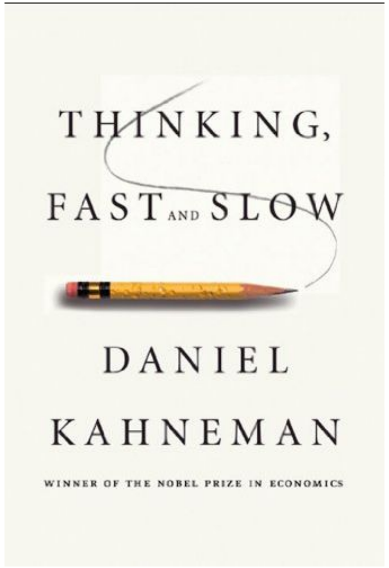
equivalent to the function two slides before:

```
factorial <- function(n) {
  if (n < 1) {
    return(1)
  } else {
    return(n * factorial(n - 1))
  }
}
```



A Short Detour to Human Psychology

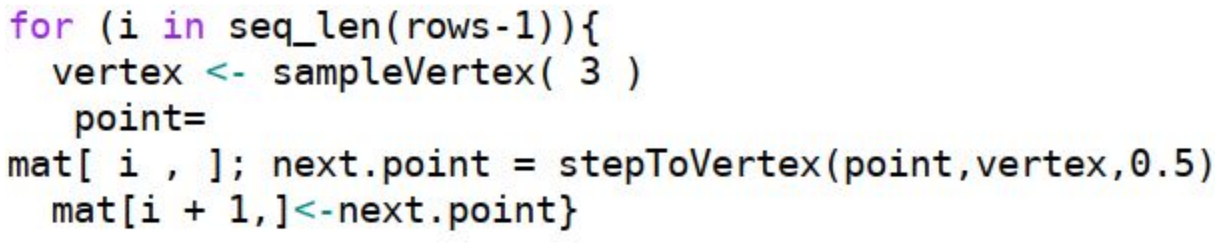
- Kahneman: Thinking, Fast and Slow
  - "System 1": emotional, stereotypic, unconscious, going by first appearances, fast, automatic
  - "System 2": logical, calculating, conscious effort, **slow, effortful**
- Computers do "System 2"!
  - does not care about what your code "looks like"
  - there is no ambiguity, just does the calculation
- Humans prefer "System 1"!
  - judge by appearances and familiarity
- Your program must satisfy both: System 2 (or the computer will not do what you want) and System 1 (Or it will be slow and effortful to understand what is happening)



Programming Style (I): Avoid Unnecessary Noise & Variation

Programming Style

Avoid unnecessary Noise & Variation

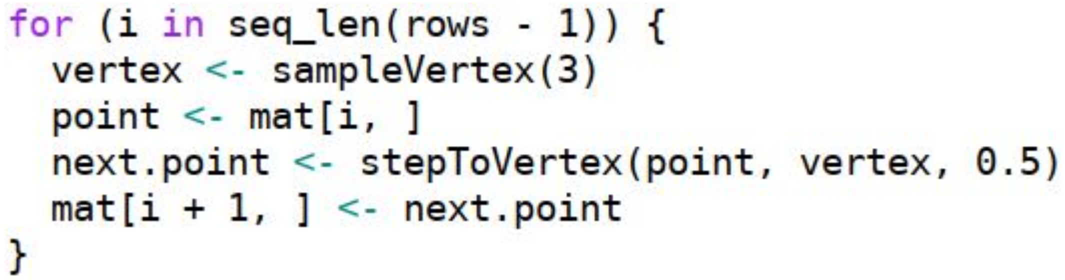


```
for (i in seq_len(rows-1)){
  vertex <- sampleVertex( 3 )
   point=
mat[ i , ]; next.point = stepToVertex(point,vertex,0.5)
  mat[i + 1,]<-next.point}
```

- Come on, it's just ugly. Have some pride in your work!

Programming Style

Avoid unnecessary Noise & Variation

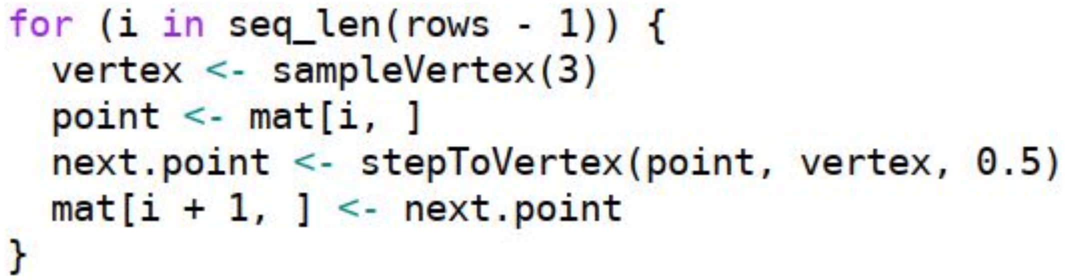


```
for (i in seq_len(rows - 1)) {
  vertex <- sampleVertex(3)
  point <- mat[i, ]
  next.point <- stepToVertex(point, vertex, 0.5)
  mat[i + 1, ] <- next.point
}
```

- Much more regular!

Programming Style

Avoid unnecessary Noise & Variation



```r
for (i in seq_len(rows - 1)) {
  vertex <- sampleVertex(3)
  point <- mat[i, ]
  next.point <- stepToVertex(point, vertex, 0.5)
  mat[i + 1, ] <- next.point
}
```

- don't write `a+b` at one point and `a + b` at another etc.
- this is sometimes referred to as "**code style**" in the narrower sense

Programming Style: Code Style

- where to put your parentheses (), braces {}, brackets []
- where to put your spaces, and how many of them
- how to name your variables and functions

Programming Style: Code Style

- where to put your parentheses (), braces {}, brackets []
- where to put your spaces, and how many of them
- how to name your variables and functions

e.g.

```
if (x == 1) {
  y <- 2
}
```

vs.

```
if(x==1)
     {
          y=2
     }
```

Programming Style: Code Style

- where to put your parentheses (), braces {}, brackets []
- where to put your spaces, and how many of them
- how to name your variables and functions

e.g.

```
if (x == 1) {
  y <- 2
}
```

vs.

```
if(x==1)
    {
        y=2
    }
```

- could both be fine as long as you are consistent
- should be chosen for easy readability, but to some degree a matter of aesthetic preferences

Programming Style: Code Style

- In this course, your code style will be **checked automatically**.
  - Your code deviates from what we dictate --> no points
  - But don't worry, the checker will give you informative feedback!

Programming Style: Code Style

- In this course, your code style will be **checked automatically**.
  - Your code deviates from what we dictate --> no points
  - But don't worry, the checker will give you informative feedback!
- We **mostly** use Google's (old) style guide:
  - Well written, short and to the point without being ambiguous
  - We add the **following alterations**:
    - Function naming: use `lowerCamel` for *functions* and `UpperCamel` for *classes* (you will see classes in a few weeks)
    - Line length: limit to 120 characters instead of 80. Welcome to the future!
    - Indentation: indent one level deeper per `{`, `(` or `[` one level up per `}`, `)` or `]`. Lines starting with closing parens get the reduced indentation level.
    - Don't use `return()` at the end of functions if you don't need to
    - Put comments describing the actions of a function *before* the function, to be consistent with roxygen2 which we will see later in the course.
    - Plus some good practices that you will find out about when checking your answers ;-)

Programming Style: Code Style

- Notable other style guides:
  - "tidyverse" style guide.
    - Mostly similar, but much more to read. Largely concerned with "tidyverse"-internal extensions to R that are a bit niche.
    - Notable difference to what we do: they use `snake_case`, while we avoid underscores in variable and function names
  - Style of the "mlr"-package
    - Not that notable in the wide scheme of things, but the Bischl group at LMU uses it, so you will probably see it at some point.
    - Prominent differences to what we (and most other people) do: uses "`=`" instead of "`<-`" (which has some drawbacks). Make integers explicit with the "`L`" suffix.
- If this interests you, there is a study on prevalence of different styles in the R community by Chia-Yi Yen et al.

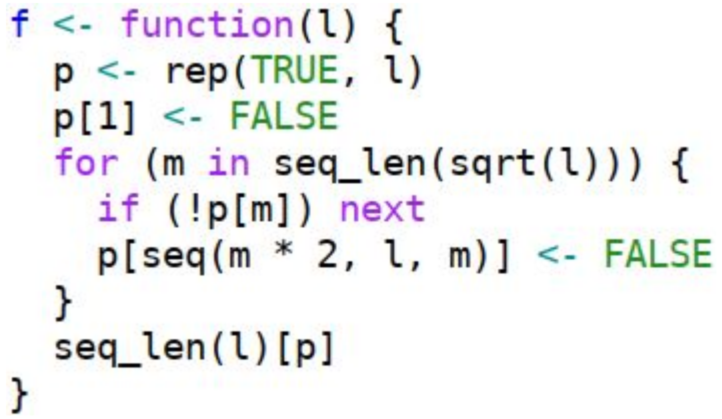
Programming Style (II):
Use All Communication Channels Available to You

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names

  Not so nice: single letters

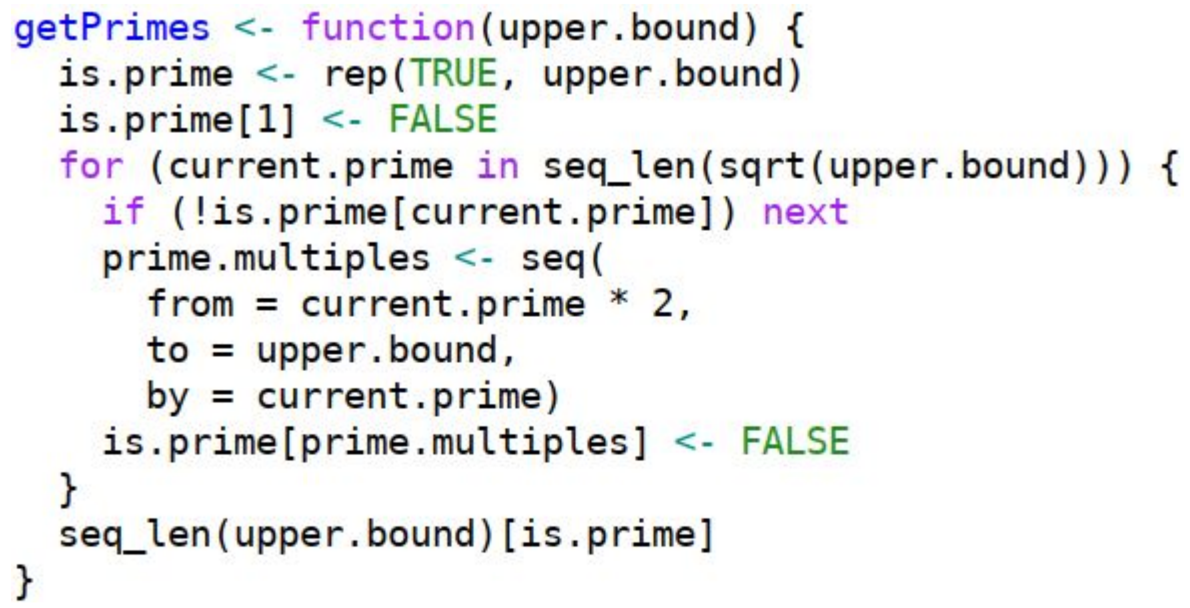


```
f <- function(l) {
  p <- rep(TRUE, l)
  p[1] <- FALSE
  for (m in seq_len(sqrt(l))) {
    if (!p[m]) next
    p[seq(m * 2, l, m)] <- FALSE
  }
  seq_len(l)[p]
}
```

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names



```r
getPrimes <- function(upper.bound) {
  is.prime <- rep(TRUE, upper.bound)
  is.prime[1] <- FALSE
  for (current.prime in seq_len(sqrt(upper.bound))) {
    if (!is.prime[current.prime]) next
    prime.multiples <- seq(
      from = current.prime * 2,
      to = upper.bound,
      by = current.prime)
    is.prime[prime.multiples] <- FALSE
  }
  seq_len(upper.bound)[is.prime]
}
```

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names

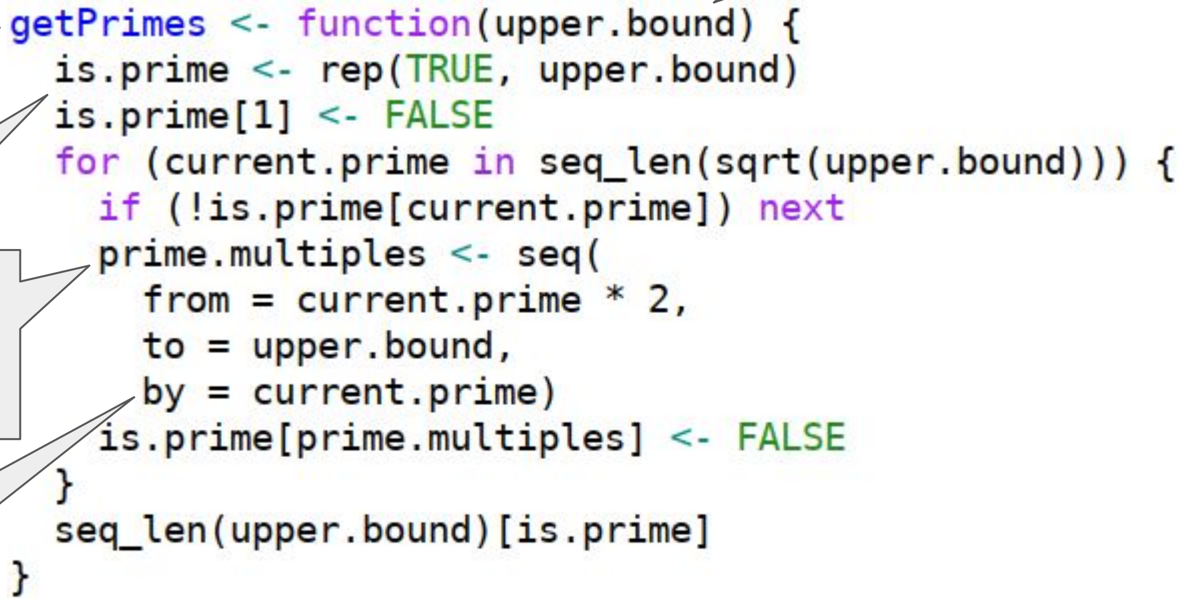
Descriptive argument name

Descriptive function name

English. Always. No exceptions.

Introduce temporary variable we didn't have before for clarity

call less-well-known positional function arguments by name



```r
getPrimes <- function(upper.bound) {
  is.prime <- rep(TRUE, upper.bound)
  is.prime[1] <- FALSE
  for (current.prime in seq_len(sqrt(upper.bound))) {
    if (!is.prime[current.prime]) next
    prime.multiples <- seq(
      from = current.prime * 2,
      to = upper.bound,
      by = current.prime)
    is.prime[prime.multiples] <- FALSE
  }
  seq_len(upper.bound)[is.prime]
}
```

Programming Style

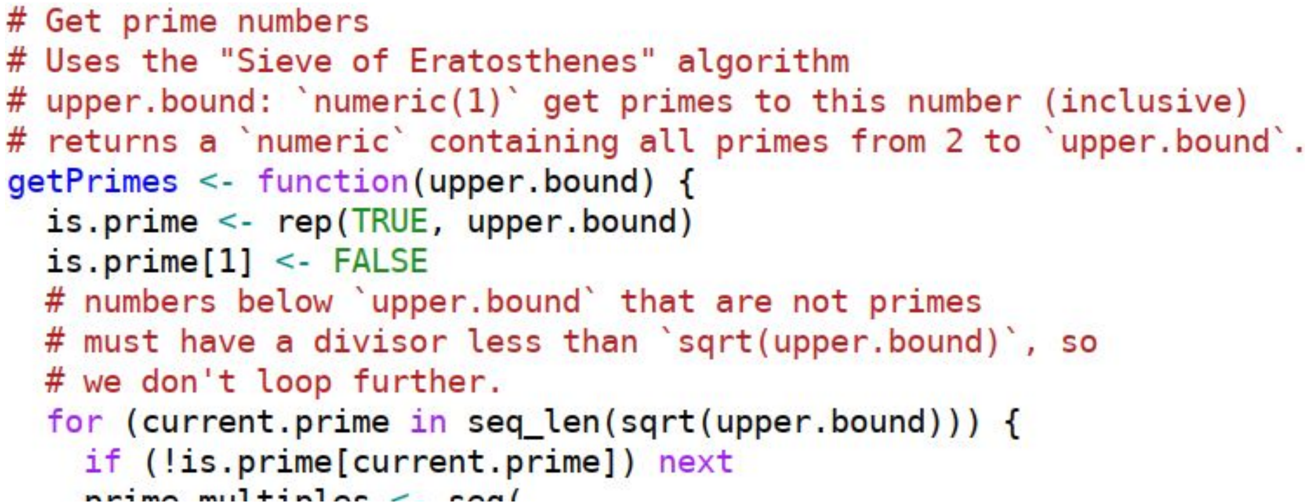
Use All Communication Channels Available to You

- Use descriptive variable / function names
  - Some further notes:
    - short variable names are fine if they are established practice. E.g. "`i`" as iterator in for-loops, "`tmp`" for temporary values.
    - avoid collisions with functions in base R or common packages. Don't call your function "`mean`" or "`ggplot`". Don't call your variable "`c`" because of collision with `c(1, 2)`!
    - avoid names that look similar, e.g. only differentiated through `1` (one) vs. `l` (lowercase L) vs. `I` (uppercase i). Even if *your* system has a font that distinguishes those, someone else's might not.
    - Keep with a pattern. The pendant to "`coord.x`" should *not* be "`y.coordinate`"
    - Consider tab-completion when naming things: names should be `<general>.<special>`. "`coord.x`" is preferred, because if someone else is editing the program and wants to get a coordinate, they enter `coord.`<tab> and can see what coordinates are available.

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names
- Use comments!



```r
# Get prime numbers
# Uses the "Sieve of Eratosthenes" algorithm
# upper.bound: `numeric(1)` get primes to this number (inclusive)
# returns a `numeric` containing all primes from 2 to `upper.bound`.
getPrimes <- function(upper.bound) {
  is.prime <- rep(TRUE, upper.bound)
  is.prime[1] <- FALSE
  # numbers below `upper.bound` that are not primes
  # must have a divisor less than `sqrt(upper.bound)`, so
  # we don't loop further.
  for (current.prime in seq_len(sqrt(upper.bound))) {
    if (!is.prime[current.prime]) next
    prime.multiples <- seq(
```

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names
- Use comments!

What does the function do?

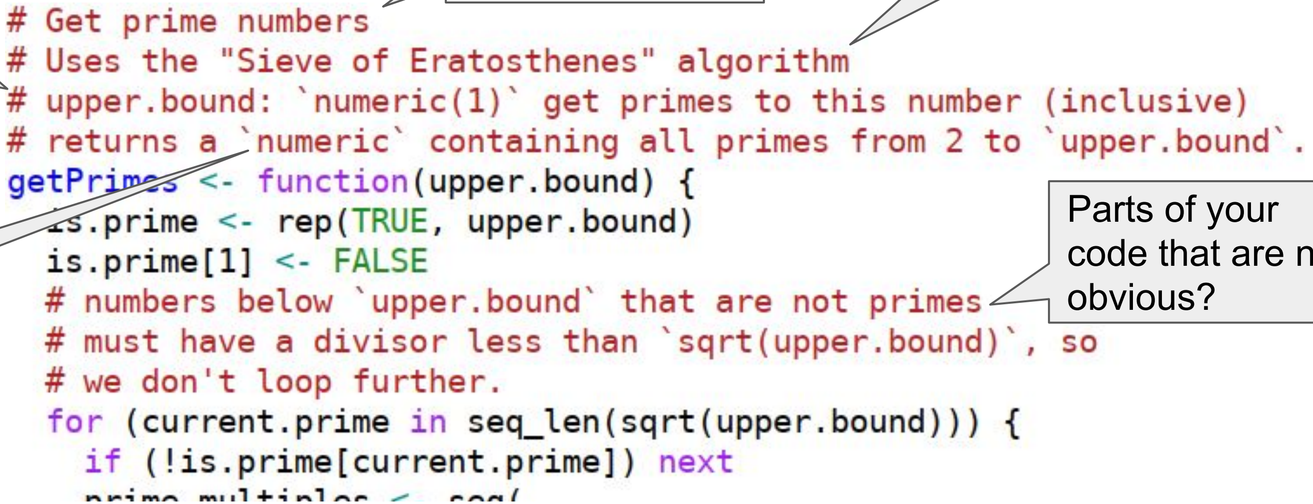
English. Always. No exceptions.

What are its arguments?

What is the return value?

What are the argument / return **types**?

Parts of your code that are not obvious?



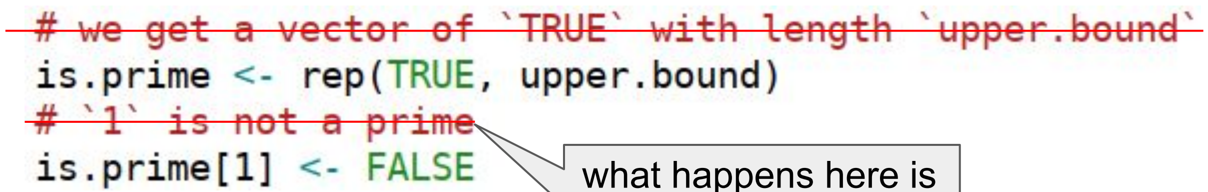
```r
# Get prime numbers
# Uses the "Sieve of Eratosthenes" algorithm
# upper.bound: `numeric(1)` get primes to this number (inclusive)
# returns a `numeric` containing all primes from 2 to `upper.bound`.
getPrimes <- function(upper.bound) {
  is.prime <- rep(TRUE, upper.bound)
  is.prime[1] <- FALSE
  # numbers below `upper.bound` that are not primes
  # must have a divisor less than `sqrt(upper.bound)`, so
  # we don't loop further.
  for (current.prime in seq_len(sqrt(upper.bound))) {
    if (!is.prime[current.prime]) next
    prime.multiples <- seq(
```

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names
- Use comments! (**but don't overdo it**)

don't just translate the code to english



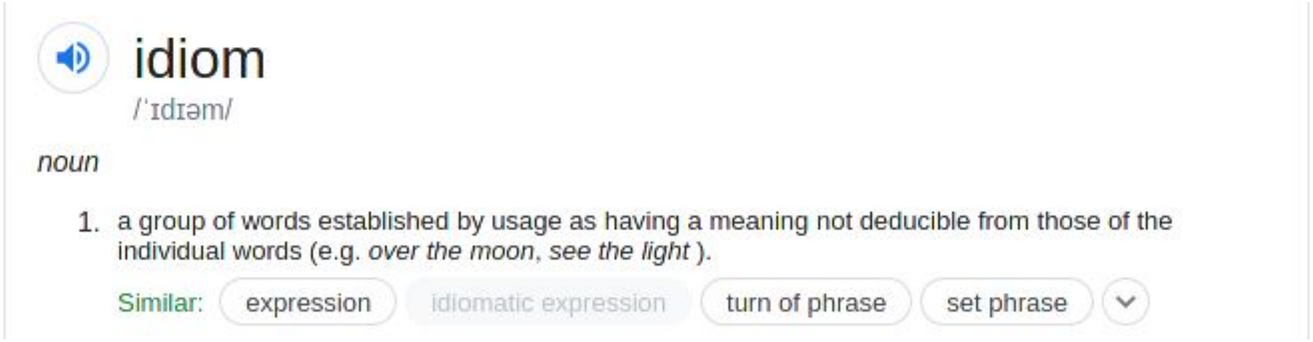
```
~~# we get a vector of `TRUE` with length `upper.bound`~~
is.prime <- rep(TRUE, upper.bound)
~~# `1` is not a prime~~
is.prime[1] <- FALSE
```

what happens here is obvious from good naming already

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names
- Use comments! (but don't overdo it)
- Make your code **idiomatic**



idiom

/ˈɪdɪəm/

noun

1. a group of words established by usage as having a meaning not deducible from those of the individual words (e.g. *over the moon*, *see the light*).

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names
- Use comments! (but don't overdo it)
- Make your code **idiomatic**
  - express it in a natural and commonly accepted way specific to the language

~~`seq_len(upper.bound)[is.prime]`~~

"what kind of trick is this?"

"I've seen this before!"

```
which(is.prime)
```

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names
- Use comments! (but don't overdo it)
- Make your code **idiomatic**
  - express it in a natural and commonly accepted way specific to the language
  - Don't be "too clever"
  - Use constructs that the reader of your code is used to from other code
  - Solve problems the way someone would expect them to be solved in R

Programming Style

Use All Communication Channels Available to You

- Use descriptive variable / function names
- Use comments! (but don't overdo it)
- Make your code **idiomatic**
  - express it in a natural and commonly accepted way specific to the language
  - Don't be "too clever"
  - Use constructs that the reader of your code is used to from other code
  - Solve problems the way someone would expect them to be solved in R
  - **This takes experience**, you will learn common idioms by reading other code

Programming Style (III): Your Audience has Tunnel Vision

Programming Style

Your Audience has Tunnel Vision

When you spent all day working on a function of course you know what is happening, but someone else should not have to spend a day to understand it

Programming Style

Your Audience has Tunnel Vision

Your code should be understandable

- without needing to see many lines at once

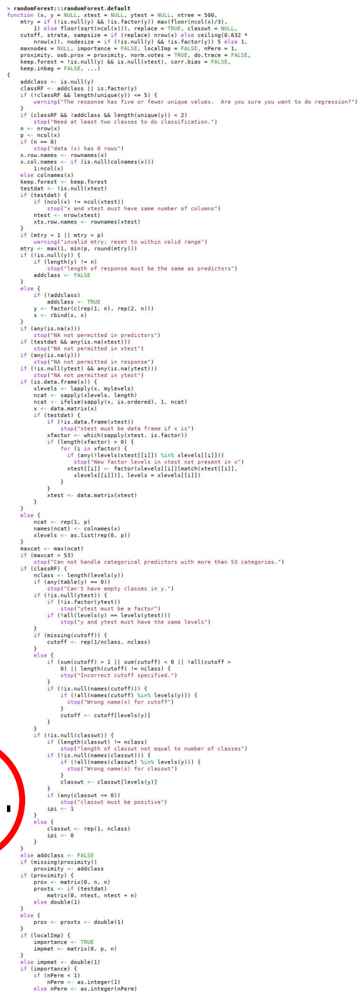
Programming Style

Your Audience has Tunnel Vision

Your code should be understandable

- without needing to see many lines at once

this is *half* of the `randomForest()` function



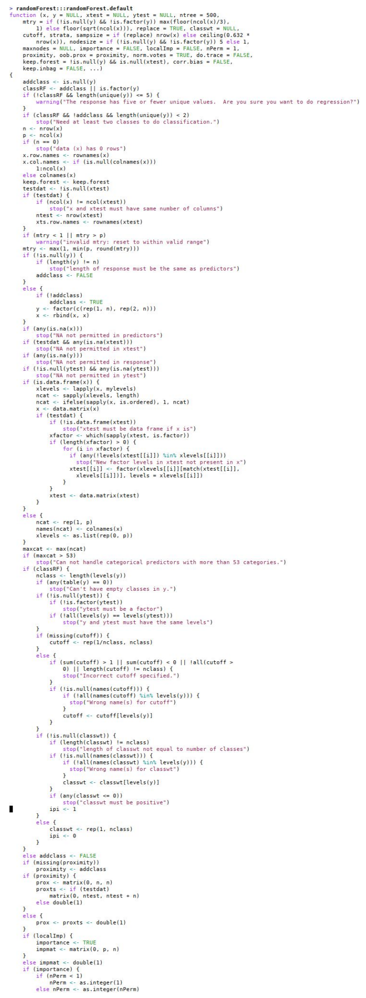
```r
> randomForest:::randomForest.default
function (x, y = NULL, xtest = NULL, ytest = NULL, ntree = 500,
    mtry = if (!is.null(y) && !is.factor(y)) max(floor(ncol(x)/3),
        1) else floor(sqrt(ncol(x))), replace = TRUE, classwt = NULL,
    cutoff, strata, sampsize = if (replace) nrow(x) else ceiling(0.632 *
        nrow(x)), nodesize = if (!is.null(y) && !is.factor(y)) 5 else 1,
    maxnodes = NULL, importance = FALSE, localImp = FALSE, nPerm = 1,
    proximity, oob.prox = proximity, norm.votes = TRUE, do.trace = FALSE,
    keep.forest = !is.null(y) && is.null(xtest), corr.bias = FALSE,
    keep.inbag = FALSE, ...)
{
    addclass <- is.null(y)
    classRF <- addclass || is.factor(y)
    if (!classRF && length(unique(y)) <= 5) {
        warning("The response has five or fewer unique values.  Are you sure you want to do regression?")
    }
    if (classRF && !addclass && length(unique(y)) < 2)
        stop("Need at least two classes to do classification.")
    n <- nrow(x)
    p <- ncol(x)
    if (n == 0)
        stop("data (x) has 0 rows")
    x.row.names <- rownames(x)
    x.col.names <- if (is.null(colnames(x)))
        1:ncol(x)
    else colnames(x)
    keep.forest <- keep.forest
    testdat <- !is.null(xtest)
    if (testdat) {
        if (ncol(x) != ncol(xtest))
            stop("x and xtest must have same number of columns")
        ntest <- nrow(xtest)
        xts.row.names <- rownames(xtest)
    }
    if (mtry < 1 || mtry > p)
        warning("invalid mtry: reset to within valid range")
    mtry <- max(1, min(p, round(mtry)))
    if (!is.null(y)) {
        if (length(y) != n)
            stop("length of response must be the same as predictors")
        addclass <- FALSE
    }
    else {
        if (!addclass)
            addclass <- TRUE
        y <- factor(c(rep(1, n), rep(2, n)))
        x <- rbind(x, x)
    }
    if (any(is.na(x)))
        stop("NA not permitted in predictors")
    if (testdat && any(is.na(xtest)))
        stop("NA not permitted in xtest")
    if (any(is.na(y)))
        stop("NA not permitted in response")
    if (!is.null(ytest) && any(is.na(ytest)))
        stop("NA not permitted in ytest")
    if (is.data.frame(x)) {
        xlevels <- lapply(x, mylevels)
        ncat <- sapply(xlevels, length)
        ncat <- ifelse(sapply(x, is.ordered), 1, ncat)
        x <- data.matrix(x)
        if (testdat) {
            if (!is.data.frame(xtest))
                stop("xtest must be data frame if x is")
            xfactor <- which(sapply(xtest, is.factor))
            if (length(xfactor) > 0) {
                for (i in xfactor) {
                  if (any(!levels(xtest[[i]]) %in% xlevels[[i]]))
                    stop("New factor levels in xtest not present in x")
                  xtest[[i]] <- factor(xlevels[[i]][match(xtest[[i]],
                    xlevels[[i]])], levels = xlevels[[i]])
                }
            }
            xtest <- data.matrix(xtest)
        }
    }
    else {
        ncat <- rep(1, p)
        names(ncat) <- colnames(x)
        xlevels <- as.list(rep(0, p))
    }
    maxcat <- max(ncat)
    if (maxcat > 53)
        stop("Can not handle categorical predictors with more than 53 categories.")
    if (classRF) {
        nclass <- length(levels(y))
        if (any(table(y) == 0))
            stop("Can't have empty classes in y.")
        if (!is.null(ytest)) {
            if (!is.factor(ytest))
                stop("ytest must be a factor")
            if (!all(levels(y) == levels(ytest)))
                stop("y and ytest must have the same levels")
        }
        if (missing(cutoff)) {
            cutoff <- rep(1/nclass, nclass)
        }
        else {
            if (sum(cutoff) > 1 || sum(cutoff) < 0 || !all(cutoff >
                0) || length(cutoff) != nclass) {
                stop("Incorrect cutoff specified.")
            }
            if (!is.null(names(cutoff))) {
                if (!all(names(cutoff) %in% levels(y))) {
                  stop("Wrong name(s) for cutoff")
                }
                cutoff <- cutoff[levels(y)]
            }
        }
        if (!is.null(classwt)) {
            if (length(classwt) != nclass)
                stop("length of classwt not equal to number of classes")
            if (!is.null(names(classwt))) {
                if (!all(names(classwt) %in% levels(y))) {
                  stop("Wrong name(s) for classwt")
                }
                classwt <- classwt[levels(y)]
            }
            if (any(classwt <= 0))
                stop("classwt must be positive")
            ipi <- 1
        }
        else {
            classwt <- rep(1, nclass)
            ipi <- 0
        }
    }
    else addclass <- FALSE
    if (missing(proximity))
        proximity <- addclass
    if (proximity) {
        prox <- matrix(0, n, n)
        proxts <- if (testdat)
            matrix(0, ntest, ntest + n)
        else double(1)
    }
    else {
        prox <- proxts <- double(1)
    }
    if (localImp) {
        importance <- TRUE
        impmat <- matrix(0, p, n)
    }
    else impmat <- double(1)
    if (importance) {
        if (nPerm < 1)
            nPerm <- as.integer(1)
        else nPerm <- as.integer(nPerm)
```

Programming Style

Your Audience has Tunnel Vision

Your code should be understandable

- without needing to see many lines at once
  - chunk your code into reasonably sized functions
    - should ideally fit on a screen
  - and reasonably sized files



```
> randomForest:::randomForest.default
function (x, y = NULL, xtest = NULL, ytest = NULL, ntree = 500,
    mtry = if (!is.null(y) && !is.factor(y)) max(floor(ncol(x)/3),
        1) else floor(sqrt(ncol(x))), replace = TRUE, classwt = NULL,
    cutoff, strata, sampsize = if (replace) nrow(x) else ceiling(0.632 *
        nrow(x)), nodesize = if (!is.null(y) && !is.factor(y)) 5 else 1,
    maxnodes = NULL, importance = FALSE, localImp = FALSE, nPerm = 1,
    proximity, oob.prox = proximity, norm.votes = TRUE, do.trace = FALSE,
    keep.forest = !is.null(y) && is.null(xtest), corr.bias = FALSE,
    keep.inbag = FALSE, ...)
{
    addclass <- is.null(y)
    classRF <- addclass || is.factor(y)
    if (!classRF && length(unique(y)) <= 5) {
        warning("The response has five or fewer unique values.  Are you sure you want to do regression?")
    }
    if (classRF && !addclass && length(unique(y)) < 2)
        stop("Need at least two classes to do classification.")
    n <- nrow(x)
    p <- ncol(x)
    if (n == 0)
        stop("data (x) has 0 rows")
    x.row.names <- rownames(x)
    x.col.names <- if (is.null(colnames(x)))
        1:ncol(x)
    else colnames(x)
    keep.forest <- keep.forest
    testdat <- !is.null(xtest)
    if (testdat) {
        if (ncol(x) != ncol(xtest))
            stop("x and xtest must have same number of columns")
        ntest <- nrow(xtest)
        xts.row.names <- rownames(xtest)
    }
    if (mtry < 1 || mtry > p)
        warning("invalid mtry: reset to within valid range")
    mtry <- max(1, min(p, round(mtry)))
    if (!is.null(y)) {
        if (length(y) != n)
            stop("length of response must be the same as predictors")
        addclass <- FALSE
    }
    else {
        if (!addclass)
            addclass <- TRUE
        y <- factor(c(rep(1, n), rep(2, n)))
        x <- rbind(x, x)
    }
    if (any(is.na(x)))
        stop("NA not permitted in predictors")
    if (testdat && any(is.na(xtest)))
        stop("NA not permitted in xtest")
    if (any(is.na(y)))
        stop("NA not permitted in response")
    if (!is.null(ytest) && any(is.na(ytest)))
        stop("NA not permitted in ytest")
    if (is.data.frame(x)) {
        xlevels <- lapply(x, mylevels)
        ncat <- sapply(xlevels, length)
        ncat <- ifelse(sapply(x, is.ordered), 1, ncat)
        x <- data.matrix(x)
        if (testdat) {
            if (!is.data.frame(xtest))
                stop("xtest must be data frame if x is")
            xfactor <- which(sapply(xtest, is.factor))
            if (length(xfactor) > 0) {
                for (i in xfactor) {
                  if (any(!levels(xtest[[i]]) %in% xlevels[[i]]))
                    stop("New factor levels in xtest not present in x")
                  xtest[[i]] <- factor(xlevels[[i]][match(xtest[[i]],
                    xlevels[[i]])], levels = xlevels[[i]])
                }
            }
            xtest <- data.matrix(xtest)
        }
    }
    else {
        ncat <- rep(1, p)
        names(ncat) <- colnames(x)
        xlevels <- as.list(rep(0, p))
    }
    maxcat <- max(ncat)
    if (maxcat > 53)
        stop("Can not handle categorical predictors with more than 53 categories.")
    if (classRF) {
        nclass <- length(levels(y))
        if (any(table(y) == 0))
            stop("Can't have empty classes in y.")
        if (!is.null(ytest)) {
            if (!is.factor(ytest))
                stop("ytest must be a factor")
            if (!all(levels(y) == levels(ytest)))
                stop("y and ytest must have the same levels")
        }
        if (missing(cutoff)) {
            cutoff <- rep(1/nclass, nclass)
        }
        else {
            if (sum(cutoff) > 1 || sum(cutoff) < 0 || !all(cutoff >
                0) || length(cutoff) != nclass) {
                stop("Incorrect cutoff specified.")
            }
            if (!is.null(names(cutoff))) {
                if (!all(names(cutoff) %in% levels(y))) {
                  stop("Wrong name(s) for cutoff")
                }
                cutoff <- cutoff[levels(y)]
            }
        }
        if (!is.null(classwt)) {
            if (length(classwt) != nclass)
                stop("length of classwt not equal to number of classes")
            if (!is.null(names(classwt))) {
                if (!all(names(classwt) %in% levels(y))) {
                  stop("Wrong name(s) for classwt")
                }
                classwt <- classwt[levels(y)]
            }
            if (any(classwt <= 0))
                stop("classwt must be positive")
            ipi <- 1
        }
        else {
            classwt <- rep(1, nclass)
            ipi <- 0
        }
    }
    else addclass <- FALSE
    if (missing(proximity))
        proximity <- addclass
    if (proximity) {
        prox <- matrix(0, n, n)
        proxts <- if (testdat)
            matrix(0, ntest, ntest + n)
        else double(1)
    }
    else {
        prox <- proxts <- double(1)
    }
    if (localImp) {
        importance <- TRUE
        impmat <- matrix(0, p, n)
    }
    else impmat <- double(1)
    if (importance) {
        if (nPerm < 1)
            nPerm <- as.integer(1)
        else nPerm <- as.integer(nPerm)
```

Programming Style

Your Audience has Tunnel Vision

Your code should be understandable

- without needing to see many lines at once
    - chunk your code into reasonably sized functions
        - should ideally fit on a screen
    - and reasonably sized files
- without having to keep many things in mind at once

Programming Style

Your Audience has Tunnel Vision

- without needing to see many lines at once
    - chunk your code into reasonably sized functions
        - should ideally fit on a screen
    - and reasonably sized files
- without having to keep many things in mind at once
    - limit your "nesting depth": avoid for-loops inside if-clauses inside for-loops inside ...
    - limit the number of args of functions. The user shouldn't have to check the docs all the time.
    - limit the role fulfilled by a single function. If you can't summarize its effect in one sentence, consider splitting it up.
    - related but more general: strive for **loose coupling**, i.e. limit the interdependencies between parts of your code and the degree to which one part depends on specific implementation details of another part.

What We Expect You to Know

Programming Style

Make your program easy to read by:

1. Avoiding unnecessary noise and keeping the appearance of your code uniform.
2. Using all communication channels available to you, like variable / function names, comments, and idioms that your reader is familiar with.
3. Assuming your audience has tunnel vision and should be able to understand small blocks of your code at a time

(And remember, the code you hand in is checked for style automatically)