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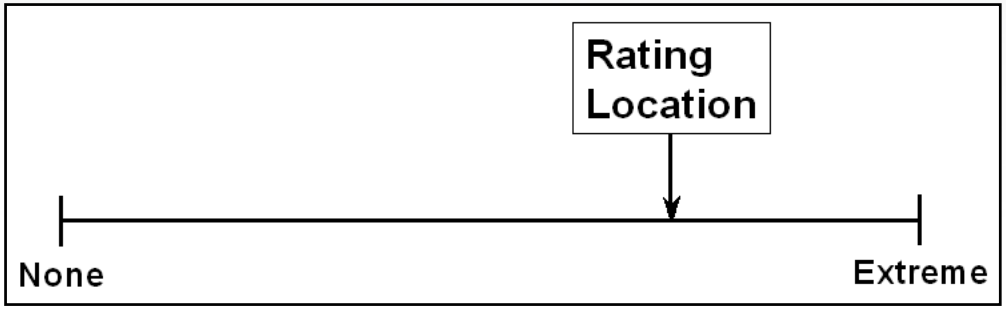
Evaluating assessor performance in a sensory lab

The SensExpert software

Introduction: The sensory panel

- Assessors are personell trained to identify and rate different attributes for different products.
- Ratings are given as scores, typically on a 0-10 scale, or the ”analog” way, by indicating a position on a line, and digitized afterwards.



Can we trust the sensory panel?

In a sensory lab where assessors come and go and time for training is short, the need for measuring and tracking each assessor's performance is great.

Even when time is on our side, assessors consistently give variable results, stemming from differences in motivation, sensitivity, and psychological response behaviors.

Motivation for analysis of the panel performance

Monitoring the consistency of each assessor and their agreement with the other assessors allows us to obtain reliable data and gives us insight into each assessor's abilities and behaviors.

Six tests that covers most sensory aspects

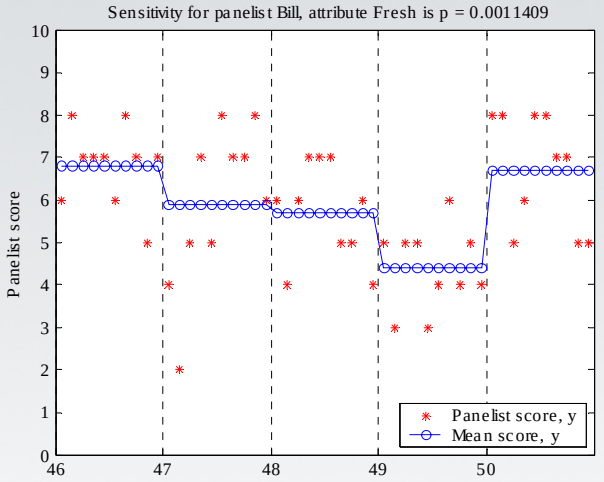
1. Assessor Sensitivity
2. Assessor Reproducibility
   - Anova on residuals
   - Spotty plot
3. Assessor Agreement
4. Assessor Crossover
5. Eggshell Correlation

Test 1: assessor sensitivity

- Sensitivity measures the ability of a single assessor to identify product differences.
- The sensitivity test checks if the variability in scores from a assessor for different products is significant (one-way ANOVA and F-test).
- a low *p*-value supports the null-hypothesis, that variability is not significant, and thus good.

Sensitivity Result

Results are displayed as table with p-values and plot indicating individual performance.



	Fresh Fish Aroma	Fishy Aroma	Overall Aroma	Fresh Fish Flavor	Fishy Flavor	Flaky Texture	Flake Size	Hardness	Mushiness	Mouth Coating	Chewiness
Alison	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Bill	0,001	0,076	0,000	0,000	0,228	0,000	0,079	0,000	0,000	0,008	0,000
Bob	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,022
Jan	0,245	0,000	0,094	0,000	0,000	0,000	0,000	0,000	0,000	0,098	0,000
Bob	0,000	0,000	0,057	0,000	0,000	0,001	0,000	0,000	0,002	0,198	0,000
Mike	0,387	0,373	0,000	0,002	0,000	0,125	0,000	0,000	0,000	0,000	0,000
Sally	0,000	0,002	0,001	0,001	0,000	0,000	0,017	0,000	0,000	0,000	0,429
Sandy	0,000	0,006	0,016	0,004	0,000	0,000	0,000	0,000	0,016	0,000	0,000
Sharon	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Full ANOVA model

- The rest of the analysis uses two-way ANOVA with effects including “Replication” pooled as random error and “assessors” random effects

y = assessors + product + assessor by product + residual

- Store the unstandardized residuals from each attribute. This will be used for further analysis

Test 2: Assessor reproducibility

- Reproducibility monitors the ability of a single assessor to reproduce their result with respect to the rest of the panel.
- The test uses the panel as a baseline against which each assessor is tested (one-way ANOVA) to identify those who considerably contribute to the error not explained in the two-way ANOVA test.

Reproducibility Results 1: ANOVA method

Results are displayed as table with p-values and plot indicating individual performance.

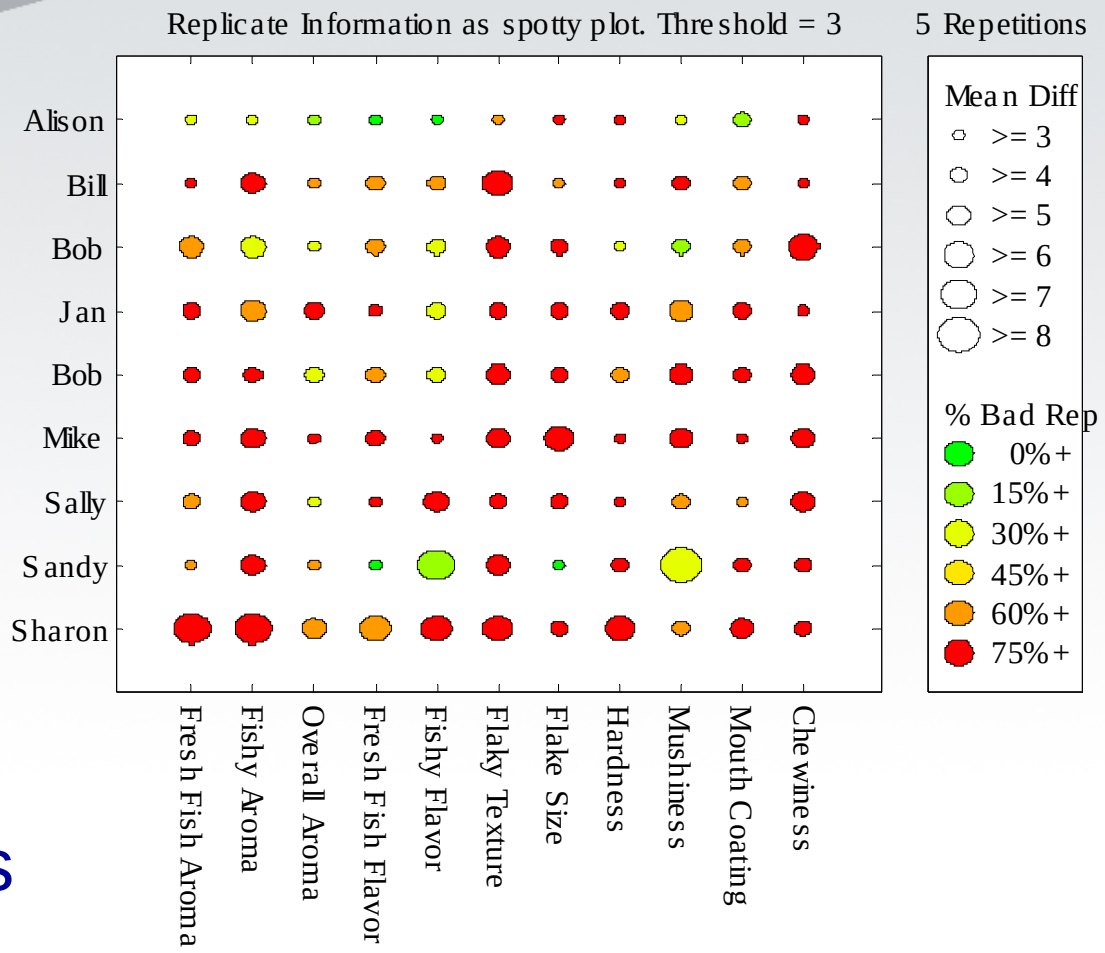
	Fresh Fish Aroma	Fishy Aroma	Overall Aroma	Fresh Fish Flavor	Fishy Flavor	Flaky Texture	Flake Size	Hardness	Mushiness	Mouth Coating	Chewiness
Alison	1,000	1,000	0,999	1,000	1,000	1,000	0,995	0,871	1,000	1,000	1,000
Bill	0,772	0,176	0,700	0,202	0,460	0,005	1,000	0,510	0,869	0,794	0,999
Bob	0,221	0,997	0,947	0,237	0,717	0,504	0,106	0,999	1,000	0,844	0,000
Jan	0,229	0,836	0,034	0,804	0,982	0,970	0,099	0,699	0,586	0,153	0,997
Bob	0,198	0,924	0,410	0,264	0,907	0,014	0,002	0,208	0,000	0,006	0,649
Mike	0,639	0,022	0,163	0,228	0,756	0,706	0,000	0,730	0,001	0,932	0,011
Sally	0,988	0,074	0,997	0,192	0,000	0,997	0,639	0,941	0,986	0,943	0,001
Sandy	0,999	0,151	0,815	1,000	0,790	0,321	1,000	0,199	0,003	0,074	0,832
Sharon	0,000	0,011	0,000	0,000	0,000	0,019	0,652	0,000	0,894	0,018	0,979

Reproducibility Results 2: Spotty Plot

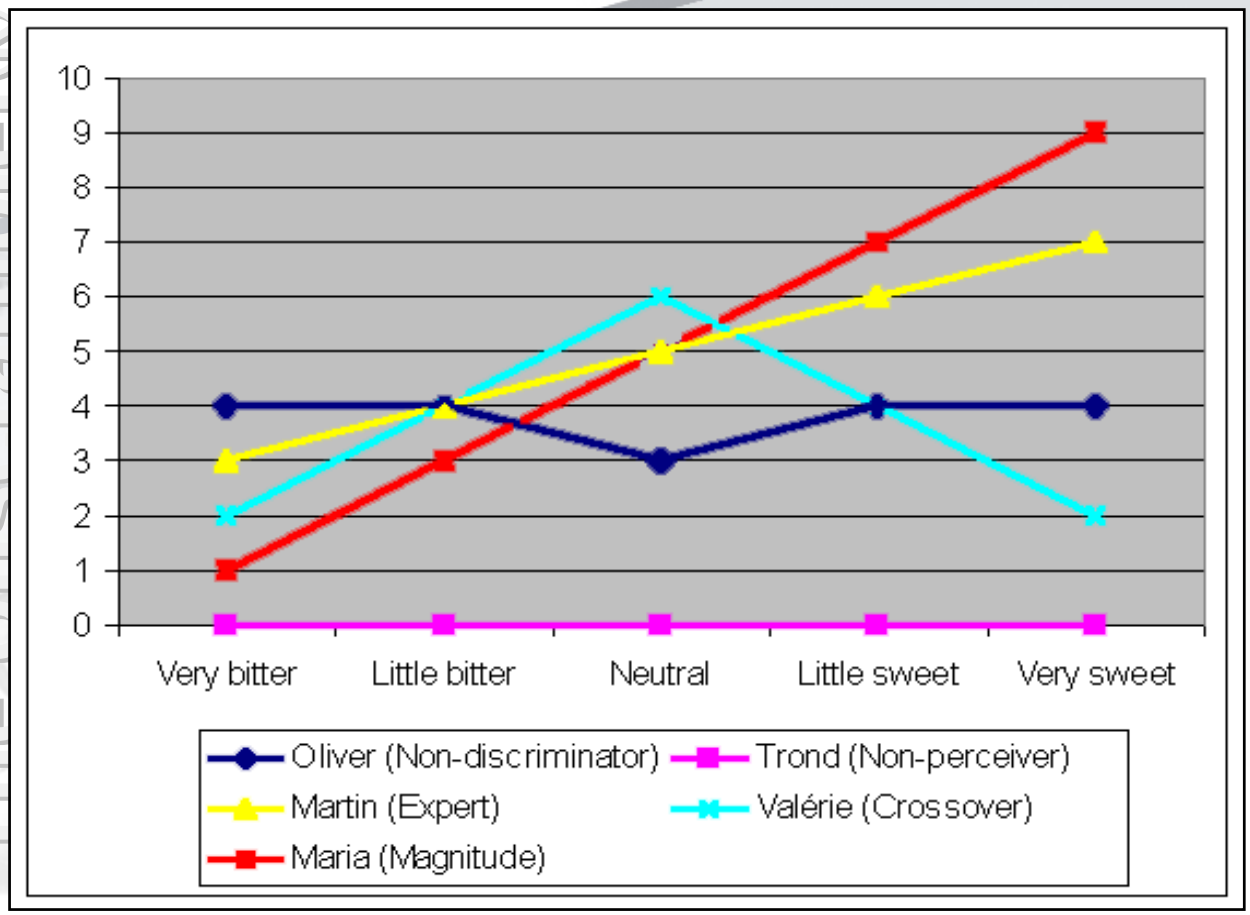
Spotty plots show a spot for each assessor for each attribute.

Large spot:
Big mean difference

Red spot:
Many bad replications



Assessor agreement



Magnitude

Expert

Non-discriminator

Cross-over

Non-perceiver

Test 3: Agreement error

- Run ”reduced” ANOVA (two-way and with no interaction)

  y = assessors + product + residual

- Use difference between this ANOVA model and the full ANOVA model.
- Run one-way ANOVA for each assessor using model effects from the subtraction

Test 4: Cross-over effects

- Subtract the product mean and panel mean and compare the sign of the subtraction.
- If signs do not match, square the subtraction value and include it in the assessor's sum of contribution to cross-over effects
- Sum of Square cross-over is then the portion of agreement error due to assessors scoring products oppositely than panel mean.

Agreement and Crossover result

P-values and crossover percentage

		Fresh Fish Aroma	Fishy Aroma	Overall Aroma	Fresh Fish Flavor	Fishy Flavor	Flaky Texture	Flake Size	Hardness	Mushiness	Mouth Coating	Chewiness
Alison	Crossover%	87,7	59,1	98,6	13,1	99,6	80,2	49,1	38,9	24,0	35,2	5,7
	Agreement p	0,080	0,241	0,000	0,036	0,742	0,004	0,237	0,101	0,000	0,059	0,003
Bill	Crossover%	100,0	93,8	77,1	65,9	99,9	23,7	100,0	0,0	18,6	46,6	4,1
	Agreement p	0,115	0,000	0,000	0,043	0,000	0,079	0,009	0,438	0,037	0,838	0,629
Bob	Crossover%	0,0	0,0	6,0	34,5	0,0	17,6	45,3	15,6	73,2	0,0	93,5
	Agreement p	0,000	0,000	0,000	0,000	0,000	0,004	0,003	0,303	0,153	0,002	0,964
Jan	Crossover%	100,0	48,8	100,0	72,6	96,5	88,8	65,6	73,7	97,6	19,3	89,3
	Agreement p	0,001	0,712	0,000	0,221	0,238	0,000	0,001	0,416	0,088	0,786	0,182
Bob	Crossover%	66,4	79,2	66,5	27,8	100,0	4,2	0,2	80,6	93,9	100,0	62,1
	Agreement p	0,533	0,377	0,825	0,086	0,491	0,423	0,012	0,000	0,000	0,000	0,042
Mike	Crossover%	94,4	96,6	19,6	83,4	85,1	98,9	5,1	15,4	14,5	89,6	0,0
	Agreement p	0,003	0,019	0,011	0,000	0,567	0,013	0,000	0,329	0,036	0,158	0,183
Sally	Crossover%	71,8	46,3	64,6	92,6	83,0	16,7	100,0	95,6	100,0	40,3	99,5
	Agreement p	0,222	0,921	0,507	0,107	0,306	0,128	0,012	0,033	0,380	0,469	0,008
Sandy	Crossover%	94,4	98,3	81,0	99,0	100,0	58,1	99,4	100,0	94,5	75,0	100,0
	Agreement p	0,056	0,008	0,427	0,000	0,002	0,033	0,016	0,265	0,034	0,000	0,902
Sharon	Crossover%	0,0	0,0	0,8	25,3	0,0	16,2	0,0	0,0	0,0	13,3	23,2
	Agreement p	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,005	0,000	0,000	0,464

Test 5: Rank Correlation

- Rank correlation can also be used as a form of agreement test.
- Here, the rank instead of score values are used.
- Rank correlation measures the correlation between an assessor and the panel consensus ranking.

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Results from Rank correlation 1

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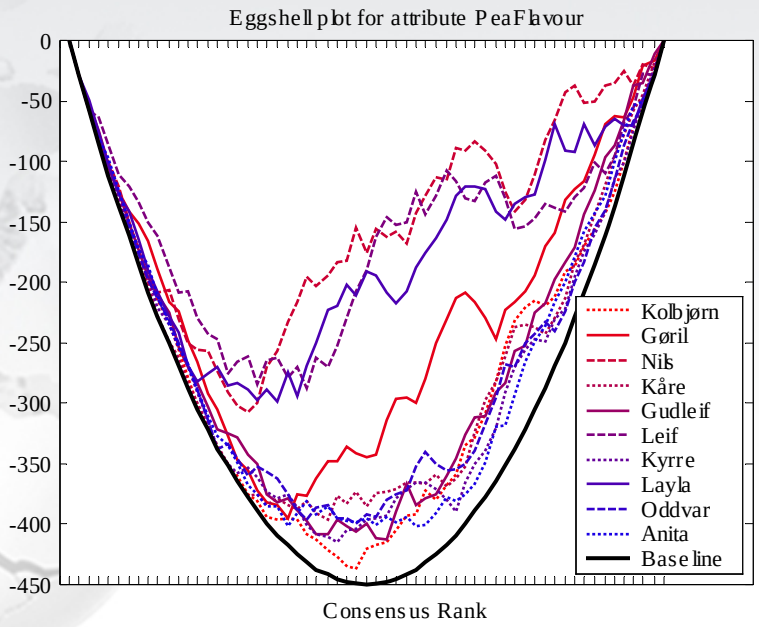
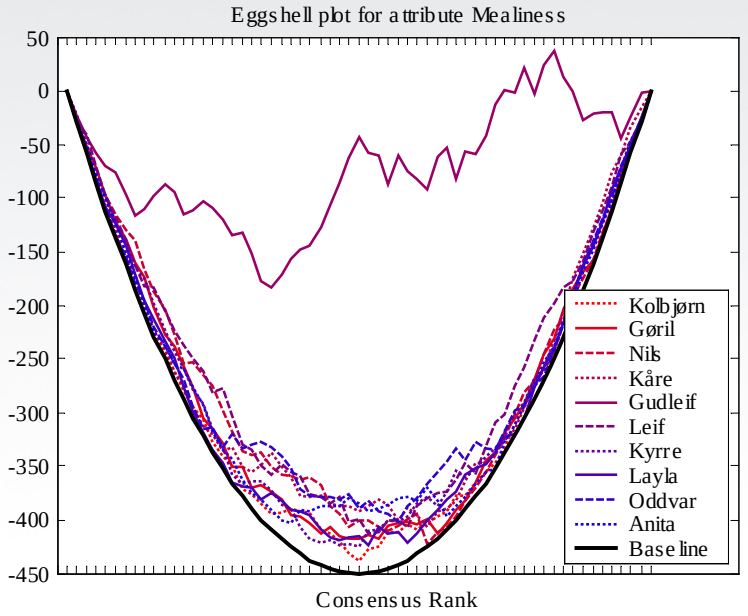
Correlation values for each assessor and for each attribute, indicating correlation with the rest of the panel.

	Fresh Fish Aroma	Fishy Aroma	Overall Aroma	Fresh Fish Flavor	Fishy Flavor	Flaky Texture	Flake Size	Hardness	Mushiness	Mouth Coating	Chewiness
Alison	0,3	0,95	0,3	0,9	1	0,7	0,9	0,95	0,95	0,6	0,9
Bill	0,6	0,4	0,4	0,7	0,8	1	0,8	1	1	0,9	1
Bob	0,9	0,9	0,6	0,6	0,9	0,85	0,8	1	0,95	0,9	0,95
Jan	0,1	0,8	0,1	0,35	0,7	0	0,5	0,8	0,9	0,9	0,8
Bob	0,9	0,9	0,8	1	0,8	0,9	0,95	0,2	0,7	-0,6	0,95
Mike	0,85	0,85	0,6	0,3	0,9	0,7	1	1	0,9	0,9	1
Sally	0,9	0,9	0,7	1	0,8	0,9	0,9	1	0,9	0,9	0,7
Sandy	0,7	0,7	0,8	0,85	0,65	0,8	0,9	1	0,9	0,7	1
Sharon	0,9	0,65	0,5	0,7	0,95	0,9	1	1	1	0,6	1

Results from Rank correlation 2

Eggshell plots





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Data set: Chocolate Cake (3 rep's)

8 Attributes:

- Rosemary aroma
- Sweet aroma
- Greasiness
- Mint flavour
- After taste
- Moistness
- Crumbleness
- Adhesiveness

6 Panelists:

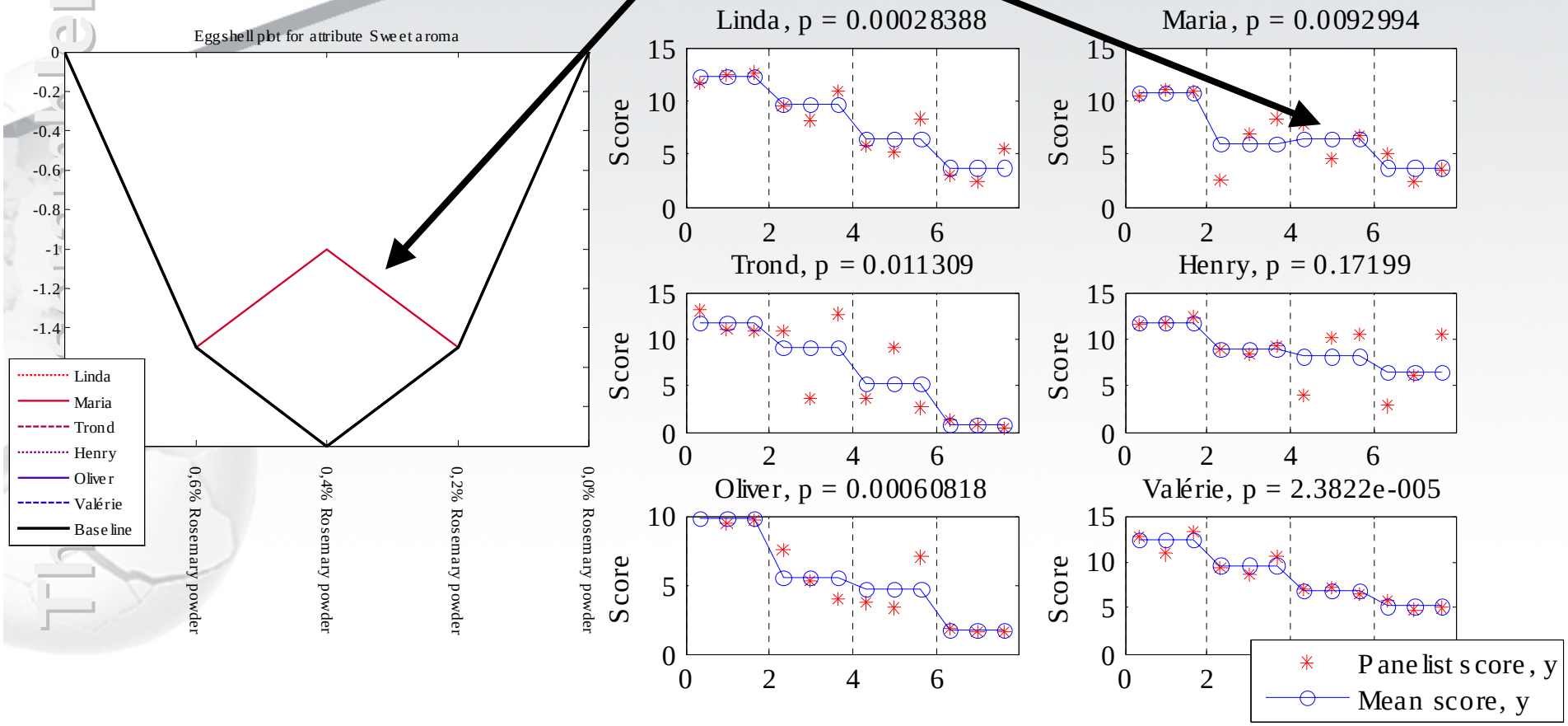
- Linda
- Maria
- Trond
- Henry
- Oliver
- Valérie

4 Samples:

- 0.0% Rosemary
- 0.2% Rosemary
- 0.4% Rosemary
- 0.6% Rosemary

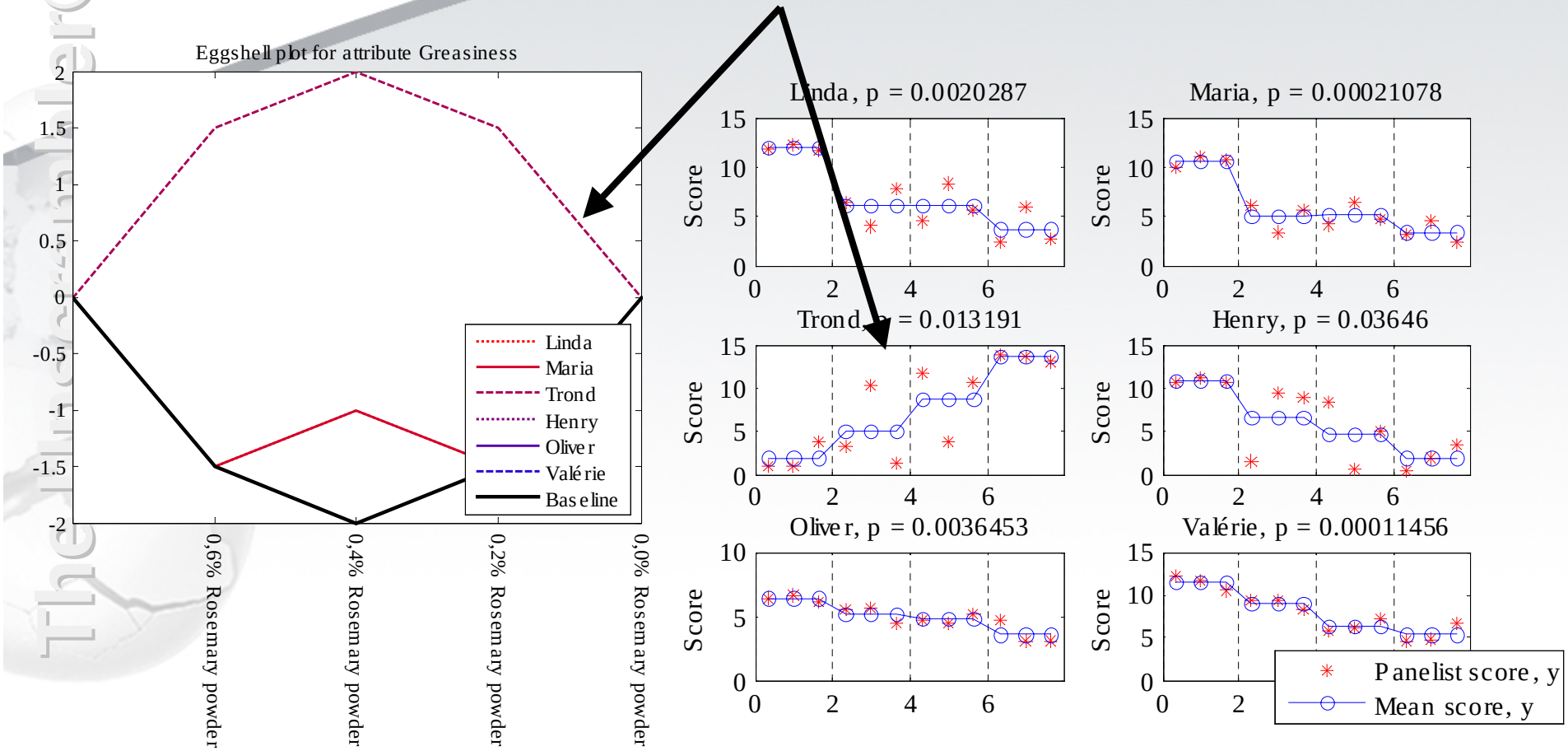
Sweet aroma: Good sensitivity

Small sensitivity error

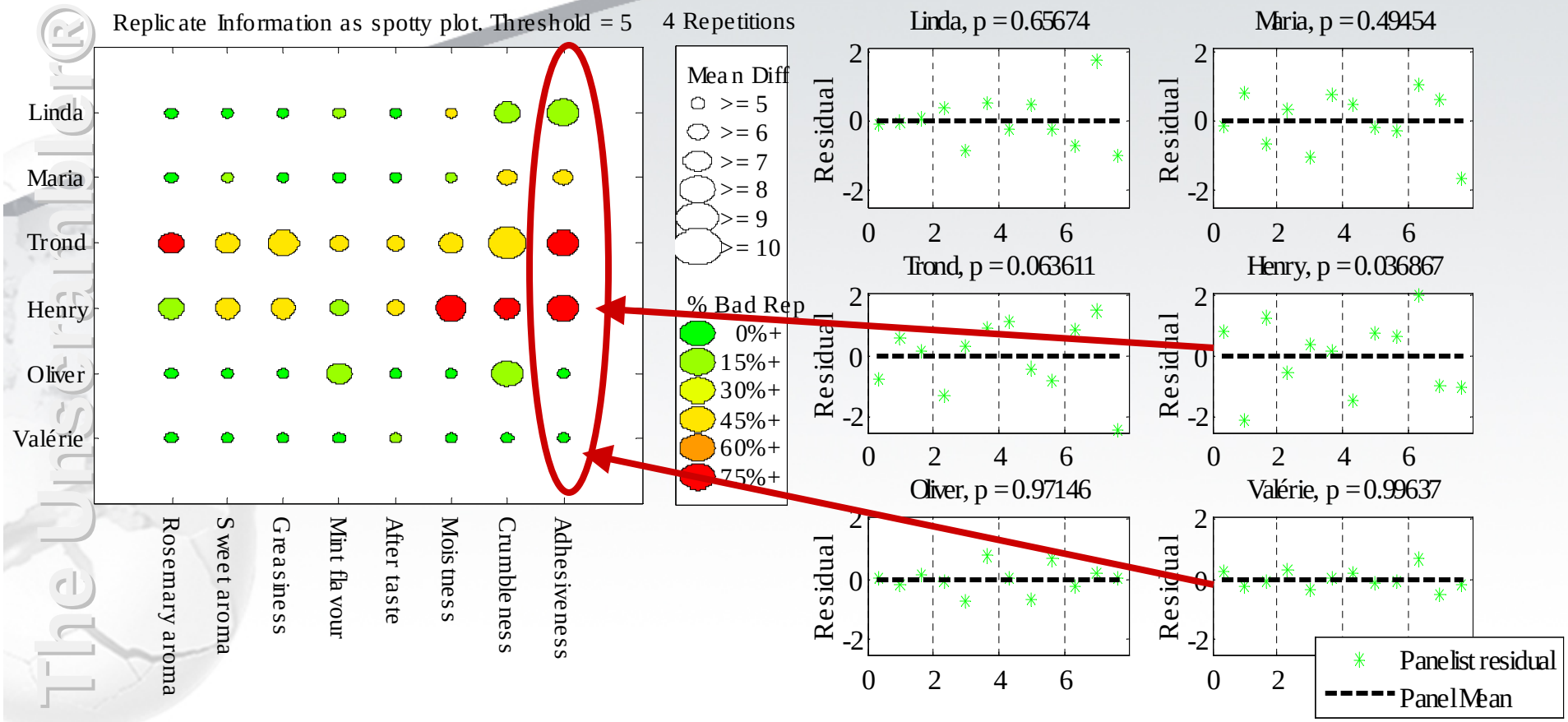


Crossover error

Poor agreement due to crossover



Panel reproducibility



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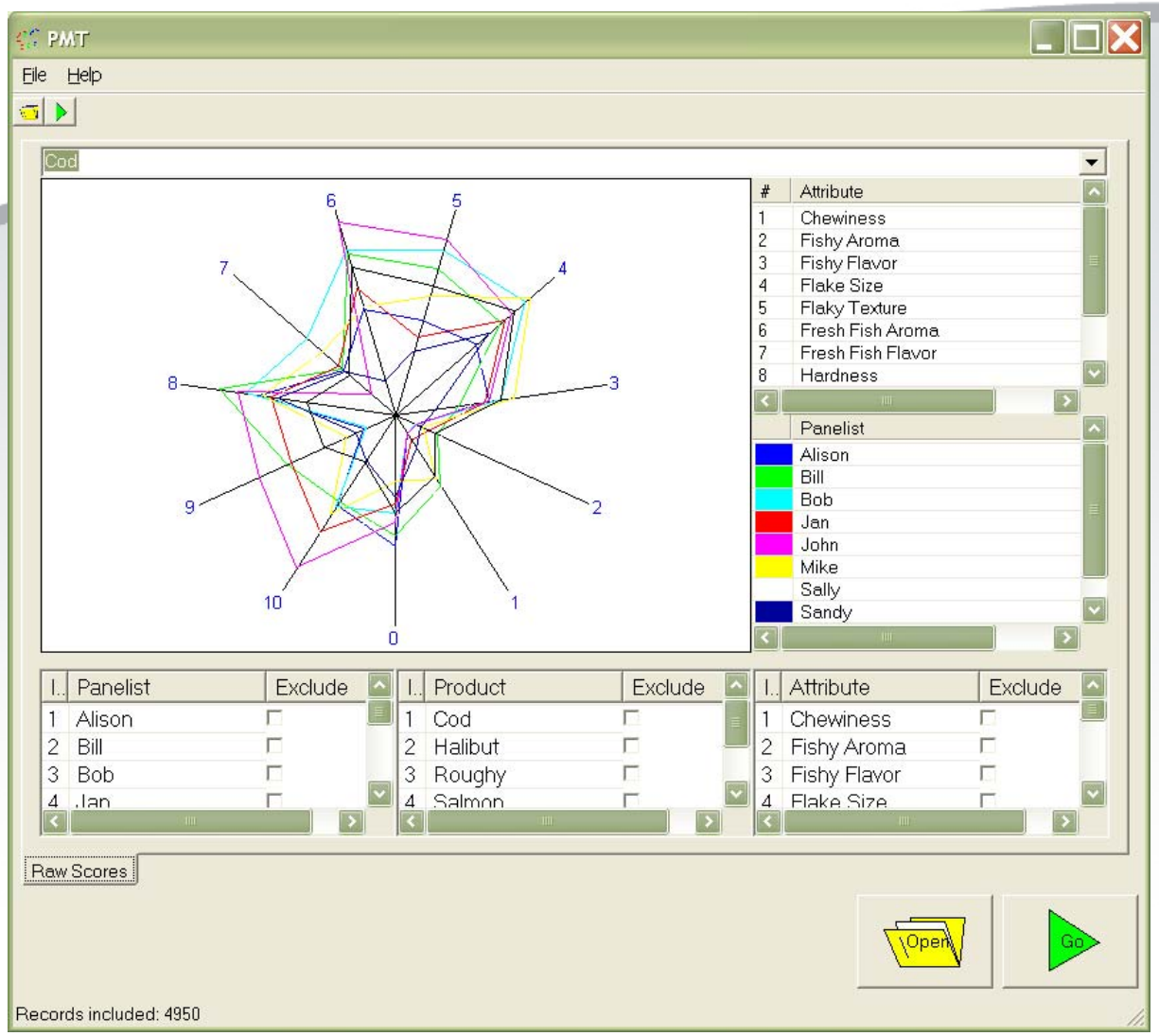
SensExpert is a software system that runs all these tests.

Data is imported and analysed.



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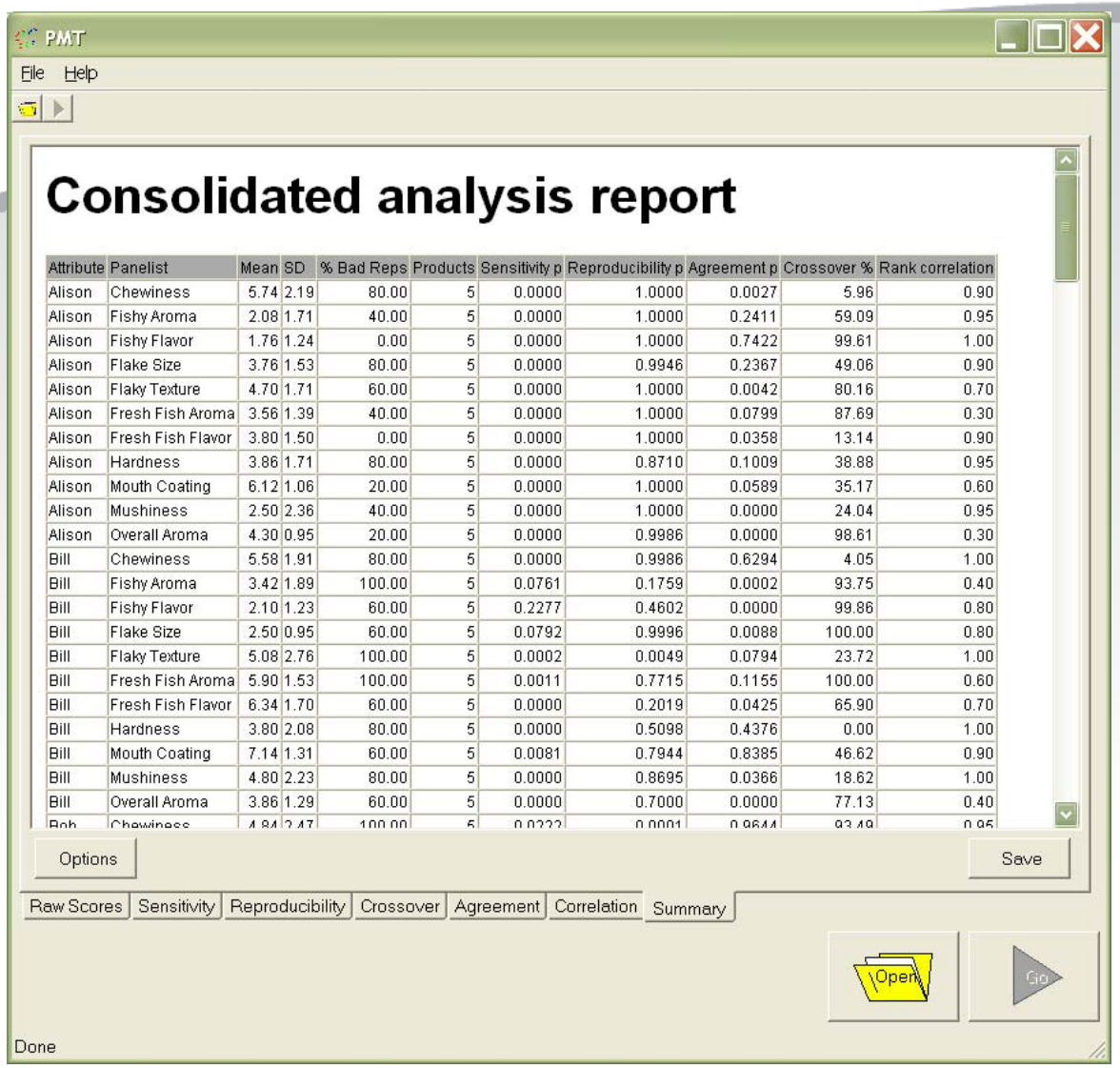
Analysis is shown as tables with p-values or SS.

An analysis report is generated presenting all results.



Attribute	Panelist	Mean	SD	% Bad Reps	Products	Sensitivity p	Reproducibility p	Agreement p	Crossover %	Rank correlation
Alison	Chewiness	5.74	2.19	80.00	5	0.0000	1.0000	0.0027	5.96	0.90
Alison	Fishy Aroma	2.08	1.71	40.00	5	0.0000	1.0000	0.2411	59.09	0.95
Alison	Fishy Flavor	1.76	1.24	0.00	5	0.0000	1.0000	0.7422	99.61	1.00
Alison	Flake Size	3.76	1.53	80.00	5	0.0000	0.9946	0.2367	49.06	0.90
Alison	Flaky Texture	4.70	1.71	60.00	5	0.0000	1.0000	0.0042	80.16	0.70
Alison	Fresh Fish Aroma	3.56	1.39	40.00	5	0.0000	1.0000	0.0799	87.69	0.30
Alison	Fresh Fish Flavor	3.80	1.50	0.00	5	0.0000	1.0000	0.0358	13.14	0.90
Alison	Hardness	3.86	1.71	80.00	5	0.0000	0.8710	0.1009	38.88	0.95
Alison	Mouth Coating	6.12	1.06	20.00	5	0.0000	1.0000	0.0589	35.17	0.60
Alison	Mushiness	2.50	2.36	40.00	5	0.0000	1.0000	0.0000	24.04	0.95
Alison	Overall Aroma	4.30	0.95	20.00	5	0.0000	0.9986	0.0000	98.61	0.30
Bill	Chewiness	5.58	1.91	80.00	5	0.0000	0.9986	0.6294	4.05	1.00
Bill	Fishy Aroma	3.42	1.89	100.00	5	0.0761	0.1759	0.0002	93.75	0.40
Bill	Fishy Flavor	2.10	1.23	60.00	5	0.2277	0.4602	0.0000	99.86	0.80
Bill	Flake Size	2.50	0.95	60.00	5	0.0792	0.9996	0.0088	100.00	0.80
Bill	Flaky Texture	5.08	2.76	100.00	5	0.0002	0.0049	0.0794	23.72	1.00
Bill	Fresh Fish Aroma	5.90	1.53	100.00	5	0.0011	0.7715	0.1155	100.00	0.60
Bill	Fresh Fish Flavor	6.34	1.70	60.00	5	0.0000	0.2019	0.0425	65.90	0.70
Bill	Hardness	3.80	2.08	80.00	5	0.0000	0.5098	0.4376	0.00	1.00
Bill	Mouth Coating	7.14	1.31	60.00	5	0.0081	0.7944	0.8385	46.62	0.90
Bill	Mushiness	4.80	2.23	80.00	5	0.0000	0.8695	0.0366	18.62	1.00
Bill	Overall Aroma	3.86	1.29	60.00	5	0.0000	0.7000	0.0000	77.13	0.40
Bob	Chewiness	4.84	2.47	100.00	5	0.0222	0.0001	0.9644	93.49	0.95

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Thank you for listening!