R 入門

投野ゼミ合宿2019

謝辞：一部は以下の作者のスライドを翻訳:

Tyler K. Perrachione (MIT)

Eugene Tseytlin (Univ. of Pittsburgh)

統計ソフトの推移

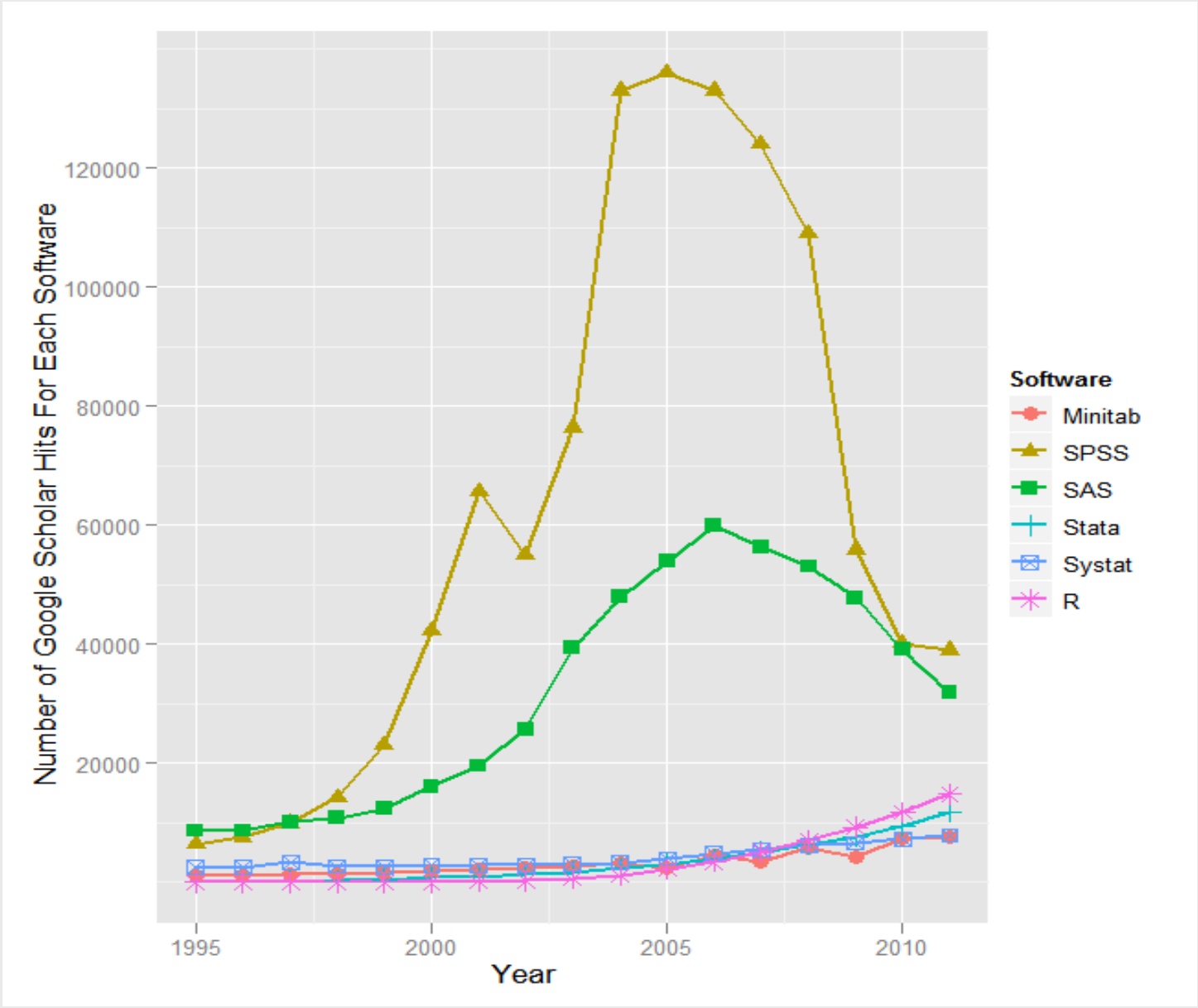
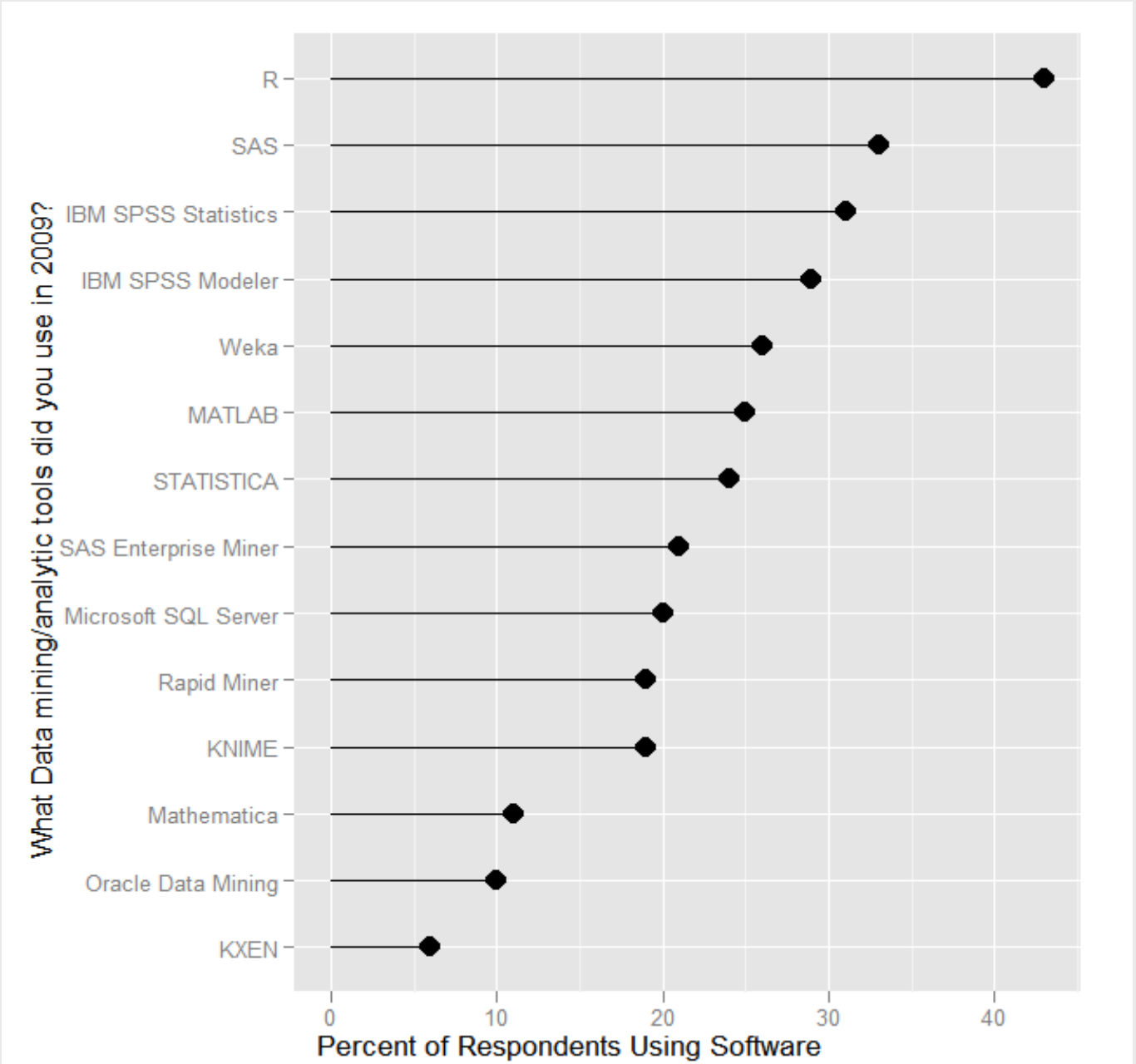
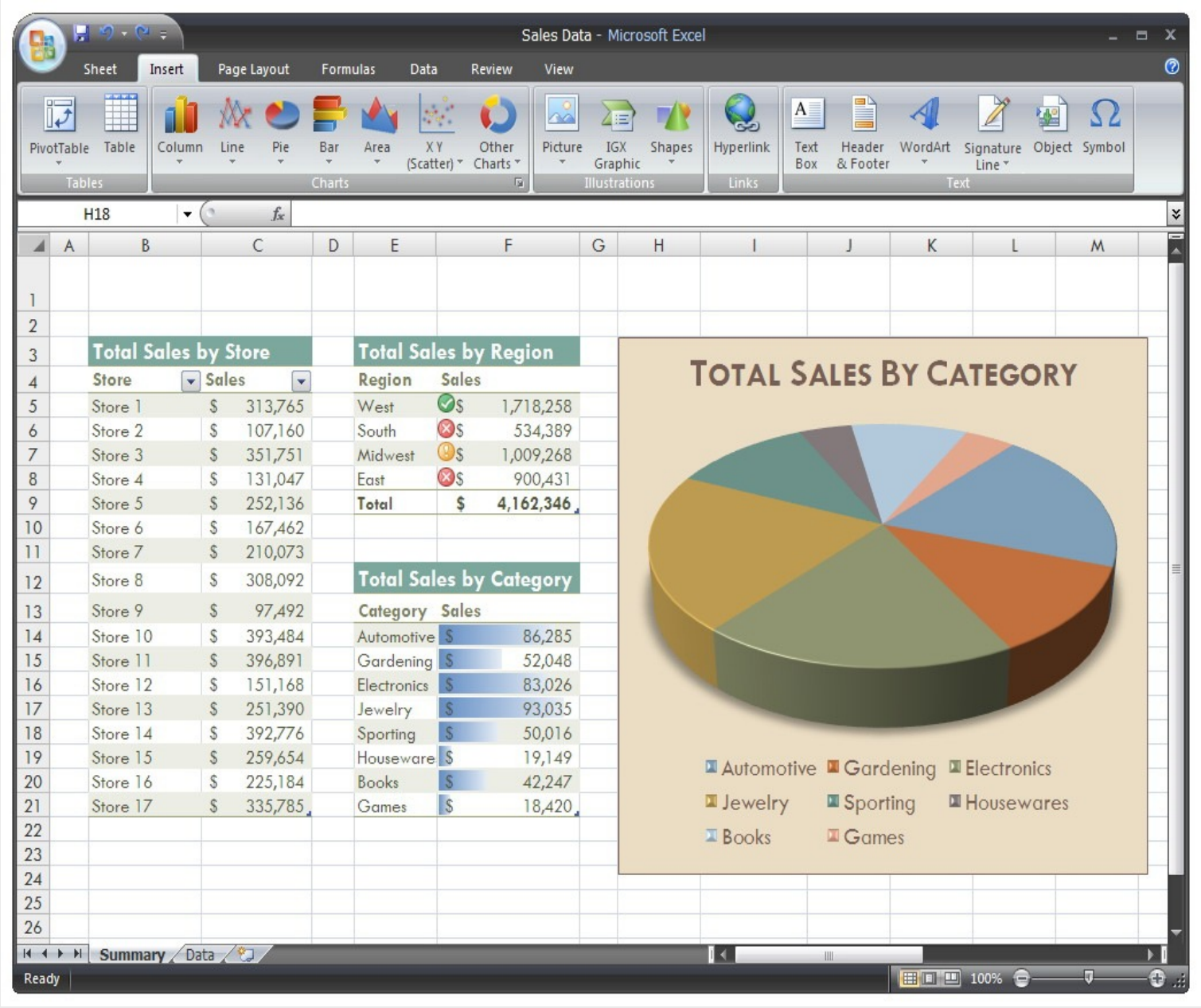


Figure 7a. Use of data analysis software in academic publications as measured by hits on Google Scholar.

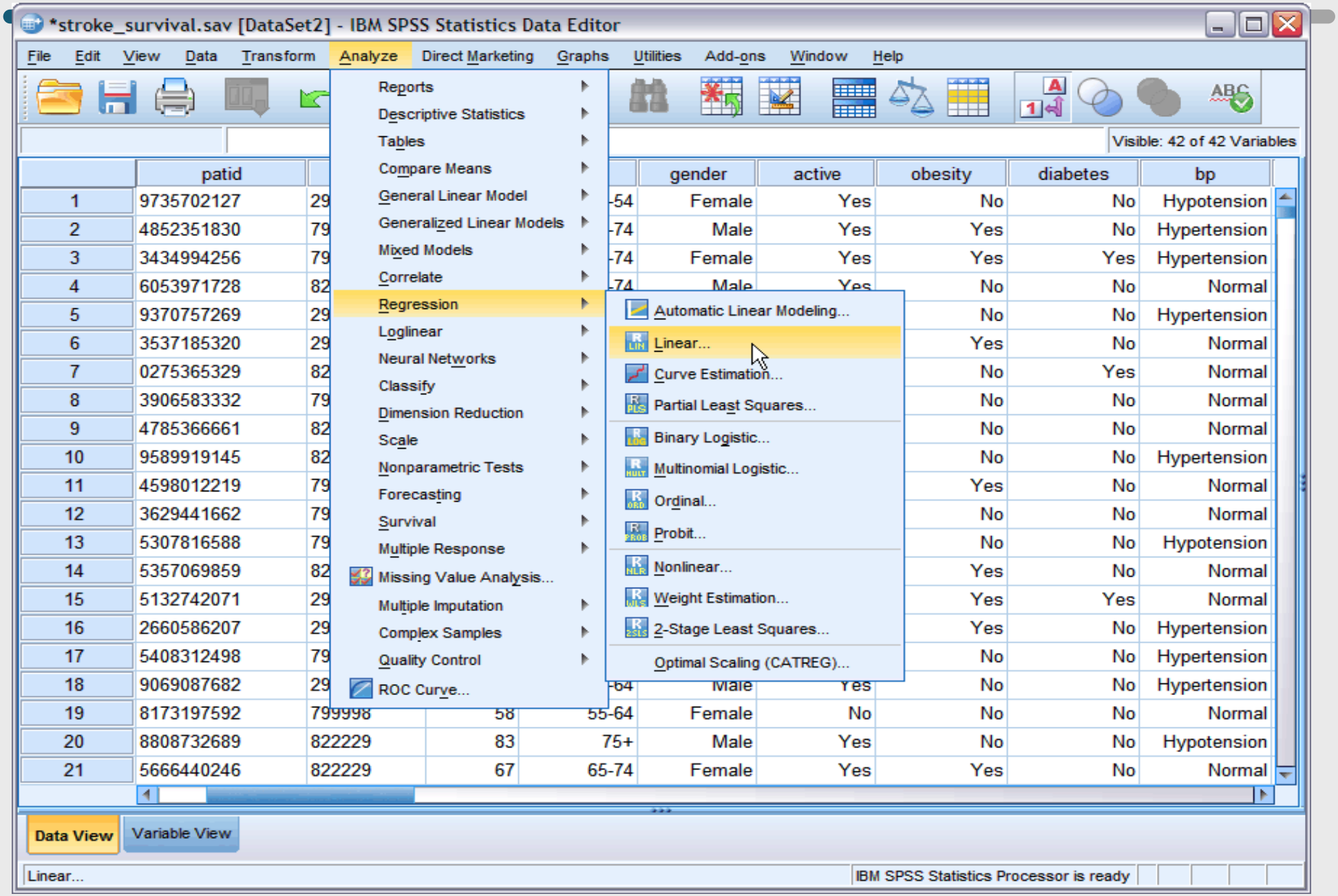
統計ソフト利用調査


What Data mining/analytic tools did you use in 2009?
R
SAS
IBM SPSS Statistics
IBM SPSS Modeler
Weka
MATLAB
STATISTICA
SAS Enterprise Miner
Microsoft SQL Server
Rapid Miner
KNIME
Mathematica
Oracle Data Mining
KXEN
0
10
20
30
40
Percent of Respondents Using Software

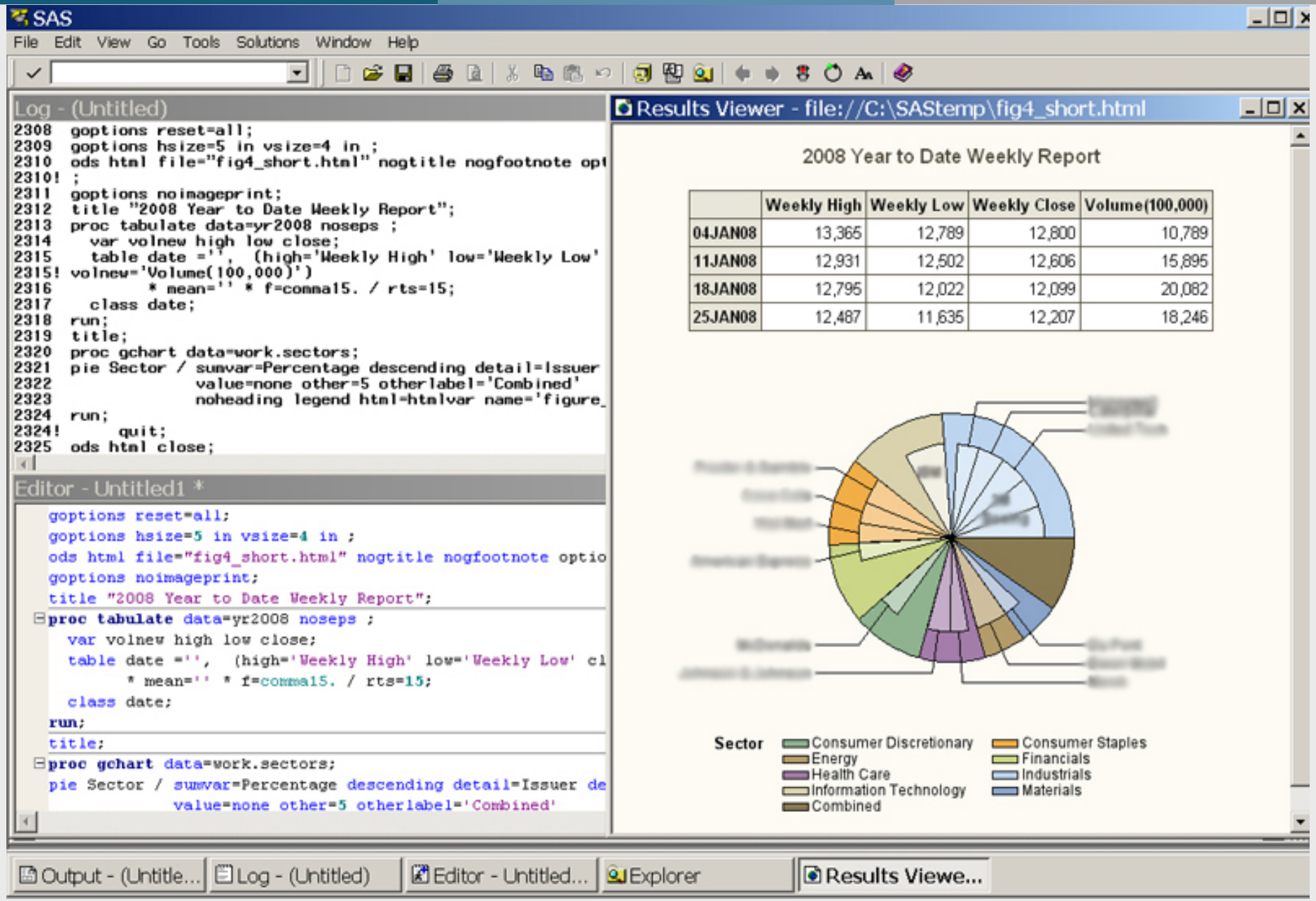
Microsoft Excel



SPSS


*stroke_survival.sav [DataSet2] - IBM SPSS Statistics Data Editor
File Edit View Data Transform Analyze Direct Marketing Graphs Utilities Add-ons Window Help
Reports
Descriptive Statistics
Tables
Compare Means
General Linear Model
Generalized Linear Models
Mixed Models
Correlate
Regression
Loglinear
Neural Networks
Classify
Dimension Reduction
Scale
Nonparametric Tests
Forecasting
Survival
Multiple Response
Missing Value Analysis...
Multiple Imputation
Complex Samples
Quality Control
ROC Curve...
Automatic Linear Modeling...
Linear...
Curve Estimation...
Partial Least Squares...
Binary Logistic...
Multinomial Logistic...
Ordinal...
Probit...
Nonlinear...
Weight Estimation...
2-Stage Least Squares...
Optimal Scaling (CATREG)...
Visible: 42 of 42 Variables
patid gender active obesity diabetes bp
1 9735702127 Female Yes No No Hypotension
2 4852351830 Male Yes Yes No Hypertension
3 3434994256 Female Yes Yes Yes Hypertension
4 6053971728 No No Normal
5 9370757269 No No Hypertension
6 3537185320 Yes No Normal
7 0275365329 No Yes Normal
8 3906583332 No No Normal
9 4785366661 No No Normal
10 9589919145 No No Hypertension
11 4598012219 Yes No Normal
12 3629441662 No No Normal
13 5307816588 No No Hypotension
14 5357069859 Yes No Normal
15 5132742071 Yes Yes Normal
16 2660586207 Yes No Hypertension
17 5408312498 No No Hypertension
18 9069087682 No No Hypertension
19 8173197592 799998 58 55-64 Female No No No Normal
20 8808732689 822229 83 75+ Male Yes No No Hypotension
21 5666440246 822229 67 65-74 Female Yes Yes No Normal
Data View
Variable View
Linear...
IBM SPSS Statistics Processor is ready

SAS

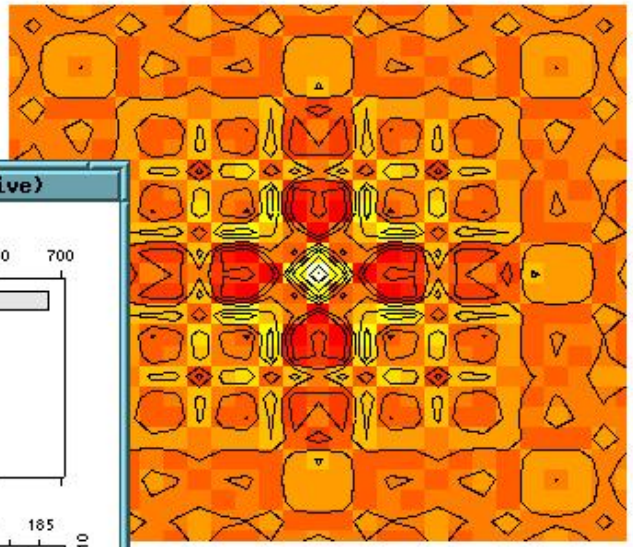

SAS
File Edit View Go Tools Solutions Window Help
Log - (Untitled)
2308 goptions reset=all;
2309 goptions hsize=5 in vsize=4 in ;
2310 ods html file="fig4_short.html" nogtitle nogfootnote opt
2310! ;
2311 goptions noimageprint;
2312 title "2008 Year to Date Weekly Report";
2313 proc tabulate data=yr2008 noseps ;
2314 var volnew high low close;
2315 table date ='', (high='Weekly High' low='Weekly Low'
2315! volnew='Volume(100,000)')
2316 * mean='' * f=comma15. / rts=15;
2317 class date;
2318 run;
2319 title;
2320 proc gchart data=work.sectors;
2321 pie Sector / sumvar=Percentage descending detail=Issuer
2322 value=none other=5 otherlabel='Combined'
2323 noheading legend html=htmlvar name='figure_
2324 run;
2324! quit;
2325 ods html close;
Editor - Untitled1 *
goptions reset=all;
goptions hsize=5 in vsize=4 in ;
ods html file="fig4_short.html" nogtitle nogfootnote optio
goptions noimageprint;
title "2008 Year to Date Weekly Report";
proc tabulate data=yr2008 noseps ;
var volnew high low close;
table date ='', (high='Weekly High' low='Weekly Low' cl
* mean='' * f=comma15. / rts=15;
class date;
run;
title;
proc gchart data=work.sectors;
pie Sector / sumvar=Percentage descending detail=Issuer de
value=none other=5 otherlabel='Combined'
Results Viewer - file://C:\SAStemp\fig4_short.html
2008 Year to Date Weekly Report
Weekly High Weekly Low Weekly Close Volume(100,000)
04JAN08 13,365 12,789 12,800 10,789
11JAN08 12,931 12,502 12,606 15,895
18JAN08 12,795 12,022 12,099 20,082
25JAN08 12,487 11,635 12,207 18,246
Sector
Consumer Discretionary
Consumer Staples
Energy
Financials
Health Care
Industrials
Information Technology
Materials
Combined
Output - (Untitle...
Log - (Untitled)
Editor - Untitled...
Explorer
Results Viewe...

R

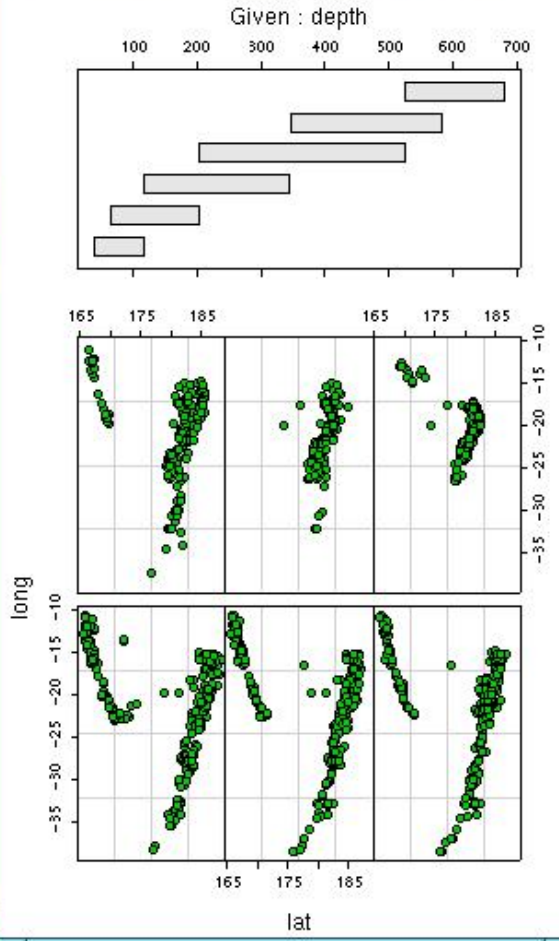
leisch@galadriel:~/work/tmp

```
R> n <- 5
R> g <- gl(n, 100, n*100)
R> x <- rnorm(n*100) + sqrt(codes(g))
R> boxplot(split(x,g), col="lavender", notch=TRUE)
R> title(main="Notched Boxplots", xlab="Group", font.main=4, font.lab=1)
R>
R> ctl <- c(4.17,5.58,5.18,6.11,4.50,4.61,5.17,4.53,5.33,5.14)
R> trt <- c(4.81,4.17,4.41,3.59,5.87,3.83,6.03,4.89,4.32,4.69)
R> group <- gl(2,10,20,labels=c("Ctl","Trt"))
R> weight <- c(ctl,trt)
R> anova(lm.D9 <- lm(weight~group))

Analysis of Variance Table
Response: weight

          Df  Sum Sq  Mean Sq      F  Pr(>F)
group      1  0.6882   0.6882  1.419   0.249
Residual  18  8.7293   0.4850

R>
R>
```

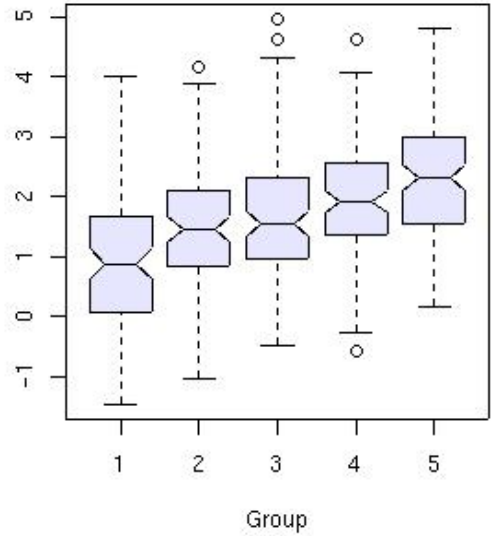
R Graphics: Device 2 (inactive)



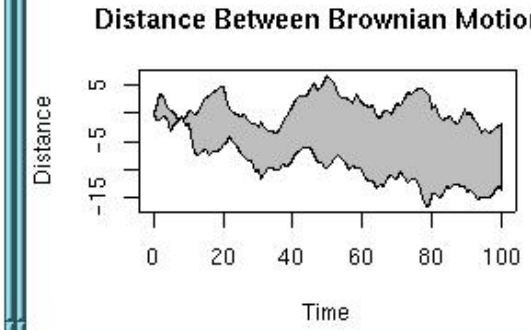
R Graphics: Device 3 (inactive)



R Graphics: Device 4 (ACTIVE)



R Graphics: Device 5 (inactive)



R

PRO

- 企業や研究所・大学で広範囲に利用されている
- パワフルで柔軟
- ユーザー層が膨大
- 本やマニュアルが多い
- User Interface も改善が進み使いやすくなっている (RStudio)

COST

- オープンソース
- **CON**
- あまりユーザーフレンドリーではない
- 学習にはそれなりの努力が必要

Rとは?

- 行列データの演算操作が強力
- データ分析のツール群を大量に実装
- データ分析結果の視覚化ツールが豊富
- プログラム言語としても基本的な機能を完備
- 無料ソフト

インストール

- How to get R:
  - http://www.r-project.org/
  - Google: “R”
  - Windows, Linux, Mac OS X, source

- Files for this tutorial:
  - 投野研究室ページからダウンロード
  - このスライドのファイル
  - Rコードとサンプル・データ
    - R_commands.R　/　T_Tutorial_Data.txt

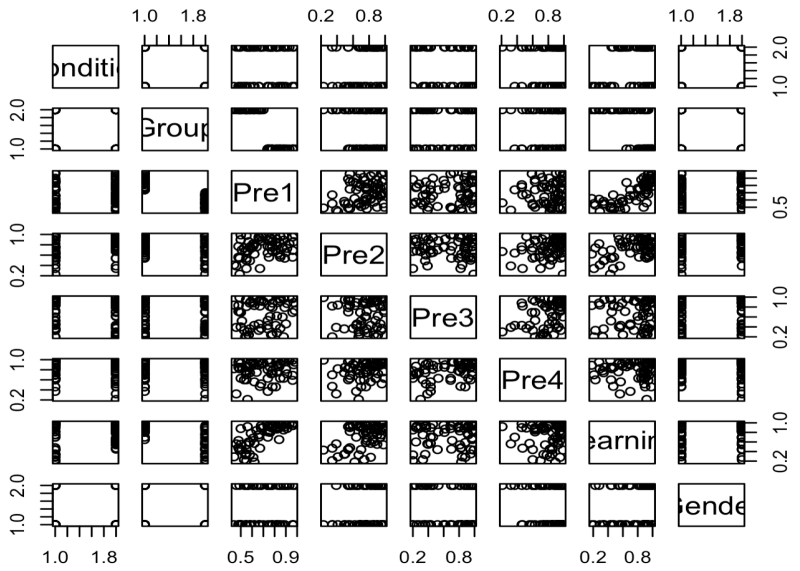
Installing, Running, and Interacting with R

~/Desktop/夏合宿/Tutorials - RStudio

```
29  z <- 1:50
30  x + y
31  x * y
32  x * z
33
34  # Functions:
35  arc <- function(x) 2*asin(sqrt(x))
36  arc(0.5)
37  x <- c(0,1,2,3,4)
38  x <- x / 10
39  arc(x)
40
41  ## Getting help:
42  help(t.test)
43  help.search("standard deviation")
44
45  ## Reading data from files:
46  myData <- read.table("R_Tutorial_Data.txt", header=TRUE, sep="\t
47  myData
48  plot(myData)
49
```

```
> y
[1] 2
> z
[1] 3
> (x + y) * z
[1] 9
> # Functions:
> arc <- function(x) 2*asin(sqrt(x))
> arc(0.5)
[1] 1.570796
> ## Reading data from files:
> myData <- read.table("R_Tutorial_Data.txt", header=TRUE, sep="\t")
> View(myData)
> plot(myData)
>
```

Data	
myData	63 obs. of 8 variables
Values	
x	1
y	2
z	3
Functions	
arc	function (x)



Installing, Running, and Interacting with R

Rコードを打ちながら解説します : “R_commands.R”

- データ入力
  - Math（数式）
  - Variables（変数）
  - Arrays（配列）
  - Math on arrays（配列の演算）
  - Functions（関数）
- Getting help（HELP の表示）
- Reading data from files（ファイルの読み込み）
- Selecting subsets of data（部分セットの抽出）

Installing, Running, and Interacting with R

Math:

```
> 1 + 1
[1] 2

> 1 + 1 * 7
[1] 8

> (1 + 1) * 7
[1] 14
```

Variables:

```
> x <- 1
> x
[1] 1
> y = 2
> y
[1] 2
> 3 -> z
> z
[1] 3
> (x + y) * z
[1] 9
```

Installing, Running, and Interacting with R

Arrays:

```
> x <- c(0,1,2,3,4)
> x
[1] 0 1 2 3 4

> y <- 1:5
> y
[1] 1 2 3 4 5

> z <- 1:50
> z
 [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15
[16] 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
[31] 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
[46] 46 47 48 49 50
```

Installing, Running, and Interacting with R

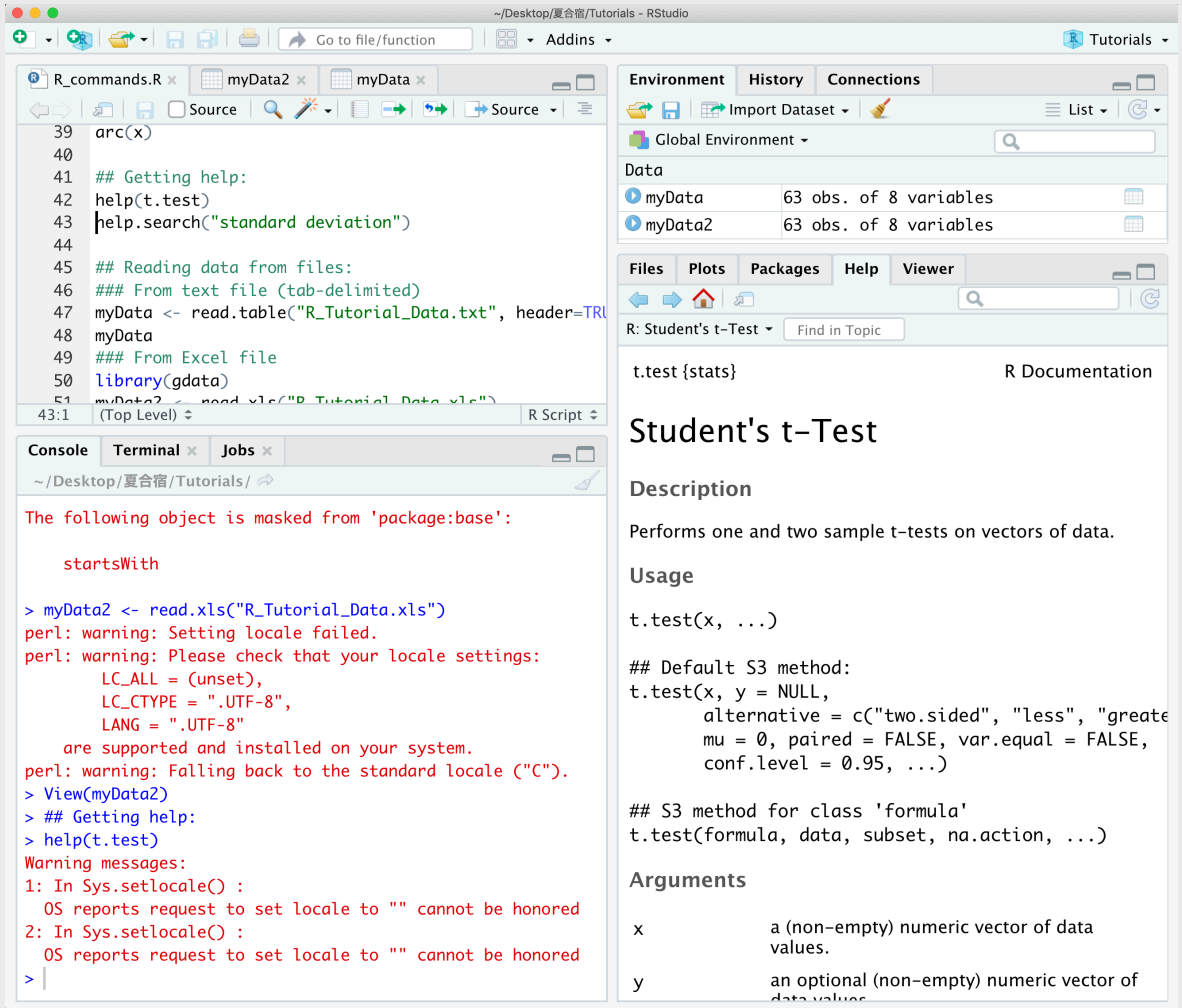
Math on arrays:

```
> x <- c(0,1,2,3,4)
> y <- 1:5
> z <- 1:50
> x + y
[1] 1 3 5 7 9
> x * y
[1]  0  2  6 12 20
> x * z
 [1]   0   2   6  12  20   0   7  16  27  40   0
[12]  12  26  42  60   0  17  36  57  80   0  22
[23]  46  72 100   0  27  56  87 120   0  32  66
[34] 102 140   0  37  76 117 160   0  42  86 132
[45] 180   0  47  96 147 200
```

Installing, Running, and Interacting with R

Getting help: ヘルプの表示

```
> help(t.test)
> help.search("standard deviation")
```



Installing, Running, and Interacting with R

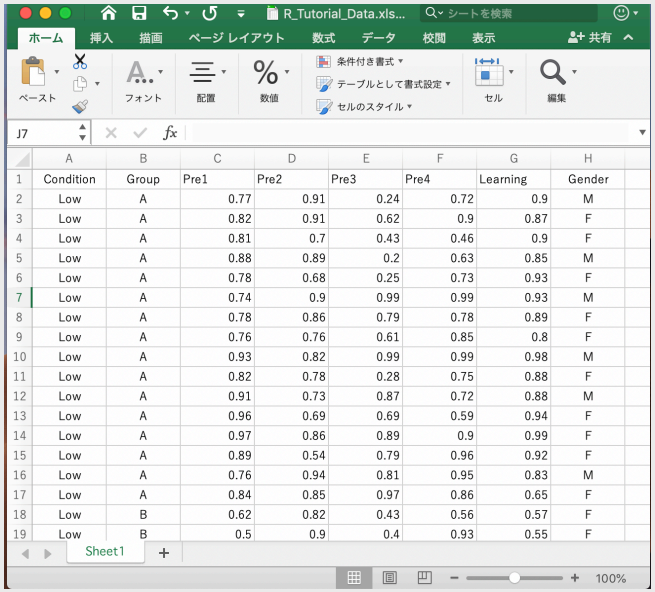
- サンプル実験データ:
  - 被験者が新しい task に取り組む:
  - 被験者は2グループ（適性 : high vs. low）
    - (“A” and “B”; high and low aptitude learners)
  - トレーニング手法が2通り :
    - (“High variability” and “Low variability”)
  - 4回のトレーニング前の評価テスト

- ファイル : “R_Tutorial_Data.txt”

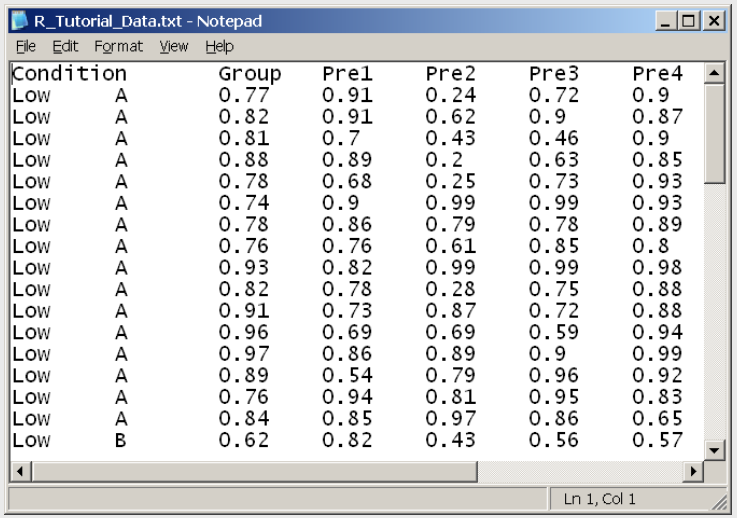
Installing, Running, and Interacting with R

ファイルからのデータ読み込み:

```
> myData <- read.table("R_Tutorial_Data.txt",
+ header=TRUE, sep="¥t")
> myData
   Condition Group Pre1 Pre2 Pre3 Pre4 Learning
1        Low     A 0.77 0.91 0.24 0.72     0.90
2        Low     A 0.82 0.91 0.62 0.90     0.87
3        Low     A 0.81 0.70 0.43 0.46     0.90
. . .
61      High     B 0.44 0.41 0.84 0.82     0.29
62      High     B 0.48 0.56 0.83 0.85     0.48
63      High     B 0.61 0.82 0.88 0.95     0.28
```



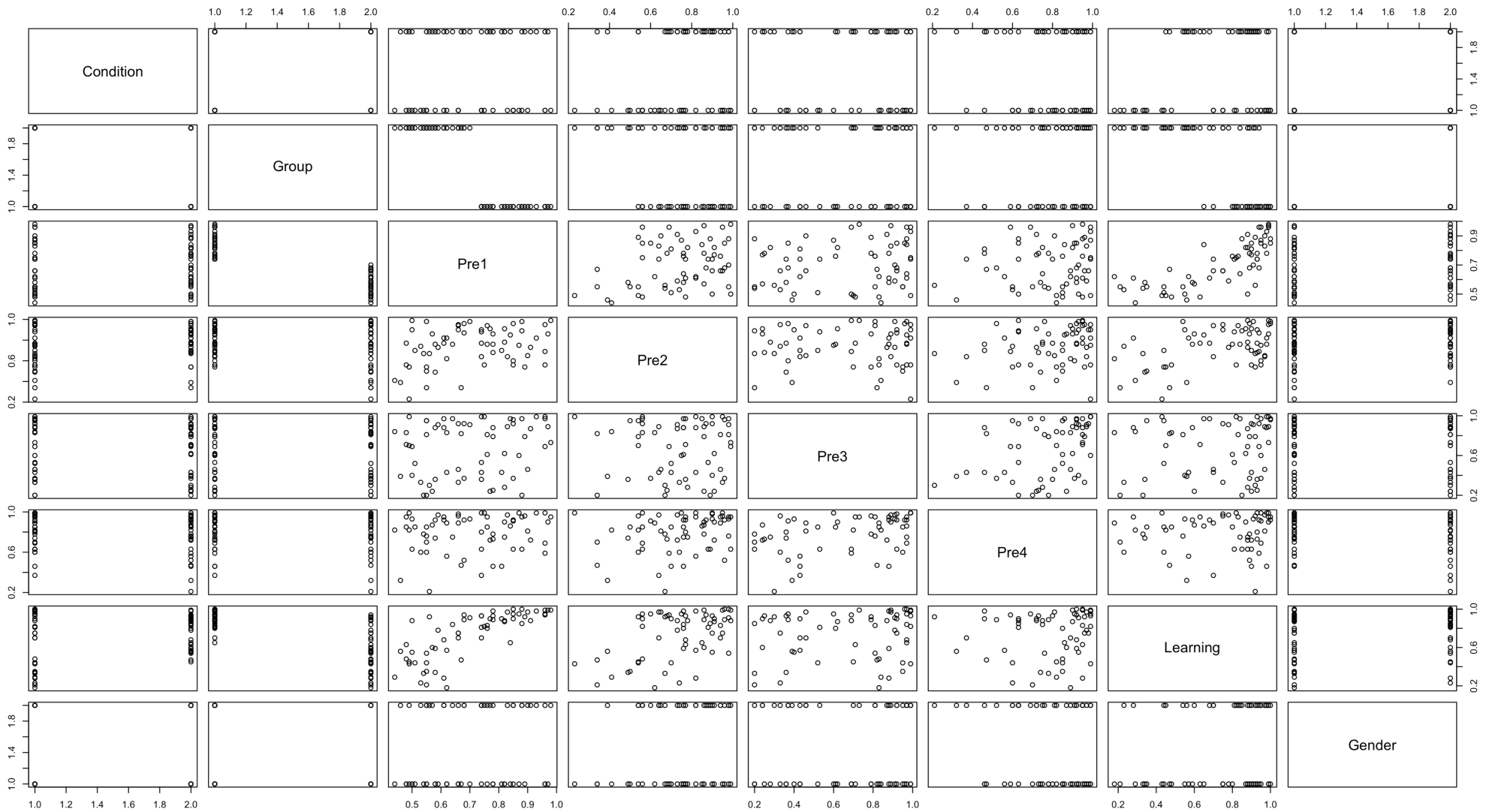
	A	B	C	D	E	F	G	H
1	Condition	Group	Pre1	Pre2	Pre3	Pre4	Learning	Gender
2	Low	A	0.77	0.91	0.24	0.72	0.9	M
3	Low	A	0.82	0.91	0.62	0.9	0.87	F
4	Low	A	0.81	0.7	0.43	0.46	0.9	F
5	Low	A	0.88	0.89	0.2	0.63	0.85	M
6	Low	A	0.78	0.68	0.25	0.73	0.93	F
7	Low	A	0.74	0.9	0.99	0.99	0.93	M
8	Low	A	0.78	0.86	0.79	0.78	0.89	F
9	Low	A	0.76	0.76	0.61	0.85	0.8	F
10	Low	A	0.93	0.82	0.99	0.99	0.98	M
11	Low	A	0.82	0.78	0.28	0.75	0.88	F
12	Low	A	0.91	0.73	0.87	0.72	0.88	M
13	Low	A	0.96	0.69	0.69	0.59	0.94	F
14	Low	A	0.97	0.86	0.89	0.9	0.99	F
15	Low	A	0.89	0.54	0.79	0.96	0.92	F
16	Low	A	0.76	0.94	0.81	0.95	0.83	M
17	Low	A	0.84	0.85	0.97	0.86	0.65	F
18	Low	B	0.62	0.82	0.43	0.56	0.57	F
19	Low	B	0.5	0.9	0.4	0.93	0.55	F



Condition	Group	Pre1	Pre2	Pre3	Pre4
Low	A	0.77	0.91	0.24	0.72	0.9
Low	A	0.82	0.91	0.62	0.9	0.87
Low	A	0.81	0.7	0.43	0.46	0.9
Low	A	0.88	0.89	0.2	0.63	0.85
Low	A	0.78	0.68	0.25	0.73	0.93
Low	A	0.74	0.9	0.99	0.99	0.93
Low	A	0.78	0.86	0.79	0.78	0.89
Low	A	0.76	0.76	0.61	0.85	0.8
Low	A	0.93	0.82	0.99	0.99	0.98
Low	A	0.82	0.78	0.28	0.75	0.88
Low	A	0.91	0.73	0.87	0.72	0.88
Low	A	0.96	0.69	0.69	0.59	0.94
Low	A	0.97	0.86	0.89	0.9	0.99
Low	A	0.89	0.54	0.79	0.96	0.92
Low	A	0.76	0.94	0.81	0.95	0.83
Low	A	0.84	0.85	0.97	0.86	0.65
Low	B	0.62	0.82	0.43	0.56	0.57

Installing, Running, and Interacting with R

```
> plot(myData)
```



Installing, Running, and Interacting with R

Selecting subsets of data:

```
> myData$Learning
 [1] 0.90 0.87 0.90 0.85 0.93 0.93 0.89 0.80 0.98
[10] 0.88 0.88 0.94 0.99 0.92 0.83 0.65 0.57 0.55
[19] 0.94 0.68 0.89 0.60 0.63 0.84 0.92 0.56 0.78
[28] 0.54 0.47 0.45 0.59 0.91 0.98 0.82 0.93 0.81
[37] 0.97 0.95 0.70 1.00 0.90 0.99 0.95 0.95 0.97
[46] 1.00 0.99 0.18 0.33 0.88 0.23 0.75 0.21 0.35
[55] 0.70 0.34 0.43 0.75 0.44 0.44 0.29 0.48 0.28

> myData$Learning[myData$Group=="A"]
 [1] 0.90 0.87 0.90 0.85 0.93 0.93 0.89 0.80 0.98
[10] 0.88 0.88 0.94 0.99 0.92 0.83 0.65 0.98 0.82
[19] 0.93 0.81 0.97 0.95 0.70 1.00 0.90 0.99 0.95
[28] 0.95 0.97 1.00 0.99
```

Installing, Running, and Interacting with R

Selecting subsets of data:

```
> myData$Learning
 [1] 0.90 0.87 0.90 0.85 0.93 0.93 0.89 0.80 0.98
[10] 0.88 0.88 0.94 0.99 0.92 0.83 0.65 0.57 0.55
[19] 0.94 0.68 0.89 0.60 0.63 0.84 0.92 0.56 0.78
[28] 0.54 0.47 0.45 0.59 0.91 0.98 0.82 0.93 0.81
[37] 0.97 0.95 0.70 1.00 0.90 0.99 0.95 0.95 0.97
[46] 1.00 0.99 0.18 0.33 0.88 0.23 0.75 0.21 0.35
[55] 0.70 0.34 0.43 0.75 0.44 0.44 0.29 0.48 0.28
> attach(myData)
> Learning
 [1] 0.90 0.87 0.90 0.85 0.93 0.93 0.89 0.80 0.98
[10] 0.88 0.88 0.94 0.99 0.92 0.83 0.65 0.57 0.55
[19] 0.94 0.68 0.89 0.60 0.63 0.84 0.92 0.56 0.78
[28] 0.54 0.47 0.45 0.59 0.91 0.98 0.82 0.93 0.81
[37] 0.97 0.95 0.70 1.00 0.90 0.99 0.95 0.95 0.97
[46] 1.00 0.99 0.18 0.33 0.88 0.23 0.75 0.21 0.35
[55] 0.70 0.34 0.43 0.75 0.44 0.44 0.29 0.48 0.28
```

Installing, Running, and Interacting with R

Selecting subsets of data:

```
> Learning[Group=="A"]
 [1] 0.90 0.87 0.90 0.85 0.93 0.93 0.89 0.80 0.98
[10] 0.88 0.88 0.94 0.99 0.92 0.83 0.65 0.98 0.82
[19] 0.93 0.81 0.97 0.95 0.70 1.00 0.90 0.99 0.95
[28] 0.95 0.97 1.00 0.99
> Learning[Group!="A"]
 [1] 0.57 0.55 0.94 0.68 0.89 0.60 0.63 0.84 0.92
[10] 0.56 0.78 0.54 0.47 0.45 0.59 0.91 0.18 0.33
[19] 0.88 0.23 0.75 0.21 0.35 0.70 0.34 0.43 0.75
[28] 0.44 0.44 0.29 0.48 0.28
> Condition[Group=="B"&Learning<0.5]
 [1] Low  Low  High High High High High High High
[10] High High High High High
Levels: High Low
```

Useful functions for text processing

```
>substr("internationalization", 6, 13)
[1] "national “

>example <- c("I", "do", , "not" "know")
>nchar(example)
[1] 1 2 3 4
>tolower(example)
[1] "i "... "do"... "not"..."know"
>toupper(example)
[1] "I"... “DO"... “NOT"... "KNOW"
```

Useful functions for text processing

```
>chartr("o", "x", example)
[1] "l"   "dx"   "nxt"   "knxw"


>example.2 <- "I do not know"
>strsplit(example.2, " ")   # " " はスペース
[[1]]
[1] "I"   "do"   "not"   "know"
# ""と何もいれないと文字単位で分割
# data 形式的には vector ではなく，list の状態
```

```
>unlist(strsplit(example.2, " "))
[1] "I"   "do"   "not"   "know"


>text <- c("This is a first example sentence.",
"And this is a second example sentence.")
>grep("second", text)
[1] 2
# grep はマッチした位置を返す
>grep("second", text, value=T)
[1] "And this is ..."
```

Package gsubfn (1)

```
>library(gsubfn)
>text <- c("This is a first example sentence.", "And this is a second example sentence.")
```

```
>strapply(text, "first")
[[1]]
[1] "first"
[[2]]
NULL
>strapply(text, "is")
[[1]]
[1] "is" "is"
[[2]]
[1] "is" "is"
```

Package gsubfn (2)

gsub(pattern, replacement, x, ignore.case=F)

>gsub(“a”, “the”, text)

[1] “This is the first exthemple sentence.”

[2] “And this is the second exthemple sentence.”

>gsub(“ a ”, “ the ”, text)

[1] “This is the first example sentence.”

[2] “And this is the second example sentence.”

>text.2 <- gsub(“ a ”, “ the ”, text)　#テキストに格納

Statistics and Data Analysis

- Parametric Tests パラメトリック・テスト
  - Independent sample t-tests
  - Paired sample t-tests
  - One sample t-tests
  - Correlation
- Nonparametric tests　ノンパラメトリック・テスト
  - Shapiro-Wilks test for normality
  - Wilcoxon signed-rank test (Mann-Whitney U)
  - Chi square test
- Linear Models and ANOVA　線形モデル

Basic parametric inferential statistics

Independent sample t-tests:

```
> t.test(Pre2[Group=="A"],
+ Pre2[Group=="B"],
+ paired=FALSE)

        Welch Two Sample t-test

data:  Learning[Group == "A"] and Learning[Group == "B"]
t = 1.6117, df = 53.275, p-value = 0.1129
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.0179193  0.1645725
sample estimates:
mean of x mean of y
0.7764516 0.7031250
```

Pre2テストのAとBグループの比較

Basic parametric inferential statistics

Independent sample t-tests:独立2標本 t検定

```
> t.test(Pre2[Group=="A"],
+ Pre2[Group=="B"],
+ paired=FALSE,
+ var.equal=TRUE)

        Welch Two Sample t-test

data:  Learning[Group == "A"] and Learning[Group == "B"]
t = 1.601, df = 61, p-value = 0.1145
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.0179193  0.1645725
sample estimates:
mean of x mean of y
0.7764516 0.7031250
```

Basic parametric inferential statistics

Independent sample t-tests:独立2標本 t検定

```
> t.test(Pre2[Group=="A"],
+ Pre2[Group=="B"],
+ paired=FALSE,
+ var.equal=TRUE,
+ alternative="greater")

        Welch Two Sample t-test

data:  Learning[Group == "A"] and Learning[Group == "B"]
t = 1.601, df = 61, p-value = 0.5727
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 -0.003169388          Inf
sample estimates:
mean of x mean of y
0.7764516 0.7031250
```

Basic parametric inferential statistics

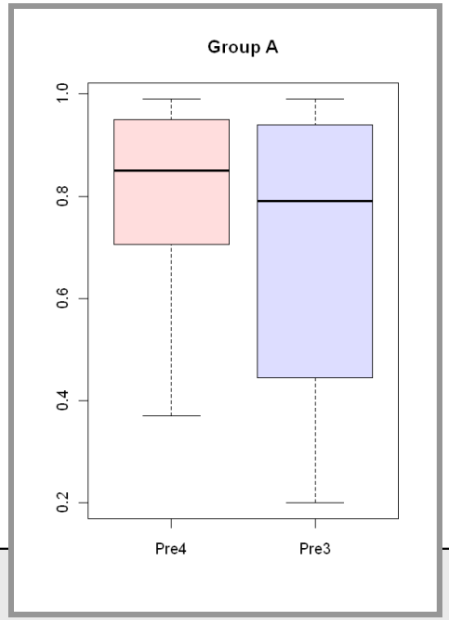
Paired sample t-test:対応のある2標本 t検定

```
> t.test(Pre4[Group=="A"],
+ Pre3[Group=="A"],
+ paired=TRUE)
```

グループAの3回目と4回目の比較

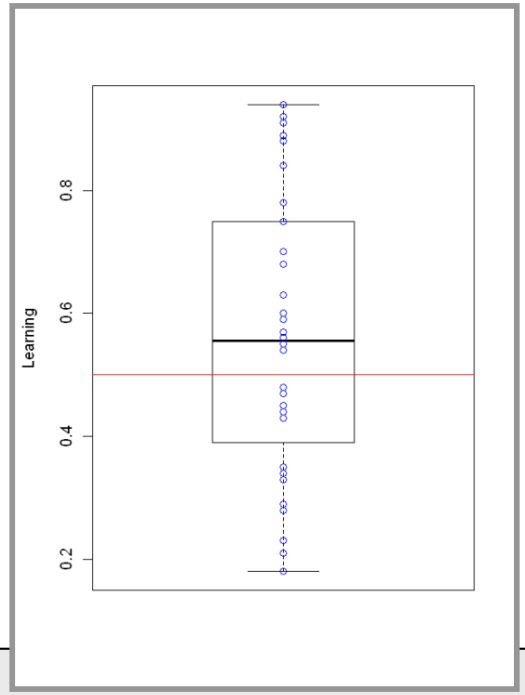
```
        Paired t-test

data:  Pre4[Group == "A"] and Pre3[Group == "A"]
t = 2.4054, df = 30, p-value = 0.02253
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.01641059 0.20100876
sample estimates:
mean of the differences
              0.1087097
```

```
> boxplot(Pre4[Group=="A"],
+ Pre3[Group=="A"],
+ col=c("#ffdddd","#ddddff"),
+ names=c("Pre4","Pre3"),main="Group A")
```



One sample t-test: 母平均との差の検定

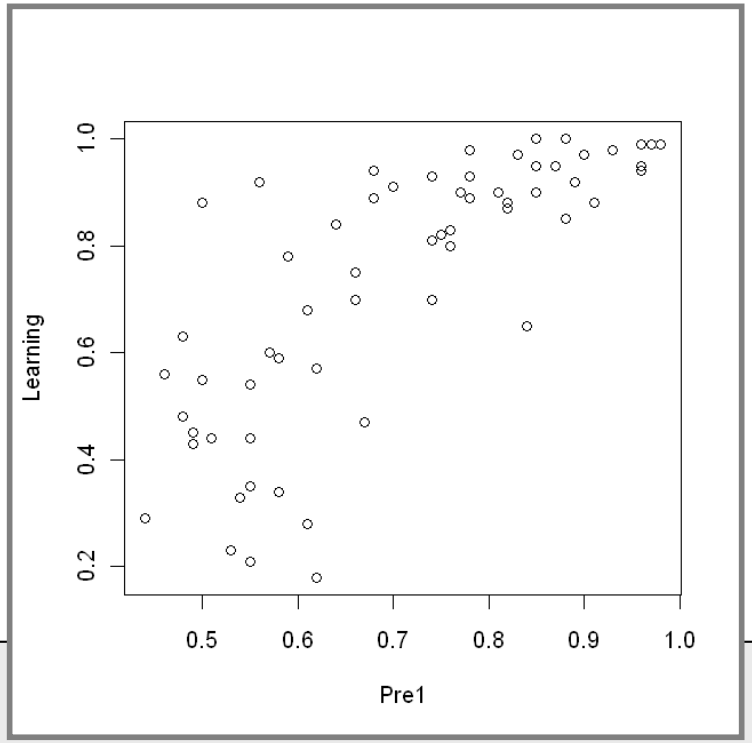
```
> t.test(Learning[Group=="B"], mu=0.5, alternative="greater")

        One Sample t-test

data:  Learning[Group == "B"]
t = 1.5595, df = 31, p-value = 0.06452
alternative hypothesis: true mean is greater than 0.5
95 percent confidence interval:
 0.4945469       Inf
sample estimates:
mean of x
   0.5625

> boxplot(Learning[Group=="B"],
+ names="Group B", ylab="Learning")
> lines(c(0,2), c(0.5, 0.5), col="red")
> points(c(rep(1,length(Learning[Group=="B"]))),
+ Learning[Group=="B"], pch=21, col="blue")
```



Basic parametric inferential statistics

Correlation: 相関分析

```
> cor.test(Pre1,Learning,method="pearson")

        Pearson's product-moment correlation

data:  Pre1 and Learning
t = 9.2461, df = 61, p-value = 3.275e-13
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.6366698 0.8506815
sample estimates:
      cor
0.7639292

> plot(Pre1,Learning)
```

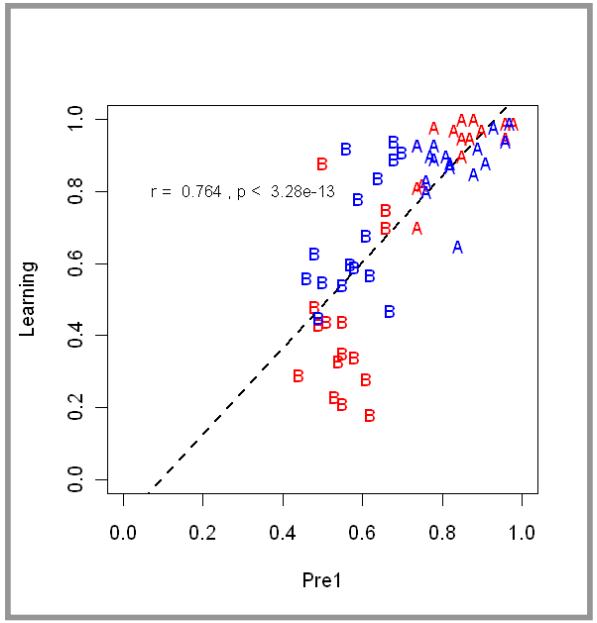


Basic parametric inferential statistics

Correlation (fancier plot example):

```
> cor.test(Pre1,Learning,method="pearson")

        Pearson's product-moment correlation

data:  Pre1 and Learning
t = 9.2461, df = 61, p-value = 3.275e-13
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.6366698 0.8506815
sample estimates:
      cor
0.7639292
```

```
> plot(Learning~Pre1, ylim=c(0,1), xlim=c(0,1), ylab="Learning", xlab="Pre1", type="n")
> abline(lm(Learning~Pre1),col="black",lty=2, lwd=2)
> points(Learning[Group=="A"&Condition=="High"]~Pre1[Group=="A"&Condition=="High"],
+ pch=65, col="red", cex=0.9)
> points(Learning[Group=="A"&Condition=="Low"]~Pre1[Group=="A"&Condition=="Low"],
+ pch=65, col="blue", cex=0.9)
> points(Learning[Group=="B"&Condition=="High"]~Pre1[Group=="B"&Condition=="High"],
+ pch=66, col="red", cex=0.9)
> points(Learning[Group=="B"&Condition=="Low"]~Pre1[Group=="B"&Condition=="Low"],
+ pch=66, col="blue", cex=0.9)
> legend(2.5,1.0, c("LV Training", "HV Training"), pch=c(19), col=c("blue","red"), bty="y")
> yCor <- cor.test(Pre1, Learning, method="pearson")
> text(0.3,0.8, paste("r = ", format(myCor$estimate,digits=3),", p < ", format(myCor$p.value,digits=3)), cex=0.8)
```

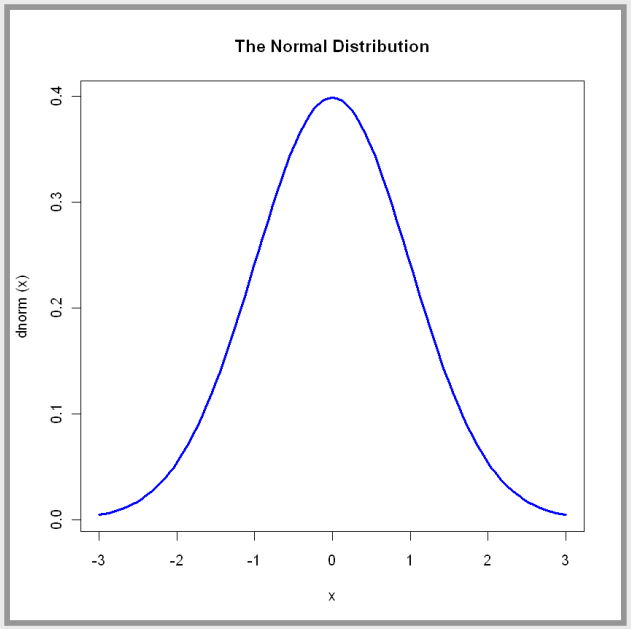


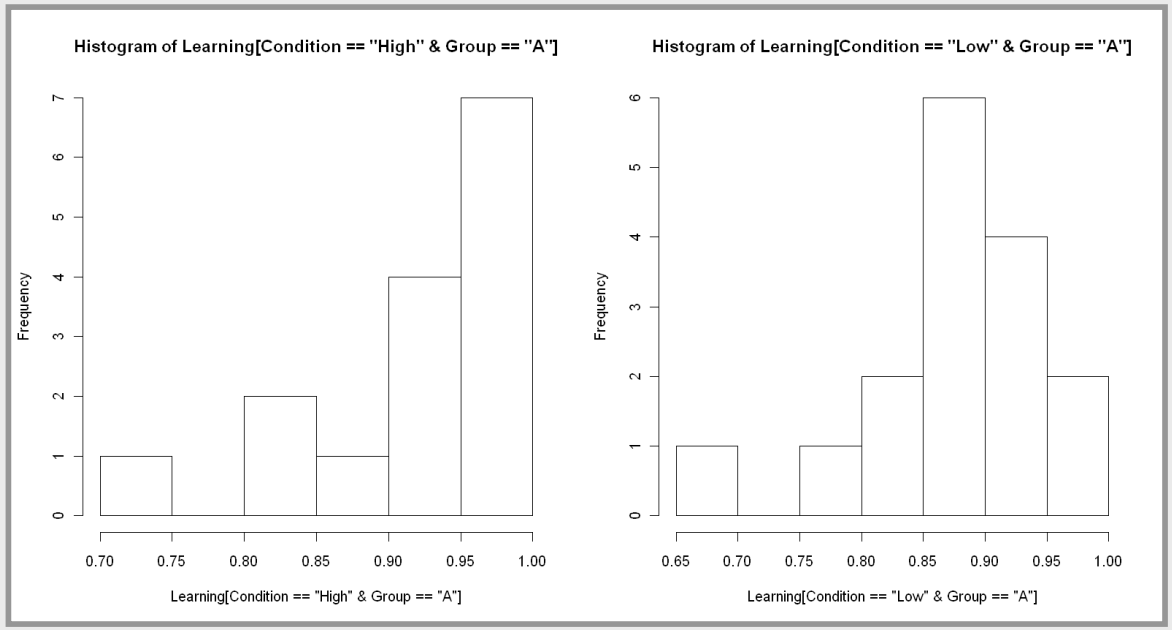
Are my data normally distributed? 正規性の検定

```
> t.test(Learning[Condition=="High"&Group=="A"],
+ Learning[Condition=="Low"&Group=="A"])

        Welch Two Sample t-test

data:  Learning[Condition == "High" & Group == "A"] and
    Learning[Condition == "Low" & Group == "A"]
t = 1.457, df = 28.422, p-value = 0.1561
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.01764821  0.10481488
sample estimates:
mean of x mean of y
0.9273333 0.8837500
```

Are my data normally distributed?

```
> plot(dnorm,-3,3,col="blue",lwd=3,main="The Normal Distribution")
> par(mfrow=c(1,2))
> hist(Learning[Condition=="High"&Group=="A"])
> hist(Learning[Condition=="Low"&Group=="A"])
```





Statistics and Data Analysis

Are my data normally distributed?

```
> shapiro.test(Learning[Condition=="High"&Group=="A"])

        Shapiro-Wilk normality test

data:  Learning[Condition == "High" & Group == "A"]
W = 0.7858, p-value = 0.002431

> shapiro.test(Learning[Condition=="Low"&Group=="A"])

        Shapiro-Wilk normality test

data:  Learning[Condition == "Low" & Group == "A"]
W = 0.8689, p-value = 0.02614
```

Basic nonparametric inferential statistics

Wilcoxon signed-rank / Mann-Whitney U tests:

```
> wilcox.test(Learning[Condition=="High"&Group=="A"],
+ Learning[Condition=="Low"&Group=="A"],
+ exact=FALSE,
+ paired=FALSE)

        Wilcoxon rank sum test with continuity correction

data:  Learning[Condition == "High" & Group == "A"] and
    Learning[Condition == "Low" & Group == "A"]
W = 173.5, p-value = 0.03580
alternative hypothesis: true location shift is not equal to 0
```

Basic nonparametric inferential statistics

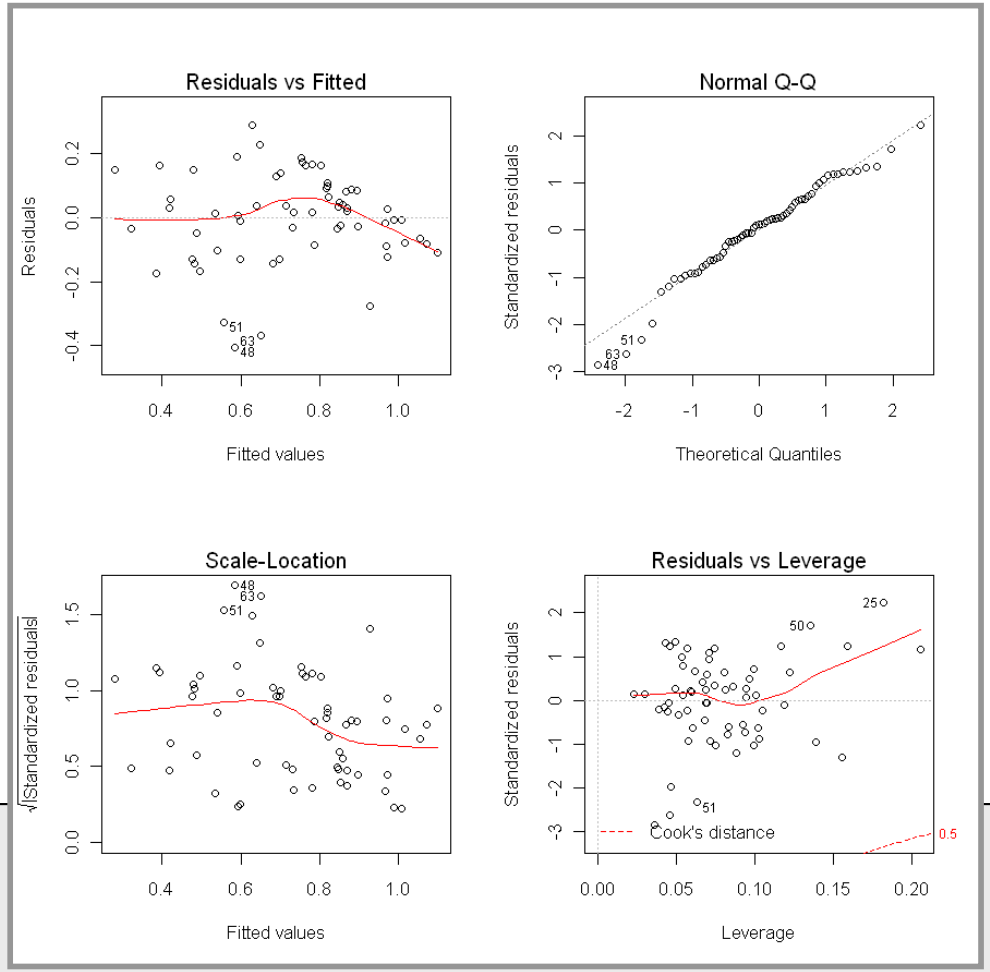
Chi square test: カイ2乗検定

```
> x <- matrix(c(
+ length(Learning[Group=="A"&Condition=="High"&Gender=="F"]),
+ length(Learning[Group=="A"&Condition=="Low"&Gender=="F"]),
+ length(Learning[Group=="B"&Condition=="High"&Gender=="F"]),
+ length(Learning[Group=="B"&Condition=="Low"&Gender=="F"])),
+ ncol=2)
> x
     [,1] [,2]
[1,]    4   12
[2,]   10    7
> chisq.test(x)

        Pearson's Chi-squared test with Yates' continuity correction

data:  x
X-squared = 2.5999, df = 1, p-value = 0.1069
```

Linear models and ANOVA

Linear models: 線形モデル

```
> myModel <- lm(Learning ~ Pre1 + Pre2 + Pre3 + Pre4)
> par(mfrow=c(2,2))
> plot(myModel)
```



Linear models and ANOVA

Linear models: 線形モデル

```
> summary(myModel)

Call:
lm(formula = Learning ~ Pre1 + Pre2 + Pre3 + Pre4)

Residuals:
     Min       1Q   Median       3Q      Max
-0.40518 -0.08460  0.01707  0.09170  0.29074

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.22037    0.11536  -1.910 0.061055 .
Pre1         1.05299    0.12636   8.333 1.70e-11 ***
Pre2         0.41298    0.10926   3.780 0.000373 ***
Pre3         0.07339    0.07653   0.959 0.341541
Pre4        -0.18457    0.11318  -1.631 0.108369
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1447 on 58 degrees of freedom
Multiple R-squared: 0.6677,     Adjusted R-squared: 0.6448
F-statistic: 29.14 on 4 and 58 DF,  p-value: 2.710e-13
```

Linear models and ANOVA

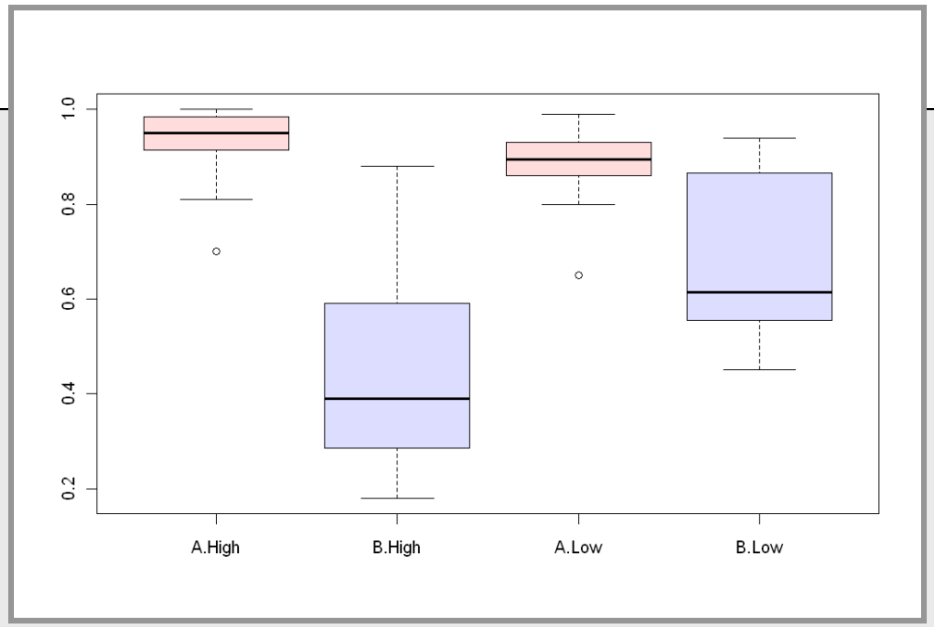
Linear models: 線形モデル

```
> step(myModel, direction="backward")
Start:  AIC=-238.8
Learning ~ Pre1 + Pre2 + Pre3 + Pre4

       Df Sum of Sq    RSS     AIC
- Pre3  1   0.01925 1.2332 -239.81
<none>              1.2140 -238.80
- Pre4  1   0.05566 1.2696 -237.98
- Pre2  1   0.29902 1.5130 -226.93
- Pre1  1   1.45347 2.6675 -191.21

Step:  AIC=-239.81
Learning ~ Pre1 + Pre2 + Pre4

       Df Sum of Sq    RSS     AIC
- Pre4  1   0.03810 1.2713 -239.89
<none>              1.2332 -239.81
- Pre2  1   0.28225 1.5155 -228.83
- Pre1  1   1.54780 2.7810 -190.58

                ...
```

```
                ...

Step:  AIC=-239.89
Learning ~ Pre1 + Pre2

       Df Sum of Sq    RSS     AIC
<none>              1.2713 -239.89
- Pre2  1   0.24997 1.5213 -230.59
- Pre1  1   1.52516 2.7965 -192.23

Call:
lm(formula = Learning ~ Pre1 + Pre2)

Coefficients:
(Intercept)         Pre1         Pre2
    -0.2864       1.0629       0.3627
```

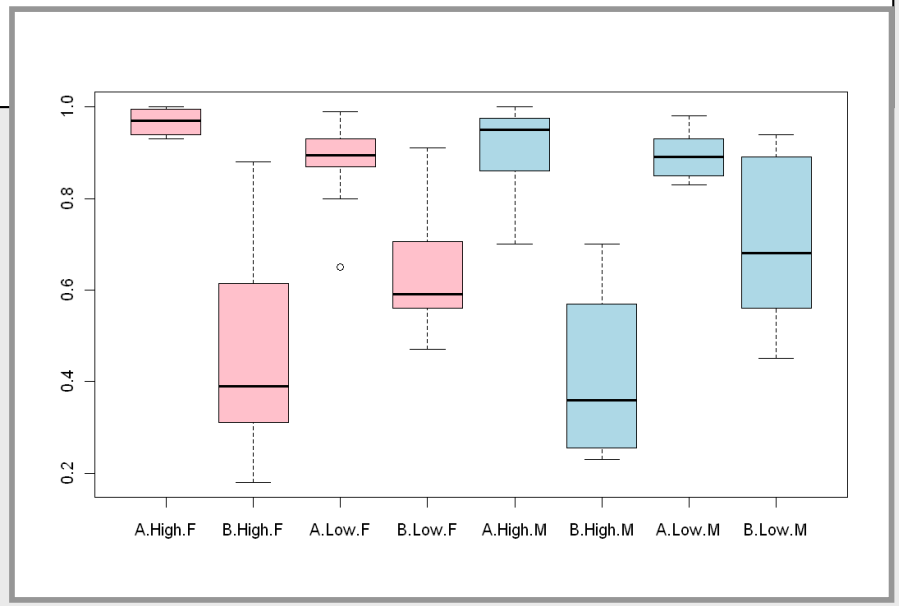
ANOVA: 分散分析

```
> myANOVA <- aov(Learning~Group*Condition)
> summary(myANOVA)
                Df Sum Sq Mean Sq F value    Pr(>F)
Group            1 1.8454 1.84537 81.7106 9.822e-13 ***
Condition        1 0.1591 0.15910  7.0448 0.0102017 *
Group:Condition  1 0.3164 0.31640 14.0100 0.0004144 ***
Residuals       59 1.3325 0.02258
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> boxplot(Learning~Group*Condition,col=c("#ffdddd","#ddddff"))
```



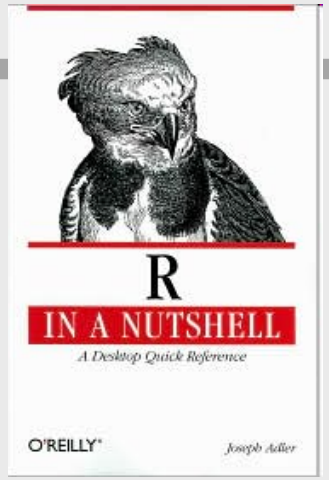
ANOVA: 分散分析

```
> myANOVA2 <- aov(Learning~Group*Condition+Gender)
> summary(myANOVA2)
                Df  Sum Sq Mean Sq F value    Pr(>F)
Group            1 1.84537 1.84537 80.3440 1.523e-12 ***
Condition        1 0.15910 0.15910  6.9270  0.010861 *
Gender           1 0.04292 0.04292  1.8688  0.176886
Group:Condition  1 0.27378 0.27378 11.9201  0.001043 **
Residuals       58 1.33216 0.02297
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> boxplot(Learning~Group*Condition+Gender,
+ col=c(rep("pink",4),rep("light blue",4)))
```



その他の R 関連サイト

- R wiki:
  http://rwiki.sciviews.org/doku.php
- R graph gallery:
  http://addictedtor.free.fr/graphiques/thumbs.php
- Kickstarting R:
  http://cran.r-project.org/doc/contrib/Lemon-kickstart/



ISBN: 9780596801700