Quantitative Text Analysis

Day 2

Petro Tolochko

Text Preprocessing

- Texts are ***highly*** dimensional
- When possible, it is nice to reduce this dimensionality
- Ideally, without losing too much information

Danny & Spirling, 2018

- Punctuation
- Numbers
- Lowercasing
- Stemming
- Stop-words
- N-grams
- Removal of words by frequency

Punctuation / Numbers / Lowercasing

- Fairly straightforward
- Often we don’t care about punctuation and/or numbers – so, might be better to remove them
- We probably do care about the letter case
    - To what extent?
    - Reduction in dimensions might be worth the reduction in accuracy
    - When would letter case be (un)important?

Stemming / Lemmatization

- A stem is the part of the word responsible for lexical meaning
- A stem is invariable part of the word under inflection
- “wait” is a stem of:
  - “Waiting”
  - “Waited”
  - “Waits”
- A lemma is the base / “original” part of the word
- Both are useful for dimension reduction and often produce similar results

Stop Words

- Words that are filtered out before the analysis begins
- Could be any type of words that you do not want in the analysis
- Usually, function words are used as stop words (FORESHADOWING…)
  - “The”
  - “Is”
  - “I”
  - “That”
  - etc.
- Domain-specific words are also often excluded from the analysis
- E.g., “Global Warming” in the corpus of texts about Global Warming

N-grams

- So far, we've only looked at "unigrams" – individual words
- Texts can be broken down into any n-gram sequences
- "I love ice-cream and bananas"
    - "I" "love" "ice-cream" "and" "bananas"
    - "I love" "love ice-cream" "ice-cream and" "and bananas"
    - 3-grams?

Removal of terms by frequency

- Further removal of dimensionality can be achieved by removing either very frequent or very infrequent terms
- If they are very frequent, they probably don’t carry much discriminating information for our analysis (think stopwords)
- If they are very infrequent, they probably carry a lot of discriminating information, but very low statistical power

Danny & Spirling, 2018

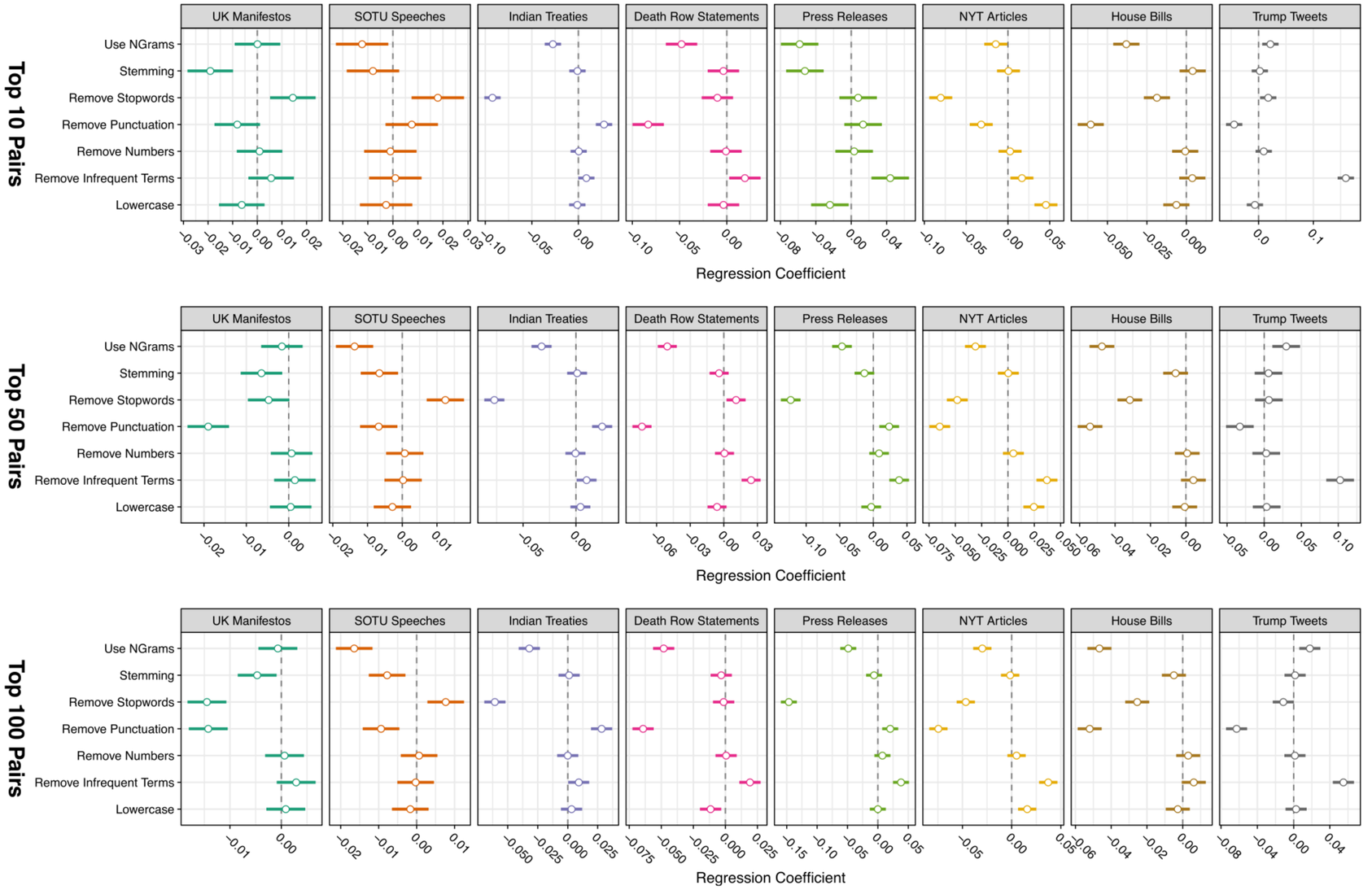

Figure 5. Regression results depicting the effects of each of the seven preprocessing steps on the `preText` score for that preprocessing combination.

Tf-idf

- We can do more than just count words
- We can transform these counts

- Use some sort of a weight in order to transform

- Term frequency inverse document frequency is one form of weighting

Term Frequency

$$tf(t,d) = \frac{f_{t,d}}{\sum_{t' \in d} f_{t',d}}$$

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Inverse Document Frequency

$$idf = log\frac{N}{n_j}$$

Number of Documents

Number of Documents where term j appears

tfidf

$$W_{ij} \times log\frac{N}{n_j}$$

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- ***Exactly!***
- Introduced in 1972 by a computer scientist (Spärck Jones, 1972)
- No theoretical justification
- Apart from “it seems to work…”

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- ***Exactly!***
- Introduced in 1972 by a computer scientist (Spärck Jones, 1972)
- No theoretical justification
- Apart from “it seems to work…”

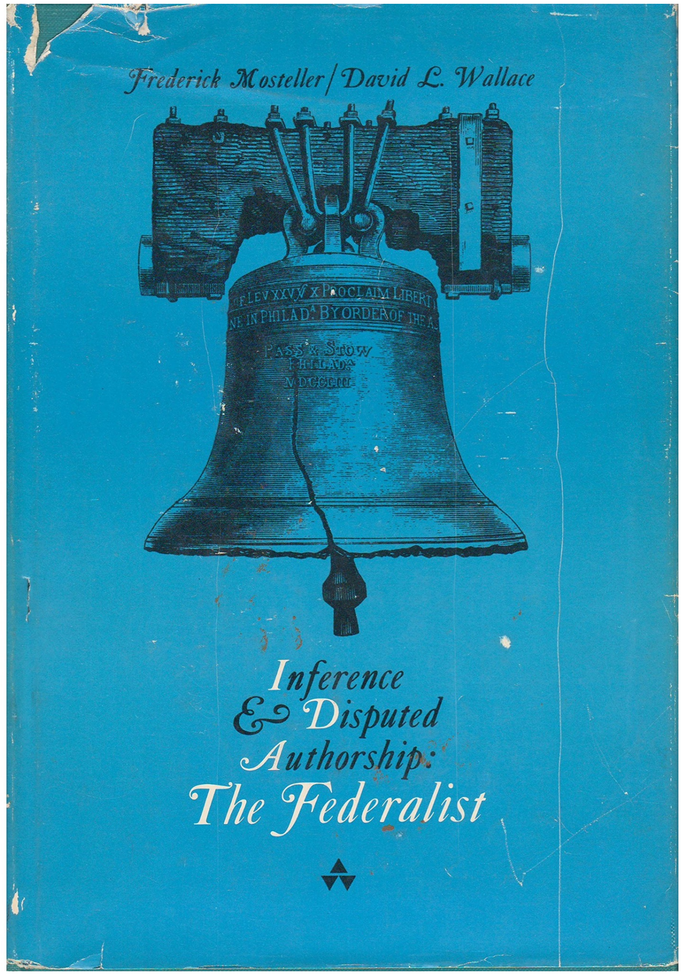
- Sometimes is does…

Log Odds / Log Odds Ratio

$$\log O_w^i = \log \frac{f_w^i}{1 - f_w^i}$$

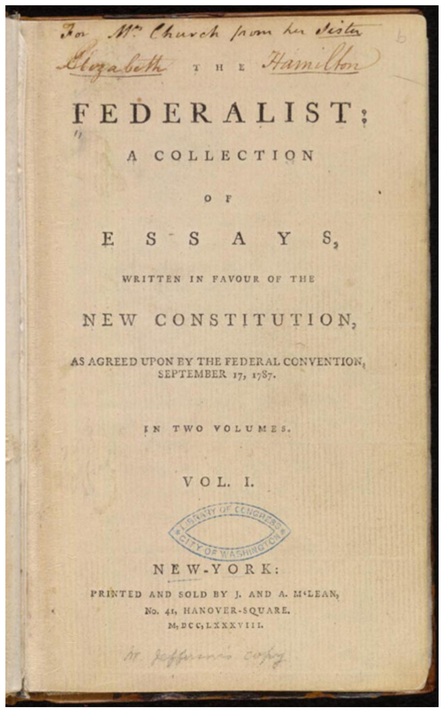
$$\log \frac{O_w^i}{O_w^j} = \log \frac{f_w^i}{1 - f_w^i} / \frac{f_w^j}{1 - f_w^j} = \log \frac{f_w^i}{1 - f_w^i} - log \frac{f_w^j}{1 - f_w^j}$$

Inference and Disputed Authorship: The Federalist



Frederick Mosteller &
David L. Wallace, 1963

One of the first (if not the first) text-as-data study



For Mrs Church from her sister
Elizabeth THE Hamilton

FEDERALIST:

A COLLECTION

OF

ESSAYS,

WRITTEN IN FAVOUR OF THE

NEW CONSTITUTION,

AS AGREED UPON BY THE FEDERAL CONVENTION,
SEPTEMBER 17, 1787.

IN TWO VOLUMES.

VOL. I.

NEW-YORK:

PRINTED AND SOLD BY J. AND A. M'LEAN,
No. 41, HANOVER-SQUARE.
M, DCC, LXXXVIII.

Mr Jefferson's copy

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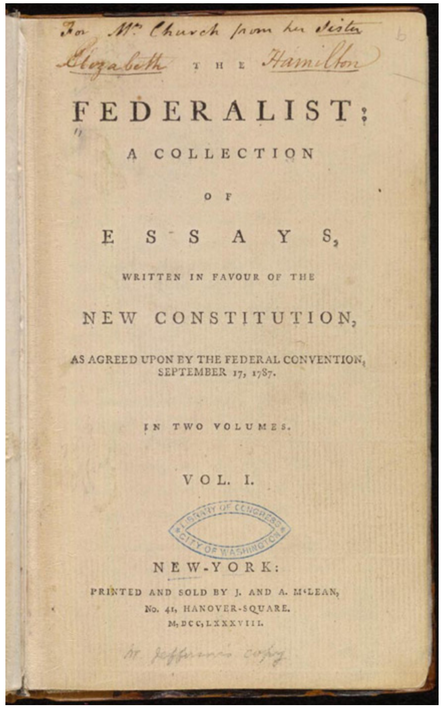
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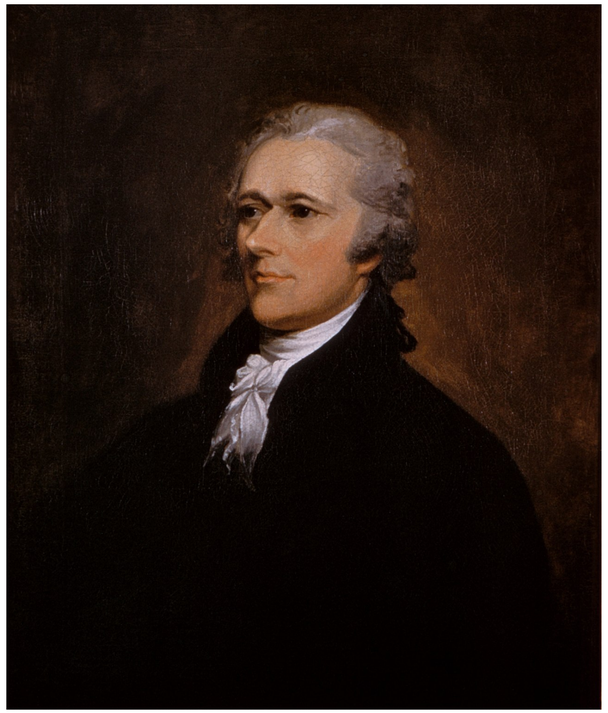
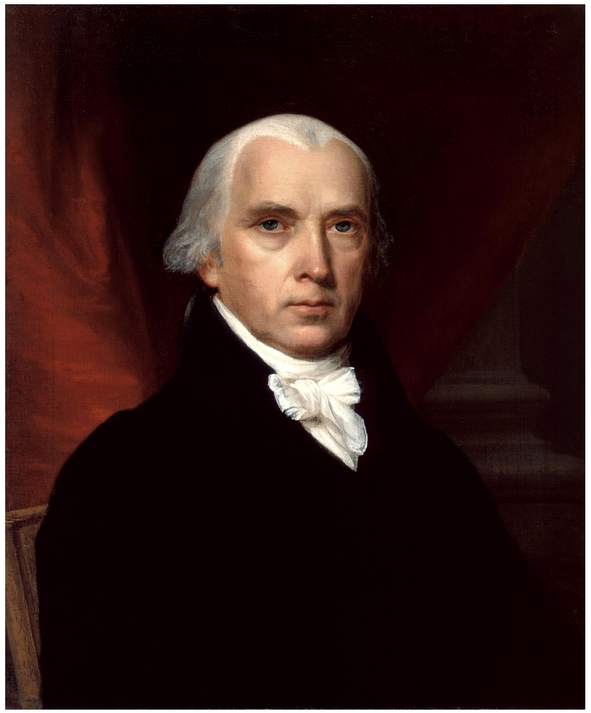
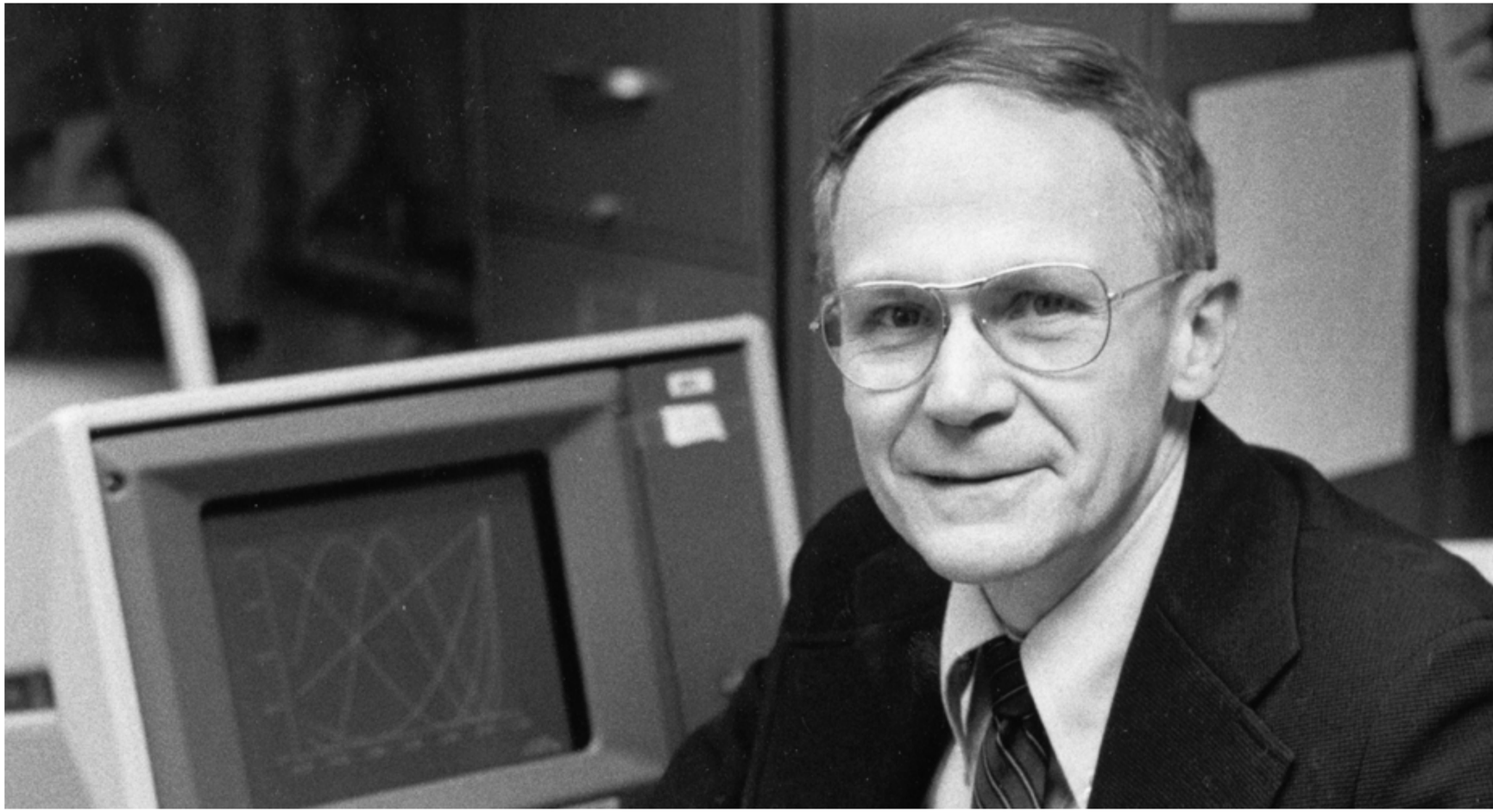




Who wrote them?

- 71 of the essays have a fairly certain authorship
- 12 are disputed
- Big historical debate as to how to ascribe authorship



Computer-assisted text analysis!

Computer-assisted text analysis…?

Dimension Reduction

- Remove all the stop-words!

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- Still… too many words!
- Remove all the words BUT the stop-words

- Maybe there is information in them!

Simplified example from Grimmer et al., 2022

- Focus on:
  - “Man”
  - “By”
  - “Upon”
- The rates with which the authors use these words may indicate authorship

Word Rates

	man	by	upon
Hamilton	102	859	374
Madison	17	474	7
Jay	0	82	1

Word Proportions

	man	by	upon
Hamilton	.076	.643	.28
Madison	.034	.952	.014
Jay	0	.988	.012

Word Proportions

Multinomial Model of Language

	man	by	upon
Hamilton	.076	.643	.28
Madison	.034	.952	.014
Jay	0	.988	.012

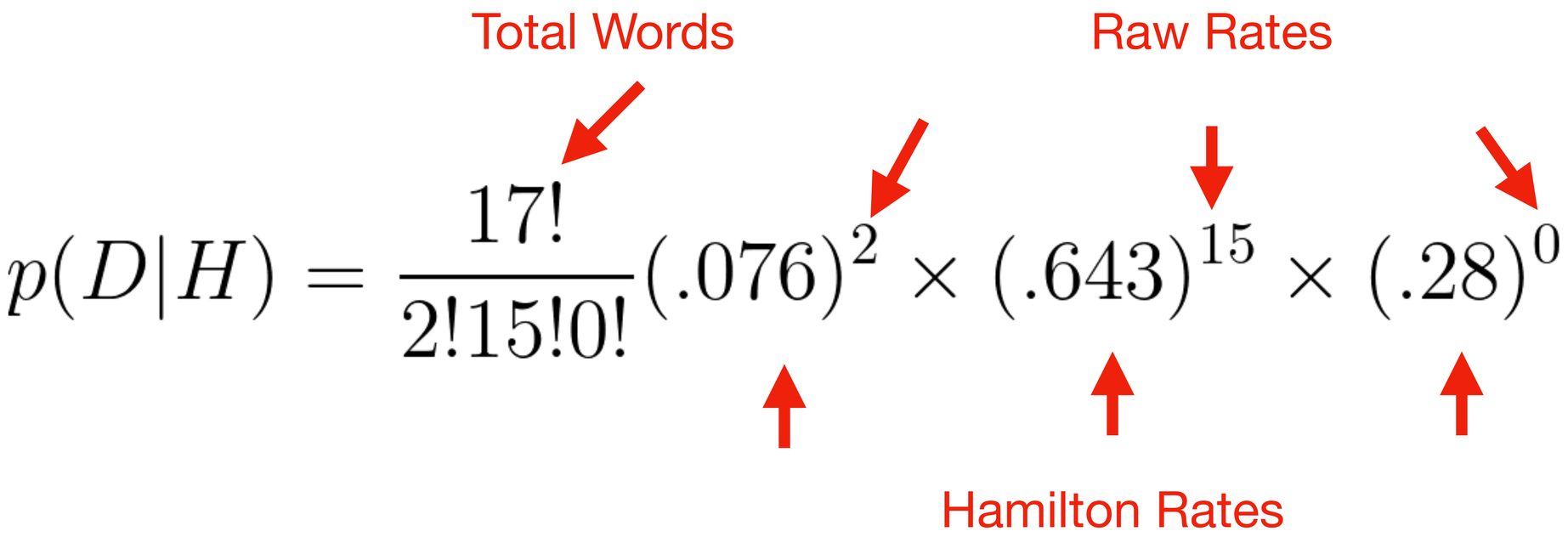
Disputed Paper

	man	by	upon
Disputed	2	15	0

Disputed Paper

$$p(D|H) = \frac{17!}{2!15!0!}(.076)^2 \times (.643)^{15} \times (.28)^0$$

Disputed Paper



Calculate Jay and Madison

$$p(D|H) = \frac{17!}{2!15!0!}(.076)^2 \times (.643)^{15} \times (.28)^0 = .001$$

$$p(D|M) = \frac{17!}{2!15!0!}(.034)^2 \times (.952)^{15} \times (.014)^0 = .076$$

$$p(D|J) = \frac{17!}{2!15!0!}(0)^2 \times (.988)^{15} \times (.012)^0 = 0$$

Federalist Vector Space Model

- In the Markdown file…