



# MULTIVARIATE ANALYSIS OF SENSORY AND CONSUMER DATA WITH JMP®



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# Covered Topics

- ❖ What influences consumers' preferences?
- ❖ The goal of sensory and consumer studies
- ❖ L-shaped Data in Consumer Preference Analysis
- ❖ Application to real data: Perfume study
- ❖ Live demo in JMP
- ❖ Conclusions



# CNN iReporter Calls Century Eggs “Disgusting,” Chinese Company Demands CNN Apologize

by [Josh Feldman](#) | 12:43 pm, July 6th, 2011

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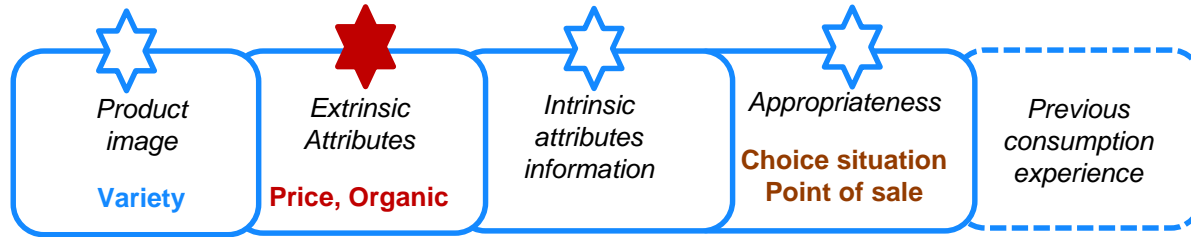


You know the saying: one man’s trash is another man’s treasure. Our eating choices are just as subjective. What tastes good to us might be disgusting elsewhere, and vice versa.

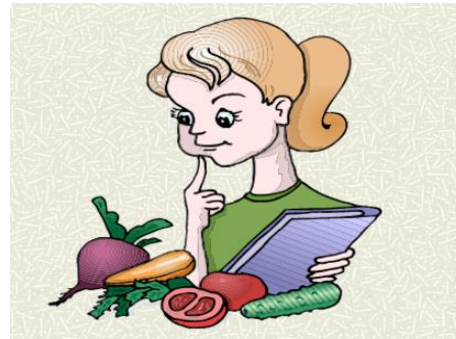
Last month, CNN asked random people (a.k.a.

iReporters) to share their experiences eating all sorts of “revolting” foods, and listed them in no particular order. [The list](#) included such yummy morsels as dog meat and stir-fried cicadas. Mmm... cicadas. The dish that made the top of the list was a Chinese dish called “century eggs.” The food was submitted to CNN by iReporter **Danny Holwerda**, who described the food on [his blog](#) as “**THE STUPIDEST**

# What Influences Consumers' Preferences?

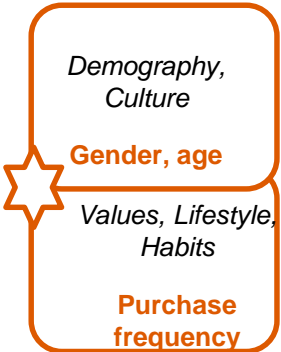
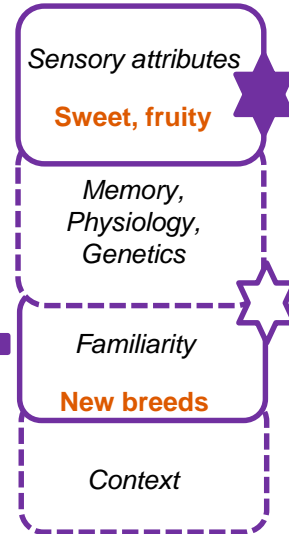


Expectations



Preferences

Perception



Attitudes



Attitudes



# The Goal of Sensory and Consumer Studies

Improve products

Make/target a new product for a population segment

## Sensory Panels



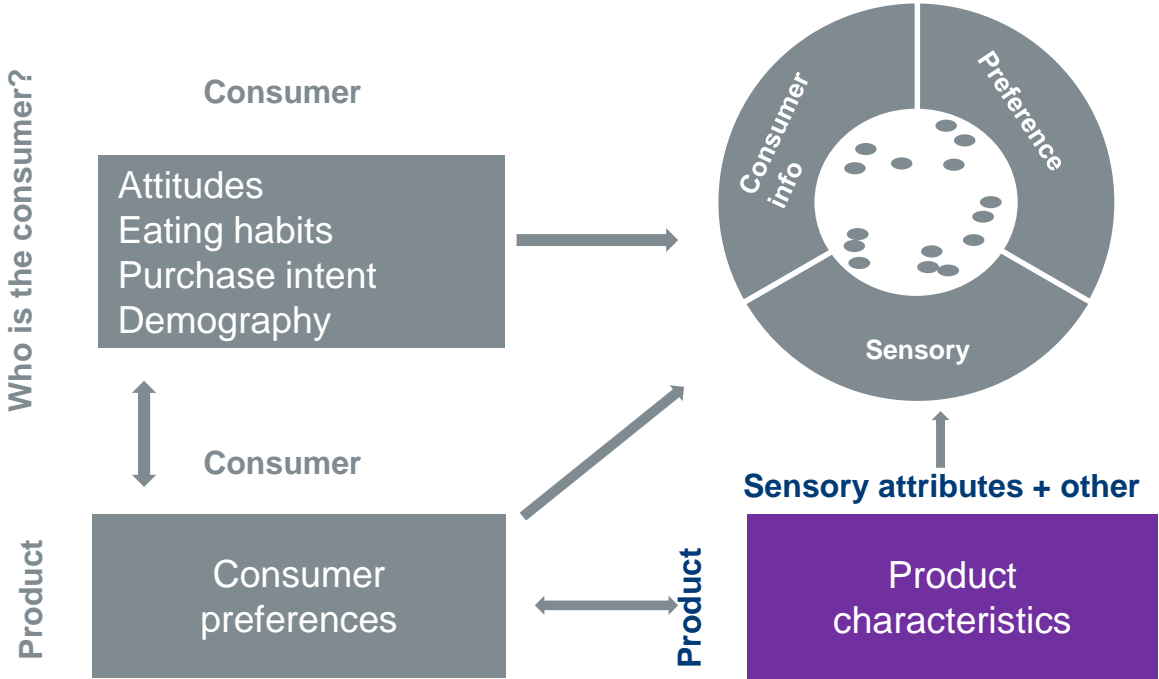
- Analytical methods
- 10 to 15 Trained panelists
- Attributes of products
- Describe products on the basis of taste, smell or feel.

## Consumer Studies

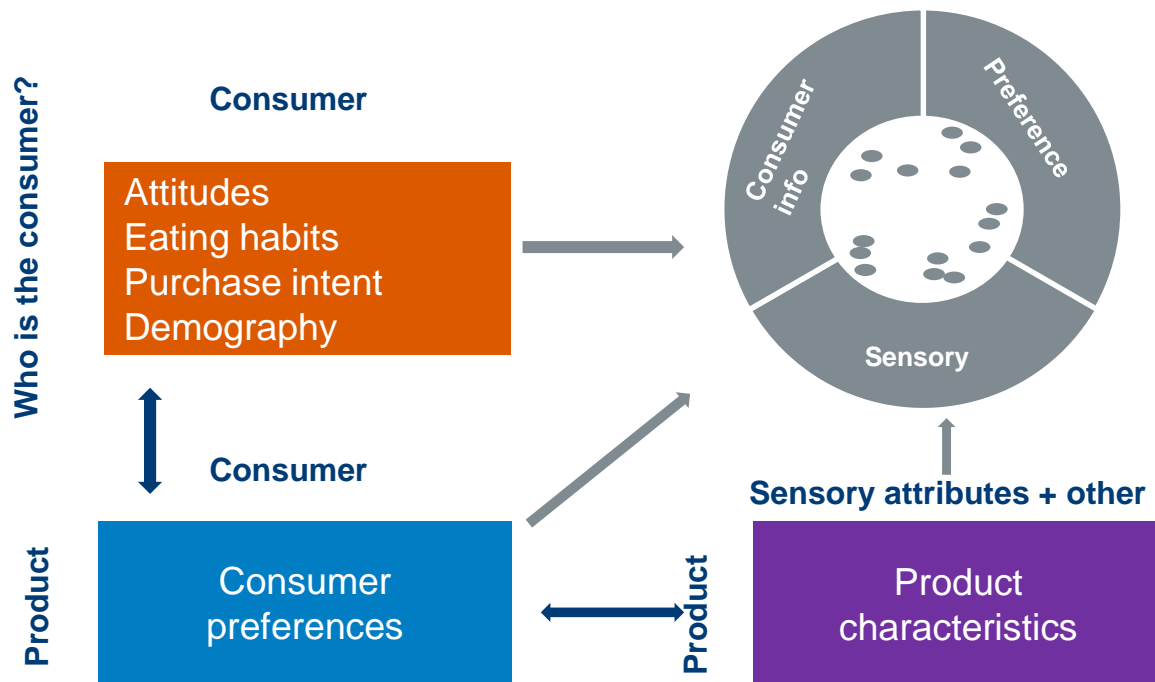


- Affective methods
- 100 to 150 consumers
- How much do you **like** this product?

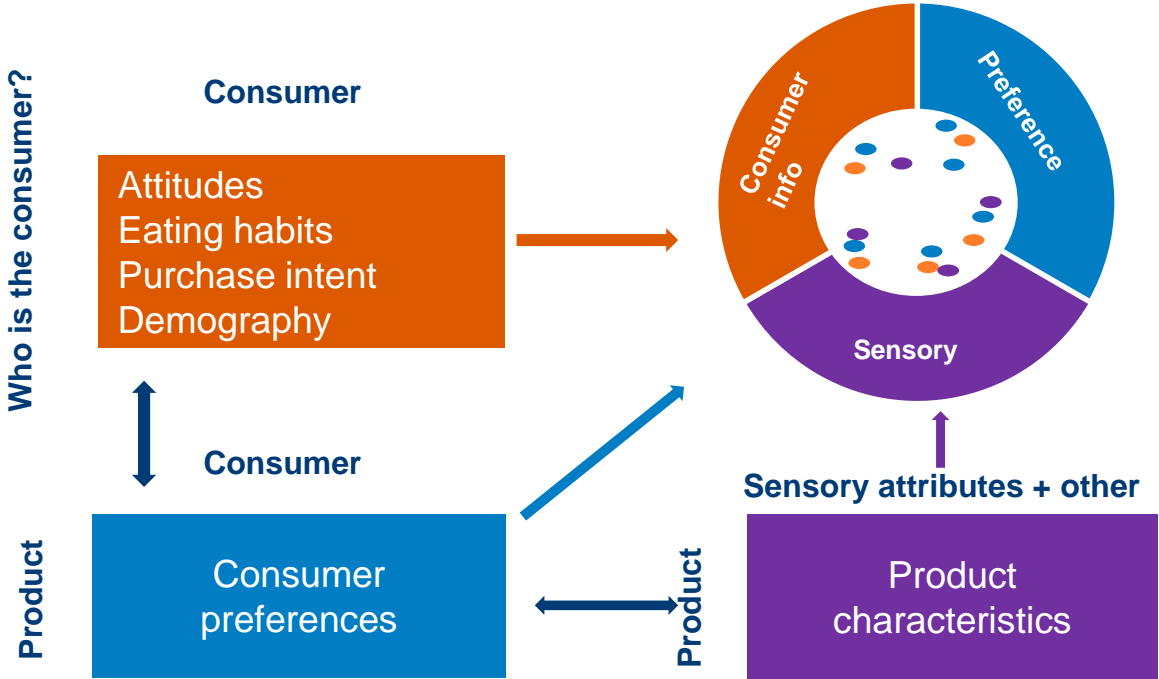
# L-shaped Data in Consumer Preference Analysis



# L-shaped Data in Consumer Preference Analysis



# L-shaped Data in Consumer Preference Analysis





# Application to Real Data: Perfume Study

## ❖ Data description

- 12 perfumes (products).
- 12 descriptive evaluations (attributes) grade: 0 to 10
- 12 trained panelists.
- All panelists evaluated all the perfumes 2 times.
- 103 consumers grading their liking of the perfumes.

These data were collected by Melanie Cousin, Maelle Penven, Mathilde Philippe, and Marie Toularhoat as part of a large master's degree project.

## ❖ Issues that we would like to discuss

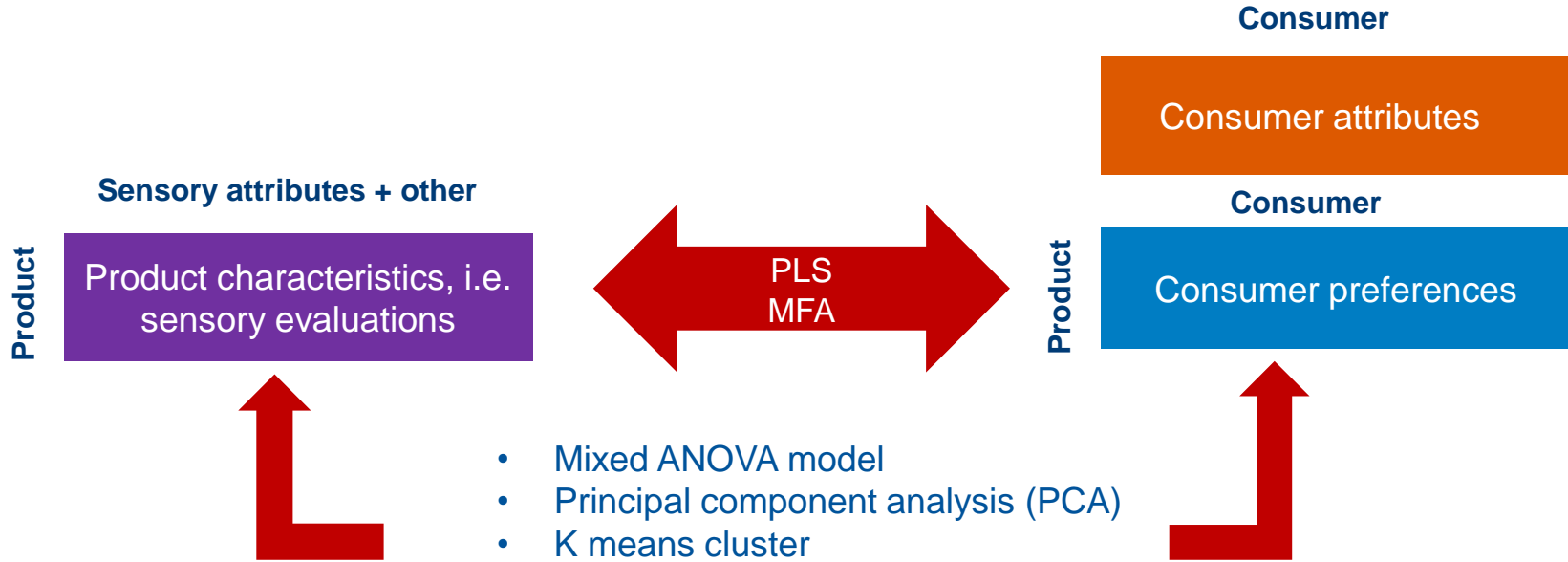
- How to assess the overall quality of sensory data?
- How to detect the sensory differences and similarities between products?
- How to approach textual data when products are described by comments?
- How to approach hedonic (liking) data?



➔ **Relating customer preference to the attributes of perfumes**



# Commonly Used Statistical Tools



- Mixed ANOVA model
- Principal component analysis (PCA)
- K means cluster
- Multiple factor analysis (MFA)
- Partial least squares (PLS)
- Text explorer
- Multiple correspondence analysis (MCA)

## Issues that we would like to discuss

- ❖ **How to assess the overall quality of sensory data?**
  - Mixed ANOVA model for attributes
  - ANOVA and MFA for panelists
- ❖ How to detect the sensory differences and similarities between products?
- ❖ How to approach textual data when products are described by comments?
- ❖ How to approach hedonic data?

# Overview of the Perfume Data (Data from Sensory Panel)

Sensory profiles and evaluations of panelists on the perfumes

Product	Session	Panelist	Wrapping	Green	Floral	Citrus	Vanilla	Woody	Fruity
1 Angel	1	CM	9.2	0	1.7	0	8.7	0	0.7
2 Angel	2	CM	5.7	0	1.5	0	3.3	0.9	0
3 Aromatics EL...	1	CM	6.4	0	4.3	0	0	2.2	0
4 Aromatics EL...	2	CM	4.2	0	2.2	0	1.2	2	0
5 Chanel N°5	1	CM	9.6	1.7	6.4	0	0.5	0	1.2
6 Chanel N°5	2	CM	8.8	0	6	0	1	0	0
7 Cinéma	1	CM	9.4	0.7	6	1	6	0	6.7
8 Cinéma	2	CM	8.8	0.2	6.1	0	7.5	0	2.2
9 Coco Made...	1	CM	9	1	8.8	4.3	0.5	0.7	2.7
10 Coco Made...	2	CM	8.8	0.7	8.8	1.8	0.3	0	3.3
11 J'adore EP	1	CM	8.1	5.7	9.3	2.1	0.5	0	7.7
12 J'adore EP	2	CM	7.5	4.2	9	2	1	0	4.3
13 J'adore ET	1	CM	5.4	3.1	9.5	1.7	0.5	0	5.5
14 J'adore ET	2	CM	6.7	0.7	9	1.2	0	0	4.2
15 L'Instant	1	CM	8.4	0	5.8	1.2	8.3	0	1.3

Perfumes are rated by panelist with several lists of attributes

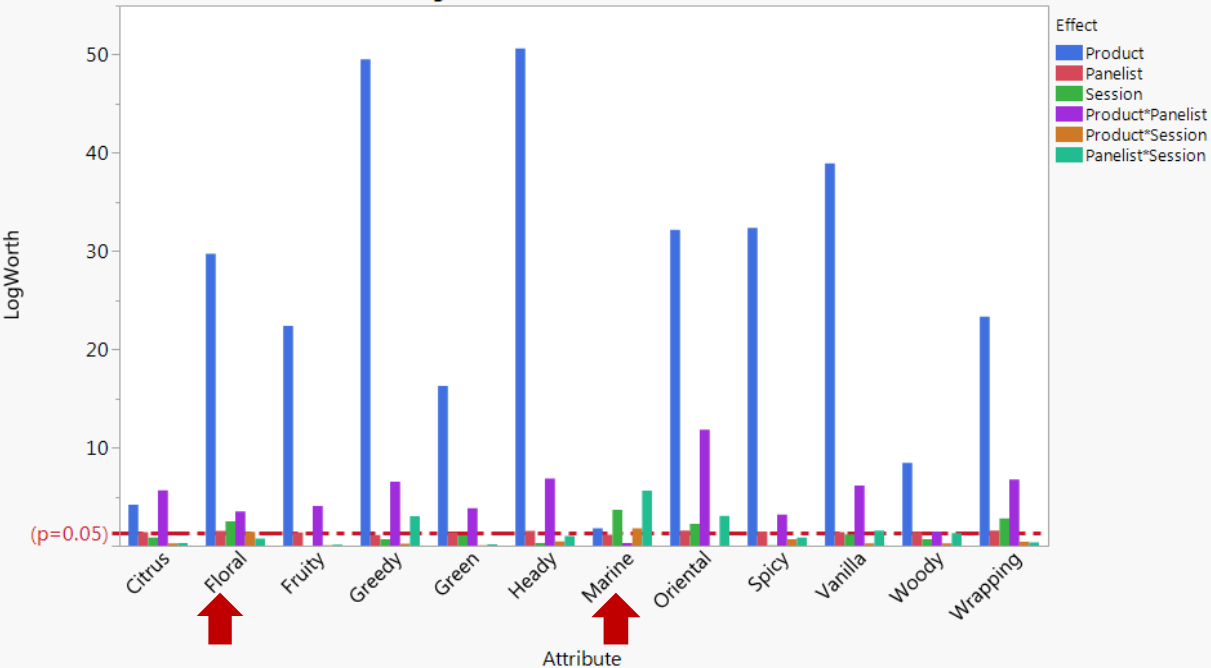
Product	Wrapping_CM	Green_CM	Floral_CM	Citrus_CM	Vanilla_CM	Woody_CM	Fruity_CR	Greedy_CR	Oriental_CR	Citrus_CR	Floral_CR	Vanilla_CR
1 Angel	7.45	0	1.6	0	6	0.45	6.6	7.1	0.15	0.9	4.1	7.05
2 Aromatic...	5.3	0	3.25	0	0.6	2.1	0.25	0.15	7.9	0.65	4.75	0.65
3 Chanel N°5	9.2	0.85	6.2	0	0.75	0	0	0.1	8.55	0.15	7.45	0.45
4 Cinéma	9.1	0.45	6.05	0.5	6.75	0	3.45	4.3	0.15	0.9	7.2	4
5 Coco Ma...	8.9	0.85	8.8	3.05	0.4	0.35	1.9	1.25	9.35	0.15	9.55	1.1
6 J'adore EP	7.8	4.95	9.15	2.05	0.75	0	8.85	1.5	4.2	0.2	9.25	0.6
7 J'adore ET	6.05	1.9	9.25	1.45	0.25	0	7.8	3	0.15	0.7	8.4	0.5
8 L'Instant	8.3	0.25	5.95	2.45	7.65	0	7.45	2	0.4	0.8	8.15	7.9
9 Lolita Le...	9.35	1.45	8.1	2.4	3.1	0	7.85	9.05	0.25	1	5.6	9.2
10 Pleasures	3.6	7.1	8.35	1	0	0	7.8	1.45	0.15	3.15	7.9	0.3
11 Pure Pois...	8.7	1.15	7.7	2.25	5.7	0	2.2	0.15	5.45	0.2	7.25	0.35
12 Shalimar	6.7	0	5.3	0	2.85	2.6	0.4	0.05	9	0	8.3	0.9

Summarized table

# Mixed Model (ANOVA) : The Importance of Sensory Attributes

$$Y_{ijs} \sim \mu + \alpha_i + \beta_j + \gamma_s + \alpha\beta_{ij} + \alpha\gamma_{is} + \beta\gamma_{js} + \epsilon_{ijs}$$

LogWorth vs. Attribute

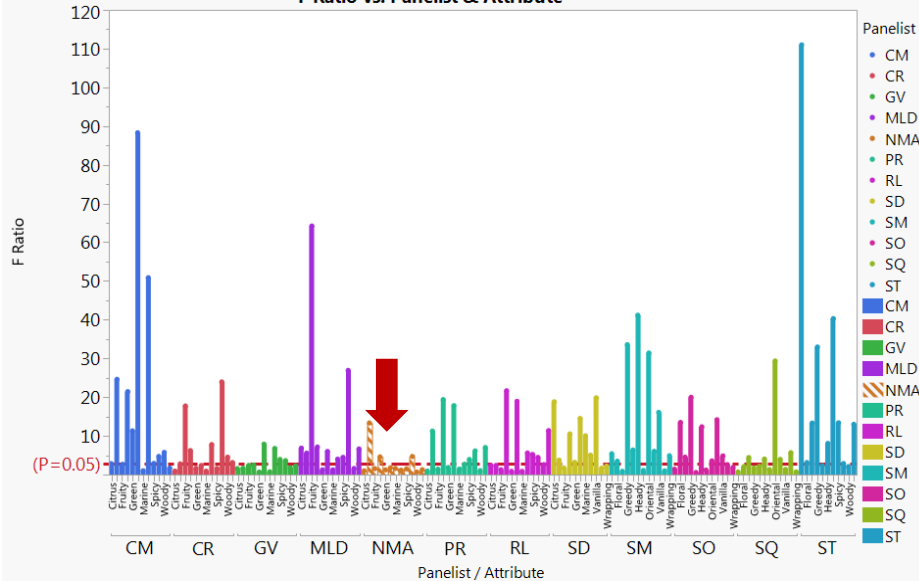


- The panel discriminates between the products for all attributes.
- The panel is repeatable from one section to the other for all attributes, except for **Floral** and **Marine** (Product\*Session).
- Attribute **Marine** is insignificant.

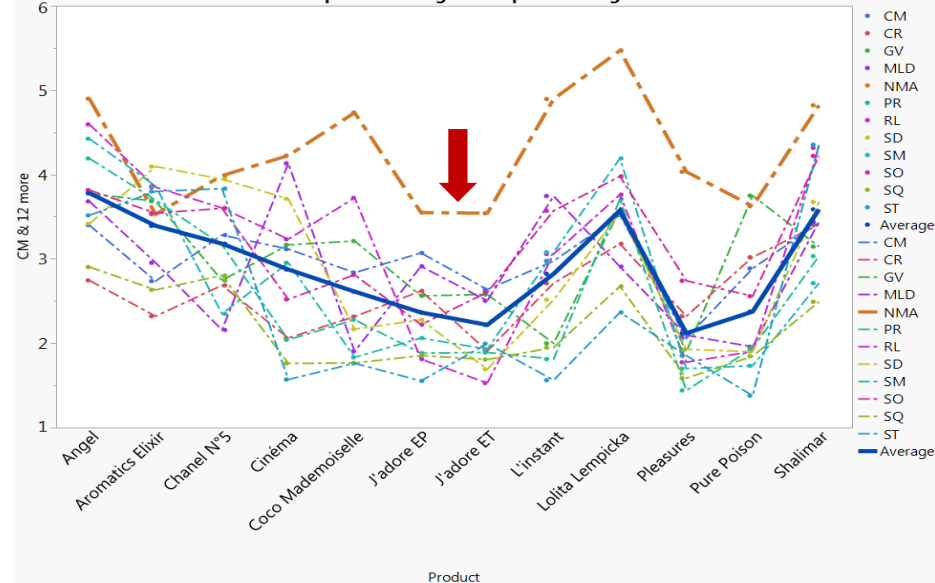
# ANOVA Model and Graph Builder : The Performance of Panelists

$$Y_{is} \sim \mu + \alpha_i + \gamma_s + \epsilon_{is}$$

F Ratio vs. Panelist & Attribute

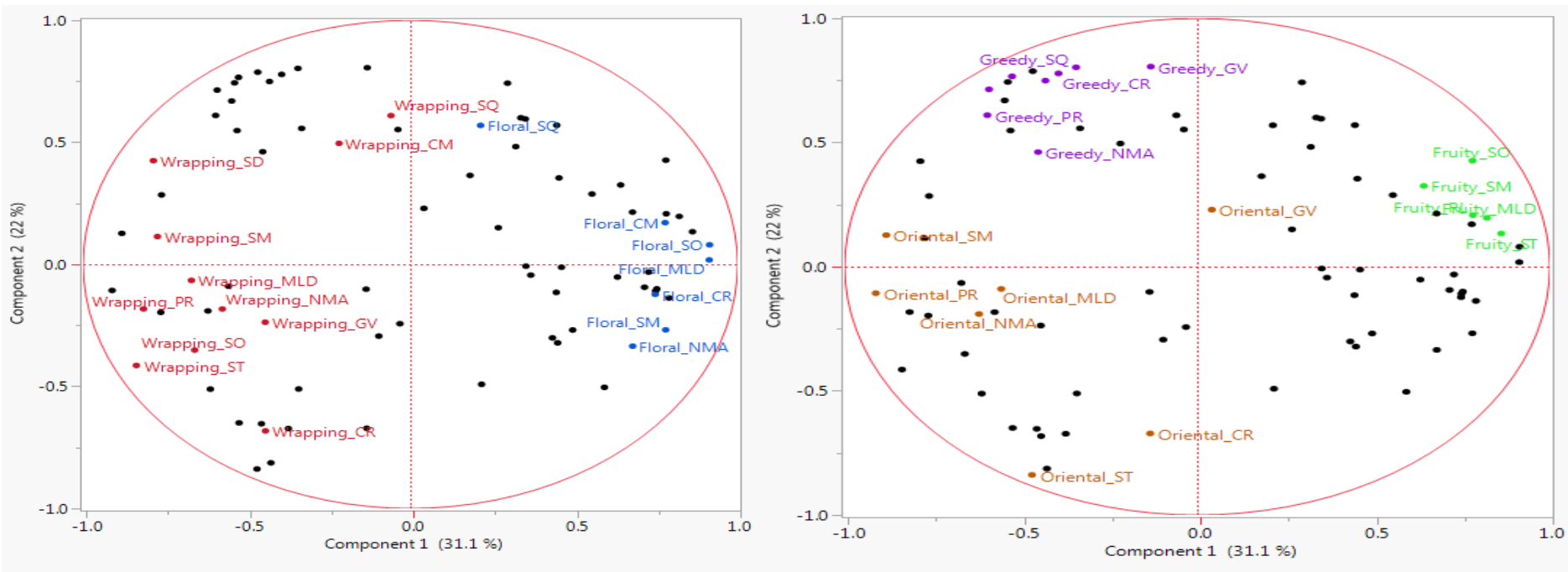


Individual panelist ratings vs the panel average



Both ANOVA and the profile plot indicate that all panelists have well discriminated the perfumes except for panelist **NMA**.

# Multiple Factor Analysis (MFA): Agreement Between Panelists



- An agreement exists between panelists on attributes such as **Greedy** and **Fruity**, but not on attribute **Oriental**.
- **Wrapping** on the one side, and **Floral** on the other side suggests that an agreement exists between panelists.

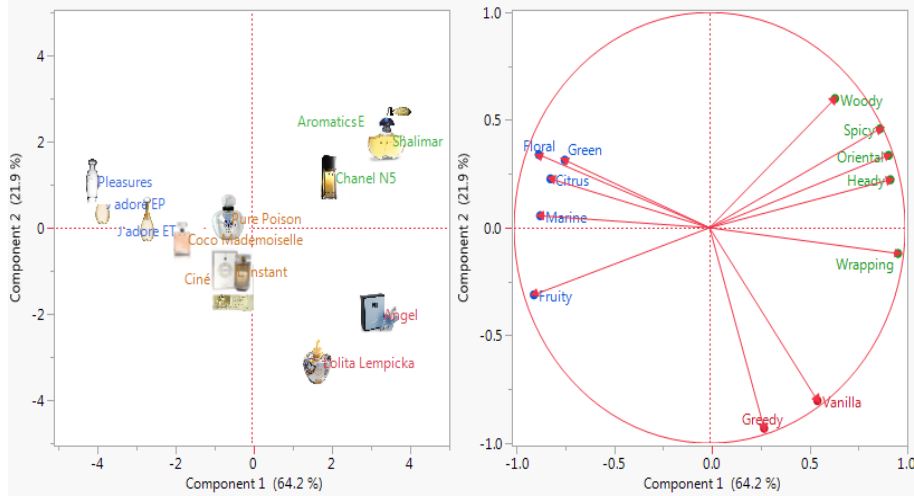
## Issues that we would like to discuss

- ❖ How to assess the overall quality of sensory data?
- ❖ **How to detect the sensory differences and similarities between products?**
  - PCA
  - K means cluster
- ❖ How to approach textual data when products are described by comments?
- ❖ How to approach hedonic data?

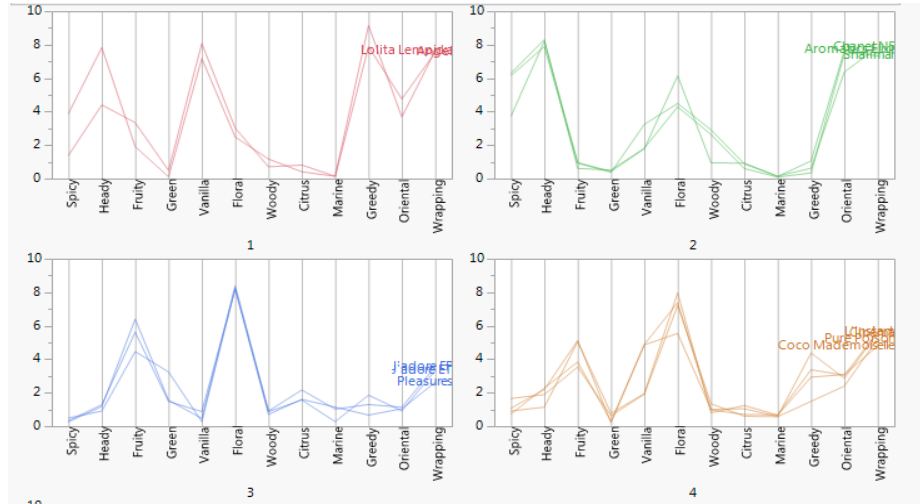


# PCA and K Means Cluster: Sensory Profile for Each Product

PCA map: relations between perfumes and attributes



K Means cluster: 4 clusters of perfumes are identified



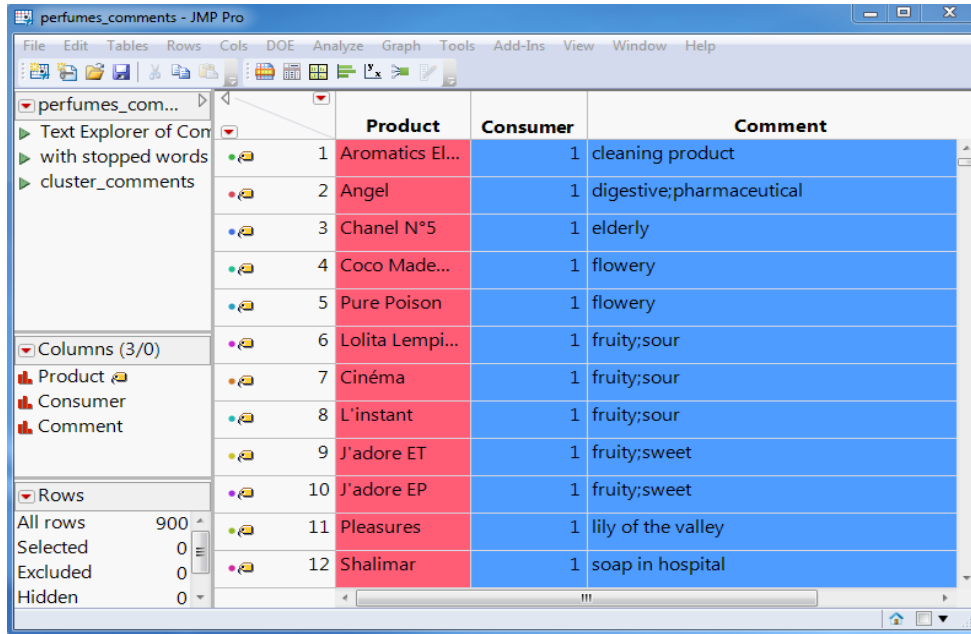
- The first dimension opposes perfume such as **Pleasure** to perfumes such as **Angel**.
- The first dimension opposes attributes such as **Floral**, **Citrus**, **Green** and **Fruity** to attributes such as **Oriental**, **Heady**, **Spicy** and **Wrapping**.
- **Angel** has been perceived as **Greedy**, **Heady**, to a lesser degree as **Spicy**.
- **Pleasure** has been perceived as **Floral**, **Fruity** and it has not been perceived as **Wrapping** nor as **Heady**.

## Issues that we would like to discuss

- ❖ How to assess the overall quality of sensory data?
- ❖ How to detect the sensory differences and similarities between products?
- ❖ **How to approach textual data when products are described by comments?**
  - Text explorer
  - MCA
  - Hierarchical cluster
- ❖ How to approach hedonic data?

# Overview of the Perfume Data (Data from Consumer Study)

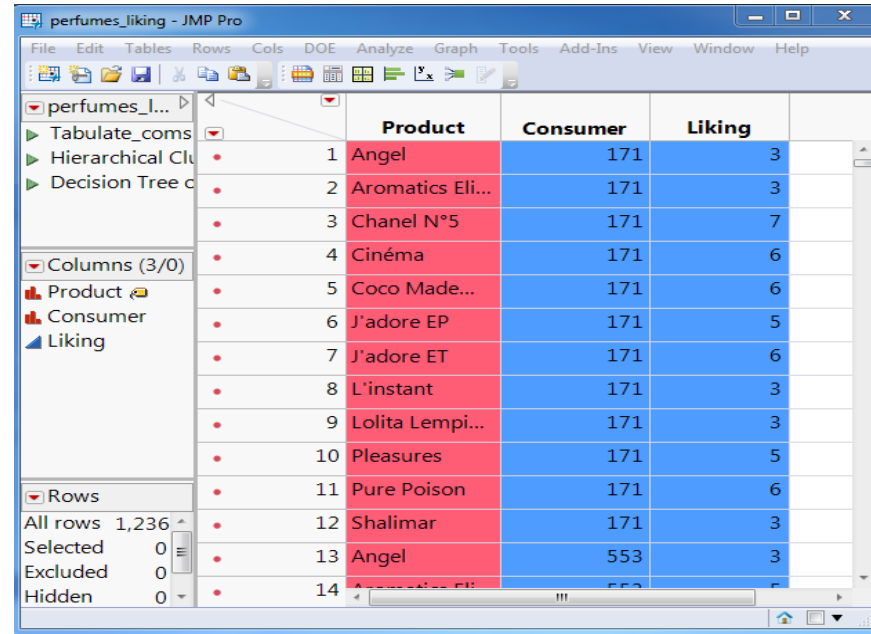
Consumer comments  
about the perfumes



The screenshot shows the JMP Pro interface with a data table titled 'perfumes\_comments'. The table has four columns: Product, Consumer, and Comment. The data is as follows:

	Product	Consumer	Comment
1	Aromatics El...	1	cleaning product
2	Angel	1	digestive;pharmaceutical
3	Chanel N°5	1	elderly
4	Coco Made...	1	flowery
5	Pure Poison	1	flowery
6	Lolita Lempi...	1	fruity;sour
7	Cinéma	1	fruity;sour
8	L'instant	1	fruity;sour
9	J'adore ET	1	fruity;sweet
10	J'adore EP	1	fruity;sweet
11	Pleasures	1	lily of the valley
12	Shalimar	1	soap in hospital

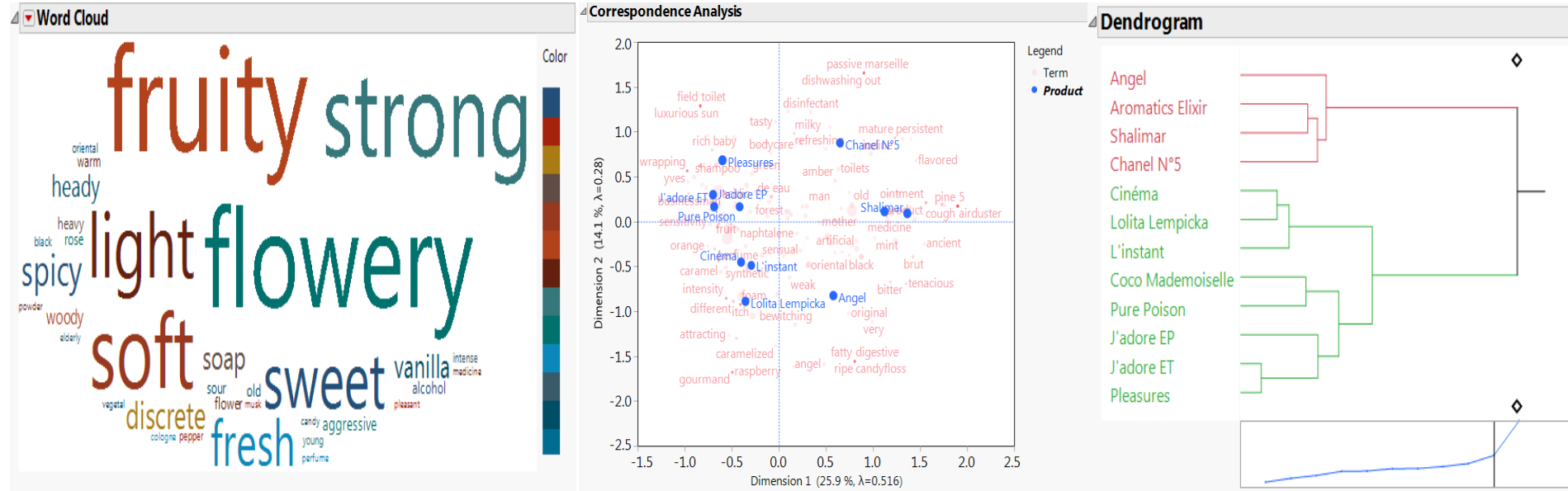
Consumers' liking  
on the perfumes



The screenshot shows the JMP Pro interface with a data table titled 'perfumes\_liking'. The table has four columns: Product, Consumer, and Liking. The data is as follows:

	Product	Consumer	Liking
1	Angel	171	3
2	Aromatics Eli...	171	3
3	Chanel N°5	171	7
4	Cinéma	171	6
5	Coco Made...	171	6
6	J'adore EP	171	5
7	J'adore ET	171	6
8	L'instant	171	3
9	Lolita Lempi...	171	3
10	Pleasures	171	5
11	Pure Poison	171	6
12	Shalimar	171	3
13	Angel	553	3
14	Aromatics El...	553	3

# Text Explorer: When Products are Depicted by Comments



Comments such as “**flowery**”, “**fresh**” and “**flowery**” are associated with perfume *J'adore ET* and *Coco Mademoiselle*, whereas comments such as “**soap**”, “**strong**” and “**spicy**” are associated with perfume *Shalimar* and *Chanel N5*. Topic analysis based on comments in Text Explorer identifies 2 clusters of perfumes.

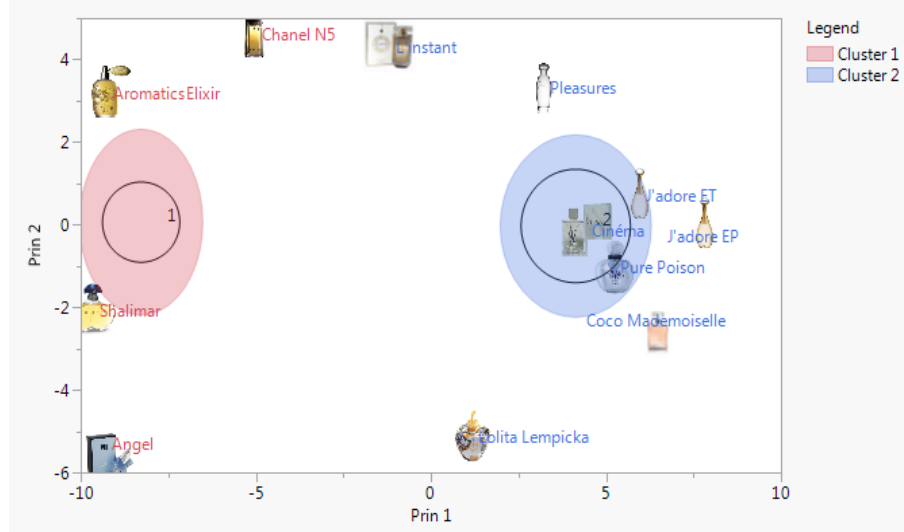
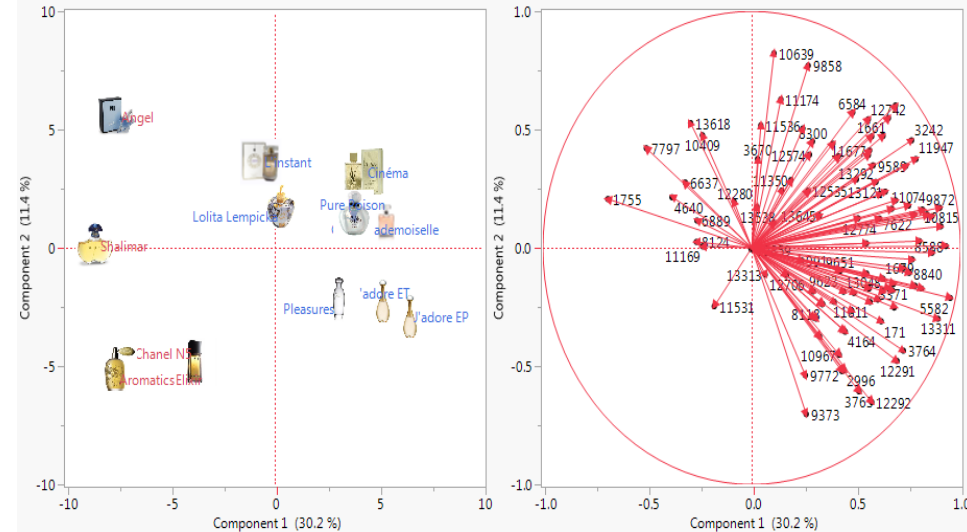
## Issues that we would like to discuss

- ❖ How to assess the overall quality of sensory data?
- ❖ How to detect the sensory differences and similarities between products?
- ❖ How to approach textual data when products are described by comments?
- ❖ **How to approach hedonic data?**
  - PCA
  - K means cluster

# PCA and K Means Cluster: Identify the Best Product with Hedonic Data

PCA map: relation between perfumes and consumers

K Means cluster: 2 clusters of perfumes are chosen



- One the first dimension, perfume **J'adore EP** and **J'adore ET** are preferred by the majority of the consumers.
- Customers who prefer perfumes such as **Shalimar** and **Chanel N5**, by opposition to consumers who prefer perfumes such as **Pleasures** and **J'adore ET**.



→ **Relating customer preference to the attributes of perfumes**

- PLS
- MFA



These data were collected by Melanie Cousin, Maelle Penven, Mathilde Philippe, and Marie Toularhoat as part of a large master's degree project.

# Combine Sensory and Consumer Data Together

perfumes\_preference\_mapping - JMP Pro

	Product	Spicy	Heady	Fruity	Green	171	553	991	1344	1661	1679	age_20+	age_30+	age_40+	age_50+
1	Angel	3.9	7.841...	1.92...	0.1125	3	3	7	5	5	5	-0.0404...	0.05722...	-0.1583...	0.27829...
2	Aromatics ...	6.30...	8.308...	0.6125	0.516...	3	5	6	6	4	4	0.00933...	0.00702...	-0.0510...	0.10433...
3	Chanel N°5	3.73...	8.2125	0.96...	0.4375	7	1	8	8	1	5	0.09252...	0.06470...	-0.1756...	0.11597...
4	Cinéma	1.08...	2.195...	5.125	0.2125	6	4	6	8	7	6	-0.0574...	0.10735...	-0.0078...	-0.0392...
5	Coco Mad...	0.91...	1.141...	5.0625	0.779...	6	7	7	6	5	5	0.01112...	0.04302...	-0.1055...	0.10932...
6	J'adore EP	0.26...	1.179...	6.40...	1.5625	5	8	7	9	5	6	0.11840...	0.06346...	-0.1944...	-0.0427...
7	J'adore ET	0.34...	1.2875	5.625	1.483...	6	6	8	7	7	5	0.06633...	0.13258...	-0.2322...	0.09649...
8	L'instant	0.73...	2.283...	3.84...	0.295...	3	4	9	6	7	3	0.01898...	0.16850...	-0.1067...	0.08247...
9	Lolita Lem...	1.4	4.408...	3.35	0.491...	3	3	6	8	7	5	0.04013...	-0.1395...	0.04710...	0.04013...
10	Pleasures	0.49...	0.9125	4.4625	3.25	5	6	8	7	7	7	0.14091...	-0.0144...	-0.0560...	-0.0649...
11	Pure Poison	1.66...	1.895...	3.54...	0.629...	6	5	7	7	6	5	-0.0448...	-0.0435...	-0.0441...	0.05858...
12	Shalimar	6.16...	7.8875	0.925	0.379...	3	3	6	8	3	2	0.06120...	-0.0258...	-0.0544...	0.10747...

Sensory

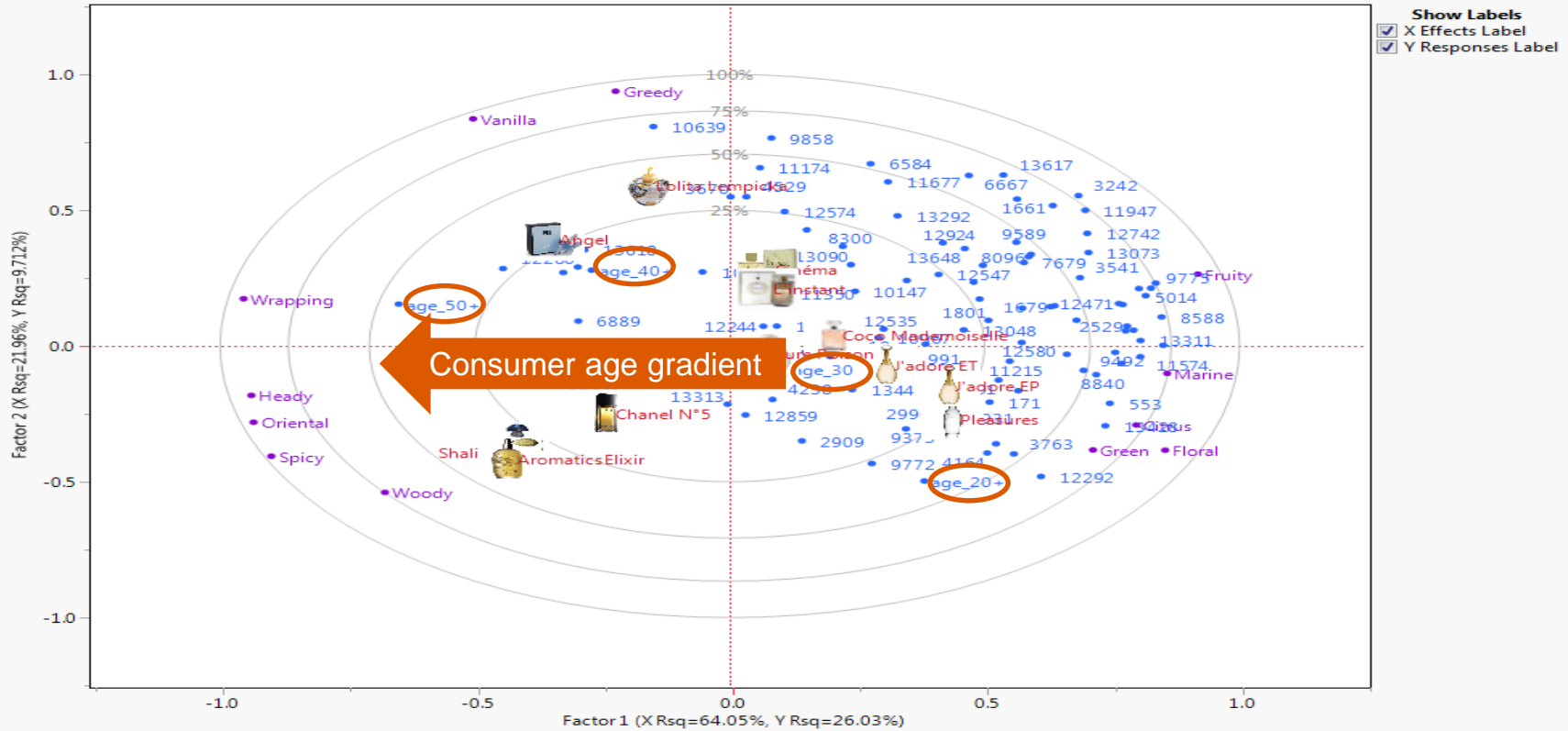
Consumer preferences

Consumer attributes

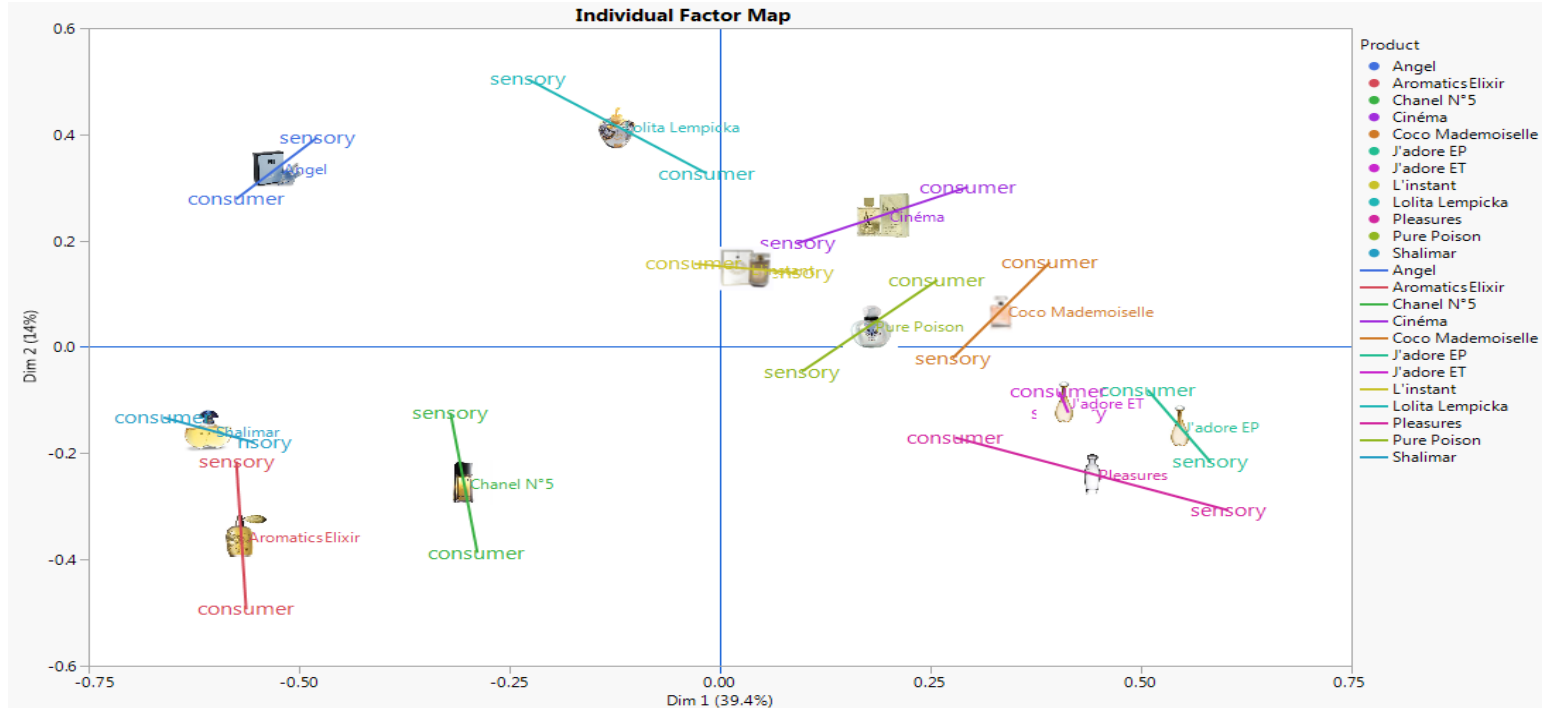


# PLS and MFA: Link between Sensory Profiles, Products and Consumers' Preference

Correlation Loading Plot



# PLS and MFA: Link between Sensory Profiles, Products and Consumers' Preference



MFA shows that sensory profiles can be used to explain consumer preferences. **J'adore ET** and **L'instant** are the most common products to the two groups, whereas **Lolita Lempicka** and **Pleasures** are less common to the two groups.

# Conclusions

- ❖ Support all standard methods.
- ❖ The most appropriate methods are related to each other.
- ❖ PLS and MFA are very efficient.
- ❖ An automatic way to do MFA and L-PLS is on the way.



Thank you for your attention

thank you merci  
 grazie dêkuji  
 danke spasibo  
 obrigado ありがとう

warm ta shukran  
 black shukran  
 谢谢  
 powder stinky takk  
 epharisto  
 grand oriental candy  
 dziekuję  
 tack  
 tak pepper young kilitos  
 perfume  
 todas  
 please  
 intense dankie  
 lovely  
 name  
 medicine  
 changes  
 black  
 blue



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