

Panel performance in Temporal Dominance of Sensations studies

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- **Background & objectives**

- TDS data
- Evaluation of panel performance

- **Alternative method to assess discrimination (panel)**

- Method used as a reference: Permutation approach
- Alternative method based on Analysis of Variance
- Comparison of the results between both approaches

- **Same approach for agreement and individual performance**

- The same approach can be used to measure the agreement between panellists
- The same approach can be used at individual level

- **Conclusion**



Example of a TDS screen



“What sensation do you perceive as dominant in the product ?”

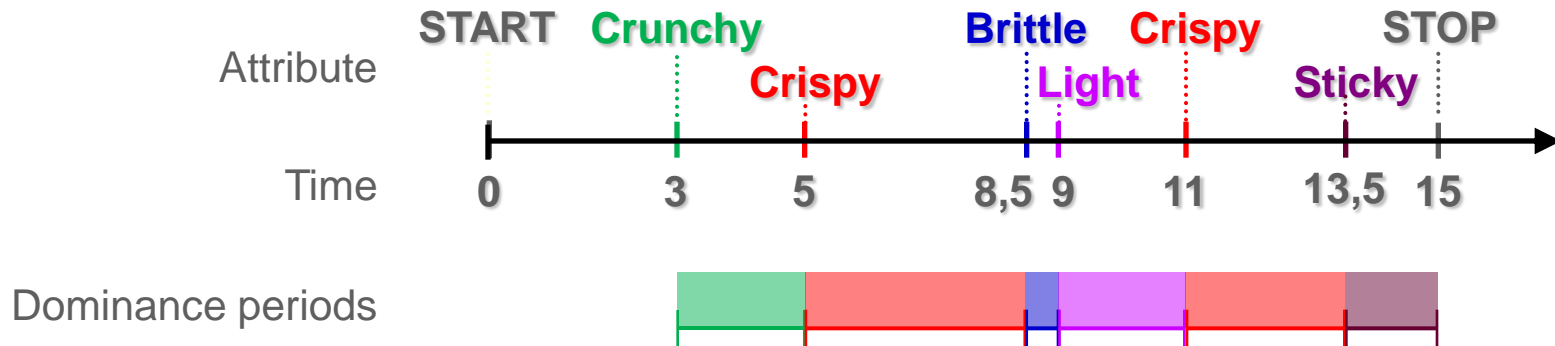
- evaluation from intake to swallowing
- dominant sensation can change over time

NB: in TDS, attribute buttons can be replaced by intensity scale, but here we'll focus on the dominant sensations and not on the intensity of the sensations.



TDS data are sequences of dominant attributes

- An attribute is considered as dominant from the time it is chosen until another one is picked (for instance, Crunchy is dominant from 3 to 5 seconds, i.e. for a period of 2 seconds)



- Numerically, the result of an evaluation is coded in a attribute*time matrix

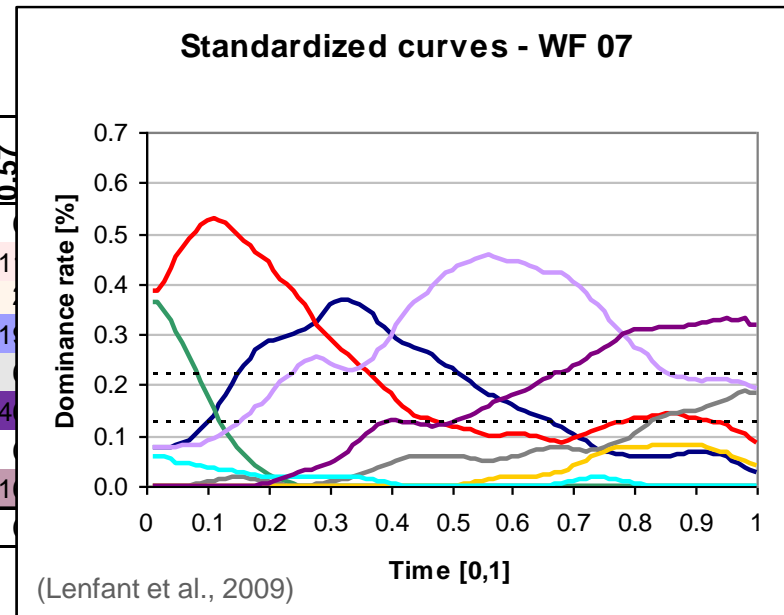
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15			
Crunchy	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Crispy	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0		
Gritty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Brittle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	
Hard	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Sticky	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
STOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

From TDS data to TDS curves

	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	
Crunchy	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crispy	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Gritty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brittle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Hard	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sticky	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
STOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1



	0.00	0.03	0.07	0.10	0.13	0.17	0.20	0.23	0.27	0.30	0.33	0.37	0.40	0.43	0.47	0.50	0.53	0.57
Crunchy	38	35	25	19	12	6	3	0	0	0	0	0	0	0	0	0	0	0
Crispy	39	42	49	53	51	46	43	39	35	31	28	23	19	18	15	13	12	1
Gritty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Brittle	8	8	10	13	18	26	30	32	34	35	38	35	32	29	26	24	22	1
Dry	0	0	1	1	2	2	1	0	0	2	2	4	4	6	7	6	5	0
Light	8	8	9	9	12	17	20	24	26	25	23	26	30	33	39	44	44	4
Hard	7	7	6	5	5	3	2	3	2	2	2	2	1	0	0	0	0	0
Sticky	0	0	0	0	0	0	1	2	3	5	7	10	14	14	13	13	15	1
STOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



- Available solutions to check performance in TDS

	Discrimination ability	Agreement
Panel level	<ul style="list-style-type: none"> •TDS difference curves¹ •Permutation test² 	<ul style="list-style-type: none"> •TDS curves¹ •Permutation test³
Panellist level		<ul style="list-style-type: none"> •Permutation test³

- Two additional constraints since it has to be used as a routine
 - relatively fast to execute
 - easy to implement

1: Pineau N., Schlich P. *et al.* (2009). Food Quality and Pref.

2: Meyners M., Pineau N. (2010). Food Quality and Pref.

3: Meyners M. Submitted in Food Quality and Pref.

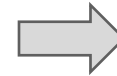


- **Background & objectives**
 - TDS data
 - Evaluation of panel performance
- **A new method to assess discrimination (panel)**
 - Method used as a reference: Permutation approach
 - Alternative method based on Analysis of Variance
 - Comparison between both approaches
- **Extension to agreement and individual performance**
 - The same approach can be used to measure the agreement between panellists
 - The same approach can be used at individual level
- **Conclusion**



Permutation approach to test the discrimination ability 1/3

			time									
			t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉	t ₁₀
P1	Subject 1	A1	1	1	1	0	0	0	0	1	1	1
		A2	0	0	0	1	1	0	0	0	0	0
		A3	0	0	0	0	0	0	0	0	0	0
		A4	0	0	0	0	0	1	1	0	0	0
	Subject 2	A1	1	1	0	0	0	0	1	1	0	0
		A2	0	0	0	0	1	1	0	0	0	0
		A3	0	0	1	1	0	0	0	0	1	1
		A4	0	0	0	0	0	0	0	0	0	0
									
	Subject 20	A1	0	0	0	0	0	0	0	0	1	1
		A2	0	0	1	1	0	0	0	0	0	0
		A3	1	1	0	0	0	0	0	0	0	0
A4		0	0	0	0	1	1	1	1	0	0	
P2	Subject 1	A1	0	0	0	0	0	0	0	0	0	0
		A2	1	1	1	1	0	0	0	0	0	0
		A3	0	0	0	0	1	1	1	1	0	0
		A4	0	0	0	0	0	0	0	0	1	1
	Subject 2	A1	0	0	0	0	0	0	0	1	1	1
		A2	1	1	1	0	0	0	0	0	0	0
		A3	0	0	0	1	1	1	1	0	0	0
		A4	0	0	0	0	0	0	0	0	0	0
									
	Subject 20	A1	0	0	1	1	0	0	1	1	0	0
		A2	1	1	0	0	0	0	0	0	0	0
		A3	0	0	0	0	1	1	0	0	0	0
A4		0	0	0	0	0	0	0	0	1	1	



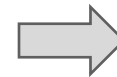
P1.

0.5	0.4	0.33	0.1	0.15	0.2	0.2	0.2	0.3	0.1
0.2	0.15	0.28	0.3	0.26	0.4	0.15	0.2	0.3	0.3
0.2	0.25	0.16	0.45	0.14	0.05	0.3	0.2	0.3	0.25
0.1	0.2	0.23	0.15	0.45	0.35	0.35	0.4	0.1	0.35

$(P1. - P2.)^2$ observed

P2.

0.2	0.2	0.16	0.3	0.25	0.45	0.35	0.33	0.41	0.25
0.3	0.1	0.24	0.4	0.25	0.15	0.5	0.17	0.19	0.2
0.1	0.2	0.3	0.15	0.2	0.2	0.15	0.1	0.1	0.35
0.4	0.5	0.3	0.15	0.3	0.2	0	0.4	0.3	0.2



Permutation approach to test the discrimination ability 2/3

« If the products are not different, response given to product 1 could have been given to product 2 »

			time									
			t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉	t ₁₀
P1	Subject 1	A1	1	1	1	0	0	0	0	1	1	1
		A2	0	0		1	1	0	0	0	0	0
		A3	0	0		0	0	0	0	0	0	0
		A4	0		0	0	0	1	1	0	0	0
	Subject 2	A1	1	1	0	0	0	0	1	1	0	0
		A2	0	0	0	0	<u>1</u>	1	0	0	0	0
		A3	0	0	1	1	0	0	0	0	1	1
		A4	0	0	0	0	0	0	0	0	0	0
									
	Subject 20	A1	0	0	0	0	0	0	0	0	1	1
		A2	0	0	1	1	0	0	0	0	0	0
		A3	1	1	0	0	0	0	0	0	0	0
A4		0	0	0	0	1	1		1	0	0	
P2	Subject 1	A1	0	0	0	0	0	0	0	0	0	0
		A2	1	1		1	0	0	0	0	0	0
		A3	0	0	0	0	1	1	1	1	0	0
		A4	0	0	0	0	0	0	0	0	1	1
	Subject 2	A1	0	0	0	0	0	0	0	1	1	1
		A2	1	1	1	0	0	0	0	0	0	0
		A3	0	0	0	1	<u>1</u>	1	1	0	0	0
		A4	0	0	0	0	0	0	0	0	0	0
									
	Subject 20	A1	0	0	1	1	0	0		1	0	0
		A2	1	1	0	0	0	0	0	0	0	0
		A3	0	0	0	0	1	1	0	0	0	0
A4		0	0	0	0	0	0	0	0	1	1	

P1. for permutation 1

0.4	0.5	0.28	0.2	0.7	0.24	0.12	0.1	0.6	0.25
0.3	0.25	0.13	0.25	0	0.25	0.15	0.1	0.2	0.3
0.2	0.15	0.12	0.35	0	0.26	0.38	0.5	0.05	0.1
0.1	0.1	0.47	0.2	0.3	0.25	0.35	0.3	0.15	0.35

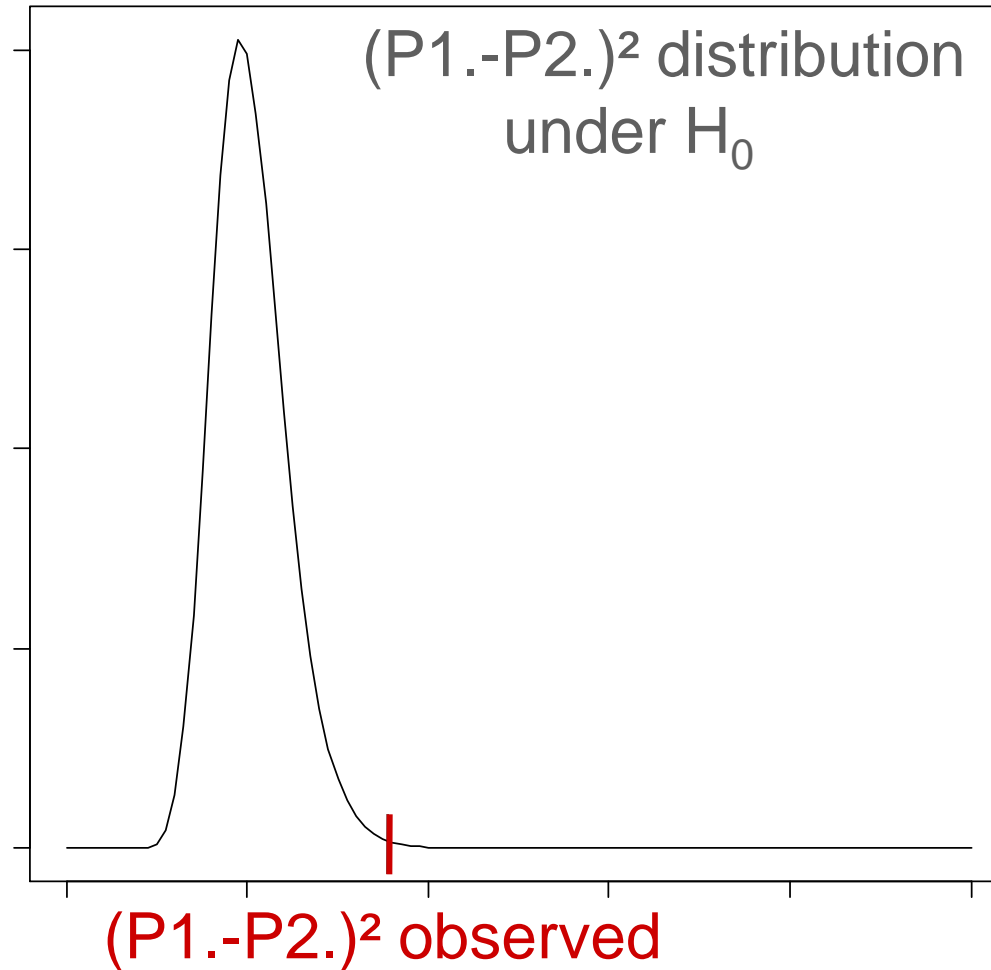
$(P1. - P2.)^2$ simulated

P2. for permutation 1

0.4	0.5	0.26	0.15	0.3	0.24	0.15	0.13	0.5	0.2
0.3	0.05	0.38	0.3	0.2	0.24	0.15	0.14	0.25	0.3
0.15	0.15	0.06	0.35	0.1	0.33	0.25	0.25	0.15	0.15
0.15	0.3	0.3	0.2	0.4	0.19	0.45	0.48	0.1	0.35

X 10.000
permutations

- Distribution under H_0 from 10.000 simulations:



- Permutation approach is used to test discrimination ability between product pairs at different levels

- Global
- Per attribute
- Per time point
- Per attribute*time point

Brittleness

Crispiness

Crunchiness

Dryness

Grittiness

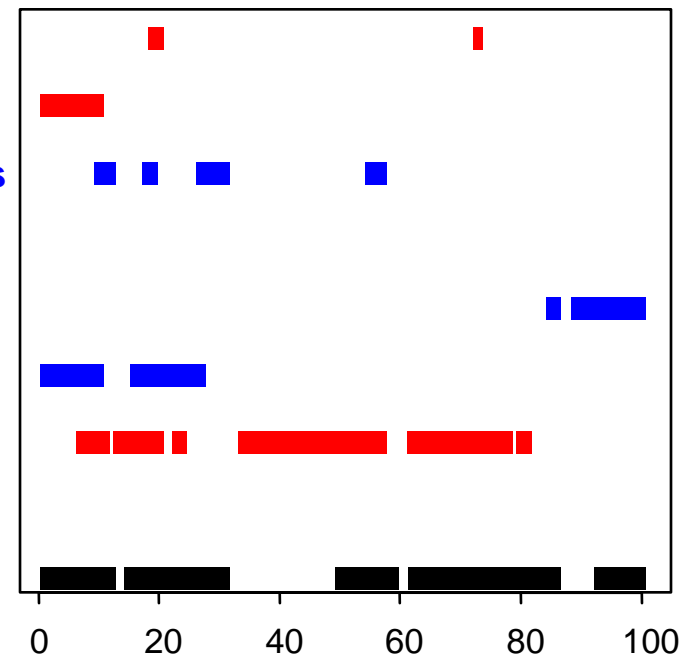
Hardness

Melting

Stickiness

timepoint

ProductC – ProductE



			time									
			t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉	t ₁₀
P1	Subject 1	A1	1	1	1	0	0	0	0	1	1	1
		A2	0	0	0	1	1	0	0	0	0	0
		A3	0	0	0	0	0	0	0	0	0	0
		A4	0	0	0	0	0	1	1	0	0	0
	Subject 2	A1	1	1	0	0	0	0	1	1	0	0
		A2	0	0	0	0	1	1	0	0	0	0
		A3	0	0	1	1	0	0	0	0	1	1
		A4	0	0	0	0	0	0	0	0	0	0
									
	Subject 20	A1	0	0	0	0	0	0	0	0	1	1
		A2	0	0	1	1	0	0	0	0	0	0
		A3	1	1	0	0	0	0	0	0	0	0
A4		0	0	0	0	1	1	1	1	0	0	
P2	Subject 1	A1	0	0	0	0	0	0	0	0	0	0
		A2	1	1	1	1	0	0	0	0	0	0
		A3	0	0	0	0	1	1	1	1	0	0
		A4	0	0	0	0	0	0	0	0	1	1
	Subject 2	A1	0	0	0	0	0	0	0	1	1	1
		A2	1	1	1	0	0	0	0	0	0	0
		A3	0	0	0	1	1	1	1	0	0	0
		A4	0	0	0	0	0	0	0	0	0	0
									
	Subject 20	A1	0	0	1	1	0	0	1	1	0	0
		A2	1	1	0	0	0	0	0	0	0	0
		A3	0	0	0	0	1	1	0	0	0	0
A4		0	0	0	0	0	0	0	0	1	1	

B: **BETWEEN** products
(P1 - P2)²

Vs.

W: **WITHIN** products
(variability between evaluations)



Ratio B/W



			t_1
P1	Subject 1	A1	1
		A2	0
		A3	0
		A4	0
Subject 2	A1	1	
	A2	0	
	A3	0	
	A4	0	
...	
Subject 20	A1	0	
	A2	0	
	A3	1	
	A4	0	
P2	Subject 1	A1	0
		A2	1
		A3	0
		A4	0
Subject 2	A1	0	
	A2	1	
	A3	0	
	A4	0	
...	
Subject 20	A1	0	
	A2	1	
	A3	0	
	A4	0	

P1	A1	0.21
	A2	0.28
	A3	0.07
	A4	0.44

P2	A1	0.25
	A2	0.31
	A3	0.17
	A4	0.27

B: BETWEEN products
(P1 - P2) ²

Vs.

W: WITHIN products
(variability between evaluations)



			t_1
P1	Subject 1	A1	1
		A2	0
		A3	0
		A4	0
	Subject 2	A1	1
		A2	0
		A3	0
		A4	0

	Subject 20	A1	0
		A2	0
		A3	1
A4		0	
P2	Subject 1	A1	0
		A2	1
		A3	0
		A4	0
	Subject 2	A1	0
		A2	1
		A3	0
		A4	0

	Subject 20	A1	0
		A2	1
		A3	0
A4		0	

ANOVA model
For 1 time point

Product



0

+ Subject



0

+ Attribute



MS_A

+ $P*S$



0

+ $S*A$



Disagreement toward
attribute use

+ $P*A$



B

+ ϵ

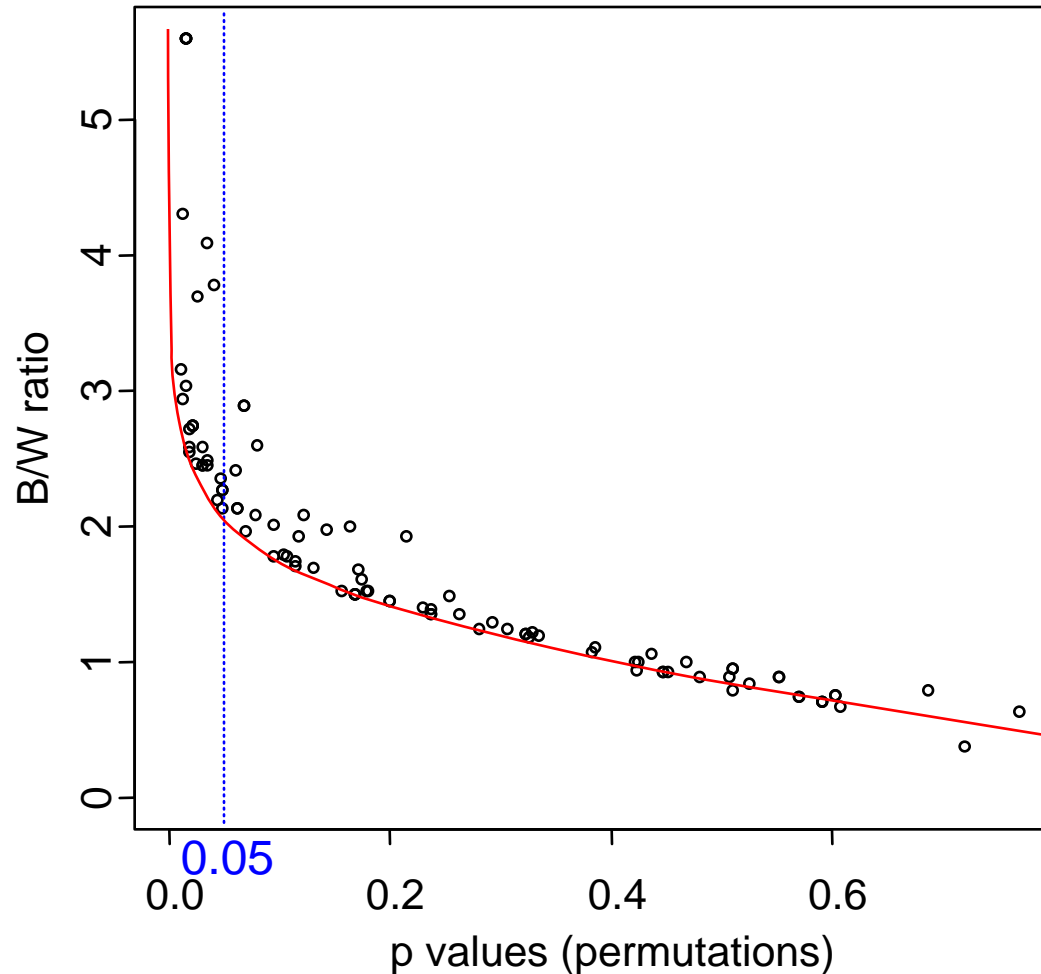


W

) B/W



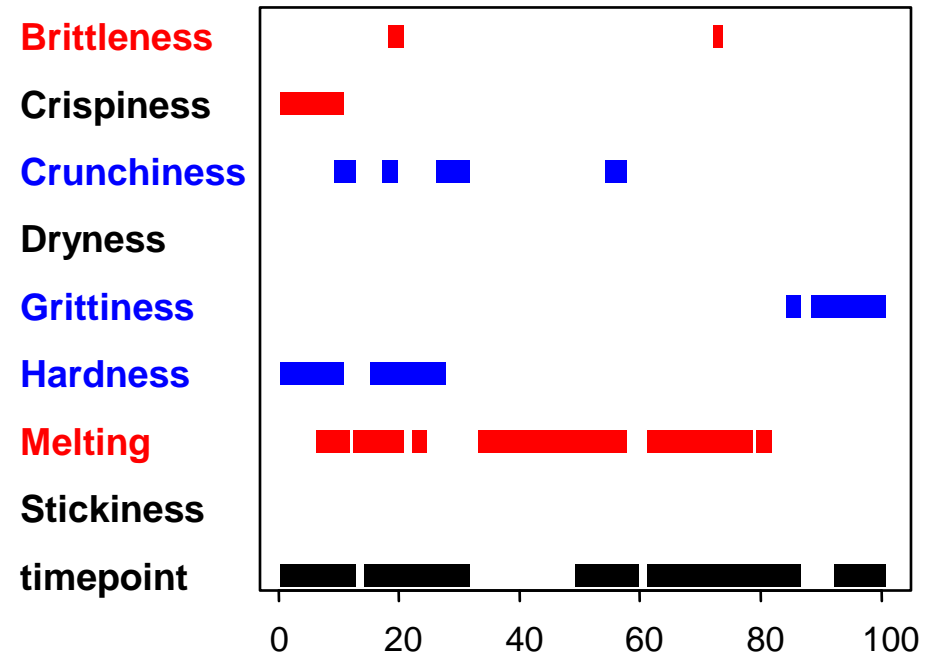
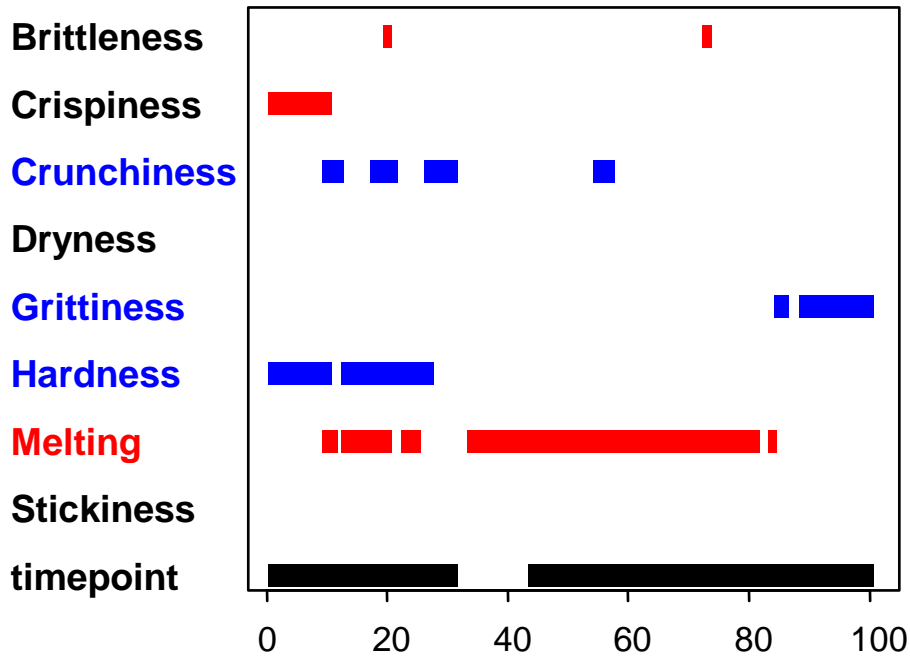
Timepoints: ProductA - ProductE



— Probability from Fisher(df_{num}, df_{den})

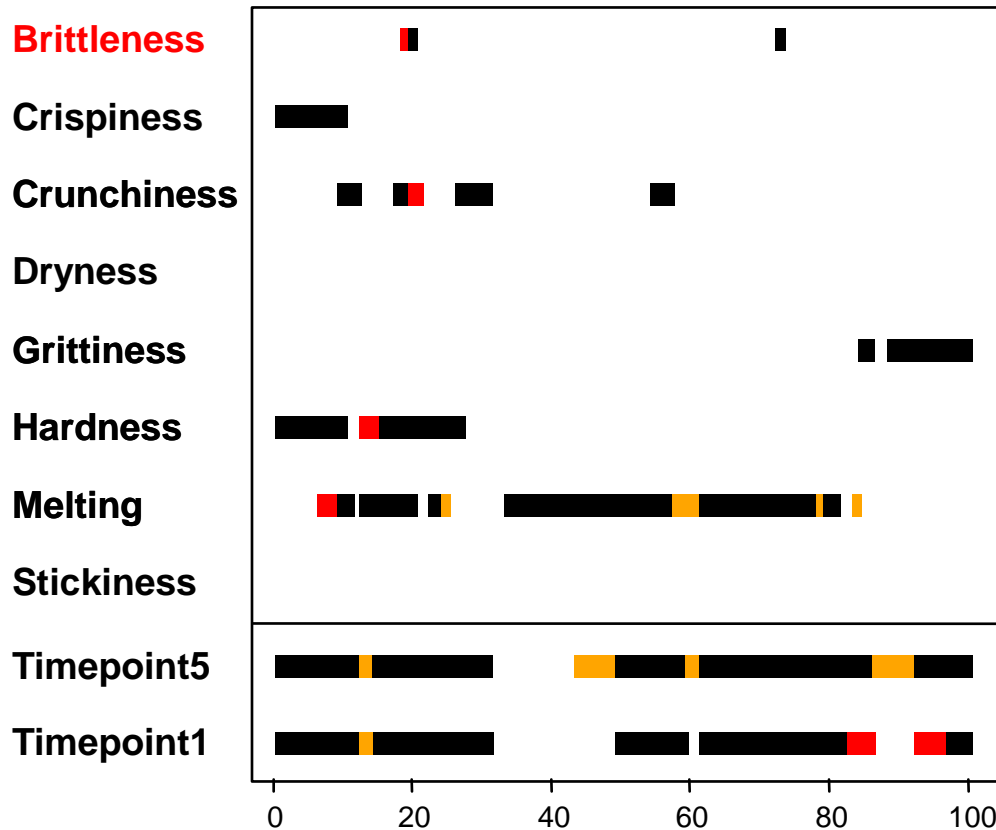
ProductC – ProductE B/W 5%

ProductC – ProductE PERMUTATION



- Test per time point: B/W
- Test per attribute : B/W
- Test per time point*attribute: McNemar

ProductC – ProductE



Perm. Vs. McNemar

Perm. Vs. B/W 5%

Perm. Vs. B/W 1%
(9% mismatch)

- Perm. significant but not McNemar or B/W
- McNemar or B/W significant but not Perm.
- Both significant

Comparison of the results based on 18 studies



Good Food, Good Life

% Mismatch vs. Permutation approach			
dataset	Timepoint		Att x Timepoint
	5%	1%	
AROMA	12.53	3.24	1.21
CAKE	10.56	5.28	0.17
CEREAL1	5.35	3.71	0.76
CEREAL2	15.58	9.31	0.17
CEREAL3	14.13	7.06	0.36
CEREAL4	8.32	2.38	0.37
CEREAL5	14.57	4.69	0.45
CEREAL6	13.25	4.69	0.42
CEREAL7	9.9	3.12	0.51
CHOCOLATE	7.07	2.81	0.19
CREAMER	9.26	2.97	0.42
GEL	11.14	2.94	0.69
ICECREAM1	0.99	3.63	0.13
ICECREAM2	1.98	5.94	0.2
REDWINE1	10.64	4.49	0.83
REDWINE2	6.51	4.24	0.34
TASTE1	10.53	4.85	0.39
TEXTURE	10.64	6.24	0.46
AVERAGE	9.6%	4.5%	0.45%

Attributes	Products	Panellists	Replicates	Evaluations
3	12	15	3	44
8	3	7	3	21
8	6	26	2	52
7	6	16	2	32
17	6	16	2	32
15	6	16	2	32
8	10	16	2	32
16	10	16	2	32
16	10	16	2	32
18	9	13	3	39
7	8	12	4	48
5	9	43	1	43
5	3	44	1	44
5	3	44	1	44
10	8	16	3	48
5	8	15	4	60
10	12	15	3	45
9	12	15	3	45



Vs. ANOVA

Vs.

McNemar

- **Background & objectives**

- TDS data
- Evaluation of panel performance

- **Alternative method to assess discrimination (panel)**

- Method used as a reference: Permutation approach
- Alternative method based on Analysis of Variance
- Comparison of the results between both approaches

- **Same approach for agreement and individual performance**

- The same approach can be used to measure the agreement between panellists
- The same approach can be used at individual level

- **Conclusion**

- Agreement at panel level
 - from the ANOVA model
 - Interaction Subject*Product*Attribute: expresses the (dis-) agreement between panellists regarding attributes dominance within products
 - NB: Replicated are needed to measure this interaction
- Agreement at panellist level
 - from the ANOVA model also
 - Contribution of each subject to the interaction
- Discrimination ability at panellist level
 - from the ANOVA model also
 - Model at individual level

But very few data
(and only 0/1) !
And not really 100
time points (≈ 5).



Summary in
5 time points



- Smart way of doing: permutation approach
- But B/W approach gives very close results
 - As long as alpha level is decreased
- And easy to run
 - Analysis with any ANOVA/GLM software
 - Faster to run
 - Time for 10.000 permutations : 6h
 - Time for 1.000 permutations: 30 minutes
 - Time for B/W approach: about 1 minute
- Next step: validation at panellist level