

Advanced Text Analysis

Day 1 / Session 1

Petro Tolochko

Contents of the Course

Day 1	Motivation / Examples / Text Representation
Day 2	Statistical Models of Language
Day 3	Traditional ML models
Day 4	Deep Learning / Word Embeddings
Day 5	Transformer Models / LLMs

Course Structure

- 10:00–12:00 Morning Session
- 13:30–15:30 Afternoon Session
- Pass/Fail – Default Grading
- 2 (90% attendance / participation) /4 ECTS (take-home paper)
- Deadline: ***End of July***

Introduction

Introduction

- Post-Doc, Computational Communication Science Lab, University of Vienna
- Research focus: Text complexity, social networks
- petro.tolochko@univie.ac.at

Introduction

- Name?
- Affiliation?
- Background?
- Experience with Text Analysis?
- Programming?
- What are the expectations and wishes for the workshop?

Objectives

- Getting to know methods of automated text analysis
- Practical Challenges
- Critical Reflection
- Utility for your own projects

Course Structure

- Theoretical Input
- Coding Practice
- Coding Exercise

Course assessment

- Participation + Engagement + Take-home class

Personal Feedback

- Informal feedback on your projects
- Research question, Data, Methods, Current struggles

Course repository

- GitHub link

Today

- R / GitHub refresher
- Text representation
- Practice

Questions?

R / GitHub refresher

Break

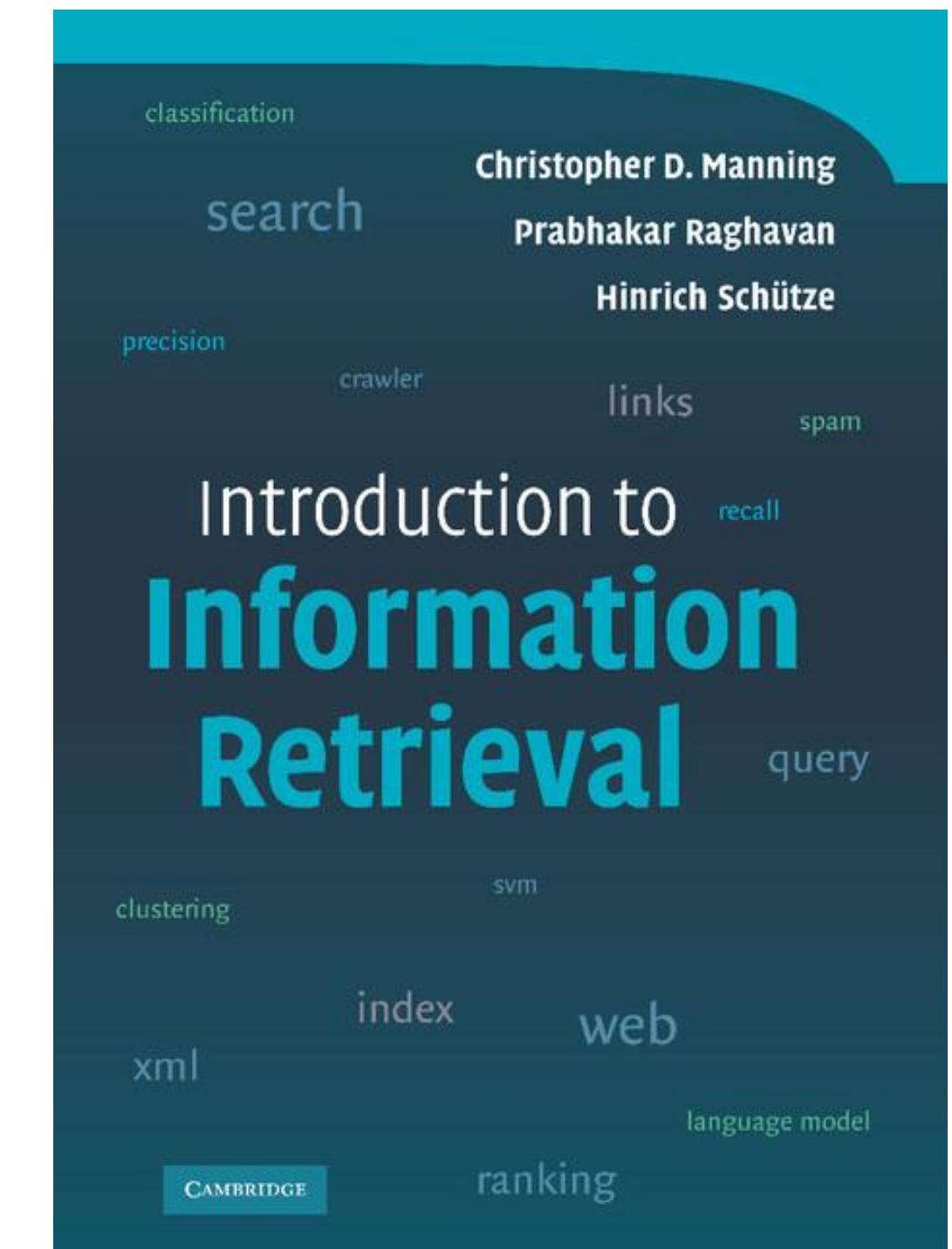
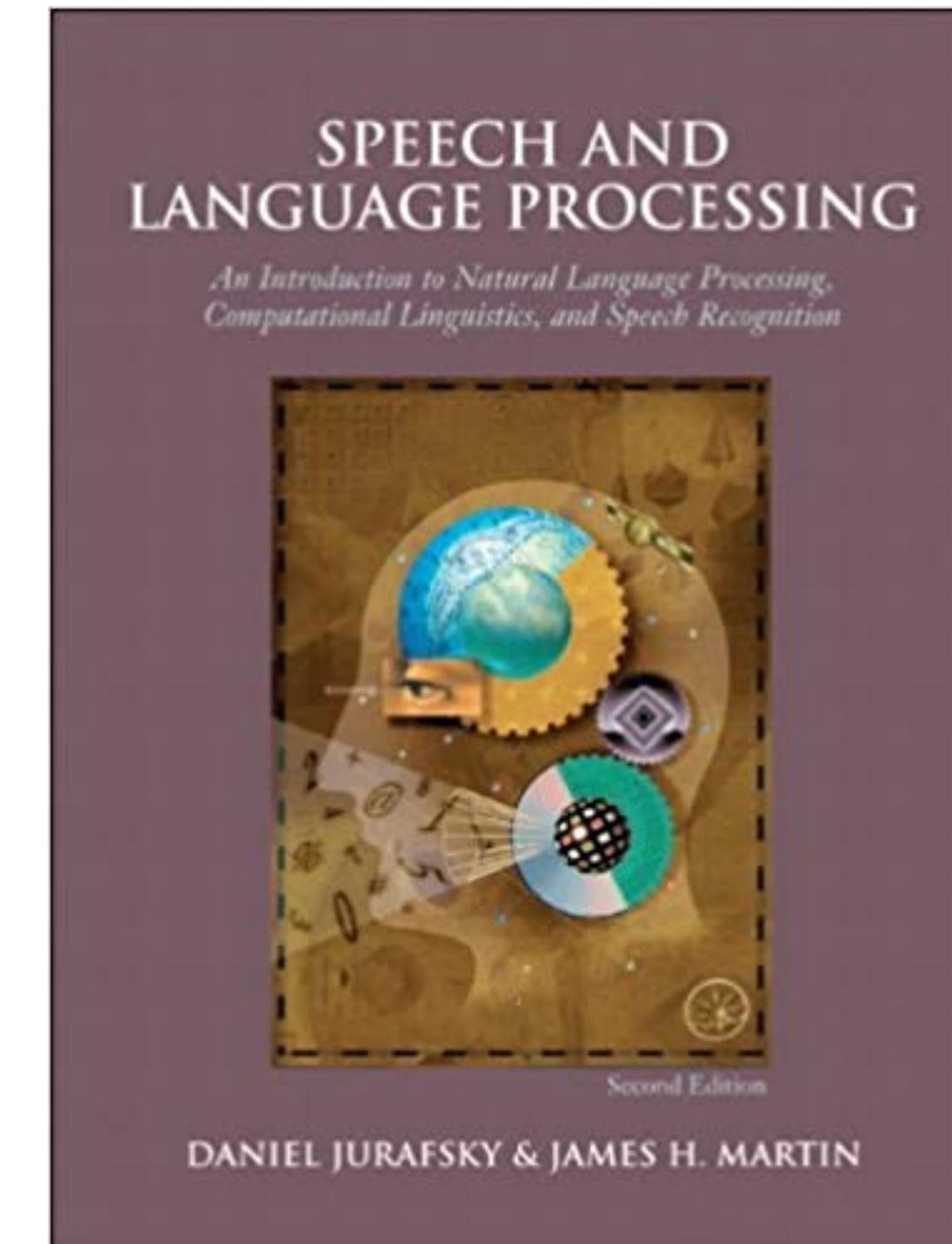
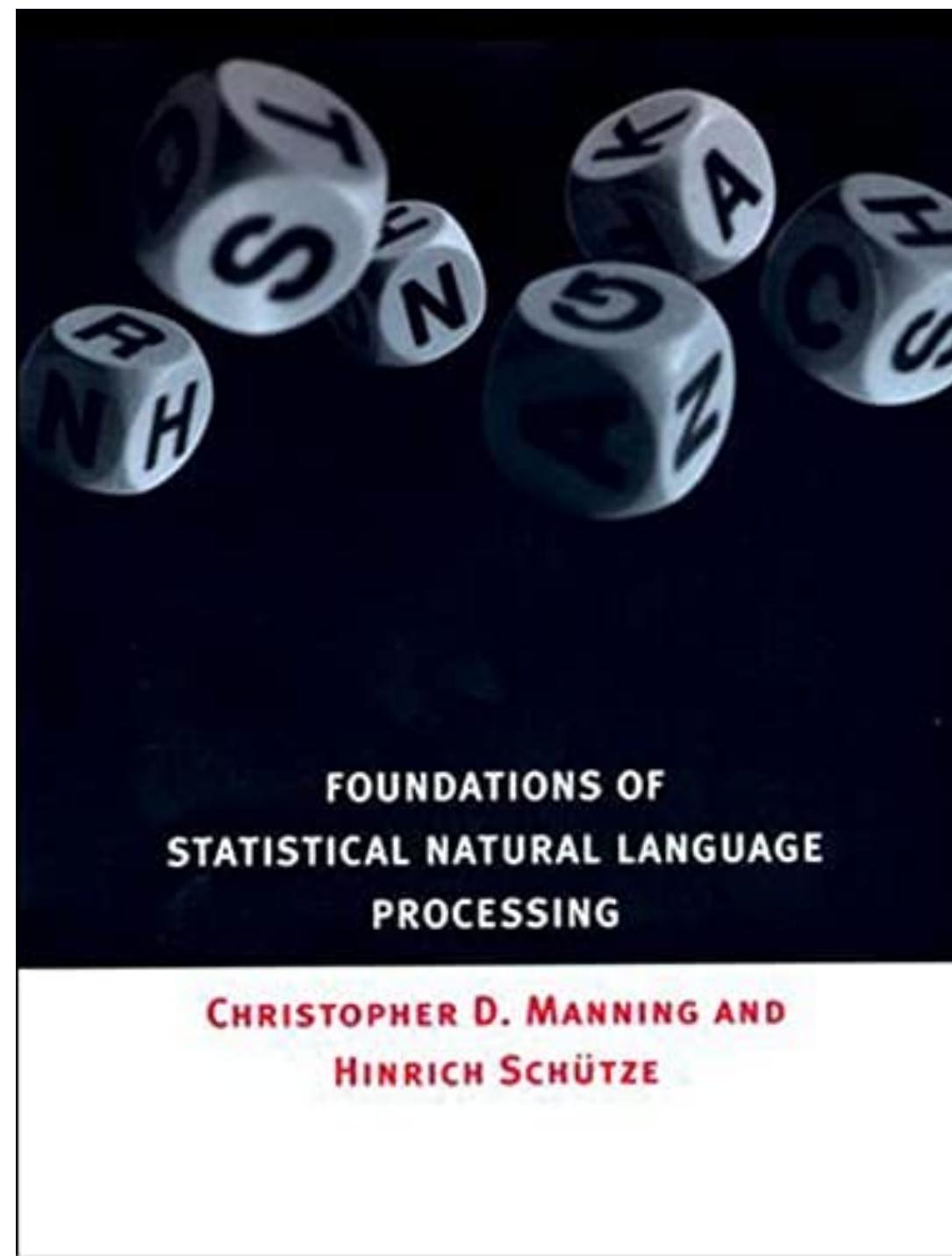
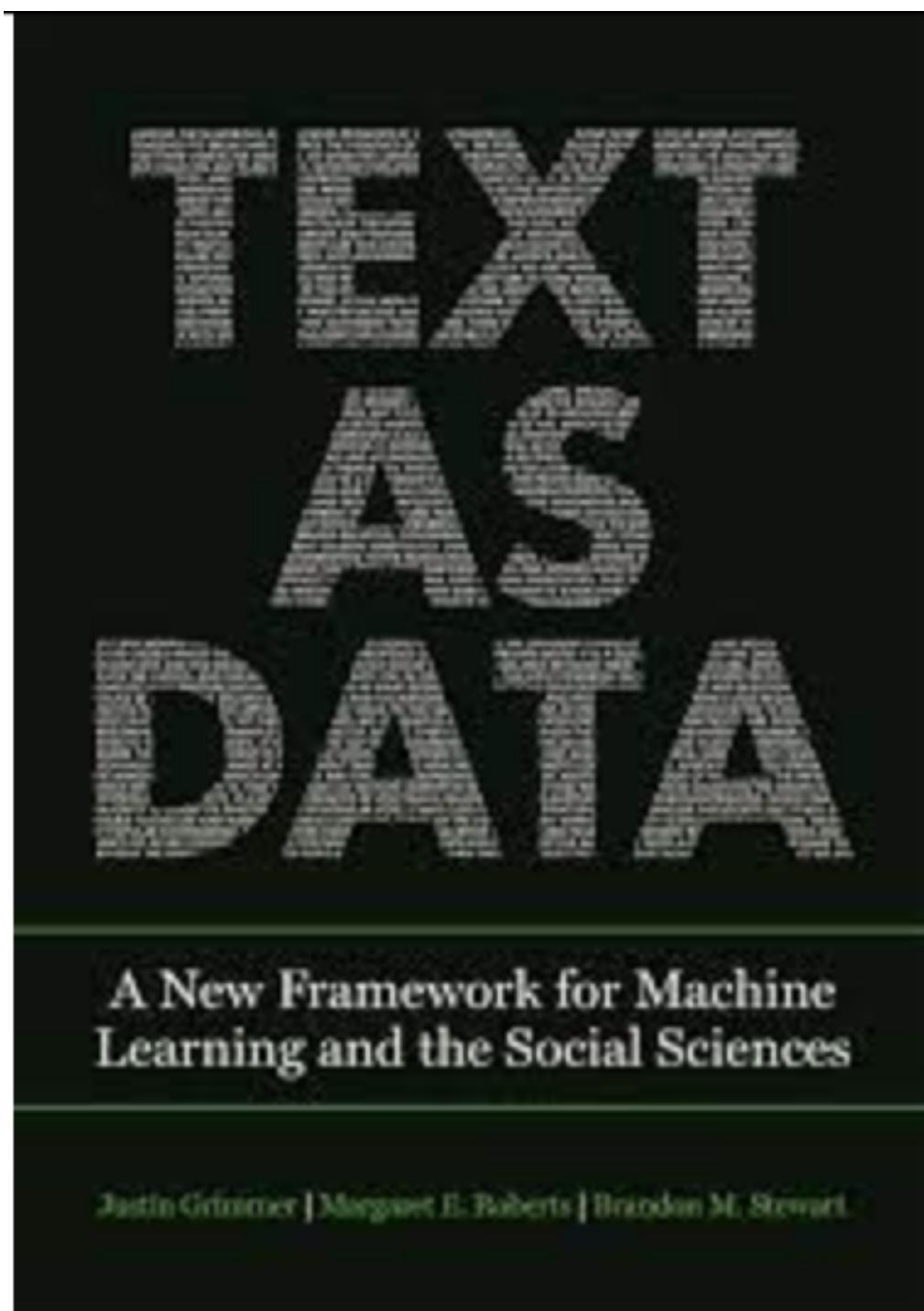
Advanced Text Analysis

Day 1 / Session 2

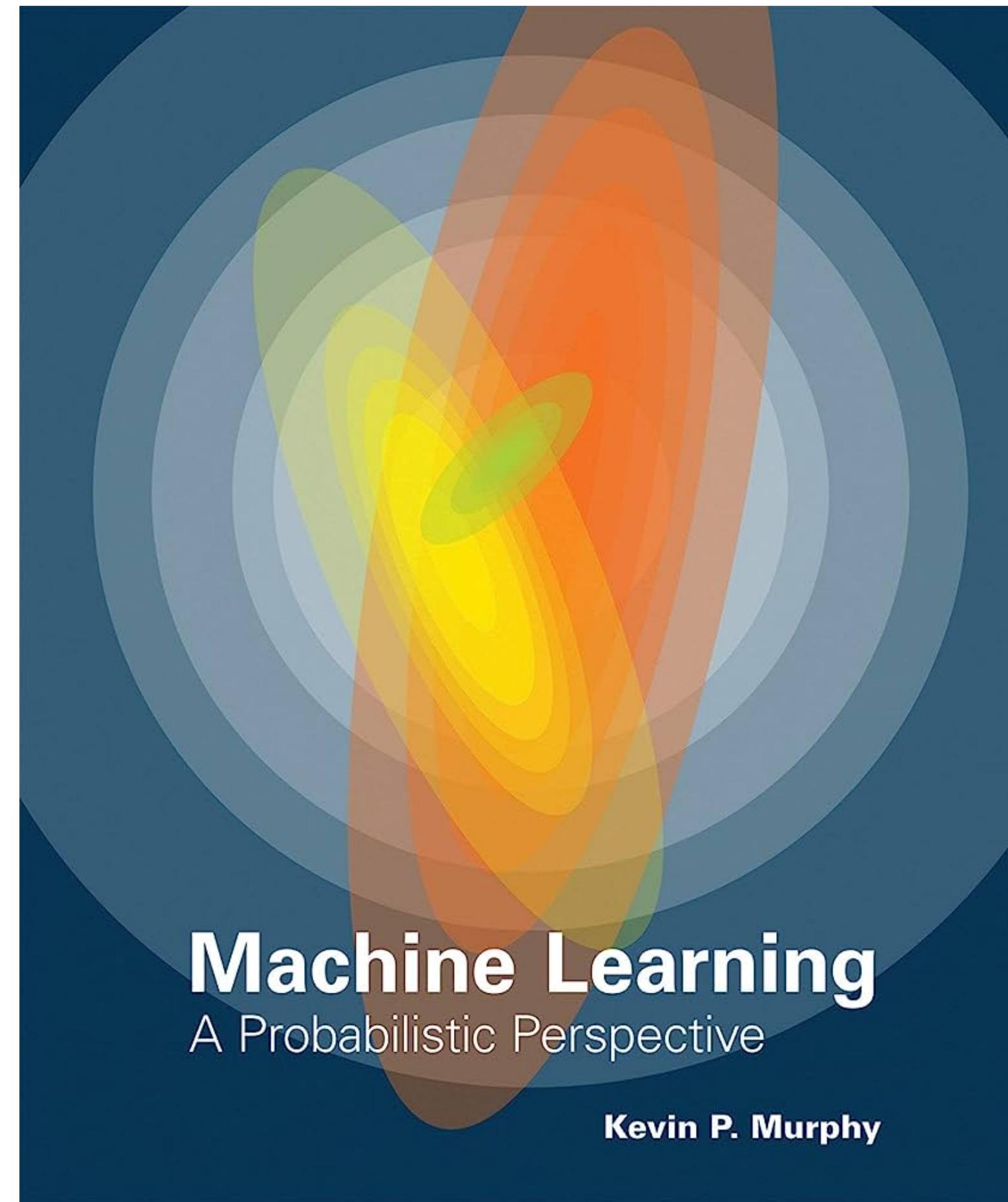
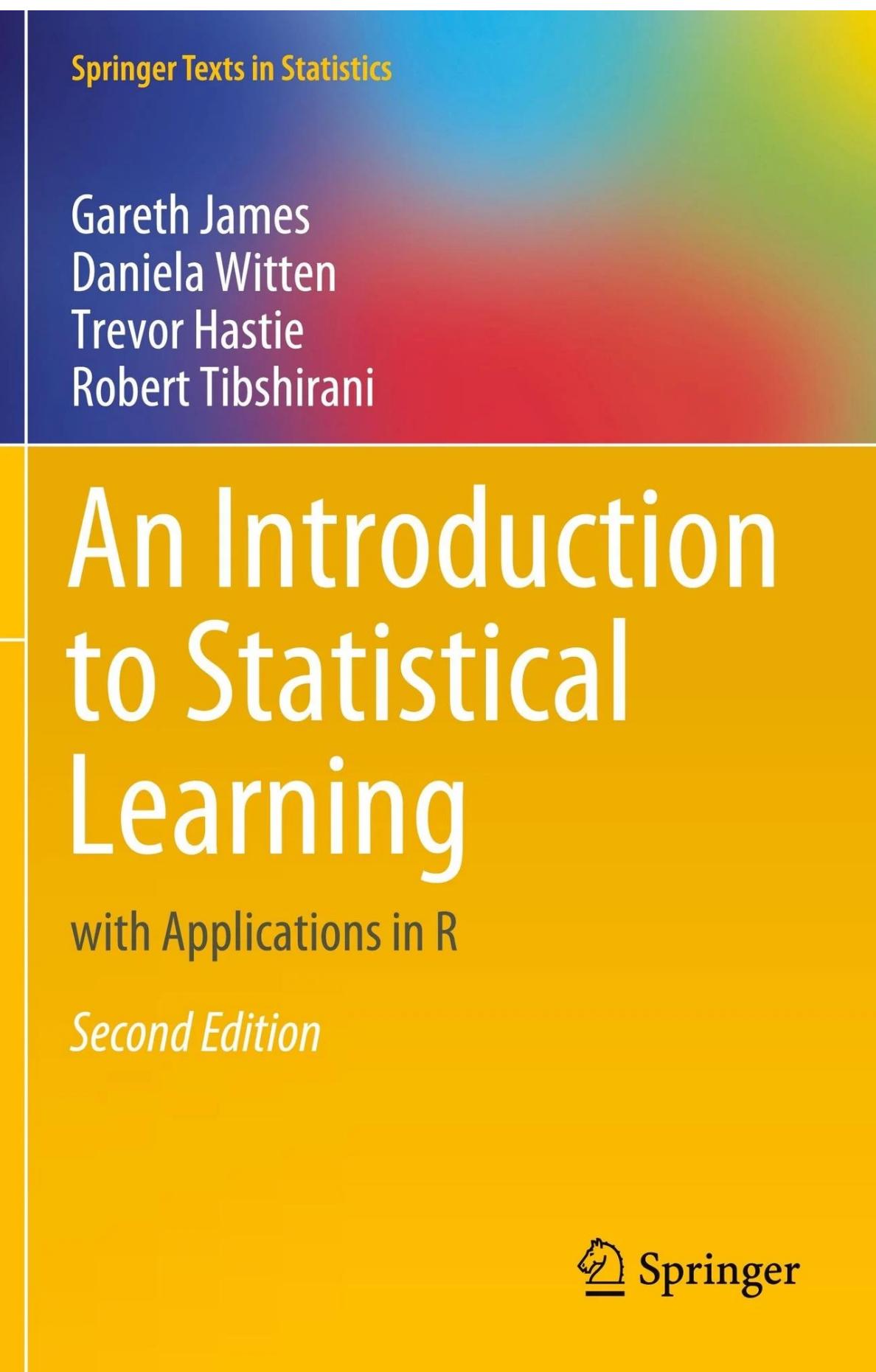
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Resources

Resources



Resources



Resources

- *Advanced Data Analysis from an Elementary Point of View*
 - Cosma Rohilla Shalizi
 - ***Free online***

Why analyse texts?

- Vast quantities of data available
- Texts carry meaning
- Texts capture social behaviour

Quantitative Analysis of Culture Using Millions of Digitized Books

Article in Science · January 2011

DOI: 10.1126/science.1199644 · Source: PubMed

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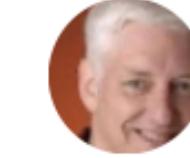


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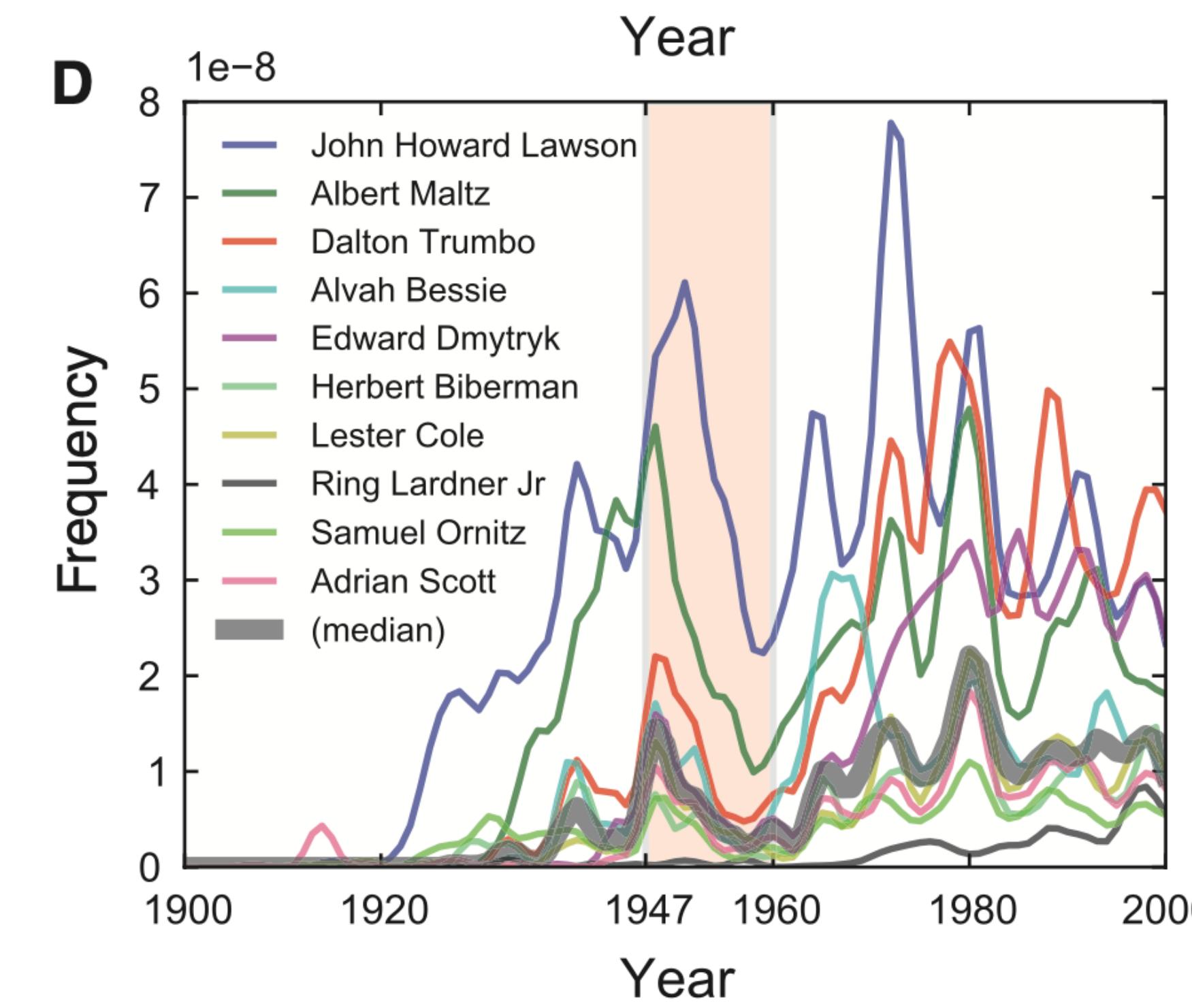
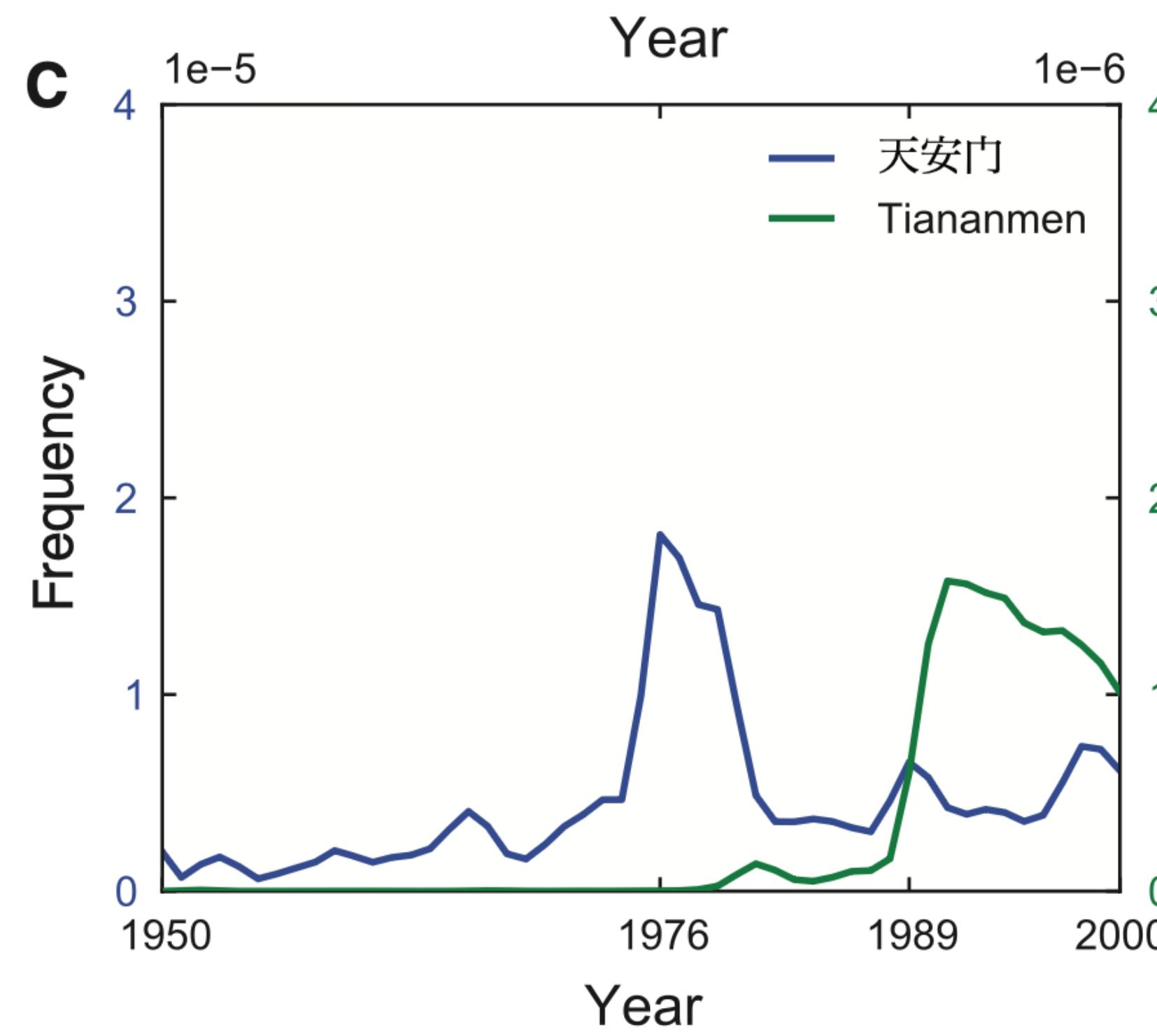
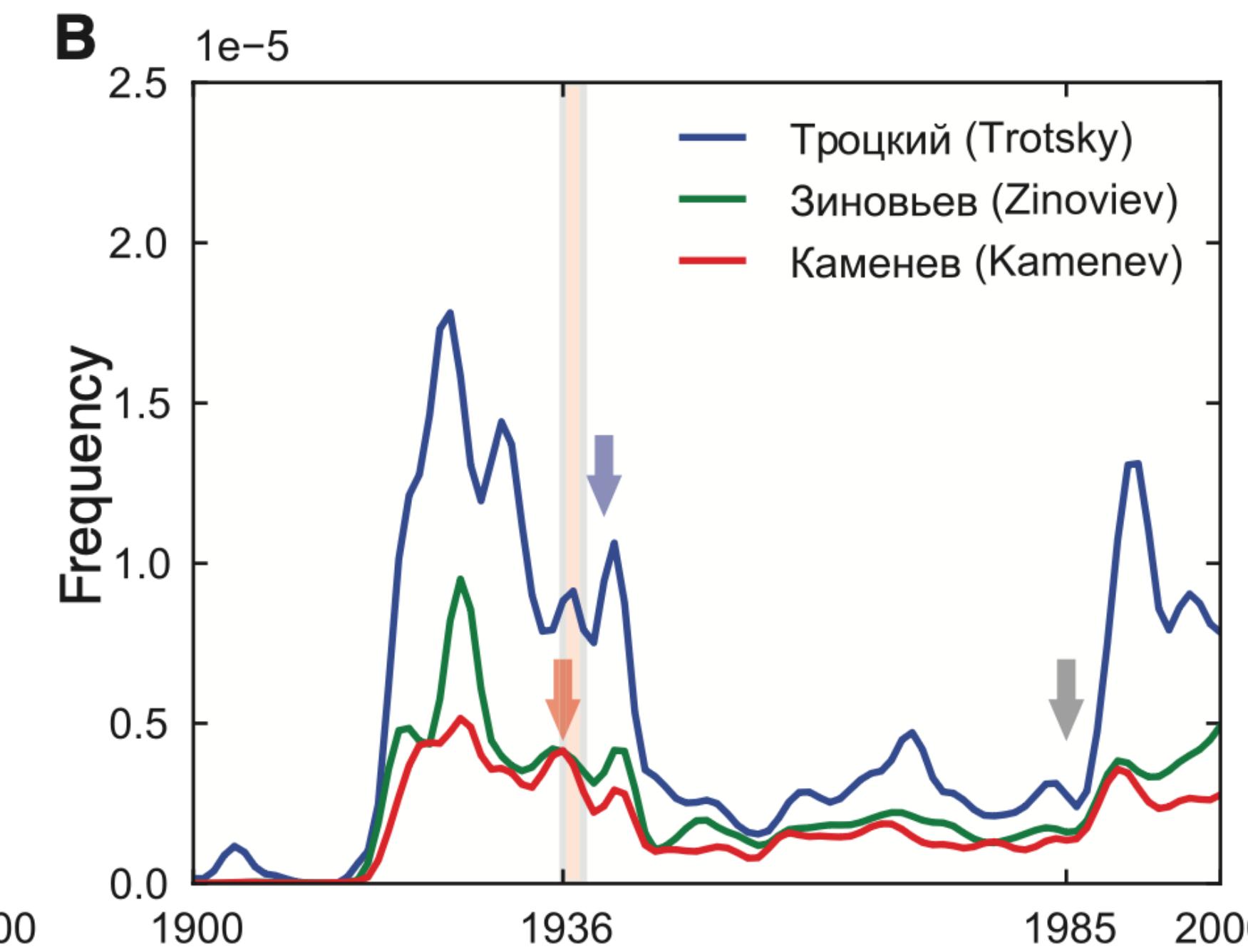
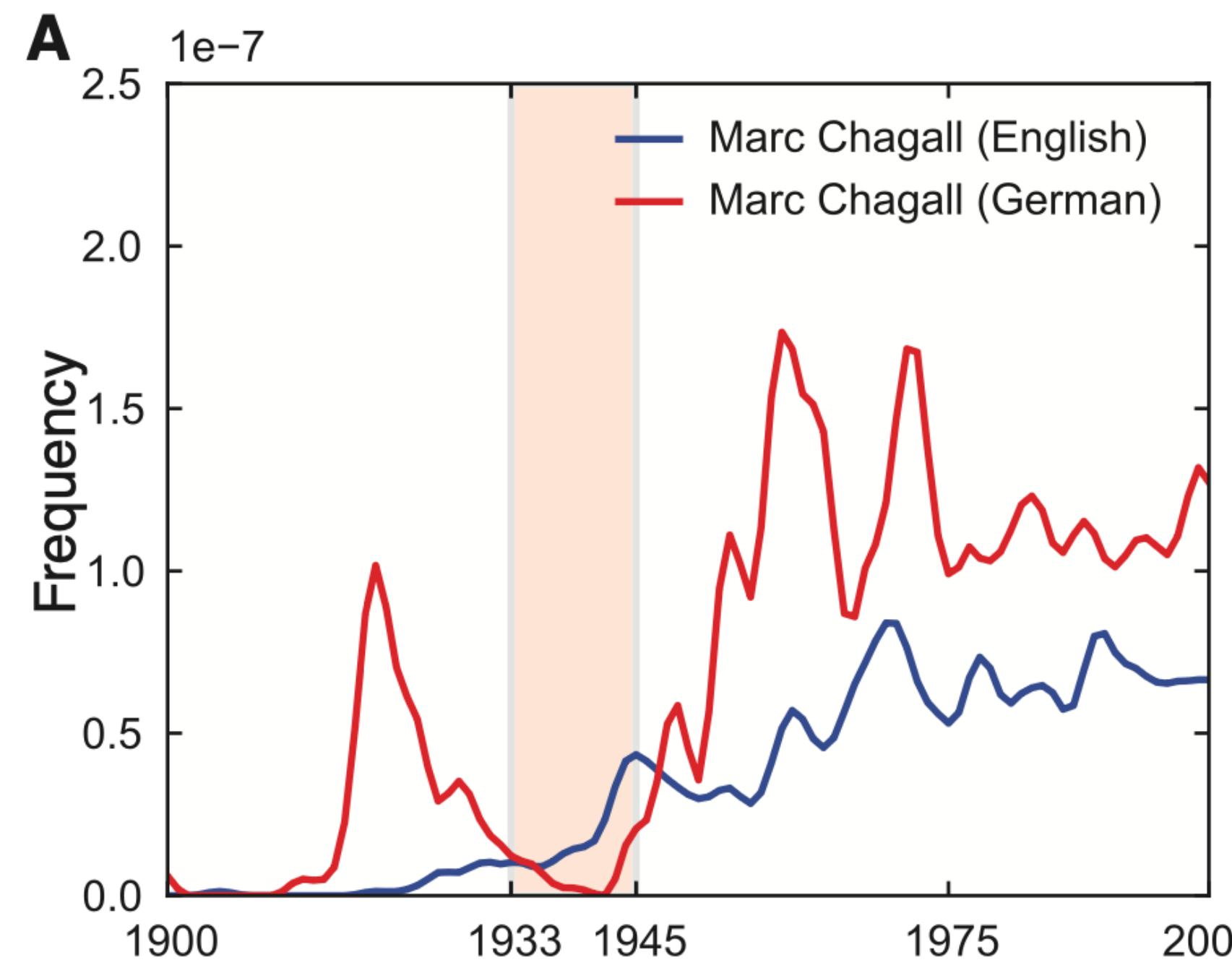


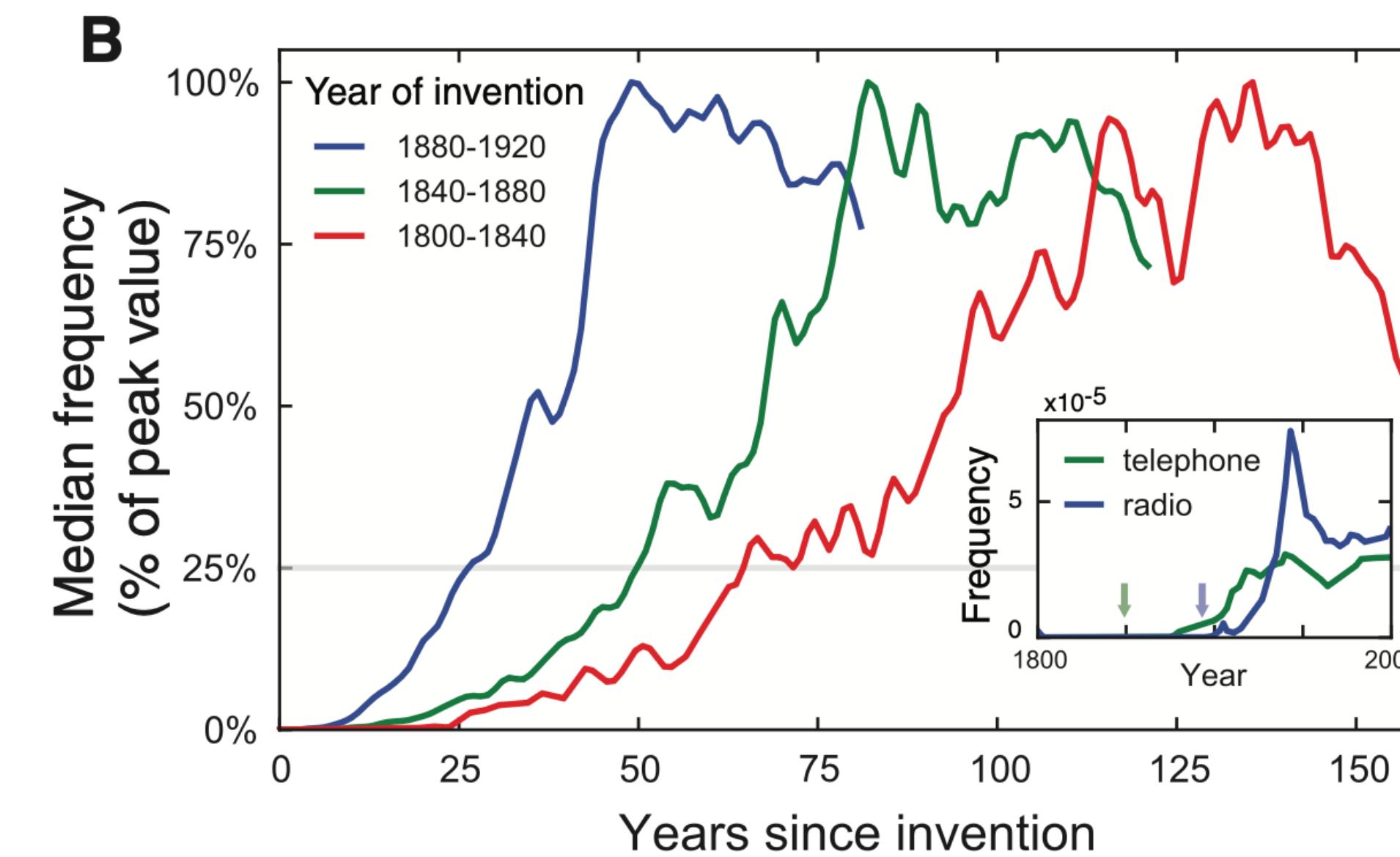
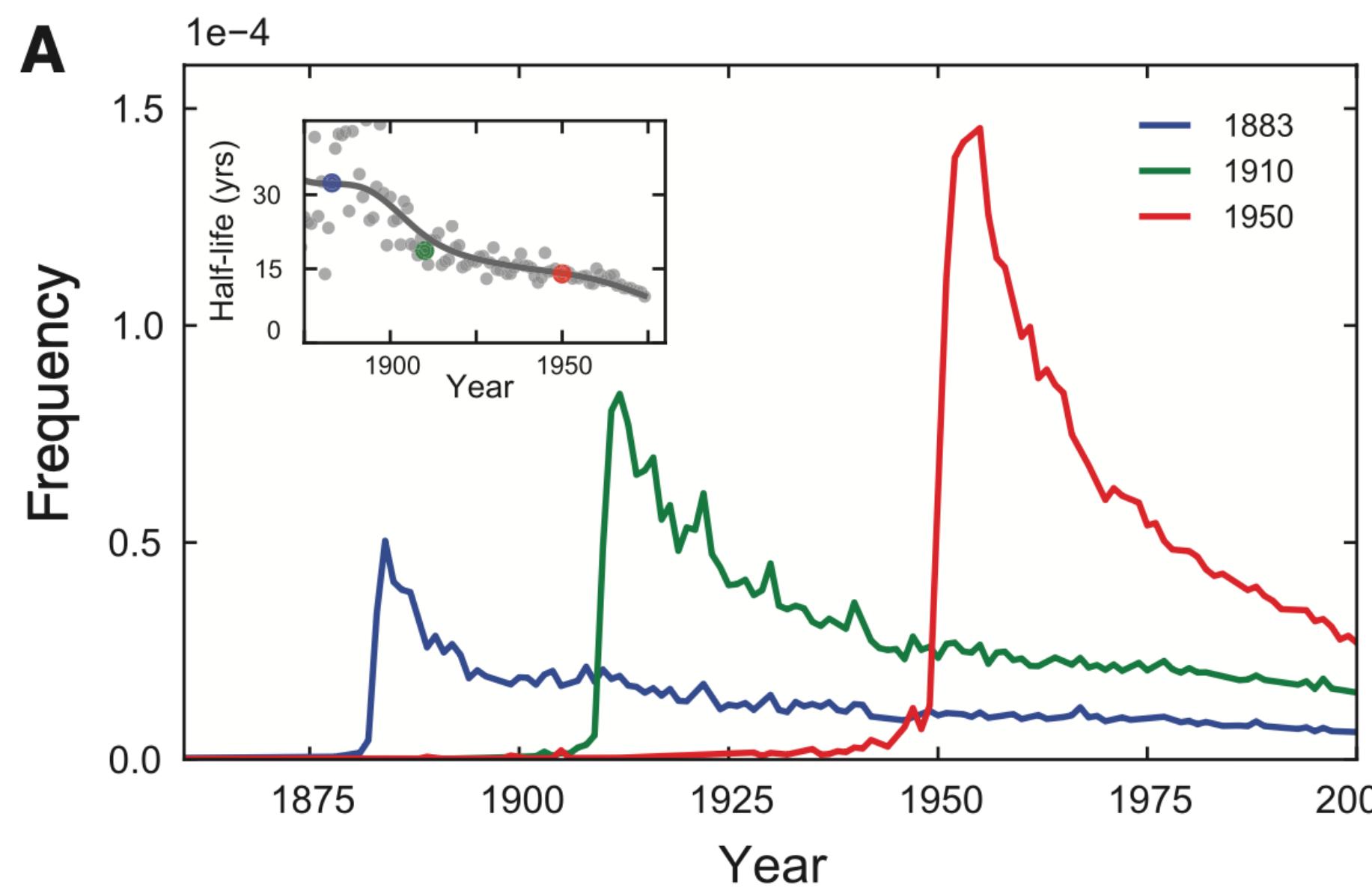
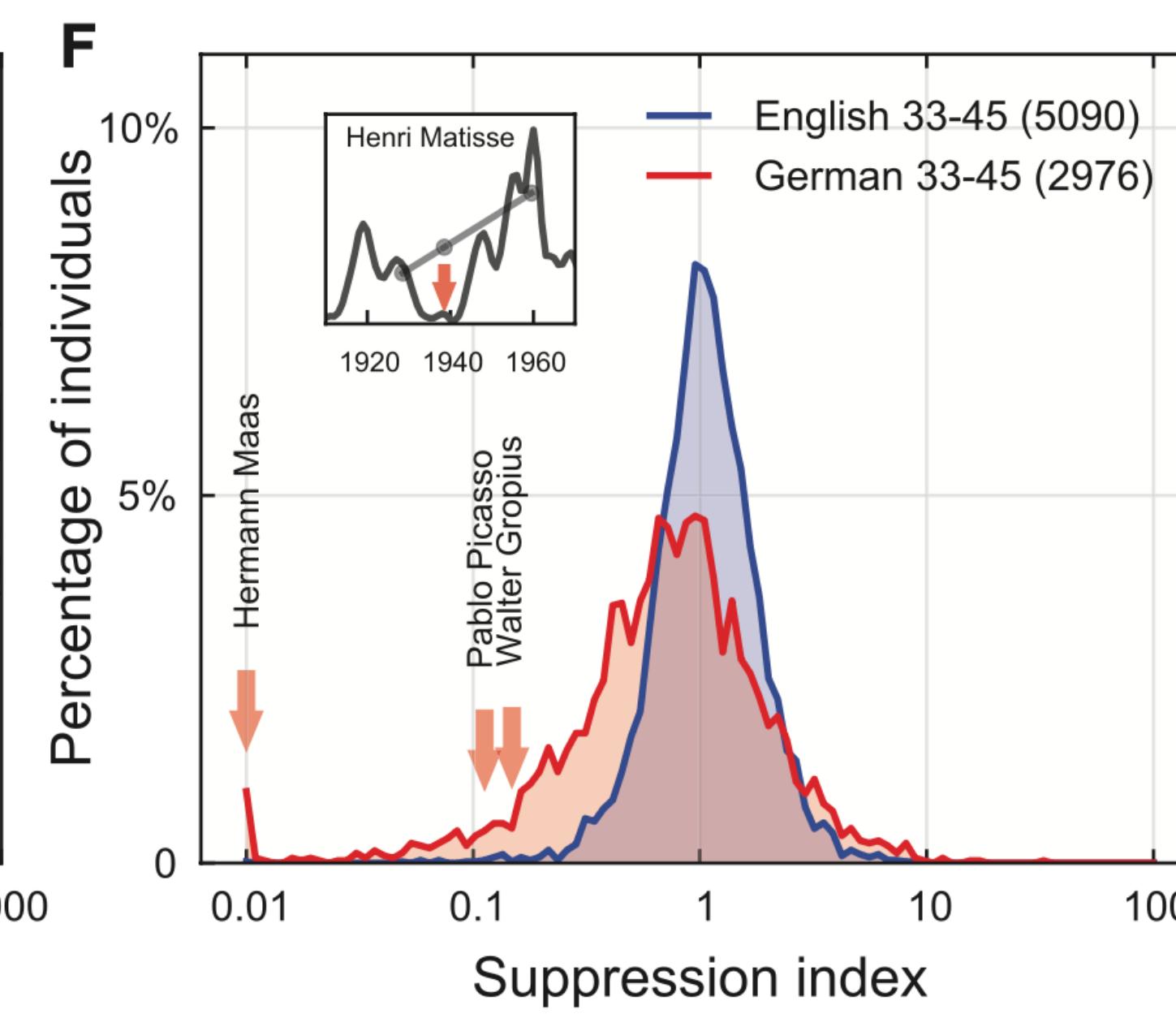
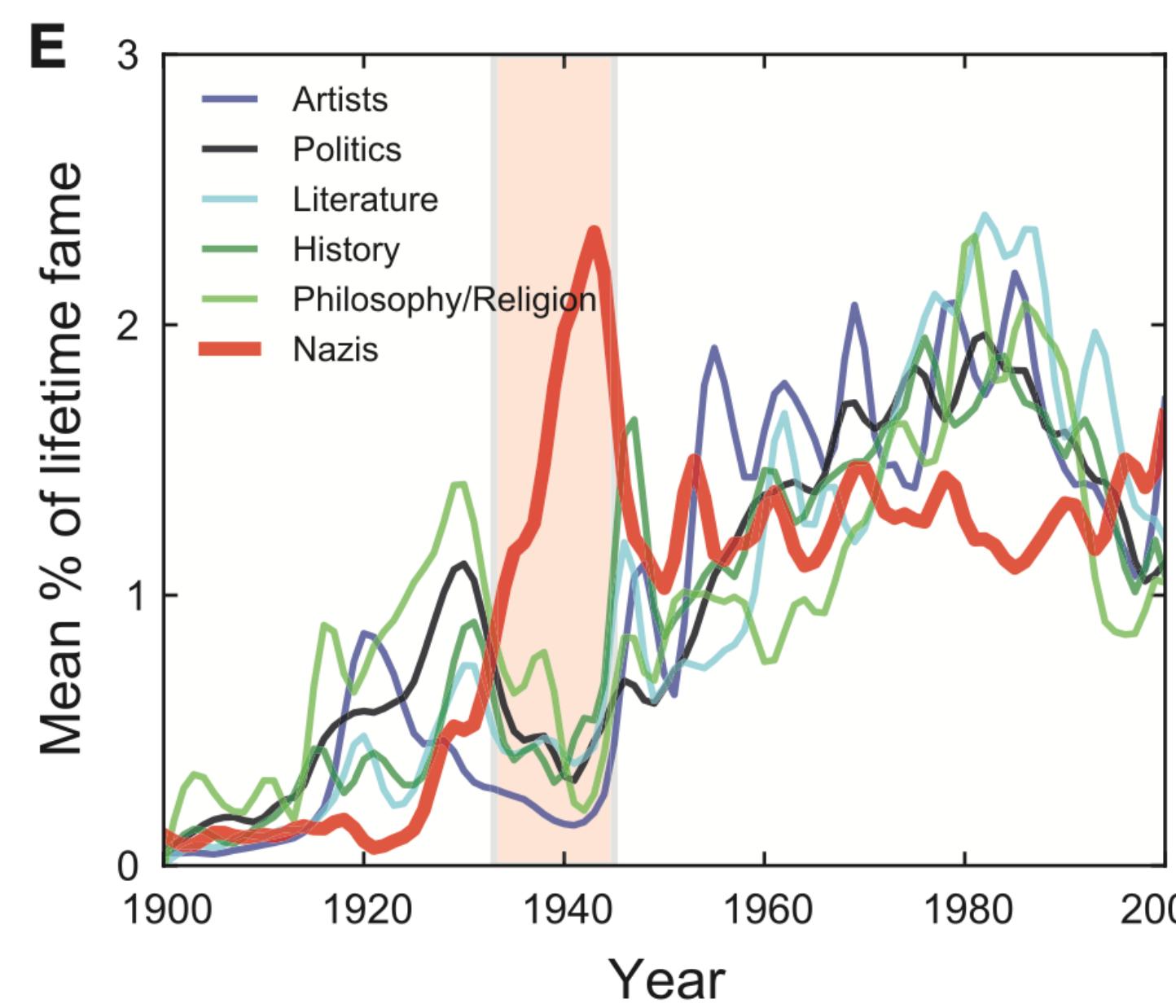
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Predicting and Interpolating State-Level Polls Using Twitter Textual Data



Nicholas Beauchamp Northeastern University

Abstract: Spatially or temporally dense polling remains both difficult and expensive using existing survey methods. In response, there have been increasing efforts to approximate various survey measures using social media, but most of these approaches remain methodologically flawed. To remedy these flaws, this article combines 1,200 state-level polls during the 2012 presidential campaign with over 100 million state-located political tweets; models the polls as a function of the Twitter text using a new linear regularization feature-selection method; and shows via out-of-sample testing that when properly modeled, the Twitter-based measures track and to some degree predict opinion polls, and can be extended to unpolled states and potentially substate regions and subday timescales. An examination of the most predictive textual features reveals the topics and events associated with opinion shifts, sheds light on more general theories of partisan difference in attention and information processing, and may be of use for real-time campaign strategy.

Policy Diffusion: The Issue-Definition Stage



Fabrizio Gilardi University of Zurich
Charles R. Shipan University of Michigan
Bruno Wüest Forschungsstelle sotomo

Abstract: We put forward a new approach to studying issue definition within the context of policy diffusion. Most studies of policy diffusion—which is the process by which policymaking in one government affects policymaking in other governments—have focused on policy adoptions. We shift the focus to an important but neglected aspect of this process: the issue-definition stage. We use topic models to estimate how policies are framed during this stage and how these frames are predicted by prior policy adoptions. Focusing on smoking restriction in U.S. states, our analysis draws upon an original data set of over 52,000 paragraphs from newspapers covering 49 states between 1996 and 2013. We find that frames regarding the policy's concrete implications are predicted by prior adoptions in other states, whereas frames regarding its normative justifications are not. Our approach and findings open the way for a new perspective to studying policy diffusion in many different areas.

Verification Materials: The data and materials required to verify the computational reproducibility of the results, procedures, and analyses in this article are available on the *American Journal of Political Science* Dataverse within the Harvard Dataverse Network, at <https://doi.org/10.7910/DVN/QEMNP1>.

Tweeting From Left to Right: Is Online Political Communication More Than an Echo Chamber?



**Pablo Barberá¹, John T. Jost^{1,2,3}, Jonathan Nagler³,
Joshua A. Tucker³, and Richard Bonneau⁴**

¹Center for Data Science, ²Department of Psychology, ³Department of Politics, and ⁴Center for Genomics and Systems Biology, New York University

Psychological Science
2015, Vol. 26(10) 1531–1542

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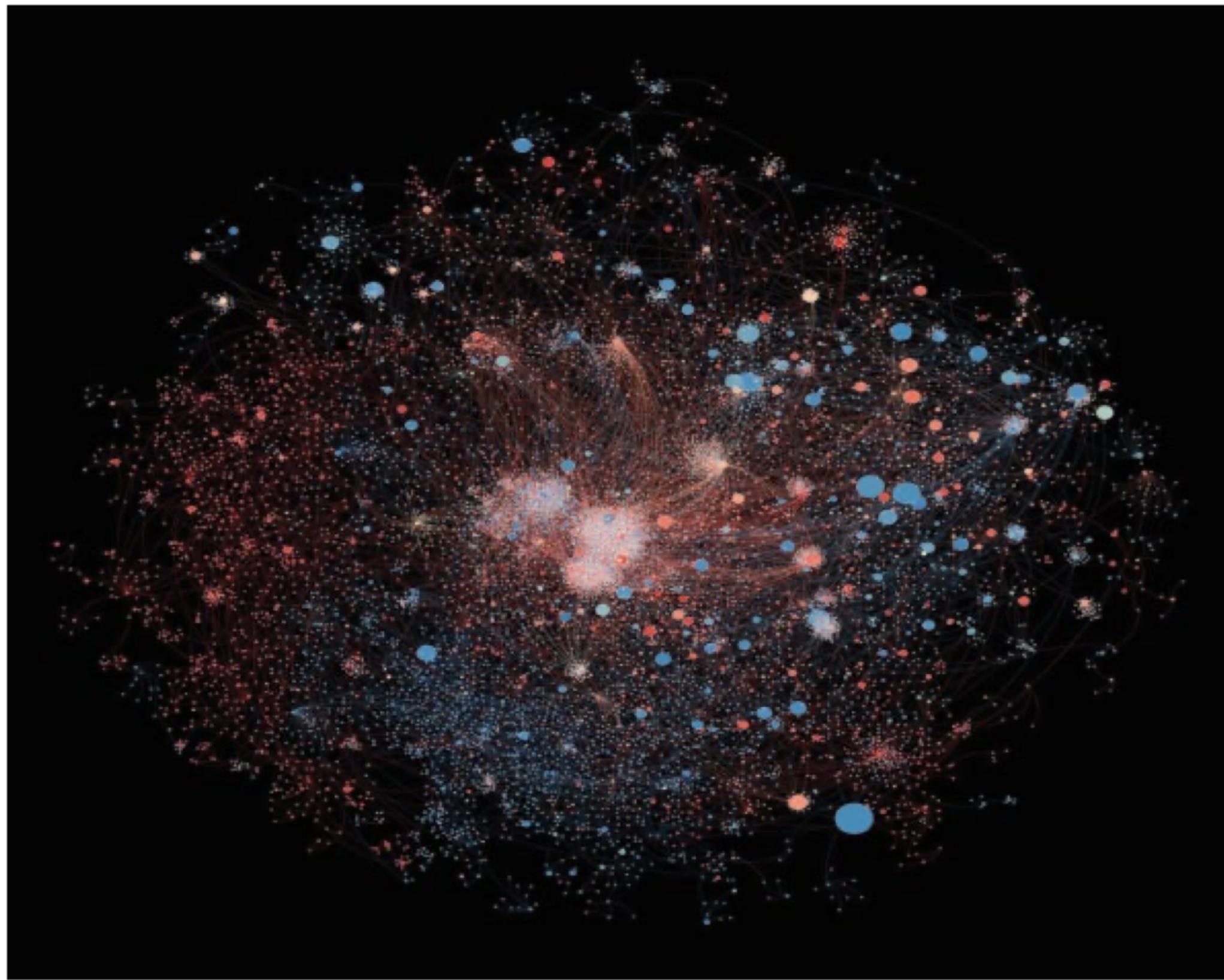
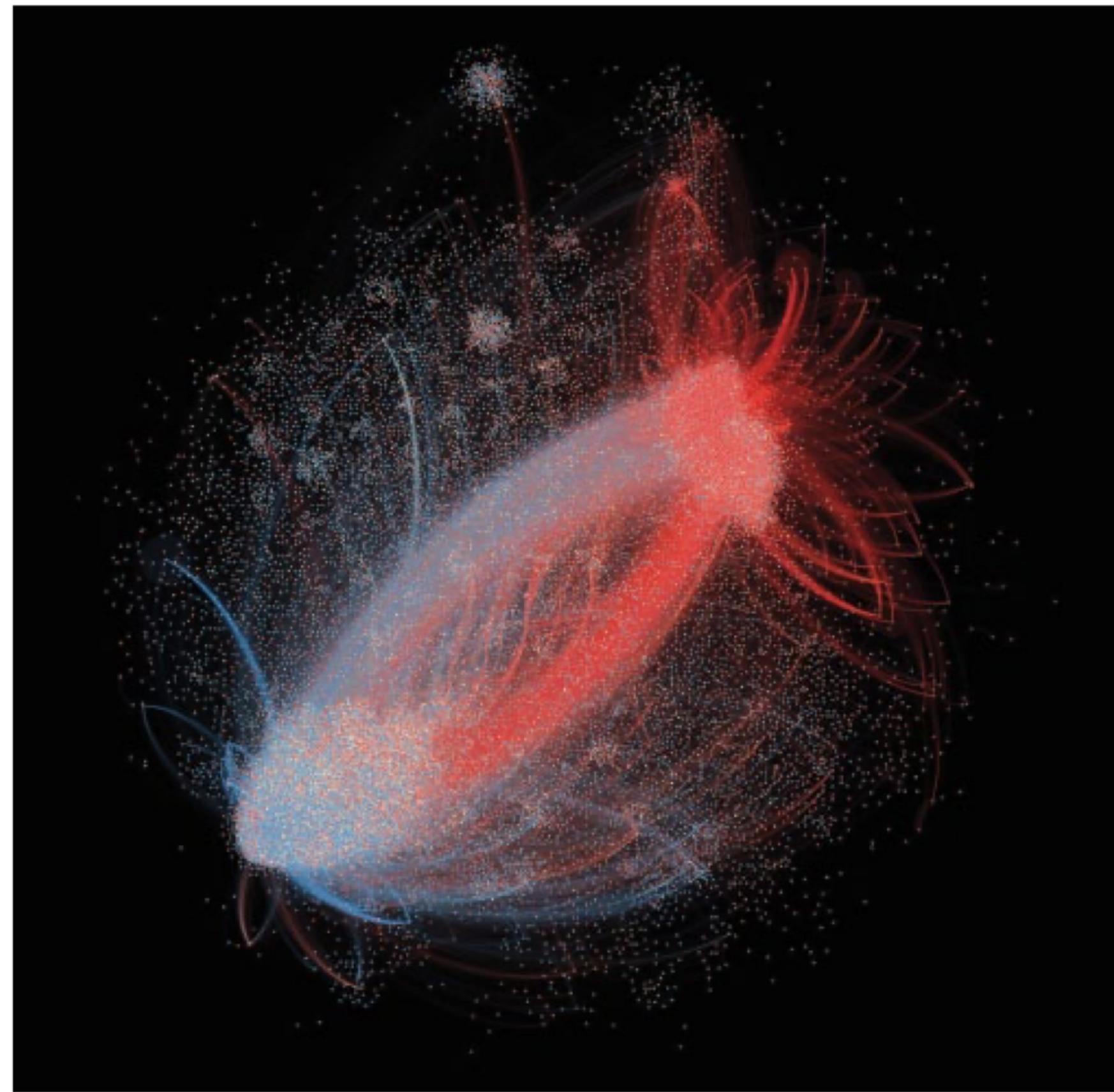
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DOI: [10.1177/0956797615594620](https://doi.org/10.1177/0956797615594620)

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SAGE



Text Representation

What is text?

- Data
- Unstructured
- (Highly) Multidimensional
 - In general, difficult to work with (if you're not human)

From Text to Structure

- We need to “structure” the text before we perform analyses
- Different ways to *represent* text so that computers “understand”
- Different ways to model text so that both (we and computer) “understand”
 - Different research questions
 - Different ways to think about what text is

Document-Term Matrix

$$X = \begin{bmatrix} 1 & 1 & \dots & 0 \\ 2 & 1 & \dots & 0 \\ \dots & \dots & \dots & \\ 2 & 0 & \dots & 3 \end{bmatrix}$$

$X = N * K$ matrix

N = number of documents

K = number of terms/features

Example

- Corpus (Collection of texts)
- Document 1: “John loves ice-cream”
- Document 2: “John loves oranges”
- Document 3: “Marry hates ice-cream”
- N? K?

Terms

Docs	icecream	john	loves	oranges	hates	marry
1	1	1	1	0	0	0
2	0	1	1	1	0	0
3	1	0	0	0	1	1

$$N = 3$$

$$K = 6$$

$$X = 3 \times 6 \text{ matrix}$$

Types & Tokens

- Types: unique words in a text
- Tokens: all words in the text
- Types and tokens in our example corpus?

Types & Tokens

- Types: unique words in a text
- Tokens: all words in the text
- Types and tokens in our example corpus?
- 6 types (unique words) / 9 tokens (total length of the corpus)

Bag-of-Words representation

- Representation of text as a bag of words
- Collection of words
- Order is irrelevant
- Each text is represented as a ***count*** of words contained in ti

Terms

Docs	icecream	john	loves	oranges	hates	marry
1	1	1	1	0	0	0
2	0	1	1	1	0	0
3	1	0	0	0	1	1

Multinomial Model of Language

- You can think of a text as a draw from a Multinomial distribution

Binomial Distribution

$$\binom{n}{k} p^k (1 - p)^{n-k}$$

Binomial Distribution

$$\binom{n}{k} p^k (1 - p)^{n-k}$$

n = number of events

k = number of successes

Multinomial Distribution

$$\frac{n!}{x_1! \dots x_k!} p_1^{x_1} \cdots p_k^{x_k}$$

n = text length

k = size of vocabulary

p = probability of a word

Example Texts

- Text_1 = "banana banana banana banana chocolate"
- Text_2 = "chocolate chocolate chocolate banana fudge"
- Text_3 = "banana banana"
- Text_4 = "icecream icecream fudge ice-cream"
- Text_5 = "fudge fudge fudge"
- Text_6 = "ice-cream ice-cream fudge fudge"

Example Texts

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John

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- Text_6 = "ice-cream ice-cream fudge fudge"

Mary

Document Term Matrix

	banana	chocolate	fudge	icecream
4		1	0	0
2		0	0	0
1		3	1	0
0		0	1	3
0		0	3	0
0		0	2	2

Document Term Matrix

banana	chocolate	fudge	icecream
7	4	1	0

John Rates

banana	chocolate	fudge	icecream
1	3	7	5

Mary Rates

Document Term Matrix

banana	chocolate	fudge	icecream
7	4	1	0

John Language Model

banana	chocolate	fudge	icecream
1	3	7	5

John Rates

Mary Rates

Mary Language Model

New Texts

- new_text_1 = "ice-cream fudge fudge"
- new_text_2 = "chocolate chocolate banana banana"

New Texts

- new_text_1 = "ice-cream fudge fudge"
- new_text_2 = "chocolate chocolate banana banana"
- What's the probability that they have been generated by John or Marry?

New Texts

banana	chocolate	fudge	icecream
0	0	2	1
2	2	0	0

Probability Spoken by John

- new_text_1 = "ice-cream fudge fudge"

$$Pr(b = 0, ch = 0, f = 2, i = 1) = \frac{3!}{0!0!2!1!} 0.583^0 \times 0.333^0 \times 0.08^2 \times 0^1 = 0$$

Probability Spoken by John

- new_text_2 = "chocolate chocolate banana banana"

$$Pr(b = 2, ch = 2, f = 0, i = 0) = \frac{4!}{2!2!0!0!} 0.583^2 \times 0.333^2 \times 0.08^0 \times 0^0 = 0.23$$

Probability Spoken by Marry

- new_text_1 = "ice-cream fudge fudge"
- P = 0.18
- new_text_2 = "chocolate chocolate banana banana"
- P = 0.0008

Vector Space Representation

- Representation of texts as vectors in a multidimensional space

Multidimensional?

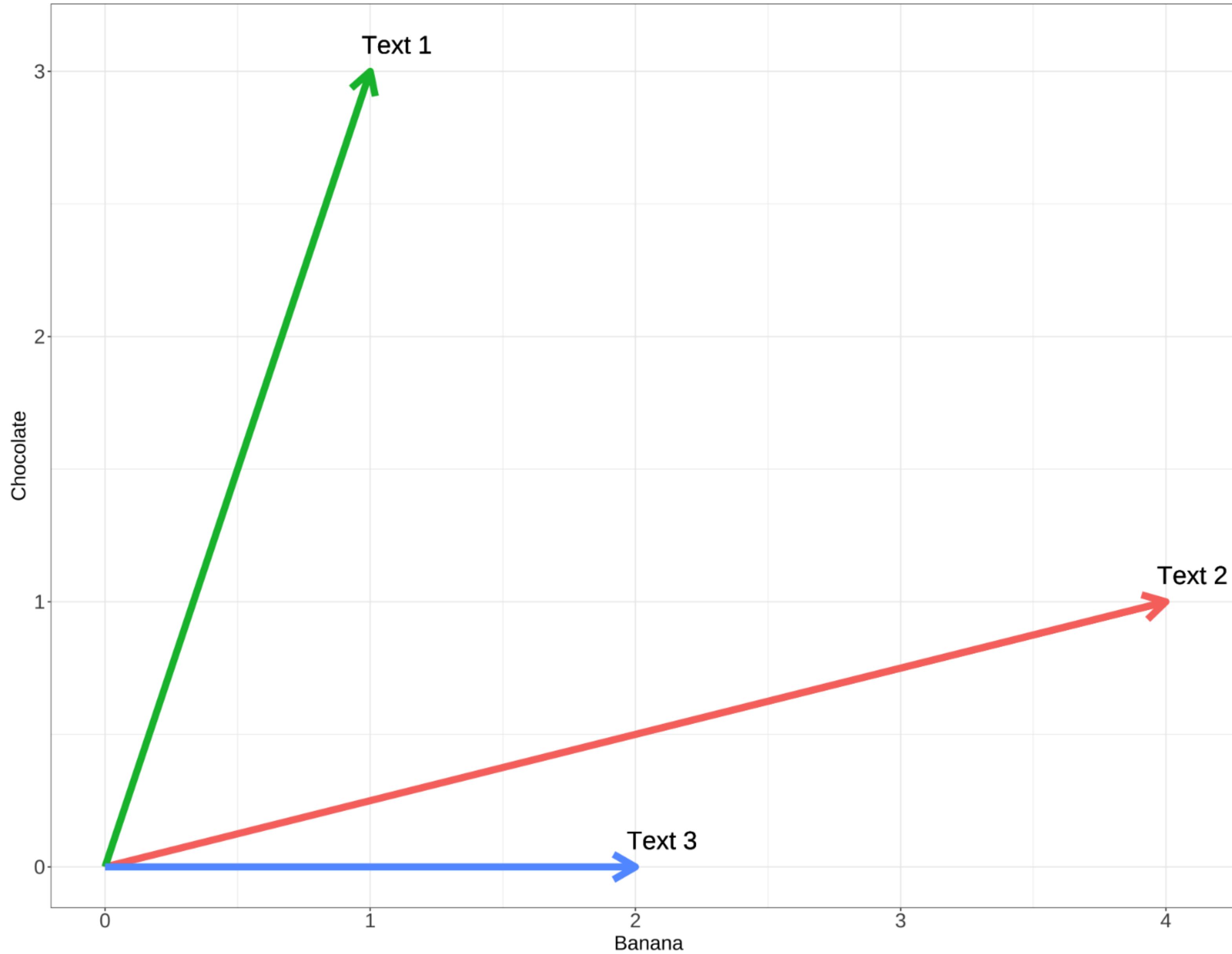
- Position on a map:
 - X = Longitude Y = Latitude
- Position in a real world:
 - X = Longitude Y = Latitude Z = Height
- Point in time and space
 - X = Longitude Y = Latitude Z = Height T = Time

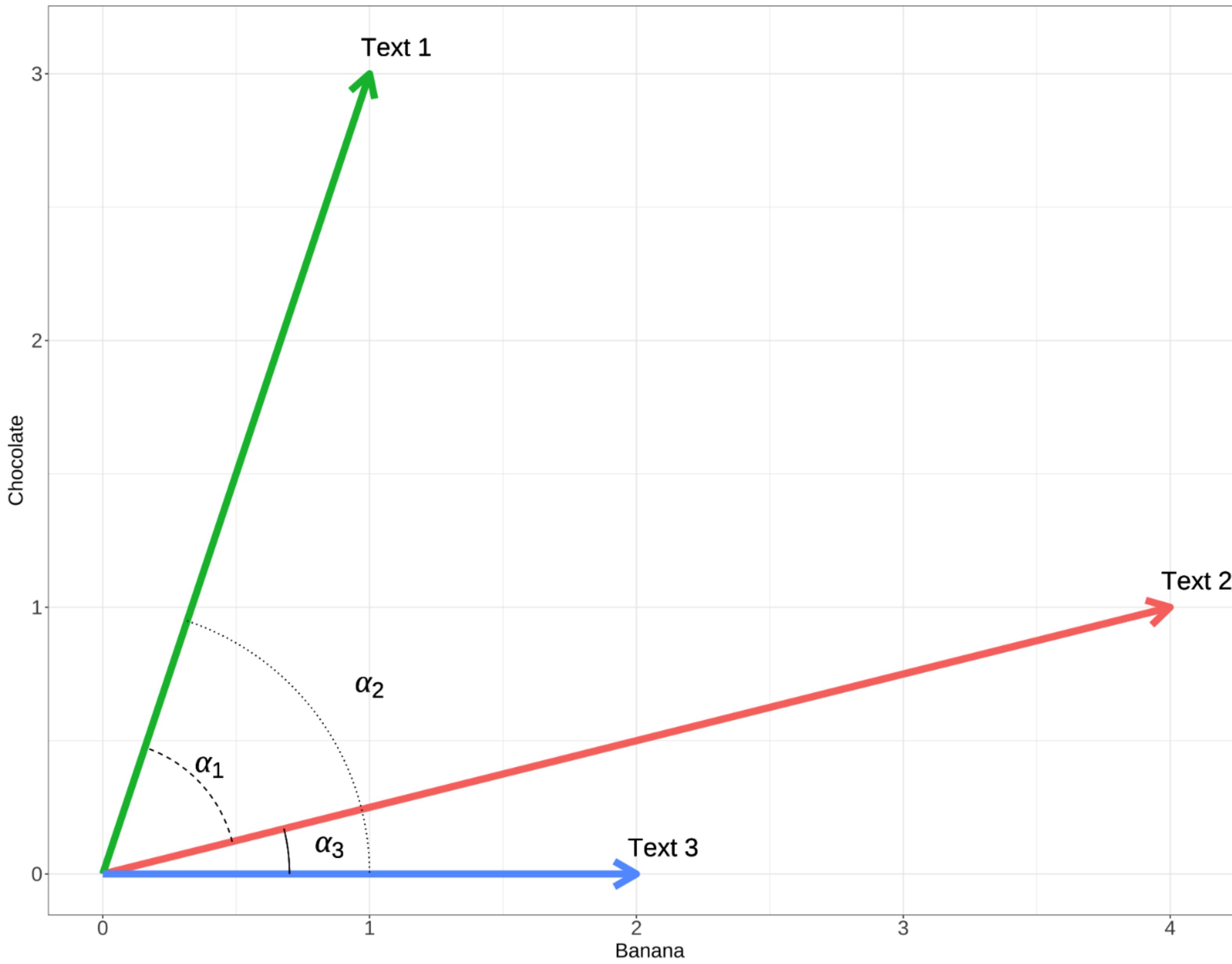
Multidimensional?

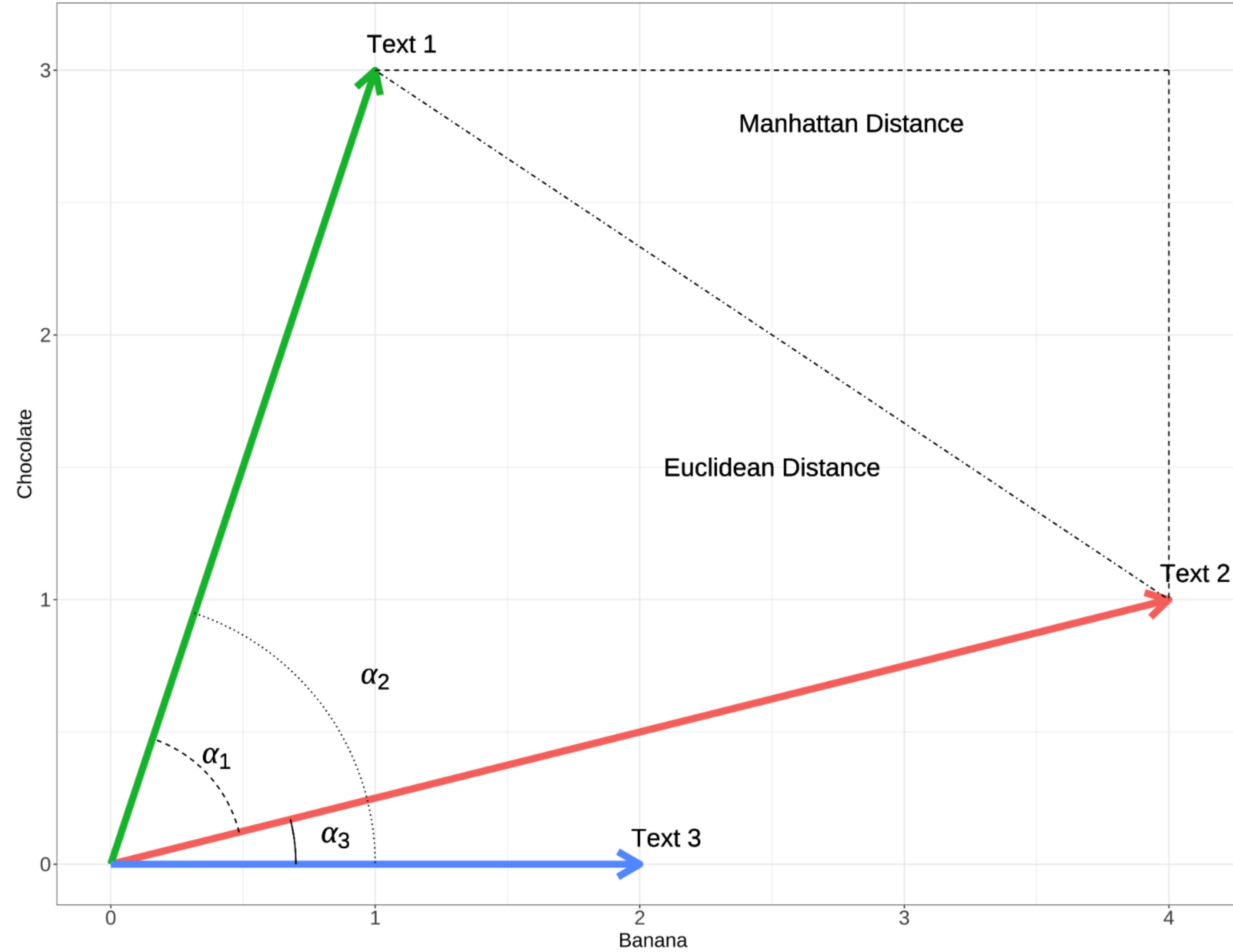
- Number of dimensions is the number of data points needed to describe an object in space
 - **Coordinates** in the context of *geographical position*
 - **Words** in the context of position of text within a *linguistic space*

Two-dimensional space

- vocabulary = {"banana", "chocolate"}
- Text 1 = "chocolate, chocolate, chocolate, banana"
- Text 2 = "banana, banana, banana, banana, chocolate"
- Text 3 = "banana, banana"







Multidimensional?

- Estimated ~1,022,000 words in English language
- ~ 1,022,000-dimensional space

A man with glasses and a mustache is looking upwards with a surprised expression. He is surrounded by a vibrant, multi-colored nebula or galaxy against a dark background. The nebula features shades of pink, purple, blue, and white, with numerous small stars visible.

[adult swim]

- Same math, though

Distributional Hypothesis / Word Embeddings

- The new thing kids do...

Distributional Hypothesis / Word Embeddings

- The new thing kids do... at least since '57...

Distributional Hypothesis / Word Embeddings

- In most cases, the meaning of a word is its use (Wittgenstein, 1953)
- Distributional hypothesis: difference of meaning correlates with difference of distribution (Harris, 1954)
- A word is characterized by the company it keeps (Firth, 1957)
- Words which are similar in meaning occur in similar contexts (Rubenstein & Goodenough, 1965)
- Words with similar meanings will occur with similar neighbors if enough text material is available (Schütze & Pedersen, 1995)

Distributional Hypothesis / Word Embeddings

- Each word is embedded in an n-dimensional vector space (typically, 300 dimensions)
- Neural network that “learns” the context of a word by looking at the words around it
- Word2Vec (Mikolov, 2013) – one of the most famous methodologies

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[0.20778	,	-2.4151	,	0.36605	,	2.0139	,	-0.23752	,	-3.1952	,
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2.0758e+00	,	-1.0663e+00	,	-8.4464e-01	,	-5.2534e-02	,	-7.9447e-01	,	
3.0140e+00	,	-8.9454e-01	,	2.1576e+00	,	-3.0407e+00	,	1.3439e+00	,	
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2.6262e+00	,	2.2010e-02	,	1.4596e+00	,	-1.1558e+00	,	1.8789e-01	,	
9.4600e-01	,	-2.9744e+00	,	-2.2531e+00	,	7.7054e-01	,	-5.4315e-01	,	
-2.2618e+00	,	2.2210e+00	,	-1.2964e+00	,	1.0105e+00	,	5.8169e-01	,	
3.5617e-01	,	-2.4568e-01	,	-2.0808e+00	,	3.5410e+00	,	-5.2889e-01	,	
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6.2643e-01	,	2.9279e-01	,	3.1008e+00	,	-3.2464e+00	,	1.5747e+00	,	
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-1.2936e+00	,	-1.3023e+00	,	1.0400e+00	,	-9.1724e-01	,	1.0221e+00	,	
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-1.3337e+00	,	2.9608e+00	,	-3.7193e+00	,	-1.1941e+00	,	-1.0349e+00	,	
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-3.9196e-01	,	1.7773e+00	,	-6.8698e-01	,	-1.0951e+00	,	-1.5319e+00	,	
2.8311e+00	,									

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Banana



Car

Chocolate



Car

Banana



Chocolate