Experimentally Created Intensity Scales for the Five Basic Tastes: Sweet, Sour, Salty, Bitter and Umami

Melinda Karalus (Murray), Célia Pontet & Zata Vickers - University of Minnesota Department of Food Science and Nutrition

Introduction

- Scaling of the intensity of the basic tastes is common in descriptive analysis techniques; however, to the authors' knowledge, universal taste scales that have been experimentally constructed so a specific numerical point represents equal intensities across all tastes have not been experimentally determined or validated Such universal scales would aid in the interpretation within and across descriptive analysis studies.
- Perhaps the most commonly used taste scales in the food industry were created by Sensory Spectrum and published in Meilgaard, Civille and Carr's book *Sensory Evaluation Techniques* (2007). These scales were created through repeated tests with trained panels at Sensory Spectrum and at Hill Top Research Inc. References for these scales at intensity levels of 2, 5, 10, and 11 are provided in the Meilgaard et al text. However, documentation of the experimental procedures used to create and validate these scales has not been published.

Objective

The objective of this study was to experimentally create universal intensity scales (intensity values 0-20) for the five basic tastes: sour, salty, bitter, sweet and umami. These scales will be 'universal' in that specific numerical points on these scales represent equal intensities across all taste scales.

Materials & Methods

Participants

- We recruited 32 participants (23 females, 9 males) from the University of Minnesota to participate in a series of tests that were held at the Sensory Center Testing Facility located on the Saint Paul campus of the University. We recruited the participants from a database of students and staff on the University of Minnesota Saint Paul campus.
- The University of Minnesota Institutional Review Board approved all procedures of the study.

Products

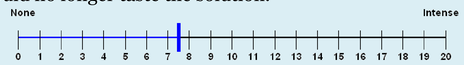
- We presented the following products to the participants in a range of concentrations (selected by the authors in preliminary sessions to cover the range of intensities possible for each tastant) dissolved in drinking water (Premium Waters, Minneapolis, Minnesota)

Sour Scale	• Citric Acid Anhydrous
Salty Scale	• Sodium Chloride
Bitter Scale	• Caffeine Anhydrous
Sweet Scale	• Sucrose
Umami Scale	• A mixture of 88% Monosodium Glutamate and 12% Ajitide I+G - 50% Disodium 5' Isoninate, 50% Disodium 5' Guanylate

Materials and Methods

Development of the Citric Acid Scale

- We instructed participants to taste and rate a series of citric acid solutions (concentrations ranged from 0% to 2%, selected by the authors in preliminary sessions to cover the range of intensities produced by citric acid solutions) on a 20-point line scale with the adjectives 'none' to 'intense' at the scale end-points.
- We asked participants to wait at least 1 minute between each sample and to rinse their mouth repeatedly with water until they could no longer taste the solution.



- We used the best fit regression line between concentration and intensity rating to help determine the citric acid concentration for each intensity value of 0 to 20.
- We subsequently used his citric acid scale as the reference scale to create the salty, bitter, sweet and umami scales.

Development of the salty, bitter, sweet and umami scales

- Similarly as in the development of the citric acid scale, we instructed participants to taste and rate a series of solutions (concentrations selected in the same manner as for the sourness scale) of each of the tastes on the 20-point line scale.
- We gave participants the 20 samples of citric acid that defined the sourness scale and asked them to use those labeled samples as calibration references when they rated the intensities of the salty, bitter, sweet, and umami solutions.
- Samples were presented in a rotated sequence of a salty sample, a bitter sample, a sweet sample and an umami sample to help reduce carryover effects.
- We used the best fit regression line between concentration and intensity rating to determine the salty, bitter, sweet or umami concentration for each intensity value.

Scale Verification

- We used paired comparison tests to verify that the created scales were 'universal' in nature.
- The pairs consisted of a citric acid solution (intensity 0-20) paired with each of the other tastants (salty, bitter, sweet, an umami) at the respective intensity. Participants identified the more intense sample in a pair.

Example Pairs:

- Pairs that were significantly different from each other were rescaled by the participants on the 20-point intensity rating scale and then subjected to the paired comparisons test again. This process was repeated until all paired comparisons tests were not statistically significant and the scales were 'universally' created.

Data Analysis

Development of the sour, salty, bitter, sweet and umami scales

- We evaluated participants individually to determine their skill level at differentiation of the samples and for their ability to correctly order the samples by intensity by evaluating the R-squared value of a regression line between their intensity ratings and the concentration of the samples for each tastant. If their R-squared value was below 0.7, their data were removed before the creation of the best fit regression lines using the group mean intensities.
- To determine the concentration for each tastant (sour, salty, bitter, sweet, and umami) at each intensity level, the tastant mean rating was plotted versus the respective tastant concentration.
- We used the equation that best fit the line for each of the tastants to predict the tastant scale values. To improve the prediction power of the regression equations, the graphs were divided into sections if a different regression line equation worked better for one section of the concentrations versus another.

Scale Verification

- Tom Carr's Test Sensitivity Analyzer was used to determine if samples were significantly different ($\alpha = 0.05$) in the paired comparison tests. The probability of a correct guess was set to 0.50 and the proportion of distinguishers was set at 0.25.

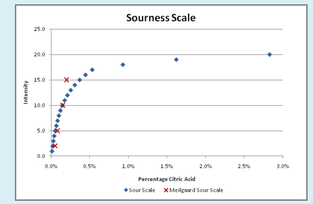
Results

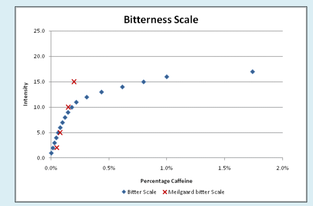
- The table below shows for each intensity value the percentages of tastant (citric acid, caffeine, sucrose, NaCl or MSG + I+G) and the grams/L of the tastant for each of the taste scales created in this research . The plots below show each of the newly created taste scales along with the references from Meilgaard, Civille and Carr (2007).

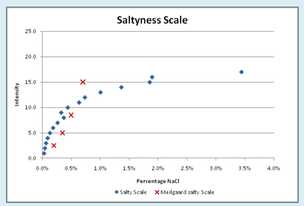
Taste Intensity Scales

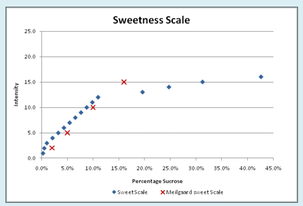
Percentages and grams/L of for each taste scale, citric acid, caffeine, NaCl, sucrose, or MSG + I+G , for each intensity

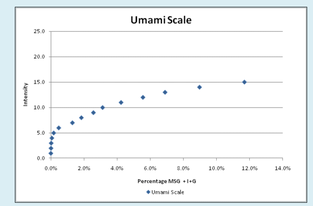
Intensity value	Sour		Bitter		Salty		Sweet		Umami		
	%	g citric acid/L	%	g caffeine/L	%	g of NaCl/L	%	g sucrose/L	%	g MSG/L	g I+G/L
1	0.010%	0.173	0.002%	0.026	0.035%	0.759	0.251%	3.979	0.00%	0.047	0.006
2	0.019%	0.310	0.016%	0.193	0.049%	1.065	0.502%	7.959	0.01%	0.196	0.027
3	0.028%	0.462	0.030%	0.369	0.069%	1.495	1.003%	15.914	0.02%	0.344	0.047
4	0.038%	0.634	0.045%	0.557	0.097%	2.099	2.109%	33.470	0.06%	0.935	0.127
5	0.050%	0.839	0.062%	0.758	0.136%	2.947	3.215%	51.025	0.18%	2.541	0.346
6	0.066%	1.105	0.079%	0.976	0.191%	4.137	4.321%	68.581	0.48%	6.906	0.942
7	0.082%	1.366	0.099%	1.216	0.268%	5.808	5.428%	86.136	1.30%	18.773	2.560
8	0.099%	1.649	0.121%	1.486	0.377%	8.154	6.534%	103.692	1.84%	26.543	3.620
9	0.119%	1.990	0.147%	1.804	0.331%	7.173	7.640%	121.247	2.57%	37.000	5.045
10	0.144%	2.402	0.179%	2.205	0.444%	9.612	8.746%	138.803	3.13%	44.979	6.134
11	0.174%	2.899	0.218%	2.683	0.640%	13.856	9.852%	156.358	4.24%	61.000	8.318
12	0.210%	3.499	0.308%	3.793	0.740%	16.021	10.959%	173.914	5.56%	80.000	10.909
13	0.253%	4.224	0.436%	5.363	1.010%	21.867	19.600%	311.045	6.90%	99.220	13.530
14	0.305%	5.100	0.616%	7.582	1.370%	29.661	24.725%	392.390	8.98%	129.160	17.613
15	0.368%	6.158	0.800%	9.840	1.860%	40.269	31.268%	496.229	11.69%	168.134	22.927
16	0.445%	7.436	1.000%	12.300	1.900%	41.135	42.638%	676.657	-	-	-
17	0.532%	8.904	1.742%	21.426	3.444%	74.562	-	-	-	-	-
18	0.929%	15.612	-	-	-	-	-	-	-	-	-
19	1.622%	27.454	-	-	-	-	-	-	-	-	-
20	2.833%	48.539	-	-	-	-	-	-	-	-	-











Acknowledgements

This work was supported by the Minnesota Agricultural Experiment Station, and the Sensory Center in the Department of Food Science and Nutrition.

For further information please contact: Zata Vickers at zvickers@umn.edu