Using Range Voting Analysis Techniques for Odor Profiling Data

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Odor Profiling

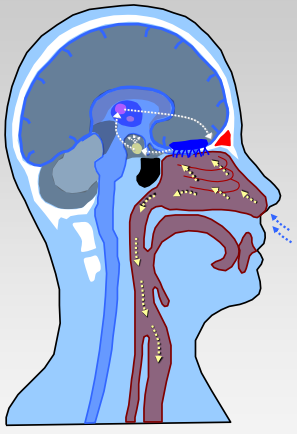
Challenges

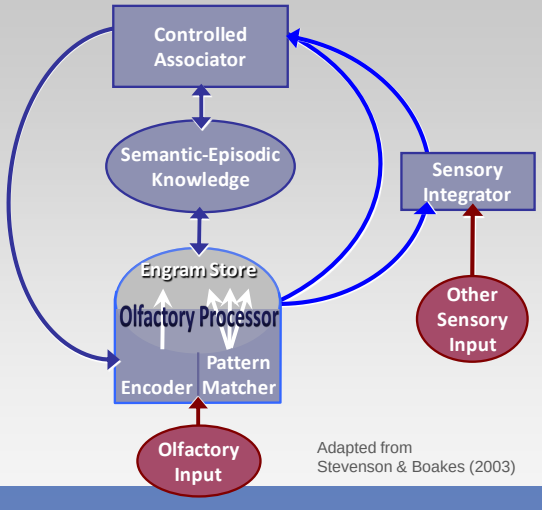
- Odor complexities
- Unlimited odor "attributes"
- Panel training demands
  - practice
  - calibration
- Researcher time demands

One Possible Approach

- Olfaction theory
- Hybrid testing method
  - odor identification
  - similarity ratings
- Unique analysis
  - Range Voting approach
  - Compositional data
- Utility

Mnemonic Theory of Odor Perception





Adapted from Stevenson & Boakes (2003)

Corresponding Sensory Methodology

Mnemonic Theory

Neural odor representations matched to memory encodings.

Better matches leads to more memory activation.

Pattern of activations represent the perception of the odor.

Odors easily confused if memory activations are slight.

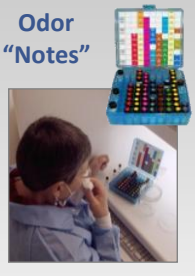
Odor Profiling Method

Standard Odor Referent Set

Identify "Matching" Odors

Rate Identified Odors

Odor "Notes"

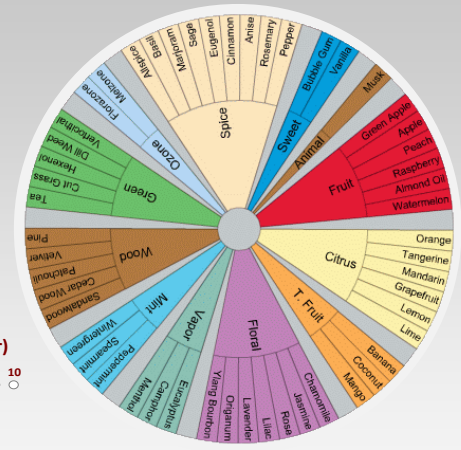


Similarity Scale

0 2 4 6 8 10

Key Method Factors

- Panelists select referent odor notes independently.
- Rate "**similarity**" to test odor.
- Adjunct elements:
  - Odor Groupings / Families
  - Overall Intensity Ratings



Traditional Intensity Rating (combined odor)

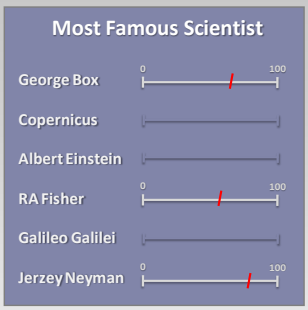
0 1 2 3 4 5 6 7 8 9 10

Low Mid High

Range Voting *with Extras*

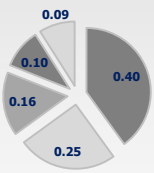
Range Voting

- Winner-take-all elections
- Assign points to candidates
  - Bounded 0-100 scale; can assign 0
  - Add up – highest score wins

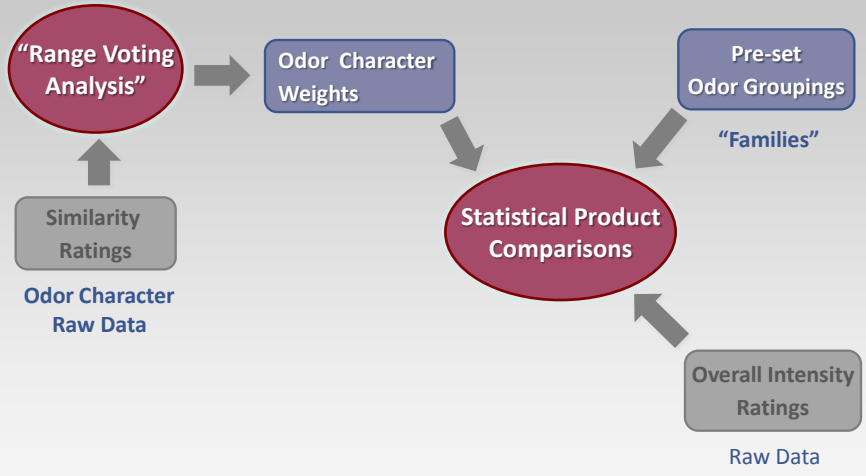


Compositional Data

- Proportional parts of a whole
- Sum constrained to a constant e.g. 100%
- Relative information
- Non-linear



The Analysis Plan



"Range Voting" Analysis Step 1

Logit Transformation

- Work on individual similarity ratings
- Can use cumulative density function (CDF)
  - PROC RANK (Blom normalization)
- e Blom Score

compositions have distributions that are logistic-normal

partially remove rater-to-rater variation

within panelists

"Range Voting" Analysis Step 2

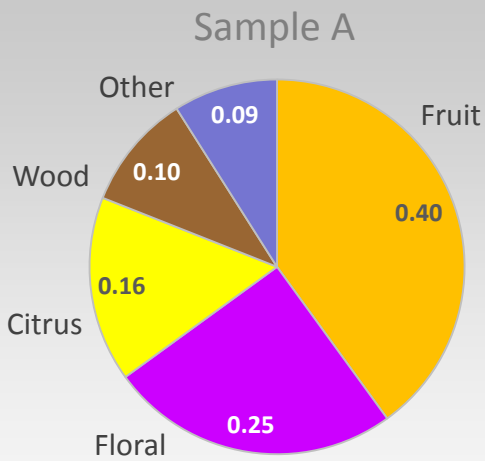
Scale the exponents

- Scale $e^{\text{Blom Score}}$
- Odors sum to 100%
  - within product x panelist

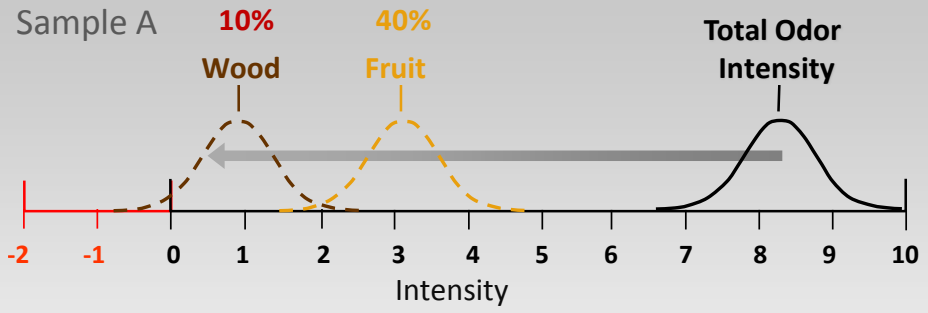
Can combine over panelists to obtain average odor referent notes

Calculate Proportions (Weights)

- Base on Scale values
- Pool across odor families
  - by sample
- Individual notes
  - detailed list



Hypothesis Testing



- Use total odor intensities
- Shift distribution
- Base on proportion
- Per sample x odor family
- Analyze with General Linear Models (ANOVA)

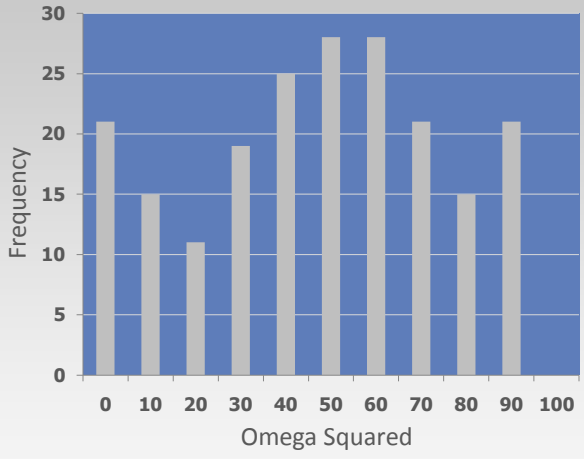
A Useful Method?

Three Criteria for Test "Goodness"

- Discriminates Between Products
- Measures Consistently
- Provides Meaningful Info

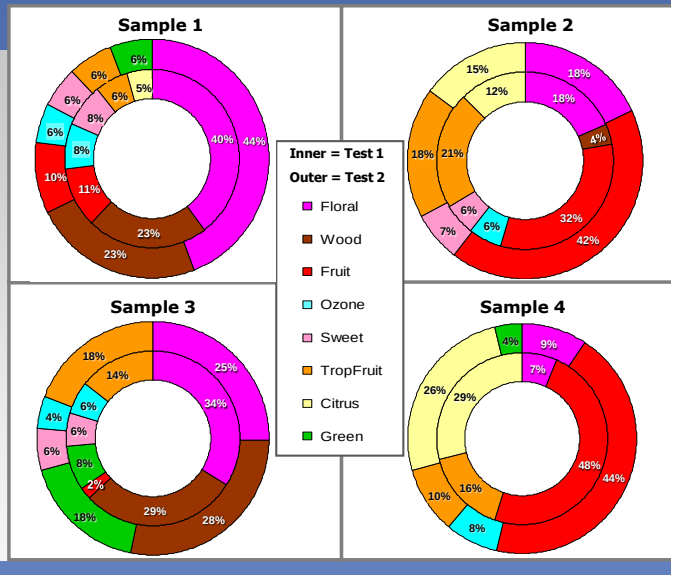
Discriminating

- Historical data
- Discrim. Index
  - omega squared
  - 0-100
- n = 204
  - families x samples
  - over 50 studies



Consistency

- Test-retest reliability
  - for good discrim:
  - r > 0.90
- No test x sample interactions
- Consistent proportions
  - RMS < 6%



Meaningful Information

Generalizability

- What to compare to?

Utility

- Aging stability
- Fragrance target confirmation
- Matching fragrances
- Select fragrance submissions

Summary

- Odor profiling methodology
  - less labor intensive
- "Range Voting" analysis
  - compositional data
- Demonstrated utility

Key References

Stevenson RJ., Boakes RA. 2003. A mnemonic theory of odor perception. Psychological Review 110:340–364.

Brams SJ, Fishburn PC. 2007. 2nd ed. Approval voting. Springer. 198p.

Aitchison J. 1986. The statistical analysis of compositional data. Springer. 416p.

Acknowledgements

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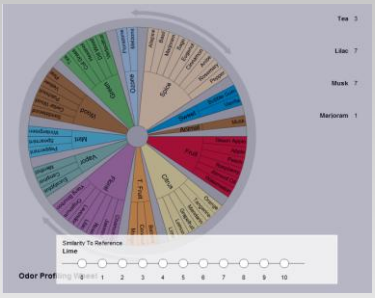
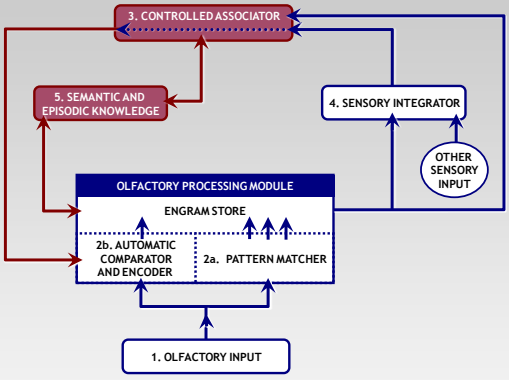
Range Voting Analysis for Odor Profiling Data





Questions?

Mnemonic Theory of Odor Processing
Stevenson & Boakes (2003)