# NLP!!!

April 9, 2019
Data Science CSCI 1951A
Brown University
Instructor: Ellie Pavlick
HTAs: Wennie Zhang, Maulik Dang, Gurnaaz Kaur

# Announcements

- ...

# Today

- NLP!
- Bag-of-words models of documents/words
- Preprocessing
- LSA Topic Models

# What is a “unit” of language

- Words
- Sentences
- Documents
- …EVERYTHING????

# Compositionality

"meaning of the whole is a function of a meaning of the parts and the way in which they are combined"

# Compositionality

Words

# Compositionality

Sentences

Words

# Compositionality

Sentences = f(Words, Syntax)

Words

# Compositionality

Documents = f(Sentences, Discourse)



Sentences = f(Words, Syntax)



Words

Very difficult...
(impossible?)
...to achieve

# Compositionality

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Words

# Compositionality

Very difficult...
(impossible?)
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Documents = f(Sentences, Discourse)

↑

Sentences = f(Words, Syntax)

↑

Words

horse shoes ≈ alligator shoes?

# “Bag of Words” (BOW)

Documents = f(Words)

Words

Syntax/order doesn't matter, context doesn't matter...

# “Bag of Words” (BOW)

- Foundation of most of modern NLP

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- Information Retrieval/Search

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# “Bag of Words” (BOW)

- Foundation of most of modern NLP
- Information Retrieval/Search
- Clustering/Recommendation
- As input to most ML models
- Changing a bit for sentences, but not for documents (yet)

# “Bag of Words” (BOW)

Is it ok to copy and paste the data into javascript, or is there a filereader that can open a local file?

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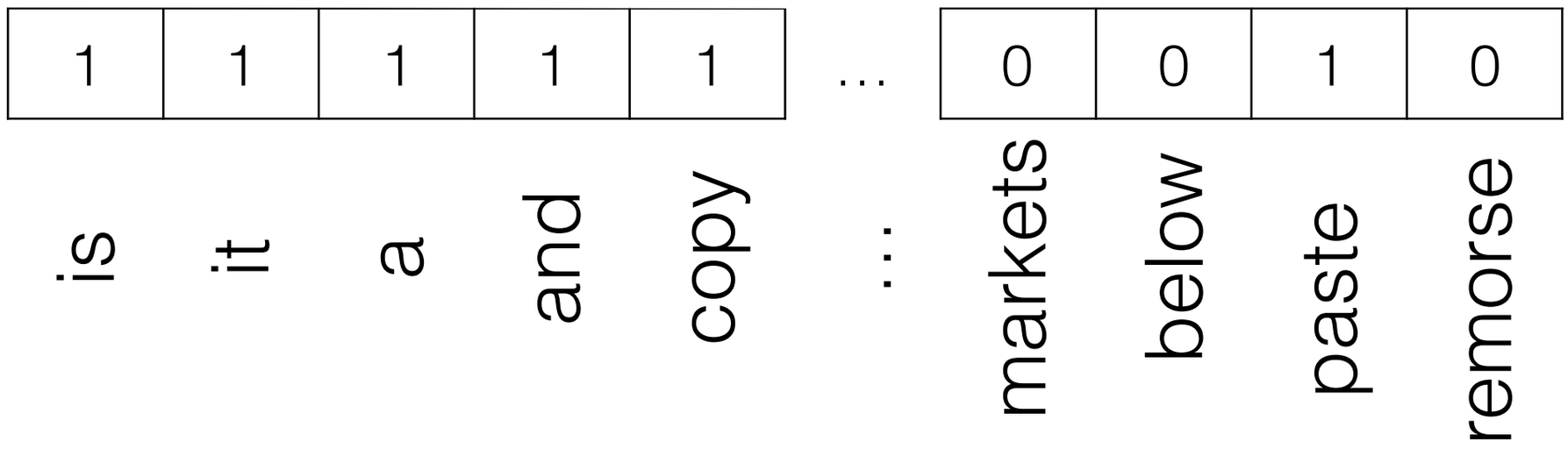

# “Bag of Words” (BOW)

Is it ok to copy and paste the data into javascript, or is there a filereader that can open a local file?

“one hot”

| is | it | a | and | copy | … | markets | below | paste | remorse |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | … | 0 | 0 | 1 | 0 |

# “Bag of Words” (BOW)

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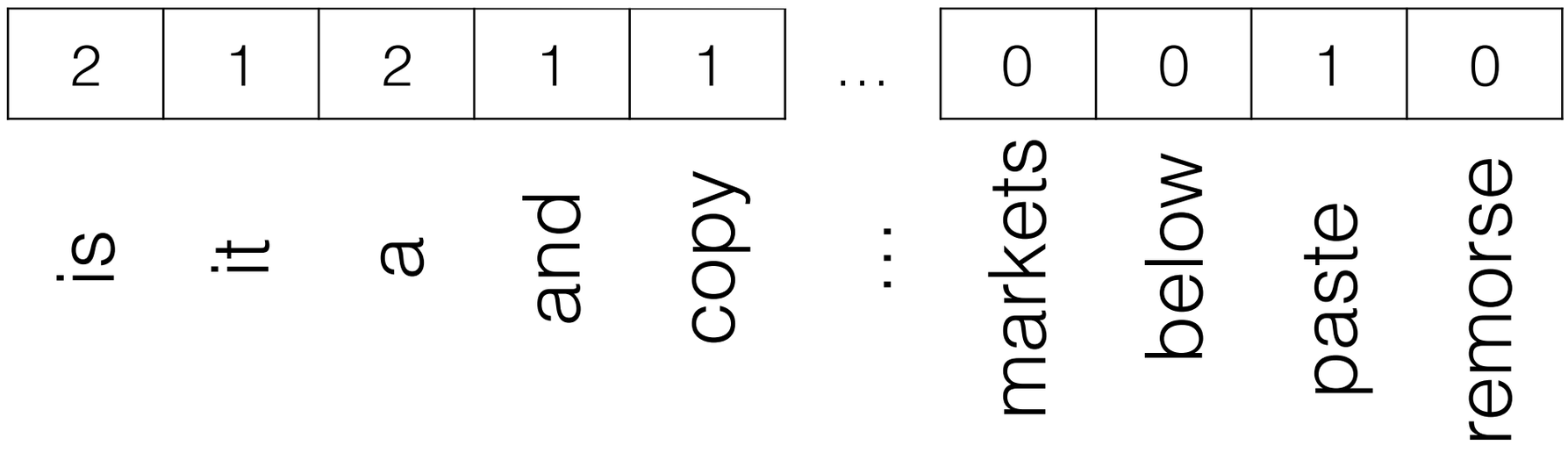
counts/frequencies



# “Bag of Words” (BOW)

| | is | it | a | and | copy | … | markets | below | paste | remorse |
|---|---|---|---|---|---|---|---|---|---|---|
| doc 1 | 1 | 1 | 2 | 1 | 0 | … | 2 | 1 | 0 | 0 |
| doc 2 | 3 | 1 | 4 | 0 | 0 | … | 1 | 2 | 0 | 1 |
| doc 3 | 2 | 1 | 2 | 1 | 1 | … | 0 | 0 | 1 | 0 |

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“Term Document Matrix”

# “Bag of Words” (BOW)

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| doc 3 | 2 | 1 | 2 | 1 | 1 | … | 0 | 0 | 1 | 0 |

**How similar are document 1 and document 2?**

# Similarity Metrics

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Thoughts?

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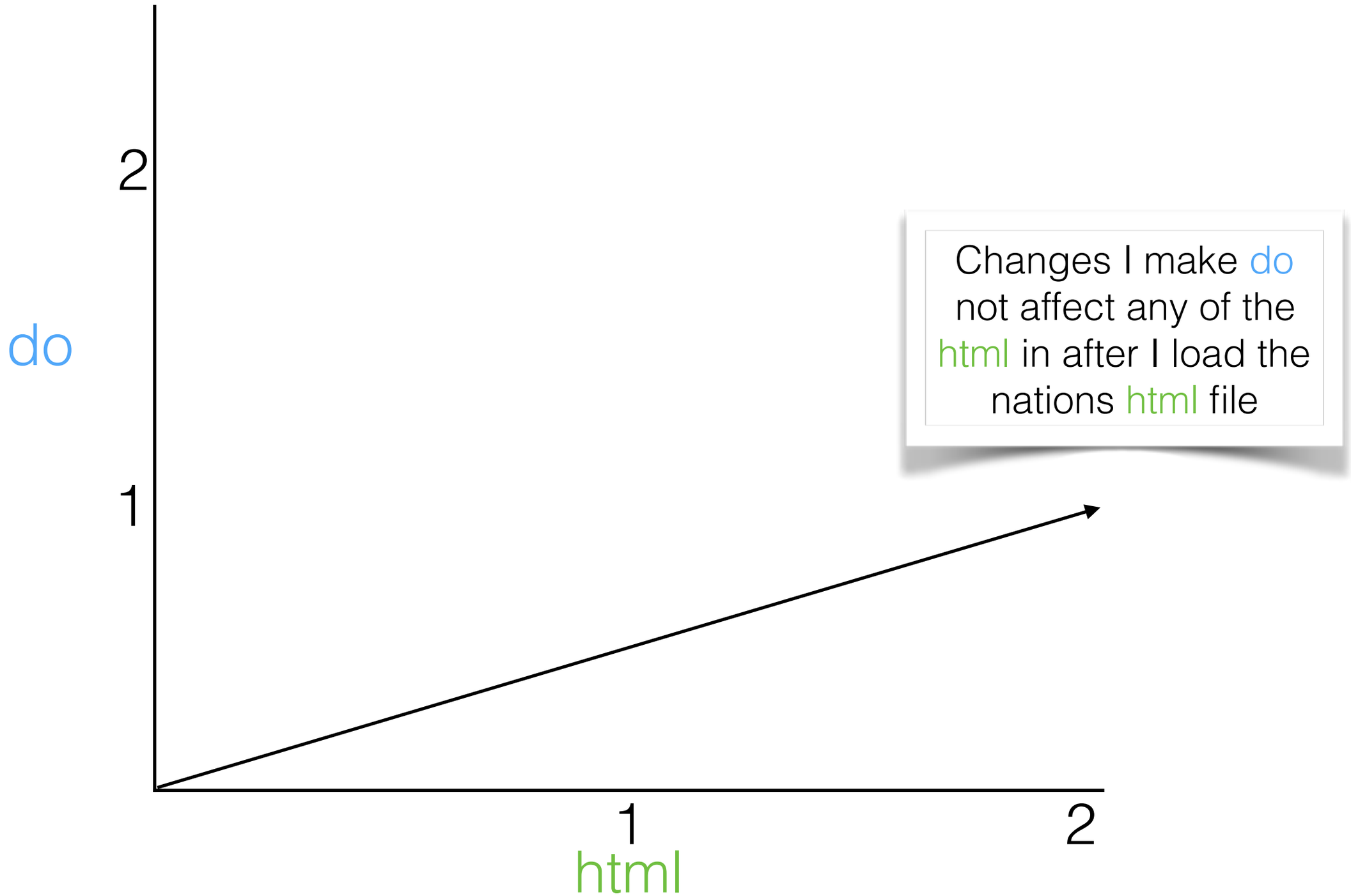
- Jaccard Similarity: words in common / total words

# Clicker Question!

# Similarity Metrics

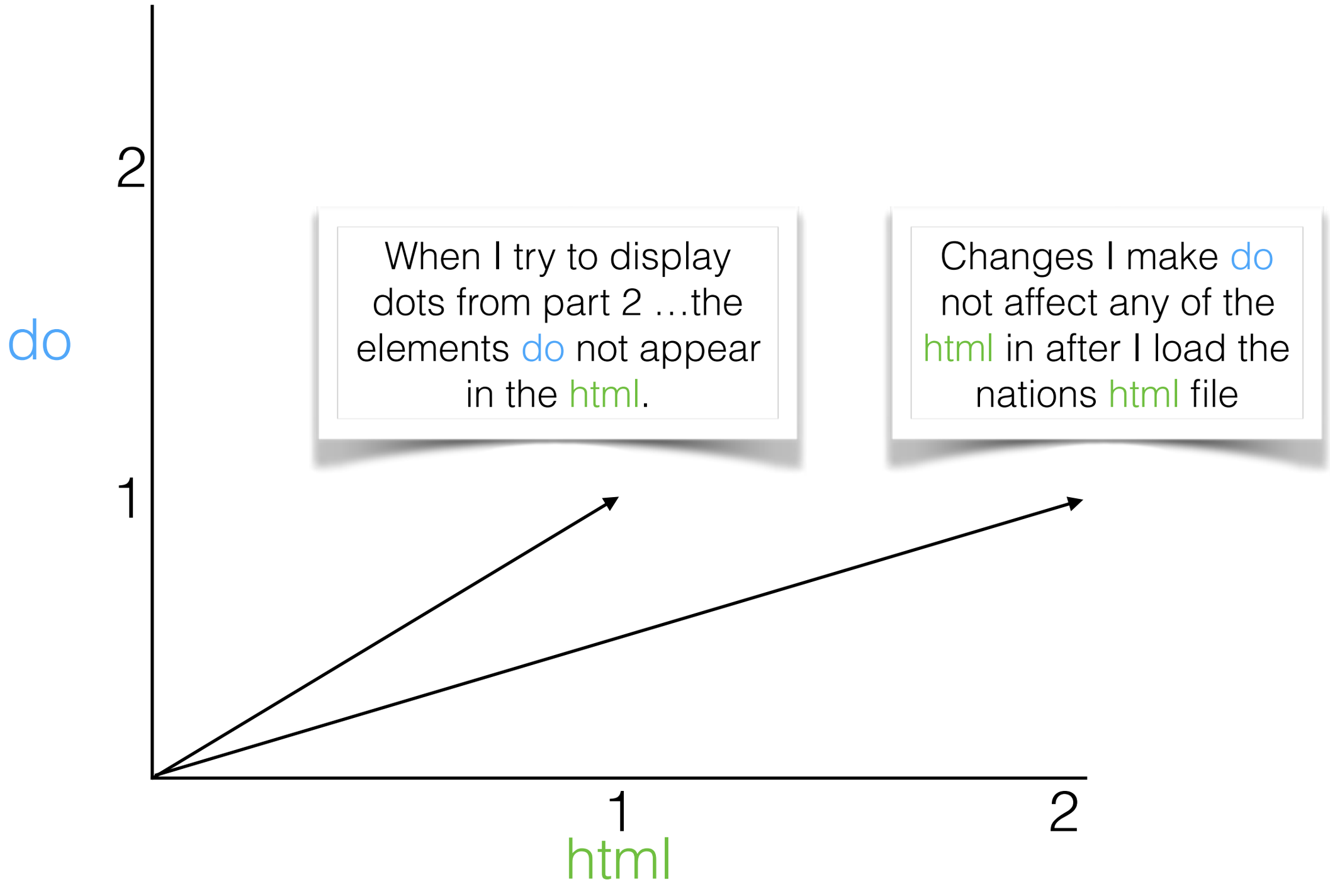
- Edit Distance: Minimal number of edits (inserts, deletes, substitutions) needed to transform string 1 into string 2.
- Jaccard Similarity: words in common / total words
- Cosine Similarity: by far the most popular metric

# Cosine Similarity



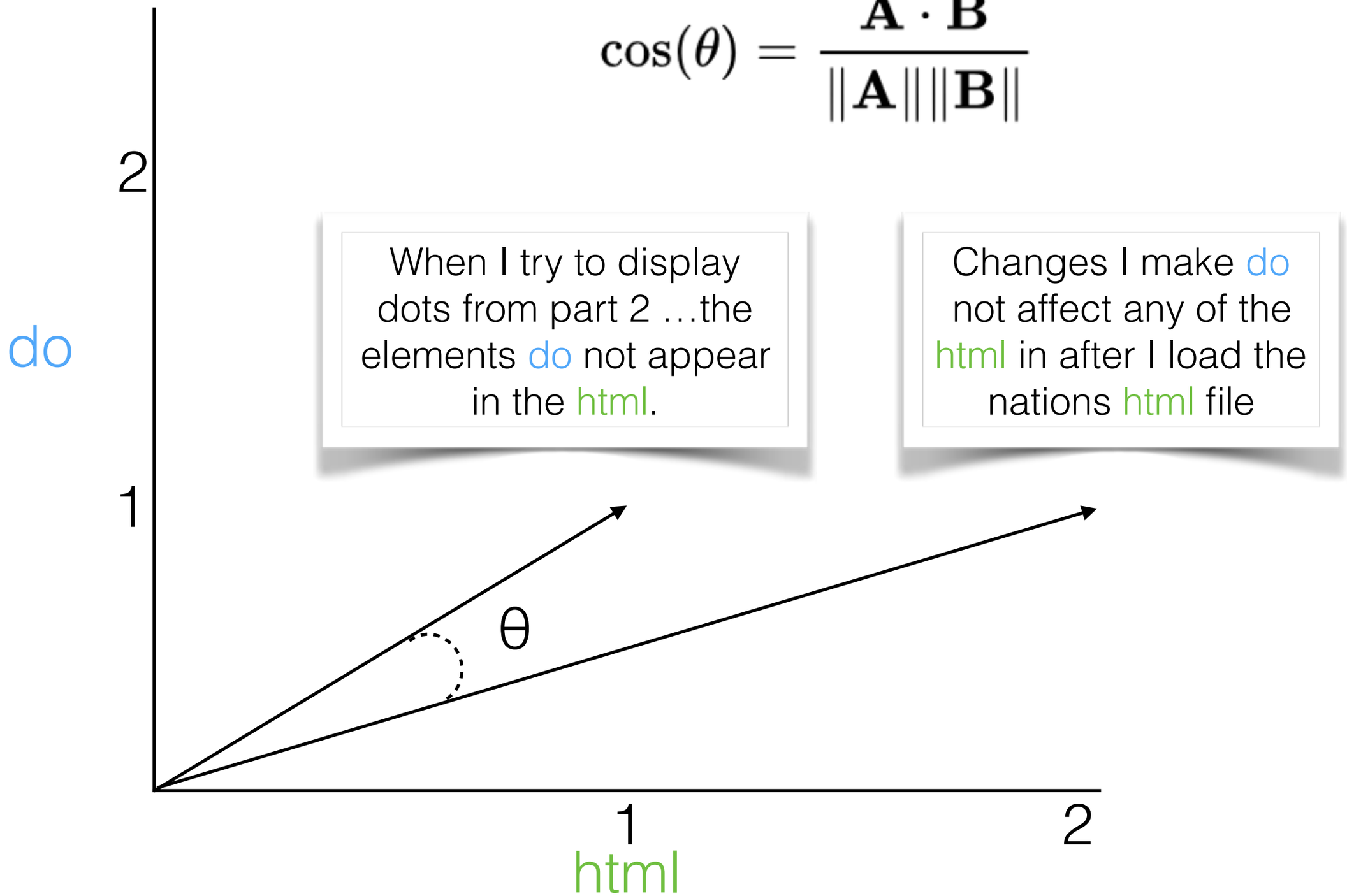

Changes I make do not affect any of the html in after I load the nations html file

# Cosine Similarity



# Cosine Similarity

$$\cos(\theta) = \frac{\mathbf{A} \cdot \mathbf{B}}{\|\mathbf{A}\|\|\mathbf{B}\|}$$

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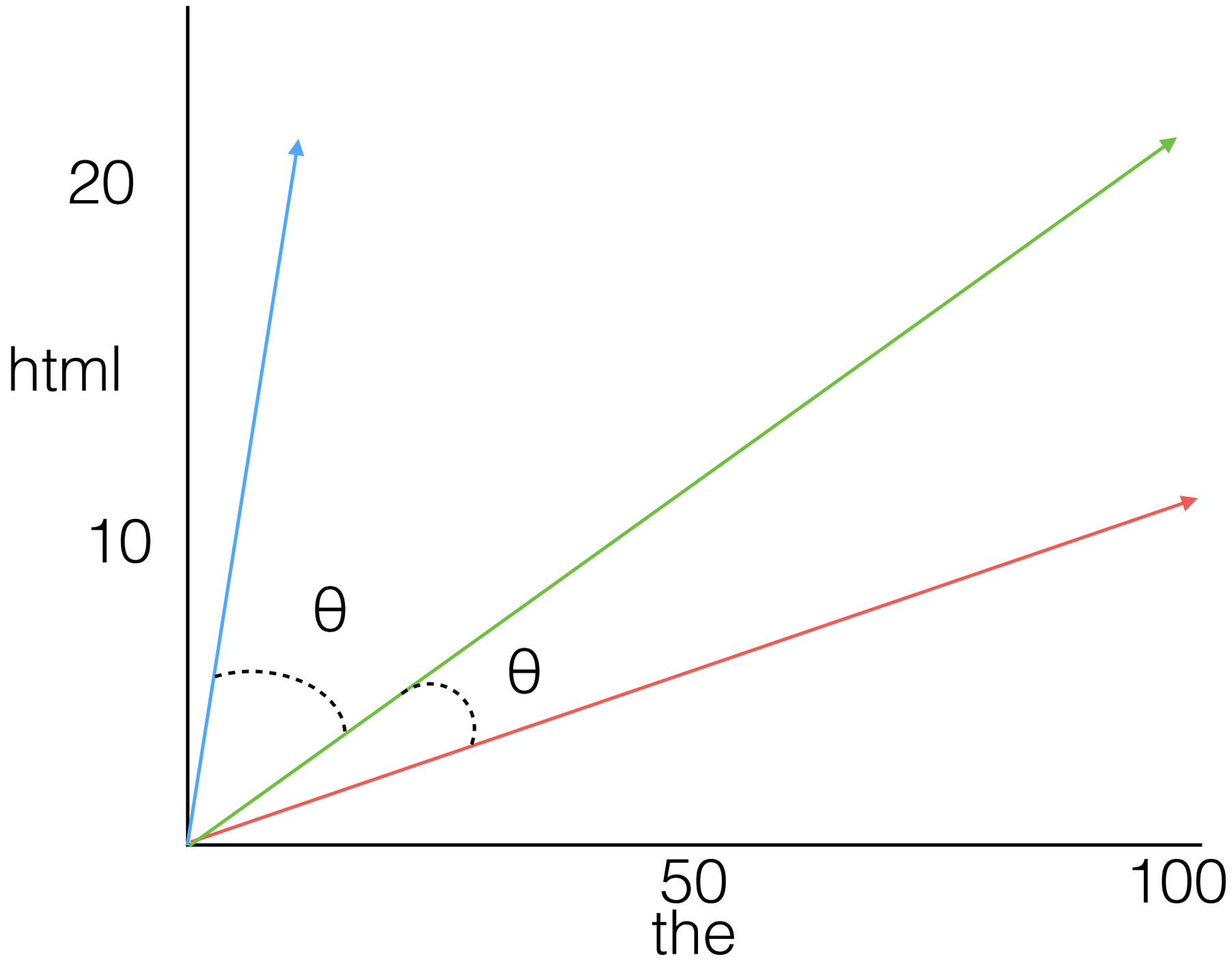
# Clicker Question!

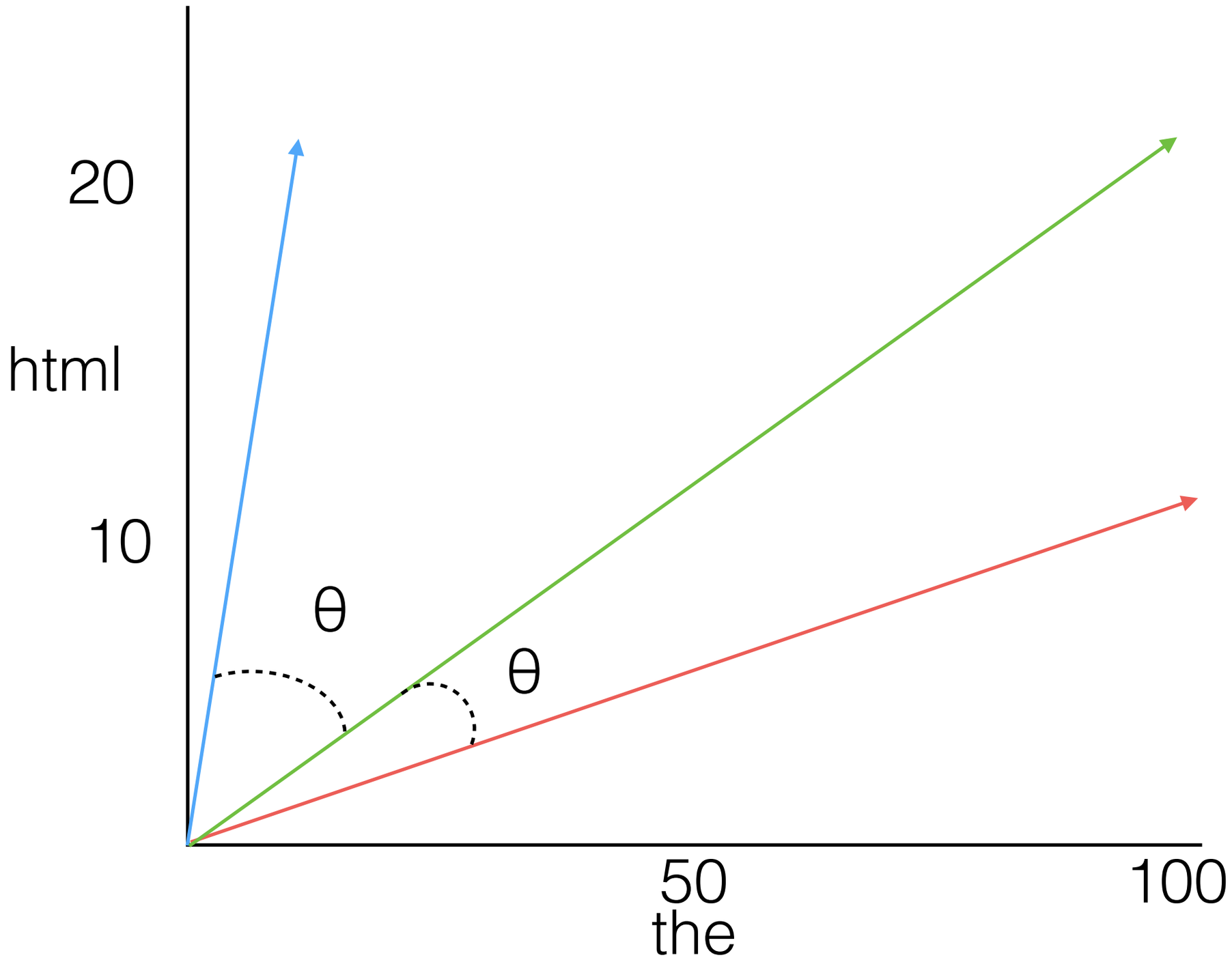
# Frequency Biases



# Tf-Idf

- Term-Frequency Inverse-Document-Frequency
- Goal is to down-weight words which occur often
- tf-idf(w,d) = (# times w appears in d) / (# of times w appears across all documents)

# Frequency Biases



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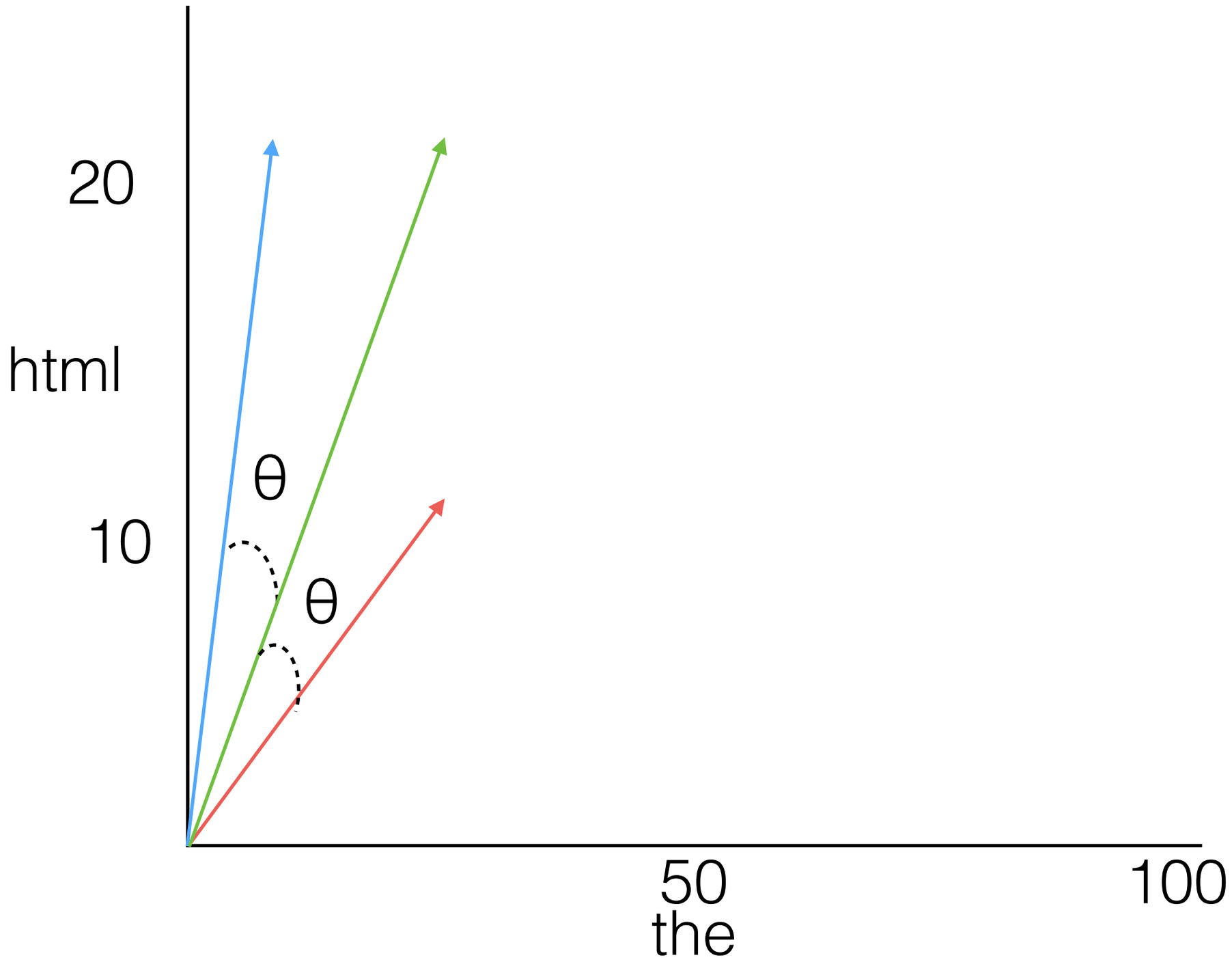

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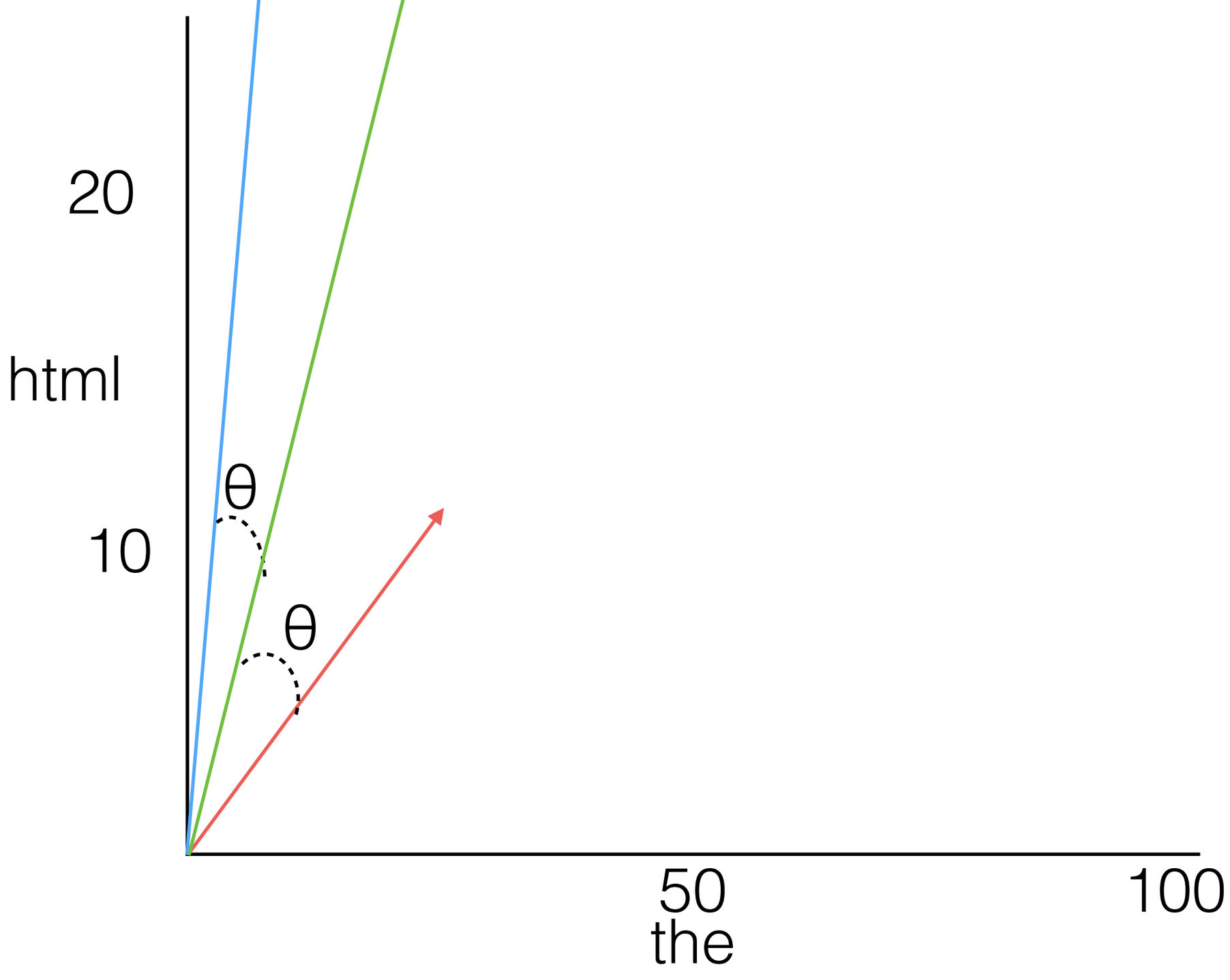

# Clicker Question!

# Linguistic Preprocessing

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Language is ambiguous

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Language is ambiguous

sorry, no, i have class.

# Linguistic Preprocessing

Language is ambiguous

sorry, no, i have **class**.

# Linguistic Preprocessing

Language is ambiguous

want to go get a coffee?

sorry, no, i have **class**.

# Linguistic Preprocessing

Language is ambiguous

want to go eat junk food and light random things on fire?

sorry, no, i have **class**.

# Linguistic Preprocessing

Language is ambiguous

but also redundant

want to go eat junk food and light random things on fire?

sorry, no, i have **dignity and taste**.

# Linguistic Preprocessing

Constant Tradeoff

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Collapse!

Try to treat more words as though they are the same

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Try to treat more words as though they are the same

Differentiate!

Try to preserve as much differences/ nuance as possible

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Constant Tradeoff

Collapse!

Try to treat more words as though they are the same

Differentiate!

Try to preserve as much differences/ nuance as possible

normalization, stemming

tagging, collocations

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| 日文 | 章魚 | 怎麼 | 說 | ? |
|---|---|---|---|---|
| Japanese | octopus | how | say | ? |

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- Stop words — “pb and jelly” vs. “pb or jelly”

try_VB display_VB dot_NN part_NN <NUM>_NUM mac_NNP
try_VB chrome_NNP firefox_NNP safari_NNP nothing_DT
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- Tagging — “fish fish fish fish fish”

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try_VB chrome_NNP <OOV> <OOV> nothing_DT display_VB
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- Remove out-of-vocabulary (OOV)

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# Topic Models

Can you elaborate on exactly what the directions are in part 2 step 3, the stencil code does not quite imply what we are supposed to do…

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UI: html, javascript, debug, display, elements…
systems: mac, windows, linux, chrome, firefox, os…
fillers: I, you, when, the, and, a

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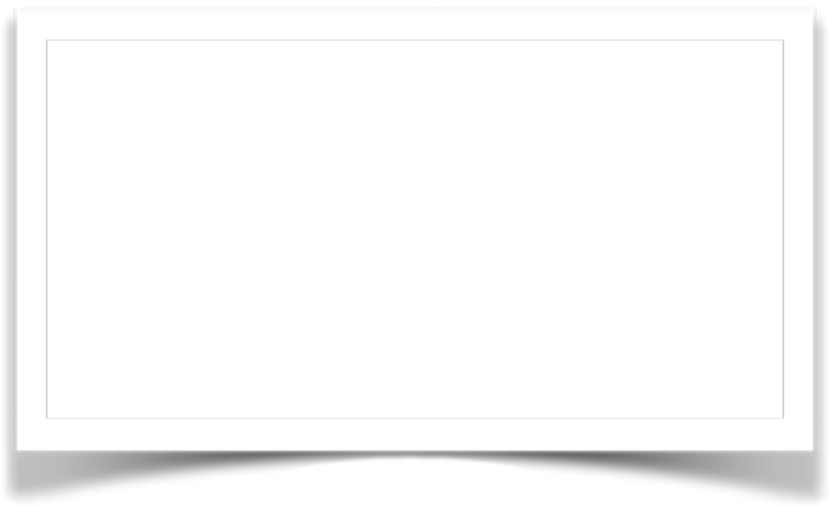

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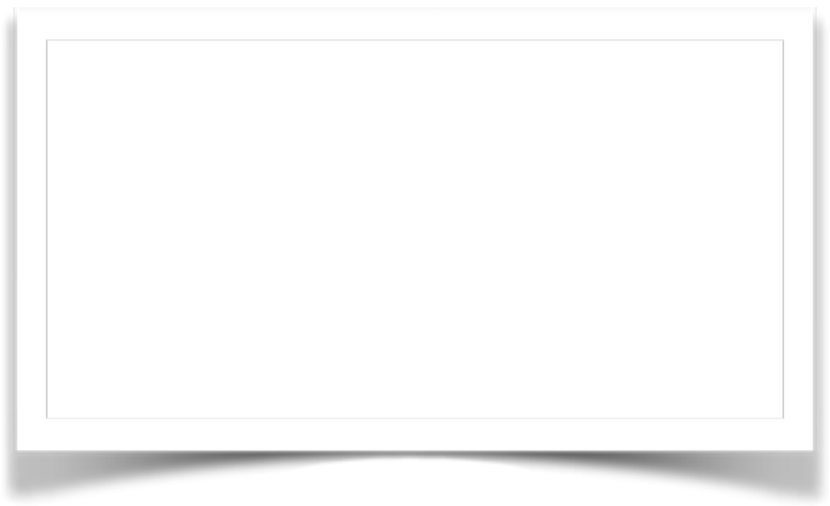

1. Sample a topic

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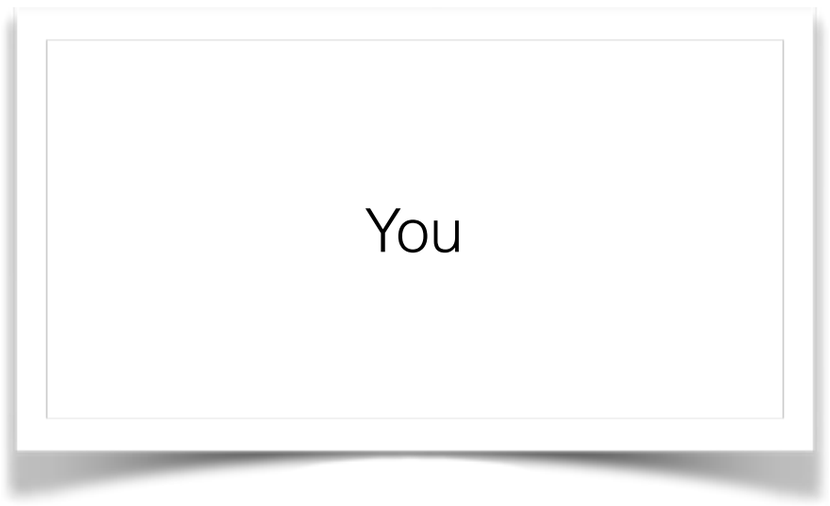


2. Sample a word from that topic

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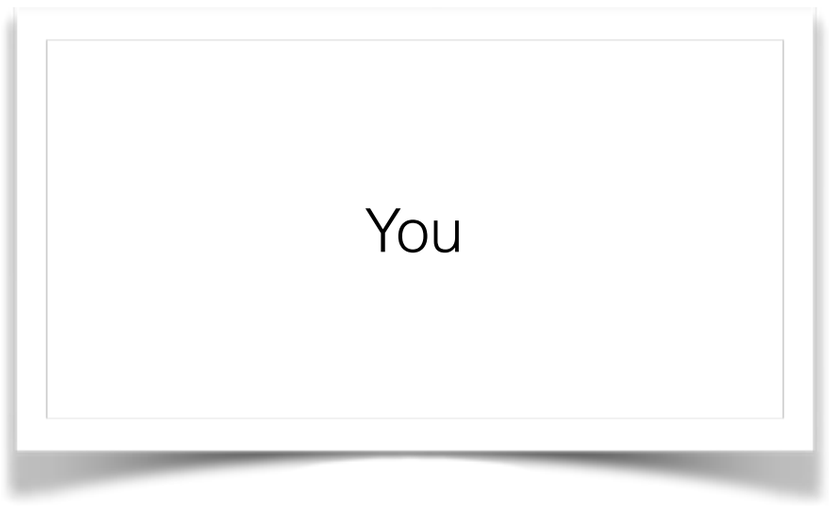


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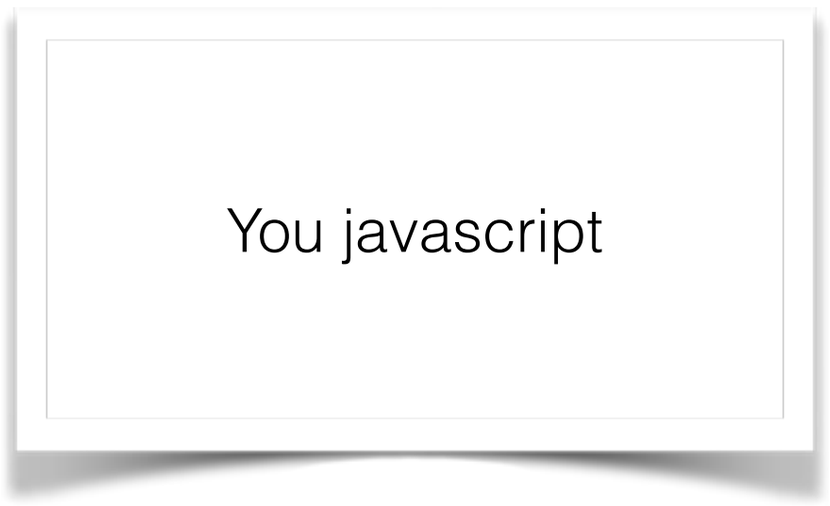


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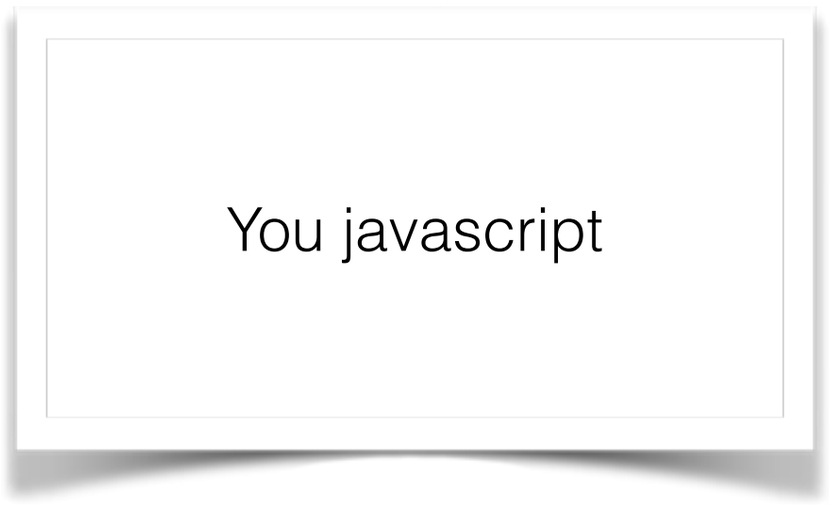


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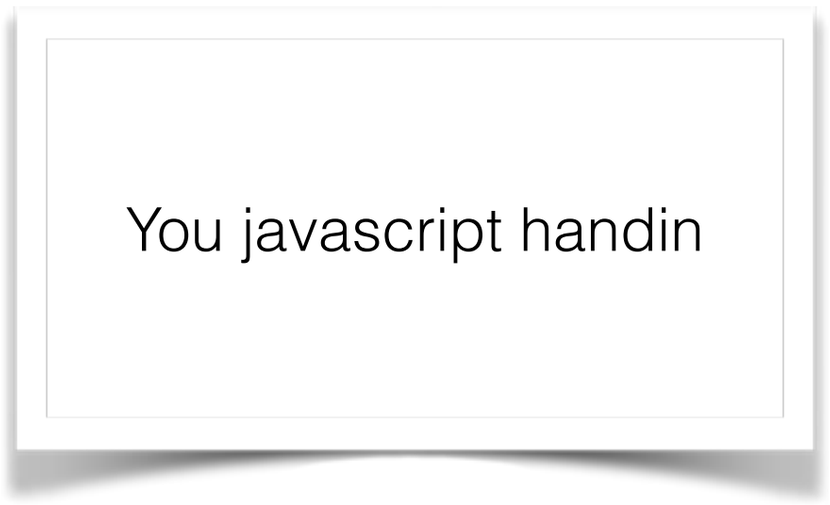


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"Latent Semantic Analysis" (LSA)

$$P(w_i) = \sum_{j=1}^{T} P(w_i \mid z_i = j) P(z_i = j)$$

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$$P(w_i) = \sum_{j=1}^{T} P(w_i \mid z_i = j) P(z_i = j)$$

"latent" variable (not observed)

# Topic Models

"Latent Semantic Analysis" (LSA)

$$P(w_i) = \sum_{j=1}^{T} P(w_i \mid z_i = j) P(z_i = j)$$

words are determined by topic
(and are conditionally independent of each other)

# Topic Models

"Latent Semantic Analysis" (LSA)

$$P(w_i) = \sum_{j=1}^{T} P(w_i \mid z_i = j) P(z_i = j)$$

documents are a distribution over topics

# Topic Models

"Latent Semantic Analysis" (LSA)

$$P(w_i) = \sum_{j=1}^{T} P(w_i \mid z_i = j) P(z_i = j)$$

set parameters to maximize probability of observations

# Topic Models

part 2 html does not work

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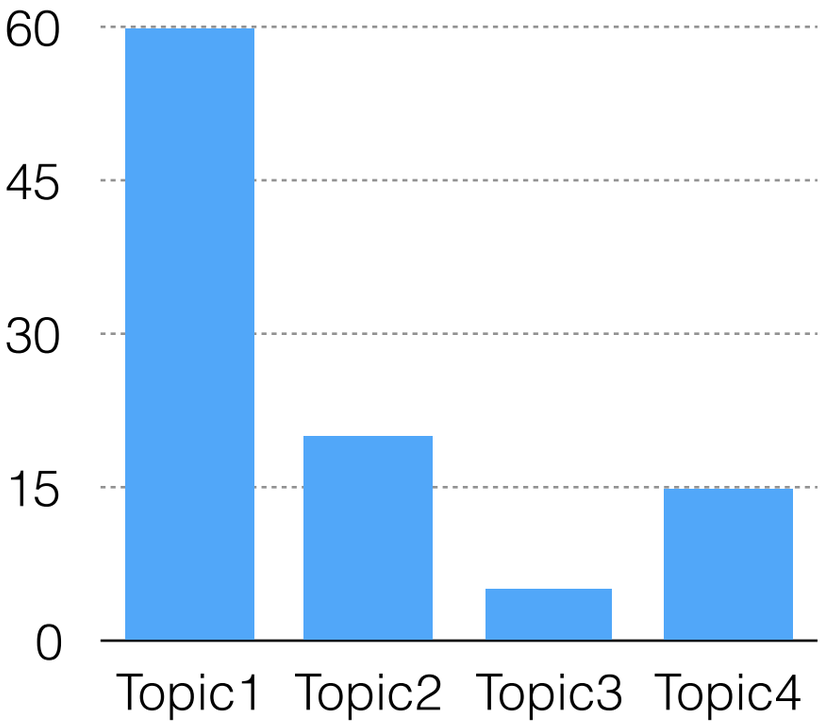

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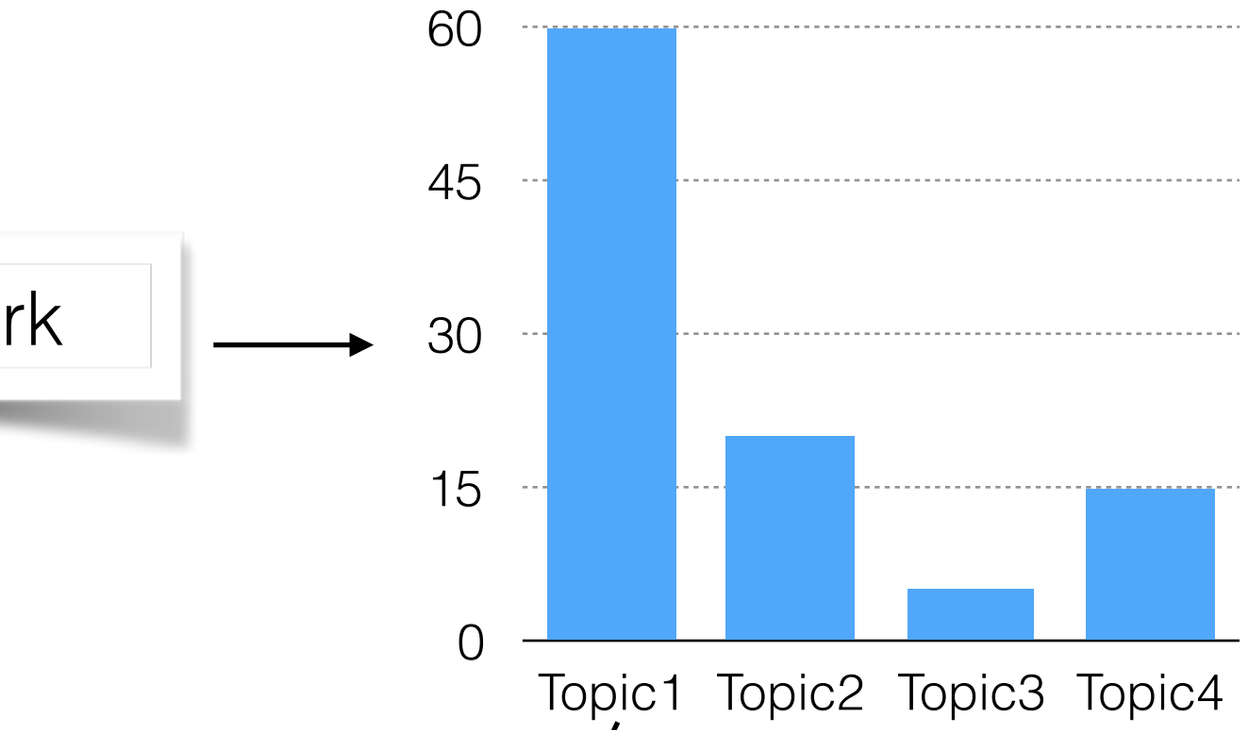


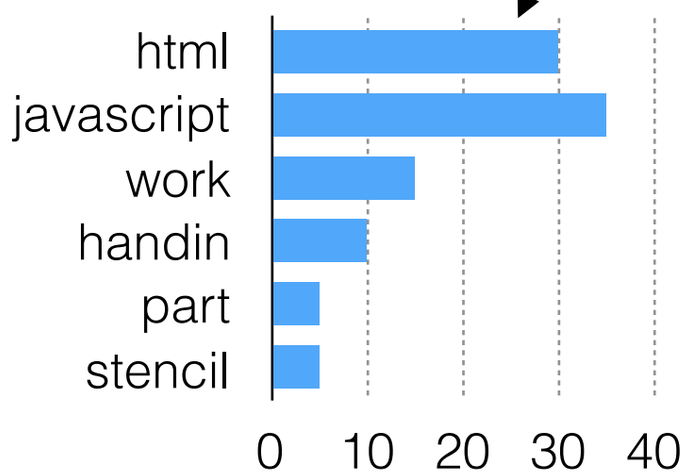


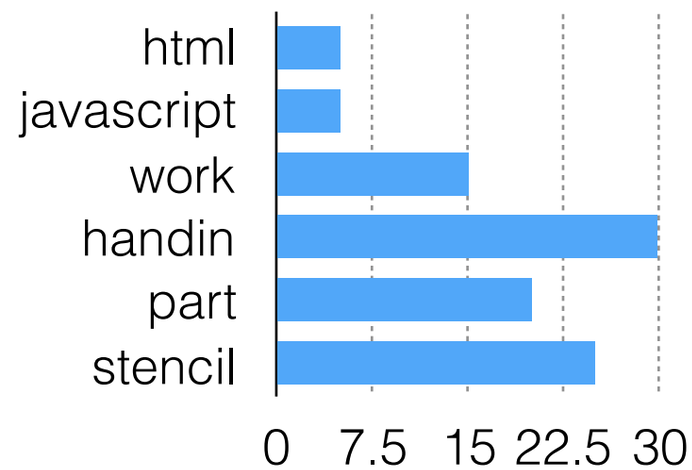

# Clicker Question!

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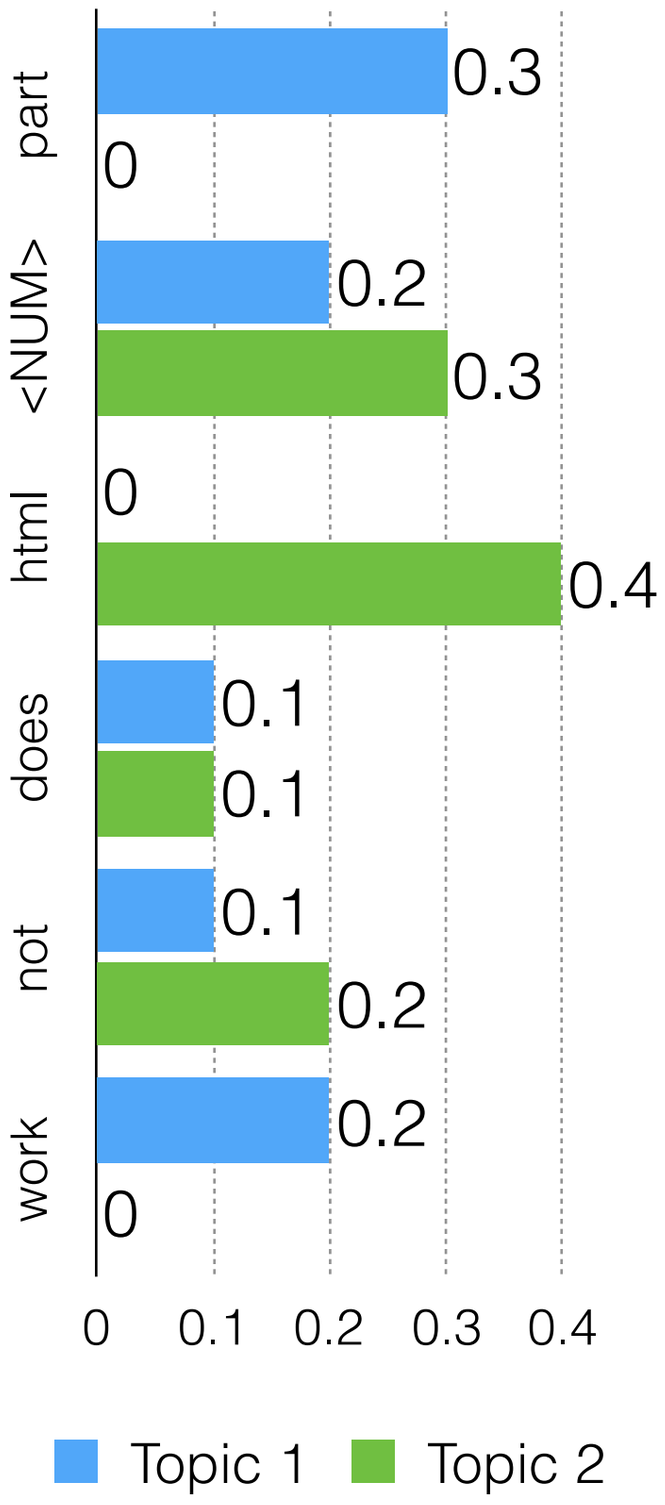
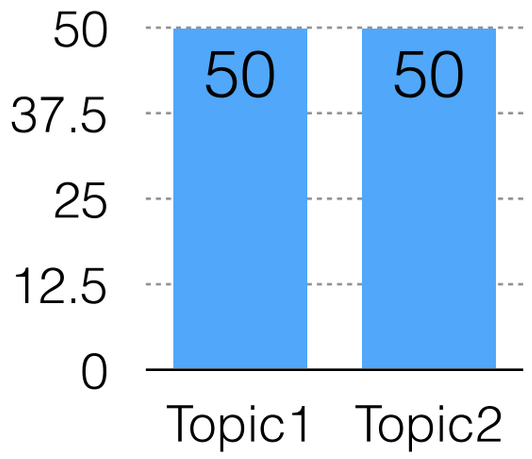


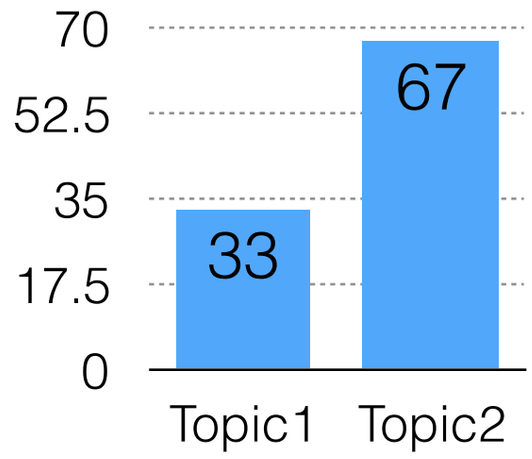

Which is the best parameter setting for the observed data?

$$P(w_i) = \sum_{j=1}^{T} P(w_i \mid z_i = j) P(z_i = j)$$

part <NUM> html does not work




(a)




(b)

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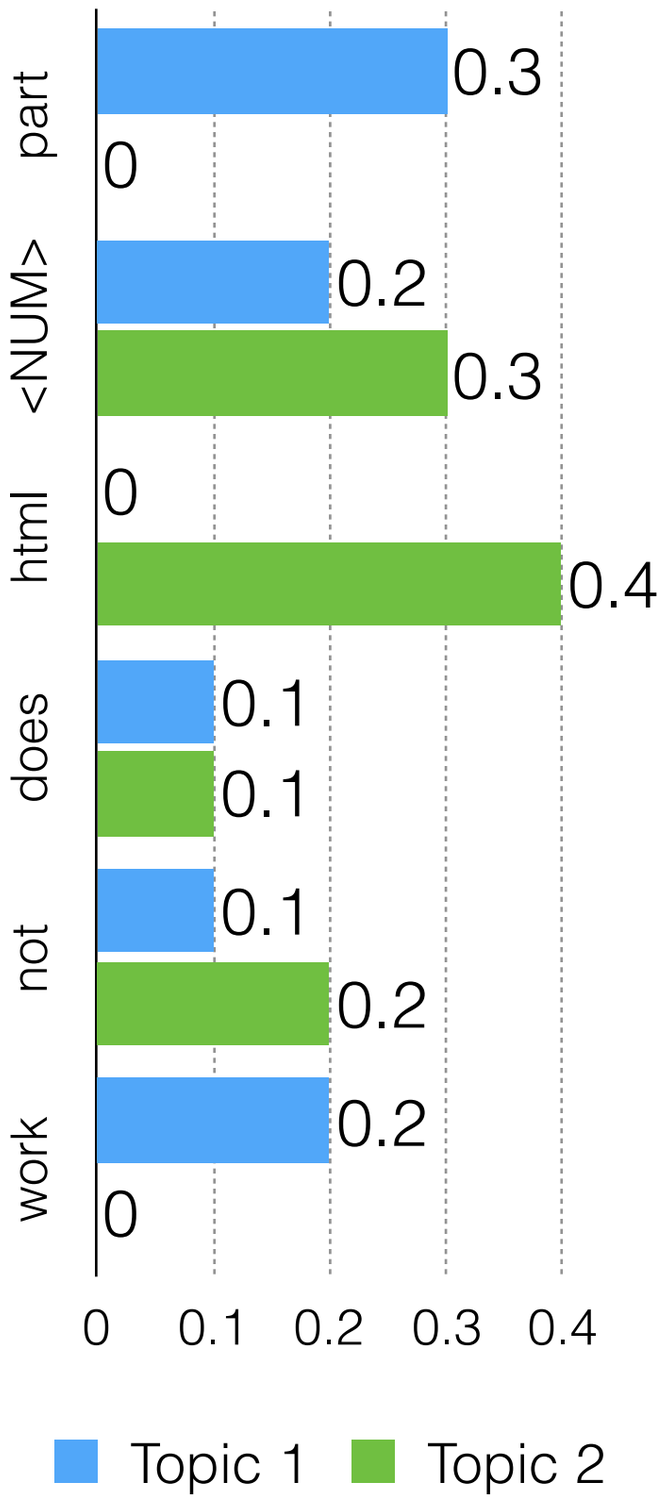
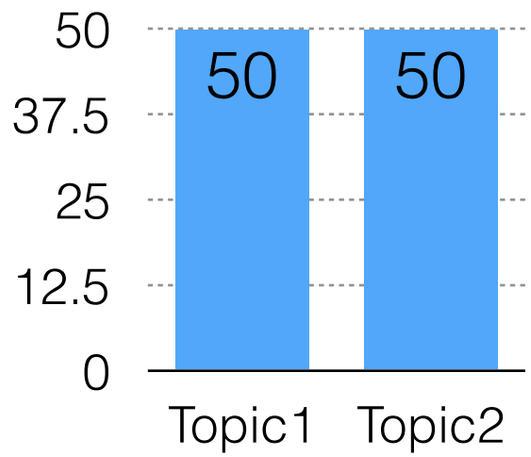
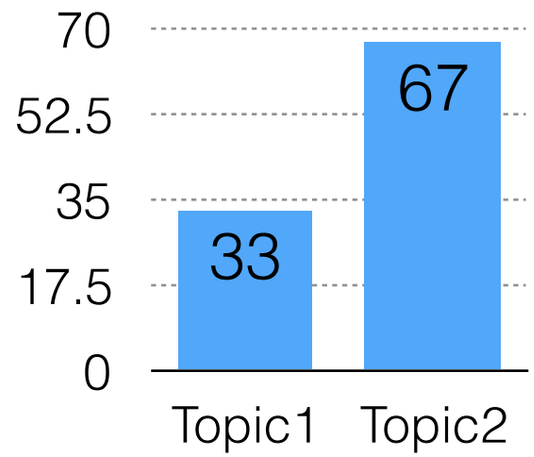



a: (0.3+0.2+0+0.1+0.1+0.2)x0.5

part <NUM> html does not work

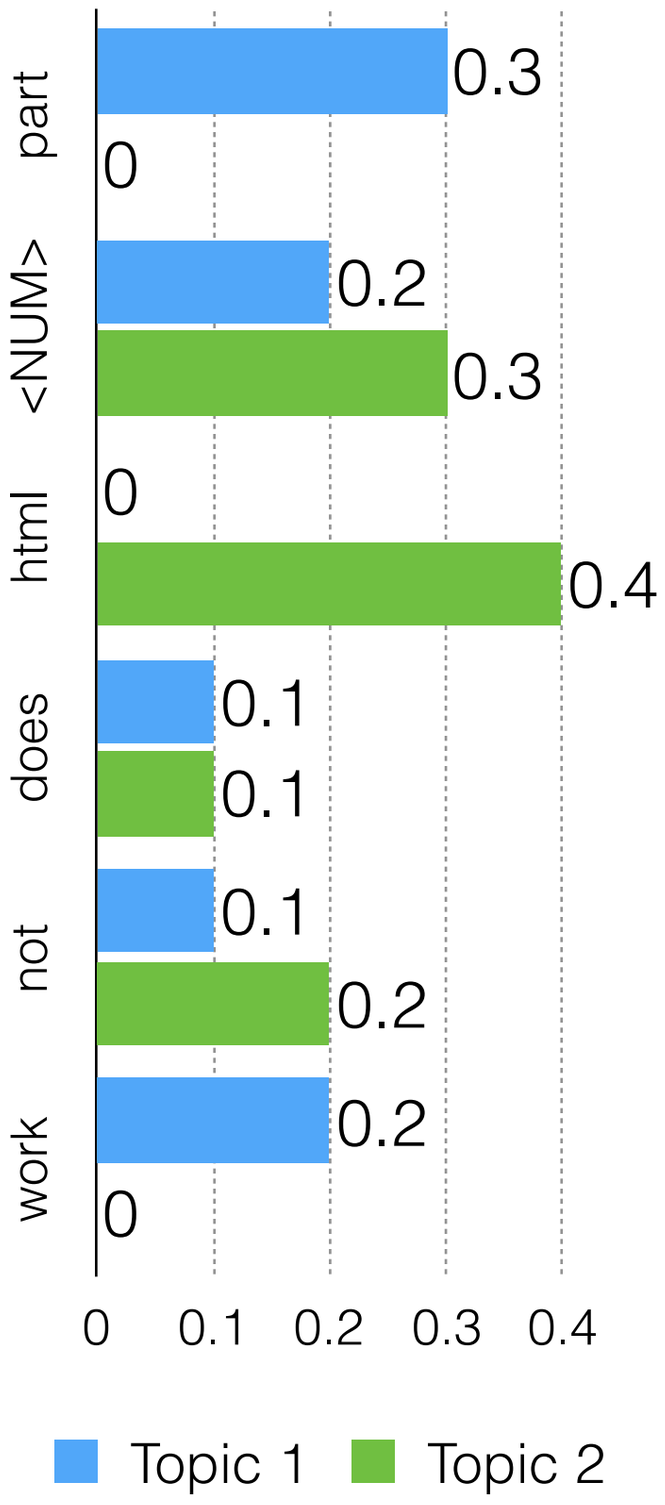



(a)



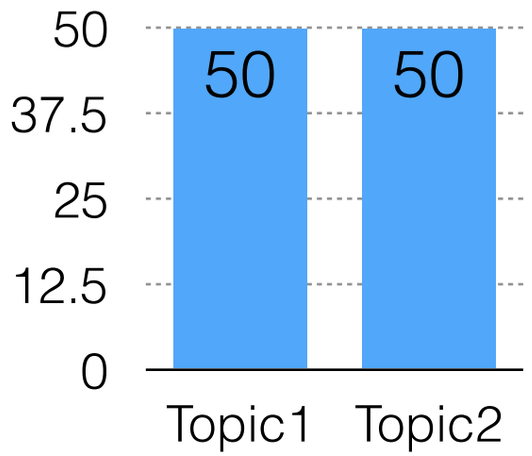

(b)

# Clicker Question!

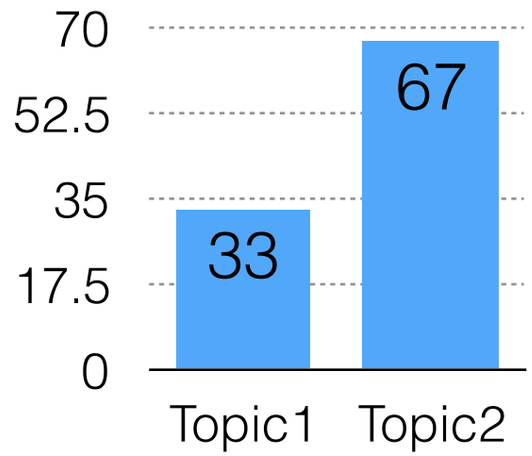



a: (0.3+0.2+0+0.1+0.1+0.2)x0.5
(0+0.3+0.4+0.1+0.2)x0.5

part <NUM> html does not work

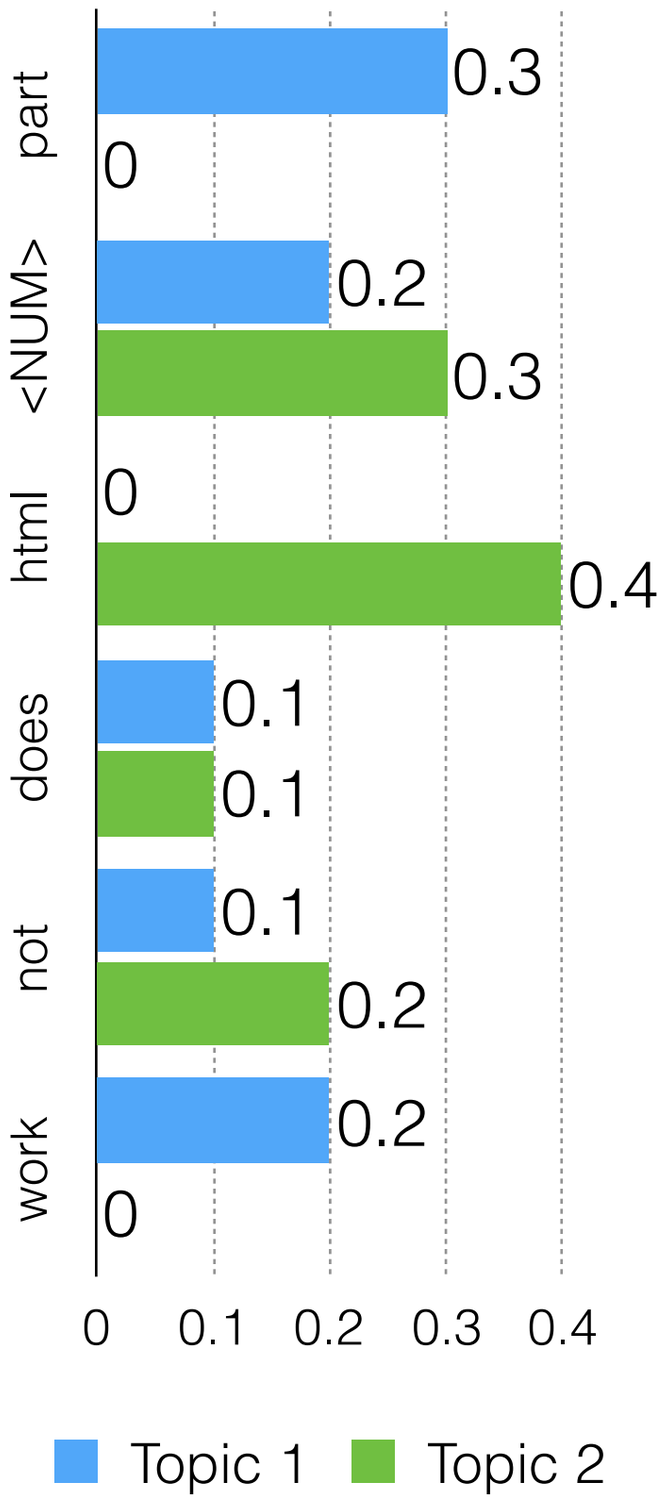



(a)



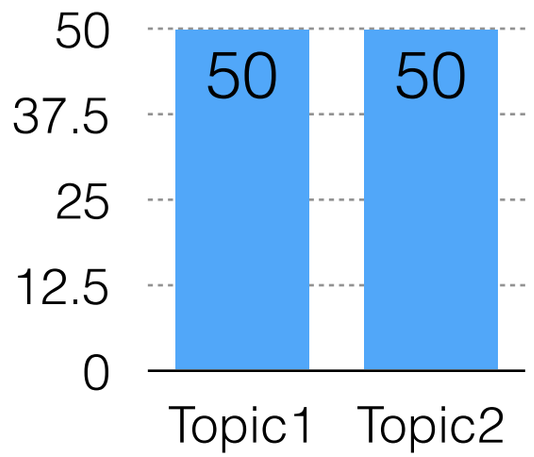

(b)

# Clicker Question!

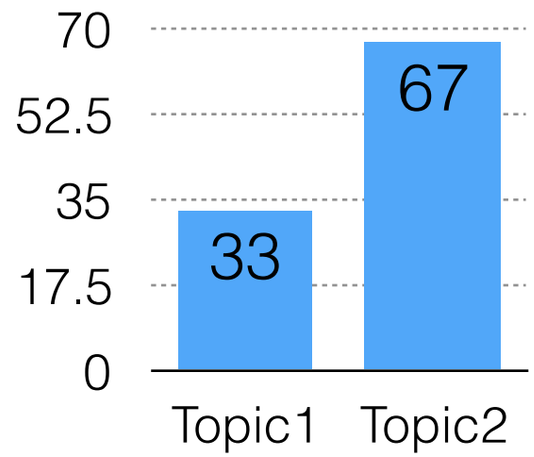



a: (0.3+0.2+0+0.1+0.1+0.2)x0.5
(0+0.3+0.4+0.1+0.2)x0.5
= 0.45 + 0.5
= 0.95

part <NUM> html does not work

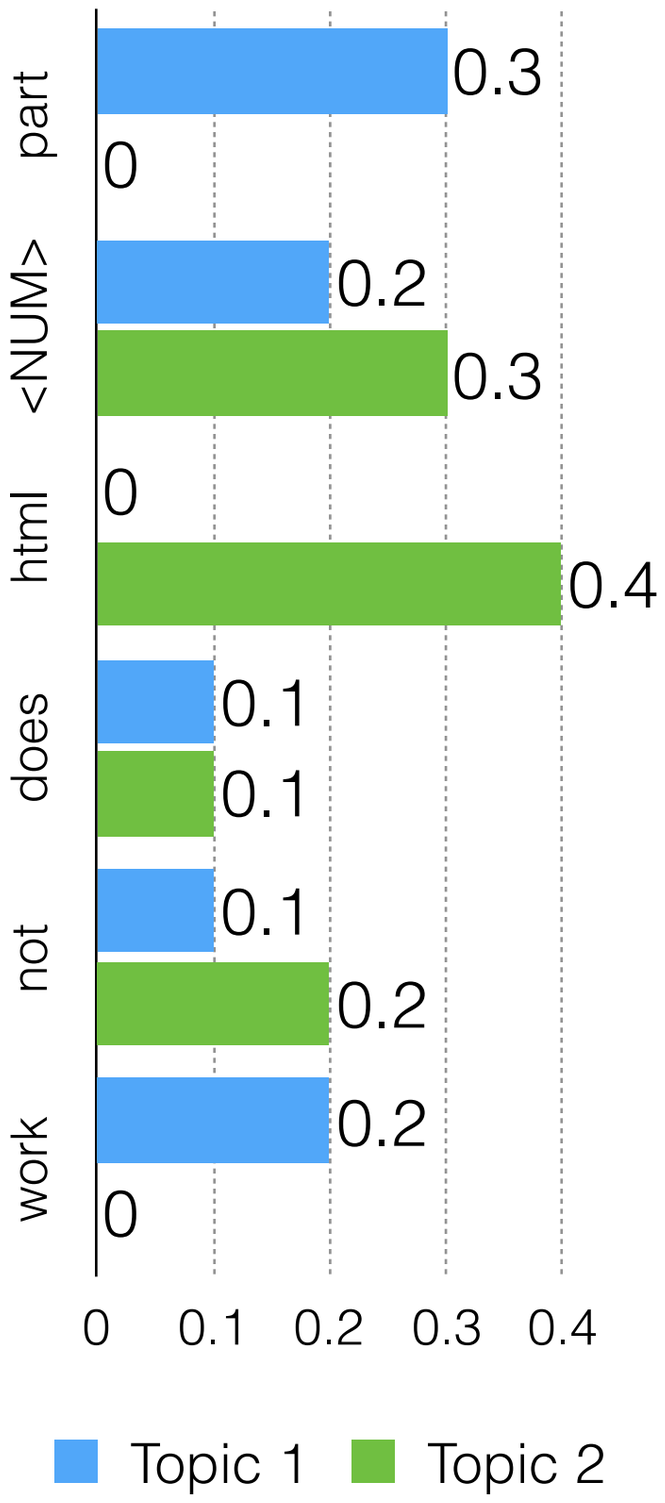



(a)



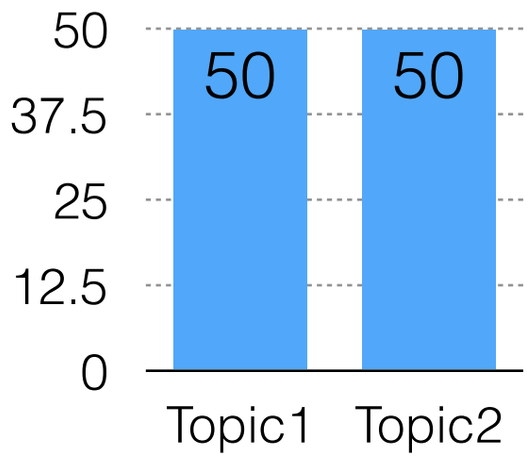

(b)

# Clicker Question!

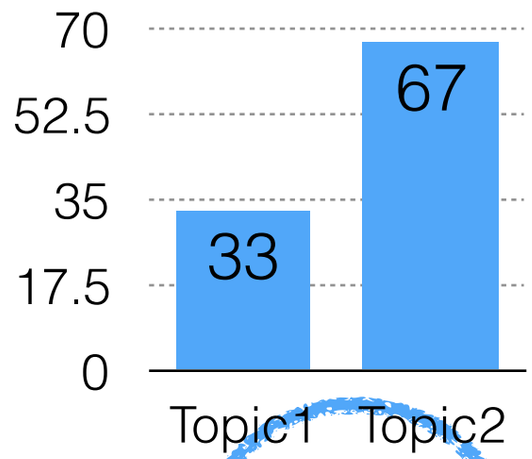



b: (0.3+0.2+0+0.1+0.1+0.2)x0.33
(0+0.3+0.4+0.1+0.2)x0.67
= 0.297 + 0.67
= 0.967

part <NUM> html does not work




(a)




(b)

# Word Representations

# Vector Space Models

You shall know a word by the company it keeps!

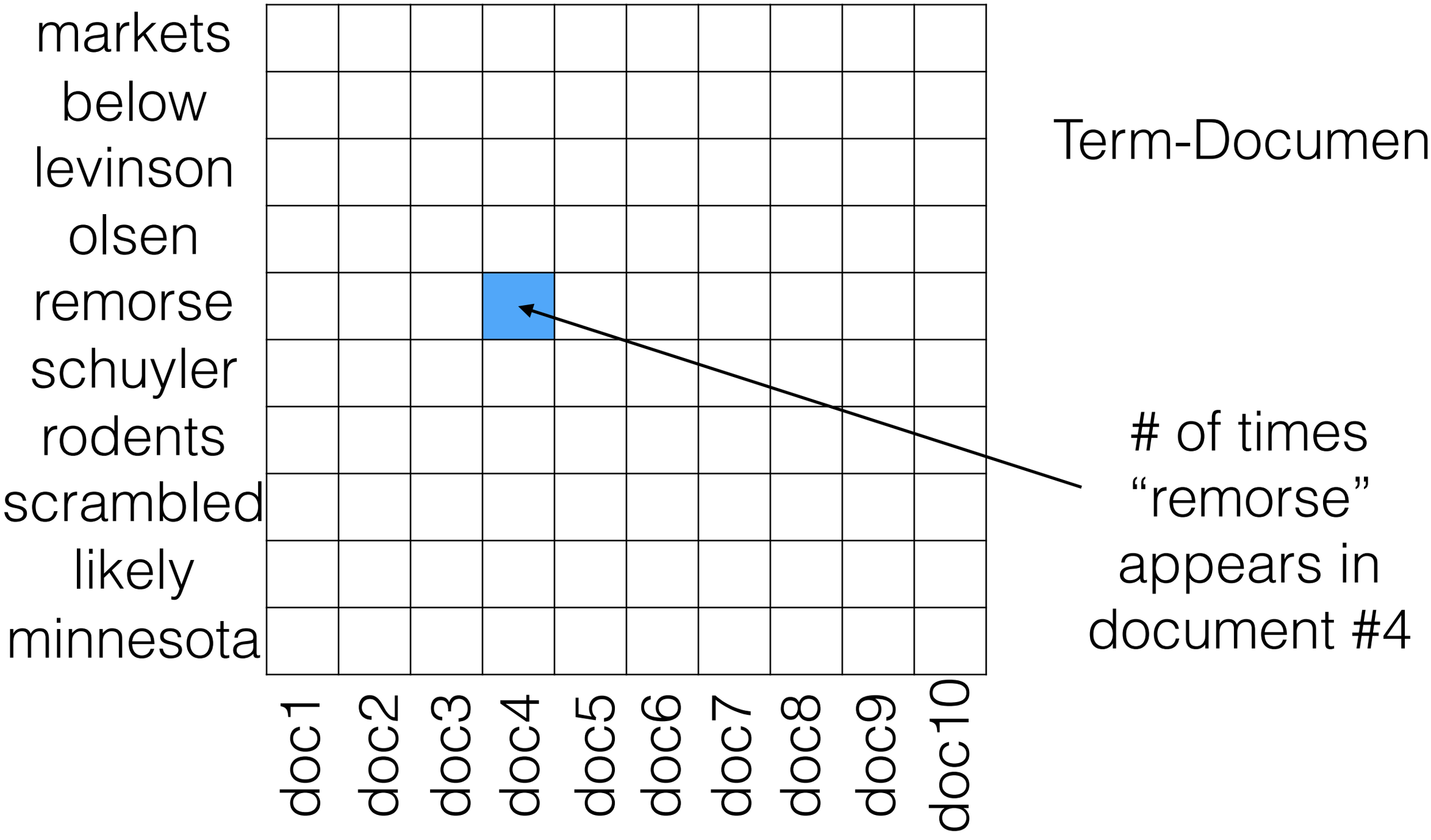
↓

Words that occur in similar contexts tend to have similar meanings.

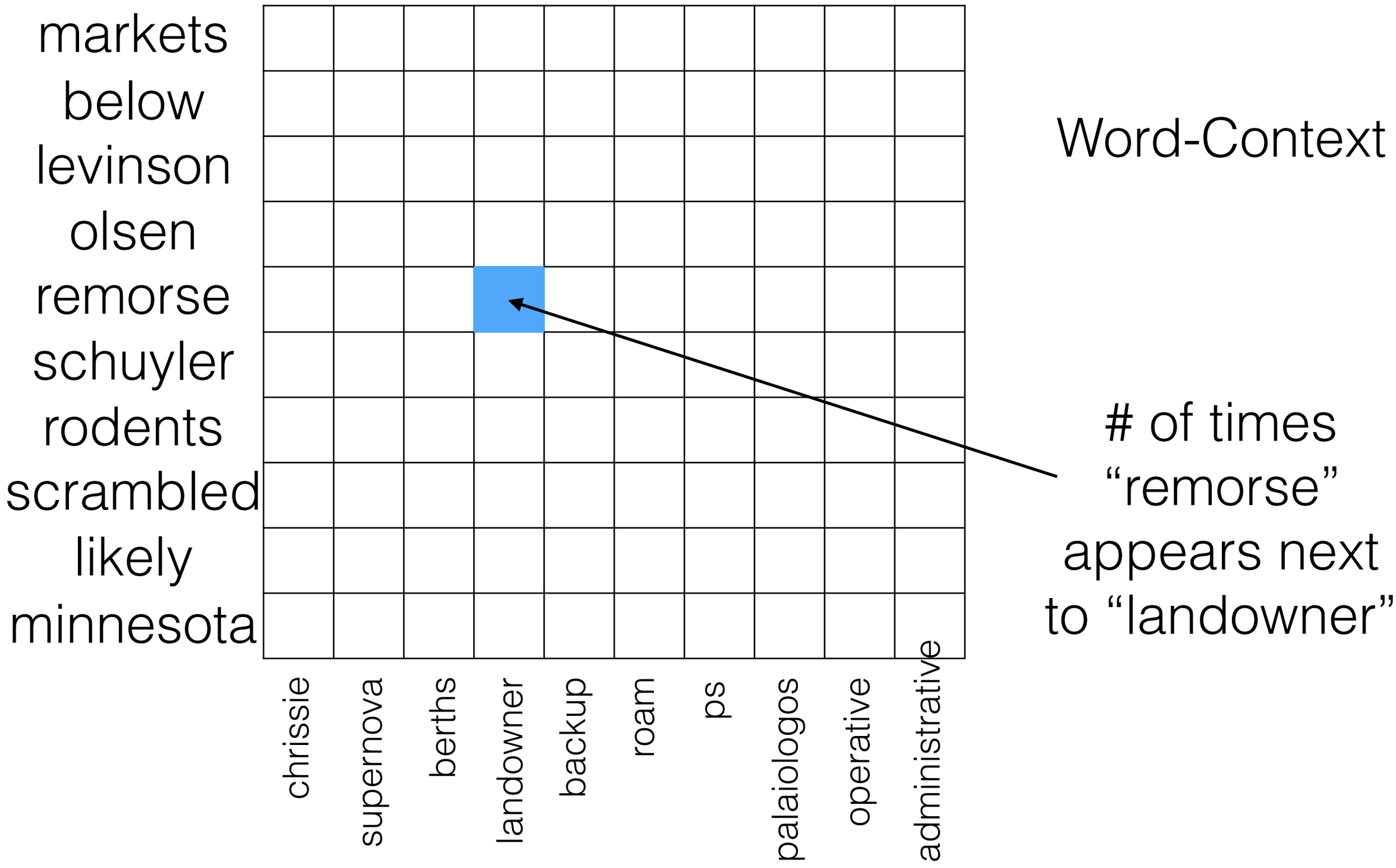
↓

If words have similar row vectors in a word–context matrix, then they tend to have similar meanings.

# Vector Space Models



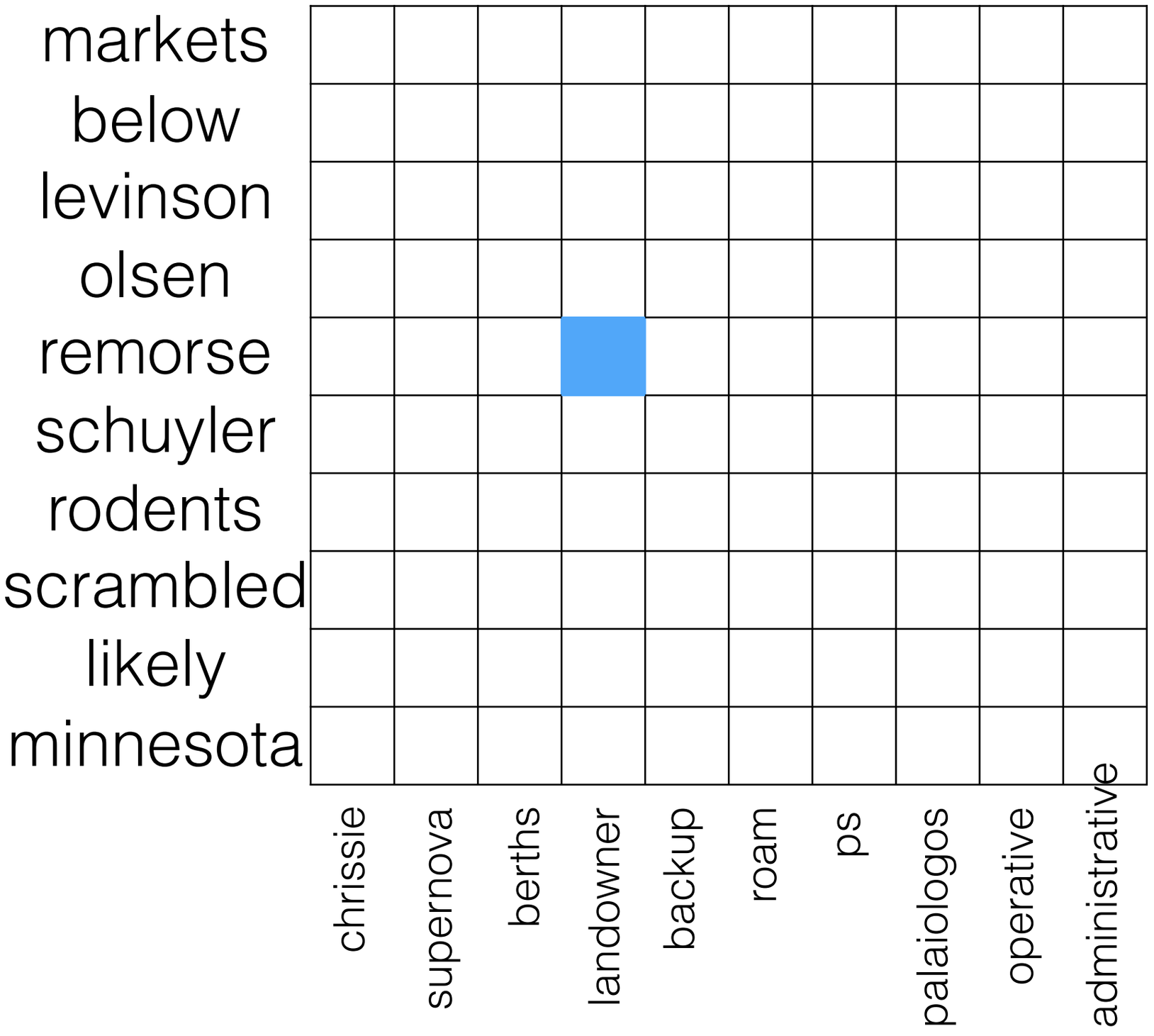
# Vector Space Models




Word-Context

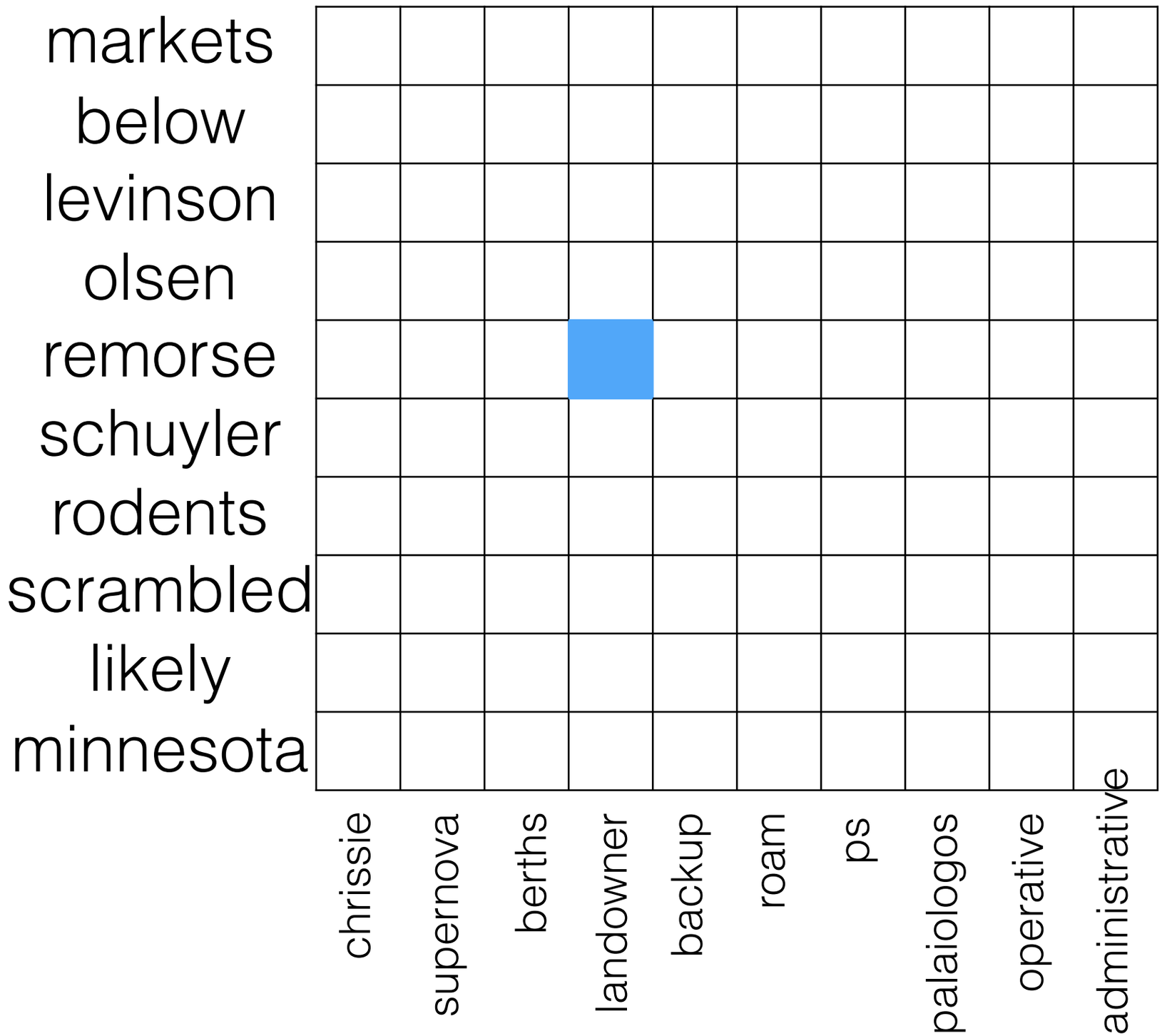
# of times “remorse” appears next to “landowner”

# Vector Space Models



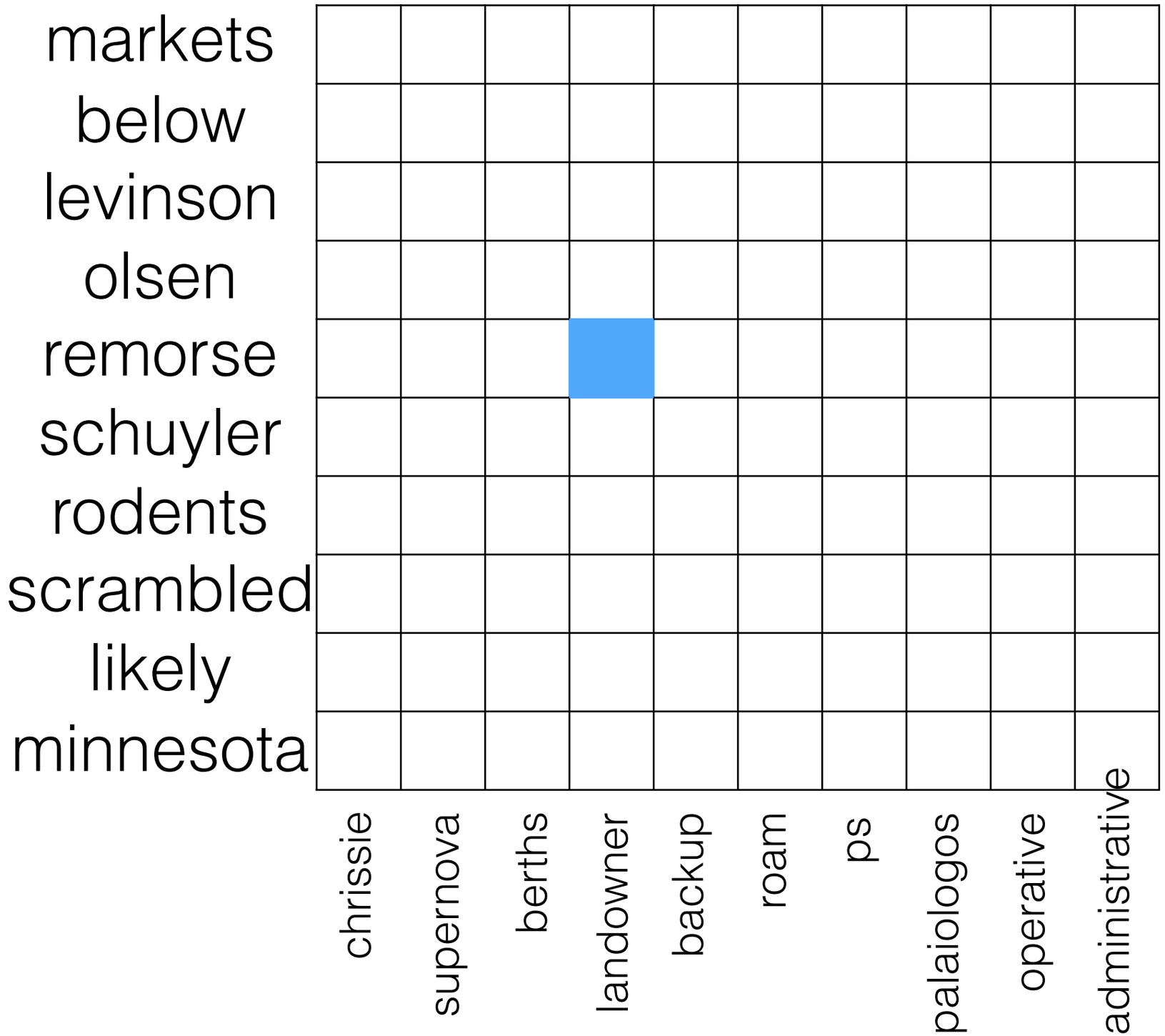

These matrices are ***very*** sparse

# Vector Space Models




One option:
Matrix
Factorization
(next week)

# Vector Space Models




One option:
Matrix
Factorization
(next week)

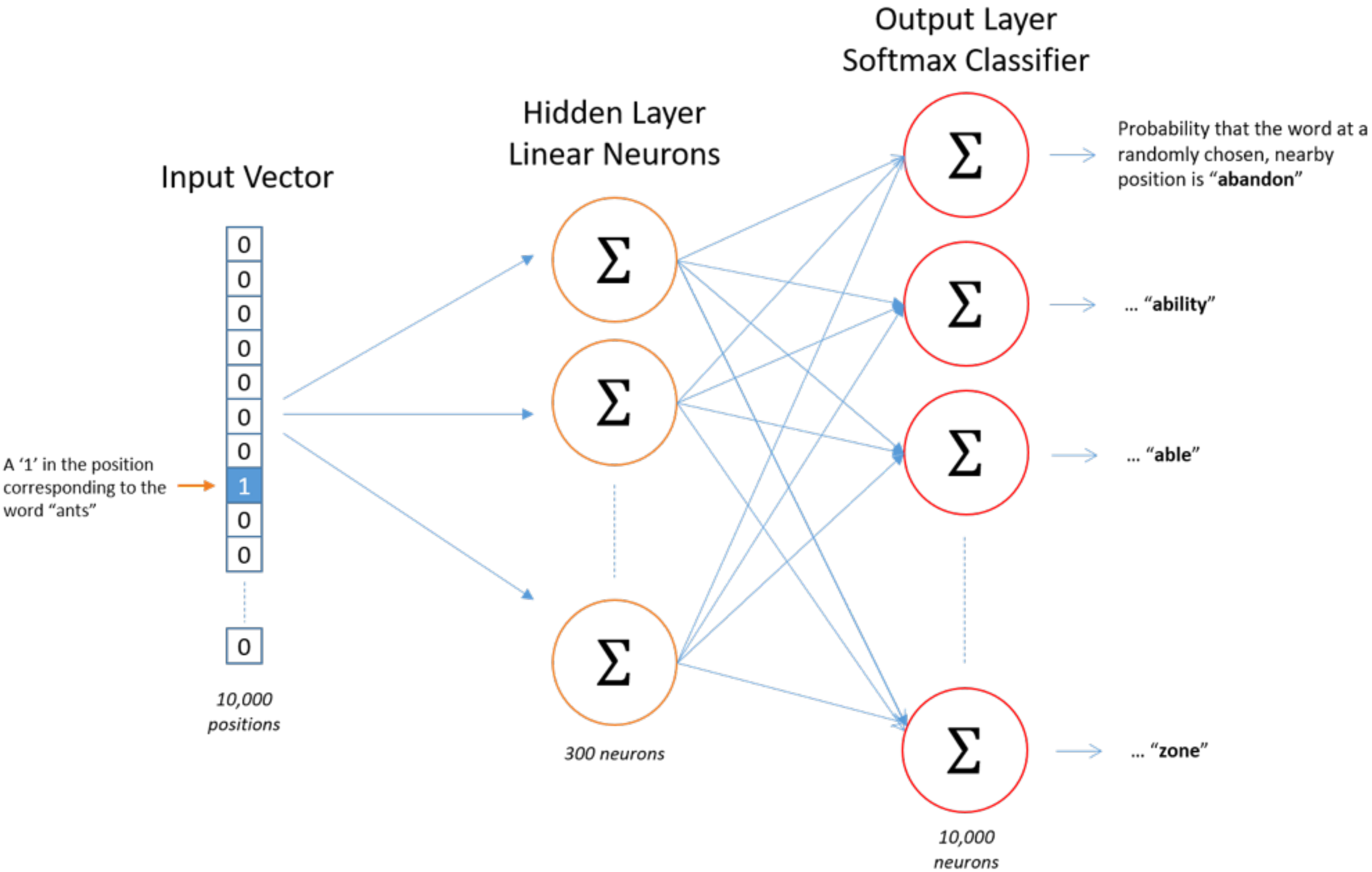
Another option:
Deep Learning
(also next week)

# Vector Space Models

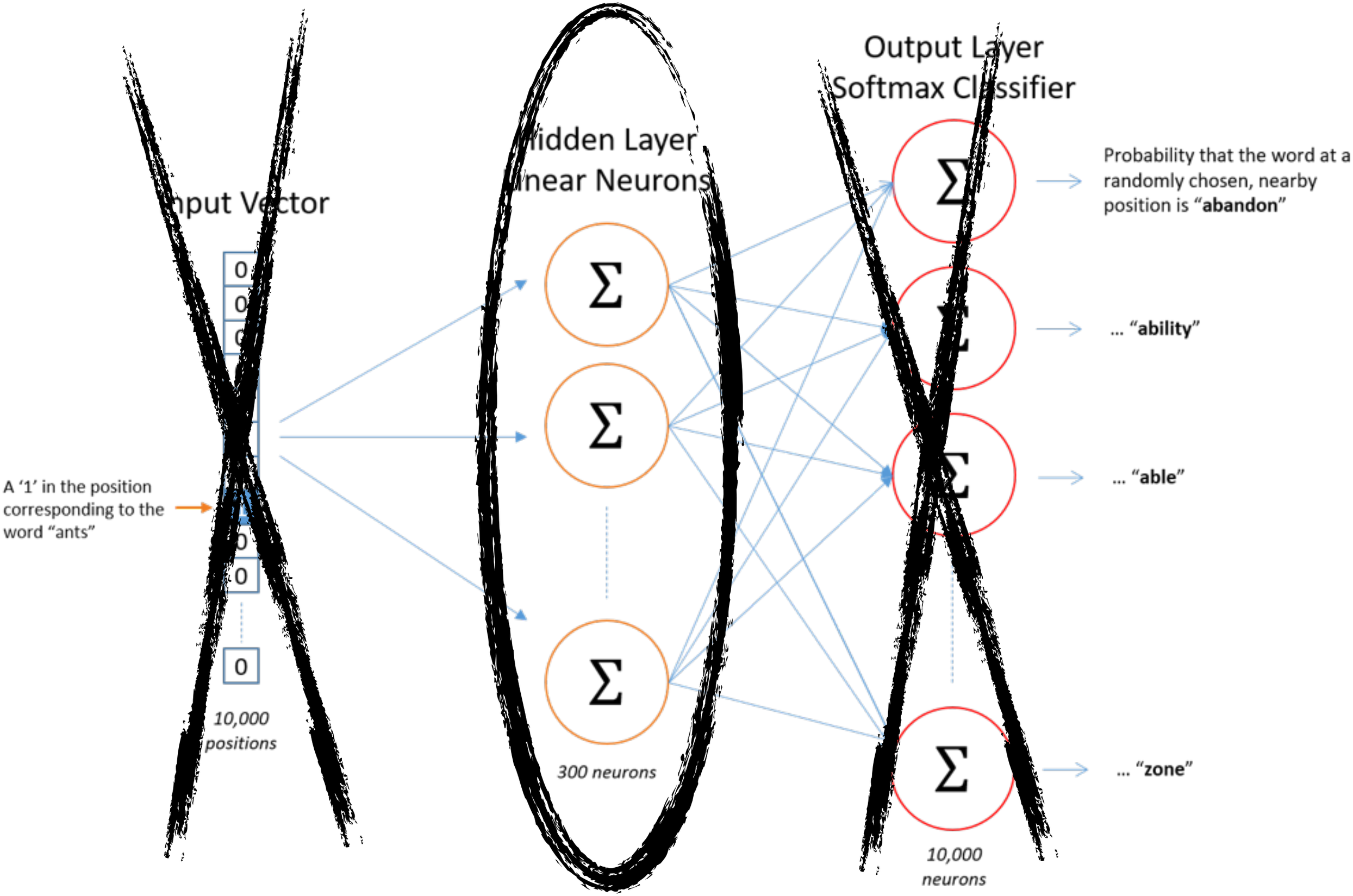
markets

| |
|---|
| 0 |
| 0 |
| 1 |
| 0 |
| 0 |
| 0 |
| 0 |
| 0 |
| 0 |
| 0 |

| | |
|---|---|
| 1000 | chrissie |
| 40 | supernova |
| 500 | berths |
| 700 | landowner |
| 400 | backup |
| 3 | roam |
| 80 | ps |
| 100 | palaiologos |
| 15 | operative |
| 6 | administrative |




https://towardsdatascience.com/word2vec-skip-gram-model-part-1-intuition-78614e4d6e0b

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