Application of Consumer Ideal Point Mapping to a 3-Factor Experimental Design and its Graphical Representation

Jean-François Meullenet
Professor of Sensory Science
University of Arkansas

Preference Mapping

- Group of multivariate statistical techniques
  - Develop a deeper understanding of consumer liking for products
  - Category appraisal
  - Internal, external
- Why preference mapping?
  - Import sensory attributes: Drivers of liking
  - Assist product developers with optimizing sensory properties
  - What is the ideal product like?

Context of Preference Mapping

Consumer panel assesses the products for liking

Set of competitive products

Trained panelists describe the products in sensory terms

Hedonic Scores

	C1	C2	...	Cn-1	Cn
P1					
P2					
. . .					
Pk					

Statistical modeling

K=number of products
T=number of sensory attributes
N=number of consumers

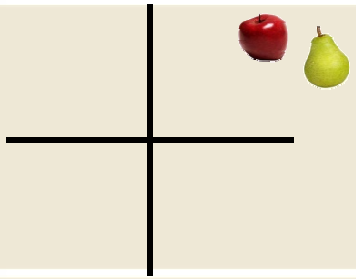
Sensory Profiles

	S1	S2	...	St-1	St
P1					
P2					
. . .					
Pk					

From P. Schlich

Concepts

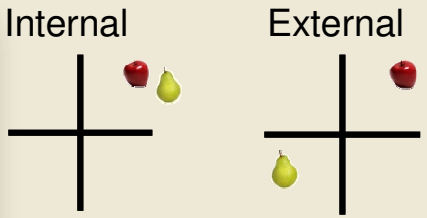
Mapping methods yield a graphical representation of consumer preference and/or sensory differences for a set of products



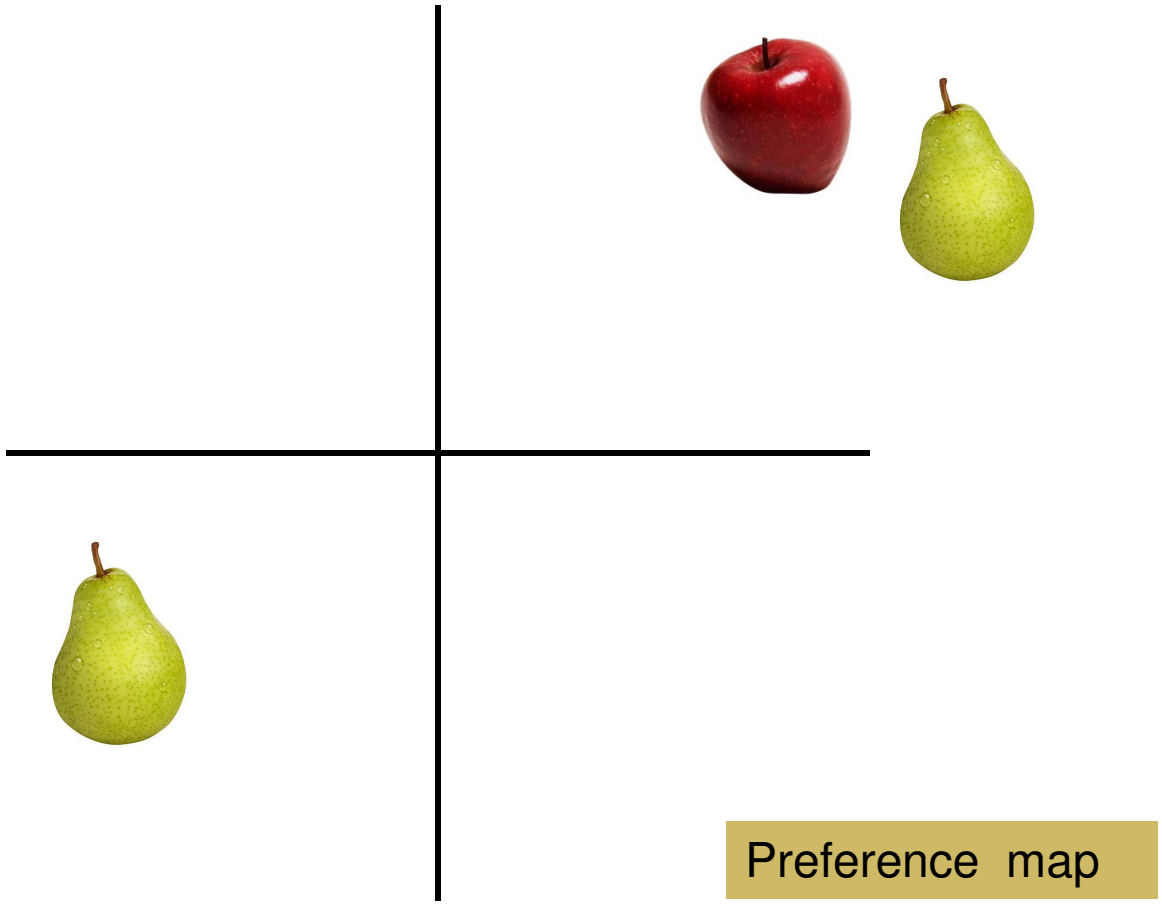
Consumers evaluate 6 or more products

- Some competitor products
- Some potential prototypes

External versus Internal Preference Mapping



Mapping perceptions or preferences?



Preference map

Internal vs. External

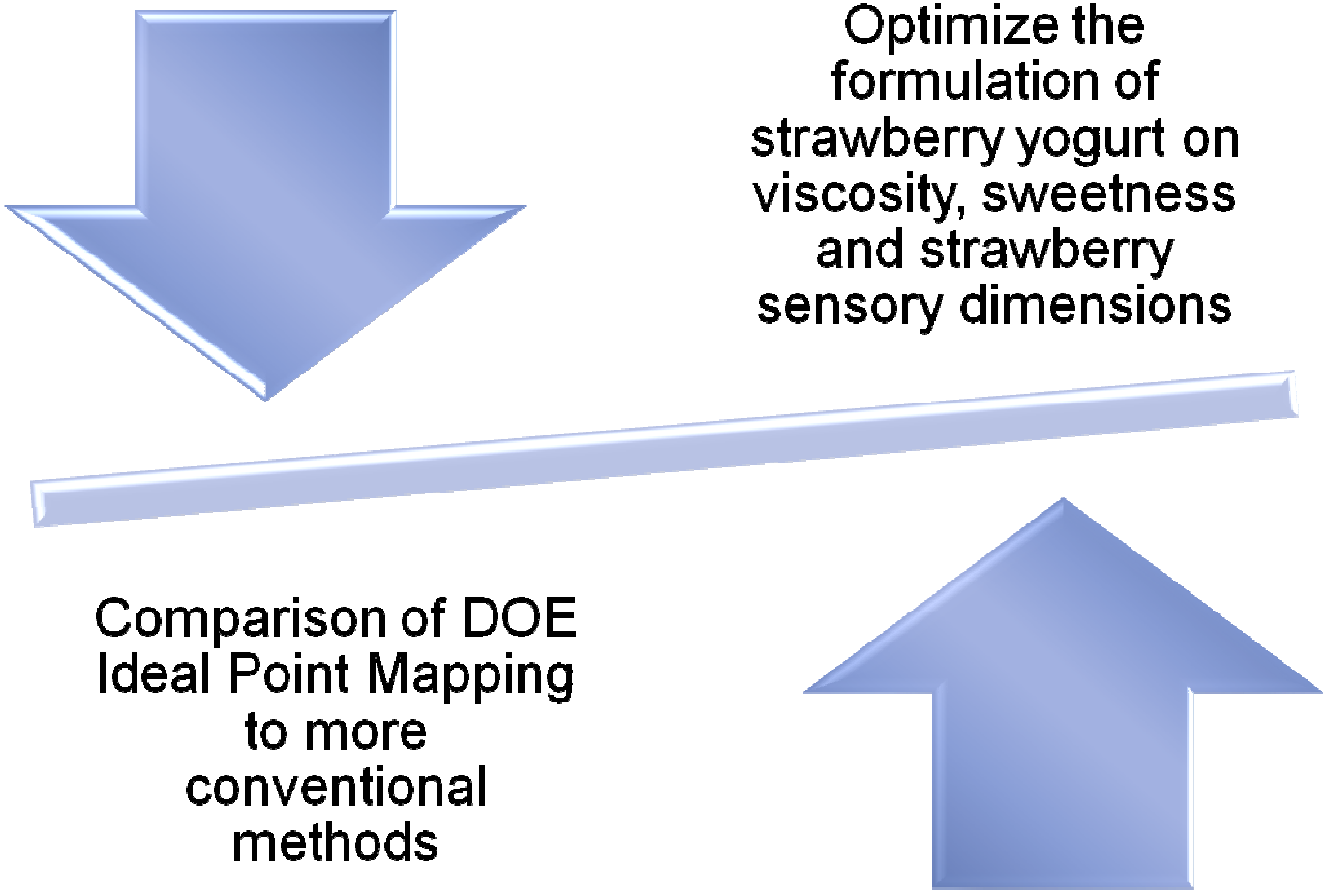
Internal preference analysis

- Stimulus location based on liking (hedonic data drives orientation of the map)
- Sensory attributes can be fitted into preference space afterwards
- First dimension explains maximum variability in hedonic directions

External preference analysis

- Stimulus locations based on similarity in sensory properties (sensory data drive orientation of the map)
- Preference data can be fitted into fixed space afterwards
- First Dimension explains maximum variance in sensory attribute descriptions

Objectives

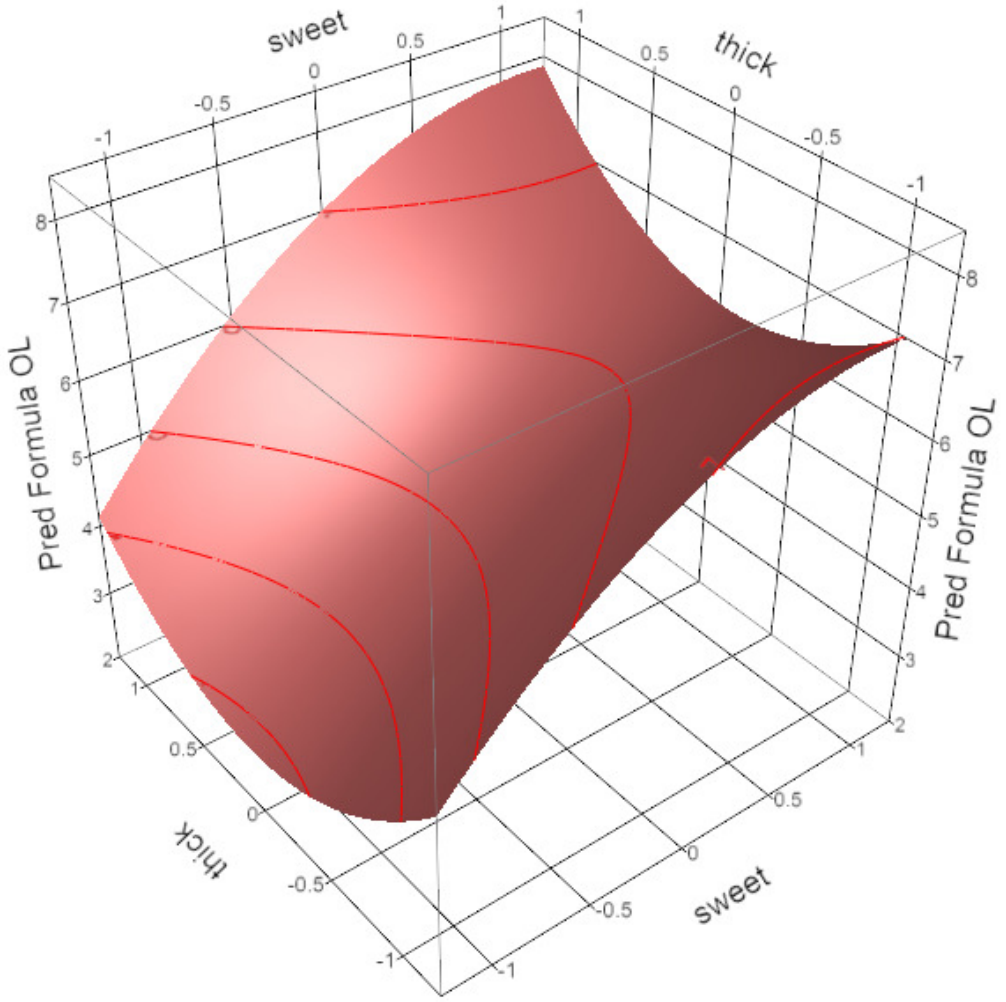


Optimize the formulation of strawberry yogurt on viscosity, sweetness and strawberry sensory dimensions

Comparison of DOE Ideal Point Mapping to more conventional methods

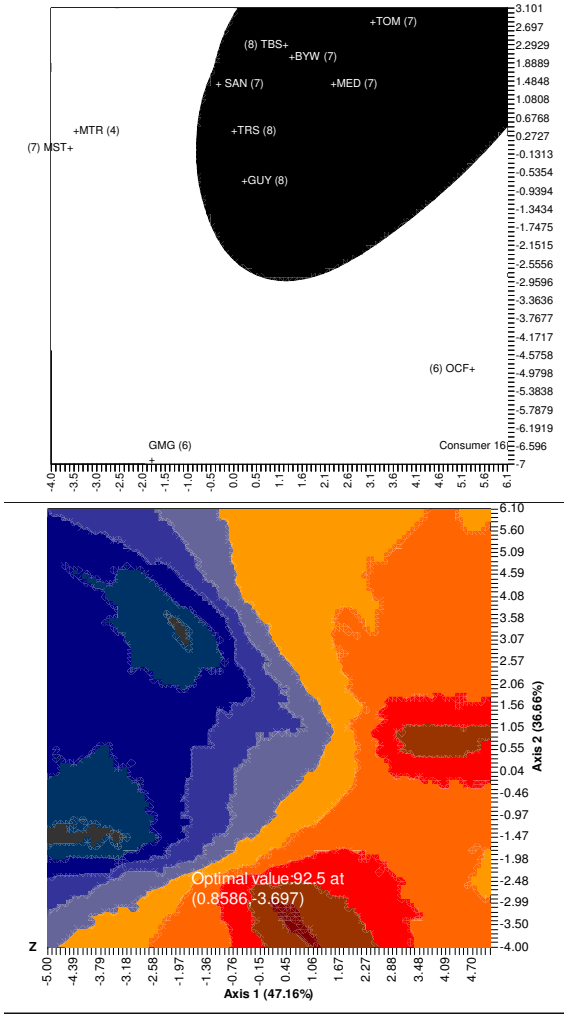
Modeling liking (DOE)

- Liking data fitted to DOE using RSM models (quadratic)
- Hedonic data averaged across consumers
  - Loss of information from averaging
  - Overfitting and number of treatments
    - 2 factors, 6df
    - 3 factors, 11df



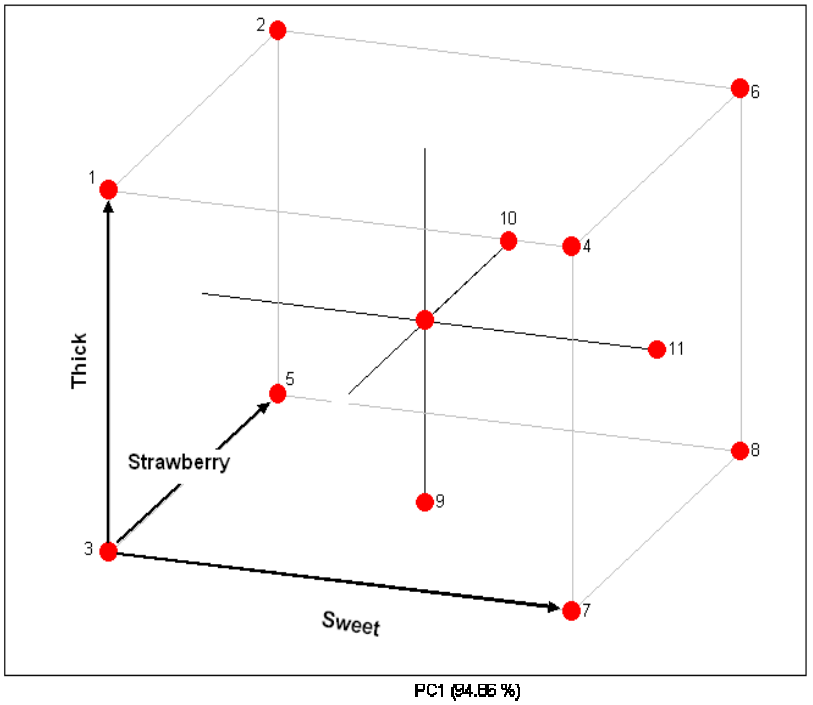
Euclidean Distance Ideal Point Mapping

- EDIPM, an enhancement to internal preference mapping (MDPREF vector models) to identify ideal points (Meullenet et al., 2007)
  - Individual ideals identified
  - Density of individual ideals
  - Group Ideals
  - Projection of sensory attributes to determine ideal profiles



EDIPM

- Starting point: a multidimensional representation of products in a space
- Derived from
  - consumer liking (OL) data (internal framework)
  - sensory profiles (external framework)
  - DOE



Ideal Point Mapping

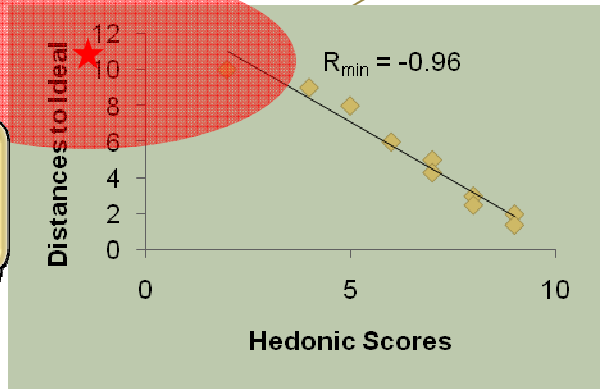
Point of maximum density in the sensory space taken as group ideal

f correlation not different from he minimum correlation this second location is added to the acceptable region of the sensory space for a consumer

Group Ideal

ndividual consumer Ideal

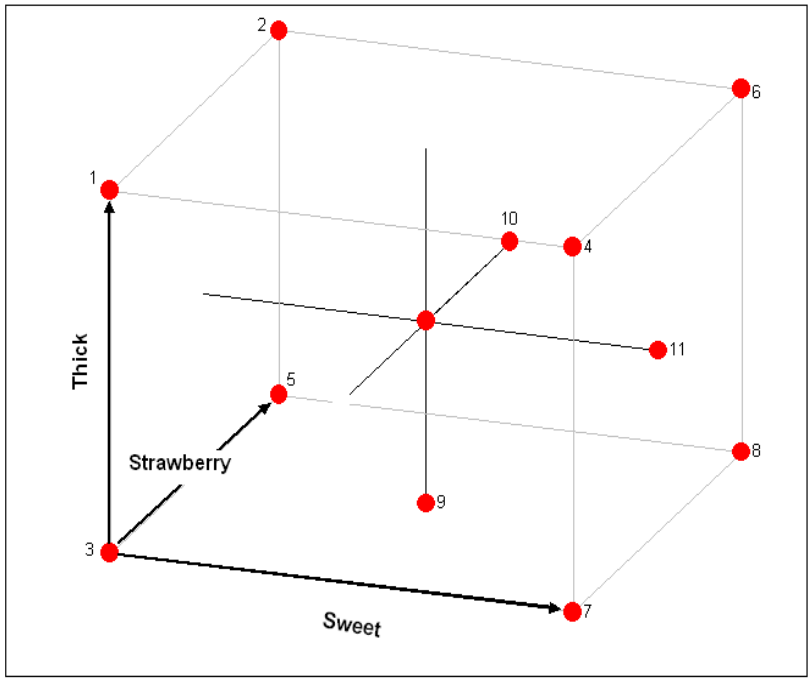
Significance of the correlation can be assessed (defined by α_1=0.05)



Methods

Experimental Design

- 3 variables and 3 levels
  - Thickness, Sweetness, and Strawberry Flavor
  - High (1), medium (0), and low (-1)
- Design-Expert® 7.1, Stat-Ease, Inc.
  - D-optimal, 3 factor design with 11 treatments



Method of Production

Milk + SMP + gelatin

- heated at 85°C
- 5 minutes

Cooled in ice bath

- 40°C

Inoculation

- plain yogurt

Incubation in oven

- 5.5 hours
- 37°C to 40°C

Addition of:

- Strawberry flavor
- Sugar Syrup
- Strawberries
- Food coloring

8oz plastic cups

Descriptive Analysis Methods

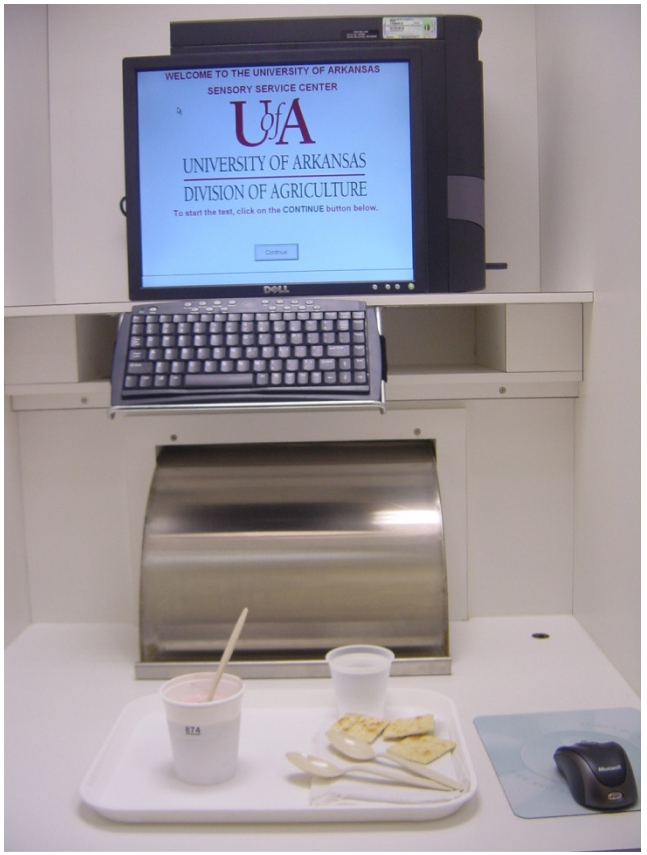
- Spectrum Method® trained panelists
  - Texture and Flavor Evaluation
  - 0 to 15 intensity scale
- Universal Scale for flavor
- Texture References
  - Based on previous work of panel
  - Current commercial products

- Visual Texture:
  - spoon impression, clumpy, thickness, and smooth
- Oral Texture:
  - thickness, stickiness, chalky, and dairy film

- Basic Tastes: sweet, salt, sour, bitter
  - Aqueous solutions as references for 0 to 15 scale
- Aromatics:
  - overall strawberry impression, musty/overripe, caramelized/ cooked, green/ unripe, vanillin, cultured dairy, butter fat, milky, and other.

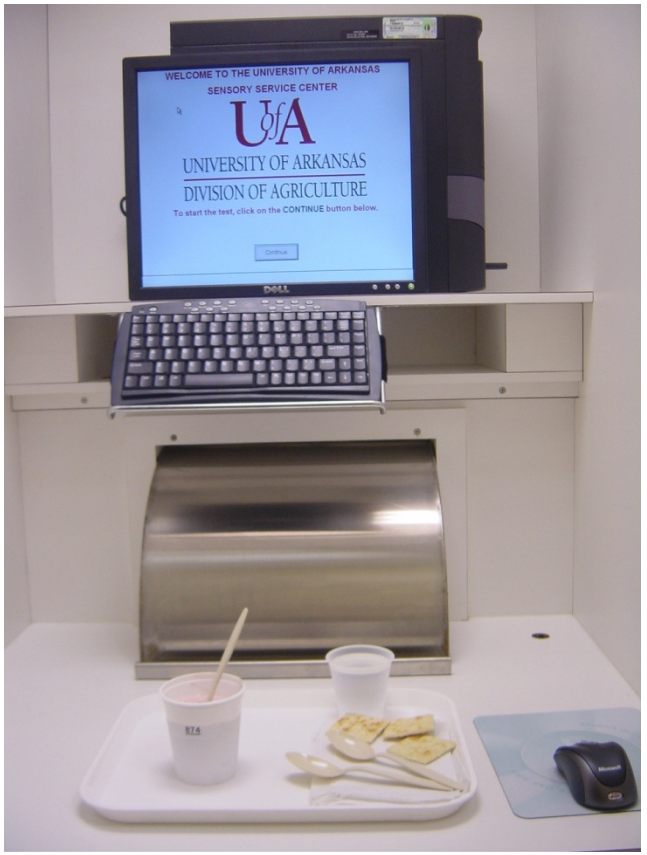
Consumer Testing

- Email recruiting from UofA Sensory Laboratory database (N=2500)
- 120 self-reported strawberry yogurt consumers (70% female, 30% male)
- Testing over 2 days: 11 samples
  - Balanced randomization across both days
  - 6 samples on day one, 5 samples on day 2



Consumer Testing

- 9-pt hedonic scale:
  - 1= dislike extremely, 5=neither like nor dislike, 9= like extremely
  - Overall impression, Appearance, Flavor, Texture
- Just-About-Right scales:
  - 1=not nearly sweet enough, 3= just about right, 5= much too sweet
  - Overall flavor, Sourness, Strawberry flavor, Thickness, Creaminess, Smoothness, Sweetness, Amount of fruit



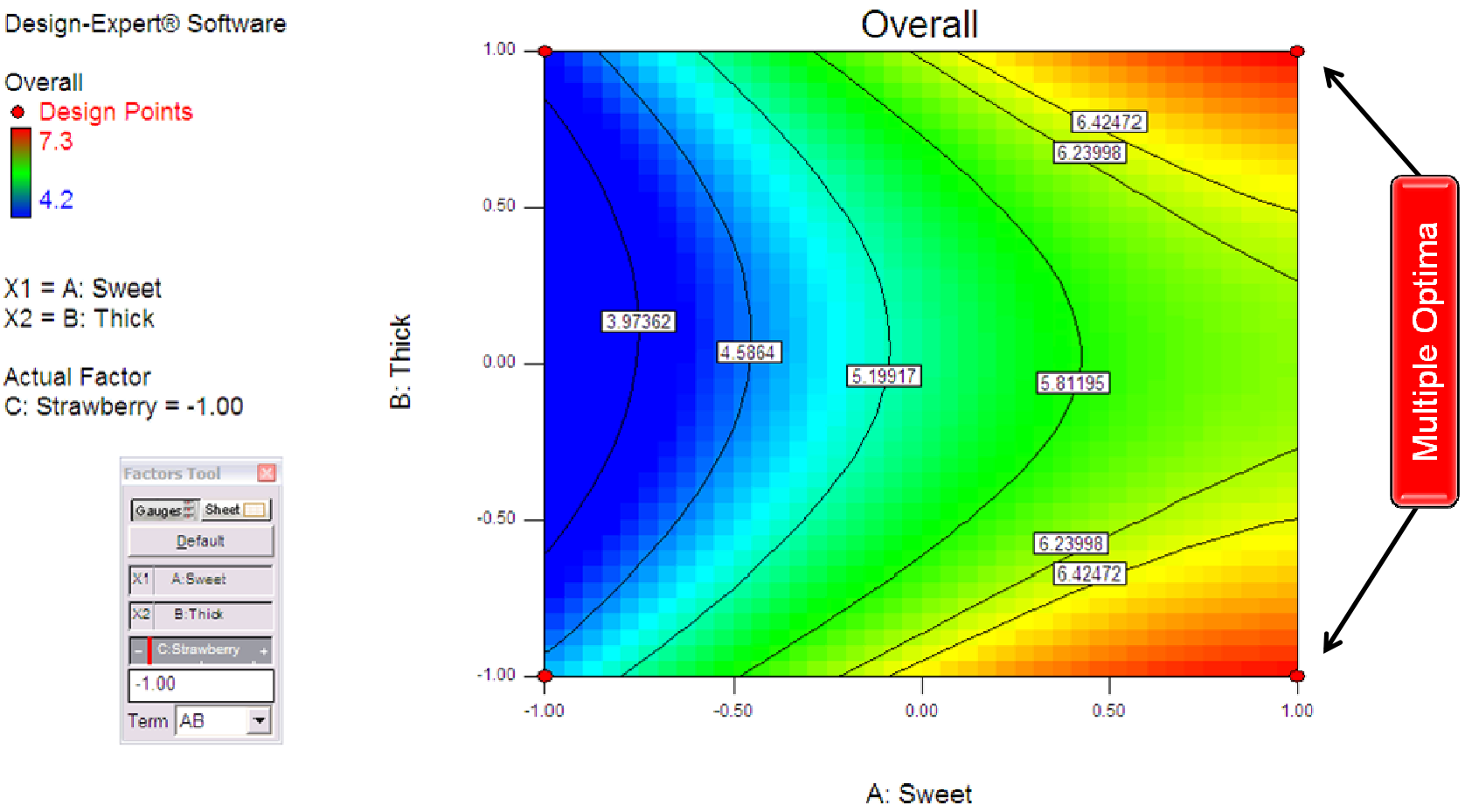
Results

Overall Liking Means

Response Surface Methodology

Fitting a quadratic model on mean liking data results in multiple optima

Consumers liked either thick or thin



RSM

RSM

Considering multiple hedonic responses

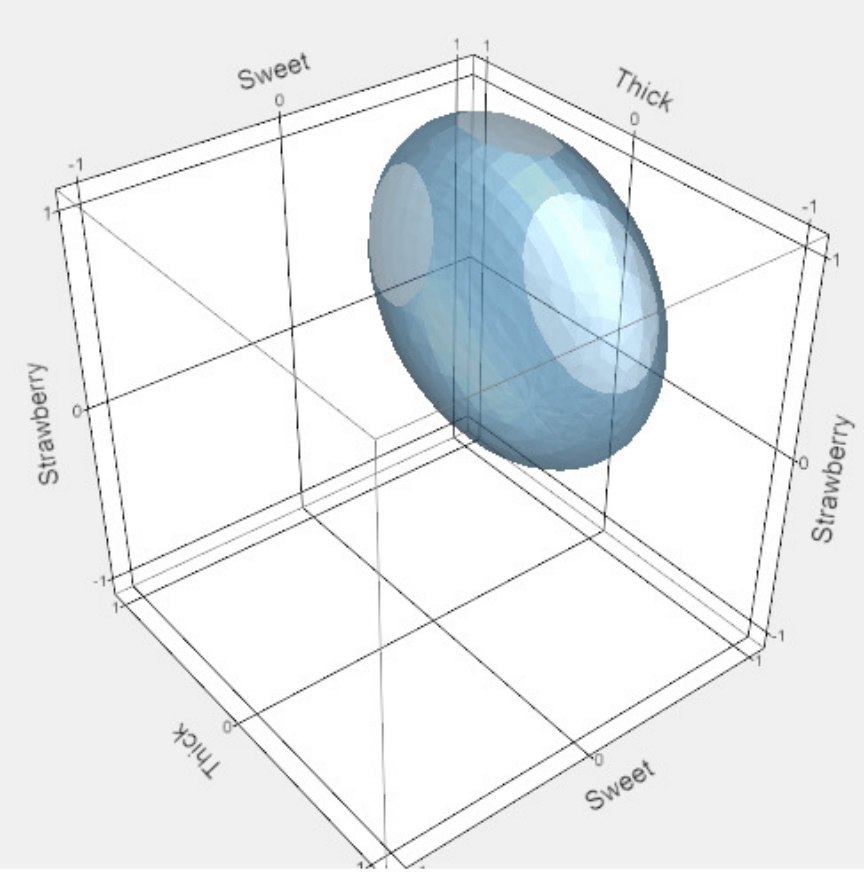
- Overall Impression
- Appearance
- Flavor
- Texture

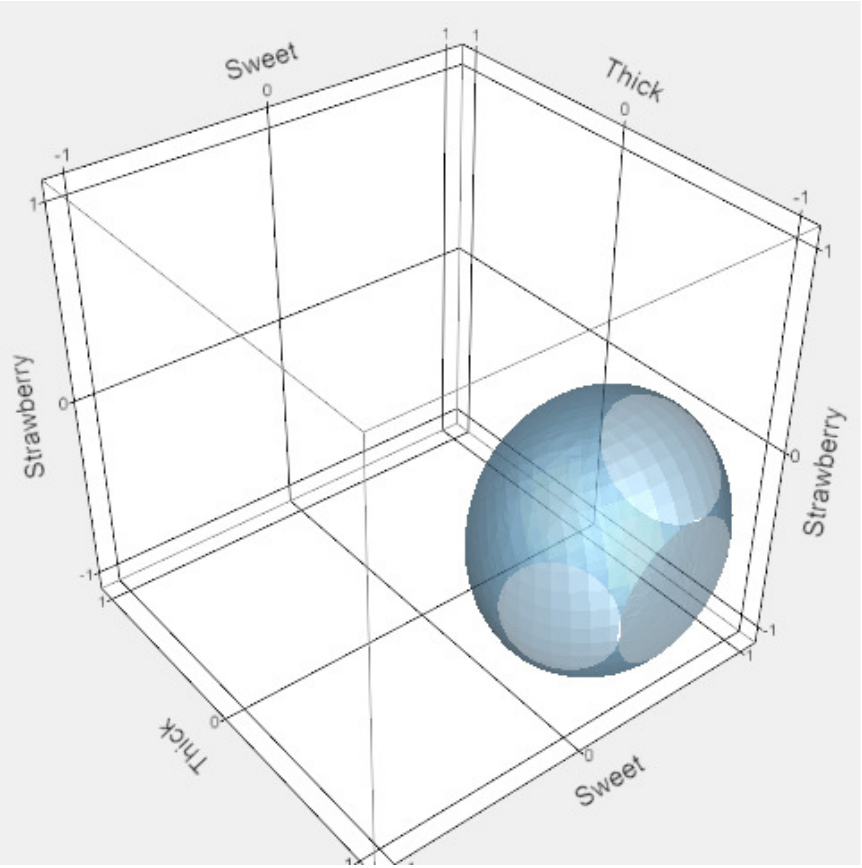
Acceptable formulation

- Thick>0.75
- Sweet>0.80

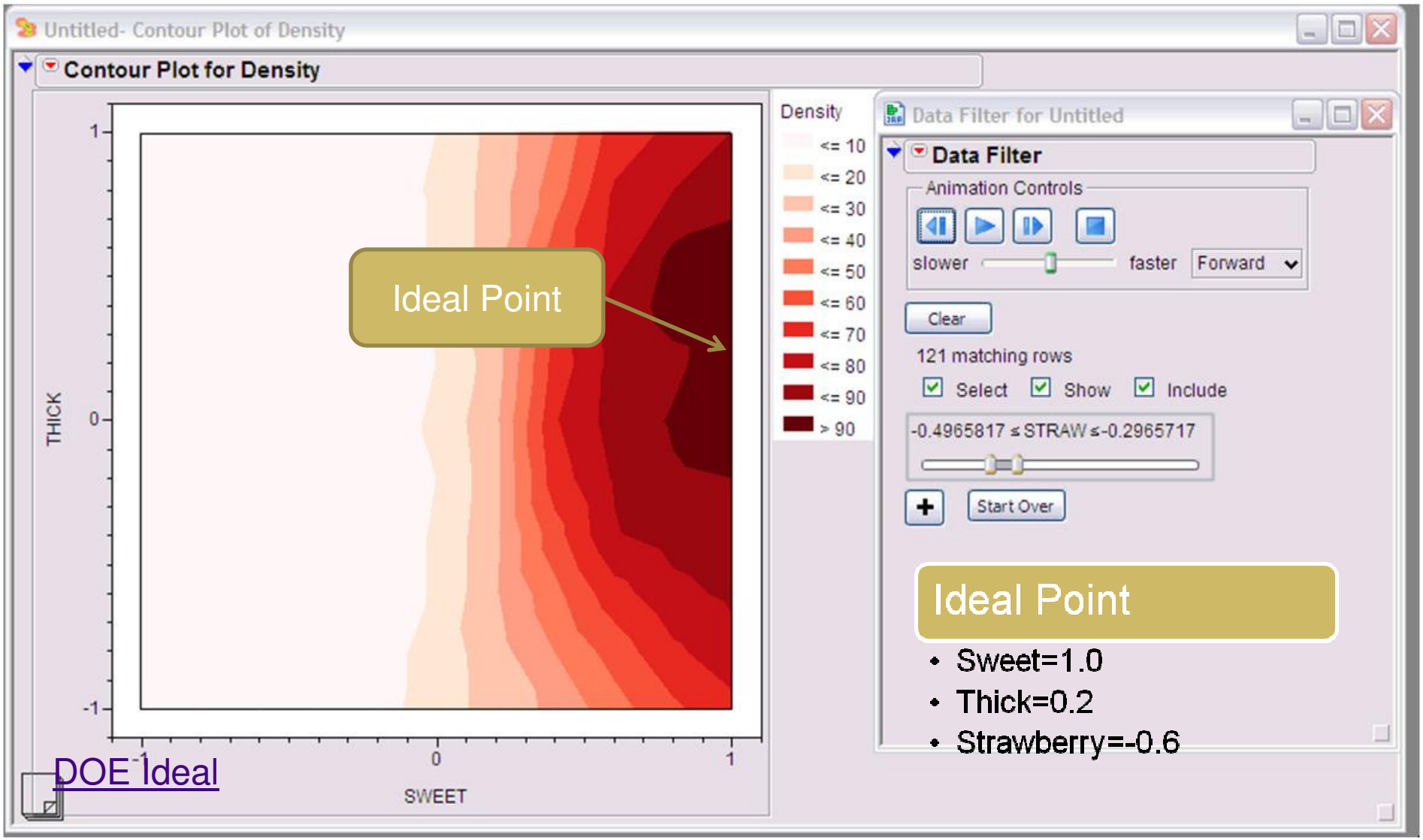
Individual Consumers

Ideal DOE: Ellipses represent acceptable areas for two different consumers





DOE Ideal Point Mapping



Optimal Formulations

DOE EDIPM is different from preference mapping solutions especially for thickness, the second most important factor

Method	Thick	Sweet	Strawberry
LSA	0.45	0.58	1.09
JAR	0.52	1.04	-1.1
EXT	1.06	0.81	0.17
EDIPM	0.88	1.1	-1.08
DOE EDIPM	0.20	1.00	-0.60

1=high

0=medium

-1=low

Consumer Fit

Is the hedonic data (individual consumers) well fitted in the DOE?

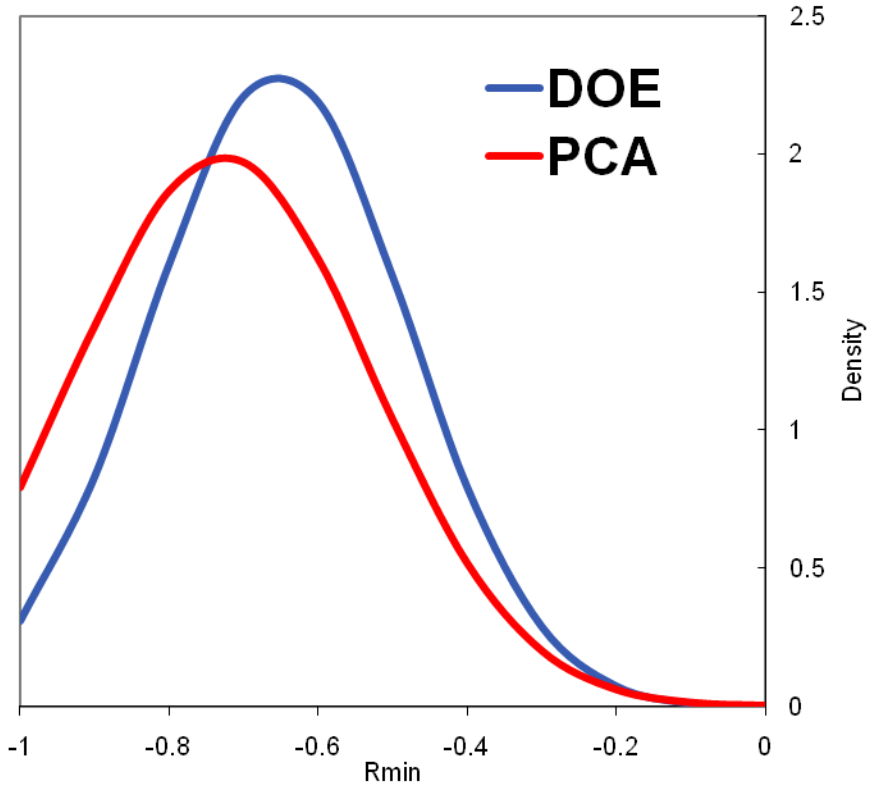
How does it compare to Internal Preference mapping?

Distribution of R_{min} values for consumers in:

- Internal map space
- DOE space

Consumers slightly better fitted in internal map space

Why use DOE Ideal Point Mapping?



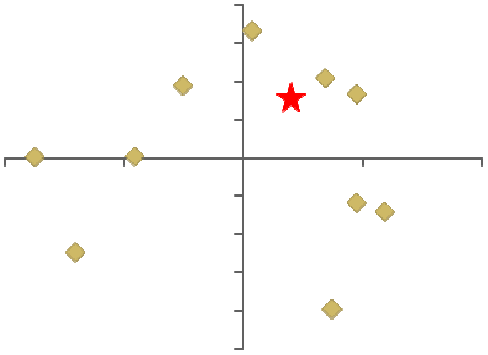
Internal mapping with DOE

Many modeling steps are necessary when internal preference mapping is used with a DOE…multiple errors

Hedonic Scores

	C1	C2	…	Cn-1	Cn
P1					
P2					
. . .					
Pk					

PCA



	PC1	PC2
P1		
P2		
. . .		
Pk		
Ideal	$PC1_{Ideal}$	$PC2_{Ideal}$

Information loss

Multiple Regression

- PC1=f(sweet, thick, strawberry)
- PC2=f(sweet, thick, strawberry)
- •OR
- S1=f(sweet, thick, strawberry)
- S2=f(sweet, thick, strawberry)
- .
- .
- Sp=f(sweet, thick, strawberry)

Target

- $PC1_{Ideal}$
- $PC2_{Ideal}$
- •OR
- $S1_{Ideal}$
- $S2_{Ideal}$
- .
- .
- Sp_{Ideal}

Solve

Ideal

- Sweet
- Thick
- Strawberry

Information loss

DOE Ideal Points

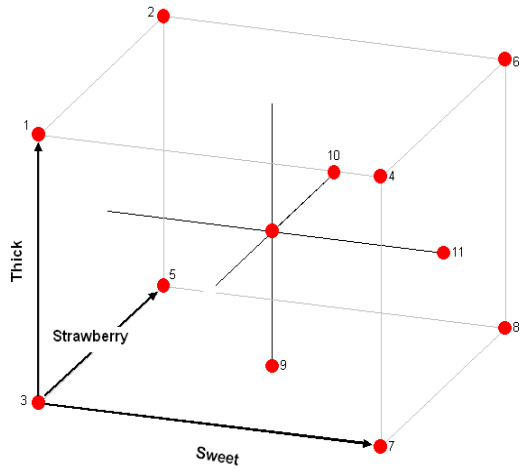
DOE Ideal Point Modeling is a more direct way to identify ideal

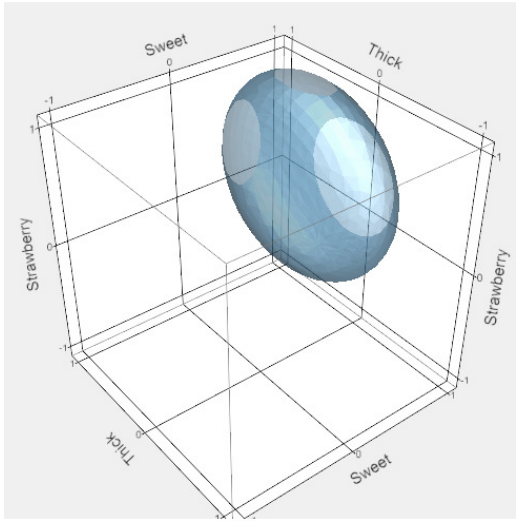
Retains consumer individuality

Hedonic Scores

	C1	C2	…	Cn-1	Cn
P1					
P2					
. . .					
Pk					

Ideal Points



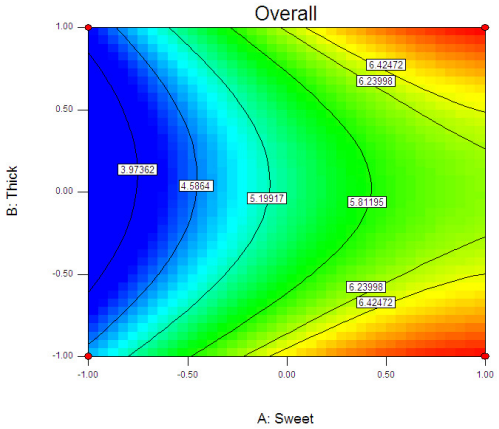


Averaging

Max Density

	Liking avg
P1	
P2	
. . .	
Pk	

RSM



Max Predicted

Ideal

- Sweet
- Thick
- Strawberry

Conclusions

Ideal solutions for Ideal Point DOE and RSM are different	• Preserving consumer individuality seems more sensible!
Ideal Point DOE also yielded different answers than internal or external preference mapping	• Internal or external preference mapping applied to a DOE results in cumbersome modeling • Prediction errors for various modeling steps are cumulated
IPM not regression based	• no overfitting • not limited to 3 factors

Sensory & Consumer Research Center

UNIVERSITY OF ARKANSAS

DIVISION OF AGRICULTURE

http://www.uark.edu/ua/sensory

Acknowledgements
Caroline Lovely, MS Food Science
Givaudan