Principles and applications of perceptual mapping techniques in culinary research and menu development

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Outline

• The evolving food service industry
• Factors influencing research in the culinary field
• Fundamentals of perceptual mapping
• Applications of perceptual mapping:
  - perception of spice aromas
  - flavor and preferences for water
Eating out has become a behavioral norm
(Moskowitz, 2007)

Foodservice share of the consumer’s food $ is increasing

(Source: Technomic and NRA Fact Sheet, 2004)
Factors influencing research in the culinary field

- Increasingly cross-disciplinary field
- Technical challenges and advances
- In-context studies
- Critical evaluation of culinary medium
Fundamentals of perceptual mapping

- Psychophysical principles
- Data collection process
  - napping
  - sorting
- Underlying statistics
Psychophysical principles of perceptual mapping

• Psychophysics
  - the study of the relation between physical stimuli and subjective experience (Stevens, 1975)
  - knowledge is obtained by understanding the patterns in nature (Moskowitz, 2010)

• Flavor is conceptual and is influenced by attention of the perceiver (Cain, 2010)

• It is difficult to articulate flavor percepts; mapping does not require preconceived vocabulary
Data collection process for perceptual mapping

- Individual panelists asked to place coded samples based on their own descriptive criteria:
  - in groups based on similarity (sorting)
  - on a two dimensional space relative to each other based on similarity (napping)

- Panelists are asked to provide sensory descriptors for the products

- The collective patterns in these groupings or spatial orientations are resolved by statistical programs
Underlying statistics for perceptual mapping

- Napping utilizes multi-factoral analysis (MFA)
- Sorting utilizes multi-dimensional scaling (MDS)
  - frequency of pairings of products
- Multiple regression analysis of perceived attributes is used to help interpret the dimensions product space.
Napping the aromas of Huajiao

- **Background**
  - increasing diversity of ingredients available to the food service industry that require evaluation
  - Huajiao is integral to a vital and emerging *Sichuan* cuisine.

- **Objectives:**
  - characterize aromas of huajiao samples from different regions in China
  - better understand general quality attributes of huajiao

- **Method:**
  - 26 untrained panelists (17♂/9♀; Avg. age 45; CIA staff, students)
  - samples (blind) placed on 60cm X 60cm sheet: samples with similar aromas close and different aromas far apart
  - perceived aroma attributes recorded; no visual cues
Origin of huajiao samples

Sichuan province

Map showing the origin of huajiao samples in Sichuan province, with specific locations marked by red and green circles.
## Variability of Huajioa quality

<table>
<thead>
<tr>
<th>Sample#</th>
<th>Sample origin and type (year harvested)</th>
<th>Gram/Tbsp (stdev)</th>
<th>Husk/Tbsp (stdev)</th>
<th>Husk with seeds intact /Tbsp (stdev)</th>
<th>Diameter of husk (mm)</th>
<th>citrus</th>
<th>light/mild</th>
<th>lemon</th>
<th>pine</th>
<th>tea-like</th>
<th>strong</th>
<th>wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mao Wen red dry huajiao (2008)</td>
<td>3.6 (0.1)</td>
<td>215 (8)</td>
<td>0</td>
<td>3.76 – 5.18</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Hanyuan red dry huajiao (2009)</td>
<td>3.3 (0.6)</td>
<td>255 (5)</td>
<td>17 (4)</td>
<td>3.38 – 5.08</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Red dry huajiao, distributed in USA (unknown)</td>
<td>3.4 (0.2)</td>
<td>161 (1)</td>
<td>14 (6)</td>
<td>4.09 – 6.60</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Jin Yang green dry huajiao (2008)</td>
<td>4.6 (0.1)</td>
<td>186 (5)</td>
<td>59 (6)</td>
<td>3.68 – 5.82</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Emei green dry huajiao (2008)</td>
<td>3.4 (0.2)</td>
<td>201 (10)</td>
<td>8 (1)</td>
<td>4.12 – 5.66</td>
<td>5</td>
<td>10</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Yunnan green dry huajiao (2008)</td>
<td>4.5 (0.1)</td>
<td>188 (4)</td>
<td>67 (11)</td>
<td>3.99 – 5.82</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Hanyuan huajiao powder (2009)</td>
<td>5.6 (ND)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>9</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

Weights and measurements

Aroma descriptors

- citrus
- light/mild
- lemon
- pine
- tea-like
- strong
- wood
Perceptual map of huajiao aromas using napping

collective perception of the aromas of 13 samples by 26 panelists
Summary of Huajiao napping

- 39% of the variability amongst 13 samples can be described by 2 aroma dimensions by an untrained panel

- 11 aroma attributes correlate significantly with the samples; dimension 1 being a mild/not strong characteristic.

- Additional dimensions can be explored

- Chefs can use this information to help them incorporate the product’s flavor profile into food service and retail applications

- Culinary educators can use this information introduce students to the diversity of a spice that is integral to a major Asian cuisine style
Assessing the flavor differences and preferences for water

- Justification
  - perceived quality of water is an integral component of food service operation
  - issues of sustainability are influencing the sourcing of water and purchase of water filtration systems.

- Objectives:
  - Determine consumer’s perceived differences in water flavors
  - Determine preferences for waters
Assessing the flavor differences and preferences for water

- Methods:
  - 55 untrained panelists (20♂, 35♀; Avg. age 30; CIA staff, students)
  - 8 water samples (6 commercial, 2 tap)
  - ranked preferences tests
  - sorting into groups based on similarity; perceived attributes noted
  - unfolding model of the preference data using MDS
  - chemical analysis of the water samples (NFL)
## Physiochemical analysis of water samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH</th>
<th>Chloride (mg/l)</th>
<th>TDS (mg/l)</th>
<th>Nitrate (mg/l)</th>
<th>Calcium (µg/l)</th>
<th>Sodium (µg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>7.60</td>
<td>9.2</td>
<td>238</td>
<td>0.5</td>
<td>16,000</td>
<td>15,700</td>
</tr>
<tr>
<td>C2</td>
<td>7.54</td>
<td>46.4</td>
<td>227</td>
<td>0.6</td>
<td>3,750</td>
<td>44,400</td>
</tr>
<tr>
<td>C3</td>
<td>6.09</td>
<td>4</td>
<td>21</td>
<td>0.3</td>
<td>97.8</td>
<td>857</td>
</tr>
<tr>
<td>C4</td>
<td>7.42</td>
<td>1.2</td>
<td>110</td>
<td>0.4</td>
<td>5,440</td>
<td>10,100</td>
</tr>
<tr>
<td>C5</td>
<td>8.25</td>
<td>8.4</td>
<td>151</td>
<td>0.9</td>
<td>30,200</td>
<td>6,710</td>
</tr>
<tr>
<td>C6</td>
<td>6.06</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>T</td>
<td>7.14</td>
<td>8.2</td>
<td>106</td>
<td>0.3</td>
<td>4113</td>
<td>13,067</td>
</tr>
<tr>
<td>FT</td>
<td>6.51</td>
<td>8.35</td>
<td>100</td>
<td>0.3</td>
<td>250</td>
<td>12,650</td>
</tr>
</tbody>
</table>
Ranked preferences for 8 waters revealed 2 major product segments

<table>
<thead>
<tr>
<th>Water</th>
<th>Rank sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4\textsuperscript{a}</td>
<td>199</td>
</tr>
<tr>
<td>C3\textsuperscript{a}</td>
<td>206</td>
</tr>
<tr>
<td>C5\textsuperscript{a}</td>
<td>214</td>
</tr>
<tr>
<td>FT\textsuperscript{a}</td>
<td>218</td>
</tr>
<tr>
<td>C1\textsuperscript{a}</td>
<td>228</td>
</tr>
<tr>
<td>C2\textsuperscript{a,b}</td>
<td>274</td>
</tr>
<tr>
<td>C6\textsuperscript{b,c}</td>
<td>310</td>
</tr>
<tr>
<td>T\textsuperscript{c}</td>
<td>367</td>
</tr>
</tbody>
</table>

Waters with different superscripts are significantly different (p<0.05)
Joint configuration plot of waters and panelists based on preference

Consumers (small #'s) plotted near waters they prefer
Consumers divided into 2 major groups those that prefer no-taste/nitrate and those that prefer plastic/earthy/chemical
Sorting of waters and significant (p<0.02) consumer perceived attribute
Summary of perceptual mapping of water

- Two consumer segments were revealed with regard to preferences for drinking waters.

- Besides dissolved nitrates, none of the physiochemical components were associated with consumer perceptions of water flavor.

- Filtration of tap water significantly changes consumer perception of preferences.
Summary

- Perceptual mapping revealed that huajiao samples have significant aroma characteristics that distinguish them from each other.

- Consumer segments related to preferences for water were revealed through perceptual mapping that would not have been revealed by standard preference ranking analysis.

- Culinary educators and professionals can use perceptual mapping to gain insight into the flavors of their ingredients and their consumers.

- Perceptual mapping provides a method for measuring perceived differences between foods without extensive training of panelists to develop descriptors.

- Perceptual mapping generates a lot of data and requires extensive analysis.
Acknowledgments

Lauren Koller

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For more information on culinary research at The CIA:
http://menuscience.ciachef.edu/research/mrfdi