Perceptual Mapping and Opportunity Identification

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Sensory Experience of Consumers

Science attempts to address the important aspects of food that affect consumers. The key areas of concern have been in the safety and nutritive value of the food supply. However, consumers rarely appreciate the absence of danger in the products they consume and are equally oblivious to nutrition. They judge the food that they eat on its sensory properties. They make choices on visual appearance, they sniff the aroma of the steak as it cooks, they savour the flavour as they bite into the burger, they note the effort that they have to make to chew the pork chop and they look for a toothpick to pry those little strands of connective tissue relinquished by the barbeque ribs they just enjoyed. Not only are these all sensory modalities, they do not act alone. Eating is a multi-sensorial experience. Not everyone enjoys the same set of sensory attributes when it comes to consumption of muscle foods. Understanding the attributes that are important to consumers is the key to designing products to meet their needs and desires. There is no such thing as an "average consumer." Most products targeted on the middle of the pack are perceived to be mediocre by everyone. This emphasizes the importance of being able to describe the sensory characteristics of a product category. Understanding the differences is the first step to understanding what drives liking and consumer response.

Sensory Descriptive Analysis

This analytical sensory technique is defined as:

> "any method to describe and quantify the sensory characteristics of stimuli by a panel of trained assessors." ASTM Standards 2002, E253 – 02.

The procedure is carried out in a series of steps starting with the identification of the key sensory attributes. Then the panel is trained in the attributes, a ballot is developed, the attributes are measured in the products using replicated measures and finally the results are subjected to statistical analysis and interpretation.

In practice, a descriptive panel may be optimized by ensuring that a sensory order of operations is followed and by using calibration techniques. Feedback calibration helps train the panel efficiently and gives results that can be compared over time and across studies. A history can be developed that provides a library of comparable and understandable sensory profiles. The creation of a sensory profile for our products permits us to create a perceptual map of the sensory space that they occupy.

What is a Perceptual Map?

A perceptual map is a visualization of the sensory properties of a group of products. The presentation is multidimensional and usually is reduced to a biplot. The map is a simplification of the sensory information, while retaining the most important information. Mathematically, there are many different methods that can be applied to create a map. Multidimensional scaling through the sorting of products into similar groups is a simple and powerful technique. The main problem is that, although a map is created, the factors that explain the placement of products are not clear. Principal components analysis (PCA) has become one of the most popular methods for creating a perceptual map. However, it typically uses mean values and does not provide confidence intervals for the product position on the map. Generalized Procrustes analysis (GPA) retains individual information and compensates for individual differences in the respondents. In any case, the result is a two-dimensional plot that places products and attributes in the same space. A simple example shown in Figure 1 describes four brands of chocolate chip cookies. The vectors for the attributes show that product 3 is high in chocolate flavor and sweetness while product 2 is low in those attributes and is hard. The sensory position of the products becomes interpretable and actionable.

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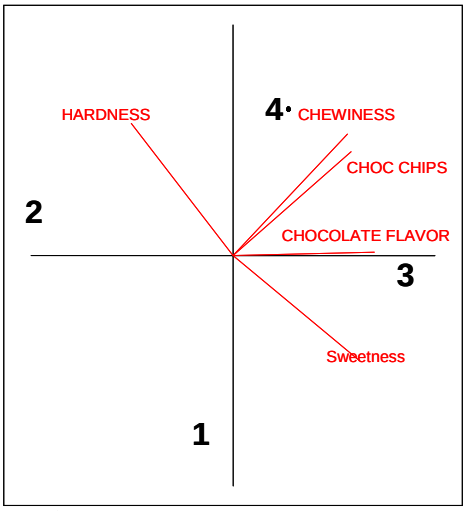

Figure 1. PCA of chocolate chip cookies.

According to Lawless & Heymann (1998), the overall goals of perceptual mapping are to learn how the products in a class are perceived with respect to strengths, weaknesses and similarities, to learn what potential buyers want and to learn how to produce or modify a product to optimize its appeal. They go on to identify the desired qualities in perceptual mapping:

- Goodness of fit (low stress in the model)
- Reliability: blind duplicates plot together
  - Similar pairs (batches) plot nearby
- Dimensionality: model has a few dimensions
  - Can be plotted meaningfully
- Interpretation: The map should make sense
- Validity: The map should relate to descriptive attributes
  - Should relate to consumer preferences
- Payoff: The map should suggest new hypotheses or may confirm previous hypotheses
- Cost efficiency: data collection is rapid and simple

A Study of Beef Striploins

To move this into a muscle food context I would like to present several actual studies. The first is a relatively simple project that was originally designed to examine the calibration of a UV fiber-optic probe for connective tissue. However, primal cuts were obtained from a range of sources and this permitted additional research to be done. In the study presented here, there were 12 products that represented four countries of origin, four age categories and four grading designation. The sensory panel or 12 profiled the products in triplicate and we focused on 6 attributes. The questions that we wanted to answer were: Are there sensory differences by country, age or grade? The data can be presented in tabular or graphic form. Figure 2 is a bar chart of all the data.

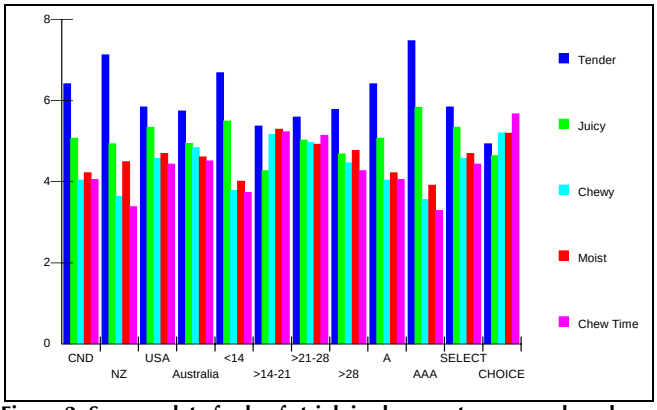

Figure 2. Sensory data for beef striploins by country, age and grade.

Even a relatively small amount of information is difficult to assimilate and consider all attributes simultaneously. By applying principal components analysis the data can be shown in a much more accessible format. (Figure 3)

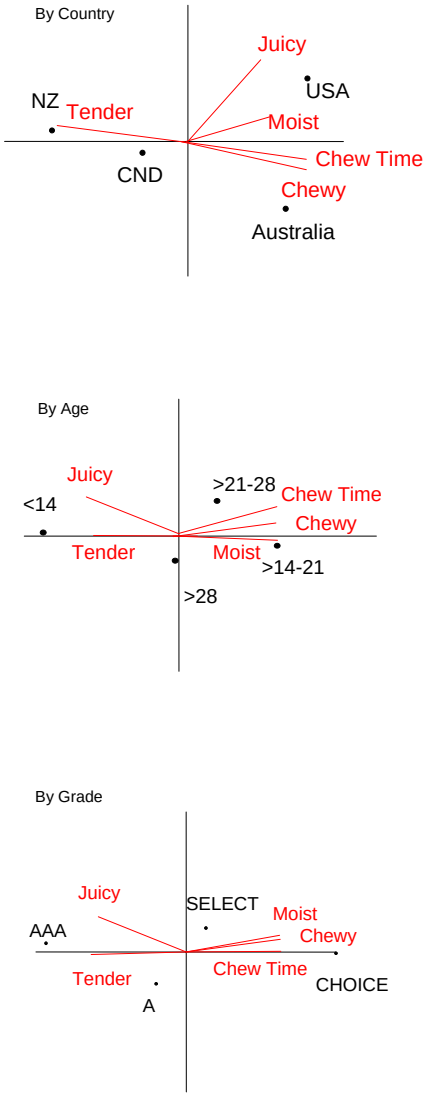

Figure 3. PCA of beef striploins by country, age and grade.

Marinated Rainbow Trout

The beef results display an outcome that we cannot control directly. The purpose of this approach is to be able to refine your development methods to understand the effect of your variable. The next example is of the marination of rainbow trout filets. The primary purpose of the project is to improve yield and increase consumer acceptance. A simple aqueous marinade with salt and phosphate was developed and injected into skin-on filet. The question that was being addressed was "How much marinade to use?" Naturally, the greater the quantity of marinade the greater the product yield. A processor would always target maximum yield, but what does it do to the product? Descriptive sensory was performed on a control rainbow trout, Atlantic and Pacific Salmon and 5 protoype products by 12 panelists with 3 replicates and 6 attributes. A GPA of the results is shown in Figure 4.

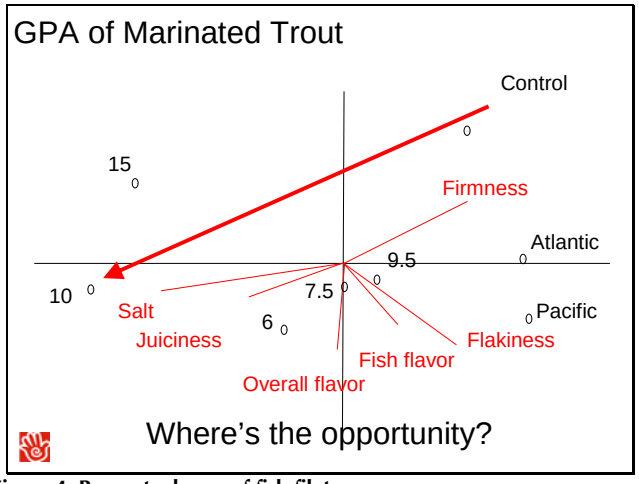

Figure 4. Perceptual map of fish filets.

It is interesting to note that as marinade increases from left to right, we see a concomitant increase in salt and juiciness. Clearly the salt is from the marinade and the juiciness from the increased moisture content. We can learn several things from this map. The optimum marination may be reached at the 6 or 7% level. The production levels do not correspond to the measurements in the products. We have no idea how far from the control we can go before the consumer objects to the product. However, this is a relatively simple system and with some consumer work we could find an ideal spot on the map.

Category Assessment – Ham

A more complex product is processed cooked ham. This example looks at the evaluation of the sensory attributes of a wide range of commercial product. The study examined 15 products, using 10 trained panelists over 3 replicates for 22 attributes. A selection of 16 attributes found significant ($P < 0.05$) through ANOVA is contained in Table 1.

The quantity of data makes it difficult to digest the information or arrive at any course of action. A PCA of the data provides us with our perceptual map. (Figure 5.)

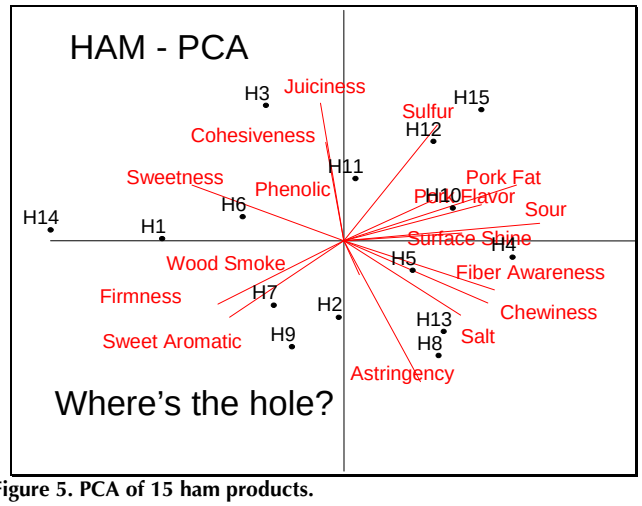

Figure 5. PCA of 15 ham products.

Table 1. Descriptive profile of 15 ham products for 16 attributes.

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
Sulfur	1.11	1.63	1.68	1.94	1.37	2.06	0.96	0.88	1.51	1.91	1.56	3.18	1.74	1.46	3.45
Sweet Aromatic	2.5	2.51	1.56	2	1.71	1.37	1.51	1.58	2.1	1.79	1.55	1.28	1.88	2.62	1.22
Surface Shine	7.09	7.93	9.1	8.41	9.1	7.85	6.67	9.64	8.19	9.1	7.19	8.32	8.22	7.68	8.47
Firmness	3.09	6.95	1.87	0.44	3.56	6.83	2.78	1.77	5.44	4.45	4	0.4	3.22	6.15	0.13
Saltiness	5.12	6	5.32	5.79	5.89	4.98	6.12	5.49	5.79	5.59	5.24	5.62	5.43	4.63	5.26
Sweetness	2.65	2.45	3.74	2.4	2.38	2.7	2.1	2.28	2.45	2.79	2.39	2.3	2.18	4.56	2.25
Sourness	1.78	2.23	2.03	2.39	2.41	1.89	1.89	2.1	1.93	2.44	2.36	2.18	2.11	1.34	2.23
Wood Smoke	0.91	0.92	1.57	0.88	1.55	2.38	3.06	1.82	1.31	1.03	2.13	1.01	2.1	0.47	1.29
Phenolic	0.19	0.31	0.57	0.3	0.83	0.29	0.53	0.29	0.45	1.43	0.82	0.55	0.72	0.36	0.58
Pork Flavor	1.45	1.81	1.51	2.39	1.3	1.65	1.34	1.77	1.38	1.69	1.83	1.55	1.75	1.43	2.28
Pork Fat	0.74	1.04	1.01	1.61	1.06	1.14	0.66	0.86	0.76	1.31	1.06	1.11	0.97	0.44	1.23
Astringency	2.61	2.72	2.1	2.7	2.73	2.59	2.65	2.88	2.89	2.8	2.34	2.22	2.73	2.24	2.46
Cohesiveness	5.12	4.73	4.39	4.23	4.47	4.21	4.28	3.69	4.46	4.8	5.24	4.89	4.23	4.52	5.06
Chewiness	4.57	5.19	4.88	5.42	5.28	4.78	4.82	5.92	5.06	5.38	4.79	5.44	5.82	5.11	5.19
Fiber Awareness	4.57	5.18	4.42	5.35	5.17	3.97	4.67	5.44	5.01	5.08	5.42	5.29	6	4.78	5.27
Juiciness	4.54	4.21	5.35	4.23	4.64	4.54	4.53	4.31	4	4.73	4.55	4.6	4.04	4.4	4.69

In this case we can see a complete array of products that are well distributed around the center of the plot. The number and complexity of the attributes makes it difficult to see where an opportunity may exist. On the basis of the nature of some attributes like astringent and chewy, we can presume that products H8 and H13 may be less desirable. But in the absence of consumer information we can only speculate about the right direction to choose. However, we can see the products that are sweet and smoky, like H14 and H1 or the ones that are juicy and cohesive, like H3. So we have an appreciation of how these products relate to one another. By using the profile from a target product it is easy to determine the product characteristics that must be changed in order to get closer to a specific product.

A Real-World Case Study

Table 2. Weiner attributes.

Mottled appearance	Salt
Color*	Sour*
Smoke aroma	Firm skin*
Smoke flavor*	Skin chew*
Green herbs*	Springiness*
Garlic flavor*	Firmness
Pepper*	Cohesiveness
Afterburn/Heat*	Coarseness
Beef flavor	Particles
Pork flavor*	Juiciness*
Poultry flavor	Residual oiliness*
Sweet	

*The highlighted attributes were found to be the most significant.

I have been attempting to describe the development of a perceptual map and what can be learned from the sensory information. However, as we can see with the ham data, the results can be more complicated than we can manage. It is clear that different tools are needed to get to the next stage. To illustrate this from start to finish, I have collaborated with the distinguished sensory statistician Tom Carr. I will provide the first part of the story and he will take it to its conclusion. A category assessment of 14 wieners was conducted. Descriptive analysis was performed by 10 panelists, using 3 replicates for 23 attributes. This sensory work was followed by a consumer study, which will be described later. A full set of attributes (Table 2) were developed to describe the entire category of wieners. The values for the most significant attributes are reported in Table 3.

Again we are confronted with a large quantity of information that can be better appreciated in graphic form. As we have seen earlier, bar charts of all attributes for all products tend to overwhelm us. It is easier to look at data one attribute at a time. If we consider the attributes in Figure 6, we can see that for juiciness, there are really two levels, low and high, so interpretation is relatively easy. But the garlic flavor results are not as tidy. We can't make clear conclusions based on a univariate plot.

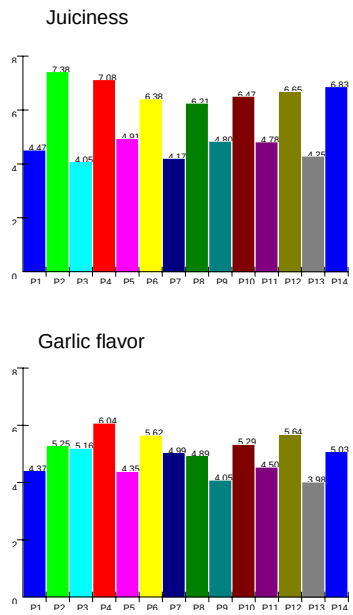

Figure 6. Juiciness and garlic for 14 wiener products.

Table 3. Summary wiener data.

Attribute	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
Color	3.76	3.23	4.81	3.96	6.24	4.64	5.45	4.31	4.67	4.56	3.87	3.74	3.91	3.13
Smoke flavor	4.85	5.21	4.33	4.24	4.11	4.39	4.9	4.24	3.37	4.41	4.07	3.18	5.07	4.76
Green herbs	5.79	6.35	5.22	6.07	4.83	6.15	6.25	5.4	6.21	6.57	6.16	6.4	5.47	6.45
Garlic flavor	4.37	5.25	5.16	6.04	4.35	5.62	4.99	4.89	4.05	5.29	4.5	5.64	3.98	5.03
Pepper	4.49	6.21	4.34	5.7	3.74	6.07	3.81	5.77	4.26	5.59	4.07	5.25	4.59	5.95
After burn/Heat	3.91	5.16	2.87	4.63	2.48	5.01	3.17	5.81	3.44	4.96	3.73	4.4	3.61	4.98
Pork flavor	4.4	4.44	4.78	4.85	4.79	4.73	4.49	3.44	3.62	3.03	3.8	2.74	3.1	3.35
Sour	5.94	5.25	5.87	5.31	5.53	5.6	5.53	5.77	4.78	5.5	5.33	5.42	5.51	6.78
Firm skin	4.47	6.1	4.87	6.5	3.75	6.88	4.24	6.2	4.03	6.32	4.73	6.59	4.8	6.39
Skin chew	3.99	5.85	4.41	5.88	3.87	6.14	3.88	5.82	3.12	6.09	3.51	5.85	4.04	5.58
Springiness	5.84	5.13	6.35	5.29	5.17	5.05	6.14	5.59	5.99	5.14	5.62	5.43	4.98	4.76
Juiciness	4.47	7.38	4.05	7.08	4.91	6.38	4.17	6.21	4.8	6.47	4.78	6.65	4.25	6.83
Residual oiliness	4.03	5.74	4.01	4.99	4.58	5.41	4.35	4.94	4.82	5.26	4.22	4.68	4.61	5.47

The Generalized Procrustes Analysis of the same data provides an integrated view of all the products (Figure 7).

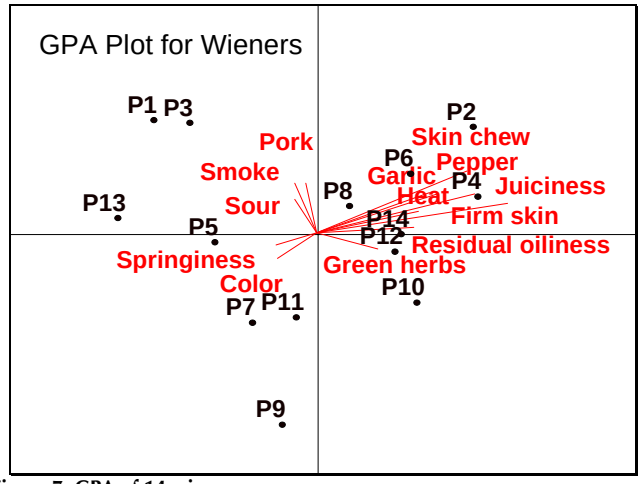

Figure 7. GPA of 14 wieners.

The quadrants of the plot suggest that there are some products that are deeper in color and springy (P7,P11), smoky, sour pork flavoured (P1,P3), pepper, garlic and juicy (P6 ,P4) and finally some that have green herb and residual oiliness (P10,P12). Are there opportunities to locate new products in this space? The answer will rest with the consumer research. In the meantime, we now understand the range of sensory properties that describe the wiener category.

Summary and Conclusions

The use of perceptual mapping can provide insight for the product developer and researcher by describing the sensory dimensions of a product category in a single biplot. The plot may reveal holes that present opportunity or sensory properties that have been over represented in a category. The quality of the descriptive analysis performed increases the value of the insights that can be obtained. Consumer research and preference mapping are required to have confidence to implement the changes that perceptual mapping suggests.

References

Lawless, H.T. and Heymann, H. 1998. Sensory evaluation of Food: principles and practices. Chapman & Hall, New York.