SensoMineR

A package for sensory data analysis with R

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Sensory analysis

- *Sensory Analysis (or Sensory Evaluation) is a scientific discipline that applies principals of experimental design and statistical analysis to the use of human senses (sight, smell, taste, touch, hearing) for the purposes of evaluating consumer products.*

A typical sensory data table

6 Chocolates (Lindt) 29 panelists
14 variables (descriptors) 2 sessions

Session	Panelist	Rank	Product	CocoaA	MilkA	CocoaF	MilkF	Caramel	Vanilla
1	1	1	choc6	7	6	6	5	5	3
1	1	2	choc4	8	5	4	4	4	4
1	1	3	choc2	8	6	5	4	7	4
1	1	4	choc5	7	5	3	5	6	2
1	1	5	choc1	7	8	8	3	3	2
1	1	6	choc3	6	7	2	7	8	4
1	2	1	choc4	6	1	8	1	0	0
1	2	2	choc5	4	1	7	1	0	0
1	2	3	choc6	5	1	8	1	0	0
1	2	4	choc3	4	2	3	4	0	0
1	2	5	choc2	5	2	8	1	0	0
1	2	6	choc1	6	1	8	0	0	0
1	3	1	choc2	8	1	6	2	6	1
1	3	2	choc6	5	6	5	3	3	2
1	3	3	choc1	8	2	8	1	3	1
1	3	4	choc4	6	1	5	0	5	2
1	3	5	choc3	5	3	2	9	6	7
1	3	6	choc5	7	2	7	3	6	3
1	4	1	choc1	9	2	9	1	6	0

SensoMineR

- SensoMineR tackles the following problems:
  - assessing panel performances
  - characterizing products
  - relating sensory data and instrumental data
  - mapping consumers' preferences
  - categorizing products

Analysis of variance model

$$\forall (i,j,k) \qquad Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \alpha\beta_{ij} + \alpha\gamma_{ik} + \beta\gamma_{jk} + \varepsilon_{ijk}$$

$$L(\varepsilon_{ijk}) = N(0,\sigma) \quad \text{and} \quad \text{cov}(\varepsilon_{ijk}, \varepsilon_{ij'k'}) = 0 \quad \forall (i,j,k) \neq (i',j',k')$$

where:

μ	the general mean
α_i	the product effect
β_j	the judge effect
γ_k	the session effect
$\alpha\beta_{ij}$	the product:judge interaction effect
$\alpha\gamma_{ik}$	the product:session interaction effect
$\beta\gamma_{jk}$	the judge:session interaction effect

Characterization of products

Anova with the following model (for CocoaA variable):

Score = Product + Panelist + Session + Prod:Sess + Prod:Pan + Pan:Sess

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Product	5	207.54	41.51	11.8830	7.752e-13
Panelist	28	390.43	13.94	3.9919	2.552e-08
Session	1	3.72	3.72	1.0662	0.3036
Prod:Pan	140	322.29	2.30	0.6590	0.9929
Prod:Sess	5	8.14	1.63	0.4659	0.8011
Pan:Sess	28	72.11	2.58	0.7373	0.8256
Residuals	140	489.03	3.49		

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	6.287356	0.100188	62.756	< 2e-16
Product1	0.798851	0.224026	3.566	0.000497
Product2	0.264368	0.224026	1.180	0.239971
Product3	-1.614943	0.224026	-7.209	3.22e-11
Product4	-0.028736	0.224026	-0.128	0.898120
Product5	0.505747	0.224026	2.258	0.025522

Characterization of products

	P-value
MilkF	9.664e-61
CocoaF	1.015e-41
Bitterness	6.529e-41
Crunchy	4.817e-37
Caramel	4.568e-31
Sweetness	1.305e-30
Astringency	1.643e-19
Melting	1.967e-17
Acidity	5.669e-15
Vanilla	1.262e-13
CocoaA	7.752e-13
MilkA	1.551e-09
Granular	6.186e-06
Sticky	0.000183

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
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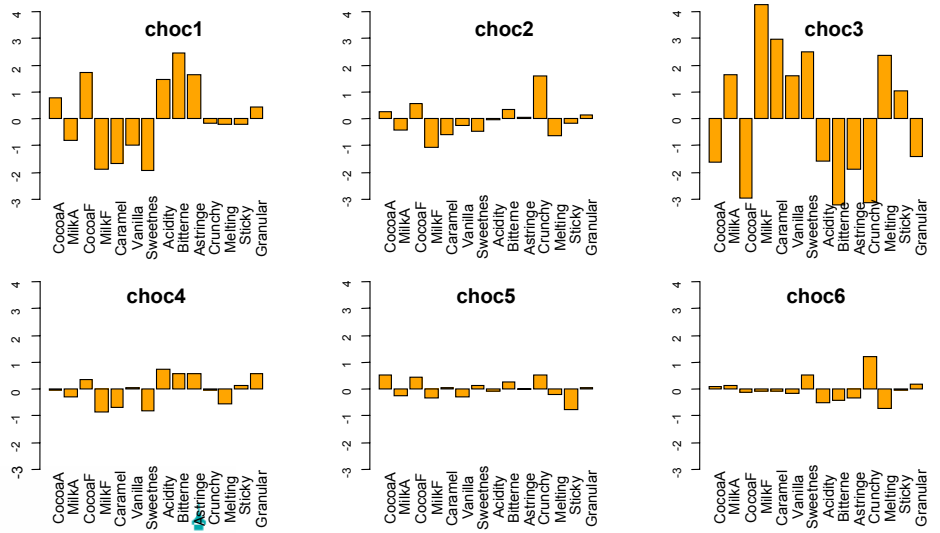
Characterization of products



Characterization of products

	CocoaA	MilkA	CocoaF	MilkF	Caramel	Vanilla	Sweetness	Acidity	Bitterness	Astringency	Crunchy	Melting	Sticky	Granular
choc1	7.086	3.586	8.069	1.569	1.672	1.103	3.138	4.655	7.069	4.759	5.966	4.741	3.759	3.448
choc2	6.552	4	6.914	2.379	2.776	1.81	4.621	3.138	4.948	3.155	7.707	4.328	3.828	3.155
choc3	4.672	6.052	3.379	7.707	6.328	3.672	7.603	1.569	1.397	1.207	2.983	7.31	5.034	1.603
choc4	6.259	4.103	6.69	2.586	2.672	2.121	4.293	3.931	5.19	3.69	6.103	4.379	4.103	3.552
choc5	6.793	4.172	6.793	3.121	3.414	1.793	5.224	3.086	4.879	3.103	6.638	4.741	3.224	3.069
choc6	6.362	4.569	6.224	3.362	3.259	1.914	5.621	2.672	4.19	2.759	7.328	4.207	3.931	3.172

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Characterization of products

	CocoaA	MilkA	CocoaF	MilkF	Caramel	Vanilla	Sweetness	Acidity	Bitterness	Astringency	Crunchy	Melting	Sticky	Granular
choc1	7.086	3.586	8.069	1.569	1.672	1.103	3.138	4.655	7.069	4.759	5.966	4.741	3.759	3.448
choc2	6.552	4	6.914	2.379	2.776	1.81	4.621	3.138	4.948	3.155	7.707	4.328	3.828	3.155
choc3	4.672	6.052	3.379	7.707	6.328	3.672	7.603	1.569	1.397	1.207	2.983	7.31	5.034	1.603
choc4	6.259	4.103												
choc5	6.793	4.172												
choc6	6.362	4.569												

$$\hat{\mu} + \hat{\alpha}_1 = 6.287 + 0.798 = 7.086$$

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	**6.287356**	0.100188	62.756	< 2e-16
Product1	**0.798851**	0.224026	3.566	0.000497
Product2	0.264368	0.224026	1.180	0.239971
Product3	-1.614943	0.224026	-7.209	3.22e-11
Product4	-0.028736	0.224026	-0.128	0.898120
Product5	0.505747	0.224026	2.258	0.025522

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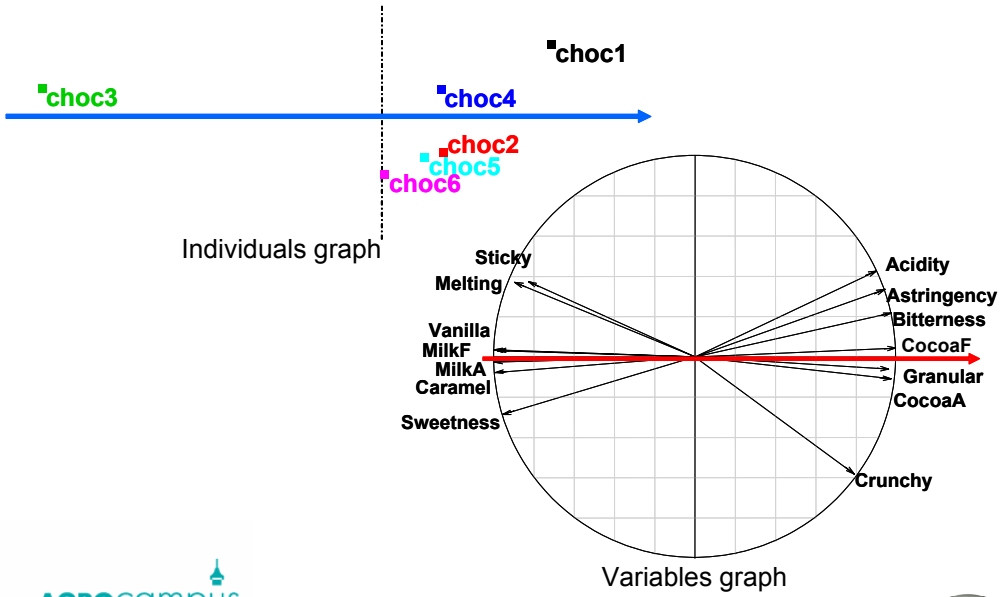
Sorting from the PCA graphs



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Characterization of products

	MilkF	MilkA	Caramel	Vanilla	Sweetness	Melting	Sticky	Crunchy	Acidity	Astringency	Granular	CocoaA	Bitterness	CocoaF
choc3	7.707	6.052	6.328	3.672	7.603	7.31	5.034	2.983	1.569	1.207	1.603	4.672	1.397	3.379
choc6	3.362	4.569	3.259	1.914	5.621	4.207	3.931	7.328	2.672	2.759	3.172	6.362	4.19	6.224
choc5	3.121	4.172	3.414	1.793	5.224	4.741	3.224	6.638	3.086	3.103	3.069	6.793	4.879	6.793
choc4	2.586	4.103	2.672	2.121	4.293	4.379	4.103	6.103	3.931	3.69	3.552	6.259	5.19	6.69
choc2	2.379	4	2.776	1.81	4.621	4.328	3.828	7.707	3.138	3.155	3.155	6.552	4.948	6.914
choc1	1.569	3.586	1.672	1.103	3.138	4.741	3.759	5.966	4.655	4.759	3.448	7.086	7.069	8.069

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Coloring the table

	MilkF	MilkA	Caramel	Vanilla	Sweetness	Melting	Sticky	Crunchy	Acidity	Astringency	Granular	CocoaA	Bitterness	CocoaF
choc3	7.707										1.603	4.672	1.397	3.379
choc6	3.362										3.172	6.362	4.19	6.224
choc5	3.121	4.172	3.414	1.793	5.224	4.741	3.224	6.638	3.086	3.103	3.069	6.793	4.879	6.793
choc4											2	6.259	5.19	6.69
choc2											5	6.552	4.948	6.914
choc1											8	7.086	7.069	8.069

If $\hat{\alpha}_i \neq 0$ (significantly) $\Rightarrow$ color the cell
if $\hat{\alpha}_i < 0$ in red
if $\hat{\alpha}_i > 0$ in blue

```
                Estimate Std. Error t value
Pr(>|t|)
(Intercept)    6.287356   0.100188  62.756  < 2e-16
Product1       0.798851   0.224026   3.566 0.000497
Product2       0.264368   0.224026   1.180 0.239971
Product3      -1.614943   0.224026  -7.209 3.22e-11
Product4      -0.028736   0.224026  -0.128 0.898120
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Characterization of products

	MilkF	MilkA	Caramel	Vanilla	Sweetness	Melting	Sticky	Crunchy	Acidity	Astringency	Granular	CocoaA	Bitterness	CocoaF
choc3	7.707	6.052	6.328	3.672	7.603	7.31	5.034	2.983	1.569	1.207	1.603	4.672	1.397	3.379
choc6	3.362	4.569	3.259	1.914	5.621	4.207	3.931	7.328	2.672	2.759	3.172	6.362	4.19	6.224
choc5	3.121	4.172	3.414	1.793	5.224	4.741	3.224	6.638	3.086	3.103	3.069	6.793	4.879	6.793
choc4	2.586	4.103	2.672	2.121	4.293	4.379	4.103	6.103	3.931	3.69	3.552	6.259	5.19	6.69
choc2	2.379	4	2.776	1.81	4.621	4.328	3.828	7.707	3.138	3.155	3.155	6.552	4.948	6.914
choc1	1.569	3.586	1.672	1.103	3.138	4.741	3.759	5.966	4.655	4.759	3.448	7.086	7.069	8.069

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Results of anova models

Note = Product + Panelist + Session + Prod:Sess + Prod:Pan + Pan:Sess

	Prod	Panelist	Session	Prod:Pan	Prod:Sess	Pan:Sess	Sigma(res)
MilkF	3.74e-40	7.512e-11	0.02138	0.006824	0.1182	0.01535	1.474
Bitterness	1.875e-29	1.639e-10	0.001103	0.0258	0.1897	0.05538	1.689
CocoaF	1.748e-28	1.997e-11	0.04235	0.00665	0.4487	0.09411	1.413
Crunchy	2.878e-27	2.88e-14	0.005173	0.02381	0.6869	0.004479	1.623
Sweetness	1.106e-24	2.416e-12	0.005932	0.1177	0.1188	0.003246	1.669
Caramel	1.183e-22	2.386e-23	0.9217	0.00312	0.07315	0.0008459	1.634
Astringency	1.467e-15	1.142e-22	0.9249	0.05936	0.08183	0.05854	1.702
CocoaA	8.85e-14	2.552e-08	0.3036	0.9929	0.8011	0.8256	1.869
Melting	4.577e-12	1.202e-17	0.04919	6.88e-05	0.3041	0.06195	1.648
Acidity	5.263e-11	6.143e-25	0.3848	0.0009151	0.9835	0.008124	1.66
Vanilla	2.785e-10	9.748e-23	0.1191	0.002577	0.3183	0.03775	1.436
MilkA	6.442e-08	1.097e-13	0.236	0.09279	0.8287	0.2333	1.892
Granular	9.083e-05	2.32e-21	0.1148	0.01502	0.283	0.3101	1.892
Sticky	0.0005312	8.365e-21	0.3641	0.05412	0.009964	0.04789	1.825

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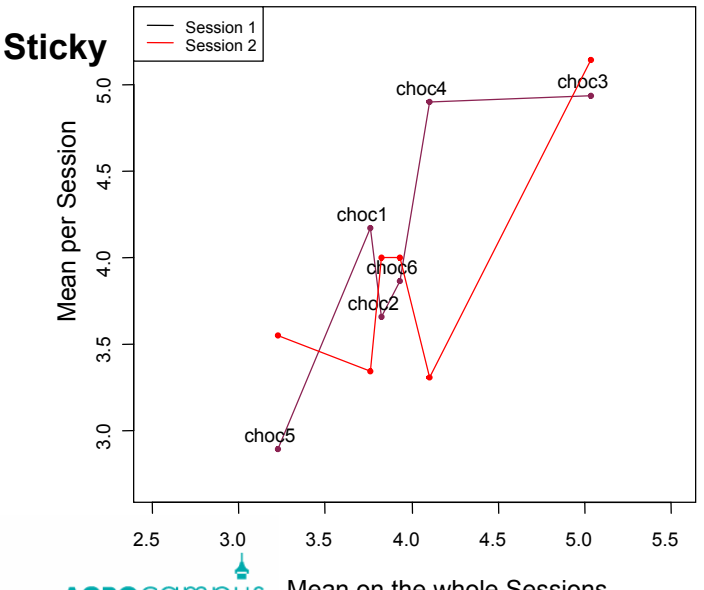
Interaction product - session



Products are sorted by mean

One line per session

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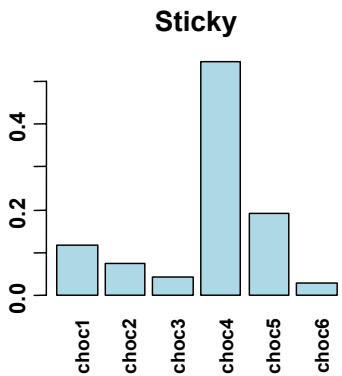
Interaction product - session



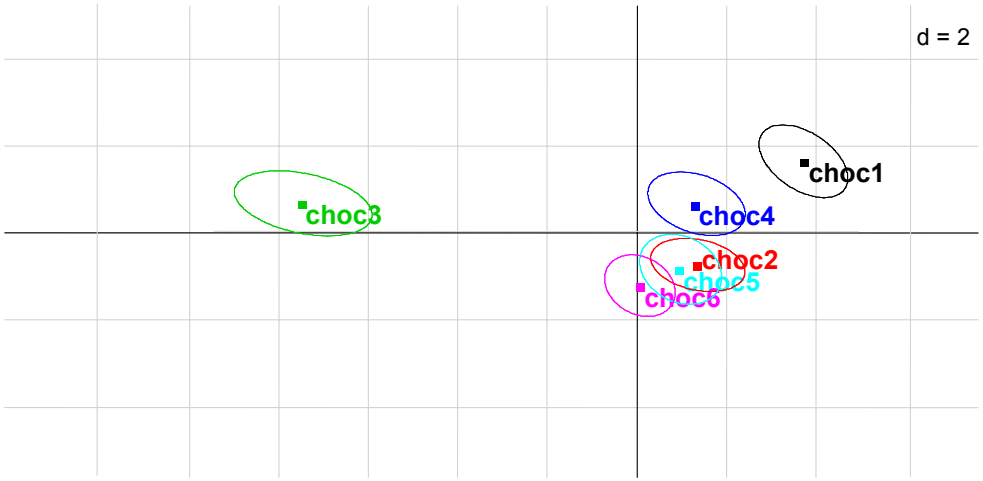
Chocolate 4 contributes more than 50% to the interaction product – session calculated in the following way:

$$Prod_i = \frac{\sum_{j=1}^{J} \alpha\beta ij^2}{\sum_{i=1}^{I}\sum_{j=1}^{J} \alpha\beta ij^2}$$

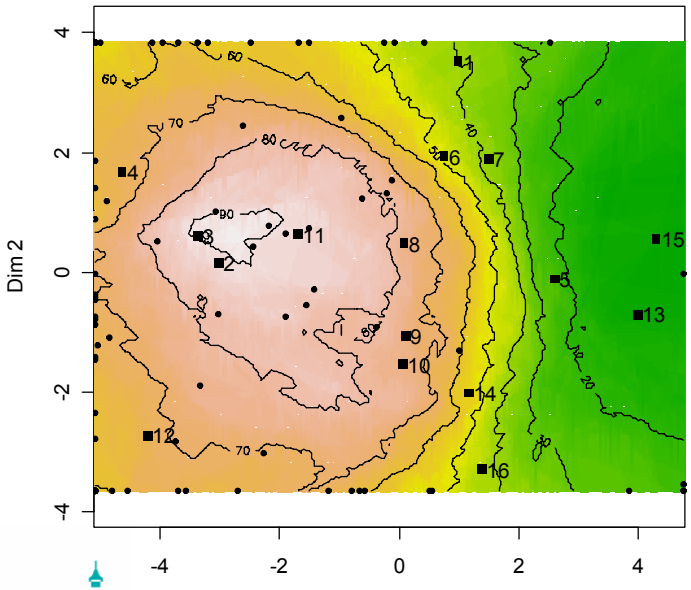
Assessing panel performances

	MilkF	Crunchy	Bitterness	CocoaF	Sweetness	Melting	Caramel	Vanilla
16	0.024	0.044	0.001	0.023	0.0078	0.0015	0.002	0.16
28	0.0015	0.086	0.0014	0.013	0.00016	0.04	0.019	0.18
24	0.078	0.021	0.06	0.015	0.024	0.37	0.022	0.032
9	0.031	0.064	0.081	0.0074	0.0025	0.31	0.022	0.34
17	0.019	0.011	0.13	0.052	0.021	0.0097	0.004	0.008
3	0.013	0.071	0.018	0.065	0.0041	0.79	0.28	0.54
15	0.065	0.047	0.016	8.3e-05	0.091	0.24	0.005	0.15
23	0.0049	0.065	0.033	0.0027	0.15	0.24	0.013	0.13
22	0.019	0.0049	0.0079	0.14	0.38	0.057	0.003	NaN
11	0.012	0.12	0.11	0.35	0.033	0.027	0.0064	0.041
10	9.4e-05	0.016	0.048	0.069	0.087	0.74	0.068	0.14
1	0.0065	0.43	0.071	0.011	0.031	0.072	0.13	0.066
14	0.1	0.097	0.1	0.061	0.26	0.11	0.025	0.83
median	0.019	0.068	0.071	0.08	0.095	0.11	0.13	0.18

Characterization of products



Mapping consumers' preferences



http://sensominer.free.fr