SEMINR

INTRODUCTION A L'ANALYSE DE DONNEES

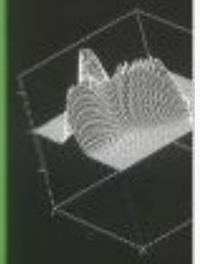
CHRISTOPHE LALANNE

www.aliquote.org

“Let’s not kid ourselves: the most widely used piece of software for statistics is Excel.” — Brian Ripley (2002)

WILEY

NUMERICAL ISSUES IN STATISTICAL COMPUTING FOR THE SOCIAL SCIENTIST



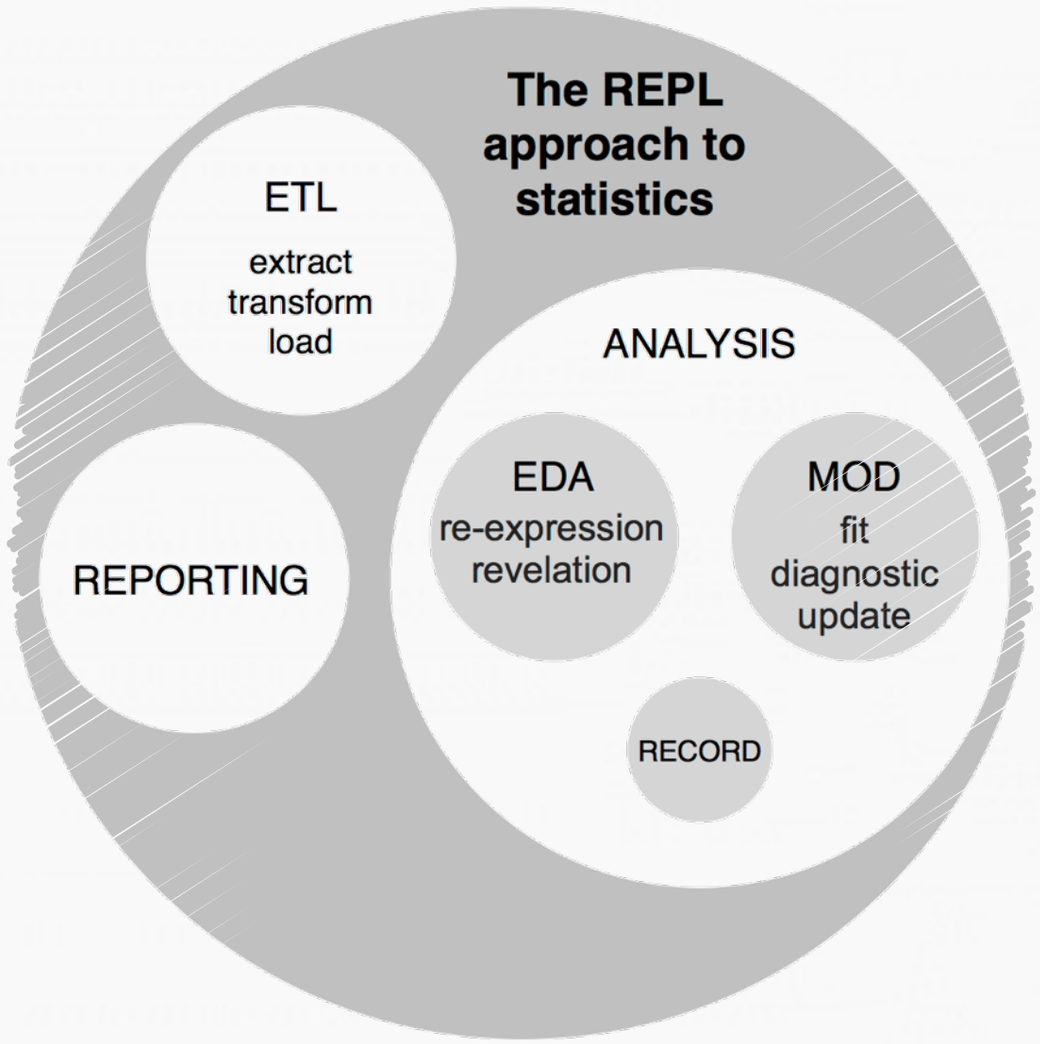
Micah Altman
Jeff Gill
Michael P. McDonald

Wiley Series in Probability and Statistics

WWW.

ANALYSE EXPLORATOIRE DE DONNEES

UNE APPROCHE INTERACTIVE

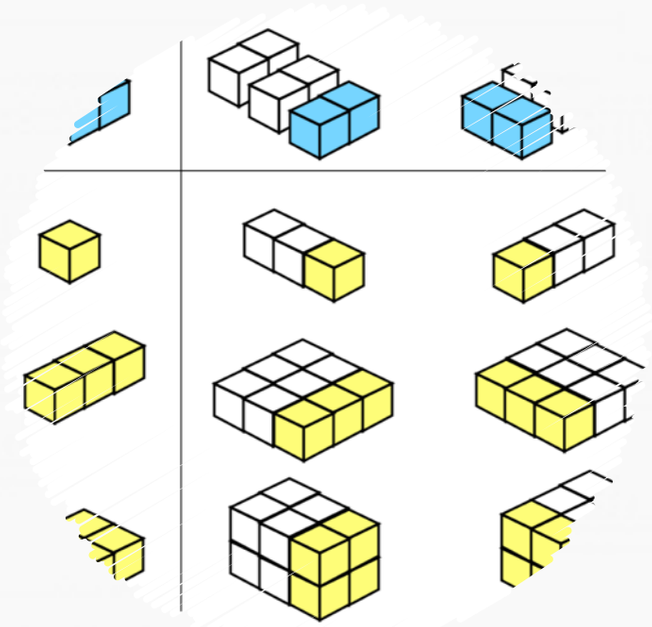


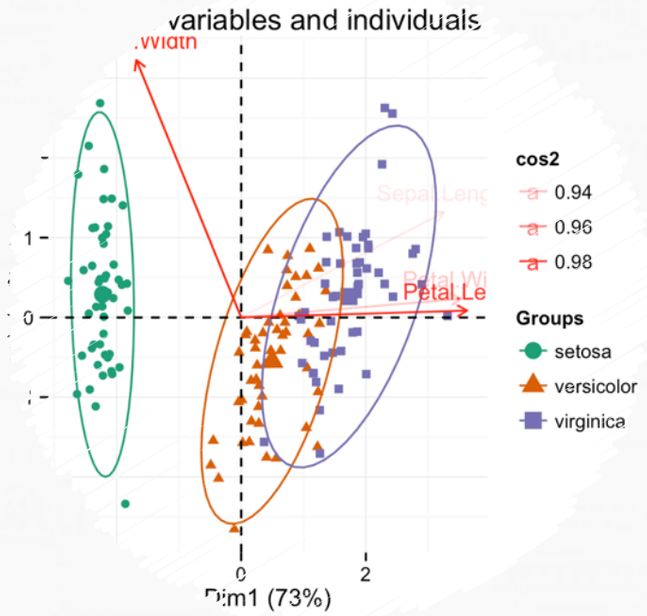
READ-EVAL-PRINT-LOOP

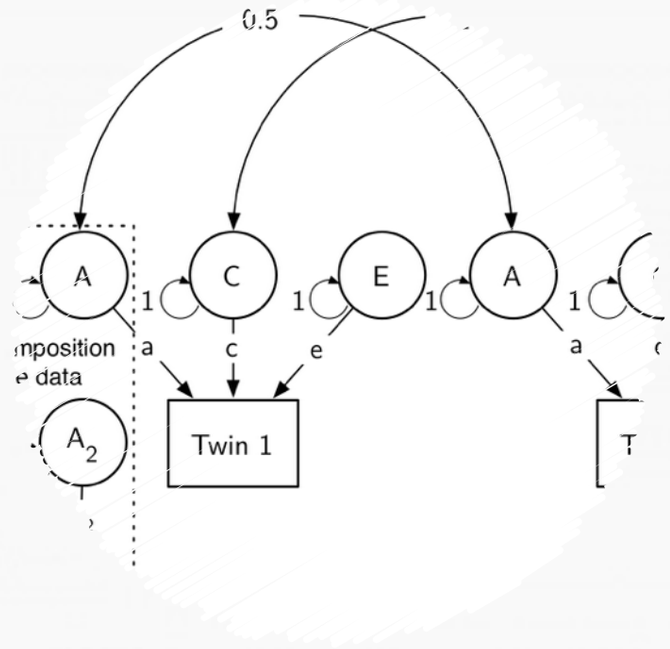
The plural of anecdote is (not) data, http://blog.revolutionanalytics.com/2011/04/the-plural-of-anecdote-is-data-after-all.html

EDA ⇋ MOD

UNE APPROCHE INTERACTIVE







ETL

Extraction de données, fusion de sources, nettoyage d'une base de données, quality control, recodage de variables, dictionnaire de données

EDA

Résumés graphiques et numériques, réduction de dimension, transformation de variables, analyse exploratoire et interactive des données

MOD

Estimation des paramètres d'un modèle statistique, analyse des résidus, prédiction ponctuelle et par intervalles

REPRODUCTIBILITE

70%

PREPARATION DES DONNEES

Nettoyage des données brutes, recodage des données catégorielles, création de variables auxiliaires, résumés numériques univariés, représentations graphiques, représentations graphiques (encore), agrégation de données, imputation, etc.

30%

MODELISATION

Modèle statistique, transformation et ré-expression des variables, qualité d'ajustement, analyse des résidus, etc.

REPORTING

Peng, R.D. Reproducible research and biostatistics. *Biostatistics*, 10(3): 405–408, 2009

EDA, TUKEY (1977)

RESISTANCE

Utilisation de techniques peu sensibles aux écarts d'ajustement locaux par rapport au modèle ou aux perturbations (breakdown point, winsorized mean, trimmed mean, etc.)

RESIDUALS

data = fit + residuals
Analyse des résidus du modèle afin d'identifier des sources potentielles de déviation ou des observations influentes (outliers ou non)

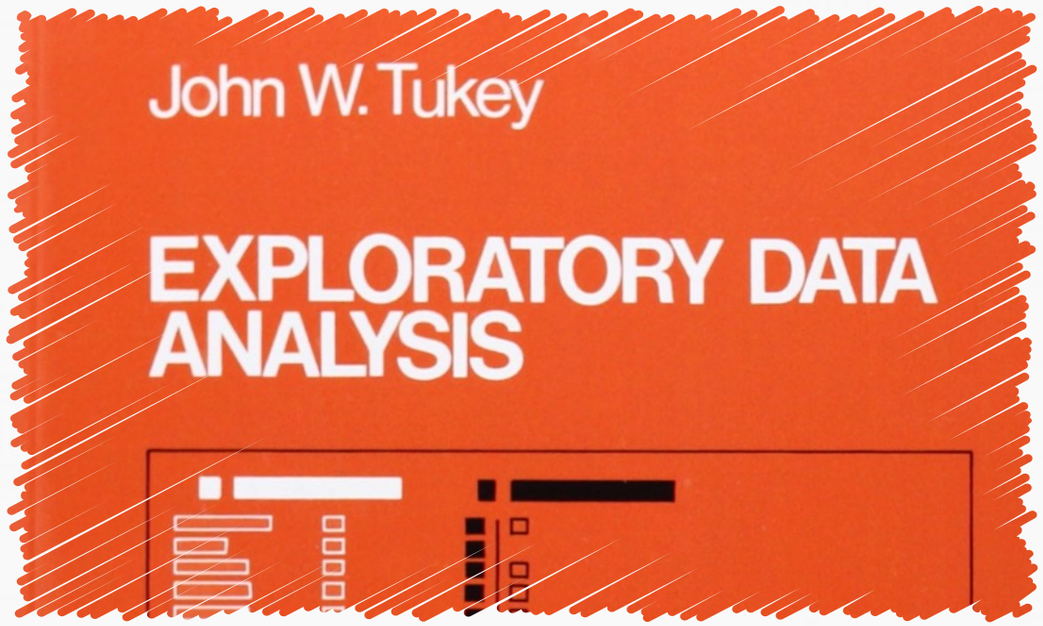
RE-EXPRESSION

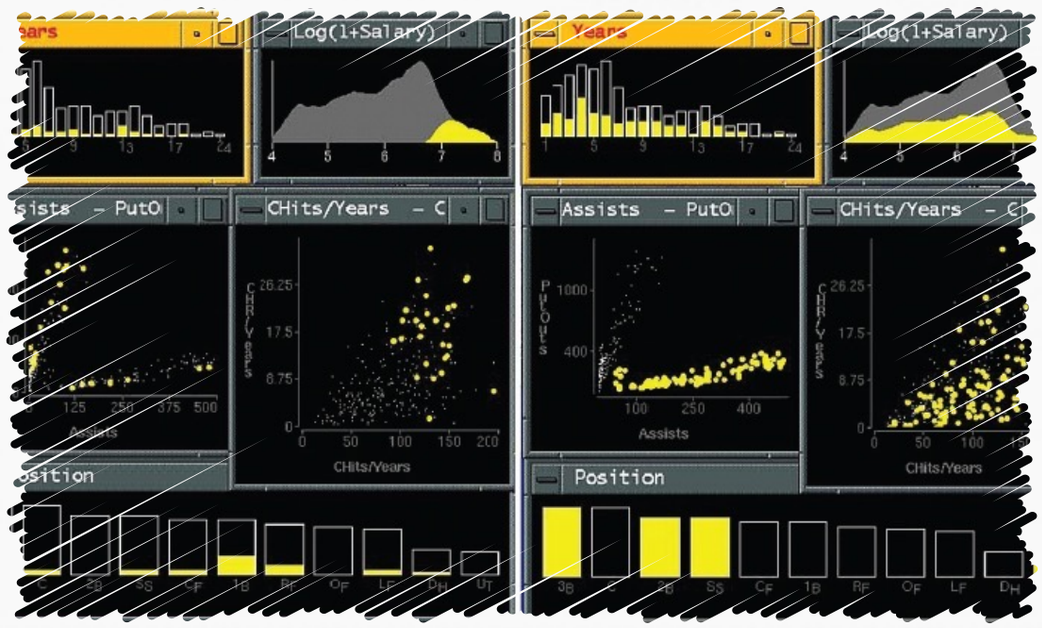
Transformation des données (arcsin, logit, z-scores, fréquences relatives, etc.) dans le but de faciliter l'analyse ou l'interprétation des résultats

REVELATION

Utilisation de graphiques « informatifs » (stem-and-leaf plot of effect sizes, dot plot, box plot, etc.) et recherche de patterns inattendus

POUR ALLER PLUS LOIN





REFERENCES

Hoaglin, D., Mosteller, F. and Tukey, J.W. *Understanding Robust and Exploratory Data Analysis*. New York: Wiley, 1985.

Tufte, E.R. *The Visual Display of Quantitative Information*. Cheshire, CT: Graphic Press, 1983.

Cleveland, W.S. *Visualizing Data*. Summit, NJ: Hobart Press, 1993.

LOGICIELS

Datadesk (http://www.datadesk.com)

LispStat

Ggobi (http://www.ggobi.org)

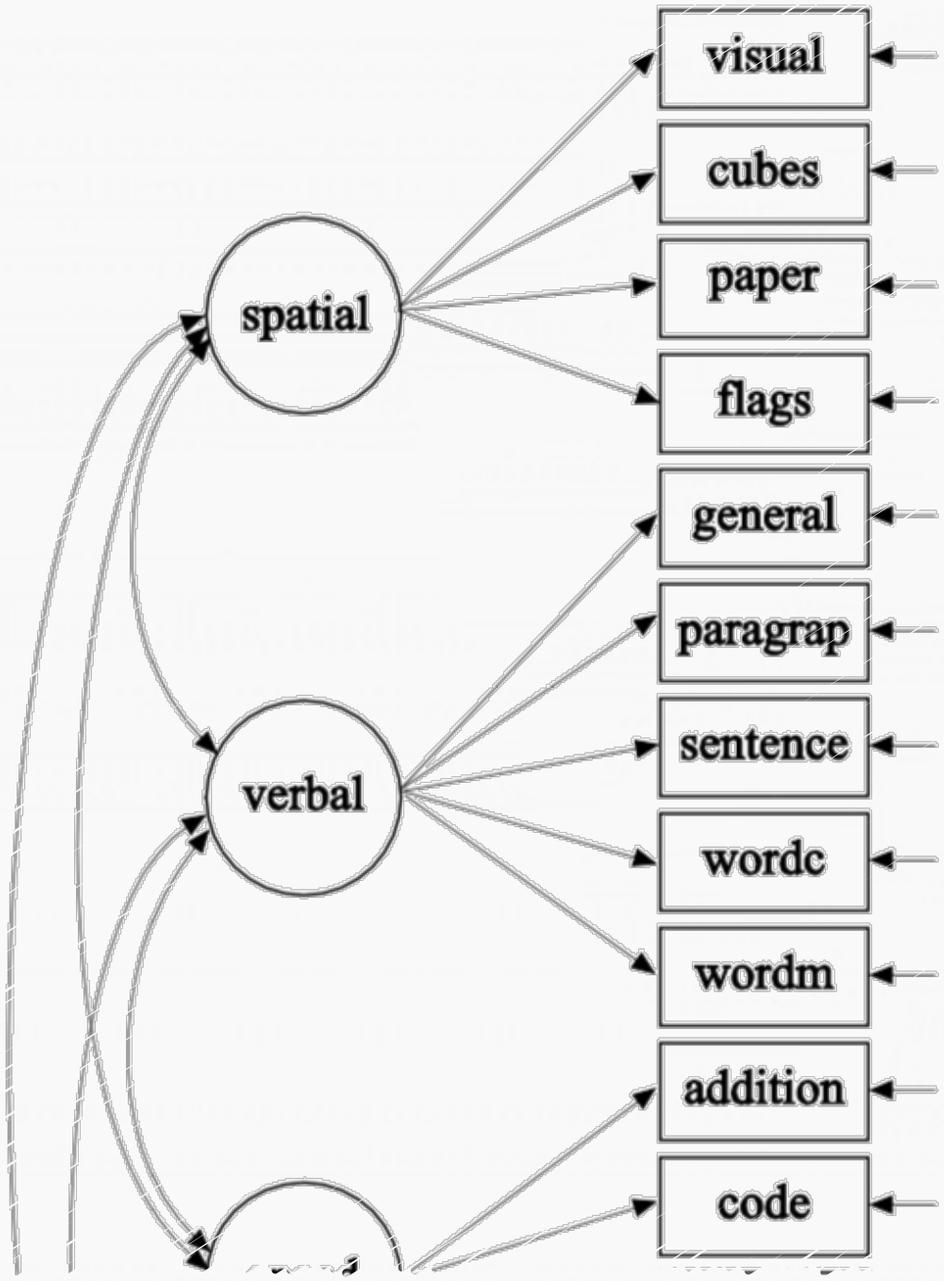
R/cranvas (http://cranvas.org)

R/ggvis (http://ggvis.rstudio.com)

SAS JMP (http://www.jmp.com)

MANIPULATION DE DONNEES AVEC R

DONNEES D'ILLUSTRATION



HOLZINGER & SWINEFORD

301 enfants de deux écoles auxquels on a administré 26 tests permettant d'évaluer les compétences suivantes : spatiales, verbales, vitesse de raisonnement, mémoire, mathématiques.

Holzinger, K. J. and Swineford, F. A. A study in factor analysis: The stability of a bi-factor solution. *Supplementary Education Monographs*, 48. University of Chicago, 1939.

```
lavaan::HolzingerSwineford1939
MBESS::HS.data
```

LOAD

tests spatiaux

	id	sex	ageyr	agemo	school	grade	visual	cubes	paper	paragrap	sentence	wordm	addition	counting	straight
1	1	1	13	1	Pasteur	7	3.333	7.75	0.375	2.333	5.75	1.286	3.39	5.75	6.36
2	2	2	13	7	Pasteur	7	5.333	5.25	2.125	1.667	3.00	1.286	3.78	6.25	7.92
3	3	2	13	1	Pasteur	7	4.500	5.25	1.875	1.000	1.75	0.429	3.26	3.90	4.42
4	4	1	13	2	Pasteur	7	5.333	7.75	3.000	2.667	4.50	2.429	3.00	5.30	4.86
5	5	2	12	2	Pasteur	7	4.833	4.75	0.875	2.667	4.00	2.571	3.70	6.30	5.92
6	6	2	14	1	Pasteur	7	5.333	5.00	2.250	1.000	3.00	0.857	4.35	6.65	7.50
7	7	1	12	1	Pasteur	7	2.833	6.00	1.000	3.333	6.00	2.857	4.70	6.20	4.86
8	8	2	12	2	Pasteur	7	5.667	6.25	1.875	3.667	4.25	1.286	3.39	5.15	3.67
9	9	2	13	0	Pasteur	7	4.500	5.75	1.500	2.667	5.75	2.714	4.52	4.65	7.36
10	11	2	12	5	Pasteur	7	3.500	5.25	0.750	2.667	5.00	2.571	4.13	4.55	4.36
11	12	1	12	2	Pasteur	7	3.667	5.75	2.000	2.000	3.50	1.571	3.74	5.70	4.31
12	13	1	12	11	Pasteur	7	5.833	6.00	2.875	2.667	4.50	2.714	3.70	5.15	4.14
13	14	2	12	7	Pasteur	7	5.667	4.50	4.125	2.667	4.00	2.286	5.87	5.20	5.86
14	15	2	12	8	Pasteur	7	6.000	5.50	1.750	4.667	4.00	1.571	5.13	4.70	4.44
15	16	1	12	6	Pasteur	7	5.833	5.75	3.625	5.000	5.50	3.000	4.00	4.35	5.86
16	17	2	12	1	Pasteur	7	4.667	4.75	2.375	2.667	4.25	0.714	4.09	3.80	5.14
17	18	2	14	11	Pasteur	7	4.333	4.75	1.500	2.000	4.00	1.286	3.70	6.65	5.25

```r
data(HolzingerSwineford1939, package="lavaan")
HS <- HolzingerSwineford1939
names(HS)[7:15] <- c("visual", "cubes", "paper",
                     "paragrap", "sentence", "wordm",
                     "addition", "counting", "straight")
```

DATA FRAME

colnames (names)

HS

	id	sex	ageyr	agemo	school	grade	visual	cubes	paper	paragrap	sentence	wordm	addition	counting	straight
1	1	1	13	1	Pasteur	7	3.333	7.75	0.375	2.333	5.75	1.286	3.39	5.75	6.36
2	2	2	13	7	Pasteur	7	5.333	5.25	2.125	1.667	3.00	1.286	3.78	6.25	7.92
3	3	2	13	1	Pasteur	7	4.500	5.25	1.875	1.000	1.75	0.429	3.26	3.90	4.42
4	4	1	13	2	Pasteur	7	5.333	7.75	3.000	2.667	4.50	2.429	3.00	5.30	4.86
5	5	2	12	2	Pasteur	7	4.833	4.75	0.875	2.667	4.00	2.571	3.70	6.30	5.92
6	6	2	14	1	Pasteur	7	5.333	5.00	2.250	1.000	3.00	0.857	4.35	6.65	7.50
7	7	1	12	1	Pasteur	7	2.833	6.00	1.000	3.333	6.00	2.857	4.70	6.20	4.86
8	8	2	12	2	Pasteur	7	5.667	6.25	1.875	3.667	4.25	1.286	3.39	5.15	3.67
9	9	2	13	0	Pasteur	7	4.500	5.75	1.500	2.667	5.75	2.714	4.52	4.65	7.36
10	11	2	12	5	Pasteur	7	3.500	5.25	0.750	2.667	5.00	2.571	4.13	4.55	4.36
11	12	1	12	2	Pasteur	7	3.667	5.75	2.000	2.000	3.50	1.571	3.74	5.70	4.31
12	13	1	12	11	Pasteur	7	5.833	6.00	2.875	2.667	4.50	2.714	3.70	5.15	4.14
13	14	2	12	7	Pasteur	7	5.667	4.50	4.125	2.667	4.00	2.286	5.87	5.20	5.86
14	15	2	12	8	Pasteur	7	6.000	5.50	1.750	4.667	4.00	1.571	5.13	4.70	4.44
15	16	1	12	6	Pasteur	7	5.833	5.75	3.625	5.000	5.50	3.000	4.00	4.35	5.86
16	17	2	12	1	Pasteur	7	4.667	4.75	2.375	2.667	4.25	0.714	4.09	3.80	5.14
17	18	2	14	11	Pasteur	7	4.333	4.75	1.500	2.000	4.00	1.286	3.70	6.65	5.25

rownames

```
1 HS[5,3]
2 HS[5,"ageyr"]
```

```
1 HS[10,7:9]
2 HS[10,c("visual", "cubes", "paper")]
```

INSPECT

Console ~/Desktop/SEMinR/

```
> str(HS)
'data.frame':   301 obs. of  15 variables:
 $ id      : int  1 2 3 4 5 6 7 8 9 11 ...
 $ sex     : int  1 2 2 1 2 2 1 2 2 2 ...
 $ ageyr   : int  13 13 13 13 12 14 12 12 13 12 ...
 $ agemo   : int  1 7 1 2 2 1 1 2 0 5 ...
 $ school  : Factor w/ 2 levels "Grant-White",..: 2 2 2 2 2 2 2 2 2 2 ...
 $ grade   : int  7 7 7 7 7 7 7 7 7 7 ...
 $ visual  : num  3.33 5.33 4.5 5.33 4.83 ...
 $ cubes   : num  7.75 5.25 5.25 7.75 4.75 5 6 6.25 5.75 5.25 ...
 $ paper   : num  0.375 2.125 1.875 3 0.875 ...
 $ paragrap: num  2.33 1.67 1 2.67 2.67 ...
 $ sentence: num  5.75 3 1.75 4.5 4 3 6 4.25 5.75 5 ...
 $ wordm   : num  1.286 1.286 0.429 2.429 2.571 ...
 $ addition: num  3.39 3.78 3.26 3 3.7 ...
 $ counting: num  5.75 6.25 3.9 5.3 6.3 6.65 6.2 5.15 4.65 4.55 ...
 $ straight: num  6.36 7.92 4.42 4.86 5.92 ...
>
```

Console ~/Desktop/SEMinR/

```
> summary(HS[,7:ncol(HS)])
     visual           cubes            paper           paragrap       sentence
 Min.   :0.67   Min.   :2.25   Min.   :0.25   Min.   :0.00   Min.   :1.00
 1st Qu.:4.17   1st Qu.:5.25   1st Qu.:1.38   1st Qu.:2.33   1st Qu.:3.50
 Median :5.00   Median :6.00   Median :2.12   Median :3.00   Median :4.50
 Mean   :4.94   Mean   :6.09   Mean   :2.25   Mean   :3.06   Mean   :4.34
 3rd Qu.:5.67   3rd Qu.:6.75   3rd Qu.:3.12   3rd Qu.:3.67   3rd Qu.:5.25
 Max.   :8.50   Max.   :9.25   Max.   :4.50   Max.   :6.33   Max.   :7.00
     wordm          addition        counting        straight
 Min.   :0.14   Min.   :1.30   Min.   : 3.05   Min.   :2.78
 1st Qu.:1.43   1st Qu.:3.48   1st Qu.: 4.85   1st Qu.:4.75
 Median :2.00   Median :4.09   Median : 5.50   Median :5.42
 Mean   :2.19   Mean   :4.19   Mean   : 5.53   Mean   :5.37
 3rd Qu.:2.71   3rd Qu.:4.91   3rd Qu.: 6.10   3rd Qu.:6.08
 Max.   :6.14   Max.   :7.43   Max.   :10.00   Max.   :9.25
>
```

Deux commandes essentielles :

`str()` : mode de représentation des variables et aperçu des observations

`summary()` : résumé numérique (5-point *versus* tableau d'effectif)

Recode

1 = M

1	1	M	13	1	Pasteur	7	3.333	7.75	0.375	2.333	5.75	1.286	3.39	5.75	6.36
2	2	F	13	7	Pasteur	7	5.333	5.25	2.125	1.667	3.00	1.286	3.78	6.25	7.92
3	3	F	13	1	Pasteur	7	4.500	5.25	1.875	1.000	1.75	0.429	3.26	3.90	4.42
4	4	M	13	2	Pasteur	7	5.333	7.75	3.000	2.667	4.50	2.429	3.00	5.30	4.86
5	5	F	12	2	Pasteur	7	4.833	4.75	0.875	2.667	4.00	2.571	3.70	6.30	5.92
6	6	F	14	1	Pasteur	7	5.333	5.00	2.250	1.000	3.00	0.857	4.35	6.65	7.50
7	7	M	12	1	Pasteur	7	2.833	6.00	1.000	3.333	6.00	2.857	4.70	6.20	4.86
8	8	F	12	2	Pasteur	7	5.667	6.25	1.875	3.667	4.25	1.286	3.39	5.15	3.67
9	9	F	13	0	Pasteur	7	4.500	5.75	1.500	2.667	5.75	2.714	4.52	4.65	7.36
10	11	F	12	5	Pasteur	7	3.500	5.25	0.750	2.667	5.00	2.571	4.13	4.55	4.36
11	12	M	12	2	Pasteur	7	3.667	5.75	2.000	2.000	3.50	1.571	3.74	5.70	4.31
12	13	M	12	11	Pasteur	7	5.833	6.00	2.875	2.667	4.50	2.714	3.70	5.15	4.14
13	14	F	12	7	Pasteur	7	5.667	4.50	4.125	2.667	4.00	2.286	5.87	5.20	5.86
14	15	F	12	8	Pasteur	7	6.000	5.50	1.750	4.667	4.00	1.571	5.13	4.70	4.44
15	16	M	12	6	Pasteur	7	5.833	5.75	3.625	5.000	5.50	3.000	4.00	4.35	5.86
16	17	F	12	1	Pasteur	7	4.667	4.75	2.375	2.667	4.25	0.714	4.09	3.80	5.14
17	18	F	14	11	Pasteur	7	4.333	4.75	1.500	2.000	4.00	1.286	3.70	6.65	5.25

```
1 HS <- within(HS, {
2   id <- factor(id)
3   sex <- factor(sex, levels = c(1, 2), labels = c("M", "F"))
4   grade <- factor(grade)
5 })
```

CHIFFRES ET LETTRES

Console ~/Desktop/SEMinR/

```
> class(HS$sex)
[1] "factor"
> levels(HS$sex)
[1] "M" "F"
> summary(HS$sex)
  M   F
146 155
> class(HS$visual)
[1] "numeric"
> summary(HS$visual)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   0.67    4.17    5.00    4.94    5.67    8.50
>
```

Deux types d'objets sous R : les nombres (entiers et flottants) et les facteurs.

Autre type : chaîne de caractères (character).

LES FACTEURS

Console ~/Desktop/SEMinR/

```
> head(HS$sex)
[1] M F F M F F
Levels: M F
> head(as.numeric(HS$sex))
[1] 1 2 2 1 2 2
>
```

(…) et les facteurs. Pour le meilleur et pour le moins pratique parfois…

SUBSET

HS

id	sex	ageyr	agemo	schooi	grade
1	M	13	1	Pasteur	7
2	F	13	7	Pasteur	7
3	F	13	1	Pasteur	7
4	M	13	2	Pasteur	7
5	F	12	2	Pasteur	7
6	F	14	1	Pasteur	7
7	M	12	1	Pasteur	7
8	F	12	2	Pasteur	7
9	F	13	0	Pasteur	7
11	F	12	5	Pasteur	7
12	M	12	2	Pasteur	7
13	M	12	11	Pasteur	7
14	F	12	7	Pasteur	7
15	F	12	8	Pasteur	7
16	M	12	6	Pasteur	7
17	F	12	1	Pasteur	7
18	F	14	11	Pasteur	7

BASE::SUBSET

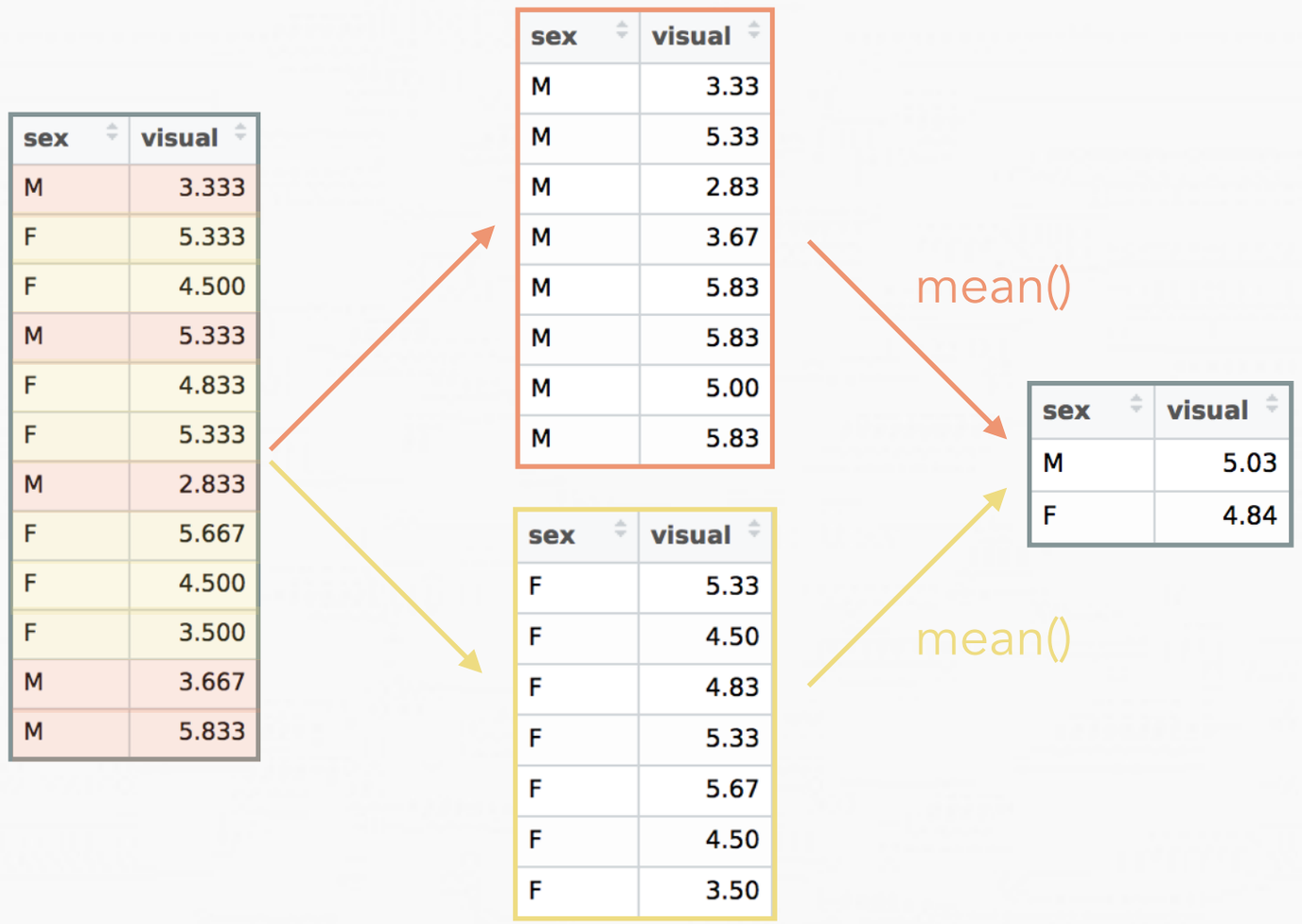
subset(data, subset, select)

subset sélection des observations (lignes) sur critère(s) logique(s)

select sélection des variables (colonnes) selon le nom ou l'index

```
1 subset(HS, subset = sex == "M")
2 subset(HS, select = c(ageyr, agemo))
```

SPLIT - APPLY - COMBINE



(...) break up a big problem into manageable pieces, operate on each piece independently and then put all the pieces back together. – Hadley Wickham (2011)

AGGREGATE

HS

sex	ageyr	agemo	school	grade	visual
M	13	1	Pasteur	7	3.333
F	13	7	Pasteur	7	5.333
F	13	1	Pasteur	7	4.500
M	13	2	Pasteur	7	5.333
F	12	2	Pasteur	7	4.833
F	14	1	Pasteur	7	5.333
M	12	1	Pasteur	7	2.833
F	12	2	Pasteur	7	5.667
F	13	0	Pasteur	7	4.500
F	12	5	Pasteur	7	3.500
M	12	2	Pasteur	7	3.667
M	12	11	Pasteur	7	5.833
F	12	7	Pasteur	7	5.667
F	12	8	Pasteur	7	6.000
M	12	6	Pasteur	7	5.833
F	12	1	Pasteur	7	4.667
F	14	11	Pasteur	7	4.333

BASE::AGGREGATE

aggregate(formula, data, function)

formula= variable réponse ~ variable explicative

function= mean, median, sd, summary, etc.

```
1 aggregate(visual ~ sex, data = HS, mean)
2 aggregate(visual ~ sex, data = HS, sd)
```

APPLICATION

Console ~/Desktop/SEMinR/

```
> aggregate(visual ~ sex + grade, HS, mean)
  sex grade visual
1   M     7   4.86
2   F     7   4.64
3   M     8   5.22
4   F     8   5.07
> aggregate(cbind(visual,cubes,paper) ~ sex, HS, mean)
  sex visual cubes paper
1   M   5.03  6.23  2.46
2   F   4.84  5.95  2.05
>
```

`visual ~ sex + grade` : 1 variable réponse + 2 variables explicatives

`cbind(visual,cubes,paper) ~ sex` : 3 variables réponses + 1 variable explicative

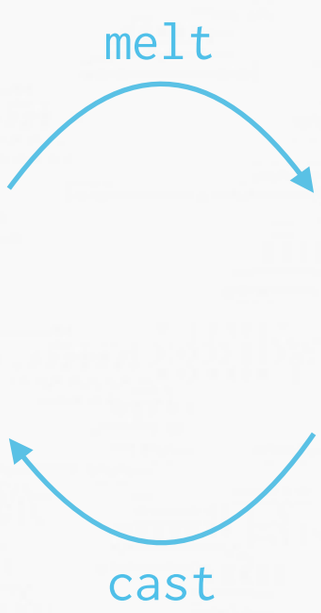
RÉSULTAT = UN DATA FRAME

LES FORMULES R

- Un moyen simple et élégant d'exprimer la relation entre une ou plusieurs variable(s) réponse(s) et une ou plusieurs variable(s) explicative(s) (Wilkinson & Rogers, 1973 ; Chambers & Hastie, 1992).
- Idée reprise dans Python (`pandas`) et Julia (`DataFrames`).
- Structuration particulière des données (Wickham, 2014) : package `reshape2`.

id	sex	visual	cubes	paper
1	M	3.333	7.75	0.375
2	F	5.333	5.25	2.125
3	F	4.500	5.25	1.875
4	M	5.333	7.75	3.000
5	F	4.833	4.75	0.875
6	F	5.333	5.00	2.250
7	M	2.833	6.00	1.000
8	F	5.667	6.25	1.875
9	F	4.500	5.75	1.500
11	F	3.500	5.25	0.750
12	M	3.667	5.75	2.000
13	M	5.833	6.00	2.875
14	F	5.667	4.50	4.125

wide format



id	sex	variable	value
344	F	visual	5.83
345	M	visual	6.17
346	M	visual	4.00
347	F	visual	3.00
348	F	visual	4.67
349	M	visual	4.33
351	M	visual	4.33
1	M	cubes	7.75
2	F	cubes	5.25
3	F	cubes	5.25
4	M	cubes	7.75
5	F	cubes	4.75
6	F	cubes	5.00

long format

RESHAPING

value ~ variable

id	sex	visual	cubes	paper
1	M	3.333	7.75	0.375
2	F	5.333	5.25	2.125
3	F	4.500	5.25	1.875
4	M	5.333	7.75	3.000
5	F	4.833	4.75	0.875
6	F	5.333	5.00	2.250
7	M	2.833	6.00	1.000
8	F	5.667	6.25	1.875
9	F	4.500	5.75	1.500
11	F	3.500	5.25	0.750
12	M	3.667	5.75	2.000
13	M	5.833	6.00	2.875
14	F	5.667	4.50	4.125

wide format

melt

cast

id	sex	variable	value
344	F	visual	5.83
345	M	visual	6.17
346	M	visual	4.00
347	F	visual	3.00
348	F	visual	4.67
349	M	visual	4.33
351	M	visual	4.33
1	M	cubes	7.75
2	F	cubes	5.25
3	F	cubes	5.25
4	M	cubes	7.75
5	F	cubes	4.75
6	F	cubes	5.00

long format

```
1 library(reshape2)
2
3 dw <- HS[,c("id","sex","visual","cubes","paper")]
4
5 dl <- melt(dw)                                    ## long
6 dw <- dcast(dl, sex + id ~ variable)              ## wide
```

APPLICATION

Console ~/Desktop/SEMinR/

```
> aggregate(cbind(visual,cubes,paper) ~ sex, HS, mean)
  sex visual cubes paper
1   M   5.03  6.23  2.46
2   F   4.84  5.95  2.05
> aggregate(value ~ variable + sex, dl, mean)
  variable sex value
1   visual   M  5.03
2    cubes   M  6.23
3    paper   M  2.46
4   visual   F  4.84
5    cubes   F  5.95
6    paper   F  2.05
>
```

value ~ variable + …

APPLY

id	sex	visual	cubes	paper
1	M	3.333	7.75	0.375
2	F	5.333	5.25	2.125
3	F	4.500	5.25	1.875
4	M	5.333	7.75	3.000
5	F	4.833	4.75	0.875
6	F	5.333	5.00	2.250
7	M	2.833	6.00	1.000
8	F	5.667	6.25	1.875
9	F	4.500	5.75	1.500
11	F	3.500	5.25	0.750
12	M	3.667	5.75	2.000
13	M	5.833	6.00	2.875
14	F	5.667	4.50	4.125

BASE::APPLY

apply(data, margin, function)

margin=1 opération par lignes

margin=2 opération par colonnes

function mean, median, sd, summary, etc.

```
1 apply(HS[,c("visual","cubes","paper")], 1, sum)
2 apply(HS[,c("visual","cubes","paper")], 2, mean)
```

APPLICATION

Console ~/Desktop/SEMinR/

```
> names(HS)
 [1] "id"       "sex"      "ageyr"    "agemo"    "school"   "grade"    "visual"
 [8] "cubes"    "paper"    "paragrap" "sentence" "wordm"    "addition" "counting"
[15] "straight"
> spatial <- apply(HS[,c("visual","cubes","paper")], 1, sum)
> verbal <- apply(HS[,c("paragrap","sentence","wordm")], 1, sum)
> speed <- apply(HS[,c("addition","counting","straight")], 1, sum)
>
```

Les variables `spatial`, `verbal` et speed sont créées dans l'espace de travail mais n'appartiennent pas au data frame HS.

APPLICATION

Console ~/Desktop/SEMinR/

```
 [1] "id"       "sex"      "ageyr"    "agemo"    "school"   "grade"    "visual"
 [8] "cubes"    "paper"    "paragrap" "sentence" "wordm"    "addition" "counting"
[15] "straight"
> spatial <- apply(HS[,c("visual","cubes","paper")], 1, sum)
> verbal <- apply(HS[,c("paragrap","sentence","wordm")], 1, sum)
> speed <- apply(HS[,c("addition","counting","straight")], 1, sum)
> HS$spatial <- apply(HS[,c("visual","cubes","paper")], 1, sum)
> HS$verbal <- apply(HS[,c("paragrap","sentence","wordm")], 1, sum)
> HS$speed <- apply(HS[,c("addition","counting","straight")], 1, sum)
> apply(HS[,c("spatial","verbal","speed")], 2, mean)
spatial  verbal   speed
  13.27    9.59   15.09
>
```

En intégrant ces variables auxiliaires au data frame, on préserve la cohérence des données.

TESTS STATISTIQUES

PROCEDURES DE TEST

TEST DE STUDENT

```
t.test(visual ~ sex, data=HS, var.equal=TRUE)
```

Test de Student avec l'option `var.equal = TRUE`, test de Welch par défaut.
Alternative non paramétrique : `wilcox.test()`.

ANALYSE DE VARIANCE

```
summary(aov(visual ~ sex, data=HS))
```

ANOVA avec sommes de carrés de type II. Voir également `drop1()` et `car::Anova()`.
Alternative non paramétrique : `kruskal.test()`.

TEST DE CORRELATION

```
cor.test(~ visual+cubes, data=HS, method="pear")
```

Test de nullité du coefficient de corrélation de Pearson (défaut) ou de Spearman (`method="spear"`).

TEST DE PROPORTION

```
summary(xtabs(~ sex+grade, data=HS))
prop.test(xtabs(~ sex+grade, data=HS),
          correct=FALSE)
```

Test du χ^2 de Pearson et test de proportion utilisant l'approximation par la loi normale.
Alternatives : `fisher.test()` et `binom.test()`.

APPLICATION

Console ~/Desktop/SEMinR/

```
> aggregate(visual ~ sex, data = HS, sd)
  sex visual
1   1   1.12
2   2   1.21
> t.test(visual ~ sex, data = HS, var.equal = TRUE)

        Two Sample t-test

data:  visual by sex
t = 1, df = 300, p-value = 0.2
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.0755  0.4535
sample estimates:
mean in group 1 mean in group 2
           5.03            4.84

>
```

```
aggregate(visual ~ sex, HS, mean)
```

Conditions d'application du test : normalité, égalité des variances parentes, indépendance (cas des échantillons appariés, `paired = TRUE`).

APPLICATION

Console ~/Desktop/SEMinR/

```
> xtabs(~ sex + grade, data = HS)
   grade
sex  7  8
  1 74 71
  2 83 72
> prop.table(xtabs(~ sex + grade, data = HS), margin = 2)
   grade
sex     7     8
  1 0.471 0.497
  2 0.529 0.503
> summary(xtabs(~ sex + grade, data = HS))
Call: xtabs(formula = ~sex + grade, data = HS)
Number of cases in table: 300
Number of factors: 2
Test for independence of all factors:
        Chisq = 0.19, df = 1, p-value = 0.7
>
```

74/(74+83)

Conditions d'application du test : effectifs théoriques « pas trop petits ».

Voir `chisq.test()` (`$expected` et `$residuals`).

GESTION DES SCRIPTS R

load.r

```r
## load.r
## Chargement des données Holzinger & Swineford (1939)
##

options(digits = 3)

## importation des données
data(HolzingerSwineford1939, package="lavaan")
HS <- HolzingerSwineford1939
names(HS)[7:15] <- c("visual", "cubes", "paper",
                     "paragrap", "sentence", "wordm",
                     "addition", "counting", "straight")

head(HS)

## indexation d'observations
HS[5,3]
HS[5,"ageyr"]

HS[10,7:9]
HS[10,c("visual", "cubes", "paper")]

## recodage des variables catégorielles
HS <- within(HS, {
  id <- factor(id)
  sex <- factor(sex, levels = c(1, 2), labels = c("M", "F"))
  grade <- factor(grade)
})
```

GESTION DES SCRIPTS R

aggregate.r

```
## aggregate.r
## Statistiques descriptives
##
## load.r : chargement des données

## sélection de sous-ensemble d'observations
subset(HS, subset = sex == "M")
subset(HS, select = c(ageyr, agemo))

## calcul de moyennes/ety conditionnels
aggregate(visual ~ sex, data = HS, mean)
aggregate(visual ~ sex, data = HS, sd)

aggregate(visual ~ sex + grade, HS, mean)
aggregate(cbind(visual,cubes,paper) ~ sex, HS, mean)

## passage du format large au format long
library(reshape2)

dw <- HS[,c("id","sex","visual","cubes","paper")]

dl <- melt(dw)                                    ## long
dw <- dcast(dl, sex + id ~ variable)              ## wide

## opérations par lignes/colonnes
apply(HS[,c("visual","cubes","paper")], 1, sum)
apply(HS[,c("visual","cubes","paper")], 2, mean)
```

EXERCICES

1. Quel le score moyen des enfants de sexe masculin et de grade 7 ?

2. Le score moyen entre garçons et filles est-il différent en considérant un seuil de 5 % ?

3. Quelles sont les corrélations entre les scores composites `verbal`, `spatial` et speed ?

4. Le score speed diffère-t-il selon le tercile d'âge ?

5. Si oui, quelle(s) paire(s) de moyenne sont statistiquement différentes ?

2. `t.test()`
3. `cor()`
4. `cut()`, `aov()`
5. `pairwise.t.test()`

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