



# Bayesian Networks

A complete framework to understand consumer perceptions and their links with external data



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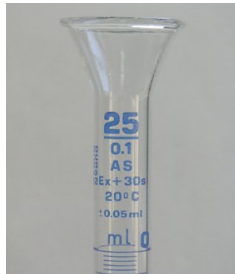
✓ **PRODUCT TESTING in France.**

- 20 market products tested in the confectionary sector
- Sequential monadic procedure
- N= 200 respondents
- Overall liking, JAR questions



✓ **SENSORY PANEL**

- 40 significant sensory attributes
- Covering aroma, texture, flavour, aftertaste and after sensation.



✓ **ANALYTICAL MEASURES**

- 20 key variables

- **GAIN UNDERSTANDING OF CONSUMER PERCEPTIONS AND DRIVERS OF LIKING, AND PROVIDE THE R&D WITH GUIDELINES FOR PRODUCT DEVELOPMENT.**



## STEP 1 : UNDERSTANDING CONSUMER PERCEPTIONS

« internal » model  
consumer attributes  
(JAR scales)

## STEP 2 : SIMPLIFYING SENSORY & TECHNICAL INFORMATION

Identification of main  
dimensions

## STEP 3 : INFLUENCE OF TECHNICAL DIMENSIONS ON CONSUMER PERCEPTIONS

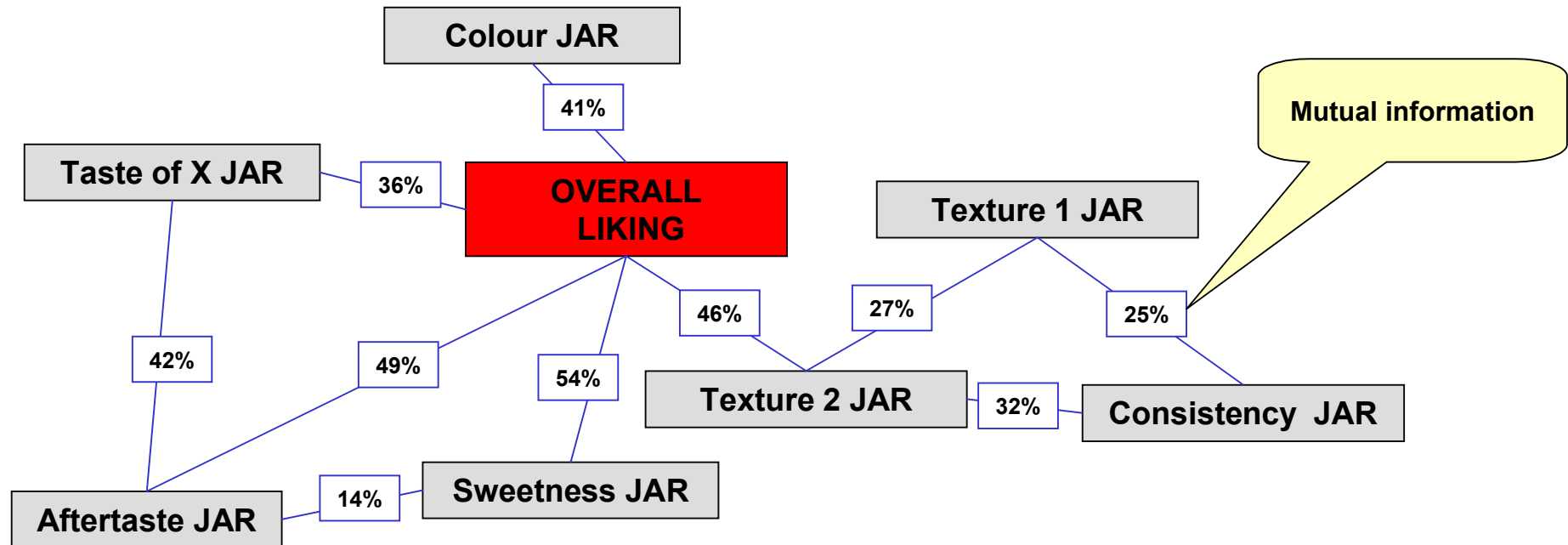
« external » model  
sensory attributes,  
analytical data



## STEP 1 : UNDERSTANDING CONSUMER PERCEPTIONS

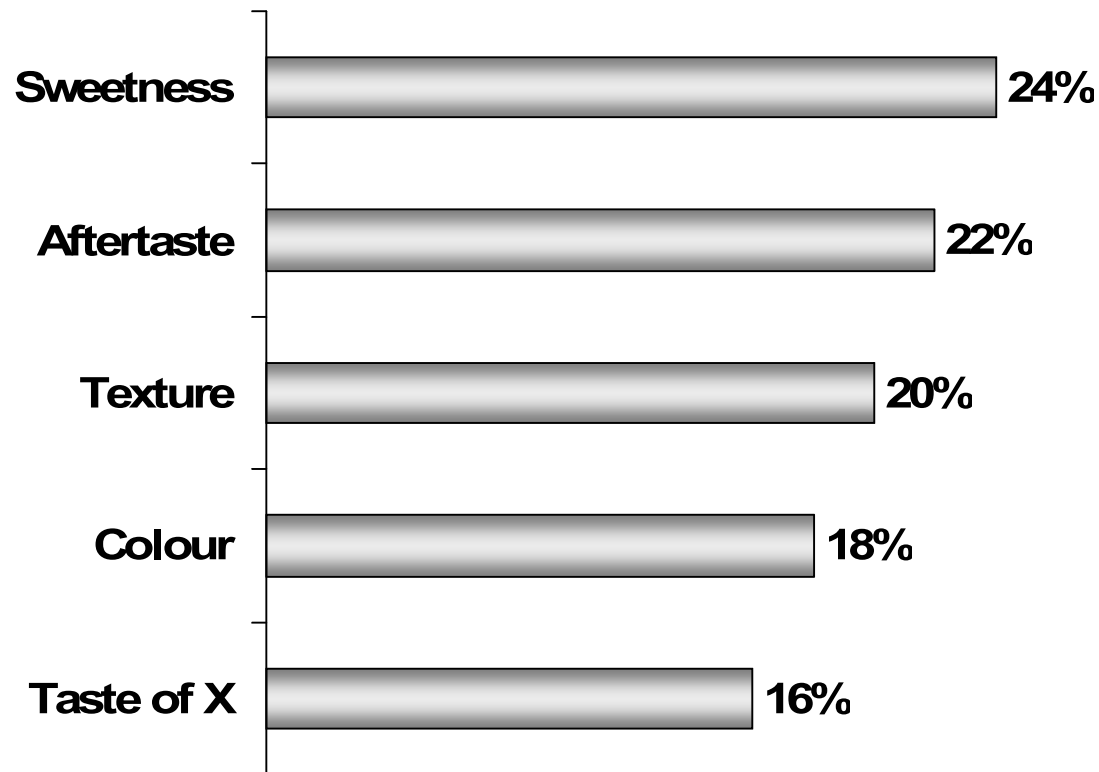
« internal » model  
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## AUTOMATIC LEARNING - discovering STRUCTURE and PARAMETERS



- HEURISTIC SEARCH ALGORITHM TO TEST DIFFERENT STRUCTURES
- QUALITY OF THE POSSIBLE NETWORKS IS ASSESSED BY A SCORE TAKING INTO ACCOUNT
  - The fit of the model to the data
  - The complexity of the structure
- CROSS VALIDATION IS USED TO ENSURE ROBUSTNESS

## OUTPUT – relative weights in overall liking



**Relative Weights in overall Liking**  
*(Mutual information normalized to sum 100%)*

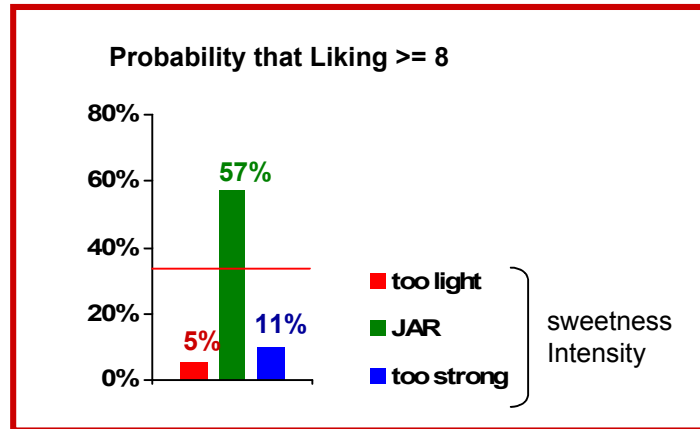
ALL DRIVERS ARE VERY CLOSE IN TERMS OF IMPACT ON TASTE LIKING (contrary to other markets where 1 or 2 drivers prevail).

OVERALL LIKING requires good performances on...

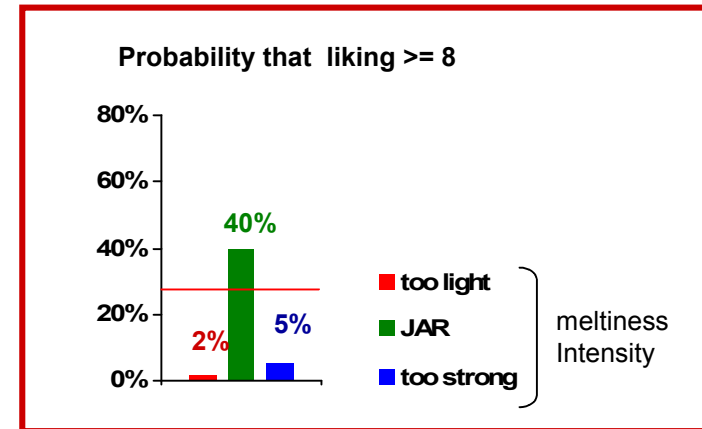
- ... TASTE dimensions (aftertaste, sweetness, taste of...)
- ... TEXTURE perception
- ... COLOUR perception

## OUTPUT – detailed impact of intensity balance

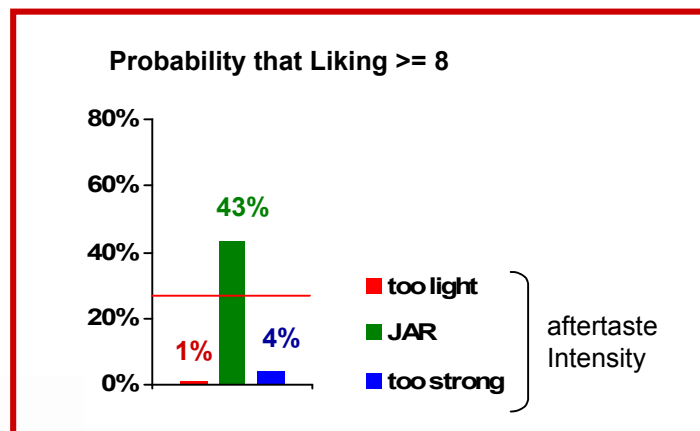
### Impact of *sweetness balance*



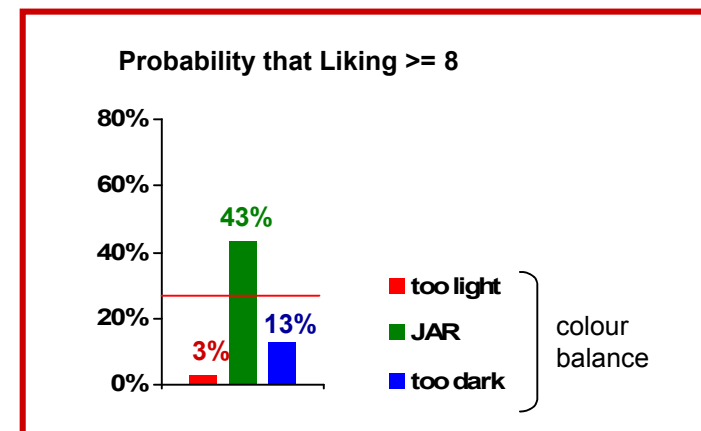
### Impact *texture balance*



### Impact of *Aftertaste balance*



### Impact of *colour intensity balance*





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## Handling sensory and analytical variables

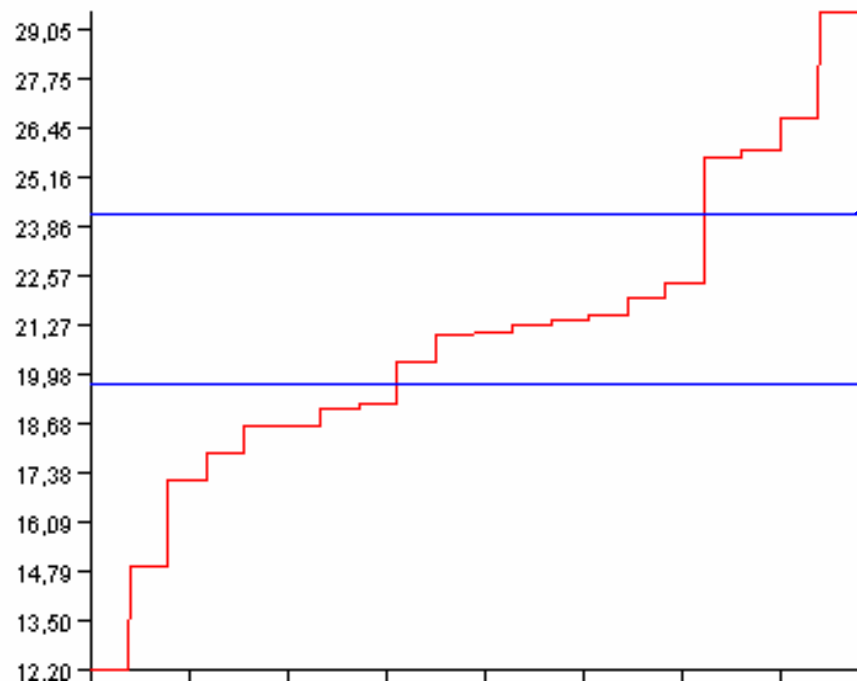
Sensory and Analytical variables have been discretized into 3 levels using a K-Means procedure, in order to adapt each discretization to the distribution of the variable.

### CHECKING CORRESPONDENCE WITH GROUPINGS BASED ON THE SENSORY PANEL

Sensory Score

Flavour Attribute 1

Falvour Attribute 1



Product	Sensory Score	Grouping
Product 1	29.55	a
Product 2	26.75	a
Product 3	25.94	a b
Product 4	25.75	a b
Product 5	22.38	b c
Product 6	21.98	b c d
Product 7	21.73	b c d
Product 8	21.36	c d
Product 9	21.33	c d
Product 10	21.11	c d
Product 11	21.02	c d
Product 12	20.31	c d
Product 13	19.91	c d
Product 14	19.20	c d e
Product 15	19.15	c d e
Product 16	18.58	c d e
Product 17	18.57	c d e
Product 18	17.95	c d e
Product 19	17.25	d e
Product 20	14.94	e f

Number of observations

## Identifying main dimensions

Unsupervised learning  
Hierarchical Clustering based on KL divergence  
**IMPORTANCE OF CROSS-VALIDATION**

**Aroma 1**

**Mouthfeel 3**

**Mouthfeel 1**

**Flavour 3**

**Mouthfeel 2**

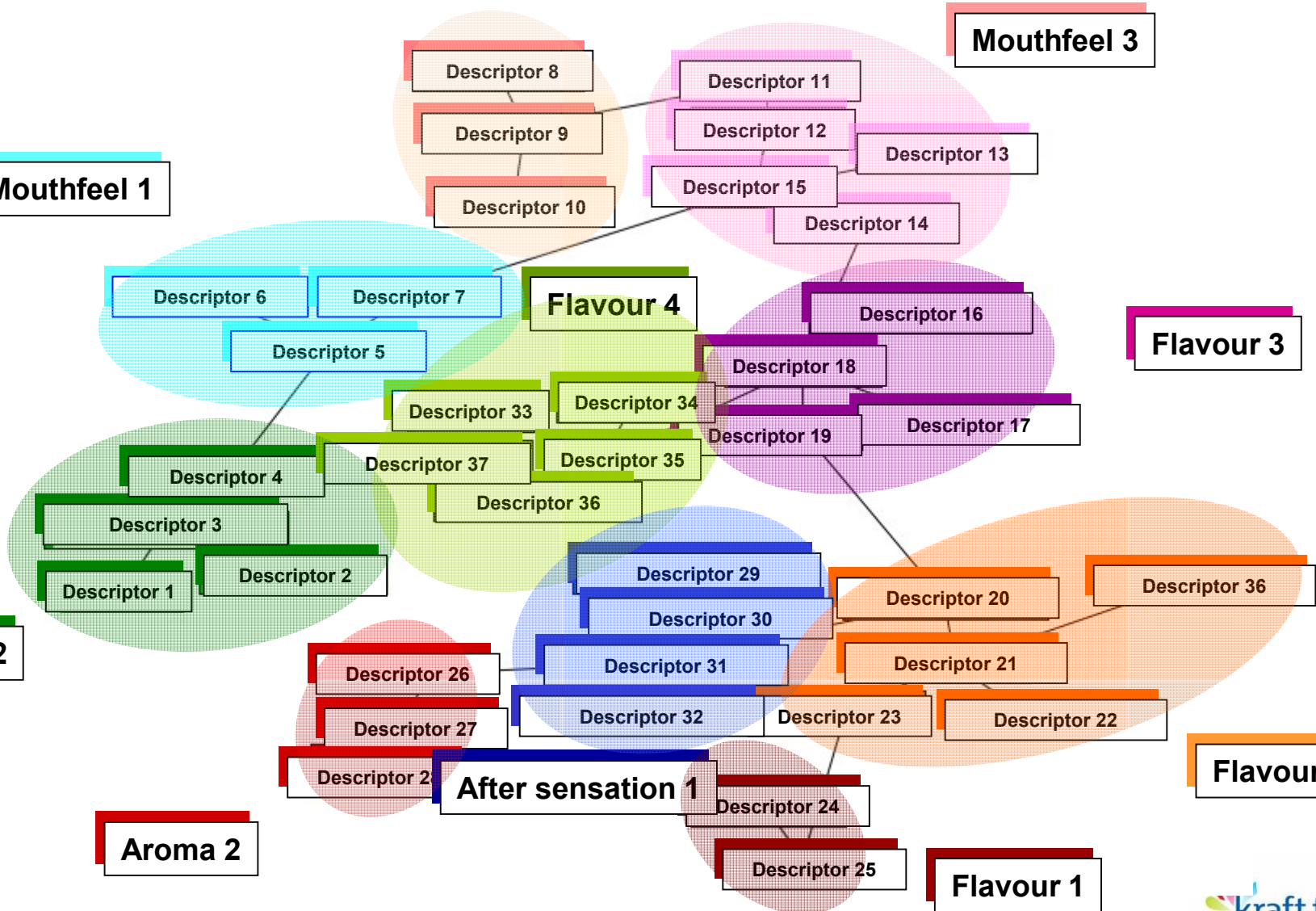
**Flavour 4**

**Aroma 2**

**Flavour 2**

**After sensation 1**

**Flavour 1**





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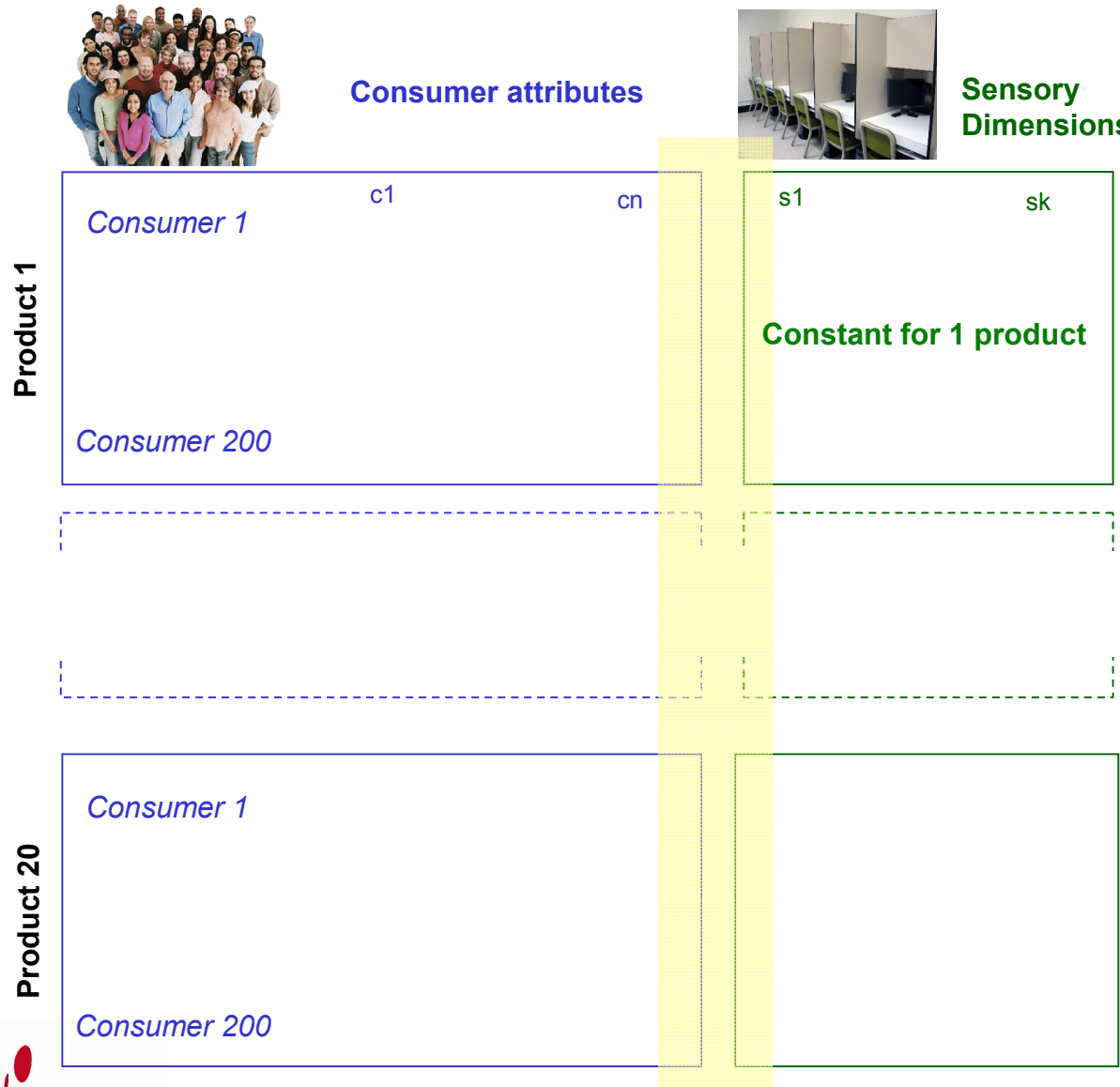
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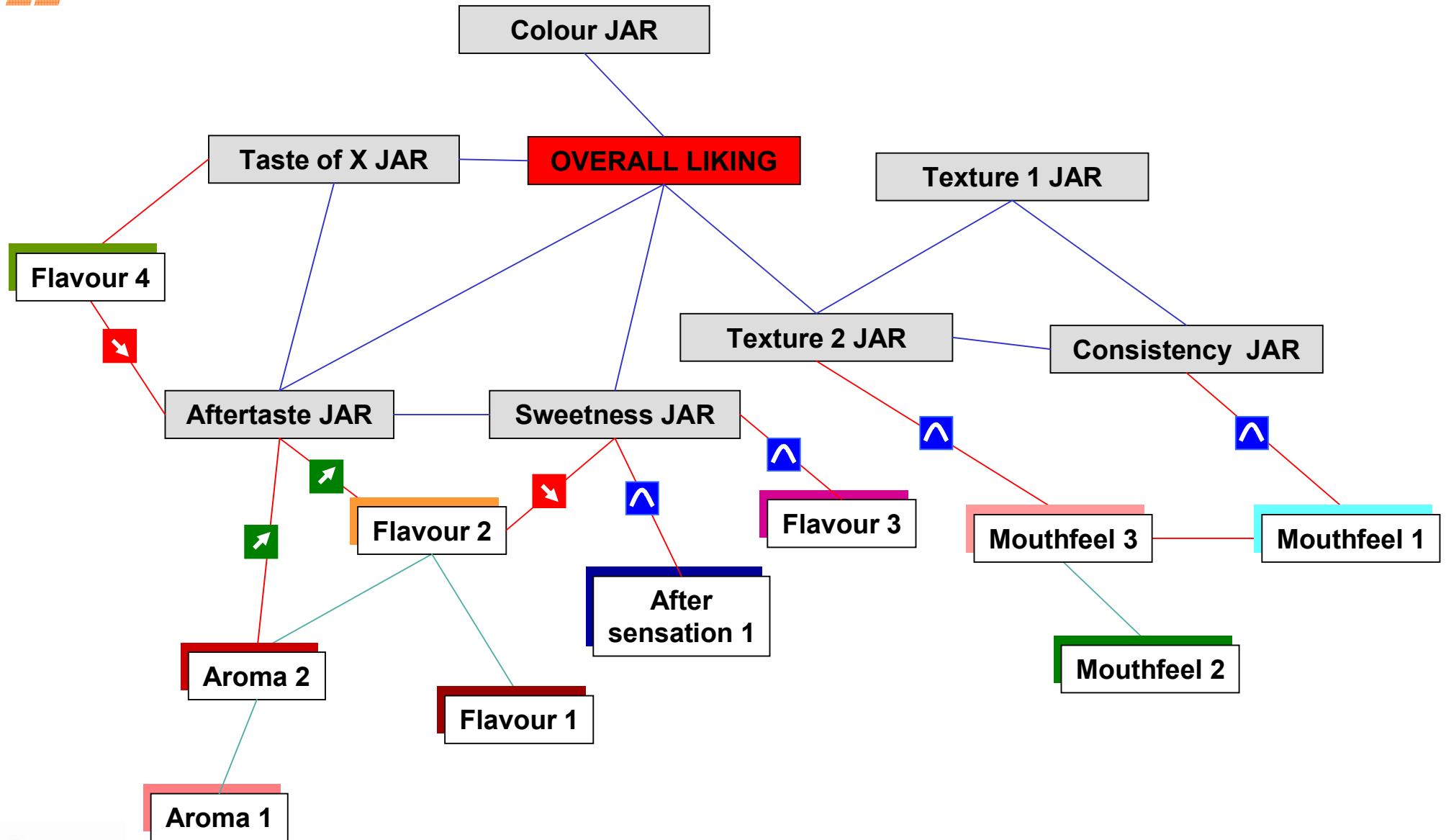
## Key issues of the modeling workflow



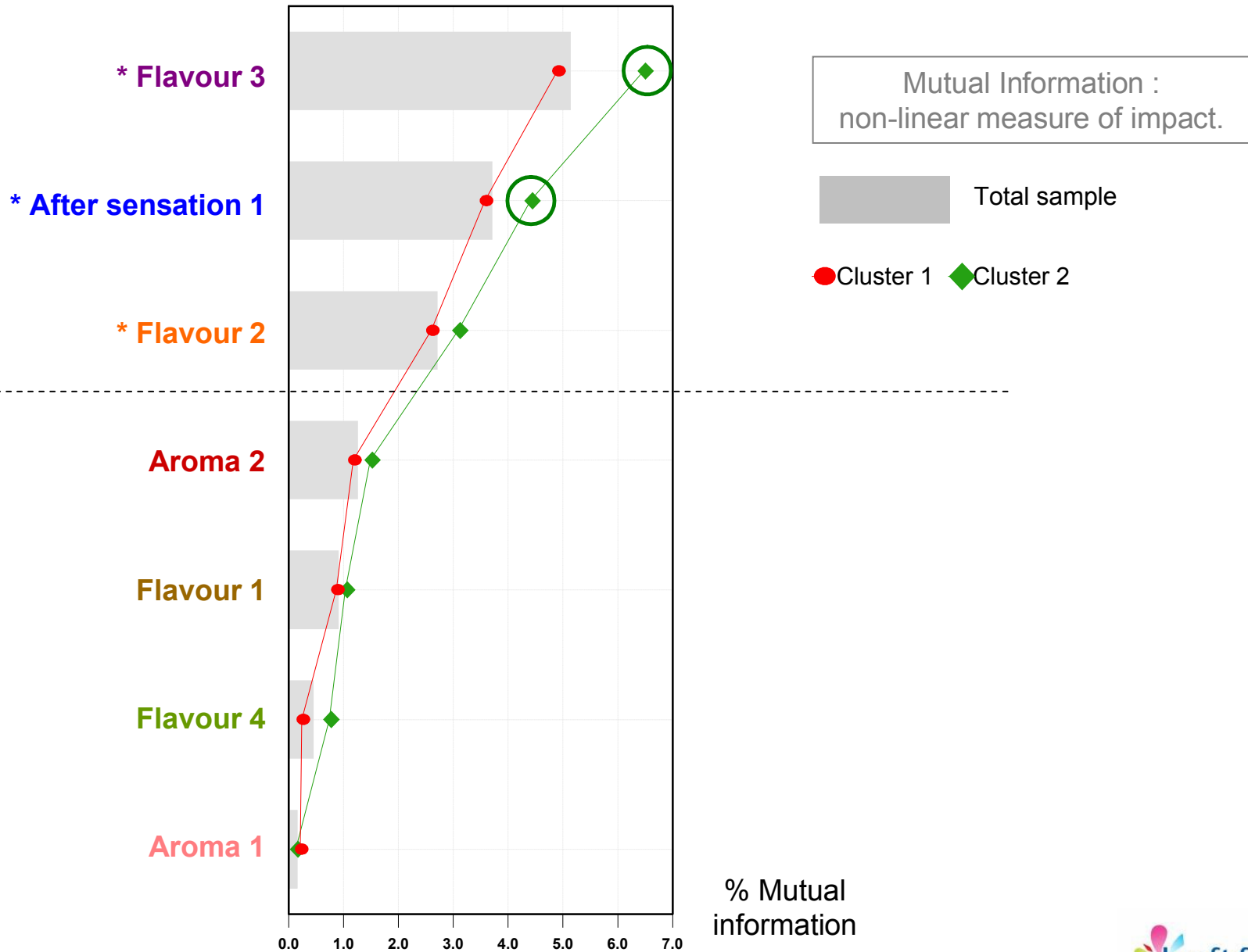
In order to let the search algorithm focus on the links between Consumer Data and Sensory Data...

- **FIXING** the arcs between consumer dimensions (already discovered)
- **FORBID** the arcs between sensory dimensions (links are too obvious: for each product => 200 times the same sensory variables)

## Structural model



## OUTPUT: importance of sensory dimensions on SWEETNESS perception

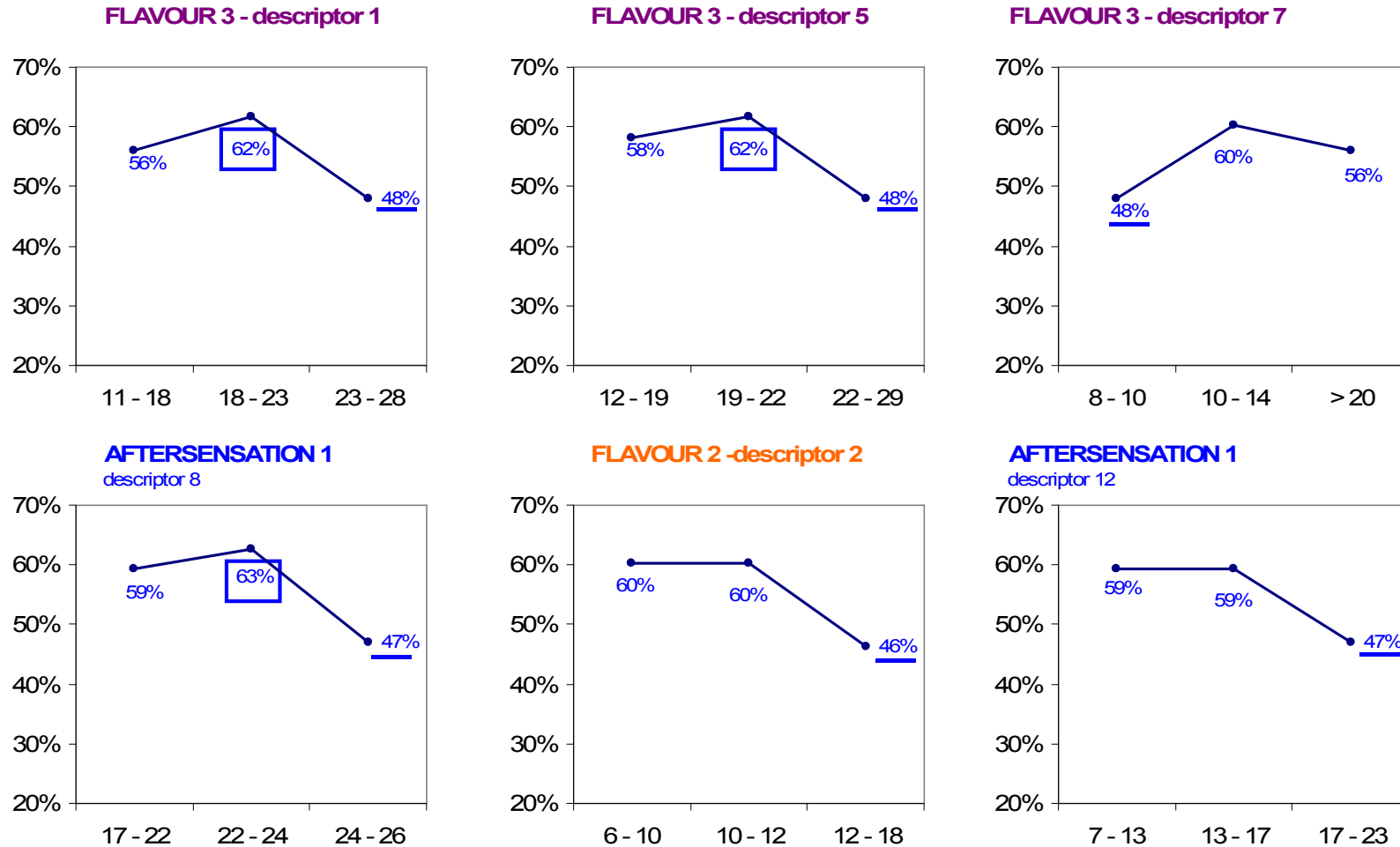


% Mutual information

Sensometrics meeting – Rotterdam – July 2010

## OUTPUT: expected sensory levels (top-6 descriptors)

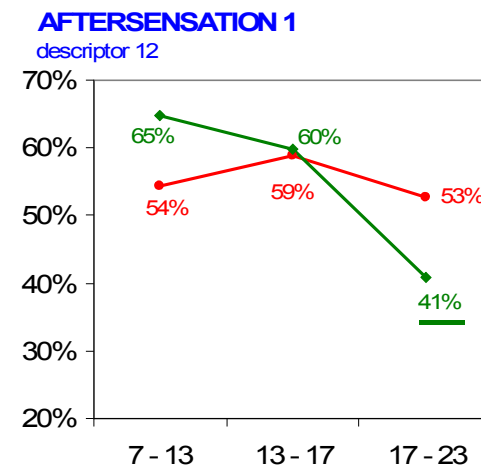
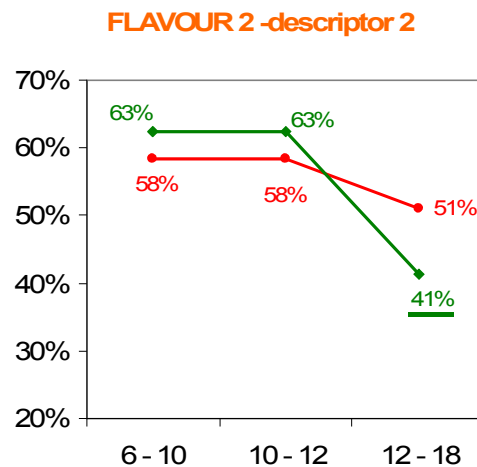
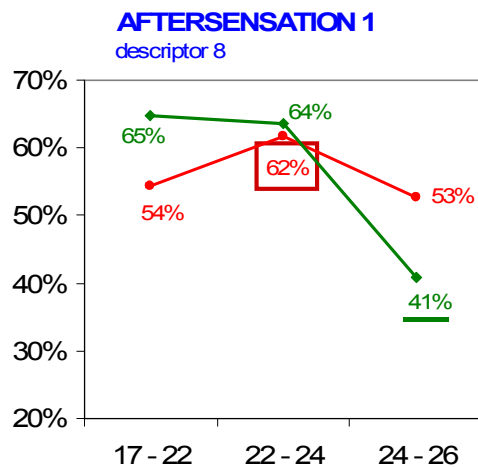
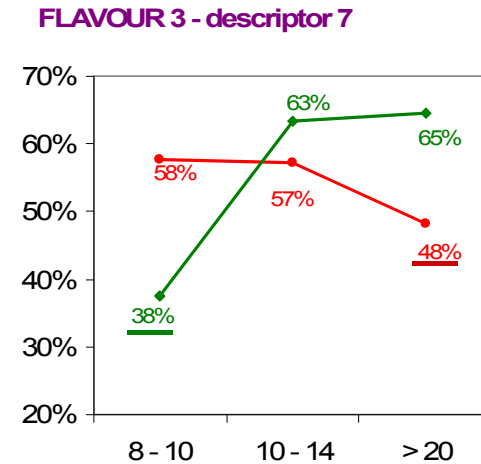
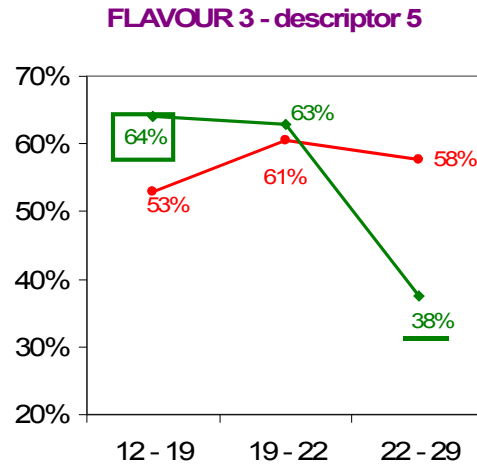
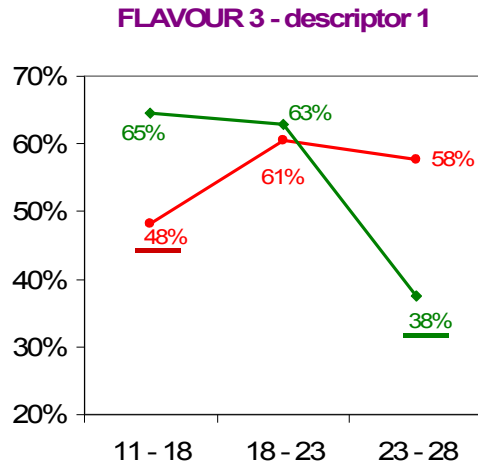
Probability that sweetness is perceived as JAR by consumers



## Preference Clusters

● Cluster 1 ◆ Cluster 2

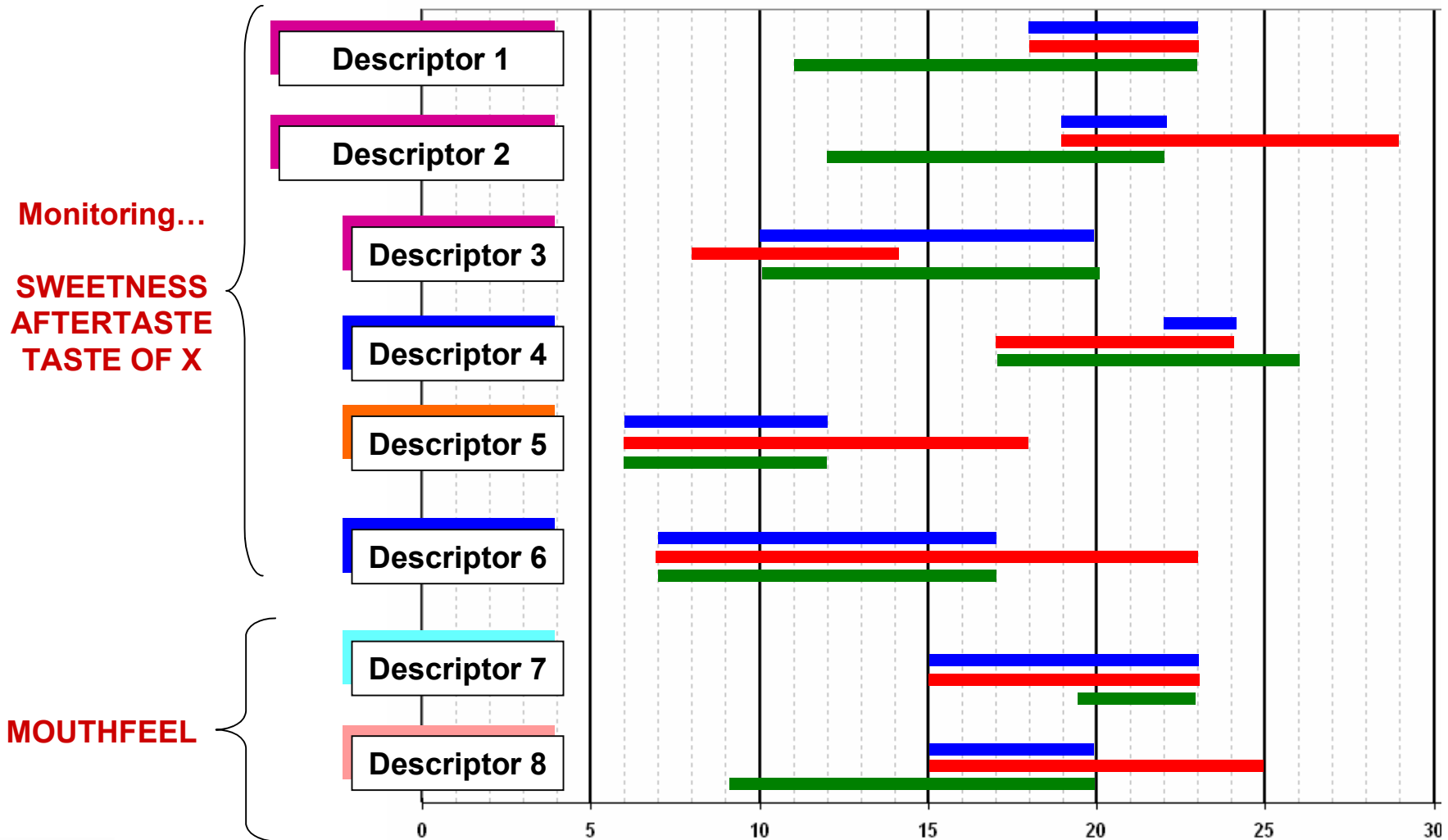
▶▶▶ **OUTPUT: expected sensory levels (top-6 descriptors)**  
Following 2 of the preference segments identified by KRAFT



□ Significant positive impact  
— Significant negative impact

OUTPUT: Summary of expected sensory levels  
KEY DESCRIPTORS

■ Main sample  
■ Cluster 1  
■ Cluster 2



- ✓ **STRUCTURAL LEARNING**  
possible to **discover the links** between variables  
enables to have a good overview of all consumer perceptions simultaneously
  
  - ✓ **NON-LINEAR RELATIONS**  
very important when dealing with links between consumer & sensory
  
  - ✓ **USE OF CROSS-VALIDATION**  
to enhance confidence into the models
- 
- ✓ **Discretizing sensory/analytical variables: tough (not natural?) job, need to check correspondence with sensory panel significant differences.**
  
  - ✓ **Non-linear relations: exercise caution, as sometimes weird relations can be discovered (U-shape like relation for example) => needs to be cleaned.**
  
  - ✓ **Causality ?**

## SOME IMPORTANT DIFFERENCES TO REMEMBER

BAYESIAN	PLS PATH MODELLING
Discover the structure	Impose the structure
Latent variables: entirely dependent on the explanatory variables	Latent variables constructed to explain TARGET
Many observations	Few observations