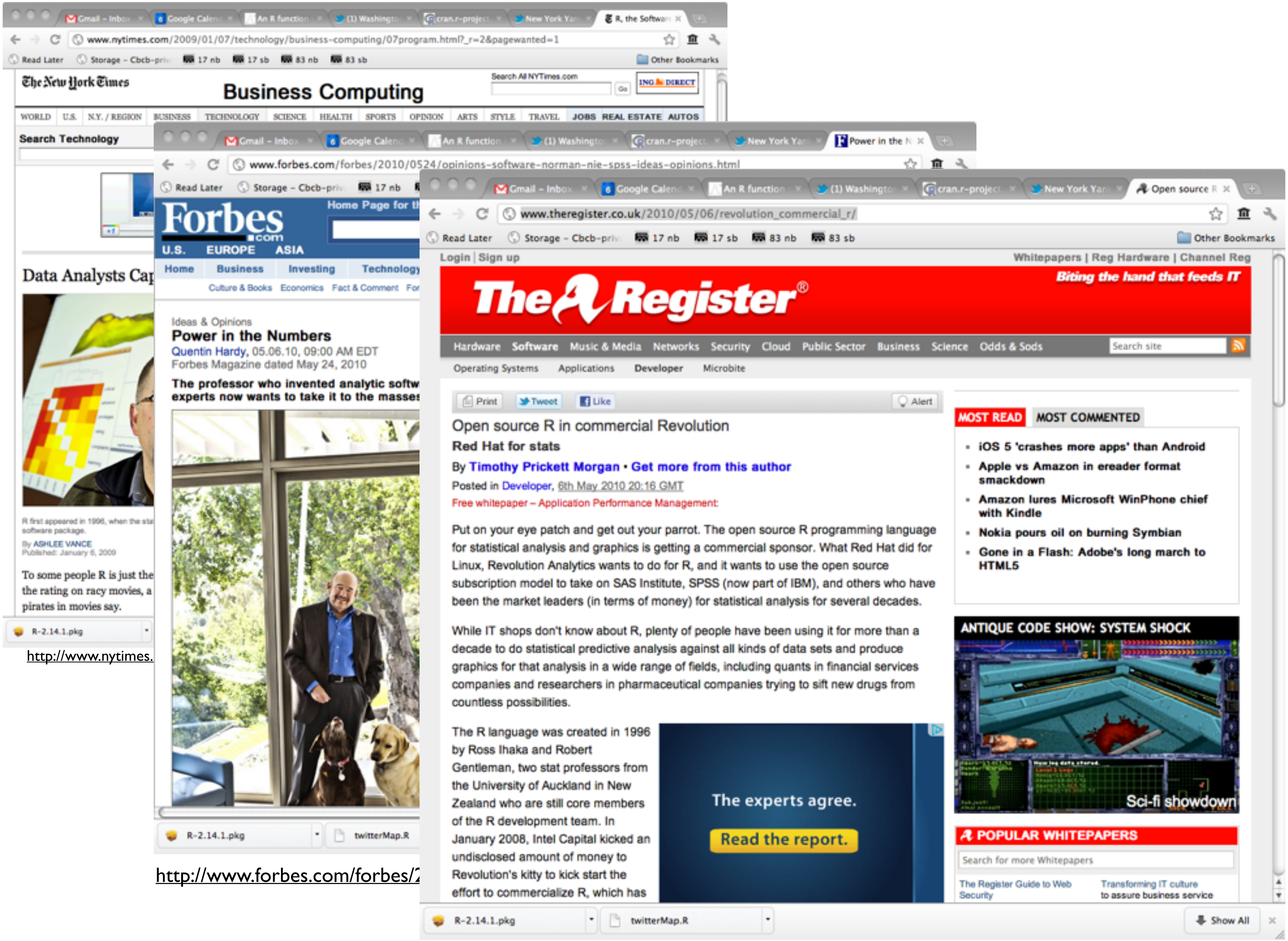
Intro to R

Héctor Corrada Bravo
CMSC498T Spring 2015
University of Maryland
Computer Science



Data Analysts Cap

R first appeared in 1996, when the sta
software package.

By ASHLEE VANCE
Published: January 6, 2009

To some people R is just the
the rating on racy movies, a
pirates in movies say.

Ideas & Opinions

Power in the Numbers

Quentin Hardy, 05.06.10, 09:00 AM EDT
Forbes Magazine dated May 24, 2010

**The professor who invented analytic softw
experts now wants to take it to the masses**

Open source R in commercial Revolution

Red Hat for stats

By **Timothy Prickett Morgan** • **Get more from this author**

Posted in Developer, 6th May 2010 20:16 GMT

Free whitepaper – Application Performance Management

Put on your eye patch and get out your parrot. The open source R programming language for statistical analysis and graphics is getting a commercial sponsor. What Red Hat did for Linux, Revolution Analytics wants to do for R, and it wants to use the open source subscription model to take on SAS Institute, SPSS (now part of IBM), and others who have been the market leaders (in terms of money) for statistical analysis for several decades.

While IT shops don't know about R, plenty of people have been using it for more than a decade to do statistical predictive analysis against all kinds of data sets and produce graphics for that analysis in a wide range of fields, including quants in financial services companies and researchers in pharmaceutical companies trying to sift new drugs from countless possibilities.

The R language was created in 1996 by Ross Ihaka and Robert Gentleman, two stat professors from the University of Auckland in New Zealand who are still core members of the R development team. In January 2008, Intel Capital kicked an undisclosed amount of money to Revolution's kitty to kick start the effort to commercialize R, which has

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http://www.nytimes.

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http://www.theregister.co.uk/2010/05/06/revolution_commercial_r/

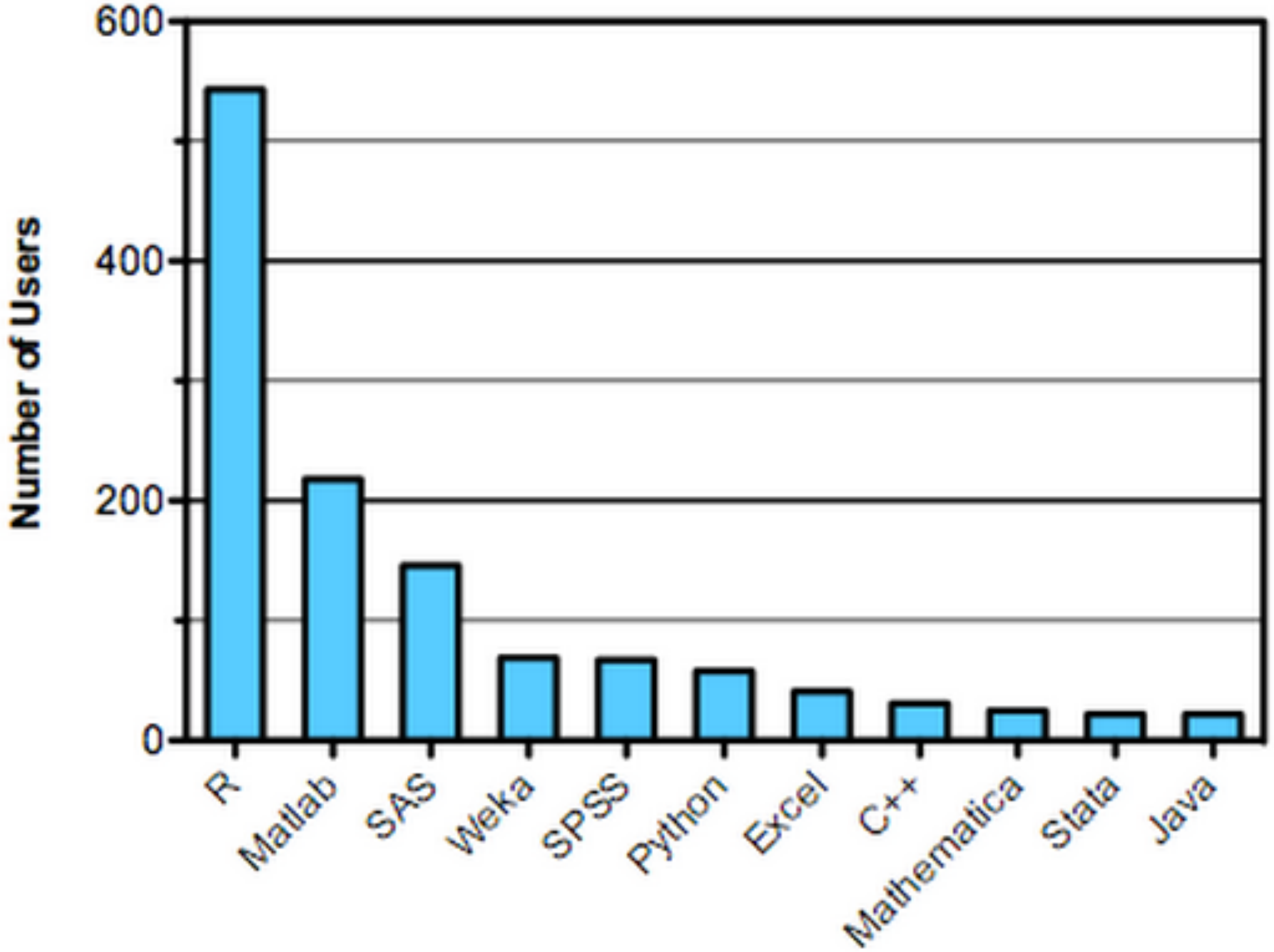
Some history

- John Chambers and others started developing the “S” language in 1976
- Version 4 of the language definition(currently in use) was settled in 1998
- That year, “S” won the ACM Software System Award

Some history

- Ihaka and Gentleman (of NYTimes fame) create R in 1991
    - They wanted lexical scoping (see NYTimes pic)
- Released under GNU GPL in 1995
- Maintained by R Core Group since1997

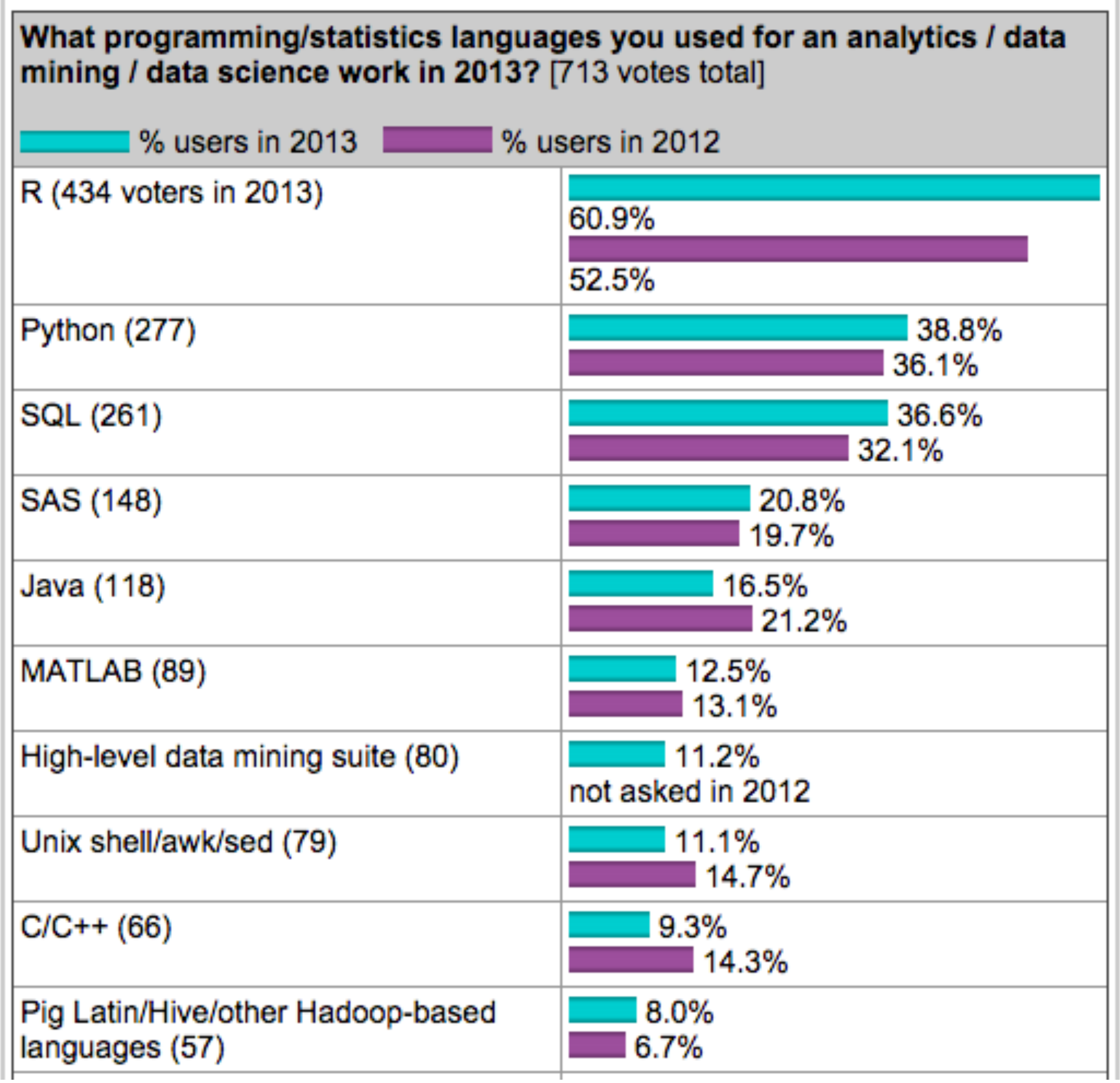
2011



Languages used in Kaggle (prediction competition site)

http://blog.kaggle.com/2011/11/27/kagglers-favorite-tools/

2013



What programming/statistics languages you used for an analytics / data mining / data science work in 2013? [713 votes total]

🟦 % users in 2013 🟪 % users in 2012

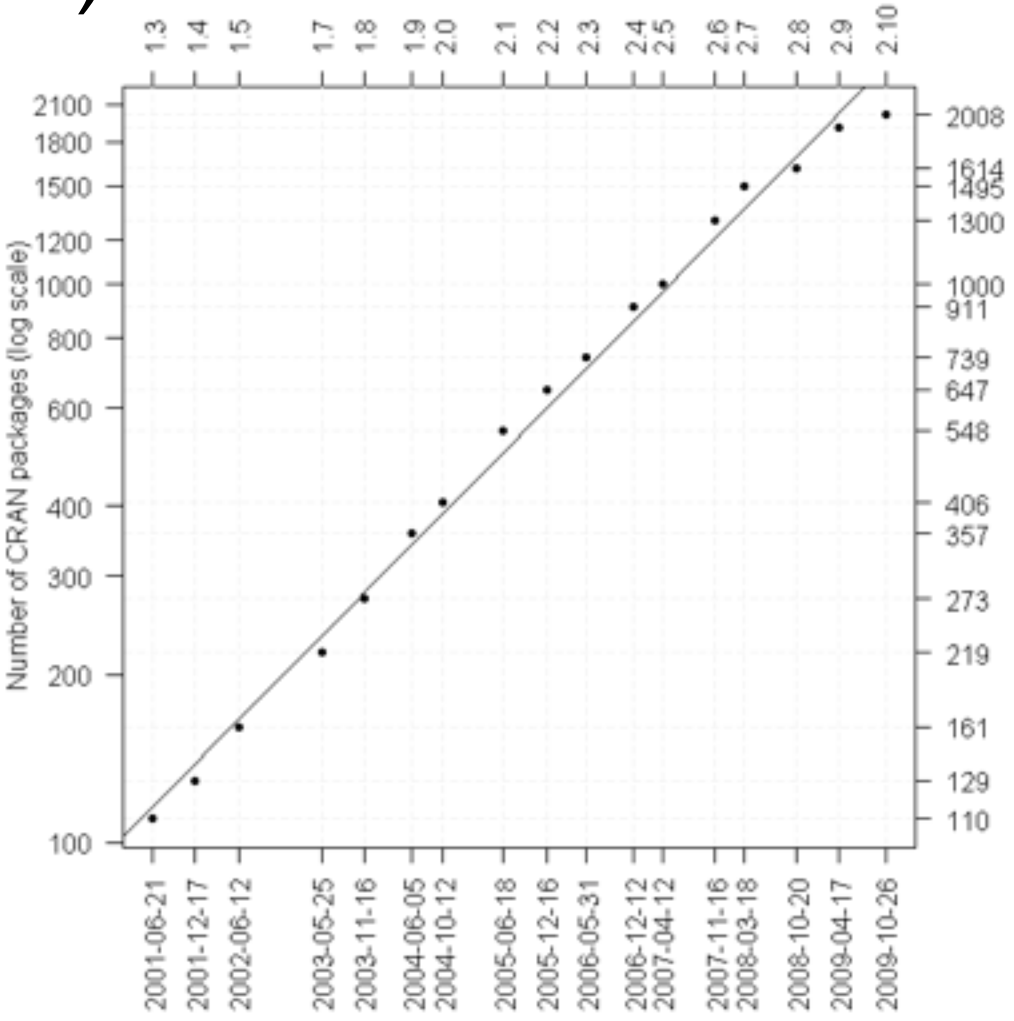
	% users in 2013 % users in 2012
R (434 voters in 2013)	60.9% 52.5%
Python (277)	38.8% 36.1%
SQL (261)	36.6% 32.1%
SAS (148)	20.8% 19.7%
Java (118)	16.5% 21.2%
MATLAB (89)	12.5% 13.1%
High-level data mining suite (80)	11.2% not asked in 2012
Unix shell/awk/sed (79)	11.1% 14.7%
C/C++ (66)	9.3% 14.3%
Pig Latin/Hive/other Hadoop-based languages (57)	8.0% 6.7%

http://www.kdnuggets.com/polls/2013/languages-analytics-data-mining-data-science.html

- Freely available: http://www.r-project.org/
- IDEs:
  - [cross-platform] http://rstudio.org/
  - [Windows and Linux] http://www.revolutionanalytics.com/
  - Also bindings for emacs [http://ess.r-project.org/] and plugin for eclipse [http://www.walware.de/goto/statet]

- Resources:
  - Manuals from r-project http://cran.r-project.org/manuals.html
  - Chambers (2008) *Software for Data Analysis*, Springer.
  - Venables & Ripley (2002) *Modern Applied Statistics with S*, Springer.
  - List of books: http://www.r-project.org/doc/bib/R-books.html

- Uses a package framework (similar to Python)
- Divided into two parts
  - **base**: what you get when you download R (base package, and other packages like stats, graphics, utils, Matrix, boot,codetools)
  - everything else:
    - [http://cran.r-project.org/]



- Documentation system:

```
> help(“sapply”)# bring up help page

> ?sapply # shortcut

> ??sapply # search for string in docs

> help.start()# open doc index
```

- Three ways of thinking required
  - Numerical computing (e.g., like Matlab)
  - Functions and lists (e.g., like Lisp and Scheme)
  - Data tables (e.g., like SQL)

vectors (numerical computing)

```
# creating
vec = c(1,10,20)
vec = 1:100
vec = seq(1,100,by=2)
vec = rnorm(100)

# indexing
vec[1]
vec[1:10]

# operations are vectorized
sum(vec)
mean(vec)
vec/10
crossprod(vec)
tcrossprod(vec)

# gotcha: scalars are vectors of size 1
is.vector(1) # TRUE
```

Matrices (numerical computing)

```
# creating
mat = matrix(c(1,10,20,30), nrow=2, ncol=2)
mat = matrix(rnorm(100), nrow=20, ncol=5)

# indexing
mat[1,1] # element in row 1 column 1
mat[,1] # column 1 (not a matrix)

# operations
sum(mat) # sum of all entries
colSums(mat) # column-wise sum
apply(mat,2,sum) # same thing

rowMeans(vec)# row-wise means

# operations with vectors and scalars
mat/10 # divide all entries by scalar

vec = runif(20)
mat/vec # divide each column by vec

vec = rnorm(5)
sweep(mat,2,vec,”/”) # divide each row by vec
```

- All your linear algebra operations:
    - crossproducts, matrix inverses, decompositions (QR, Cholesky, eigenvalue)

- Lists are basic data structure (like scheme)

```
# creating a list (with names)
> l <- list(age=1:10,
            race=rep(c(“W”,”B”),5),
            year=2013)
# accessing element by index
> l[[1]]
# slicing list
> l[1:3]
# accessing named element
> l$age
# are these equal?
> l[1] == l[[1]]
```

Function definition

```
locationGrid <- function(tab,
    gridSize=50) #default value, call can omit
    {
         <body>
    }
```

Function call

```
locationGrid(tab)
```

Functional language

```
nValues <- sapply(arrests,
    function (x) length(unique(x))))
```

Equivalent (bad idea in general)

```
nValues <- c()
for (i in 1:length(arrests)) {
 nValues[i] <- length(unique(arrests[[i]]))
}
```

Data frames: a hybrid of matrix and list

```
# creating (looks like a named list)
arrests=data.frame(age=1:10,
                   race=rep(c(“W”,”B”),10),
                   year=2013)
 # accessing
 # like a list
 arrests[[1]] # the first element (column)
 arrests$age # a named element (column)
 names(arrests) # the names of elements (columns)

 # like a matrix
 arrests[1,1] # the first value in first column
 arrests[,1] # the entire first column
```

[named] list components are vectors of the same length => treated as columns in a matrix

We’ll talk about dplyr package *for a new powerful data table operation library (https://github.com/hadley/dplyr)*

R environment features:

- Conceptually, it is very similar to *Scheme* (functional, lexical scope, lists are basic data structure) with saner syntax.
  - dynamic typing
  - copy-on-modify semantics
- Syntax is nice for numerical computation (similar to matlab)
- Many language features there to directly support data analysis (formula syntax, data.frames)
- Objects (we'll see that with Bioconductor)
- Fairly clean C interface (non-base package *Rcpp* provides *awesome* interface to C++)
- *Interactive* (REPL), but also scripting available

- Plotting: there are three graphics system in R:
    - graphics: the base system (which we'll use today)
    - lattice: a very flexible system (uses statistical model syntax we'll see later)
    - ggplot2: very pretty, very extensible (*grammar of graphics*)
- R graph gallery: http://addictedtor.free.fr/graphiques/

Formula syntax: statistical tasks are built-in

```
# a linear regression model
# fit = lm (age~race, data=arrests)
```

formula

```
# which you can get information about
summary(fit)
```

As objects you can compute with

```
# print result
fit

# get value of test statistic
summary(fit)$estimate

# get P-value for test
summary(fit)$p.value
```

- Support for literate programming: http://en.wikipedia.org/wiki/Literate_programming
  - knitR and rmarkdown: integrates Markdown and R code
  - Sweave: integrates Latex and R code

- Summary:
  - functional programming paradigm
  - data analysis support: data frames, model formula syntax, built-in statistical tests
  - data management support: efficient indexing, subsetting, aggregation
  - support for parallel computing available and rapidly improving
  - outstanding graphics support
  - growing external libraries, awesome community
  - support for data-centric web applications rapidly developed (shiny)

- Alternatives:
  - Python (with Pandas library, http://pandas.pydata.org/)
  - Julia (http://julialang.org/)
- CSers are paying attention:
  - PL semantics study: (http://r.cs.purdue.edu/pub/ecoop12.pdf)
  - re-implementations: fastr (https://github.com/allr/fastr), renjin (http://www.renjin.org/)

- A few extra pointers:
  - Advanced R Programming: http://adv-r.had.co.nz/
  - John Cook’s Intro: www.johndcook.com/R_language_for_programmers.html
  - The Art of R Programming: http://heather.cs.ucdavis.edu/~matloff/132/NSPpart.pdf
  - Why and how people use R: http://channel9.msdn.com/Events/Lang-NEXT/Lang-NEXT-2012/Why-and-How-People-Use-R?format=html5
  - Google’s R style guide: http://google-styleguide.googlecode.com/svn/trunk/Rguide.xml