Experimental Design and Sensory Analysis
Hypothesis

*hypothesis* = tentative assumption to test logical or empirical consequences of applying a variable in a research project

*null hypothesis* = statement that applying a research variable will not make a significant difference in a research project

Some examples...
Planning an experiment

• Idea
• Justification – Develop hypothesis
• Literature review
• Designing Experiment – work from hypothesis
  – Must have controls
  – Verified methods
  – Weights and measures
Planning an experiment

• Results
  – Compare treatments using objective measurements
  – Physical and sensory tests

• Discussion
  – Compare your results with those of others
  – Did your results support your hypothesis or not?
  – Rationale

• Conclusion
  – Summary of results
  – Impact of study
Controlling Experimental Variables

- **Variable** = quantity that has no fixed value
- **Independent variable** = defined by researcher (*e.g.* type of sweetner used)
- **Dependent variable** = will be a measured result from the experiment (*e.g.* affect of sweetner on color, volume, etc.)
- **Extraneous variable** = added variation that is not controlled that affects experimental outcome
Conducting an Experiment

• Objective and subjective observations
• Recording data – all information when observed
• Statistical analysis
  – Descriptive statistics – frequency, distribution (mean, variance, standard deviation)
  – Inferential statistics – probability of predicting an occurrence by use of a statistical test (t-test, ANOVA). Use significance level $P<0.05$
• Report
Sensory Tests

• Can be very objective when terms are clearly defined (consumer panel – 100s of people) or a panel that is highly trained (quantitative descriptive analysis)
Sensory Tests

- Involves use of senses – physiological response
  - **Olfactory** receptors in nose
    - Odor and taste receptors blend to give flavor
  - **Taste receptors** – tongue, taste buds (gungiforms and circumvallate)
  - Sweet, sour, bitter, salt
  - Thresholds – concentration of taste compound at barely detectable level
  - Subthreshold – concentration of taste compound at a level that is not detectable, but is capable of influencing other taste perception (e.g. salt on sweetness)
Sensory Tests

• Visual receptors – shape, color, texture
• Appearance can affect perceived flavor or texture (example)
• Lighting is important – must not mask or accentuate irrelevant traits during sensory testing
Sensory Characteristics

• Appearance-color being most important (kids)
• Color is exterior surface
• Interior appearance – lumps, air cells, etc.
• Appearance and color features should be included on sensory testing forms
Sensory Characteristics

• Aroma – second most characteristic
• Aroma ‘advertises’ food
• Consider proper temperature when evaluating food aroma
Sensory Characteristics

- Flavor – taste and aroma mix to form flavor
- Temperature is critical to extract flavor and aroma
- Flavor potentiator – compound that enhances flavor without adding a flavor of its own (MSG)
- Flavor inhibitors – substance that blocks perception of a taste (milk protein or starch on hot pepper)
Sensory Characteristics

• Texture – mouthfeel – how a food feels in your mouth
  – Mouthfeel – must clearly define what panelist is to evaluate (sticky, smooth, astringent)

• Tenderness – amount of chewing action to reach a certain consistency
Sensory Tests

• Appearance, Aroma, Flavor, Texture
  – Train panel how attribute is defined so all are using same criteria
  – Standardized and consistent experimental protocol
    • examples
Selecting a Panel

• Ability to discriminate differences you are looking for
  – Depending on test, may or may not want highly sensitive people
  – Screen using preliminary tests
  – Interest in project and serving on a panel
  – Clarity of nasal passages and ability to taste and smell
  – Demographic characteristics
Training a Panel

• Trained panelists- varies with complexity of test
• Review scorecards, clarify questions, assure that panelists are using same word definitions for scoring
Training a Panel

• Untrained panelists – need larger number for tests. Consumer panels.

• Panelist has no preparation for evaluation of product (outside of own personal experience)
Training a Panel

- Descriptive Flavor Analysis Panel and Quantitative Descriptive Analysis
- Trained panel to analyze flavor, texture, appearance of product in great detail
- Describe product characteristics and quantify intensity of traits
- Verify flavor and determine quality
- Great amount of work (9 week or so to train panel)
- Must use same ‘calibrated’ panel over and over again. Needs long term commitment
Types of Tests

- Descriptive – provide information on selected characteristics
- Affective - subjective attitude to a product. Acceptability or preference. Follows discriminative or descriptive testing
- Difference – determine whether there are detectable differences between products
Types of Tests

• Descriptive – provide selective information on characteristics of food
  – Selective scoring of critical attributes. These are developed by researcher, through focus group or preliminary panels
  – Each characteristic to be evaluated is described over entire range (min amount to excessive amount of trait x)
  – Score card with rating scales (hedonic scales – e.g. extremely sweet to not sweet). These must be carefully worded
Descriptive Tests, cont.

– Score cards with comparisons -‘the more X sample is #’
– Trained or semi-trained panel
– Profile methods (flavor and texture profiling) - Individual judgments, or ratings by a group. Develop accurate word for each characteristic to be measured
– Can be a single sample
Attribute analysis

- Not a preference test
- Problems with central tendency error
- Scales – 6-10 marks. Use objective terms as anchors (very hard) not subjective ones (much too hard).
  - Anchors must be opposites
  - Use anchors that are agreed upon during panel training. Each panelist can be calibrated based upon their tendency to use the whole scale. Can be repeated with a control as part of replication.
• Unstructured scales are best. Eliminates problems with unequal psychological intervals between traits.

• Psychological difference between terms are important. E.g ‘extremely sweet’ and ‘very sweet’ do not represent the same difference as ‘trace sweet’ and ‘not sweet’

• Hard to apply to complex traits like texture which must be characterized as individual components
• Train panel on what property IS so all will be looking for the same thing
• Include standards as scale tends to drift with time and panel’s familiarity with the product.
Type of Tests

- **Affective** – subjective attitude to a product. Acceptability or preference. Follows discriminative or descriptive testing

- **Ranking** – rate by intensity of trait. Can be used to screen one or two samples from a larger group. Must couple with another test to sort out degree of different if this is important.
  - hedonic scales (like extremely/dislike extremely)
  - consumer panels
Difference – detect differences between products
- also called discrimination tests
- Test sensitivity of judges to a certain trait
- Try to match experimental product with control
- New product formulations
Difference Tests

• Paired comparison
• Specific characteristic tested: ‘which sample is more sweet’
50% chance of being right
Control

Variable

Control

Variable

Control

or

50% chance of being right
33.3% chance of being right
Other discrimination tests

• Triangle
• 2 out of 5
• Ranking- works well when several samples need to be evaluated for a single characteristic. Rank sample in order of intensity of characteristic being measured.
Factors affecting sensory measurements

• Choosing a panel – Best scenario –
  – Panel is an analytical instrument
  – Health, interest, availability, punctual, good verbal and communication skills.
Training a panel

- Threshold tests for primary tastes not useful to screen individuals for sensitivity to different foods
- Generally screen 2-3x as many people as you will use
- Prepare test samples as you would for ‘real experiment’
- Make sure panel understands forms used and the terms used on the forms
- Expectation error – any information a panelist receives influences the outcome
- Panels finds what they are expected to find
- Trick – provide only enough information for panelist to be able to do the test
- Try not to include people already involved in the experiment (single blind)
- Avoid codes that create inherent bias (1,A etc)
• Motivated panelists
• Leniency error – rate products based upon feelings about researcher
• Suggestion effect – response of other panelists to product (need to isolate panelists and keep them quiet)
"THERE'S NOTHING TO EAT!"
Testing times

- Must not be too tired or hungry
- Late morning or mid afternoon are good
- Early AM bad for testing spicy foods
- Late day – lack of panelist motivation
Stimulus Error

• Influence of irrelevant questions (e.g. piece size, color, uniformity)
• Try to mask unwanted difference (e.g. colored lights)
• Logical error – associated with stimulus error – tendency to rate characteristics that appear to be logically associated (yellow and rancidity). Control by masking differences
Halo and Proximity Effect

• Halo effect – caused by evaluating too many factors at one time. Panelists already have an impression about the product when asked about second trait – will form a logical association (e.g. dry-> tough)

• Best to structure testing so that only one factor is tested at a time (difficult to do)

• Proximity error – rate more characteristics similar when they follow in close proximity.
Convergence Effect

• Convergence effect – large difference between two samples will mask small differences between others.
• This causes results to converge. So use random order to reduce this.
• Next slide shows how flavor interactions impact this.
Table 3.1 Effect of Subthreshold Levels

<table>
<thead>
<tr>
<th>Ingredient Increased</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>Increases sweetness</td>
</tr>
<tr>
<td></td>
<td>Decreases sourness</td>
</tr>
<tr>
<td>Acid</td>
<td>Increases saltiness</td>
</tr>
<tr>
<td>Sugar</td>
<td>Reduces saltiness</td>
</tr>
<tr>
<td></td>
<td>Reduces bitterness</td>
</tr>
</tbody>
</table>
Positional Effect and Contrast Effect

• Positional effect – tendency to rate second product higher or lower
• 2 products very different – panelists will exaggerate differences and rate ‘weaker’ sample lower than would otherwise
• Use random order. Use all possible presentation orders
Central Tendency Error

• Panelists done want to use whole scale.
• Mix up scale (don’t load one end with all the ‘good traits.
• Can also normalize form for each panelist
Physical Location

- Testing in special rooms. 22C, positive pressure, 45% RH,
- Special lighting
- No fumes
- No smoking
Sample preparation

• Preliminary preparation – grind, puree to reduce color differences (unless testing for color differences)

• Masking color – lights, glasses, blindfolds, black lined cups, added dye
Dilutions and carriers

- Spices or hot sauce – dilute in white sauce or syrup
- Hydrocolloids mask flavor
- Test actual food – icing ON cake
- 20-40C easiest range
Utensils and containers

- Glass is best (inert)
- Container should not have flavor or aroma
Quantity of sample

- Size limited by amount of product available
- Representative of what is needed to test variation in product as manufactured
- Test dependent (consumer sample or portion would require more sample)
- Discriminative – 16 ml liquid, 28 g solid. Double for preference test
- Market testing – use consumer size serving – what tastes ‘good’ at 20 ml may not at 200!
Controls

• Include reference sample in test as part of mix
• Use random numbers
• Balanced order of presentation to reduce physiological and psychological effects
• Use same ‘process’ between samples to reduce carry over.
• Neutral tasting room temperature water.
• Matzo crackers between samples
• High fat samples – warm tea, lemon water, apple slices