

## FROM PCA TO CVA AND MAM-CVA

**OBJECTIVE:** Plot a product map taking both discrimination and scaling effect into account

### TWO CONCEPTS

✓ **Discrimination:** the ratio between differences among products relative to the disagreement among panelists about these differences.

✓ **Scaling:** the extent to which a panelist spreads his scores on the scale compared to the panel. Calculations are based on the Mixed Assessor Model (MAM)[1]. The scaling effect can be decomposed into two components [2]:

- ✓ The **overall** scaling representing a « psychological » component of use of the scale
- ✓ The **specific** scaling representing the « physiological » component due to hyper or hypo sensitivity

The MAM-CVA can be calculated with the MAM or the overall scaling

### UNIVARIATE STATISTICS TO DETECT DIFFERENCES BETWEEN PRODUCTS

Product variance

**Variability  
between products**  
 $MS_{product}$

Product discrimination

**ANOVA**  
 $F = \frac{MS_{product}}{MS_{interaction}}$

Taking scaling effect into account

**MAM\* [1]**  
 $F = \frac{MS_{product}}{MS_{disagreement}}$

\* Mixed Assessor Model

$MS_{product}$ : mean squares of product effect in the two-way multiplicative product\*subject ANOVA model with subject as random effect;  $MS_{interaction}$  mean squares of interaction product\*subject effect in the two-way ANOVA model,  $MS_{disagreement}$ : mean squares of interaction freed from scaling effect (MAM)

### MULTIVARIATE STATISTICS TO SHOW THE DIFFERENCES BETWEEN PRODUCTS

Product variance

**PCA**  
Diagonalisation of  $B$

Product discrimination

**CVA [3]**  
Diagonalisation of  $W^{-1}B$

Taking scaling effect into account

**MAM-CVA**  
Diagonalisation of  $D^{-1}B$

$B$ : covariance matrix of product effect ;  $W$  covariance matrix of interaction ;  $D$  covariance matrix of disagreement freed from scaling effect

## HOW TO USE THE CVAS PACKAGE TO PRODUCE CVA AND MAM-CVA MAPS

### GETTING THE CVAS PACKAGE

- ✓ Download the CVAS.zip package from [www.timesens.com](http://www.timesens.com) (account required)
- ✓ In R, get into "Packages/Install from zip file " and choose CVAS.zip.
- ✓ Enter `library(CVAS)` in the R command prompt
- ✓ Read your data in R: `data=read.csv("Data.csv")`

### GETTING THE CVA

✓ Your dataset (data) has to be in the following format:

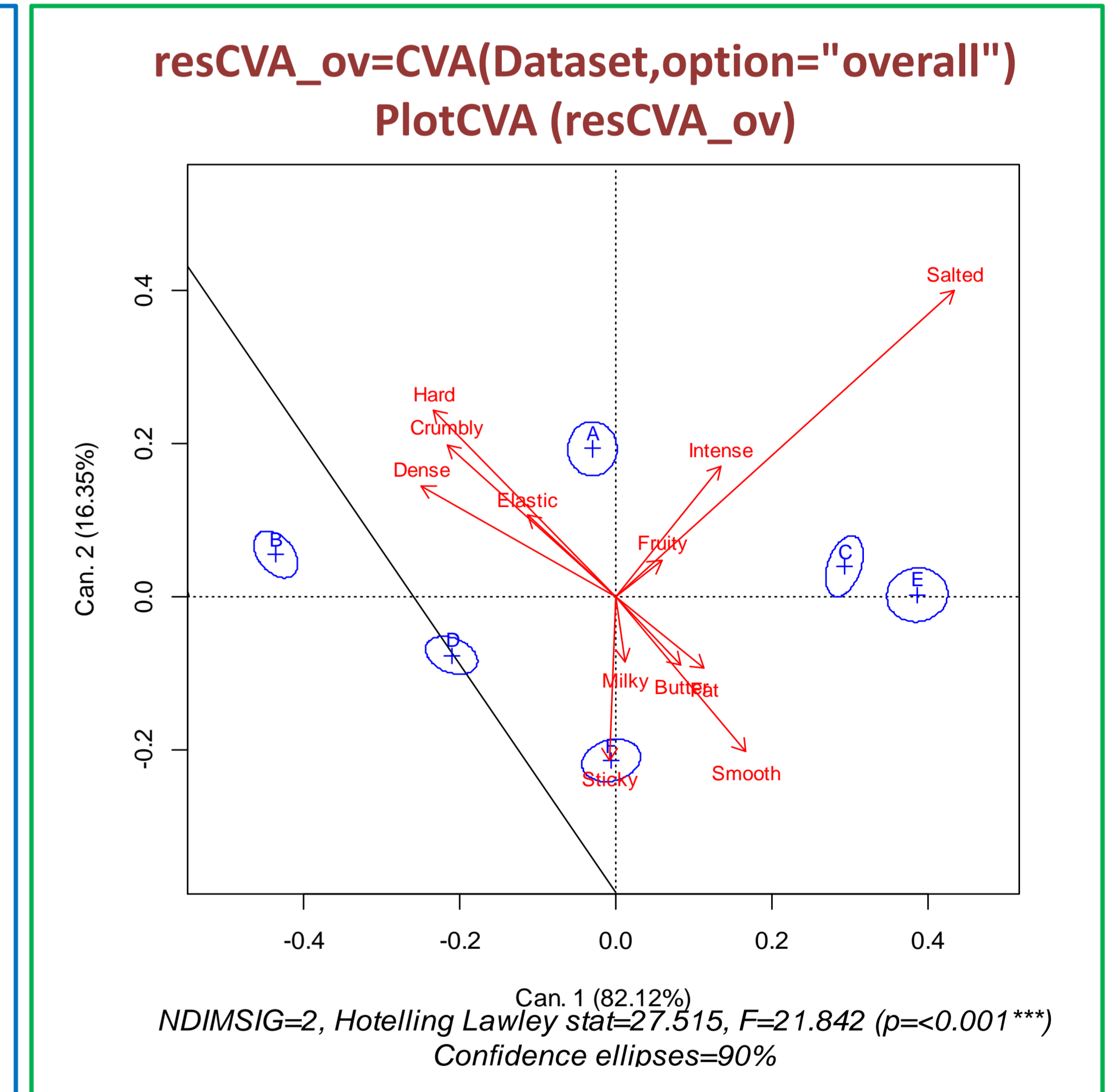
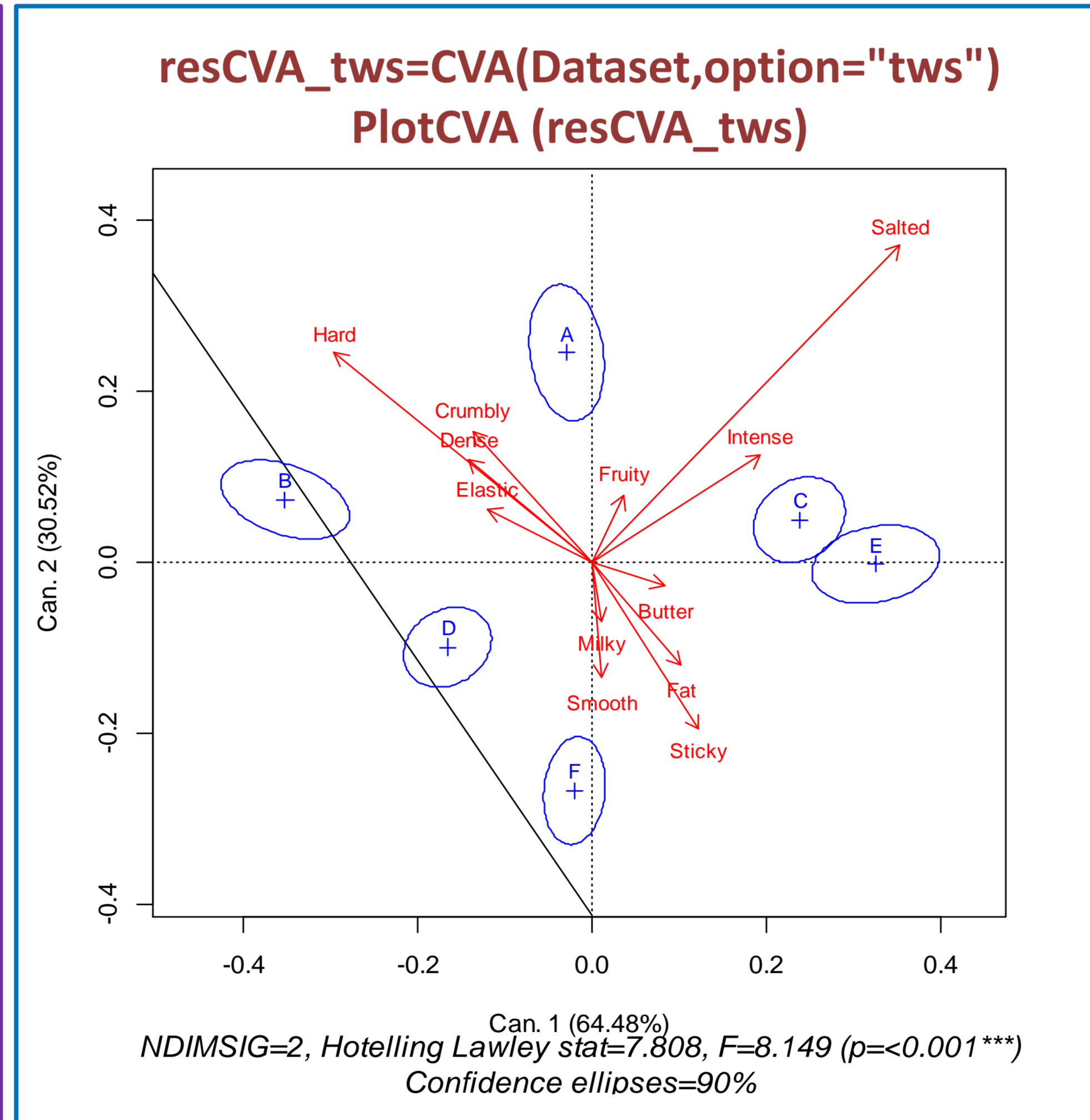
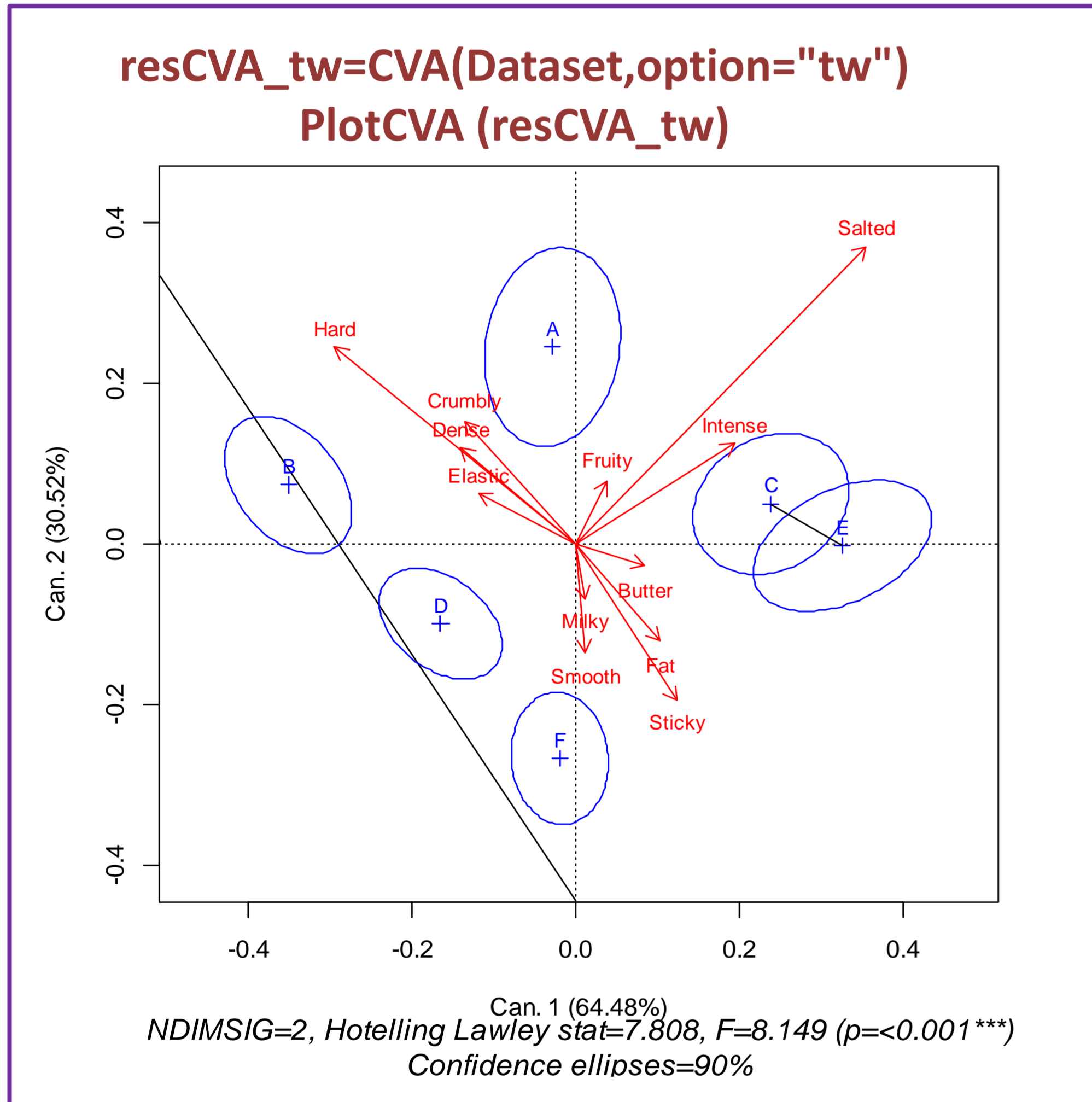
| product  | subject   | rep | Salted | ... | Crumbly |
|----------|-----------|-----|--------|-----|---------|
| Cheese 1 | Subject 1 | 1   | 2      |     | 2       |

- ✓ Compute the CVA parameters: `resCVA=CVA(data,option="tw")`
- ✓ Plot the CVA: `PlotCVA(resCVA)`

### OTHER PARAMETERS

- ✓ The subject effect can be removed from the ellipses with the "tws" model (tws for two-way without subject): `CVA(data,option="tws")`
- ✓ To plot the MAMCVA:
  - with « mam » option: `CVA(data,option="mam")`
  - with « overall » option: `CVA(data,option="overall")`

## THE CVAS ON A CHEESE EXAMPLE (6 PRODUCTS, 16 SUBJECTS, 3 REPLICATES, 12 ATTRIBUTES)



The different CVAs have the same differences among products but with different levels of significance.

Footnotes indicate the statistics of the MANOVA and the number of significant dimensions

The ellipses represent the **variability** around the product means.

**C and E are not significantly different** with the Hotelling T2 test comparing the variability between products to the variability within products (subject effect and scaling included)

The ellipses represent the **disagreement** of the subjects: the subject effect is removed from the variability around product means

**C and E are just different** with the Hotelling T2 test. This map has the same axes and the same product and attribute positions than the CVA "tw".

The ellipses represent the **pure disagreement** of the subjects (subject and scaling effect removed)

The axes are different from the "tw" and "tws" CVA ; they maximise discrimination by taking overall scaling effect into account

## TO GO FURTHER...

### DETECTING MULTIVARIATE DIFFERENCES BETWEEN PRODUCTS

- ✓ The multivariate differences between products are represented with a segment linking not statistically different products (Hotelling T2 test with two-way model, MAM or overall MAM). The table of corresponding p-values is accessible by: `resCVA$HotellingTable`

### WHEN MATRICES ARE NOT INVERTIBLE... "NON INVERSIBLE MATRIX"

- ✓ Selecting only the significant attributes... Then, invertibility issues occurred only in 1% of the cases out of 422 datasets [4]
- ✓ Plotting a PCA: `resPCA=PCA(data)` ; `PlotPCA(resPCA)`

## CONCLUSION

CVAS package allows plotting maps in accordance with a statistical model taking into account the subject effect and the scaling effect

### References:

[1] Brockhoff, P.B., Schlich, P., Skovgaard, I. (2015) Taking individual scaling differences into account by analyzing profile data with the Mixed Assessor Model. FQP 39 156-166

[2] Peltier, C., Visalli, M., Schlich, P., Multiplicative decomposition of the scaling effect in the Mixed Assessor Model into a descriptor-specific and an overall coefficients. FQP 48A 268-273

[3] Peltier, C., Visalli, M., Schlich, P. (2015) Canonical Variate Analysis of sensory profiling data. JSS 30 316-328

[4] Peltier, C., Visalli, M., Schlich, P., (2015b) Comparison of Canonical Variate Analysis and Principal Component analysis on 422 descriptive sensory studies. FQP 40B 326-333