Temporal Rate-All-That-Apply (TRATA): A novel temporal method for sensory evaluation

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Background

This study introduces temporal rate-all-that-apply (TRATA) as a new temporal sensory method. It was inspired by rate-all-that-apply (RATA) and temporal check-all-that-apply (TCATA), but is most similar to multiple-attribute time intensity (MATI) in that the TRATA method allows for simultaneous rating of attribute intensities over time. ***Only attributes that are perceived are scaled.***

In this case study, the TRATA method was used to study the interaction between three sulphur compounds in model wine. These interactions have proven problematic when evaluated by sensory descriptive analysis (DA) due to the rapid changes in the headspace aromas and their intensities. TRATA provided insights into the dynamic sensory space of closely related samples.

Methodology

Attributes and samples: based on the preliminary DA for model wine spiked with three different sulphur compounds: 3-mercaptohexanol (3MH), 3-mercaptohexylacetate (3MHA) and ethanethiol (EtSH) (Vannevel 2021)

Judges: 15 trained panelists, 26-60 yo, 10 females + 5 males; experienced in evaluating wine spiked with sulphur compounds

Procedure: training session for the use of TRATA and Compusense at-hand designed for the experiment

- judge is presented with the list of attributes as in a normal RATA analysis;
- attributes are presented in a fixed order and position;
- number of attributes limited to ten as recommended in TDS and used in TCATA;
- evaluate the sample and rate any attribute applicable to the sample at any given point in 120 s;
- judges can rate and re-rate intensity as the marker fades in 5 s, software records timestamp and report at 10 ms intervals (Fig 1-3).

Data analysis

✓ *Pre-processing:* raw data can be considered as $a = 1, ..., A$ attributes, $k = 1, ..., K$ samples, $r = 1, ..., R$ TRATA runs and $t = 1, ..., T$ time slices. This TRATA data forms a multivariate time series where the response x_{akrt} is an intensity value of either 0, when the attribute a was not rated at that point of the evaluation, or an intensity value between 0.01 and 100, when the intensity of an attribute a was rated at that time point.

✓ *Visualization of raw TRATA data:* arranged in a matrix where each row represents an attribute of a sample from a specific run and time slices in columns. This data can be visualised in curves for each product k for each attribute a and run r for the fifteen judges

✓ *Linear Mixed Model Fit by Restricted Maximum Likelihood (REML) estimation:* intensities for each evaluation and for each attribute were divided into four quarters, Q1: 0.01-30.00 s, Q2: 30.01-60.00 s, Q3: 60.01-90.00 s, and Q4: 90.01-120.00 s. The data used for analysis is thus in terms of AUC (area under the curve). Where Quarter was included in the model, it was treated as an ordered factor (Q1 < Q2 < Q3 < Q4).

✓ *TRATA product trajectories:* data organised as tables of intensities with products in rows and attributes in columns, one table per time slice. PCA on the TRATA data with the sample at each time slice forming a trajectory that shows the evolution of that sample over time (Fig 4).

Results

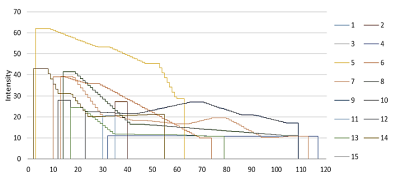

Fig 1. Intensity of attribute "Cooked Veg" in sample 1 over the 120 s evaluation for all 15 judges

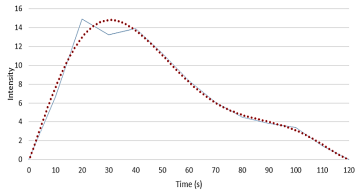

Fig 2. Average intensity of "Cooked Veg" in sample 1 for all 15 judges

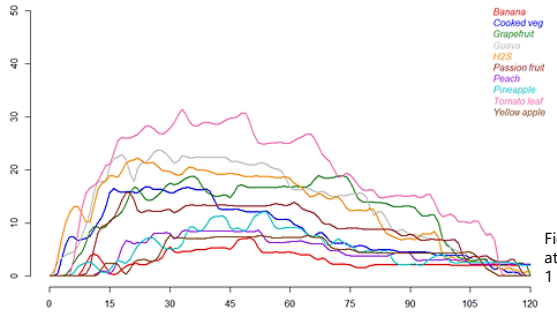

Fig 3. Average intensity for all attributes for all judges for sample 1 over the 120 s evaluation

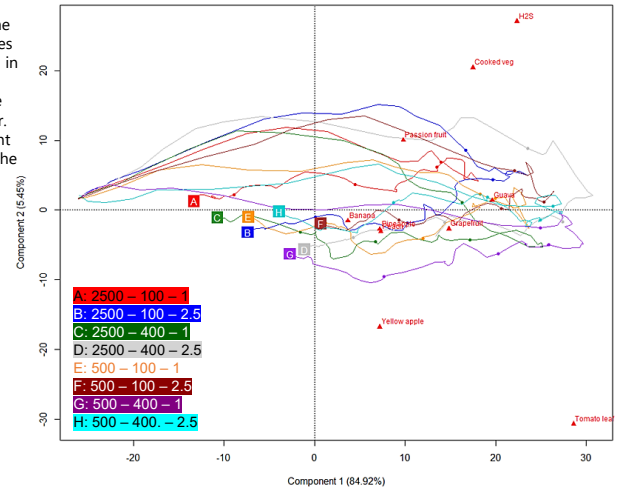

Fig 4. PCA biplot for the TRATA data. Trajectories are smoothed and end in a label indicating the sample name. Dots are shown at every quarter. Sample codes represent the concentrations in the following order: 3MH (ng/L) – 3MHA (ng/L) – EtSH (µg/L)

Table 1. Fixed effects for the attribute *Guava* (effects marked in red are significant at p<0.05). Below: effects for the 120 s evaluation time, taking into account the Quarter as a factor. Right: effects per Quarter (30 s each) indicating significant factors during the time interval.
'Estimate': estimate change per unit increase in that effect, df: degrees of freedom, t-value: calculated difference represented in units of standard error , Pr(>|t|): p-value

Fixed effects (Guava)	Estimate	Std. Error	df	t-value	Pr(>|t|)
intercept	19934.75	7881.19	16.93	2.529	0.022
3MH	4266.53	485.87	4022	8.781	<0.0001
3MHA	1367.03	1471.42	353.03	0.929	0.353
EtSH	3474.9	1975.07	164.22	1.759	0.080
Quarter	-17206.89	2430.38	4017.88	-7.08	<0.0001
3MH:3MHA	1947	686.25	4018.08	2.837	0.005
3MH:EtSH	-756.13	821.14	4018.25	-0.921	0.357
3MH:Quarter	-4772.02	958.58	4017.88	-4.978	<0.0001
3MHA:EtSH	919.4	861.02	700.69	1.068	0.286
3MHA:Quarter	-4036.92	1944.12	4017.88	-2.076	0.038
EtSH:Quarter	-4576.16	2727.47	4017.88	-1.678	0.093
3MH:3MHA:EtSH	-990.46	427.33	4018	-2.318	0.020
3MH:3MHA:Quarter	208.49	866.91	4017.88	0.241	0.809
3MH:EtSH:Quarter	2001.86	1354.8	4017.88	1.478	0.140
3MHA:EtSH:Quarter	531.49	877.97	4017.88	0.605	0.544

Guava	Estimate	Std. Error	df	t value	Pr(>|t|)
Results for Quarter 1					
intercept	28059.99	8602.526	19.22486	3.261832	0.004
3MH	7352.377	879.4686	987.6764	8.360022	<0.0001
3MHA	6032.735	2094.571	146.6934	2.880177	0.004
EtSH	6953.256	3081.597	99.28392	2.256381	0.026
3MH:3MHA	185.9141	795.1529	986.7489	0.233809	0.815
3MH:EtSH	-2644.84	1242.681	986.7868	-2.12834	0.034
3MHA:EtSH	-1035.41	965.2884	122.6286	-1.07264	0.286
Results for Quarter 2					
	Estimate	Std. Error	df	t value	Pr(>|t|)
intercept	27388.21	11658.29	17.389	2.349248	0.031
3MH	6160.387	962.4564	988.5389	6.400692	<0.0001
3MHA	4571.497	2304.678	159.5332	1.983573	0.049
EtSH	8922.901	3395.085	109.0193	2.628182	0.009
3MH:3MHA	1392.823	870.1755	987.688	1.600624	0.110
3MH:EtSH	-3477.86	1359.929	987.7227	-2.55738	0.011
3MHA:EtSH	-811.614	1062.717	133.9647	-0.76372	0.446
Results for Quarter 3					
	Estimate	Std. Error	df	t value	Pr(>|t|)
intercept	13559.89	8947.699	16.67451	1.515462	0.148
3MH	2944.283	926.8665	989.3265	3.176599	0.002
3MHA	3219.925	1999.326	254.0948	1.610506	0.108
EtSH	5551.963	2863.347	162.8265	1.938977	0.054
3MH:3MHA	478.2586	838.1498	988.8336	0.570612	0.568
3MH:EtSH	-563.774	1309.869	988.8535	-0.4304	0.667
3MHA:EtSH	-890.267	910.7517	208.4203	-0.97751	0.329
Results for Quarter 4					
	Estimate	Std. Error	df	t value	Pr(>|t|)
intercept	5028.999	6022.218	16.55402	0.835074	0.415
3MH	1278.149	712.5402	989.7262	1.793792	0.073
3MHA	2229.73	1473.006	403.8106	1.513728	0.130
EtSH	4144.327	2080.548	265.6373	1.991941	0.047
3MH:3MHA	805.4932	644.379	989.4091	1.25003	0.212
3MH:EtSH	-621.026	1007.039	989.4219	-0.61668	0.538
3MHA:EtSH	-1071.49	667.0893	337.115	-1.60622	0.109

'3MH' fixed effect shows that the intensity of *guava* attribute increased with 3MH. The 'Quarter' factor shows a negative coefficient: from one quarter to the next, the *guava* AUC decreases, intensity is the strongest at the start and decreases over time either due to dissipation of the headspace, sensory adaptation and/or other factors.

Q1&Q2: all three compounds contributed positively to *guava* intensity. Combination 3MH & EtSH has a suppressive effect
Q3: 3MHA no longer significantly contributes to intensity.
Q4: EtSH the only compound that still contributes to the intensity of *guava*
Results should be considered in context: significance change from Q to next Q can be due to small change in *p-value*

Conclusions and prospects

✓ Temporal Rate-All-That-Apply or TRATA is a novel method for the sensory evaluation over time based on the continuous rating of applicable attributes.

✓ Visualising the raw TRATA data allows for the determination of the duration of the changes in the sensory space as perceived by each assessor. TRATA curves created for each sample allow for the visualisation and identification of the most important sensory characteristics of specific samples.

✓ Linear mixed modelling allows for the estimation of fixed effects on the intensity of each attribute. This is a helpful tool to determine the interaction between the three compounds tested.

More work needs to be done to establish the method as a rapid method with assessors that are not trained or that receive limited training. Comparative studies with other temporal methods can be done to explore the advantages and disadvantages of each method so that the most appropriate method can be selected when designing a study.

Vannevel, S.M.P. (2021) *Increasing varietal thiols in South African Sauvignon Blanc wines and a novel temporal method of sensory analysis,* PhD Thesis, Stellenbosch University, South Africa

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