# CONS an R Graphical Interface Package for Consonance Analysis

**Victor Manuel Aguirre-Torres[1], Teresa Lopez-Alvarez[2], N. Sofia Huerta-Pacheco[3]**

Statistics Department, ITAM[1], Delphi Intelligence [2], Universidad Veracruzana[3], Mexico

aguirre@itam.mx, teresa@delphi.agency, nehuerta@uv.mx

Delphi Intelligence Sophisticated Research

Universidad Veracruzana

ITAM

## Introduction

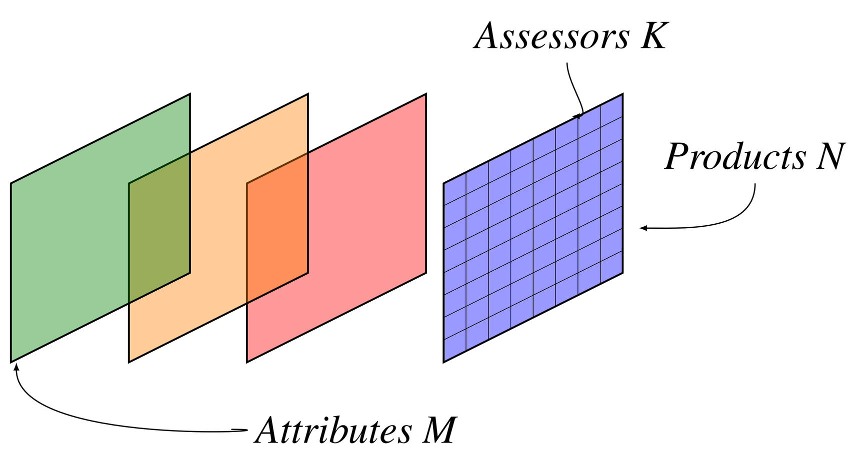
This poster present **CONS** an R package dedicated to Consonance Analysis [3]. Consonance Analysis [1, 2] is a useful numerical and graphical exploratory approach for evaluating the consistency of the measurements and the panel of people involved in sensory evaluation. It makes use of several uni and multivariate techniques either graphical or analytical, particularly Principal Components Analysis. The package is implemented in a graphical user interface in order to get a user friendly package.

Sensory and consumer research often makes use of a panel of assessors to determine product attributes. In this application we assume that the panel evaluates various products with respect to different attributes.

## Data Structure

The data consists of a matrix $\mathbf{X}$ of order $(N \times M \times K)$. The panel has $K$ assessors, $N$ products, judged with respect to $M$ attributes. If there are replications this can be handled by the package duplicating the number of products. We denote the elements of this matrix by $x_{ijk}(i = 1, ..., N, j = 1, ..., M, k = 1, ..., K)$. In order to perform the analysis, the three way matrix $\mathbf{X}$ is thought to be composed of $M$ matrices $\mathbf{X}_j$ of order $(N \times K)$, one for each attribute. Each column of this matrix corresponds to one assessor.

If the $K$ assessors interpret or evaluate an attribute similarly the $\mathbf{X}_j$ matrix would span a one dimensional space. Hence, if PCA of this matrix shows a significant deviation from unidimensionality this would be evidence that the judges are interpreting the attribute differently.




## Consonance Analysis

Denote by $\mathbf{X}_j$ the previous matrix but with standardized columns. Then the matrix $\mathbf{X}_j^T\mathbf{X}_j$ contains the inter-assesor correlations which measure the degree of agreement between assessors for this attribute. Notice that the columns of $\mathbf{X}_j$ add to zero since the column mean is substracted, hence there are $K' = K - 1$ positive eigenvalues in the spectral decomposition of $\mathbf{X}_j^T\mathbf{X}_j$.

The underlying unidimensional structure is evaluated by the PCA. A large first Eigenvalue is a signal that the attribute is being evaluated in a similar fashion by the panel. Consonance analysis uses the following Eigenvalue decomposition

$$\mathbf{X}_j^T\mathbf{X}_j = \mathbf{Q}\mathbf{\Lambda}^2\mathbf{Q}^T, \tag{1}$$

where

$$\mathbf{\Lambda}^2 = diag\{\lambda_1^2, \lambda_2^2, ..., \lambda_{K'}^2\}, \tag{2}$$

contains the Eigenvalues which are in decreasing order and the matrix $\mathbf{Q}$ has orthonormal columns. A measure of the size of each Eigenvalue is given by the "Variance Accounted For" $(VAF)$ metric

$$VAF_k = \frac{\lambda_k^2}{\sum_{r=1}^{K'} \lambda_r^2}, \tag{3}$$

for $k = 1, ..., K'$. The author also proposes a ratio $C$ that he calls the *Consonance*

$$C = \frac{\lambda_1^2}{\sum_{r=2}^{K'} \lambda_r^2} = \frac{VAF_1}{\sum_{r=2}^{K'} VAF_r}, \tag{4}$$

which measures the relative size of the first Eigenvalue with respect to the rest of Eigenvalues. The package **CONS** reports both $VAF$ and $C$ for each attribute. It also shows on a single plot all $VAF$'s corresponding to all attributes. A plot of all $C$'s is also provided.

Dijksterhuis [2] also suggests to plot what he calls the "loadings". Denote $M^{[2]}$ to be the first two columns of a matrix. The columns of matrix $\mathbf{X}_j$ correspond to assessors, then the rows of matrix $\mathbf{X}_j^T$ correspond to assessors, the loadings are defined by

$$(\mathbf{Q}\mathbf{\Lambda})^{[2]}, \tag{5}$$

notice that this is a two dimensional approximation of the rows of $\mathbf{X}_j^T$. This plot is also useful in analyzing panel consonance because if an assessor deviates too much from the cloud of the rest of the assessors this would be evidence that this assessor needs further training.

## Use of the Graphical Interface

The **CONS** package is an R based graphical interface [6], that performs consonance analysis on a data set using only point and click operations. It is based on the gWidgets library [5, 7], that provides a toolkit-independent API for building interactive GUIs and the tcltk library that provides access to the platform-independent Tcl scripting language and Tk GUI elements, and the Principal Component Analysis (PCA) from FactoMineR package [4].

### Install package

The **CONS** package is loaded in the usual fashion from the CRAN-R repository.

```
## Install
R> install.packages("CONS")
## Call library
R> library ("CONS")
## Call interface
R> CONS()
```

### Presentation

The program features three menus: file, methods and help.

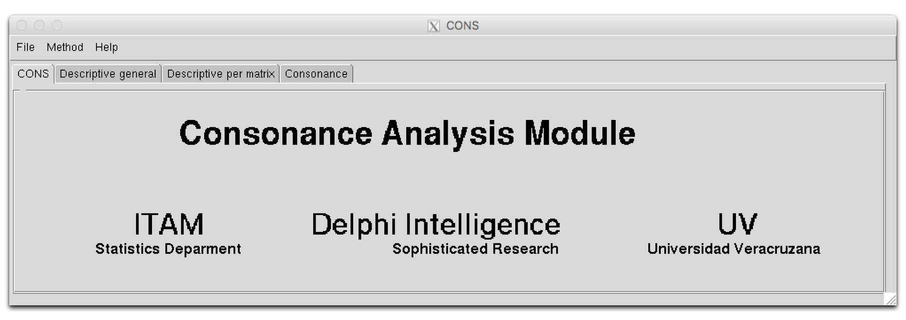



**Figure 1:** File Menu

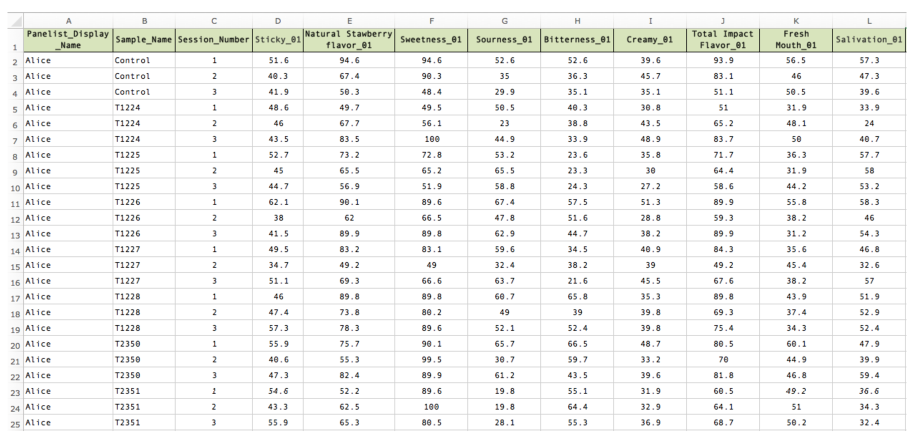


**Figure 2:** Original dataset in *.xlsx format

### Analysis

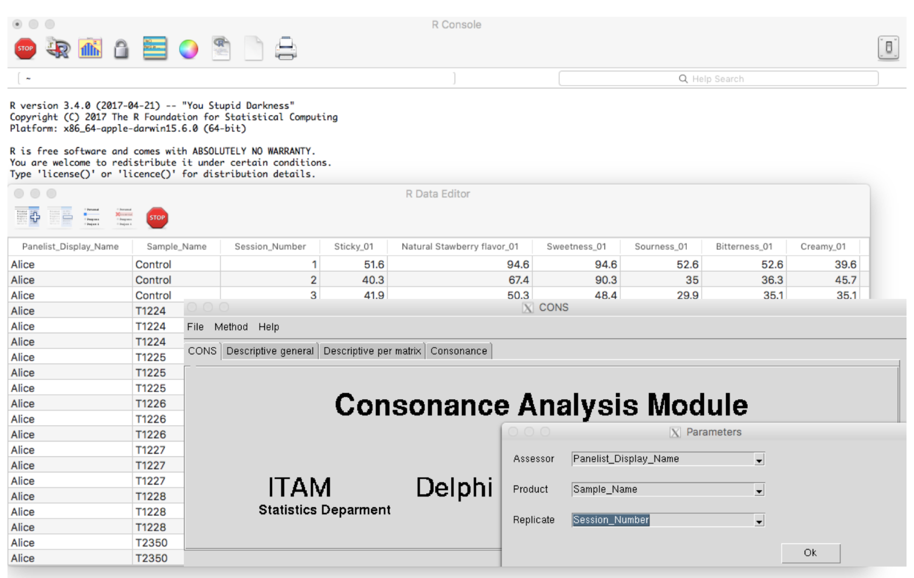



**Figure 3:** Allocation of parameters

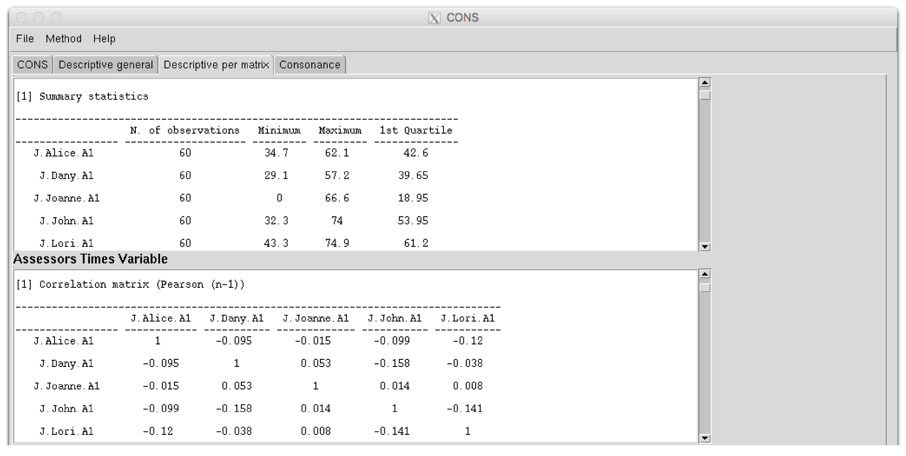


**Figure 4:** Descriptive per matrix

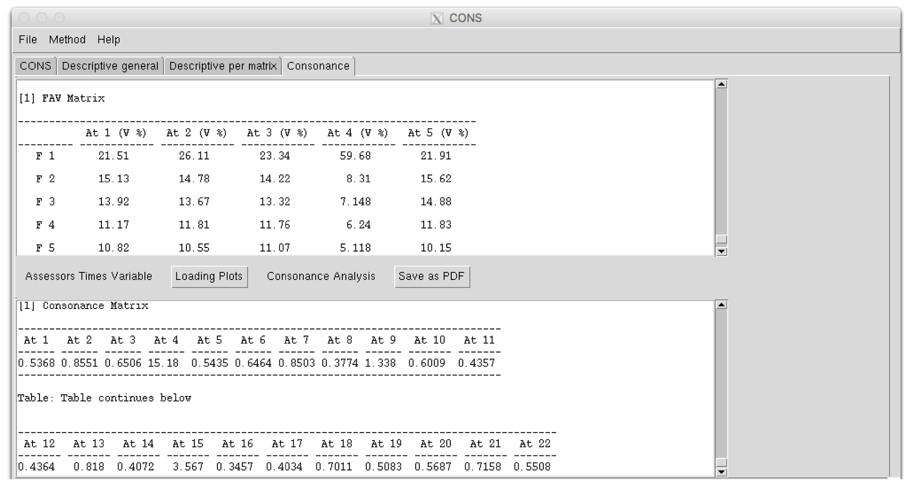


**Figure 5:** Consonance analysis statistics

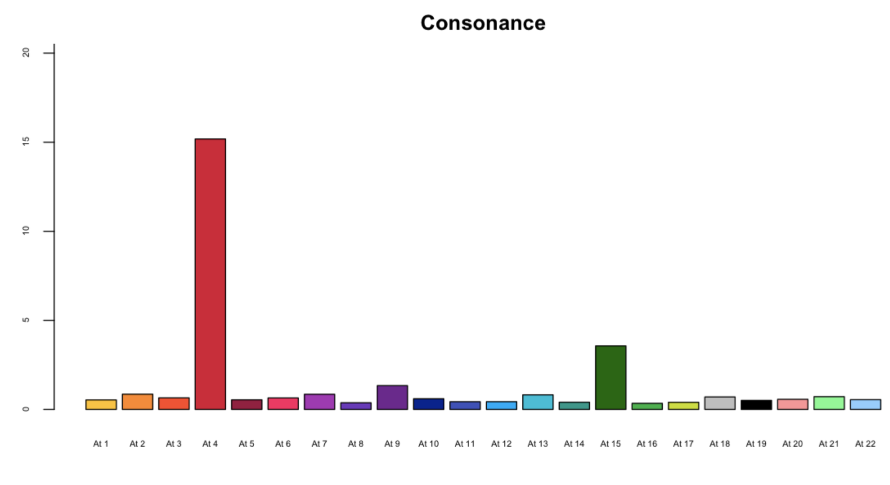



**Figure 6:** Consonance metric

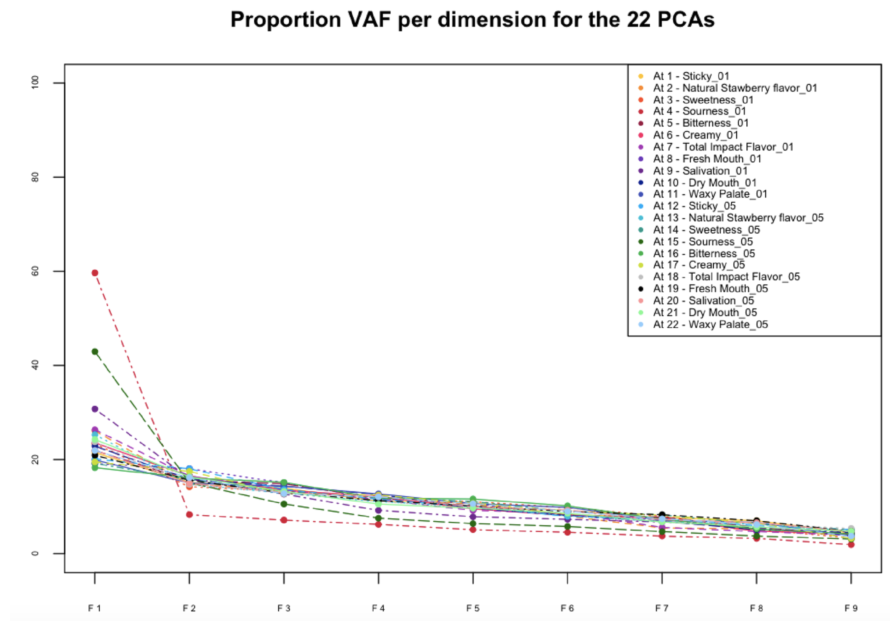



**Figure 7:** Variance accounted for metric of attributes

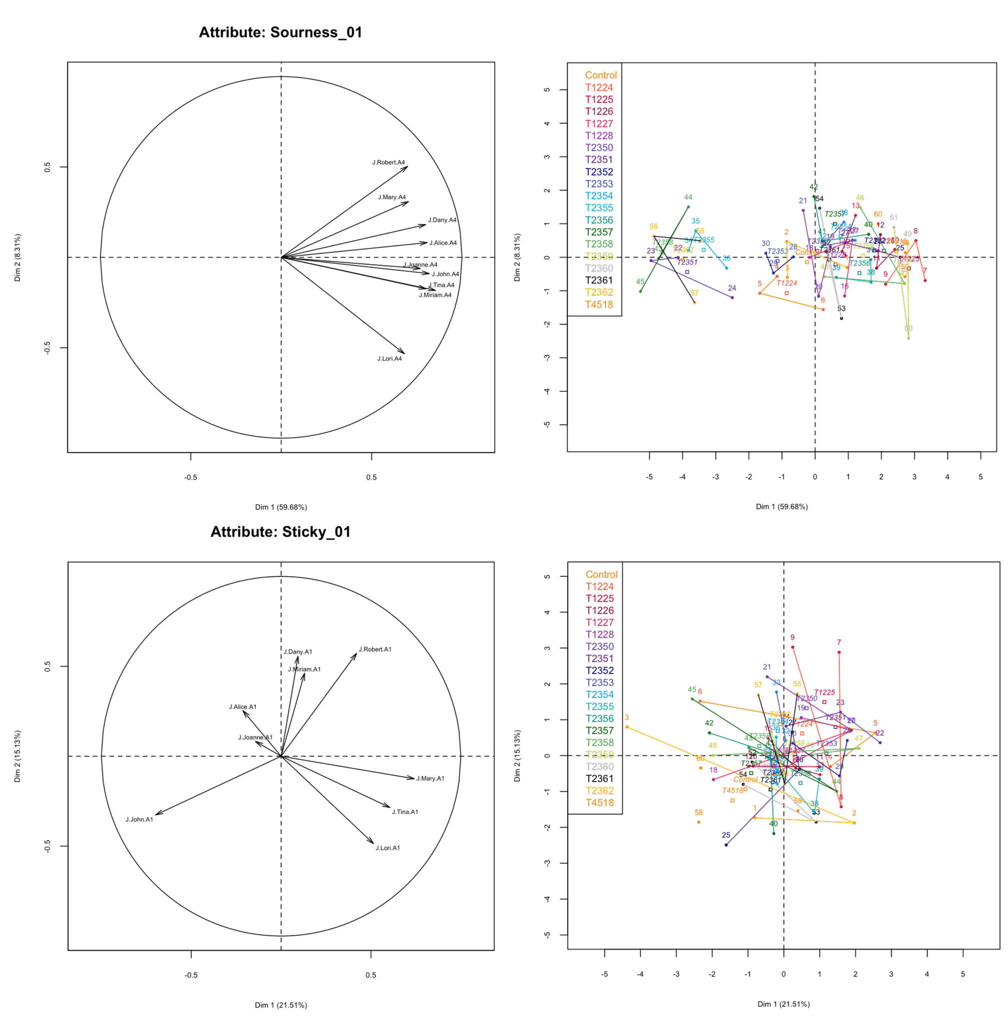



**Figure 8:** Loadings plots

## Conclusions

We have presented a graphical interface that performs consonance analysis on a three way data set that represents the evaluation of attributes of a panel on a set of products. The interface has the characteristics of being very flexible, general and very easy to use.

On the other hand, consonance analysis gives another perspective which makes it very easy to evaluate the judgements of concordance based on quantitative metrics.

## References

[1] Garmt Dijksterhuis. Assessing panel consonance. *Food Quality and Preference*, 6(1):7 – 14, 1995.

[2] Garmt B. Dijksterhuis. *Multivariate Data Analysis in Sensory and Consumer Science*. Food & Nutrition Press, Inc., 2008.

[3] Nery Sofia Huerta-Pacheco, Victor Manuel Aguirre-Torres, and Teresa Lopez-Alvarez. *CONS: Consonance Analysis Module*, 2017. R package version 0.1.1, URL https://CRAN.R-project.org/package=CONS.

[4] Sébastien Lê, Julie Josse, François Husson, et al. Factominer: an r package for multivariate analysis. *Journal of statistical software*, 25(1):1–18, 2008.

[5] John Verzani. Based on the iwidgets code of Simon Urbanek, suggestions by Simon Urbanek, Philippe Grosjean, and Michael Lawrence. *gWidgets: gWidgets API for building toolkit-independent, interactive GUIs*, 2014. R package version 0.0-54.

[6] R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2017.

[7] John Verzani. *gWidgetstcltk: Toolkit implementation of gWidgets for tcltk package*, 2014. R package version 0.0-55.