Data Science in Cooking

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Group Meeting
March 22, 2017

Main Source

SUBJECT AREAS:

STATISTICAL PHYSICS, THERMODYNAMICS AND NONLINEAR DYNAMICS

APPLIED PHYSICS

SYSTEMS BIOLOGY

STATISTICS

Flavor network and the principles of food pairing

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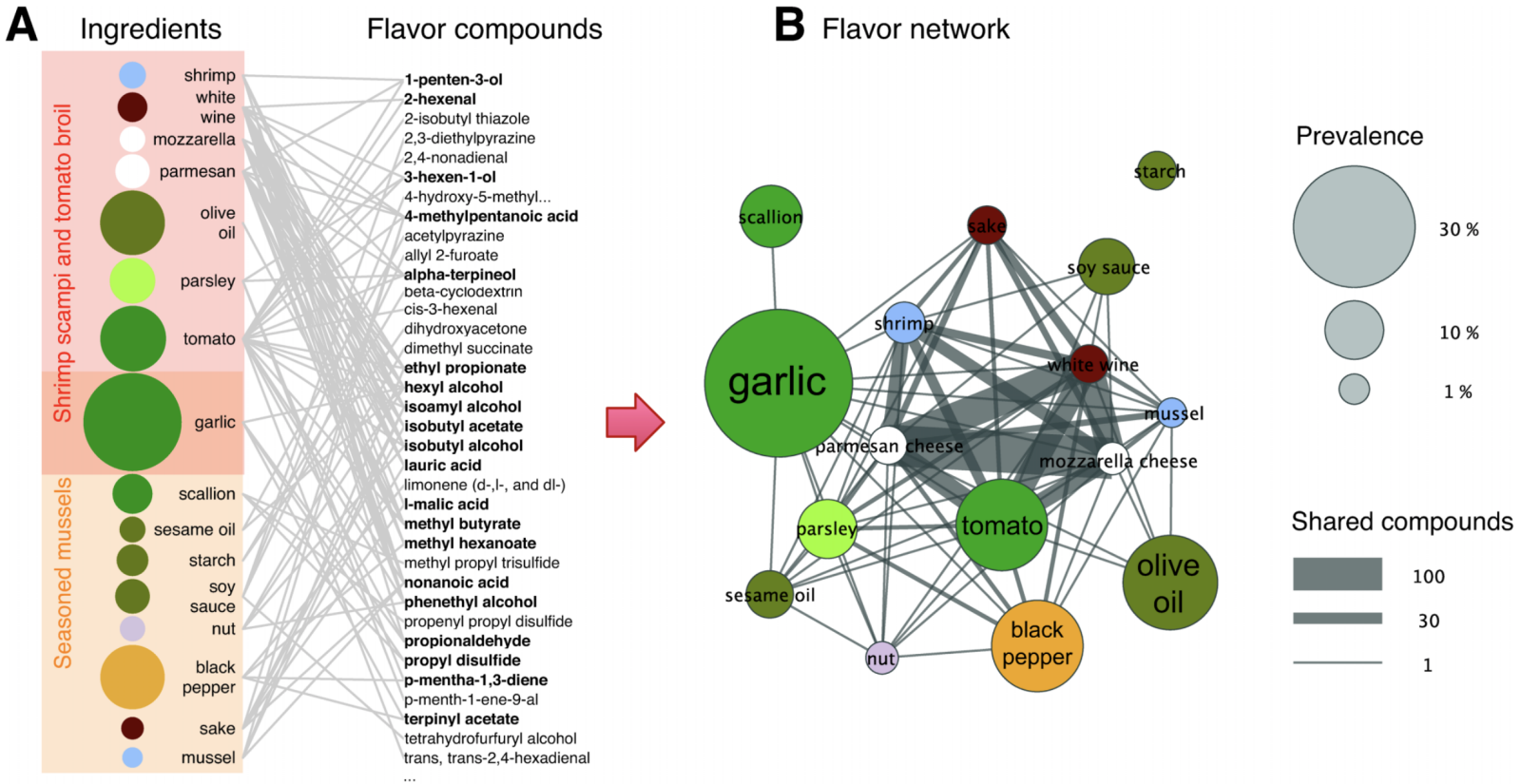
(2011)

Outline

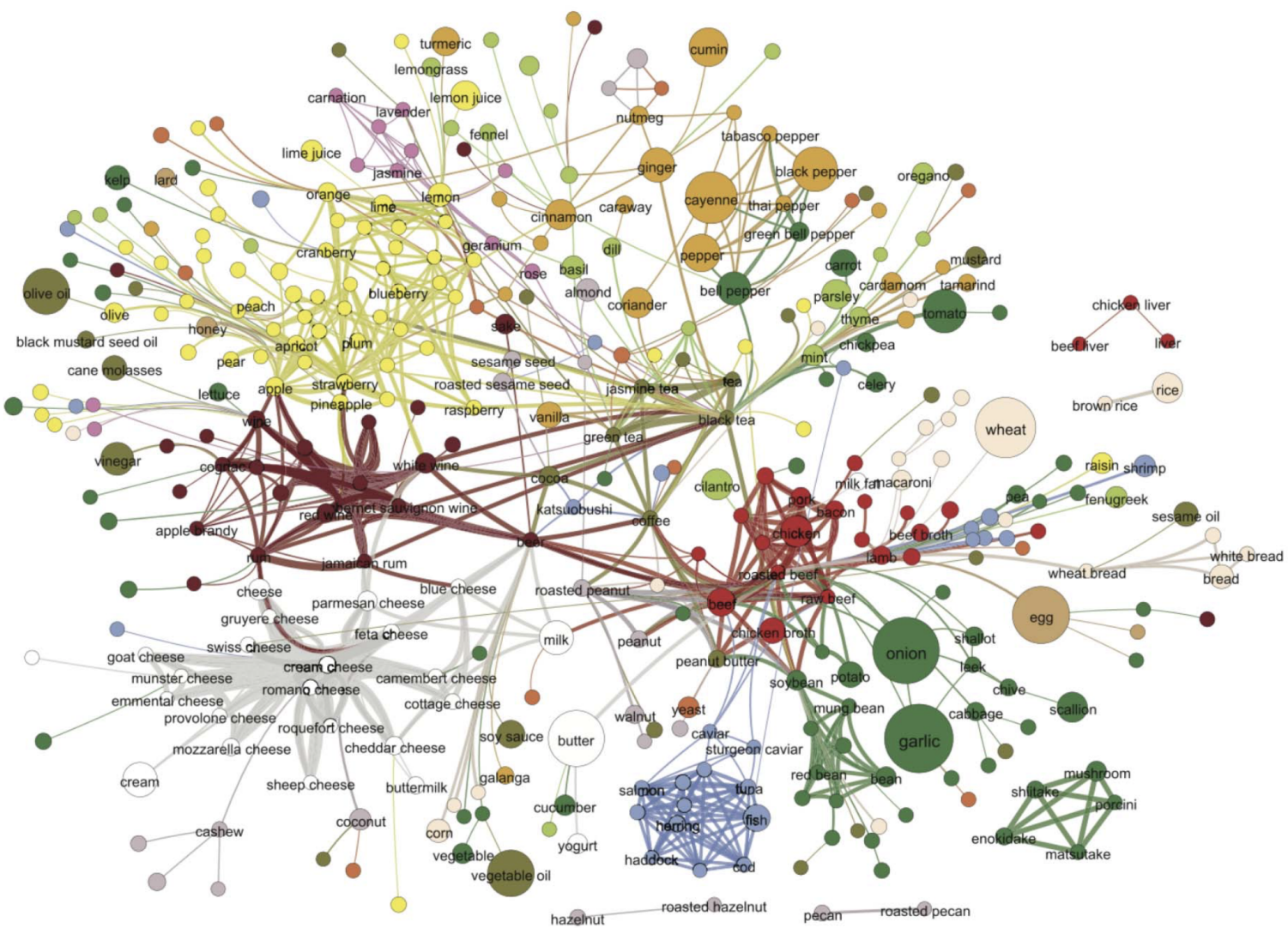
- Flavor Network
- Applications
  - Food Pairing Hypothesis
  - Regional Cuisines
  - FPH in Medieval Times
- Limitations
- Conclusions

Flavor Network



- Food scientistis have linked ingredients with flavor compounds
- Contains: 381 ingredients and 1,021 flavor components

Flavor Network



What questions can the flavor network answer?

Question 1: Food Pairing

Food Pairing Hypothesis

Ingredients sharing flavor components are more likely to taste well together than ingredients that do not.

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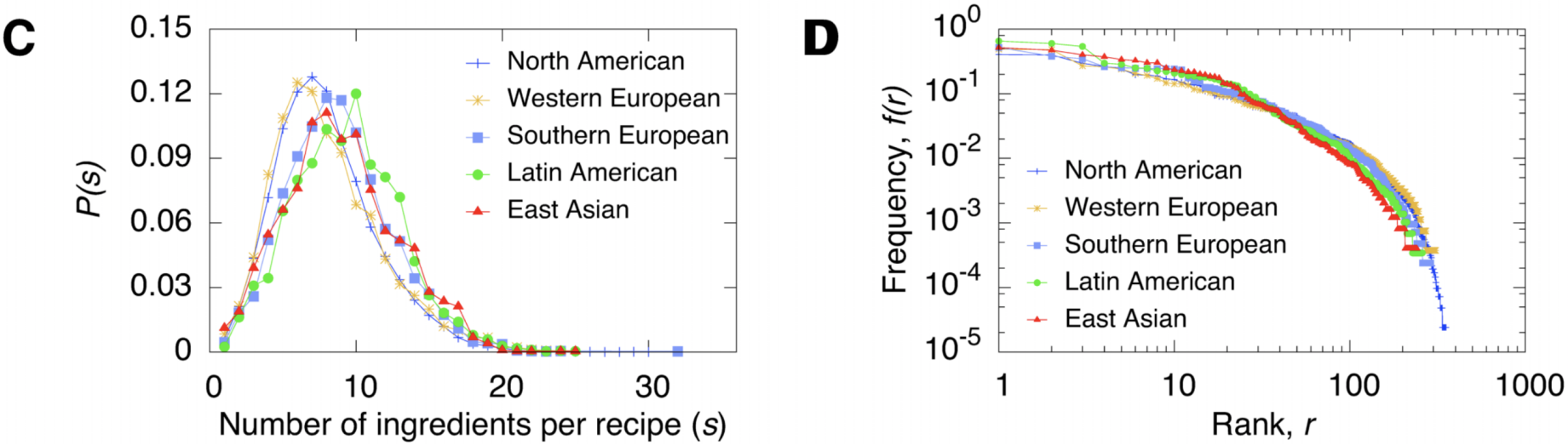
Uses:

- Learn why foods taste good
- Food science
- Search for novel food combinations:
  white chocolate and caviar,
  chocolate and blue cheese

Reformulate with math: Are ingredient pairs in recipes strongly connected in the flavor network?

Testing the Food Pairing Hypothesis

- 56,498 recipes from:
  - American sources *epicurious.com* and *allrecipes.com*
  - Korean source *menupan.com*
- Recipes grouped into distinct regions



Testing the Food Pairing Hypothesis

Number of shared compounds, C_i, in recipe R with n_R ingredients

$$N_s(R) = \frac{2}{n_R(n_R - 1)} \sum_{i,j \in R, i \neq j} |C_i \cap C_j|$$

Real examples:

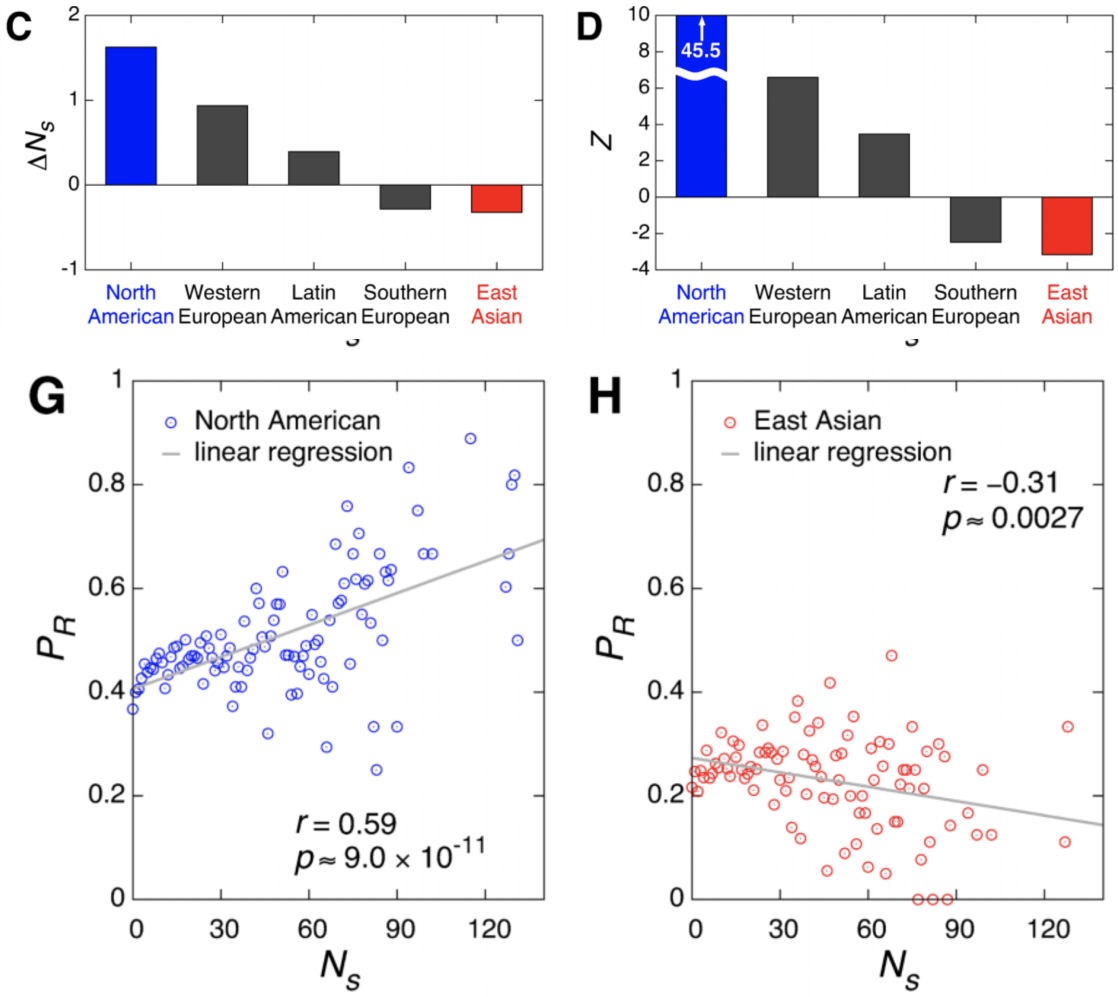
- Mustard Cream Pan Sauce: chicken broth, mustard, cream $\rightarrow N_s(R) = 0$
- Sweet and Simple Pork Chops: pork, apples, cheddar $\rightarrow N_s(R) = 60$

For each category, compared mean number of shared compounds in recipes (N_s^{real}) with the mean number in 10,000 randomly constructed reciepes (N_s^{rand})

$$\Delta N_s = N_s^{real} - N_s^{rand}$$

$$N_s^{real} = \sum_R N_s(R)/N_c$$

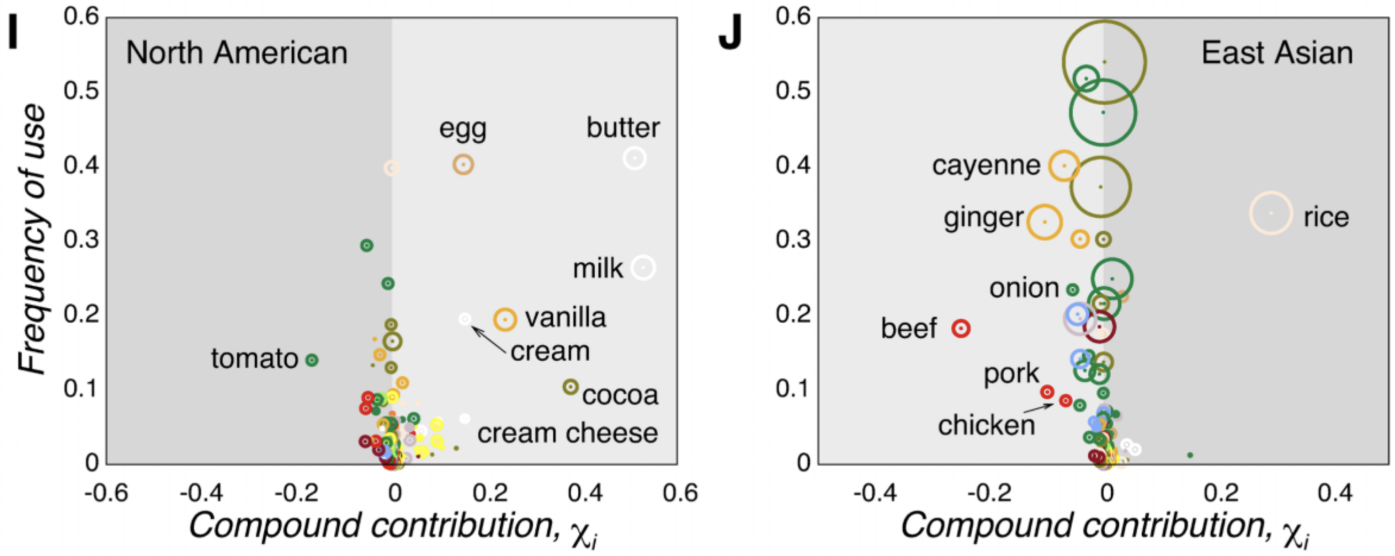
Food Pairing Hypothesis: Results



North American recipes tend to share more compounds, East Asian share less.

Question 2: Regional Cuisines

Are specific compounds/ingredients responsible for regional differences?



$$\chi_i^c = \left(\frac{1}{N_C} \sum_{i \in R} \frac{2}{n_R(n_R - 1)} \sum_{j \neq i(j, i \in R)} |C_i \cap C_j| \right) - \left(\frac{2f_i}{N_c < n_R >} \frac{\sum_{j \in c} f_j |C_i \cap C_j|}{\sum_{j \in c} f_j} \right)$$

Positive χ_i values increase the number of shared compounds.

Question 3: Flavors of Medieval Europe, 1300 - 1615

Flavor Pairing in Medieval European Cuisine:
A Study in Cooking with Dirty Data

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(2013)

Question 3: Flavors of Medieval Europe, 1300 - 1615

Was the Food Pairing Hypothesis true during Medieval Times?

Recipe Database:

- 4,133 recipes from 1300 – 1615
- 25 source texts from England, France, Germany and Italy
- Manually placed ingredients into 391 equivalence groupings
- 386 different ingredients

Compound Databases:

- Volatile Compounds in Food (VCF) - more complete dataset
- Fenaroli's Handbook of Flavor Ingredients - sparser

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FPH true with Fenaroli, not with VCF

Flavors of Medieval Europe

Columbian Exchange (1492) resulted in variety of new foods

Source: thecolumbianexchange.weebly.com

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Conjecture: Western cooks maintained FPH after Columbian Exchange

Limitations and Conclusions

Limitations:

- Flavors depend on method of cooking
- Does not account for texture, color, sound, or temperature
- Some ingredients have structural role (eggs)
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Additional Applications:

- Searching for similar recipes
- Recipe recommender
- Ingredient recommender
- Study cultural differences and mixing of cultures
- Study historical culinary trends

References

- Ahn, Y.-Y., Ahnert, S. E., Bagrow, J. P., & Barabsi, A.-L. (2011). Flavor network and the principles of food pairing. Scientific Reports, 1(1), 217. http://doi.org/10.1038/srep00196

- Varshney, K.R., L.R. Varshney, J. Wang, D. Myers, Flavor Pairing in Medieval Europen Cuisine: A study in Cooking with Dirty Data. International Joint Conference on Artificial Intelligence Workshops, Beijing, China, August 2013. arXiv:1307.7982