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Time periods segmentation in TDS and TCATA

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Introduction

- **Numerous statistical analyzes** for TDS/TCATA data, many commonalities
- **Curves of attribute proportions of citations**
 - + closest representation of raw data at panel level
 - lack of global test, several types of tests (binomial, multinomial, proportion test) at each time, unidimensional tests
- **Duration based analysis and maps** (ANOVA, PCA or CVA)
 - + global test, easy to interpret
 - sequentiality of perceived sensations is only taken into account when continuous time is divided into periods
 - subjective choice of the number and the frontiers of periods (except with semi-Markov chains)
- **Trajectory maps** (PCA, CA)
 - + “within” and “between” product evolution representation
 - subject heterogeneity not taken into account
 - no test
 - CA is not the best framework for TCATA because of multiple responses
- **What about interpretability and actionability for product design?**

Objectives

- **Automatically determine the number and frontiers of periods** that best represent the **breaks in the temporal perception** of products (at panel level)
- **Simplify and objectify product temporal characterization** using an unified multidimensional approach
- **Study key moments in perception**

Material and methods

- 6 methods: **TDS**, **TCATA**, (AEF-dominance, AEF-applicability, FC-AEF-dominance, FC-AEF-applicability)
- 6 groups of 64 consumers, each group using 1 method
- Each consumer participated in 3 separated sessions (1 in lab, 2 at home) and tasted a total of 20 samples:
 - 4 dark chocolate + 1 replicate (home)
 - 4 guacamole + 1 replicate (lab)
 - 4 iced tea + 1 replicate (lab)
 - **4 crisps + 1 replicate (home)**

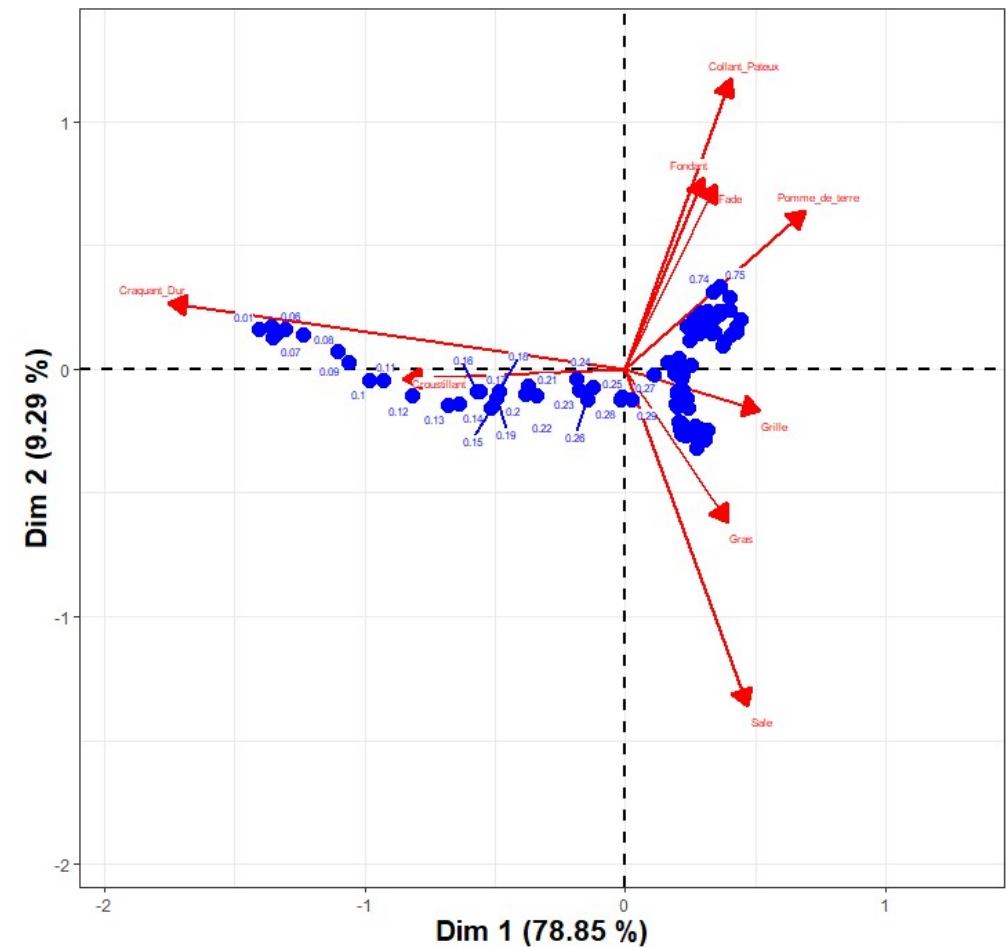
Number and frontiers of periods determination

- For each product:
 - **Standardize and discretize time in 100 points** between 0.01 (1st perception) and 1 (end of perception)
 - **Compute a mrCA considering discretized time as observations**
 - Carry out an **agglomerative clustering on mrCA row coordinates** (axes 1&2, **agglomeration method=Ward**) with a constraint of **temporal contiguity**
 - **Determine periods based on clusters, suggested partition:**
 - with the **higher relative loss of inertia between clusters** (min. 3 clusters)
 - OR **determined by user**

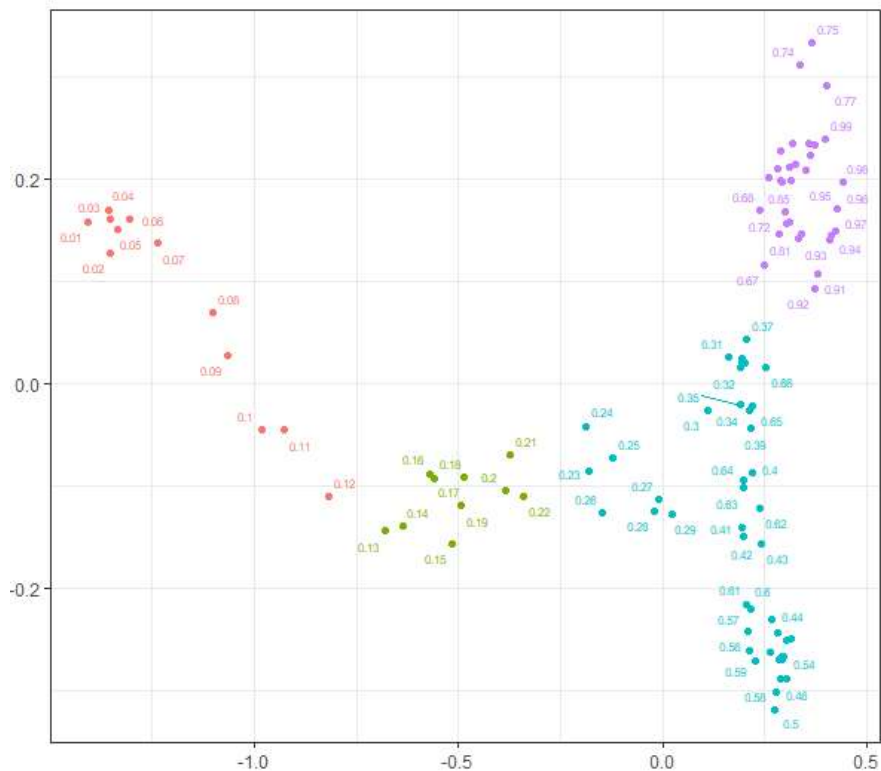
Example on crisps C3 (TDS)

Subject	Product	Discretized time	Collant Pateux	Craquant Dur	Croustillant	...	Sale
A01	C3	0.01	1	0	0		0
A01	C3	0.02	0	1	0		0
A01	C3	0.03	1	0	0		0
...	C3						
A01	C3	1.00	0	0	0		1
...	C3						

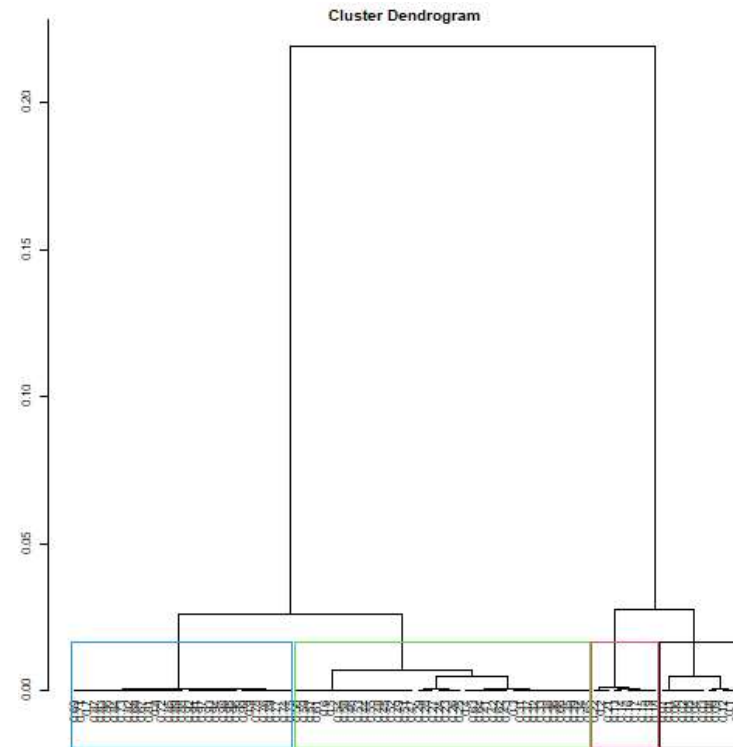
① mrCA on Product C3, considering discretized time as observations (MultiResponseR)



Example on crisps C3 (TDS)

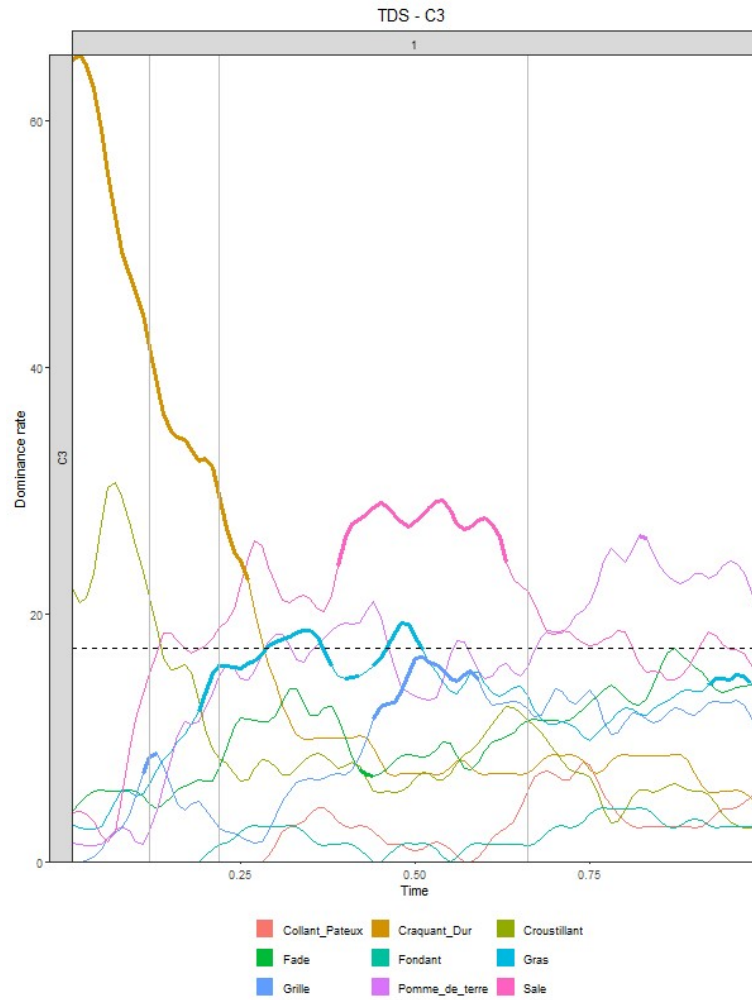


② Clustering on mrCA row coordinates with constraint of temporal contiguity (adespatial)



③ Suggested partition with the higher relative loss of inertia between clusters

Example on crisps C3 (TDS)



Projection of periods on TDS curves

Within product discrimination

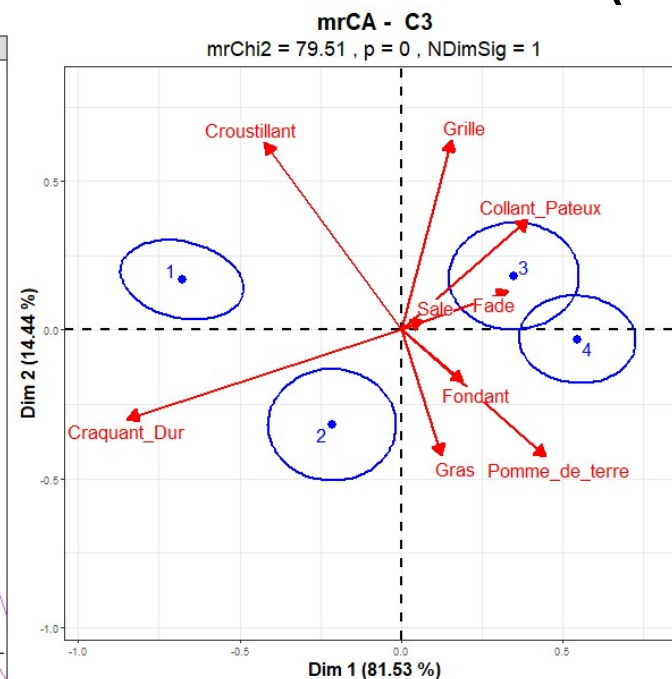
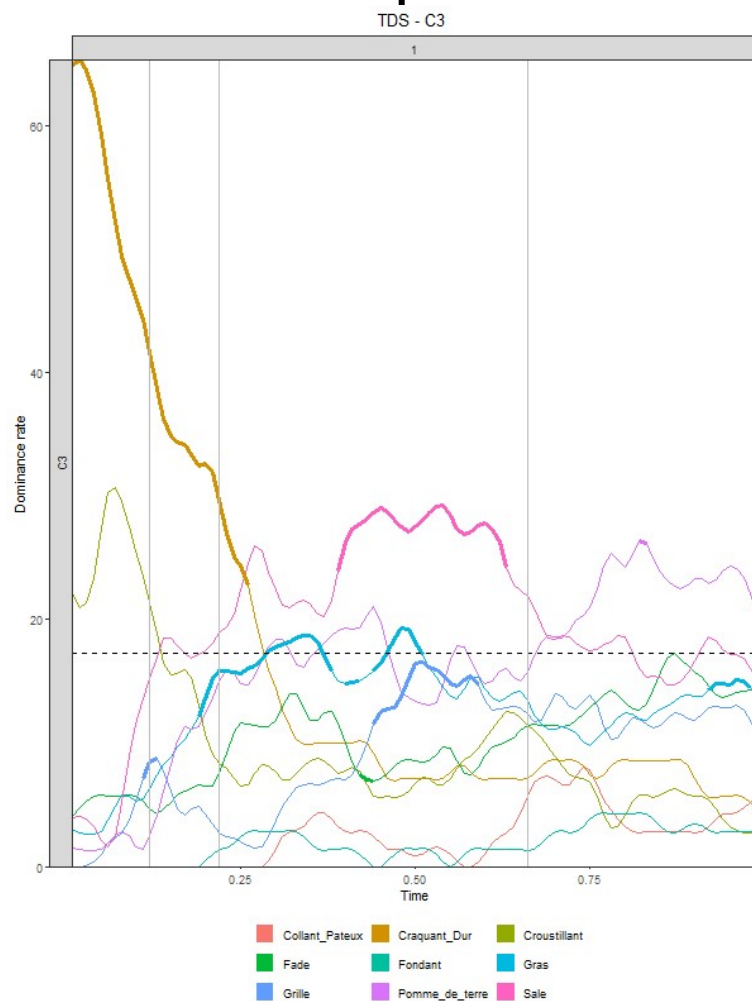
- **Discretized times replaced by periods**
- New contingency table, with 2 possible methods of aggregation at subject level:
 - **score = 1 if an attribute has been cited during the period, 0 otherwise**
 - **score = mean over period (weighting by duration)**

Subject	Product	Discretized time	Collant Pateux	Craquant Dur	Croustillant	...	Sale
A01	C3	0.01	1	0	0		0
A01	C3	0.02	0	1	0		0
A01	C3	0.03	1	0	0		0
...	C3						
A01	C3	1.00	0	0	0		1
...	C3						



Subject	Product	Discretized time	Collant Pateux	Craquant Dur	Croustillant	...	Sale
A01	C3	1	1	0	0		0
A01	C3	2	0	1	0		0
A01	C3	3	0	0	0		1
...	C3						

Within product discrimination (C3, TDS)



	1	2	3	4
Collant_Pateux	0.00	0.00	10.00	12.86
Craquant_Dur	67.14	44.29	28.57	11.43
Croustillant	42.86	22.86	25.71	15.71
Fade	5.71	8.57	20.00	20.00
Fondant	0.00	1.43	5.71	5.71
Gras	8.57	21.43	42.86	24.29
Grille	10.00	11.43	28.87	24.29
Pomme_de_terre	2.86	17.14	52.86	38.57
Sale	15.71	32.86	55.71	30.00

No weighting: cells = proportion of citations in period

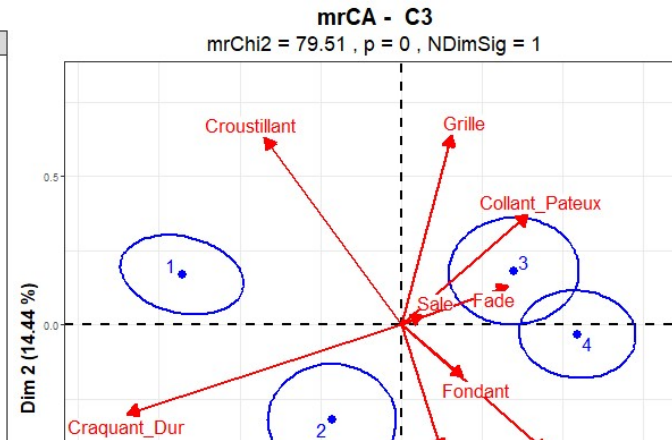
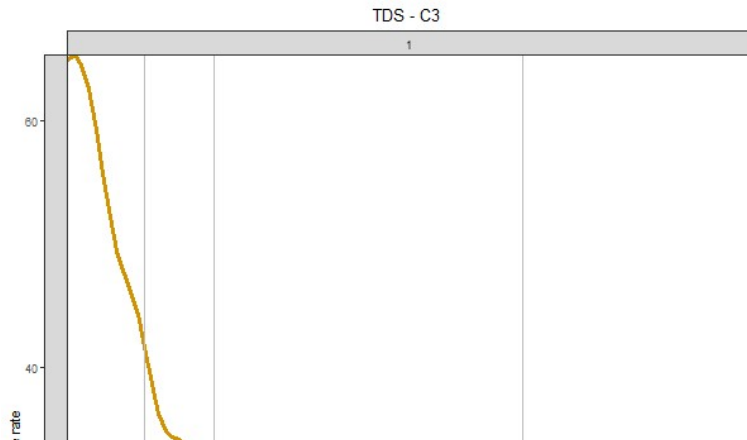
Green cells = significant differences (5%)

Orange cells = significant differences (15%)

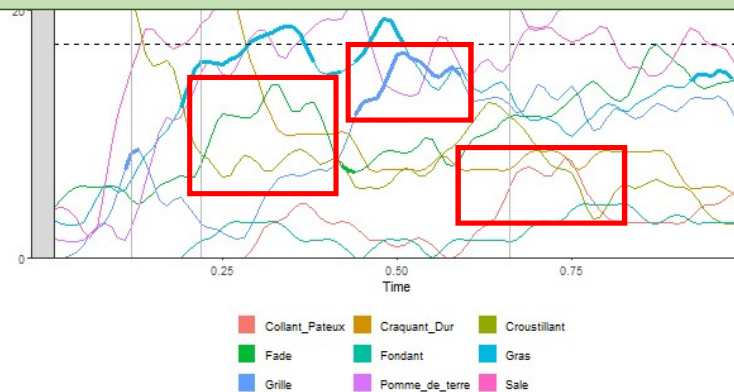
	Period 1 [0.01-0.12[	Period 2 [0.13-0.22[	Period 3 [0.23-0.66[	Period 4 [0.67-1[
TDS (vs. significance level)	Craquant_Dur, Croustillant	Craquant_Dur, (Pomme_de_terre)	Gras, Pomme_de_terre, Sale	Pomme_de_terre, Sale
mrCA	Craquant_Dur, Croustillant	(Craquant_Dur)	(Collant_Pateux), Fade, Gras, Grille, Pomme_de_terre, Sale	Collant_Pateux, Fade, (Fondant, Grille), Pomme_de_terre

→ Objective description, more agreement within periods

Within product discrimination (C3, TDS)



- Attributes never reaching significance in discretized times highlighted in mrCA
- Time lag in perception
- Changes in proportions of citations between periods



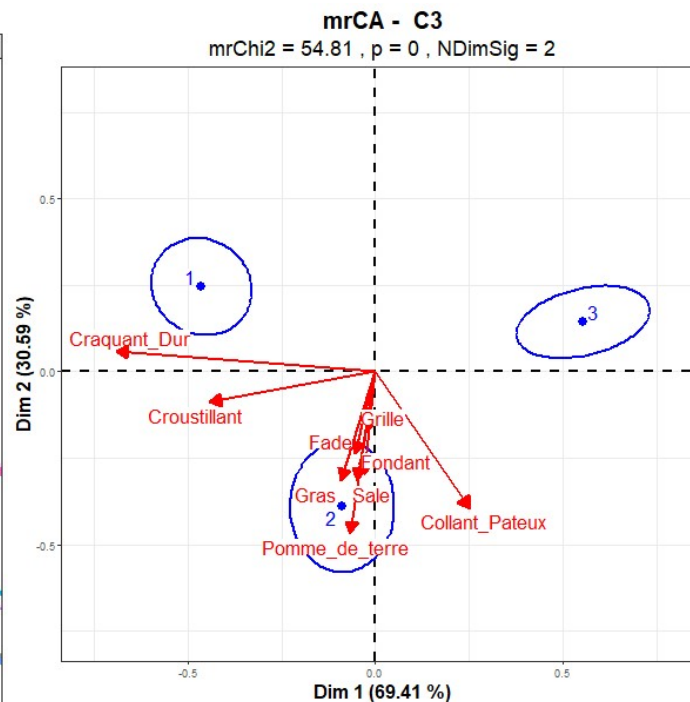
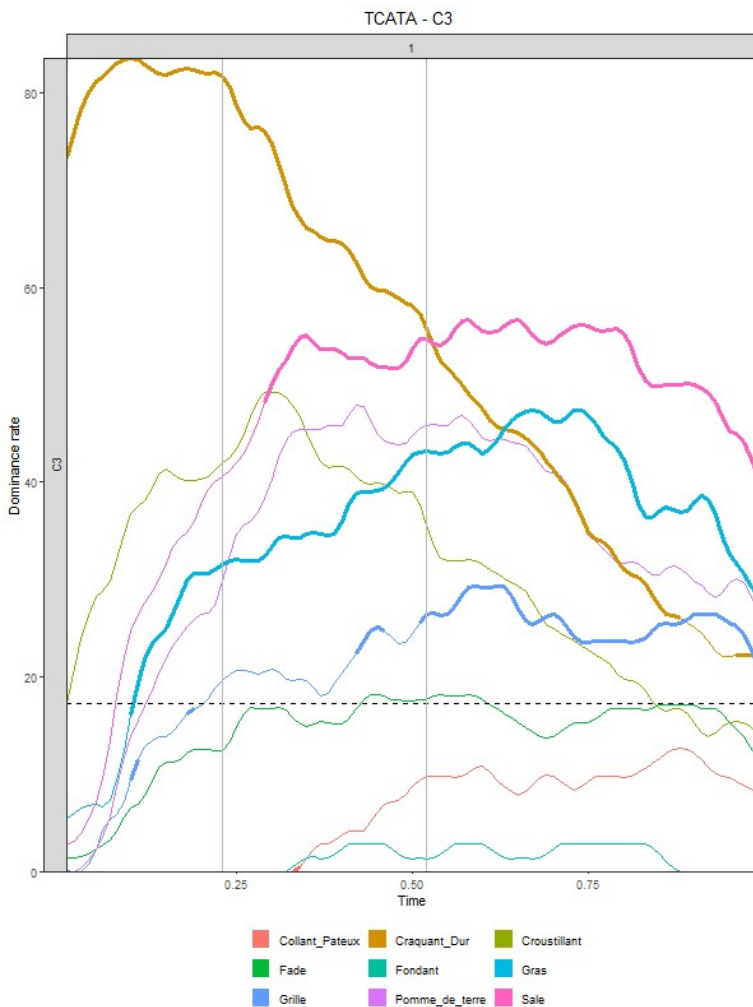
	1	2	3	4
Collant_Pateux	0.00	0.00	10.00	12.86
Craquant_Dur	67.14	44.29	28.57	11.43
Croustillant	42.86	22.86	25.71	15.71
Fade	5.71	8.57	20.00	20.00
Fondant	0.00	1.43	5.71	5.71
Gras	8.57	21.43	42.86	24.29
Grille	10.00	11.43	28.87	24.29
Pomme_de_terre	2.86	17.14	52.86	38.57
Sale	15.71	32.86	55.71	30.00

No weighting: cells = proportion of citations in period
 Green cells = significant differences (5%)
 Orange cells = significant differences (15%)

	Period 1 [0.01-0.12[	Period 2 [0.13-0.22[	Period 3 [0.23-0.66[	Period 4 [0.67-1[
TDS (significance vs. chance)	Craquant_Dur, Croustillant	Craquant_Dur, (Pomme_de_terre)	Gras, Pomme_de_terre, Sale	Pomme_de_terre, Sale
mrCA	Craquant_Dur, Croustillant	(Craquant_Dur)	(Collant_Pateux), Fade, Gras, Grille, Pomme_de_terre, Sale	Collant_Pateux, Fade, (Fondant, Grille), Pomme_de_terre

→ Objective description, more agreement within periods

Within product discrimination (C3, TCATA)



	1	2	3
Collant_Pateux	0.00	9.72	8.33
Craquant_Dur	81.94	56.94	22.22
Croustillant	41.67	34.72	13.89
Fade	12.50	18.06	11.11
Fondant	0.00	1.39	0.00
Gras	31.94	43.06	27.78
Grille	20.83	26.39	20.83
Pomme_de_terre	27.78	45.83	26.39
Sale	40.28	54.17	38.89

	Period 1 [0.01-0.23[	Period 2 [0.24-0.52[	Period 3 [0.53-1[
TCATA	No test?		
mrCA	Craquant_Dur, Croustillant	(Collant_Pateux), (Croustillant), (Fade), Gras, Pomme_de_terre, Sale	

→ Different kinetics between descriptors

Within product discrimination (all products)

Product	Frontiers TDS	Frontiers TCATA
C1	0.12, 0.40	0.10, 0.28, 0.52
C1_rep	0.19, 0.28, 0.55	0.15, 0.45
C2	0.22, 0.74	0.16, 0.30, 0.64
C3	0.12, 0.26, 0.66	0.23, 0.52
C4	0.18, 0.60	0.11, 0.47
CH1	0.26, 0.57	0.13, 0.55
CH2	0.20, 0.45	0.20, 0.77
CH3	0.18, 0.39, 0.66	0.13, 0.31, 0.66
CH4	0.20, 0.45	0.27, 0.68
CH4_rep	0.17, 0.72	0.18, 0.63
G1	0.12, 0.43	0.11, 0.34, 0.71
G1_rep	0.12, 0.35	0.23, 0.58
G2	0.16, 0.53	0.13, 0.62
G3	0.12, 0.33, 0.76	0.14, 0.56
G4	0.26, 0.65	0.12, 0.59
IT1	0.22, 0.65	0.21, 0.68
IT2	0.17, 0.72	0.14, 0.28
IT3	0.16, 0.28	0.16, 0.36
IT3_rep	0.07, 0.34, 0.53	0.10, 0.30
IT4	0.17, 0.42	0.23, 0.62

Differences between TDS and TCATA:

- **TDS: breaks in perception**
- **TCATA: changes in citation rates**

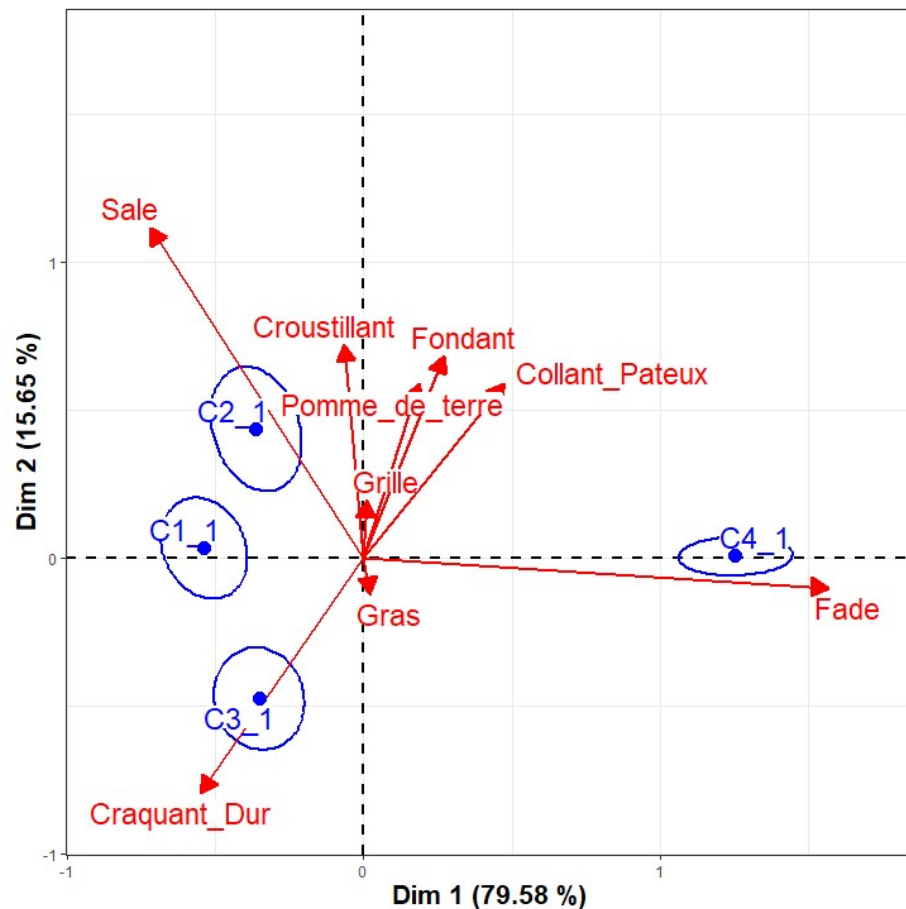
Non-uniform and product-dependent periods:

- More changes at the beginning of tasting (textures)

Different levels of product characterization

- **Within product evolution:** mrCA on **observations = periods**, restricted to a given product
- But also:
 - **within period differences:** mrCA on **observations = products*period**
 - all products
 - restricted to a given pair of products
 - **between products and periods differences (trajectories):** mrCA on **observations = products x periods**
 - all products
 - restricted to a given pair of products

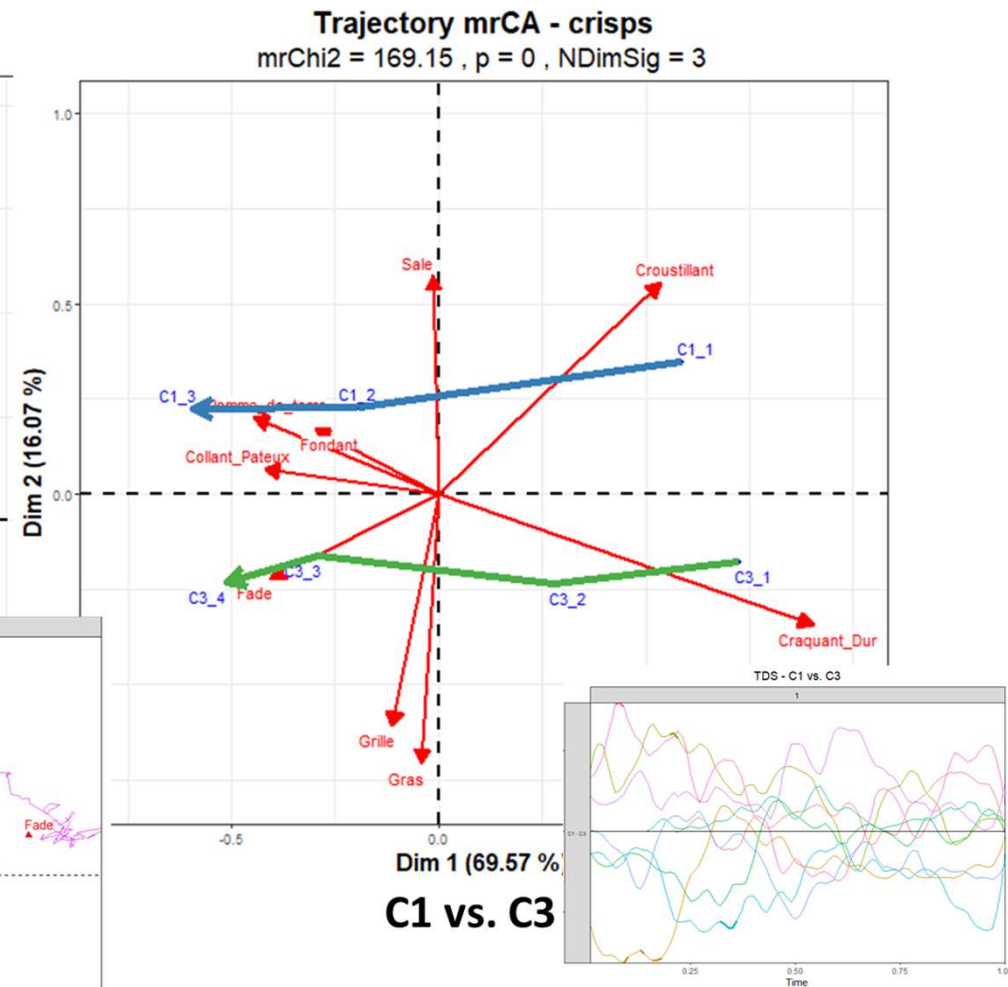
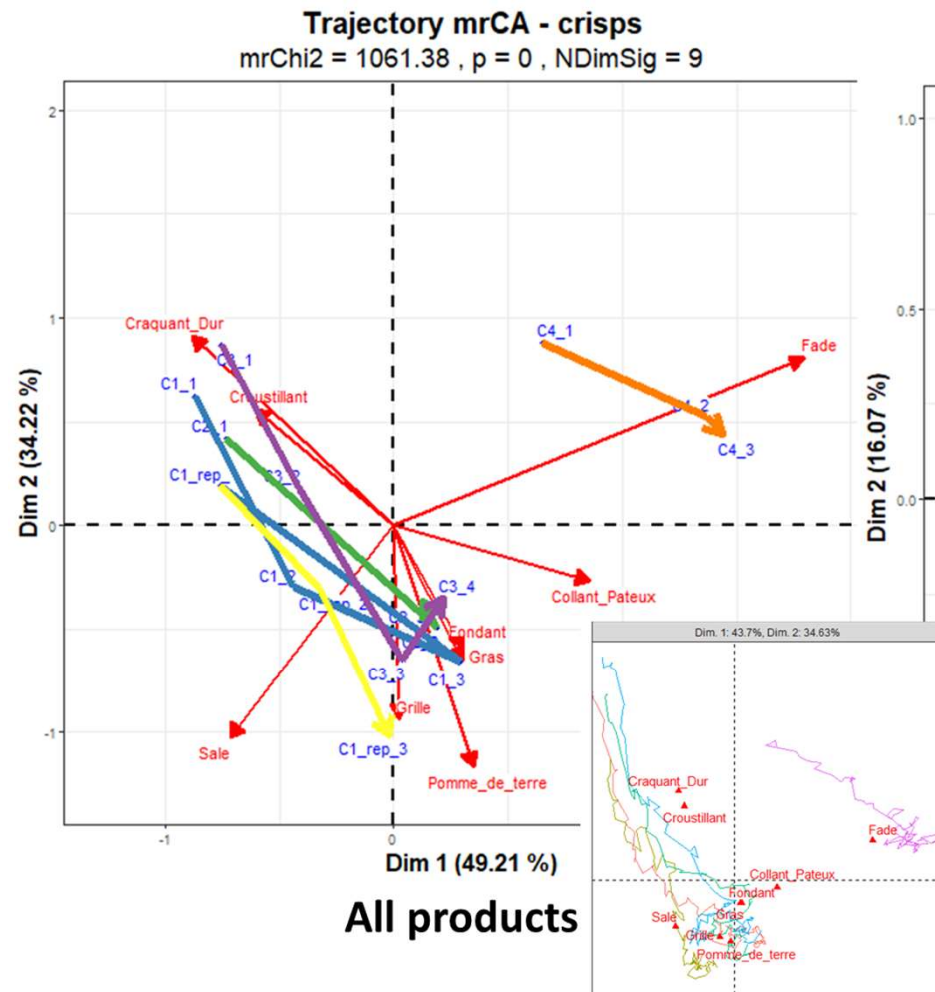
Within period differences, crisps, period 1



	C1_1	C2_1	C3_1	C4_1
Collant_Pateux	0.00	5.71	0.00	10.00
Craquant_Dur	55.71	41.43	67.14	21.43
Croustillant	55.71	68.57	42.86	51.43
Fade	2.86	2.86	5.71	64.29
Fondant	0.00	5.71	0.00	5.71
Gras	5.71	4.29	5.71	5.71
Grille	1.43	10.00	7.14	5.71
Pomme_de_terre	11.43	11.43	2.86	14.29
Sale	40.00	40.00	14.29	1.43

→ Differences between products during first period of tasting

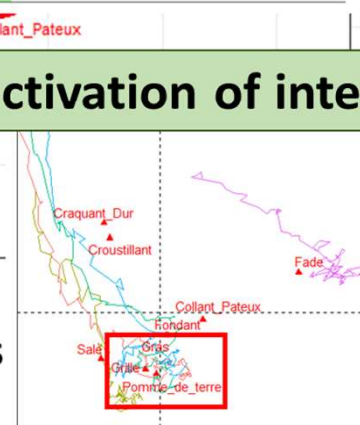
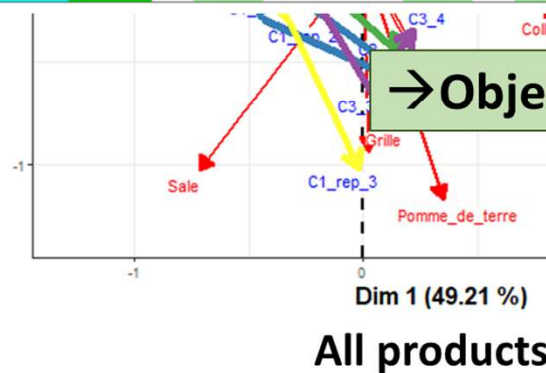
Between products and periods differences (trajectories)



Between products and periods differences (trajectories)

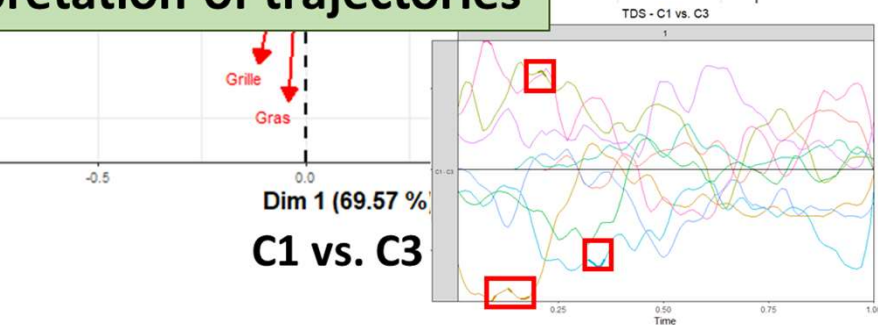
Trajectory mrCA - crisps
mrChi2 = 1061.38 , p = 0 , NDimSig = 9

	C1_1	C1_2	C1_3	C1_rep_1	C1_rep_2	C1_rep_3	C1_rep_4	C2_1	C2_2	C2_3	C3_1	C3_2	C3_3	C3_4	C4_1	C4_2	C4_3
Collant_Pateux	0.00	4.29	7.14	2.86	0.00	4.29	4.29	5.71	5.71	7.14	0.00	0.00	5.71	5.71	12.86	5.71	
Craquant_Dur	28.57	10.00	1.43	10.00	10.00	2.86	2.86	15.71	4.29	2.86	41.43	31.43	7.14	4.29	5.71	7.14	5.71
Croustillant	28.57	14.29	4.29	38.57	25.71	11.43	5.71	25.71	5.71	2.86	21.43	8.57	11.43	2.86	28.57	4.29	1.43
Fade	1.43	7.14	14.29	2.86	5.71	2.86	4.29	2.86	12.86	12.86	4.29	5.71	11.43	14.29	44.29	48.57	54.29
Fondant	0.00	2.86	5.71	1.43	4.29	5.71	4.29	5.71	8.57	5.71	0.00	1.43	1.43	2.86	4.29	2.86	1.43
Gras	4.29	8.57	2.86	7.14	7.14	7.14	4.29	4.29	5.71	4.29	7.14	17.14	14.29	12.86	2.86	7.14	8.57
Grille	1.43	4.29	2.86	2.86	7.14	12.86	12.86	5.71	12.86	14.29	8.57	2.86	12.86	10.00	0.00	0.00	2.86
Pomme_de_terre	8.57	22.86	21.43	11.43	18.57	25.71	21.43	8.57	15.71	15.71	1.43	14.29	15.71	20.00	5.71	14.29	8.57
Sale	28.57	28.57	22.86	27.14	22.86	24.29	27.14	24.29	27.14	22.86	14.29	18.57	22.86	14.29	1.43	2.86	1.43



Trajectory mrCA - crisps
mrChi2 = 169.15 , p = 0 , NDimSig = 3

	C1_1	C1_2	C1_3	C3_1	C3_2	C3_3	C3_4
Collant_Pateux	0.00	4.29	7.14	0.00	0.00	5.71	5.71
Craquant_Dur	28.57	10.00	1.43	41.43	31.43	7.14	4.29
Croustillant	28.57	14.29	4.29	21.43	8.57	11.43	2.86
Fade	1.43	7.14	14.29	4.29	5.71	11.43	14.29
Fondant	0.00	2.86	5.71	0.00	1.43	1.43	2.86
Gras	4.29	8.57	2.86	7.14	17.14	14.29	12.86
Grille	1.43	4.29	2.86	8.57	2.86	12.86	10.00
Pomme_de_terre	8.57	22.86	21.43	1.43	14.29	15.71	20.00
Sale	28.57	28.57	22.86	14.29	18.57	22.86	14.29



→ Objectivation of interpretation of trajectories

Conclusions

- **Common analyses for TDS and TCATA:**
 - Unique **multidimensional paradigm** adapted to multiple responses
 - Subject heterogeneity taken into account
 - **Number and frontiers of periods not dependent on tests**
 - Tests at different levels (within/between, all products/pairwise)
- Possibility of reducing temporal signal in a limited number of periods:
 - **Simplification and objectivation of the interpretation** of temporal data
 - Useful information on the **key moments of the temporal sensory perception** of the products (product formulation)
- **Never more than 4 periods:**
 - **Comparability with AEF**
 - **Resolution of temporal methods and granularity of temporal data**
 - **Sequentiality of sensations based on periods more appropriate than durations to study temporality?**

