Laboratoire de Physique et Mécanique Textiles

GDR 2033 TACT — Toucher Analyse Connaissance simulaTion — cnrs

UNIVERSITÉ HAUTE-ALSACE

Tactile sensory analysis

From human perception to instrumental measurement

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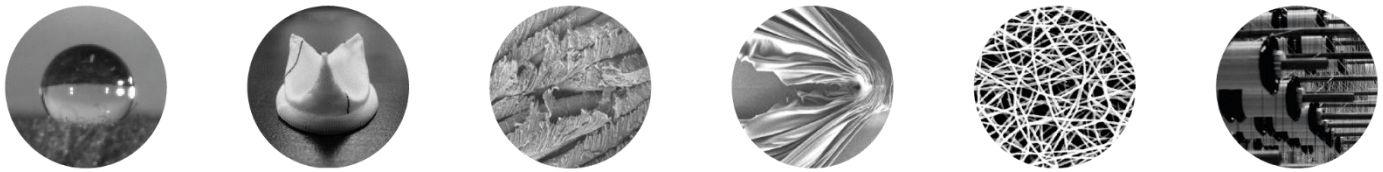


Sensory Analysis

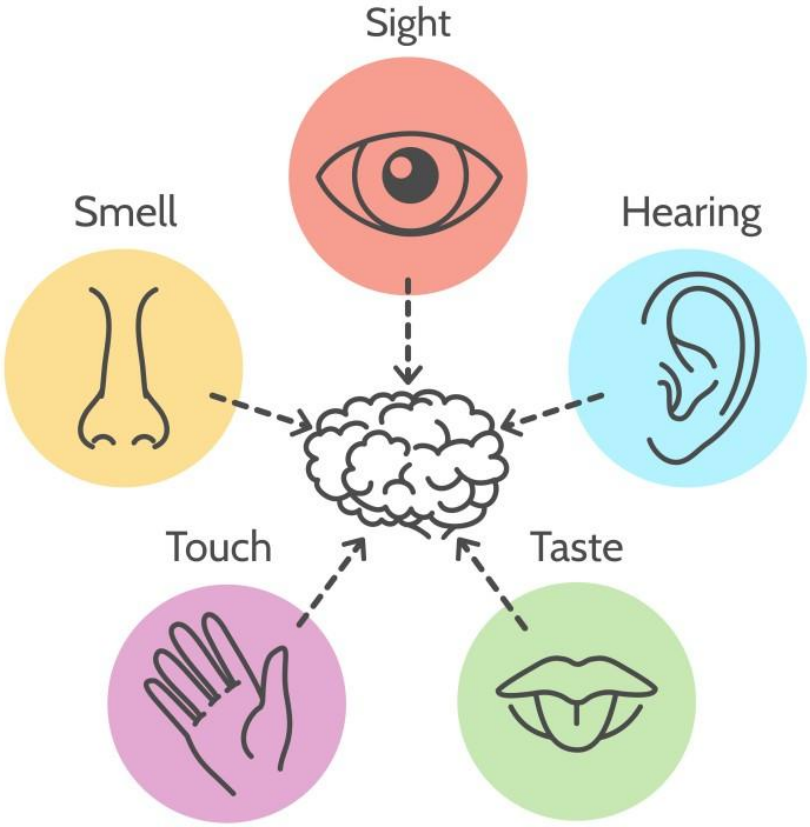
- **Definition** sensory analysis: ISO 5492:2008
  Science involved with the assessment of the organoleptic attributes of a product by the senses

- **Many areas of application**
  Agri-food sector (1961) [1]
  Cosmetics
  Automotive
  Hygiene products
  Textile

- **Strict experimental protocol**

- **(Trained) human panel**

- **Significant amount of data**



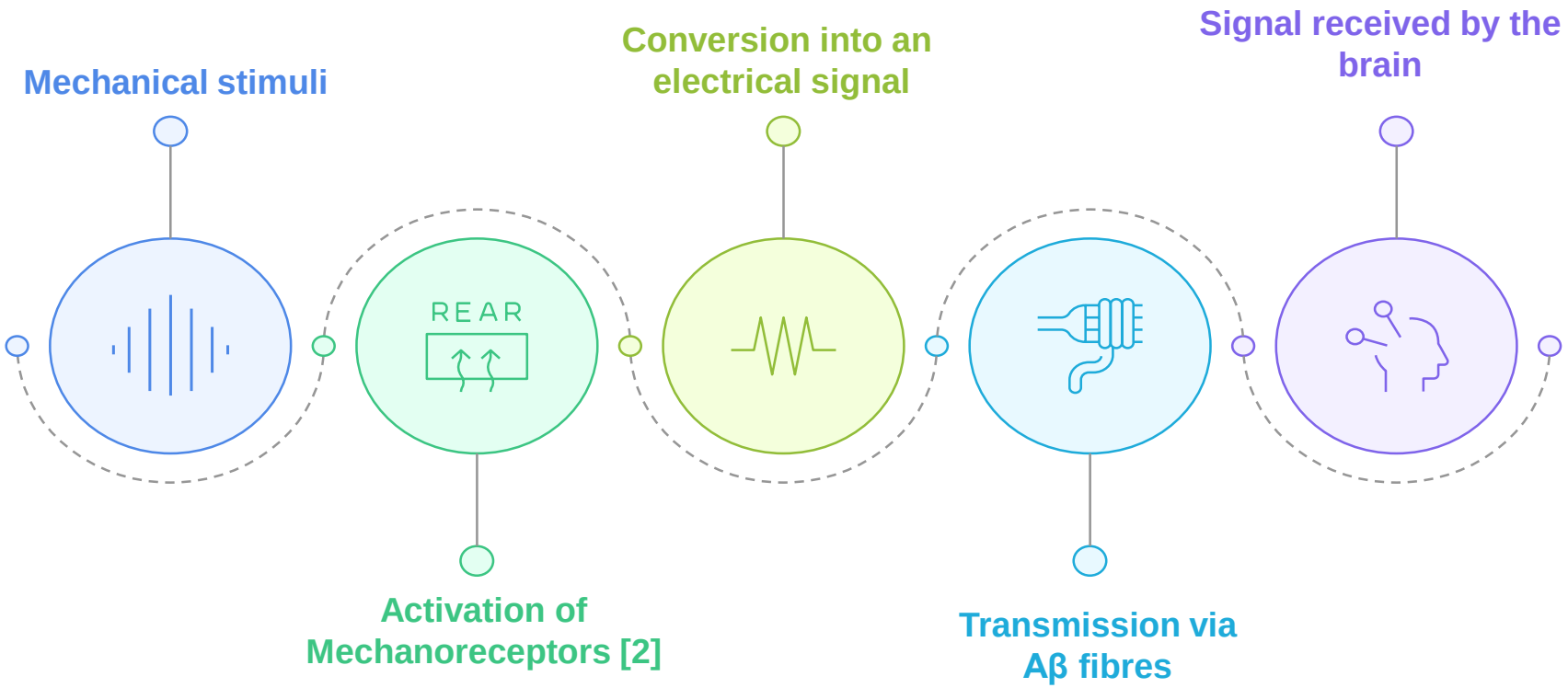
Why Sensory Analysis?

- **Why sensory analysis in textile ?**

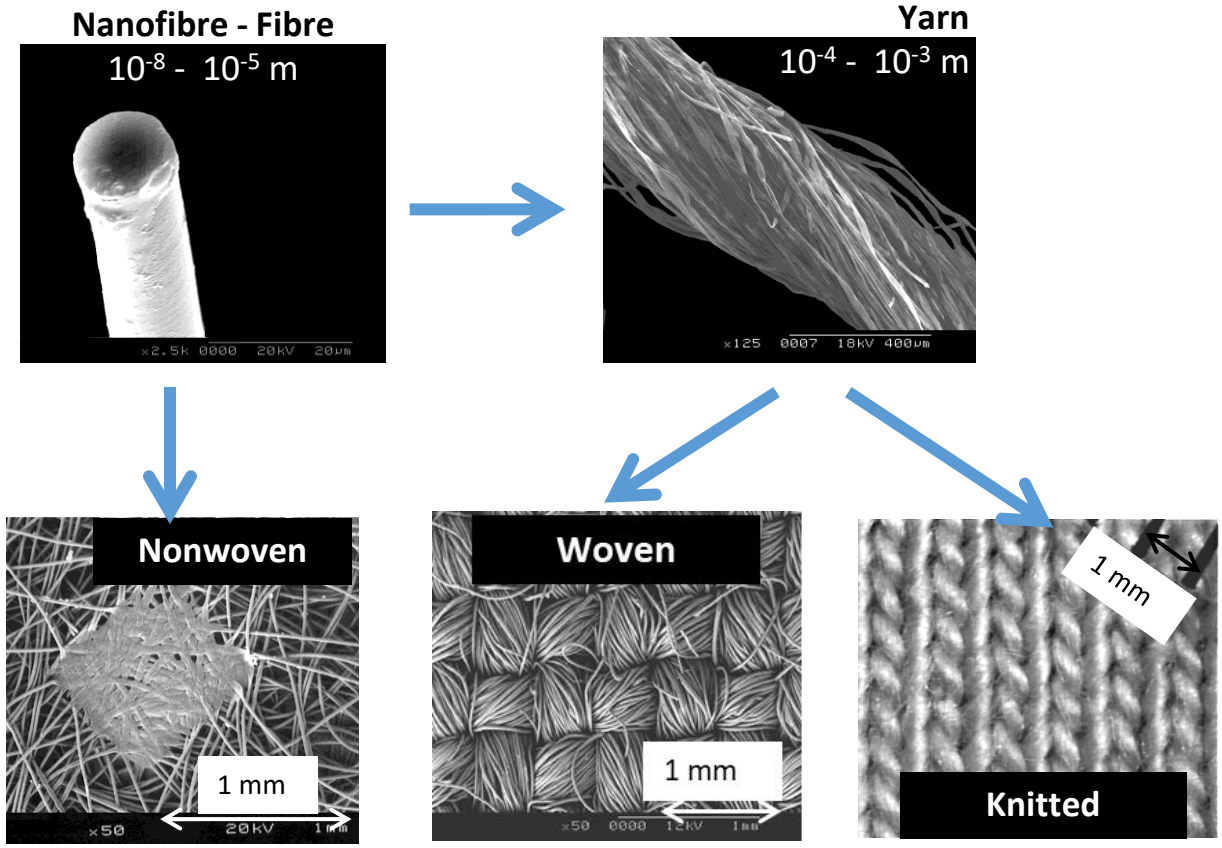
2 textiles may appear visually similar but have different tactile perceptions

What the eye does not perceive, the touch detects !

Tactile perception

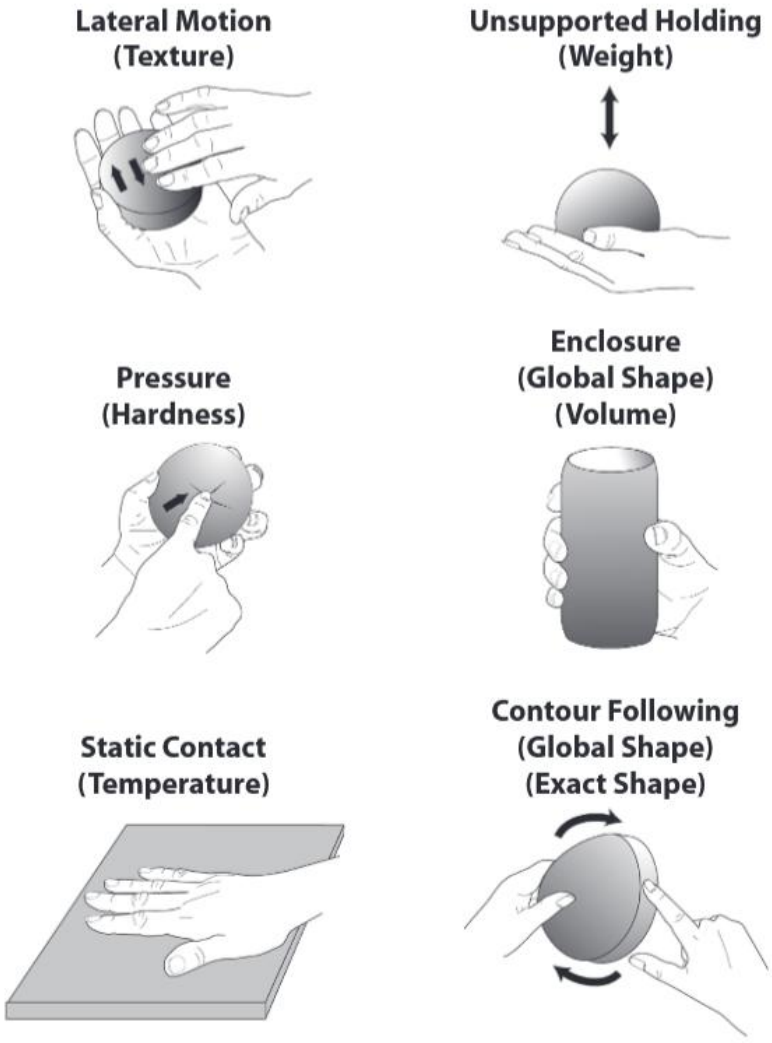


Textile diversity



Credits SEM images LPMT

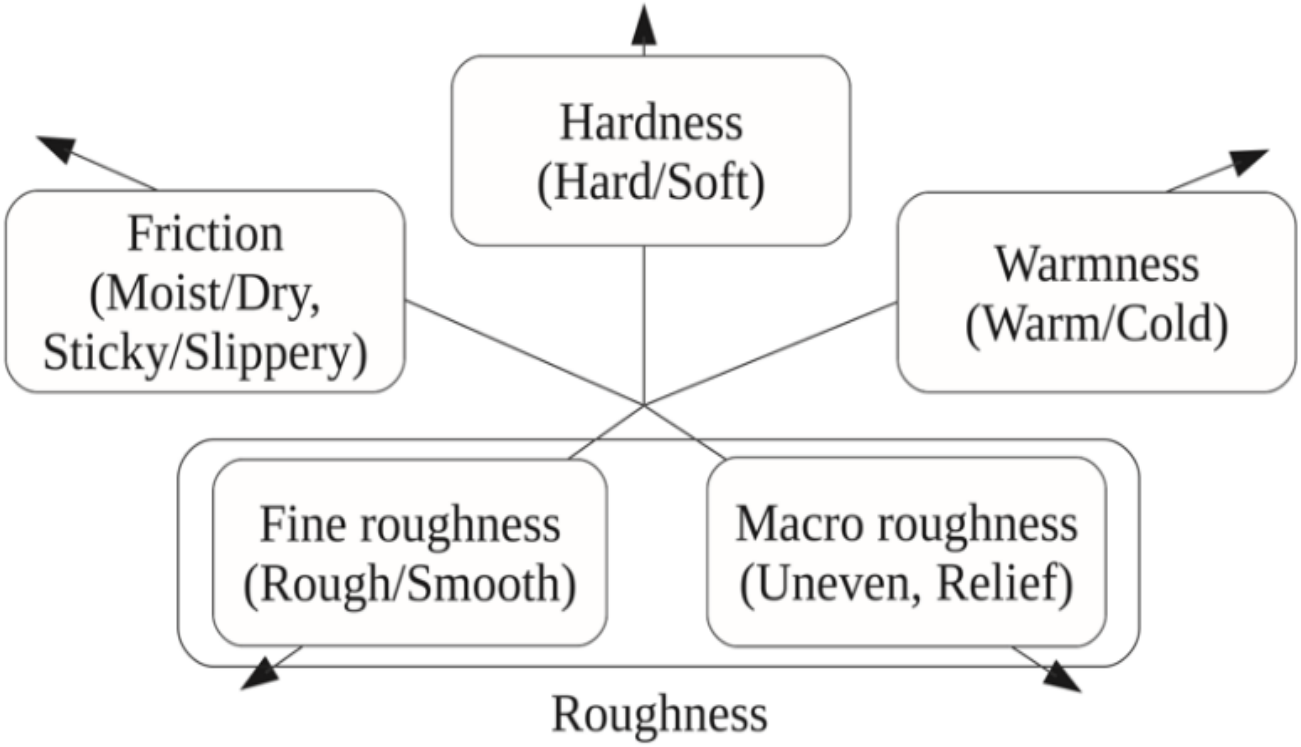
Haptic exploration [3]



- **Active or passive touch**
- **Surface or full-hand**

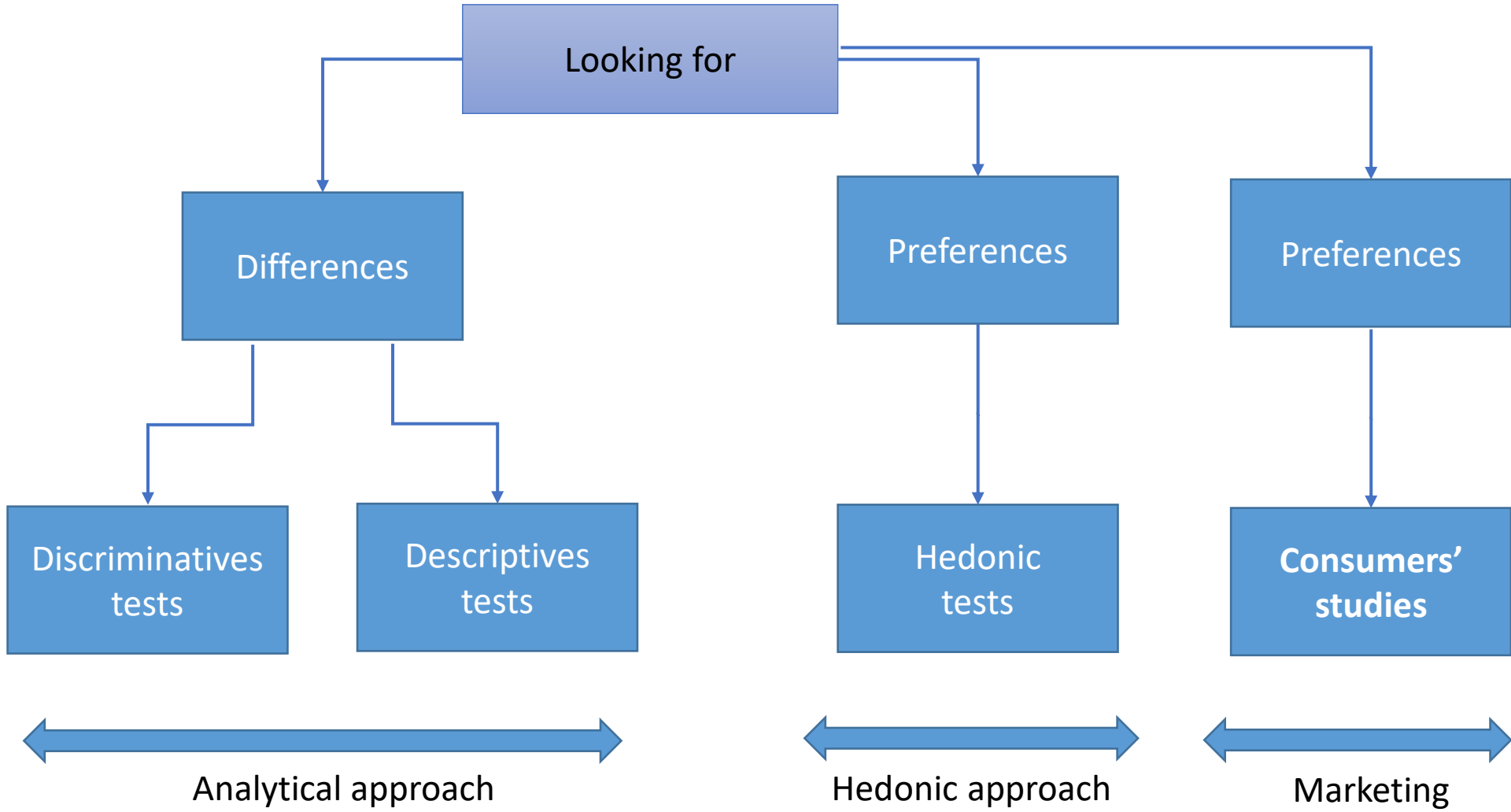
Lederman, S & Klatzky, Roberta. (2009). Haptic Perception: A Tutorial. Attention, perception & psychophysics

Psycho-perceptive dimensions of tactile perception [4]



Okamoto, S., Nagano, H.,&Yamada, Y. (2012). Psychophysical dimensions of tactile perception of textures. IEEE Transactions on Haptics [11]

Sensory analysis tests [5-9]



Félix DEPLEDT, François SAUVAGEOT 10 sept. 2002 [5]

Tests conditions

- **In laboratory:** controlled environment

  Reproductible conditions
  Individual booth
  Air conditioning (20 ±2°C, RH% 65 ± 2%)

Panel

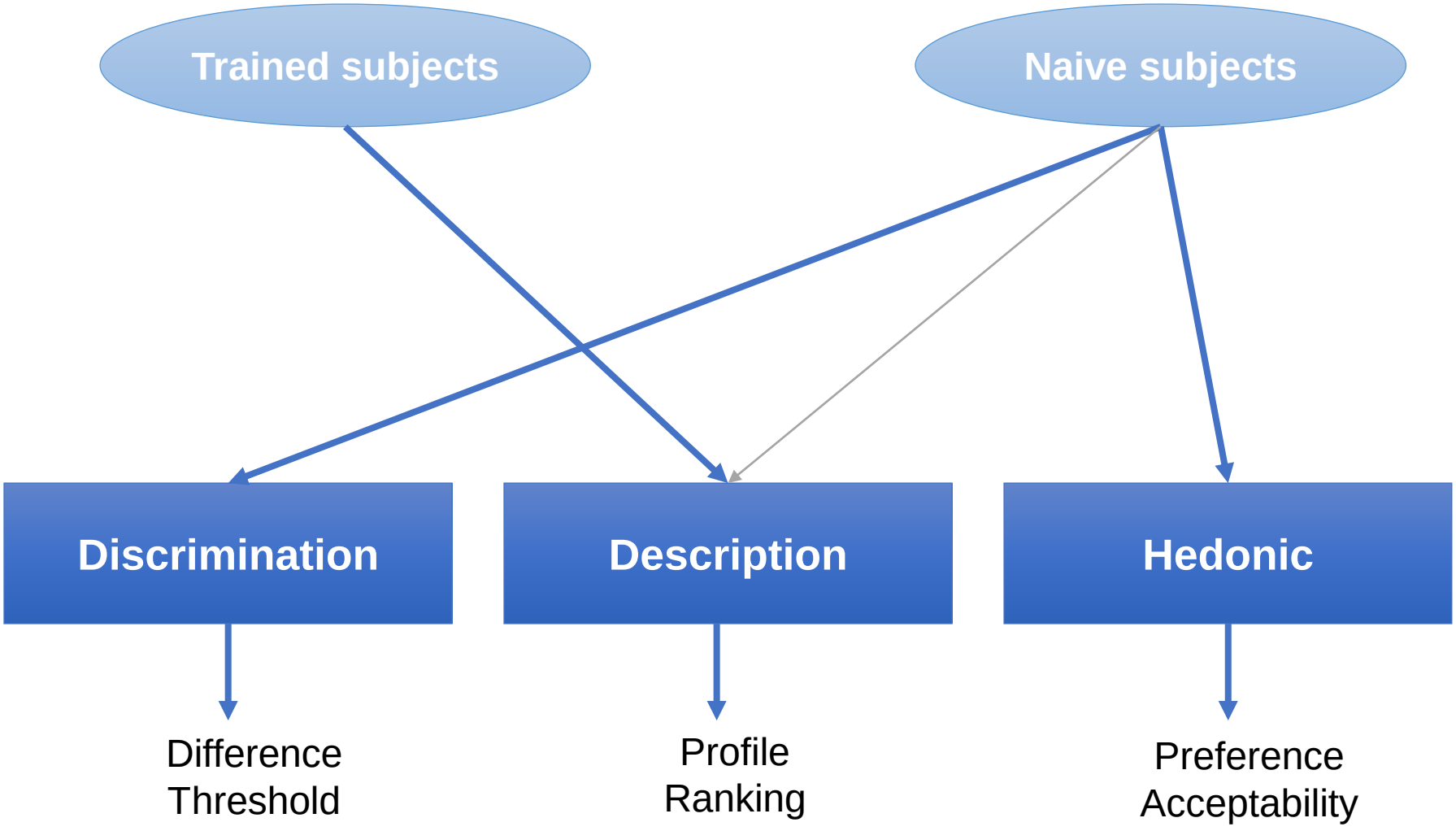
- **Recruitment**
  recruitment criteria
  internal or external

- **Number of subjects**
  depending on test, products and subject skills
  official recommendations (AFNOR)
  → number of panelists could be reduced [7]

- **Checking sensory acuity**
  Von Frey filament, discrimination of two points

- **Recommendations before the session**

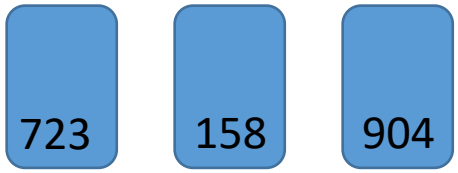
Panel


Trained subjects
Naive subjects
Discrimination
Description
Hedonic
Difference
Threshold
Profile
Ranking
Preference
Acceptability

Samples

- **Sampling:** representative of the product

- **Anonymity of the samples** → blind presentation
  minimum information on the products
  coding with a 3-digit number (drawn at random)



- **Presentation**
  homogeneous (temperature, quantity/volume, colour, etc.)
  monadic or simultaneous
  order of presentation need to be controlled: random or balanced

- **Number of samples by session**

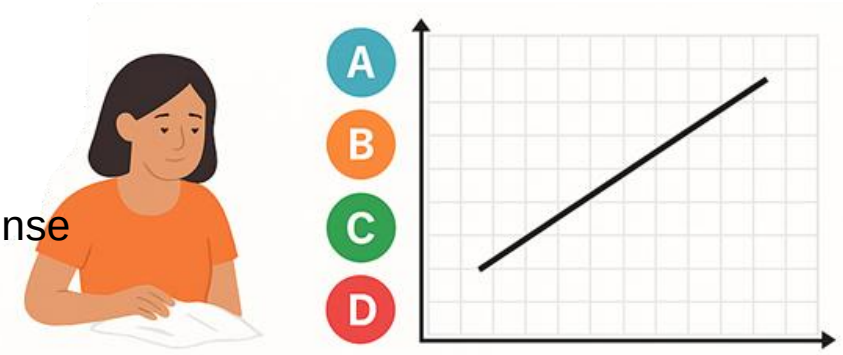
Order of apperance

Order and carry-forward effect

- **Order effect**
  the position of the sample influences the response

- **Carry-forward effect**
  one sample's perception influences the next

→ **Countermeasures**
- Rest time between samples
- Order randomization
- Balanced plans



	1	2	3	4
Sujet 1	A	B	C	D
Sujet 2	B	A	D	C
Sujet 3	C	D	A	B
Sujet 4	D	C	B	A

Order of apperance

- **Control of the order and carry-forward effect**

- **Randomization or plans**
  - Complete blocks
    - Latin square
    - Williams Latin square
    - MOLS plans
  - Balanced Incomplete Blocks

Carré latin de Williams

Sujets	Ordre de présentation			
	1	2	3	4
1	A	B	D	C
2	B	C	A	D
3	C	D	B	A
4	D	A	C	B

Carré latin mutuellement orthogonaux

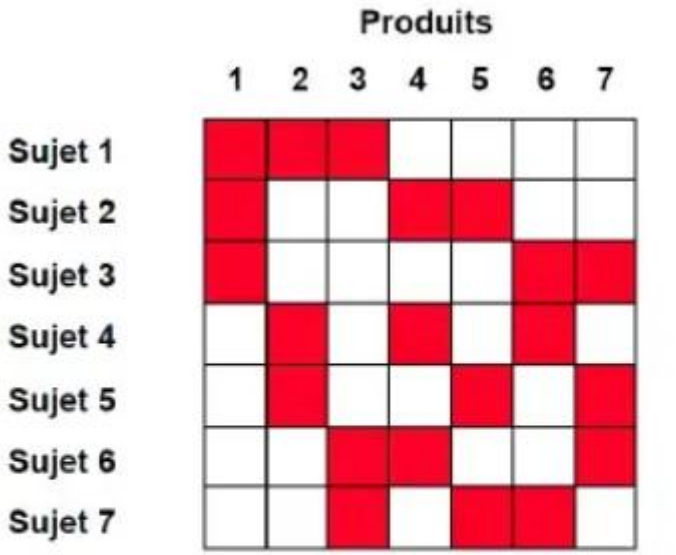
Sujets	Ordre de présentation			
	1	2	3	4
1	A	B	D	C
2	C	D	B	A
3	B	A	C	D
4	D	C	A	B
5		D	C	B
6	B	C	D	A
7	D	A	B	C
8	C	B	A	D
9	A	C	B	D
10	D	B	C	A
11	B	D	A	C
12	C	A	D	B

Order of apperance

- **Balanced Incomplete Blocks**

$$p \cdot r = s \cdot k$$

$$\lambda = \frac{r.(k-1)}{p-1}$$



$\lambda = 1$

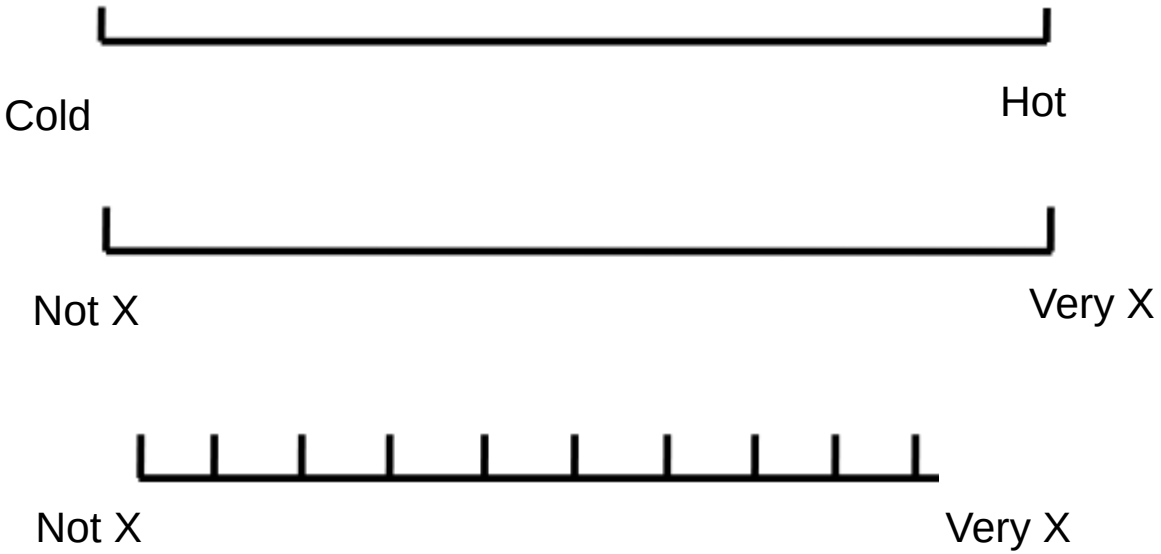
p: number of products tested
r: number of ratings per product
s: number of judges
k: number of products tested per subject
λ: Number of times a pair of products is rated

→ adapted software (e.g. optimal design in R)

Scales

- **Types of scales**

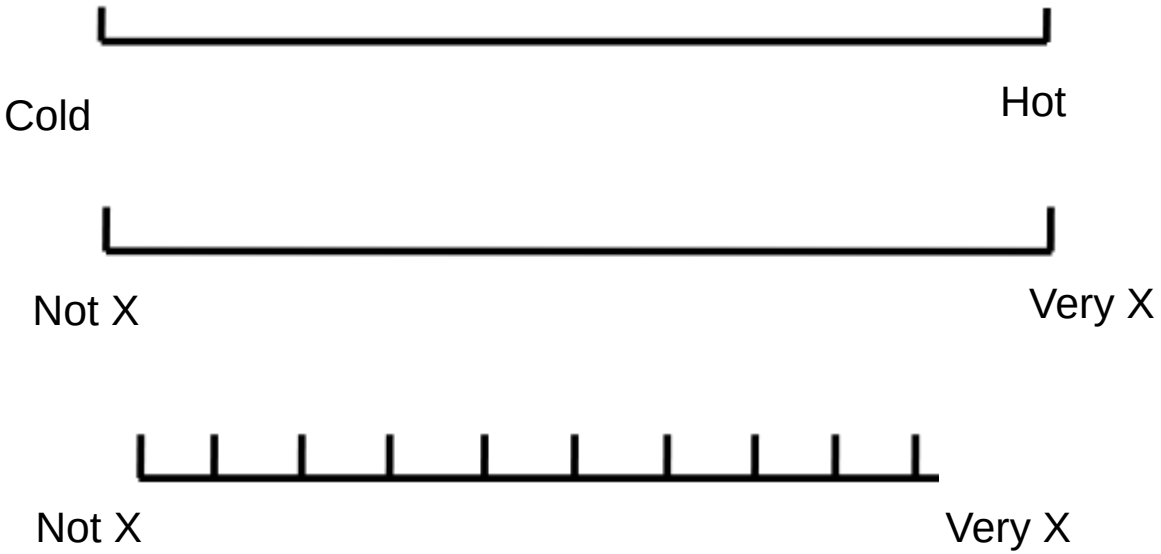
Quantitative scale
Descriptive test



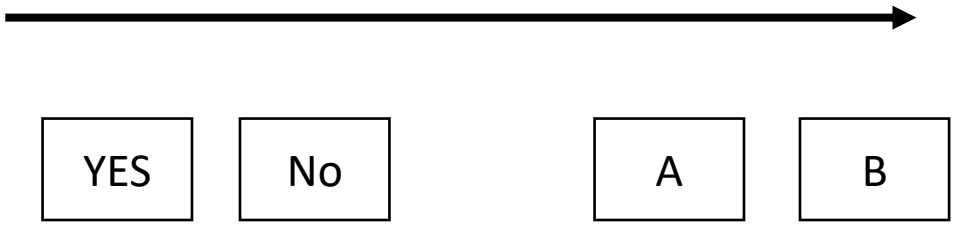
Scales

- **Types of scales**

Quantitative scale
Descriptive test



Qualitative scale
Discriminative test



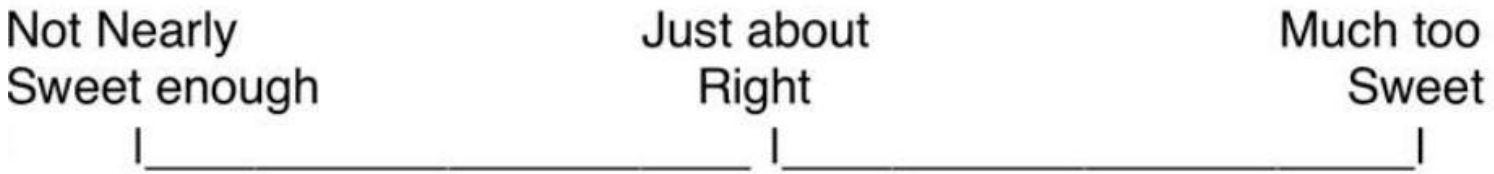
Scales

- **Types of scales**

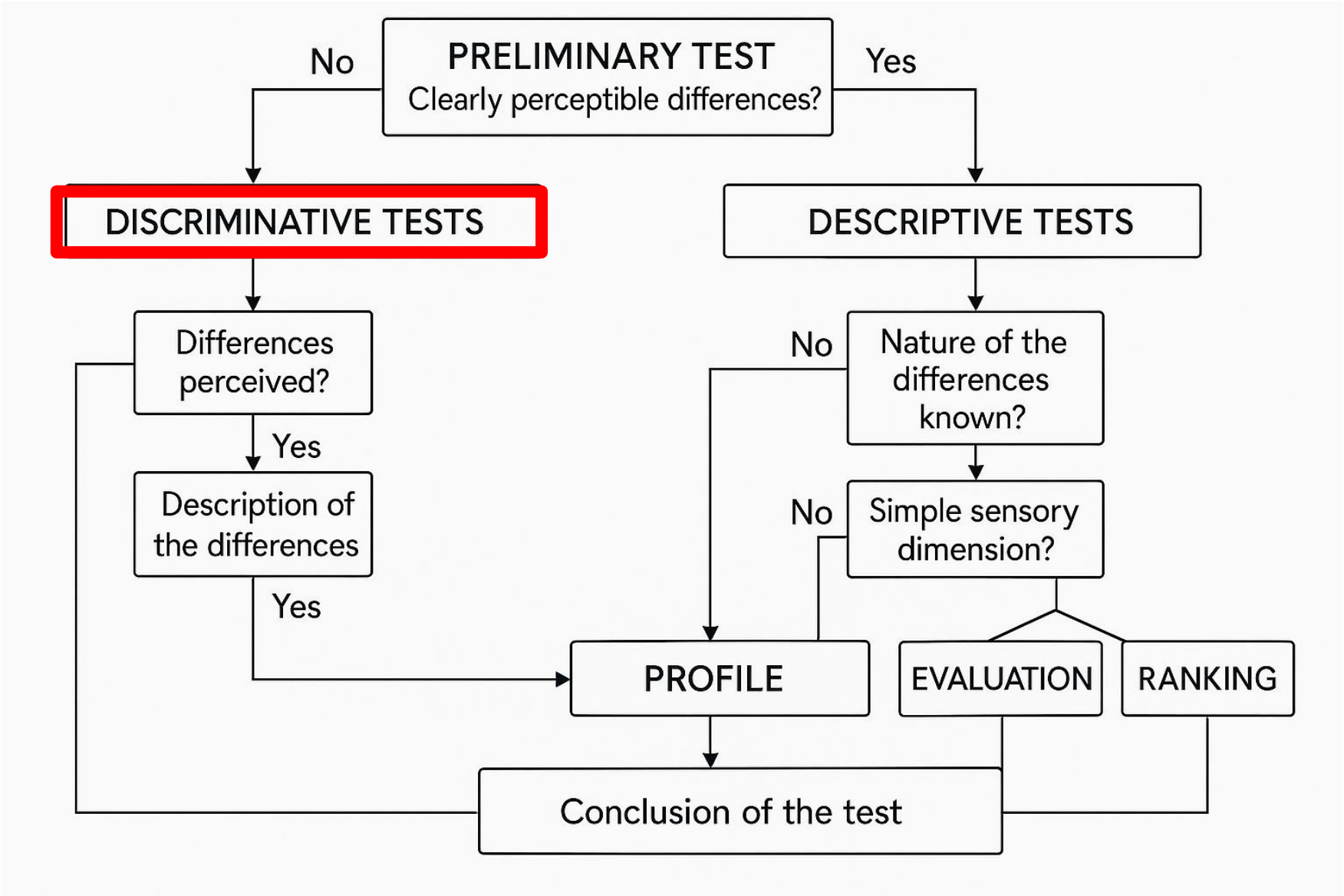
Hedonic scale

Grade	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5



Discriminatives tests



Discriminatives tests

Objectives

“Is there a perceptible sensory difference between two or more textile samples, in terms of tactile properties?”

- **Forced-choice tests (without additional questions)**

- **Compare products** (Globally, Without focusing on the nature and intensity of the difference)
  - Validate or reject a sensory similarity hypothesis
  - Support industrial decisions (material modification, finishing, supplier)
  - Prepare more in-depth tests (descriptive or acceptability tests)
  - Evaluate the discriminatory capacity of a panel.

- **Tests examples**
  - triangle test
  - duo-trio
  - 2 out of 5

Discriminatives tests: Methodology

1. Experimental design

Choice of samples: similar but supposedly different textiles
Standardized conditions: temperature, humidity, test position (bare hand, specific finger, controlled pressure)
Blind mode and experimental design

2. Selection of discriminative tests

Triangular test: 3 samples (2 identical, 1 different). Subject must identify the intruder
Duo-trio test: 1 reference sample followed by 2 samples to be compared
Matching test: presentation in pairs; subject indicates whether they are identical or different

3. Panel

Naive or semi-trained panel
Typically numerous >24

4. Statistical analysis

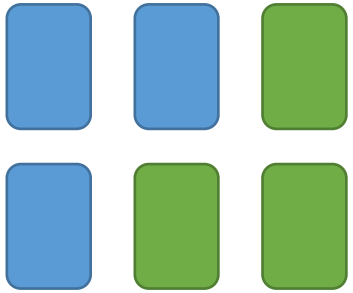
Null hypothesis: participants choose at random (performance level expected by chance)
Use binomial tests or z-tests to compare results at the critical threshold

Triangle tests

- **ISO 4120:2021 standard** (3 samples of 2 different products)

- **Objective:** To highlight the presence of a sensory difference between 2 products.

- **Methodology**
  - 1 single sample is doubled
  - 6 possibilities of presentation of two products A and B
    ABB, AAB, ABA, BAA, BBA, BAB
  - use each arrangement an equal number of times



  - Question: Of these samples, two are from the same product and the third from a different one. Indicate which one you perceive as different → Forced response

  - Recommended number of subjects 24 – 30

Triangle test

- **Statistical interpretation**

  Count the number of correct answers and compare with the table value derived from the binomial distribution.

- **Hypotheses**

  H_0: the products tested are identical (correct answers due to chance)

  H_1: the products tested are different

- **Risks**

  1st species **α** probability of rejecting H_0 when it is true

  2nd species **β** probability of accepting H_0 when it is false

Triangle test: Example

- 24 subjects - 0.05% alpha risk

→13 correct answers are required to conclude that there is a significant difference at the 95% confidence level

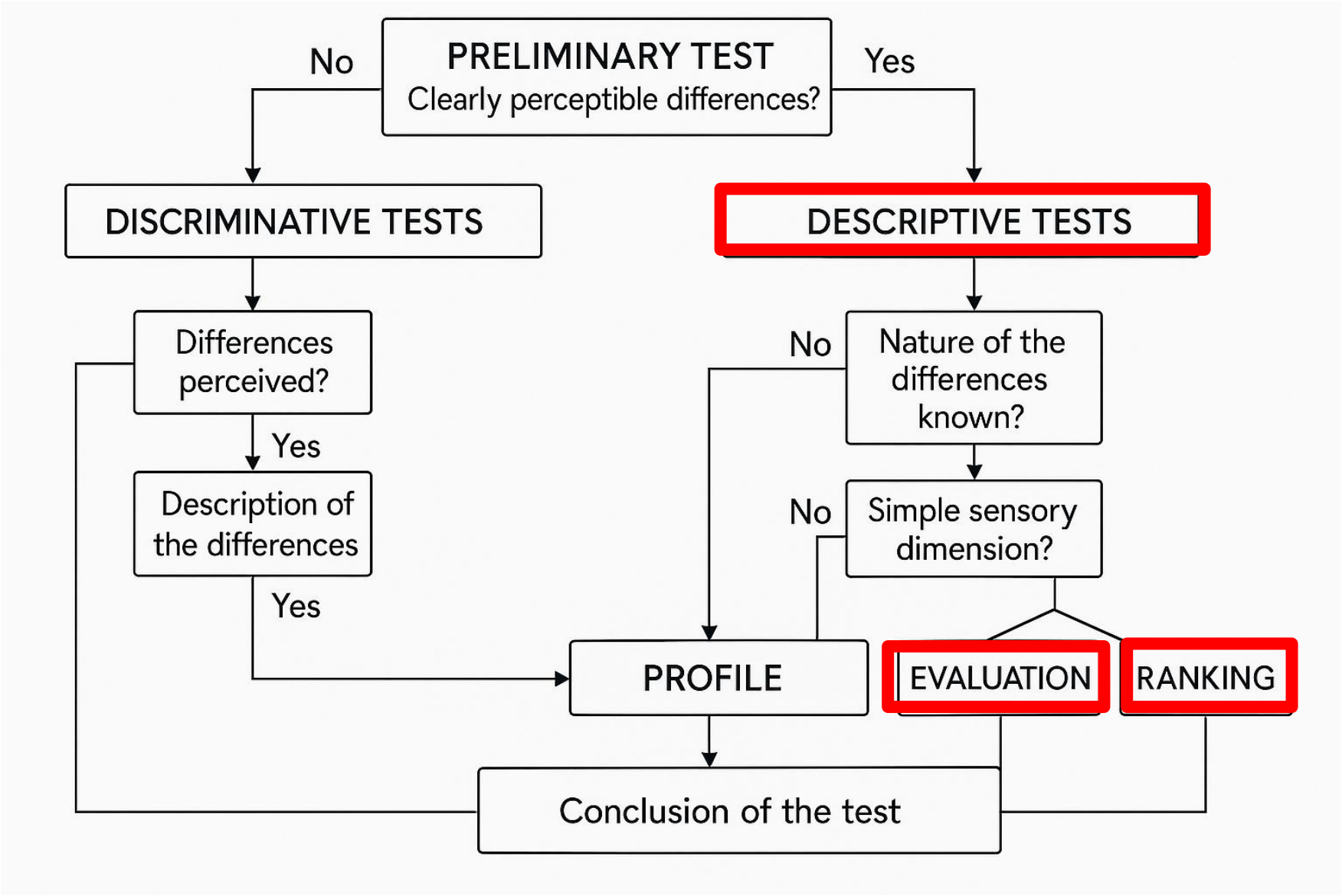
- Calculation of the lower one-sided confidence interval of the proportion of the population that can perceive a difference between the samples

$$[1{,}5\times(14/24)-0{,}5]-1{,}5\times1{,}64\sqrt{(14/24)[1-(14/24)]/24}=0{,}13$$

Table A.1 — Minimum number of correct responses needed to conclude that a perceptible difference exists based on a triangle test

n	α					n	α				
	0,20	0,10	0,05	0,01	0,001		0,20	0,10	0,05	0,01	0,001
6	4	5	5	6	—	27	12	13	14	16	18
7	4	5	5	6	7	28	12	14	15	16	18
8	5	5	6	7	8	29	13	14	15	17	19
9	5	6	6	7	8	30	13	14	15	17	19
10	6	6	7	8	9						
						31	14	15	16	18	20
11	6	7	7	8	10	32	14	15	16	18	20
12	6	7	8	9	10	33	14	15	17	18	21
13	7	8	8	9	11	34	15	16	17	19	21
14	7	8	9	10	11	35	15	16	17	19	22
15	8	8	9	10	12						
						36	15	17	18	20	22
16	8	9	9	11	12	42	18	19	20	22	25
17	8	9	10	11	13	48	20	21	22	25	27
18	9	10	10	12	13	54	22	23	25	27	30
19	9	10	11	12	14	60	24	26	27	30	33
20	9	10	11	13	14	66	26	28	29	32	35
21	10	11	12	13	15	72	28	30	32	34	38
22	10	11	12	14	15	78	30	32	34	37	40
23	11	12	12	14	16	84	33	35	36	39	43
24	11	12	13	15	16	90	35	37	38	42	45
25	11	12	13	15	17	96	37	39	41	44	48
26	12	13	14	15	17	102	39	41	43	46	50

Discriminatives tests

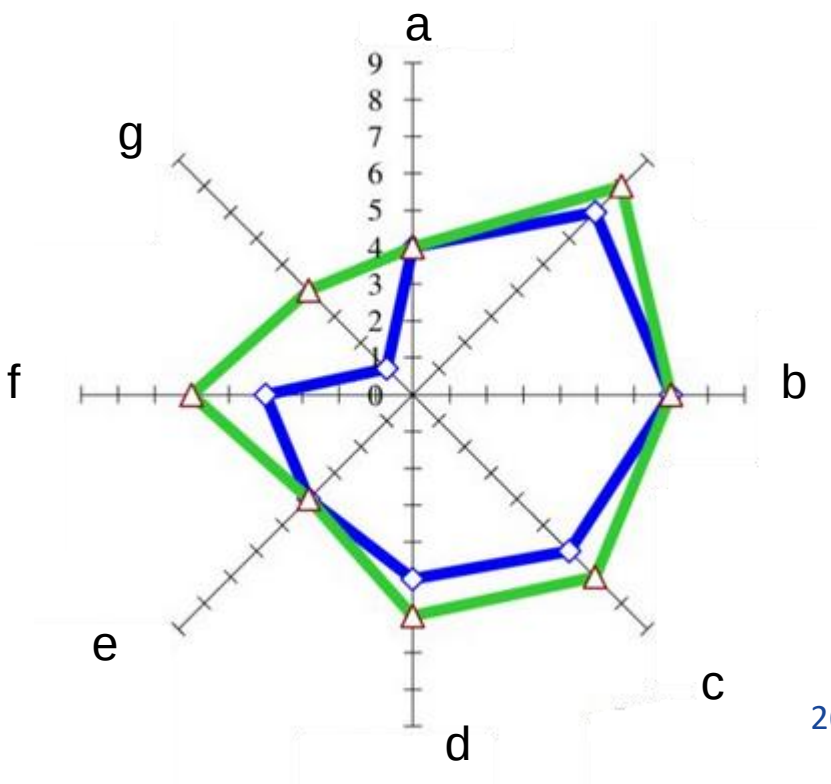


Quantified desciption

- **Objectives:** quantified description of a product according to descriptor
  - Identify relevant tactile dimensions (e.g. roughness, softness, warmth, adhesion)
  - Compare and rank several samples on each of these criteria.

- **Descriptor =** semantic intermediary for capturing the nature of perceptions

- More complex and standardized protocol

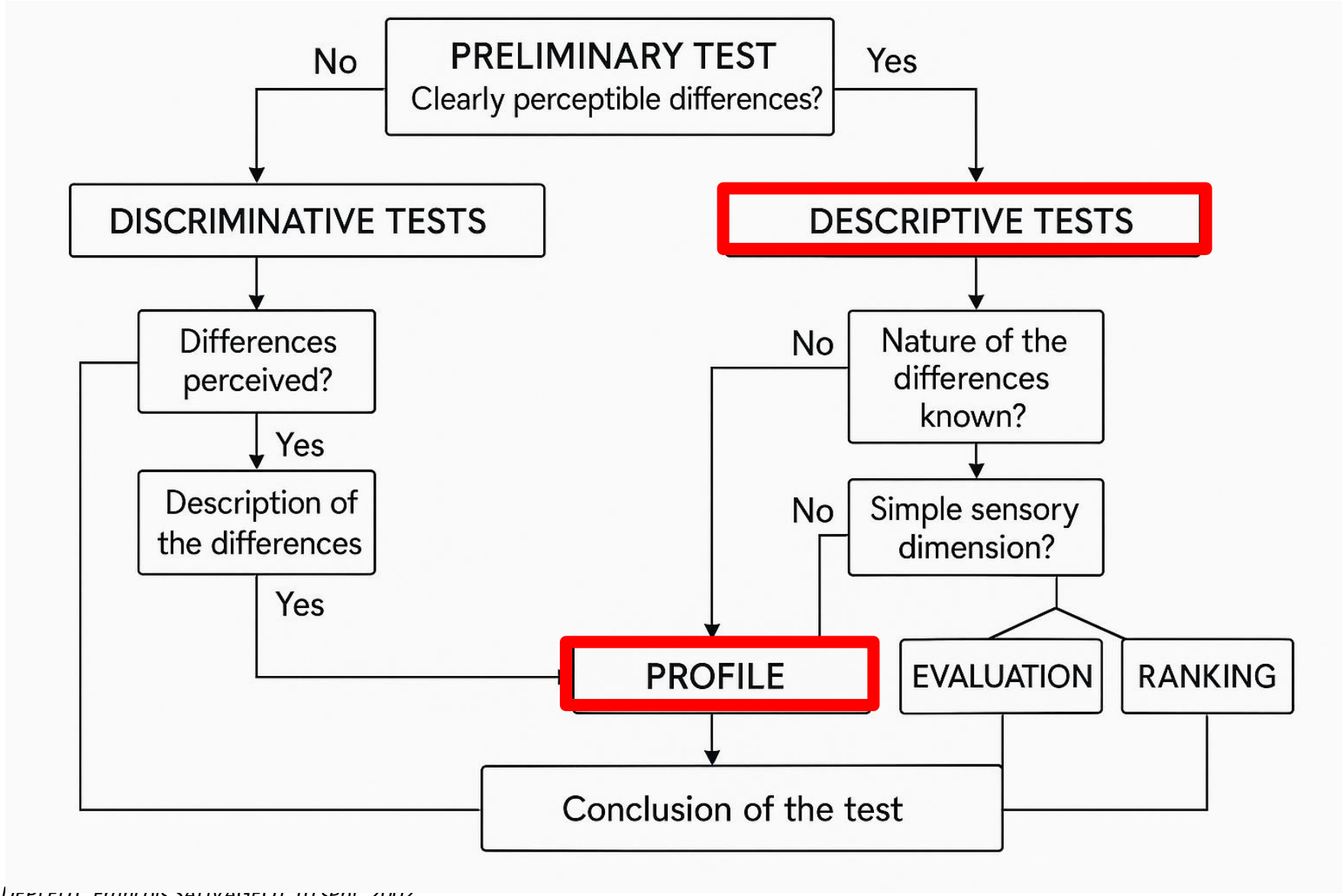


Classification test

- Evaluation of descriptor intensity
- Samples presented simultaneously are arranged in order of increasing intensity

- Evaluation of all samples before answering
- Relative indication
- Common test
  - Easy to implement, to interpret, to understand
  - Effective

Discriminatives tests



Sensory Profile

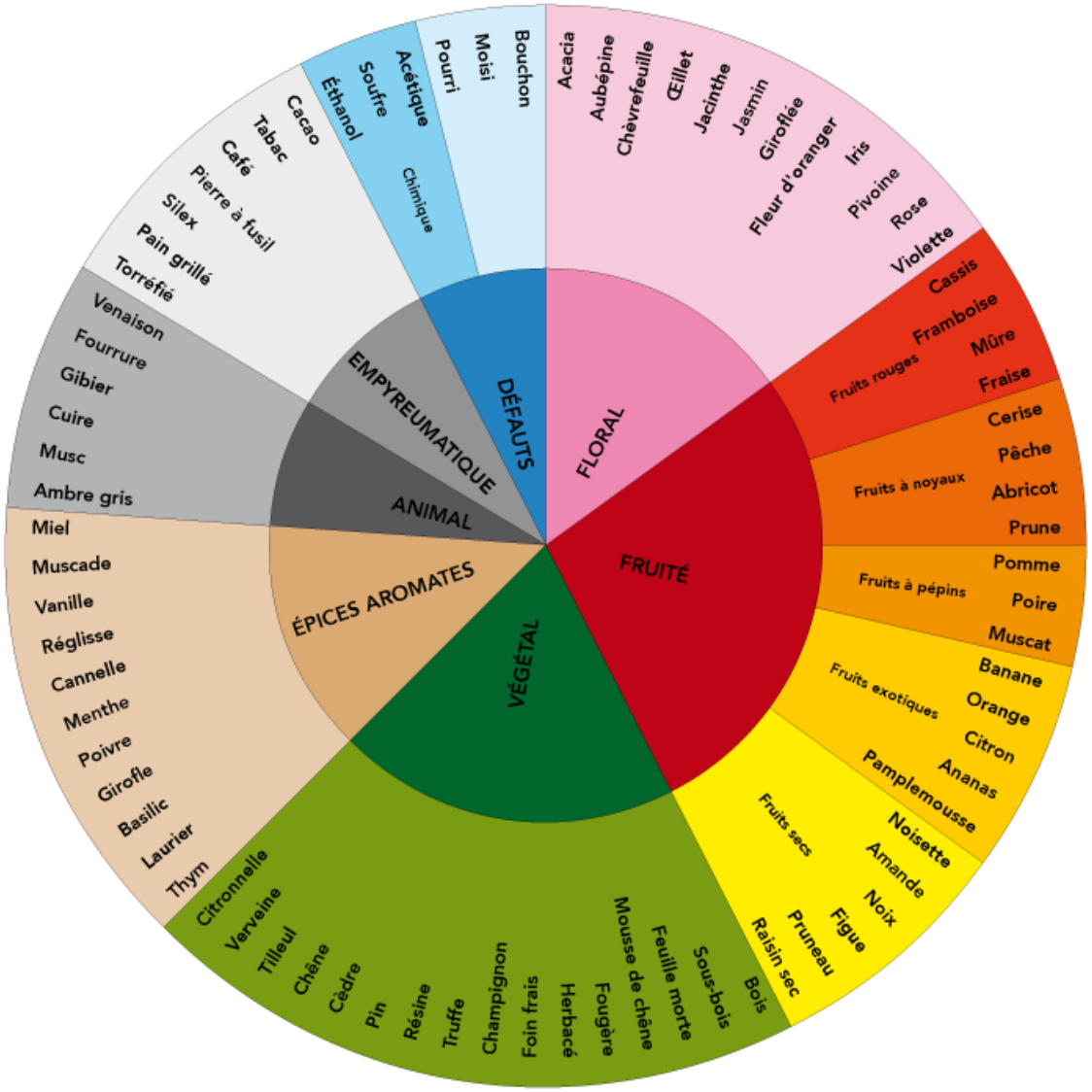
- **normes AFNOR** (NF ISO 13299 Mai 2010)

- **Objectives:** quantified description of a product according to several descriptors
  - Decomposition of complex sensory quantities into simple quantities/descriptors
  - Quantification of each of these descriptors

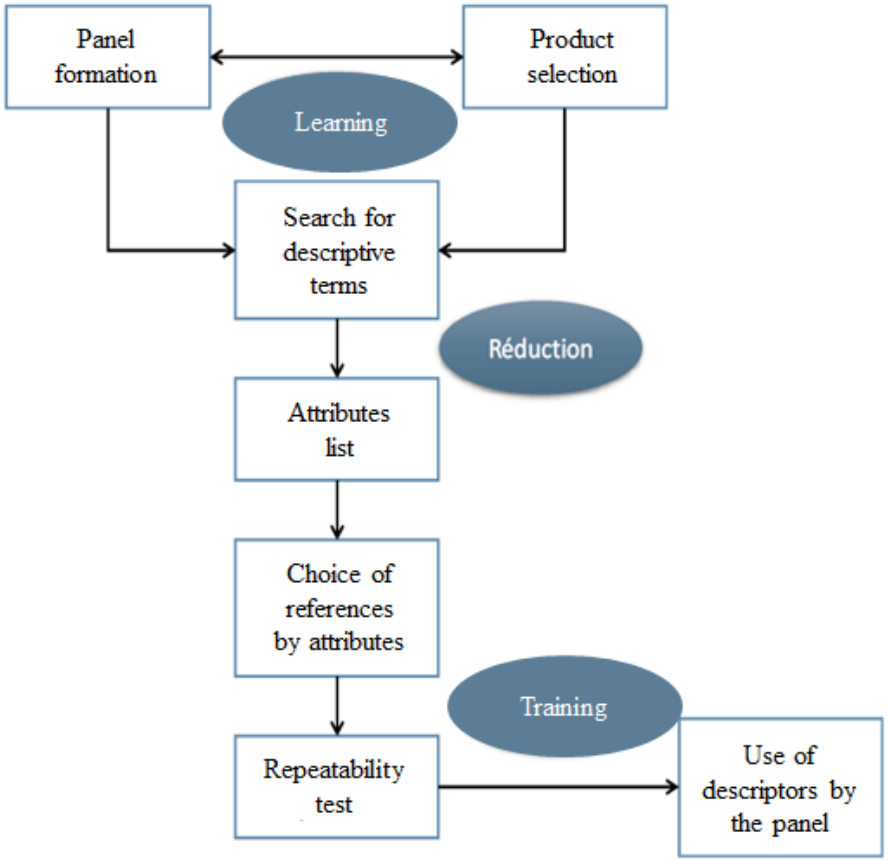
- **Sensory profile** → identity card of the product
  - Objective description (excluding any hedonic data)
  - Precise and reproducible description
  - Minimum number of words

- **Why ?**
  - Production quality control
  - Product comparison: reformulation or counter-typing
  - Development of new products
  - Suitability for consumer expectations

Sensory Profile

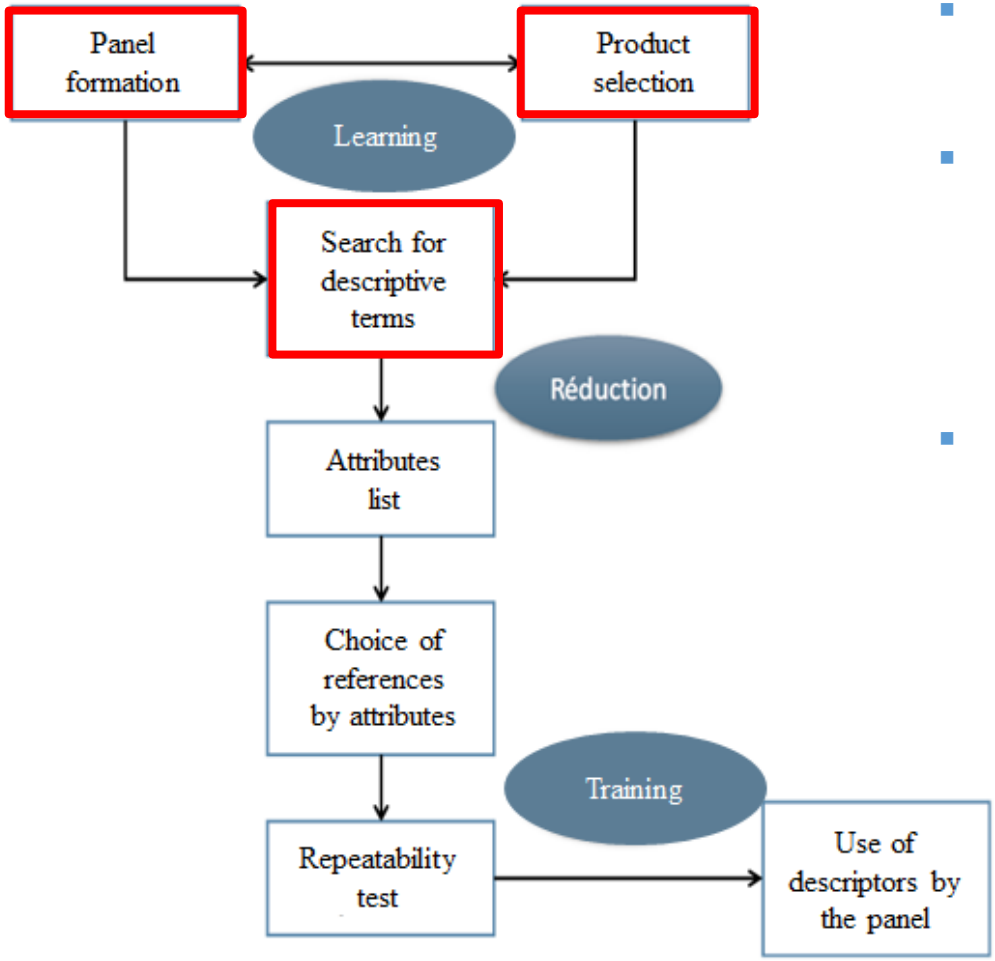


Sensory Profile



- **Standardized test**
  - ISO 6658 (2017) Sensory analysis - Methodology - General guidance
  - ISO 13299 (2016) Sensory analysis - Methodology - General guidance for establishing a sensory profile
  - ISO 8586 (2023) Sensory analysis - Selection and training of sensory assessors
  - ISO 13300-1 (2006) Sensory analysis - General guidance for the staff of a sensory evaluation laboratory - Part 1 : staff responsibilities
  - ISO 13300-2 (2006) Sensory analysis - General guidance for the staff of a sensory evaluation laboratory - Part 2 : recruitment and training of panel leaders
  - ISO 11035 (1995) Sensory analysis. Identification and selection of descriptors for establishing a sensory profile by a multidimensional approach

Sensory Profile



- **Product selection**
  Product space definition
- **Panel recruitment**
  Internal or external
  8 people minimum (ISO 13299)
  Recruit 2 to 3 times more for a sufficient pool
  Sensory acuity check
- **Search for sensory attributes**

Sensory Profile - attributes

- **Definition**
  Semantic intermediates to account for the nature of perceptions

- **Characteristics (Lawless& Heymann [10])**
  - Relevant: adequacy of the term to the perception it is intended to describe
  - Accurate and one-dimensional: be free of ambiguity and possess the least possible broad meaning
  - Discriminating: allow products to be distinguished from one another
  - Exhaustive: render account of the complete description
  - Non-redundant
  - Non-hedonic

- **List of descriptors**
  - Generated by human panel
  - Predefined list

List of attributes

1. **Search for as many descriptors as possible**
   - Each panelist evaluates 3-5 products
   - Product representative of the product space to cover all variations
   - Individual work

→ 150- 200 word list for full description [8]

Abrasif "abrasive"	Confortable "comfortable"	Feutre "felt"	Glacé "icy"	Lisse "smooth"	peau de pêche "peachskin"	Résistant "resistant"	Spongieux "spongy"
Absorbant "absorbent"	Corrosif "corrosive"	Feutré "felt-covered"	Glissant "slippery"	Lourd "heavy"	Pelucheux "fluffy"	Rigide "rigid"	Strié "ridged"
Accrochant "catching"	Coton "cotton"	Feutrine "lightweight felt"	Gomme "gum"	Malléable "malleable"	Pileux "pilous"	Roule sur lui même "coil"	Synthétique "synthetic"
Aéré "aired"	Craquant "crack"	Fibre "fibre"	Gonflant "puffed"	Microfibre "microfibre"	Plastique "plastic"	Rude "hard"	Tapis "carpet"
Agréable "pleasant"	Crêpé "crimped"	Fibreux "fibrous"	Granuleux "granulous"	Moelleux "soft"	Plat "flat"	Rugueux "rough"	Tendre "soft"
Amidonné "starched"	Creux "hollow"	Filet "net"	Gras "greasy"	Motifeux "with patterns"	Plein "full"	Sablonneux "sandy"	Tiède "tepid"
Ample "full"	Déformable "deformable"	Fin "thin"	Gratté "brushed"	Mou "flabby"	Plié "pleated"	Satiné "satin-like"	Toile de jute "hessian"
Aspérité "roughness"	Désagréable "unpleasant"	Flexible "flexible"	Huileux "oily"	Mousse "foam"	Plissé "crinkled"	Savonneux "soapy"	Tombant "falling"
Attachant "attractive"	Doux "soft"	Floconneux "fleecy"	Humide "humid"	Mousseux "foaming"	Plombant "heavy"	Sec "dry"	Traité "treated"
Bruyant "noisy"	Dur "hard"	Fluide "flowing"	Infroissable "non-crumple-like"	Nerveux "nervous"	Poilu "hairy"	Serré "close"	Tramé "waved"
Caoutchouc "rubber"	Duveteux "downy"	Foulard "foulard"	Inhomogène "inhomogeneous"	Nervuré "ribbed"	Poreux "porous"	Siliconé "silicone"	Tricot "knitting"
Cartonneux "like-cardboard"	Elastique "elastic"	Frais "fresh"	Jean "jeans"	Ondulé "wavy"	Raide "stiff"	Sillonneux "furrowed"	Vaguelettes "wavelet"
Cassant "breakable"	Émerisé "emerised"	Froid "cold"	Lâche "loose"	Papier "paper"	Rainuré "grooved"	Soie "silk"	Velours "velvet"
Chaud "warm"	Epais "thick"	Froissable "crumple-like"	Laine "wool"	Papier canson "paper canson"	Râpeux "raspy"	Solide "solid"	Velouteux "velvety"
Cireux "wax-like"	Epineux "prickly"	Froissant "hurtful"	Laineux "wool-like"	Papier de verre "glass-paper"	Rayée "striped"	Sonnant "sounded"	Viscose "viscose"
Collant "sticky"	Eponge "sponge"	Froissé "crumpled"	Léger "light"	Peau de bébé "babyskin"	Rêche "harsh"	Souple "supple"	Voile "voile"
Compact "compact"	Extensible "extensible"	Gaufré "embossed"	Lin "linen"	Peau de daim "buckskin"	Reliéfé "raised"	Soyeux "silk-like"	Volumineux "voluminous"

List of attributes

2. Qualitative sorting = 1st reduction

- Pooling and explanation of each term
- Removal of descriptors cited only once, hedonic, intensity, irrelevant, non-discriminating

3.a. Par consensus

- Group terms by family
- Choose one term per family

→ Final list

3.b. Quantitative sorting (Assisted consensus approach) - (AFNOR standard)

- 5-8 products
- Score from 0 to 5 for each descriptor
- Geometric mean (Dravnieks and al., 1978)

$MG = \sqrt{F\ I}$ F Descriptor citation frequency

I relative cumulative intensity of descriptor

→ removal of descriptors <10 to 20% of information

4. Statistical sorting (multidimensional analysis)

- CA / PCA
- HCA

→List of 10-15 terms (full description)

Lexicon

Training (with references)

List of attributes

- 136 words → 15 final descriptors

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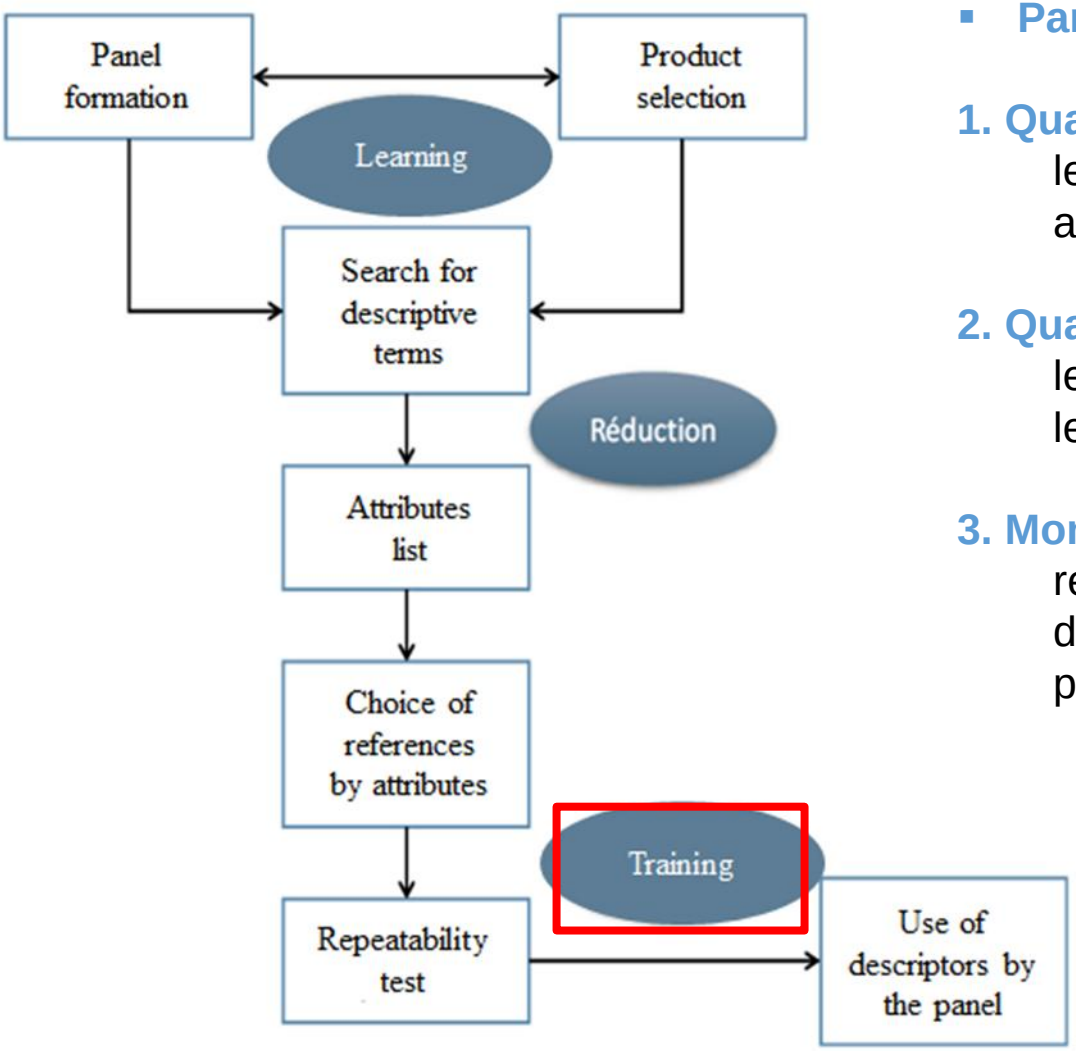
Accrochant "catching"	Coton "cotton"	Feutrine "lightweight felt"	Gomme "gum"	Malléable "malleable"	Pileux "pilous"	Roule sur lui même "coil"	Synthétique "synthetic"
Aéré "aired"	Craquant "crack"	Fibre "fibre"	Gonflant "puffed"	Microfibre "microfibre"	Plastique "plastic"	Rude "hard"	Tapis "carpet"
Agréable "pleasant"	Crêpé "crimped"	Fibreux "fibrous"	Granuleux "granulous"	Moelleux "soft"	Plat "flat"	Rugueux "rough"	Tendre "soft"
Amidonné "starched"	Creux "hollow"	Filet "net"	Gras "greasy"	Motifeux "with patterns"	Plein "full"	Sablonneux "sandy"	Tiède "tepid"
Ample "full"	Déformable "deformable"	Fin "thin"	Gratté "brushed"	Mou "flabby"	Plié "pleated"	Satiné "satin-like"	Toile de jute "hessian"
Aspérité "roughness"	Désagréable "unpleasant"	Flexible "flexible"	Huileux "oily"	Mousse "foam"	Plissé "crinkled"	Savonneux "soapy"	Tombant "falling"
Attachant "attractive"	Doux "soft"	Floconneux "fleecy"	Humide "humid"	Mousseux "foaming"	Plombant "heavy"	Sec "dry"	Traité "treated"
Bruyant "noisy"	Dur "hard"	Fluide "flowing"	Infroissable "non-crumple-like"	Nerveux "nervous"	Poilu "hairy"	Serré "close"	Tramé "waved"
Caoutchouc "rubber"	Duveteux "downy"	Foulard "foulard"	Inhomogène "inhomogeneous"	Nervuré "ribbed"	Poreux "porous"	Siliconé "silicone"	Tricot "knitting"
Cartonneux "like-cardboard"	Elastique "elastic"	Frais "fresh"	Jean "jeans"	Ondulé "wavy"	Raide "stiff"	Sillonneux "furrowed"	Vaguelettes "wavelet"
Cassant "breakable"	Émerisé "emerised"	Froid "cold"	Lâche "loose"	Papier "paper"	Rainuré "grooved"	Soie "silk"	Velours "velvet"
Chaud "warm"	Epais "thick"	Froissable "crumple-like"	Laine "wool"	Papier canson "paper canson"	Râpeux "raspy"	Solide "solid"	Velouteux "velvety"
Cireux "wax-like"	Epineux "prickly"	Froissant "hurtful"	Laineux "wool-like"	Papier de verre "glass-paper"	Rayée "striped"	Sonnant "sounded"	Viscose "viscose"
Collant "sticky"	Eponge "sponge"	Froissé "crumpled"	Léger "light"	Peau de bébé "babyskin"	Rêche "harsh"	Souple "supple"	Voile "voile"
Compact "compact"	Extensible "extensible"	Gaufré "embossed"	Lin "linen"	Peau de daim "buckskin"	Reliéfé "raised"	Soyeux "silk-like"	Volumineux "voluminous"

Bipolar attributes	Surface attributes	Handle attributes
Froid-chaud "cold-warm"	Pileux "hairy"	Tombant "falling"
Fin-épais "thin-thick"	Doux "soft"	Nerveux "nervous"
Léger-lourd "light-heavy"	Granuleux "granulous"	Froissable "crumple-like"
Souple-rigide "supple-rigid"	Collant "sticky"	Elastique "elastic"
	Reliéfé "raised"	
	Gras "greasy"	
	Glissant "slippery"	

Panel Training



- **Panel training**

1. Qualitative aspects

learn the sensory characteristic associated with each descriptor

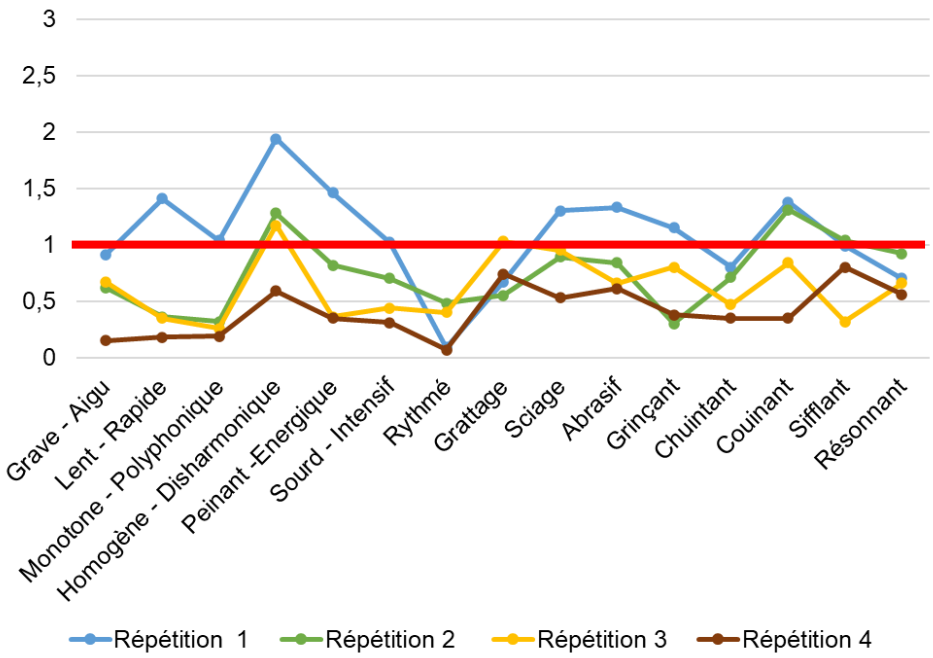
2. Quantitative aspects

learn to classify intensities
learn to use scales

3. Monitoring panel performance (ANOVA)

reproducibility
discriminatory power
panel homogeneity

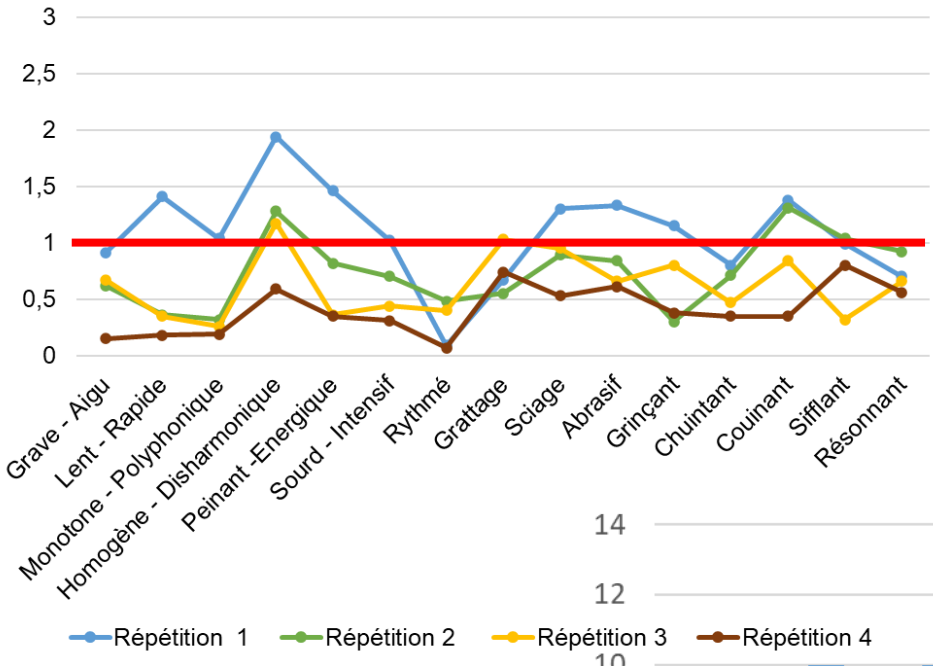
Panel Training



- **Reproducibility (ANOVA)**

$$\varepsilon = \sqrt{\frac{CMR_{intra}}{\bar{X}}}$$

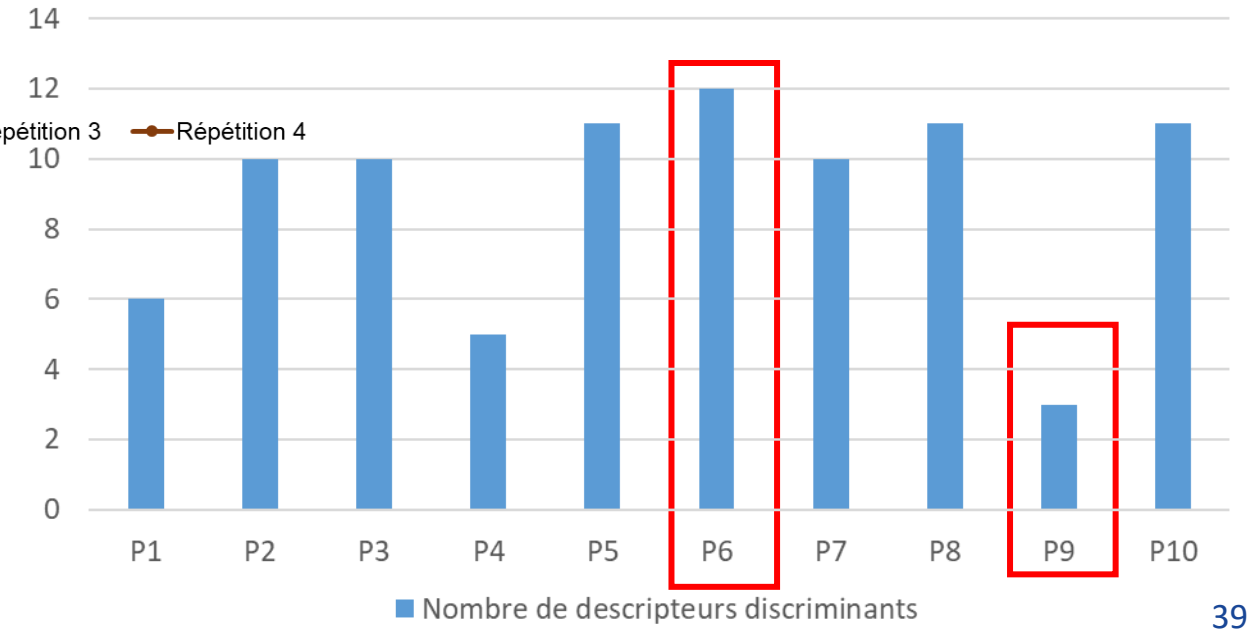
Panel Training



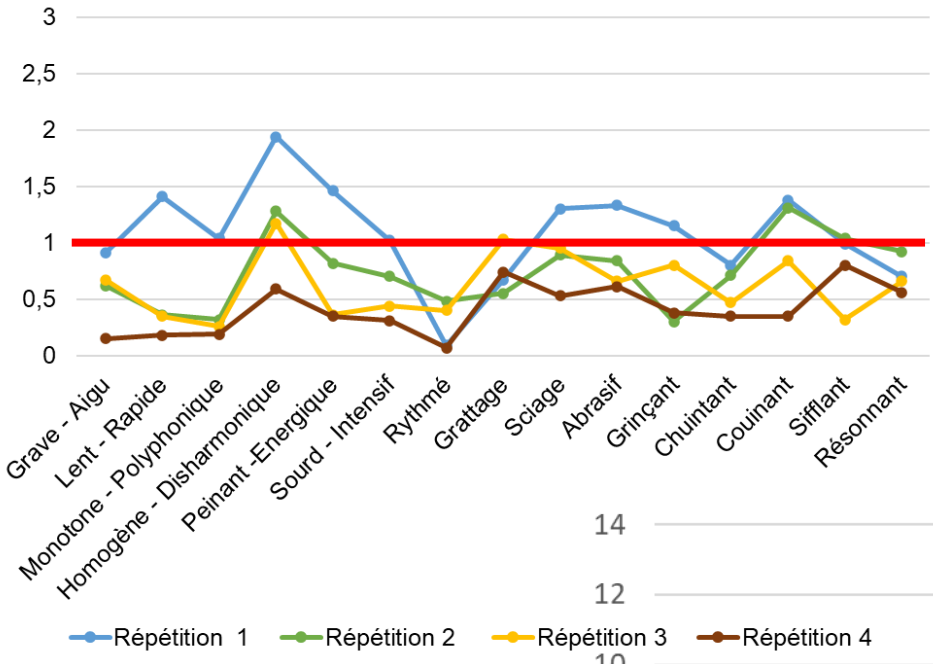
- **Reproducibility (ANOVA)**

$$\varepsilon = \sqrt{\frac{CMR_{intra}}{\bar{X}}}$$

- **Discriminatory power (ANOVA)**
  study of p-value



Panel Training

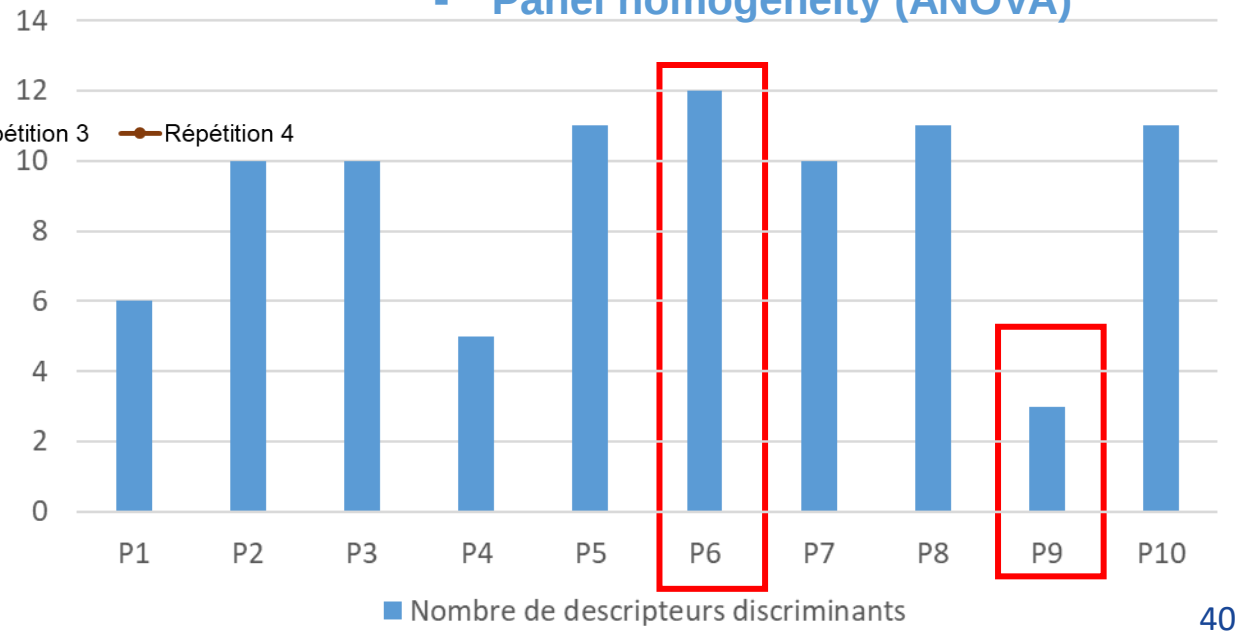


- **Reproducibility (ANOVA)**

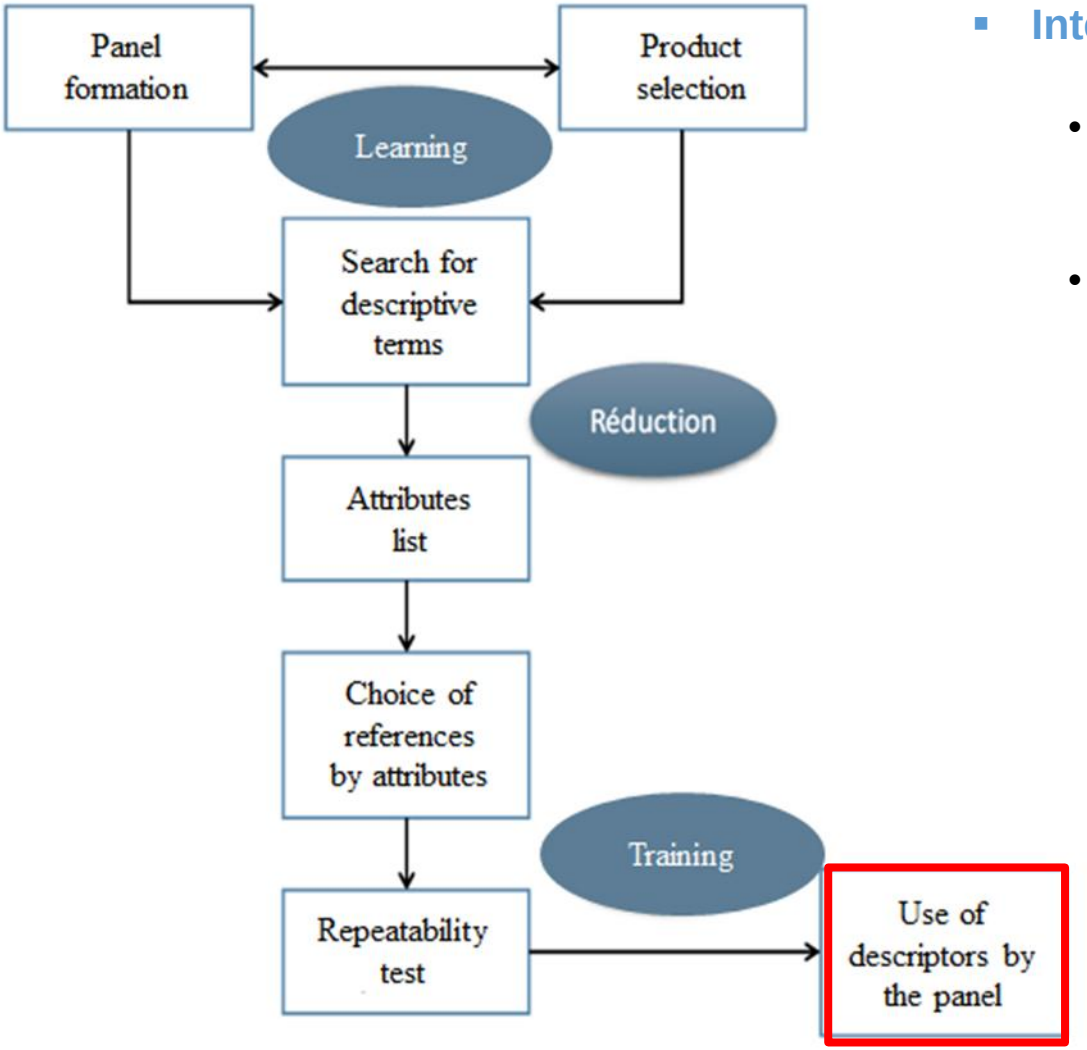
$$\varepsilon = \sqrt{\frac{CMR_{intra}}{\bar{X}}}$$

- **Discriminatory power (ANOVA)**
  study of p-value

- **Panel homogeneity (ANOVA)**

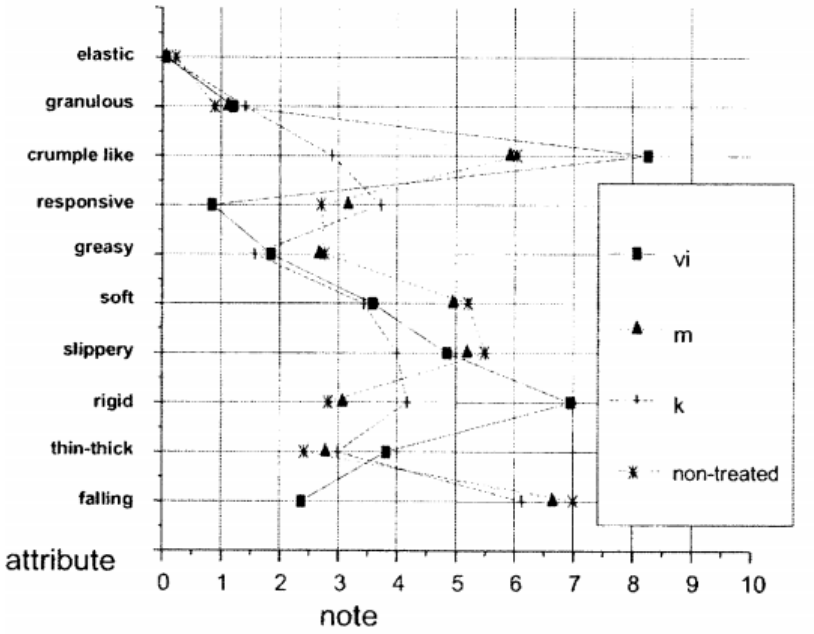


Results

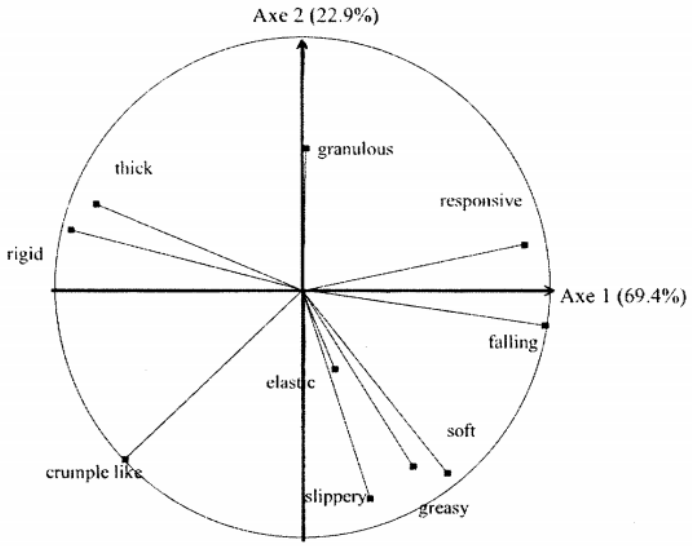


- **Interpretations & results**
  - On all descriptors
    PCA, AFM
  - On each descriptor
    Elementary descriptive statistics
    Unidimensional decision statistics

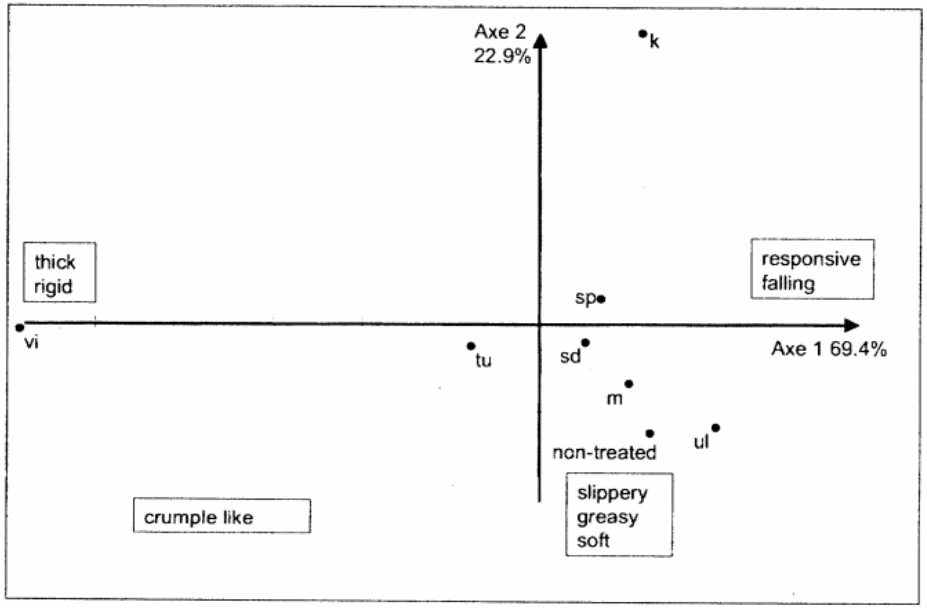
Results



- **Sensory Profile**



- **PCA**



- **Product Map**

Flora Philippe and al. , (2003),"The sensory panel applied to textile goods – a new marketing tool", Journal of Fashion Marketing and Management

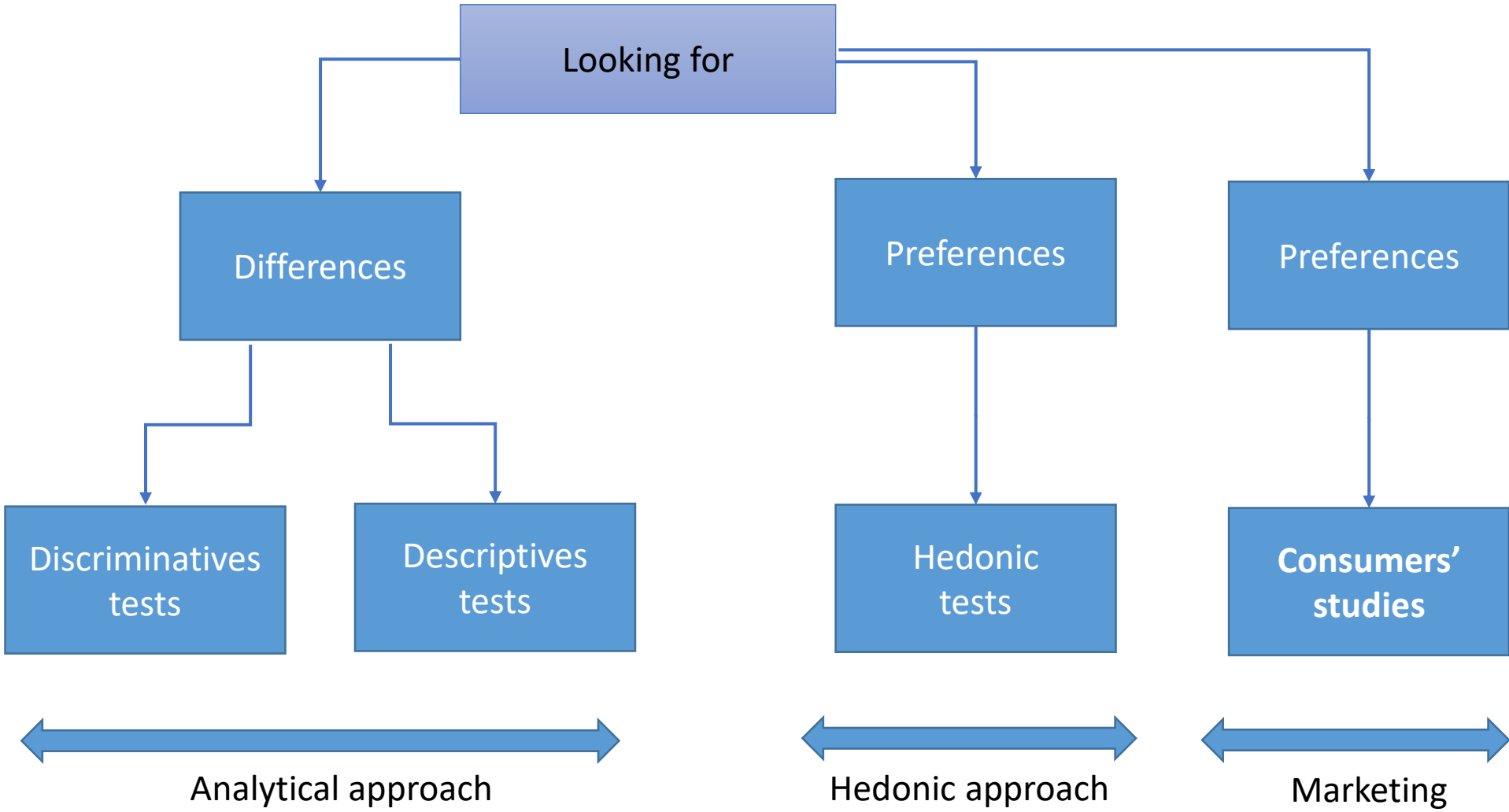
Pros & Cons

+	−
- Widely used operational technique	- Complex test
- Reliable, repeatable and reproducible results	- Long tests
- Rich in information	- Expensive

→ **faster alternative:**

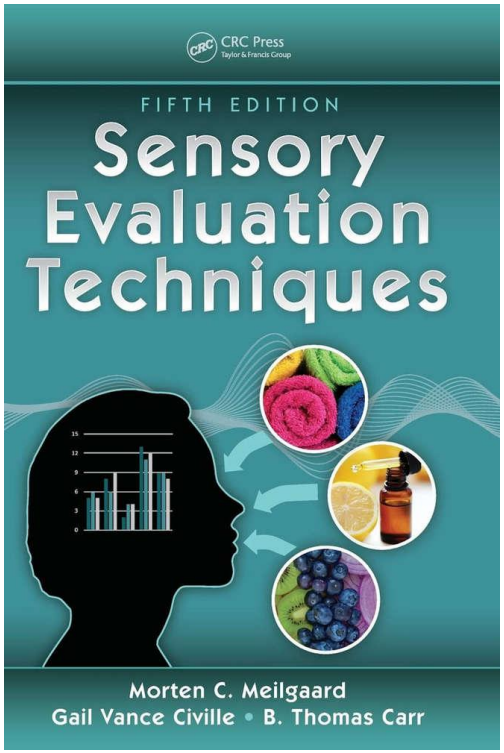
- **free profile (monadic)**
- **flash profile (comparative)**
- **CATA**

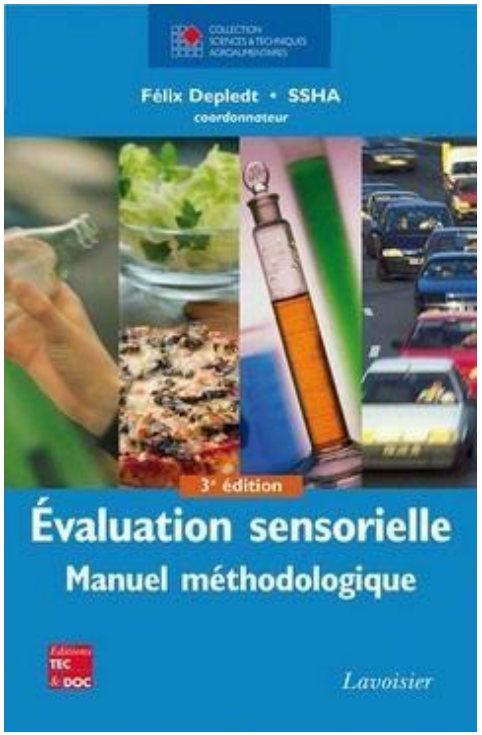
Sensory analysis tests



Toolbox

- **Softwares (non-exhaustive)**
  - R with SensominR
  - Xlstat
  - Matlab





Standards

- ISO 5492:2008 Sensory analysis – Vocabulary
- ISO 6658 (2017) Sensory analysis - Methodology - General guidance
- ISO 4120:2021 Sensory analysis – Methodology-Triangle test
- ISO 13299:2016 Sensory analysis — Methodology — General guidance for establishing a sensory profile
- ISO 13300-1 (2006) Sensory analysis - General guidance for the staff of a sensory evaluation laboratory - Part 1 : staff responsibilities
- ISO 13300-2 (2006) Sensory analysis - General guidance for the staff of a sensory evaluation laboratory - Part 2 : recruitment and training of panel leaders
- ISO 11035:1995 Sensory analysis. Identification and selection of descriptors for establishing a sensory profile by a multidimensional approach.
- ISO 8586:2023 Sensory analysis - Selection and training of sensory assessors
- ISO 11136:2017 Sensory analysis - Methodology - General guidance for conducting hedonic tests with consumers in a controlled area
- ISO 4121:2004 Sensory analysis - Guidelines for the use of quantitative response scales
- ISO 20613:2019 Sensory analysis — General guidance for the application of sensory analysis in quality control

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