Part 1.

Exploratory Data Analysis

Play with data and make lots of visualizations to probe what structure is present in the data!

Basic text analysis: how do we represent text documents?

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The Free Encyclopedia

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Opioid epidemic

From Wikipedia, the free encyclopedia

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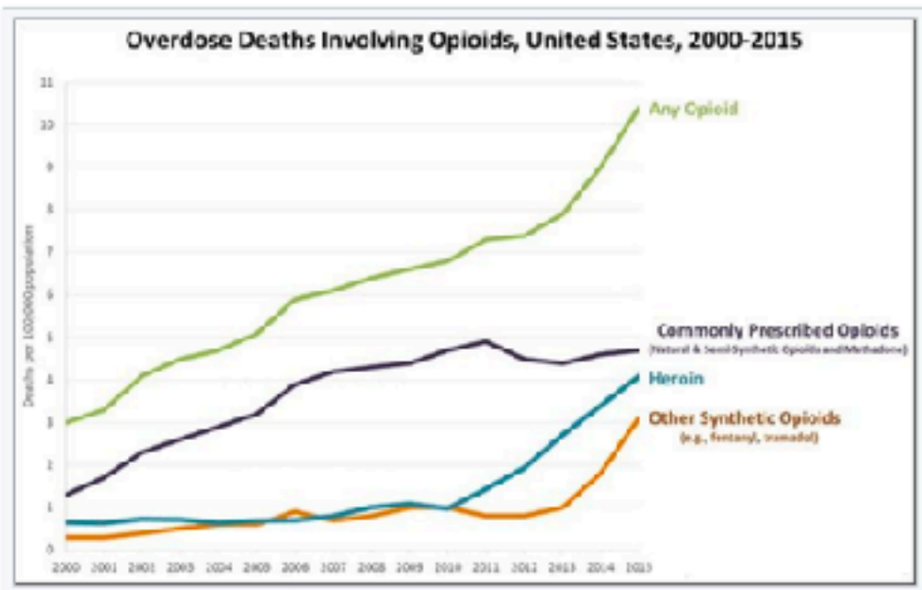

Overdose Deaths Involving Opioids, United States, 2000–2015. Deaths per 100,000 population.[1]

Source: Wikipedia, accessed 10/16/2017

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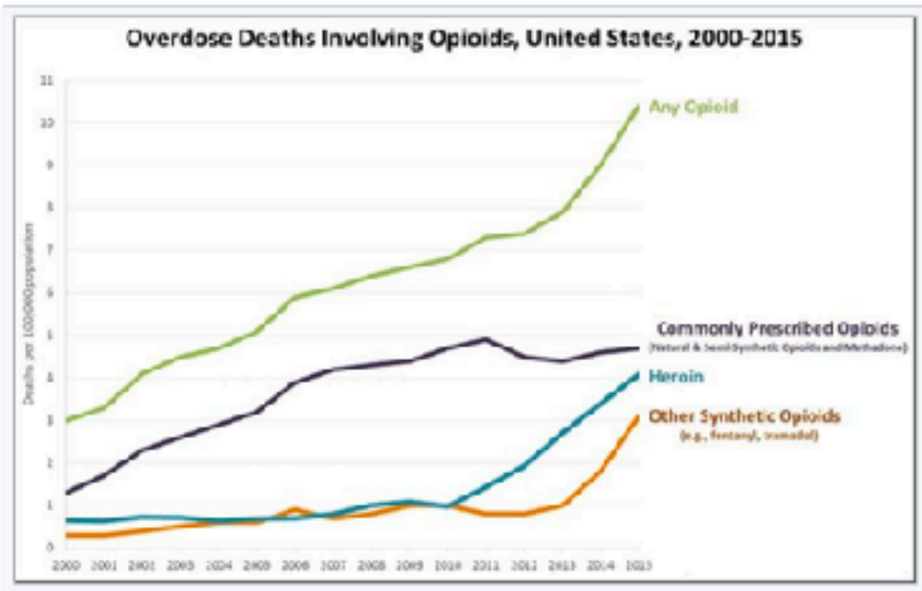

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Term frequencies

The: 1
opioid: 3
epidemic: 1
or: 1
crisis: 1
is: 1
the: 4
rapid: 1
increase: 1
in: 3
use: 1
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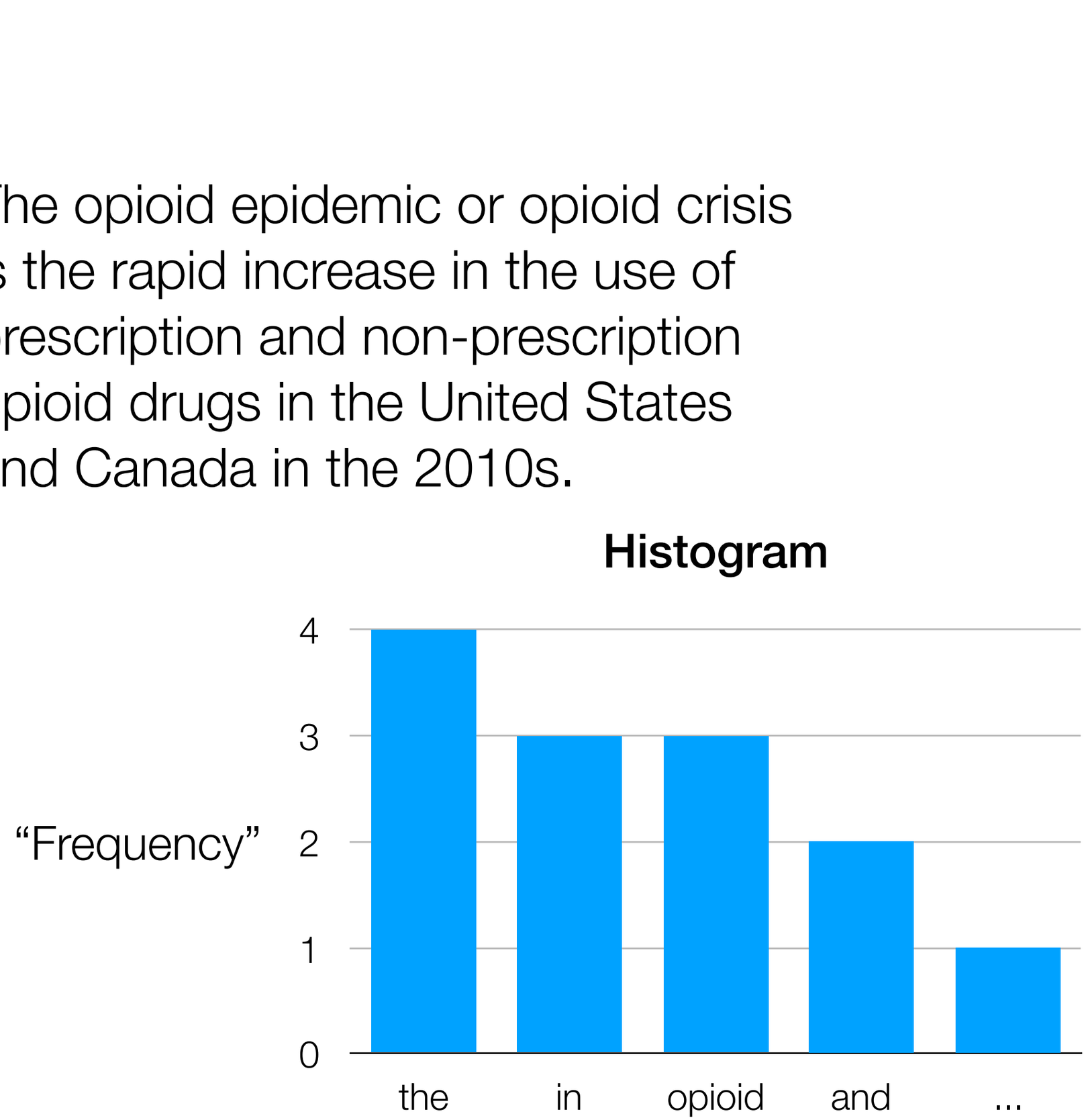

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Total number of words in sentence: 28

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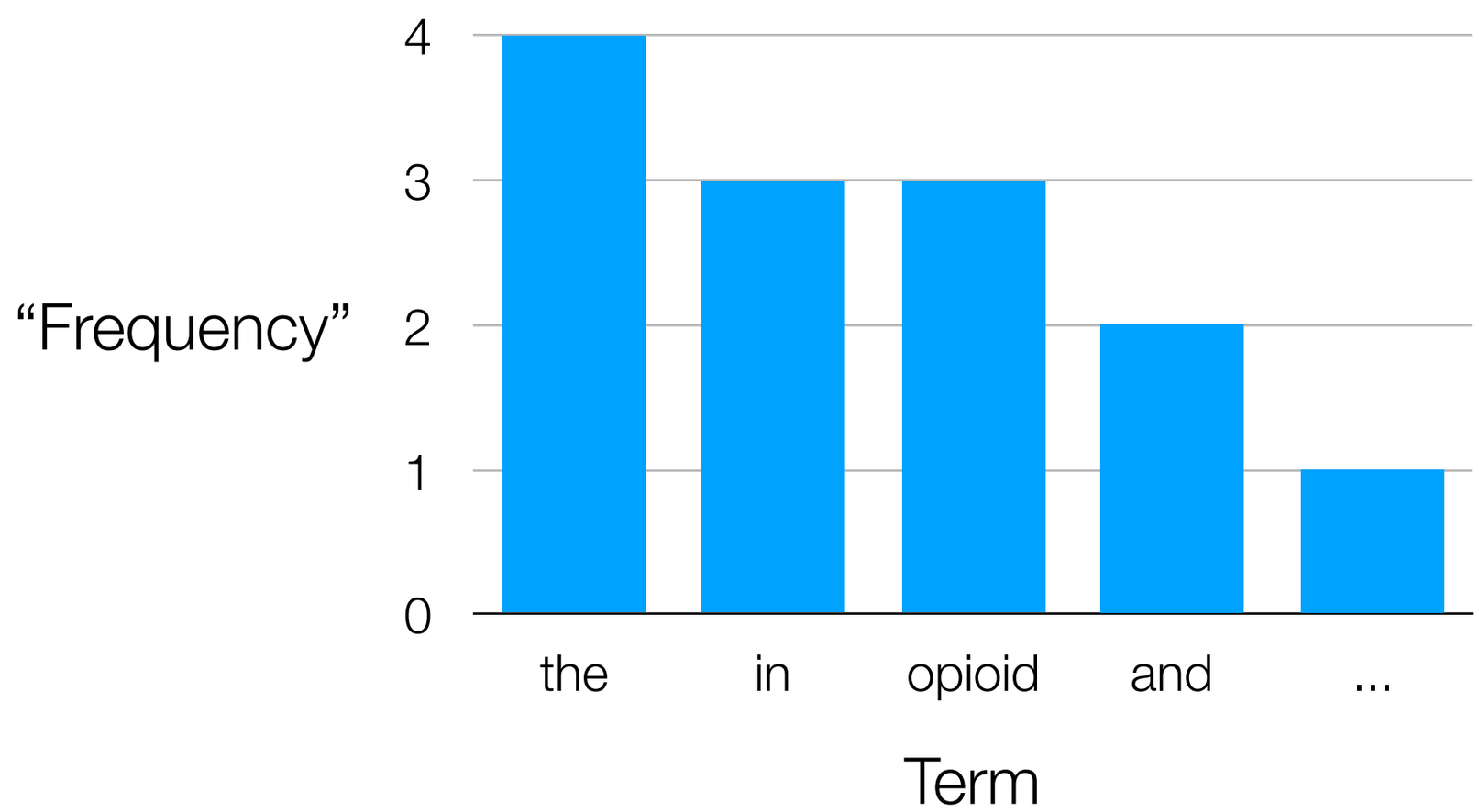

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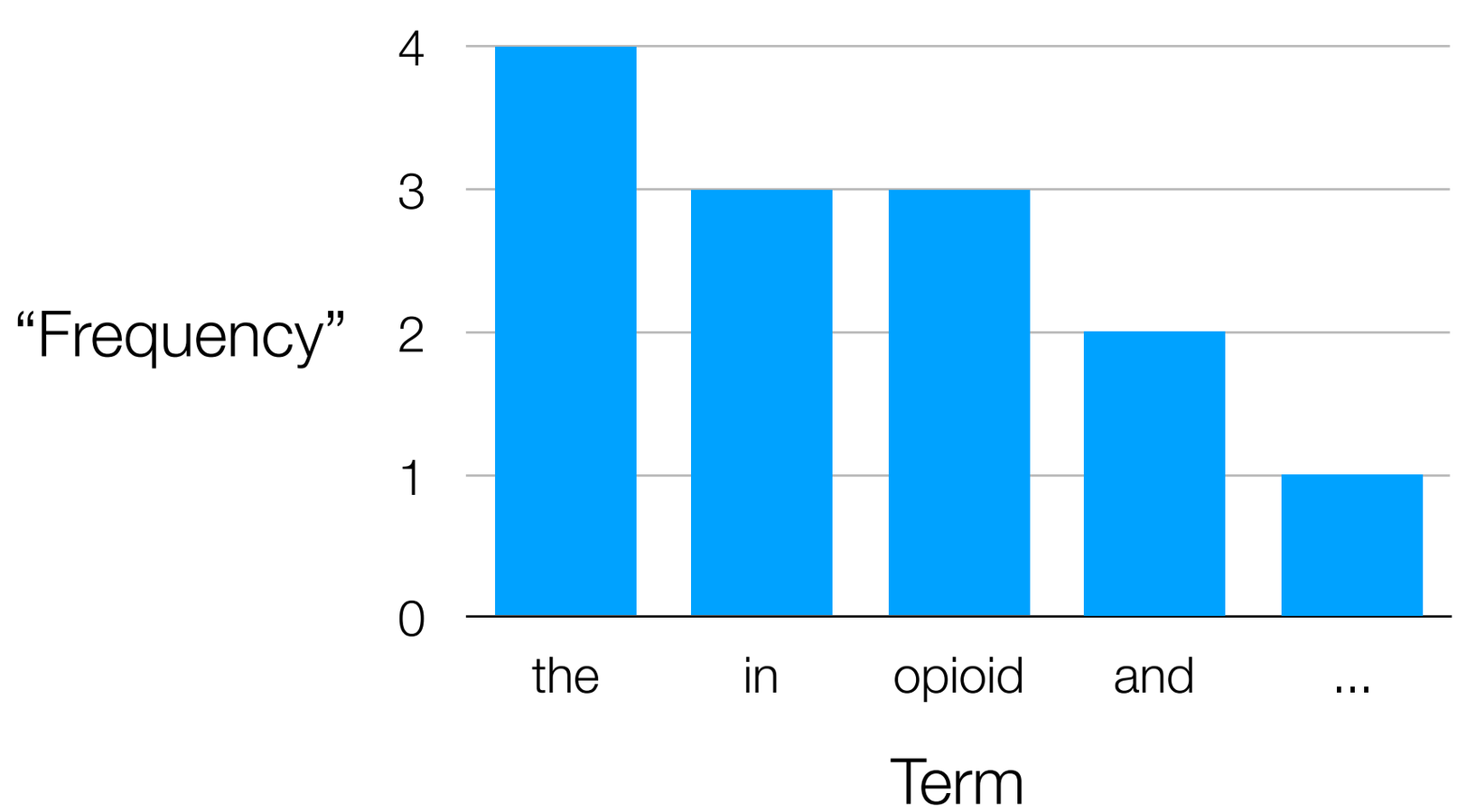

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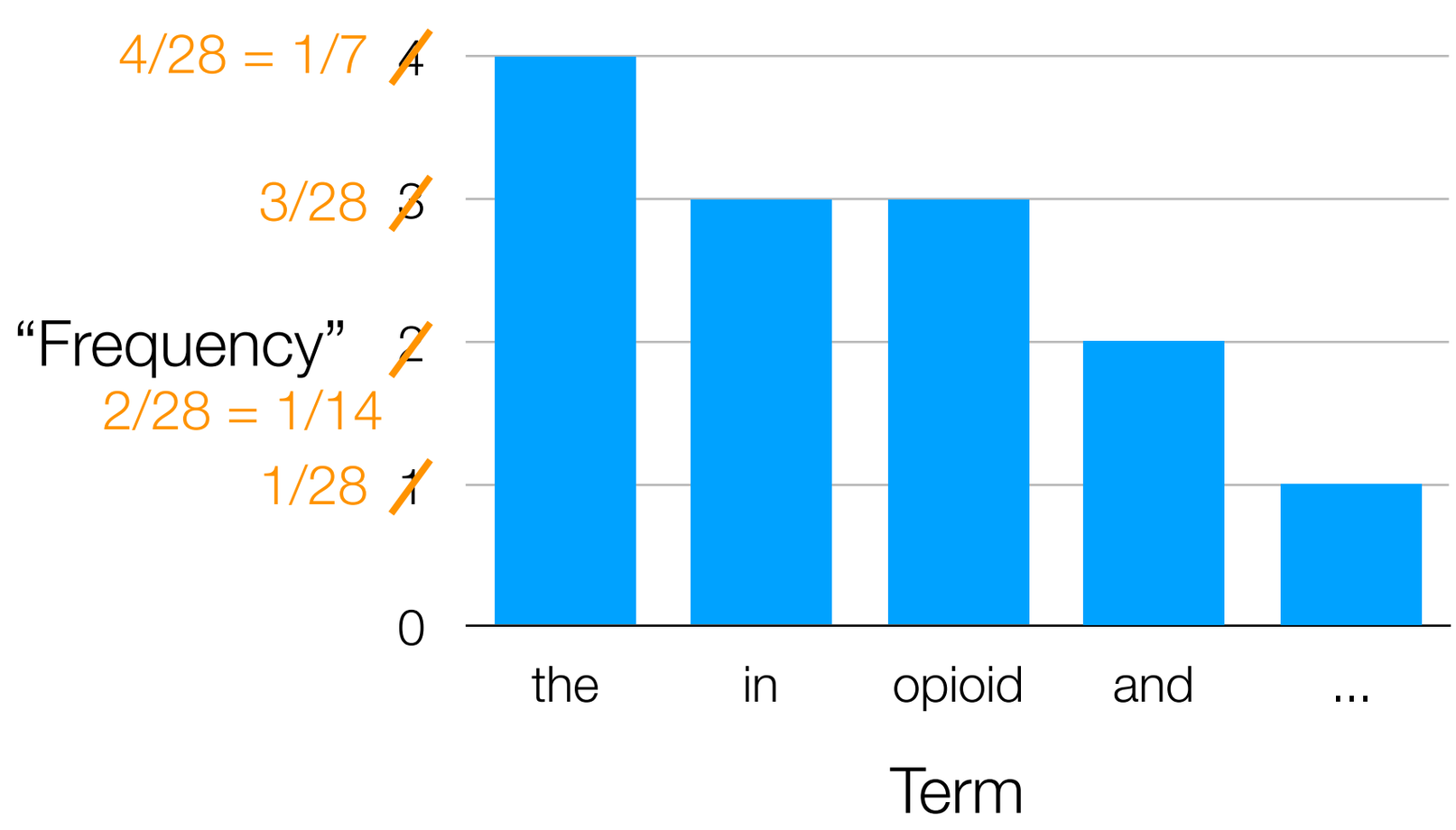

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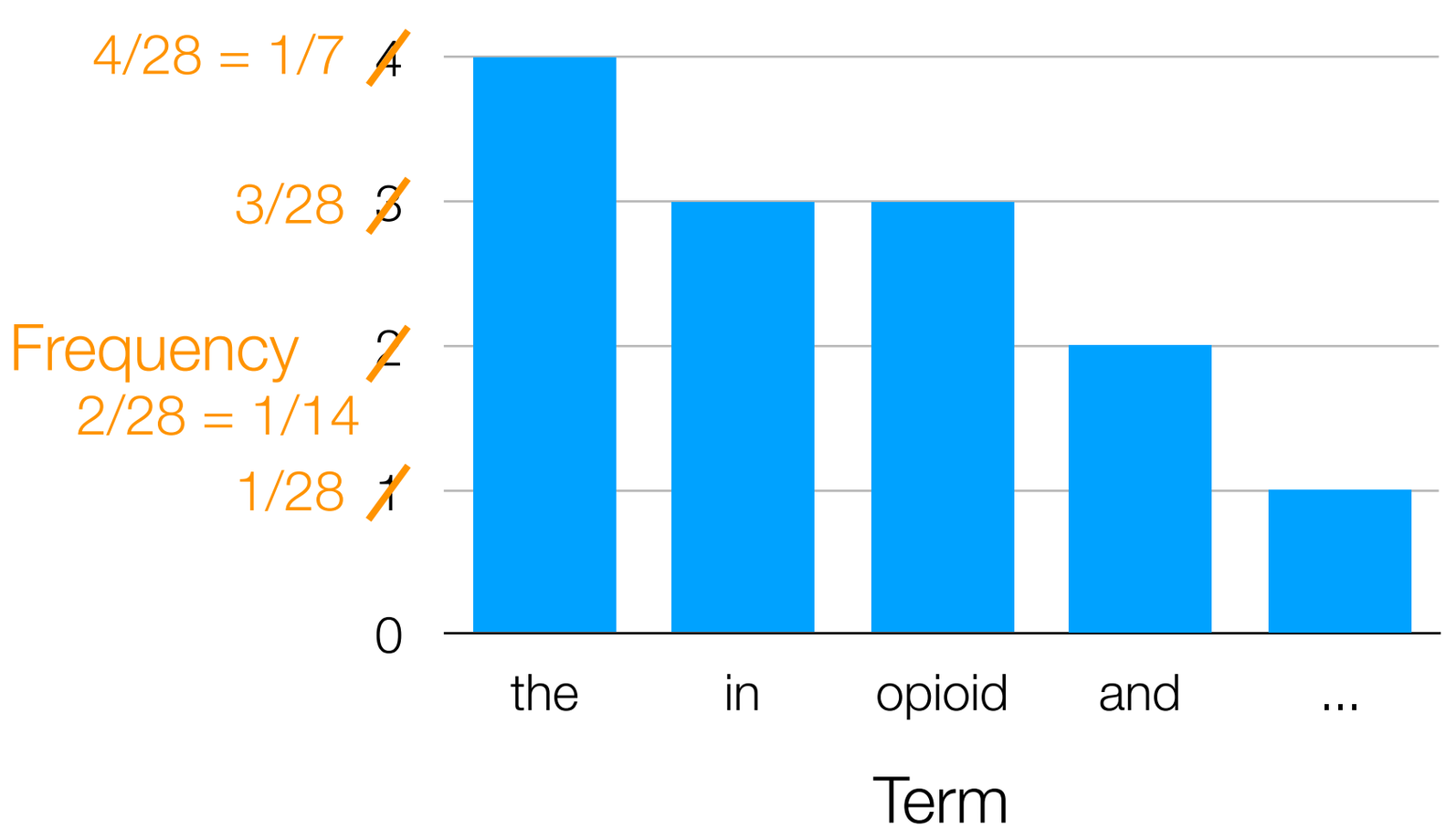

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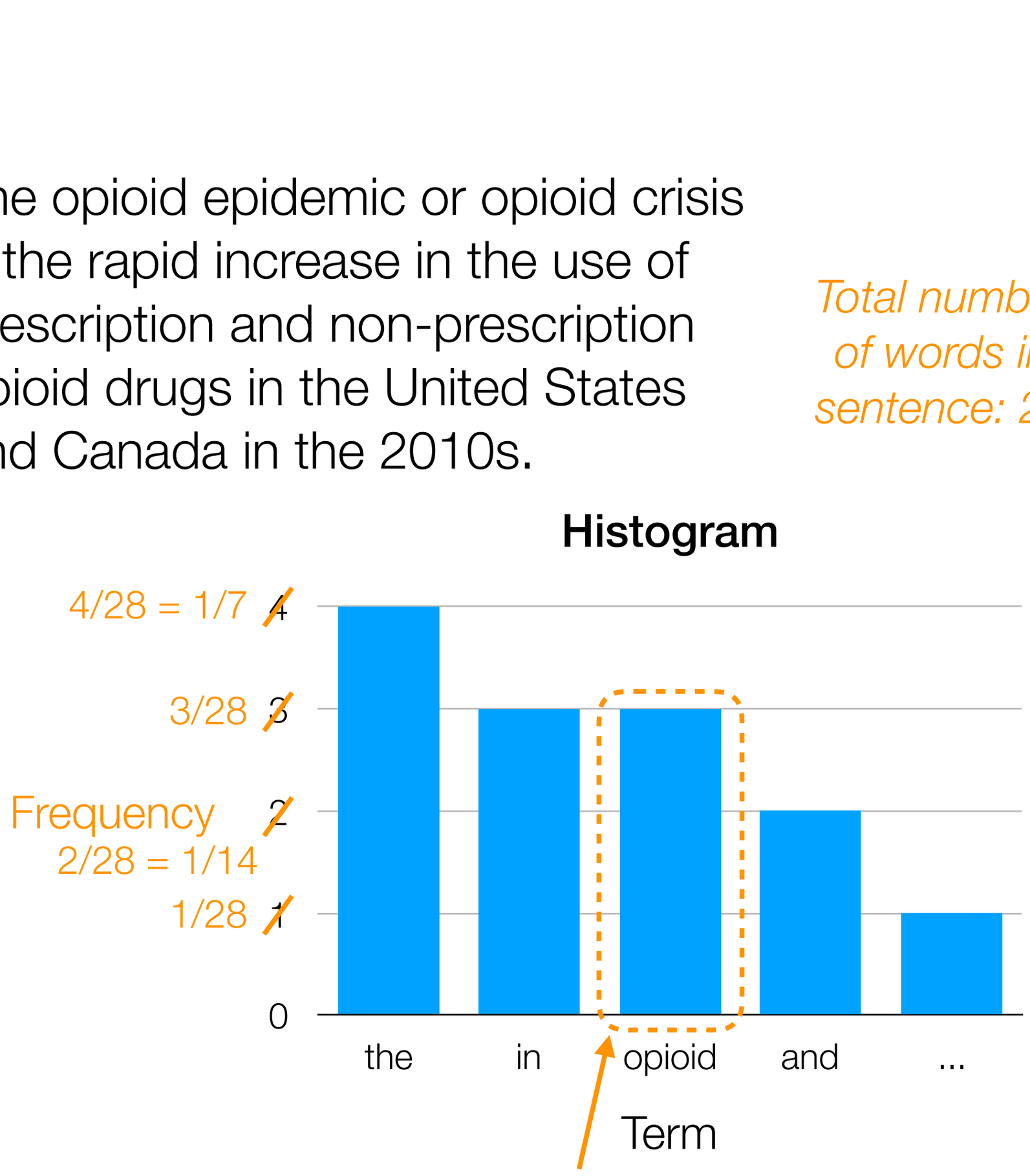

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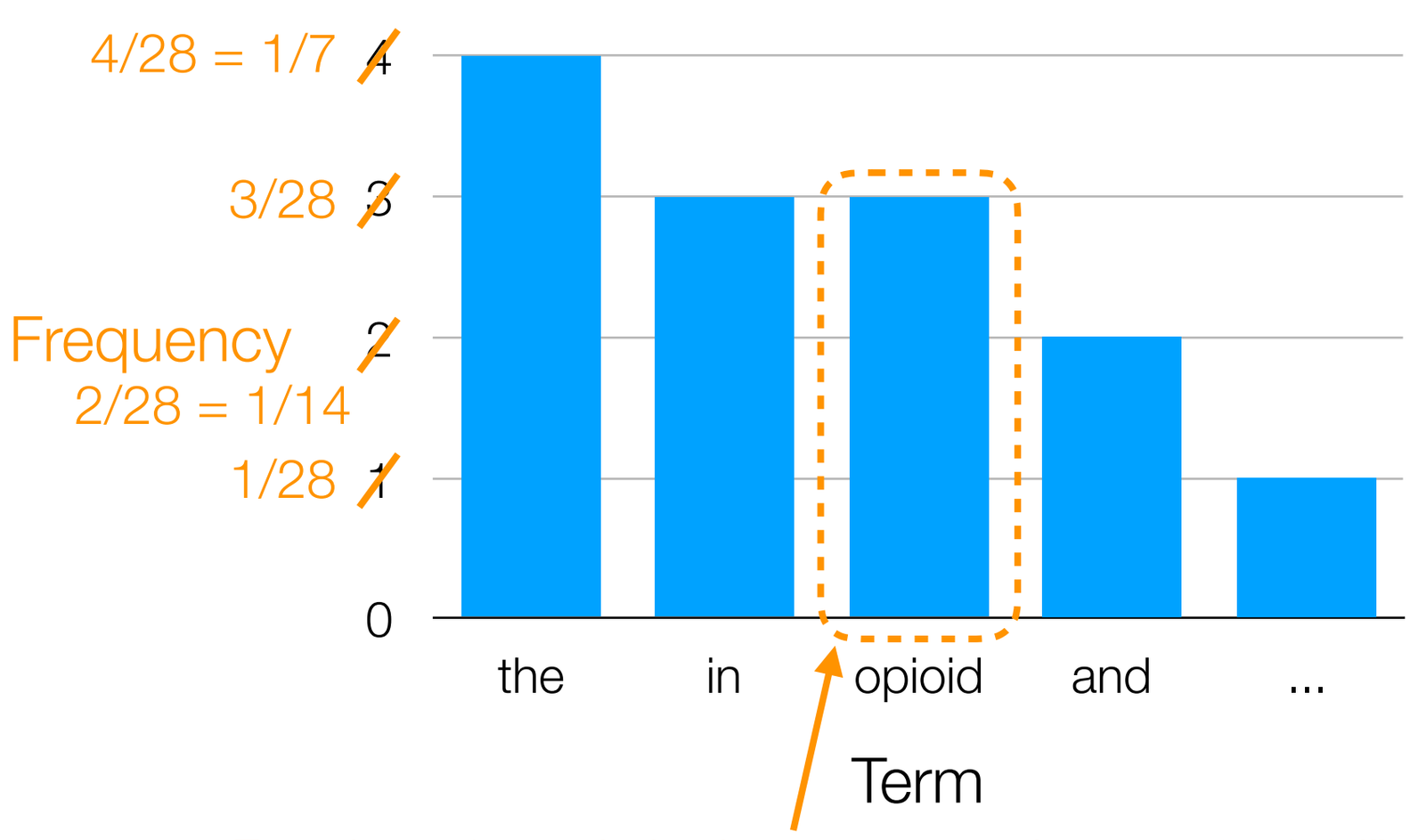

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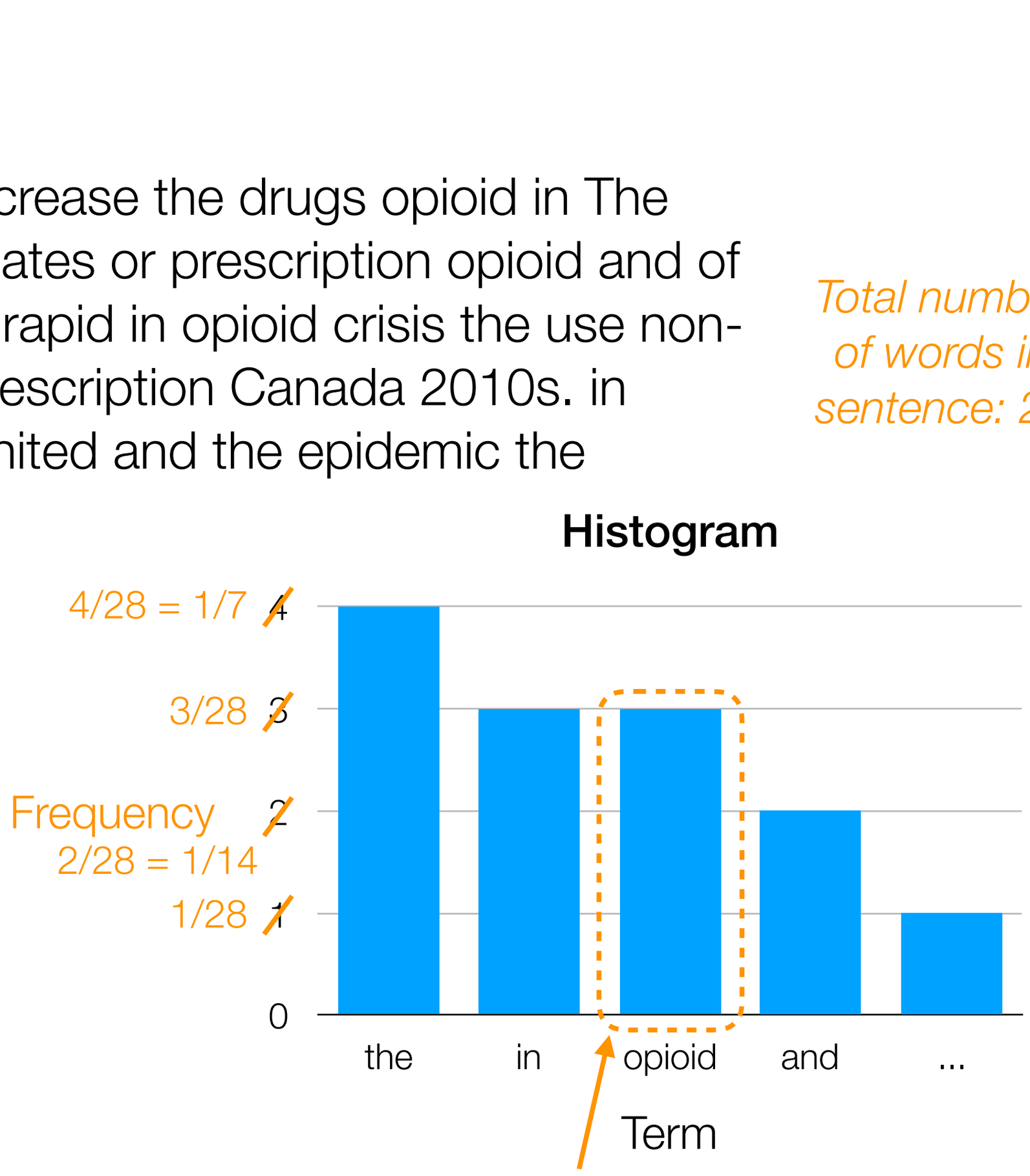

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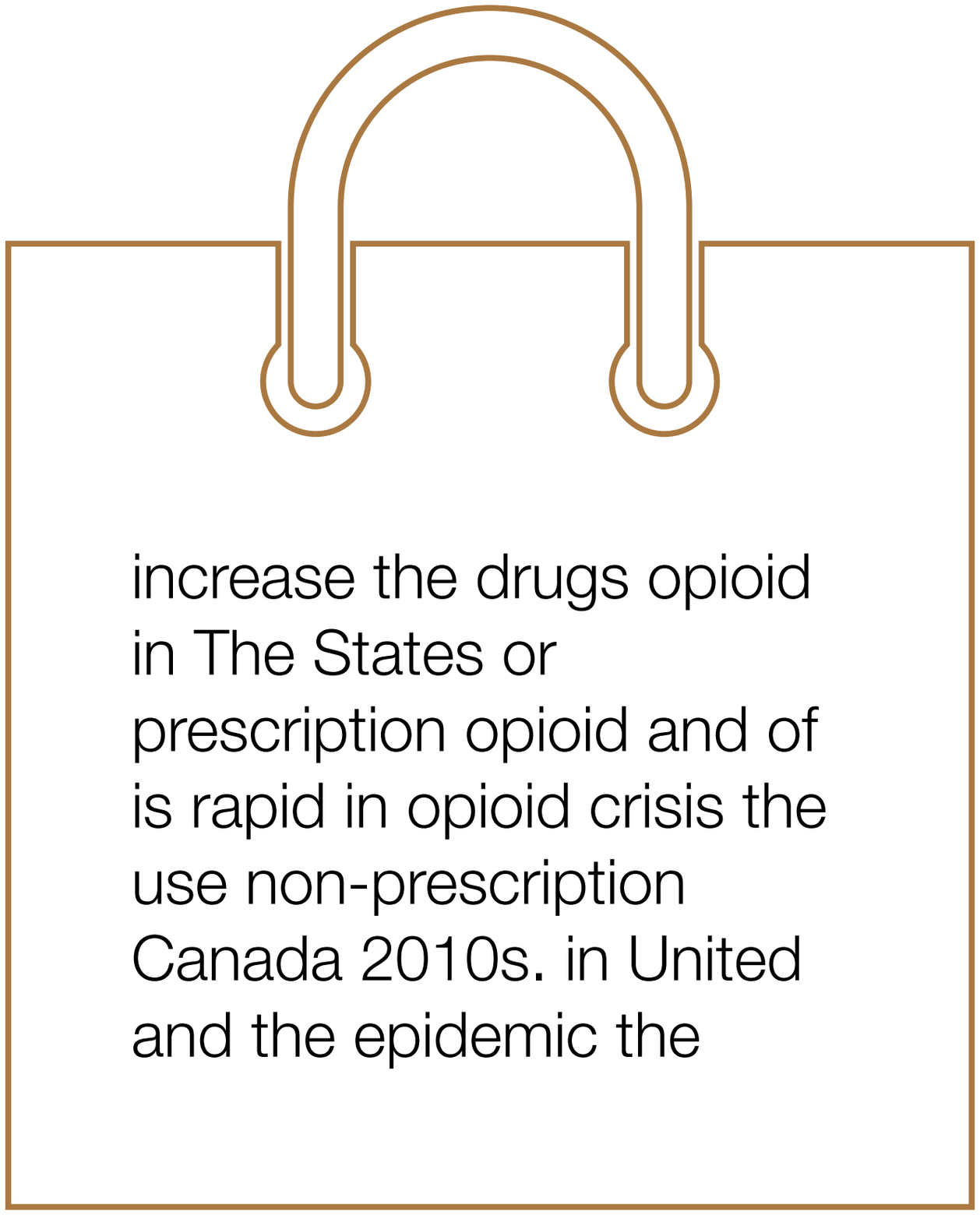

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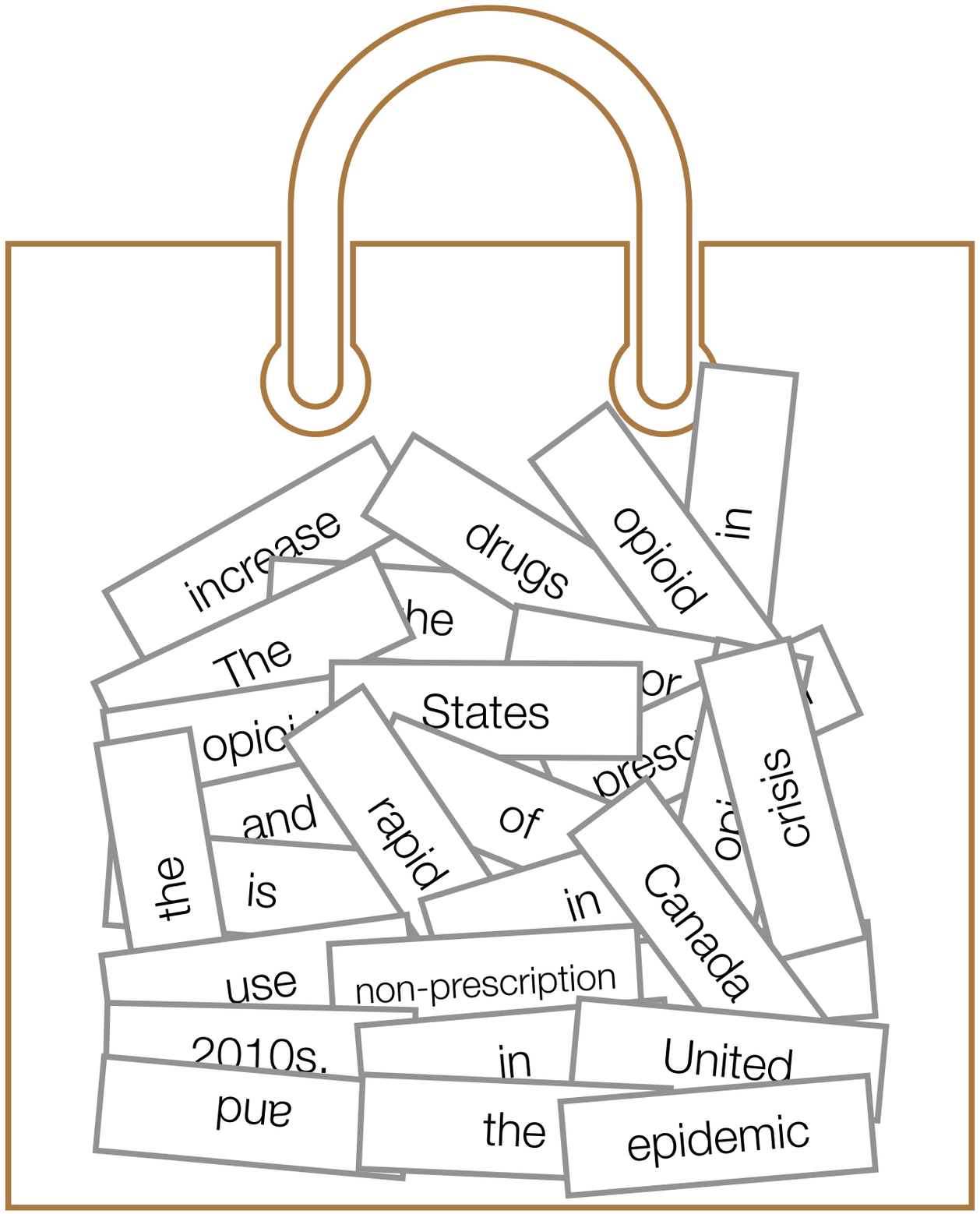
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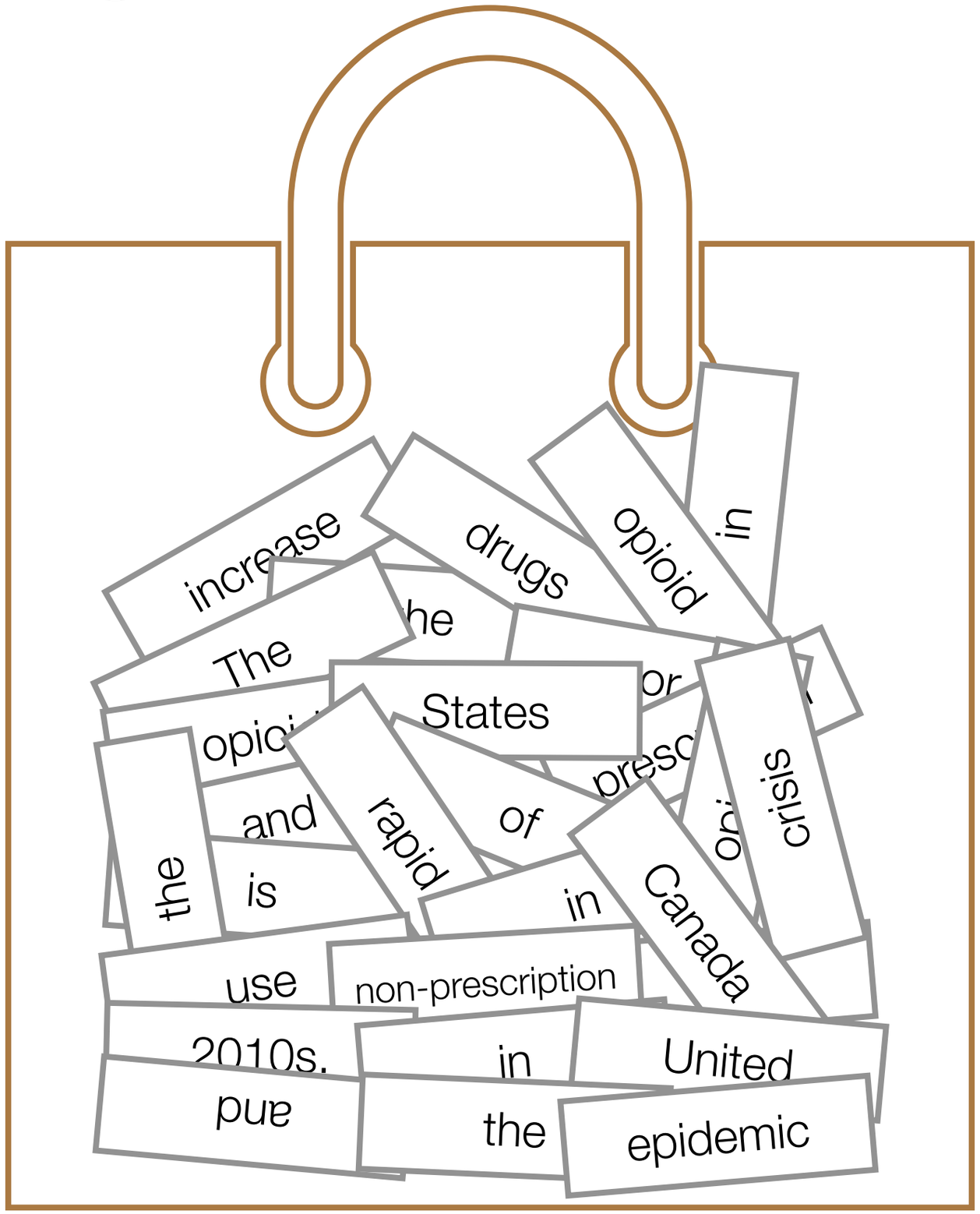

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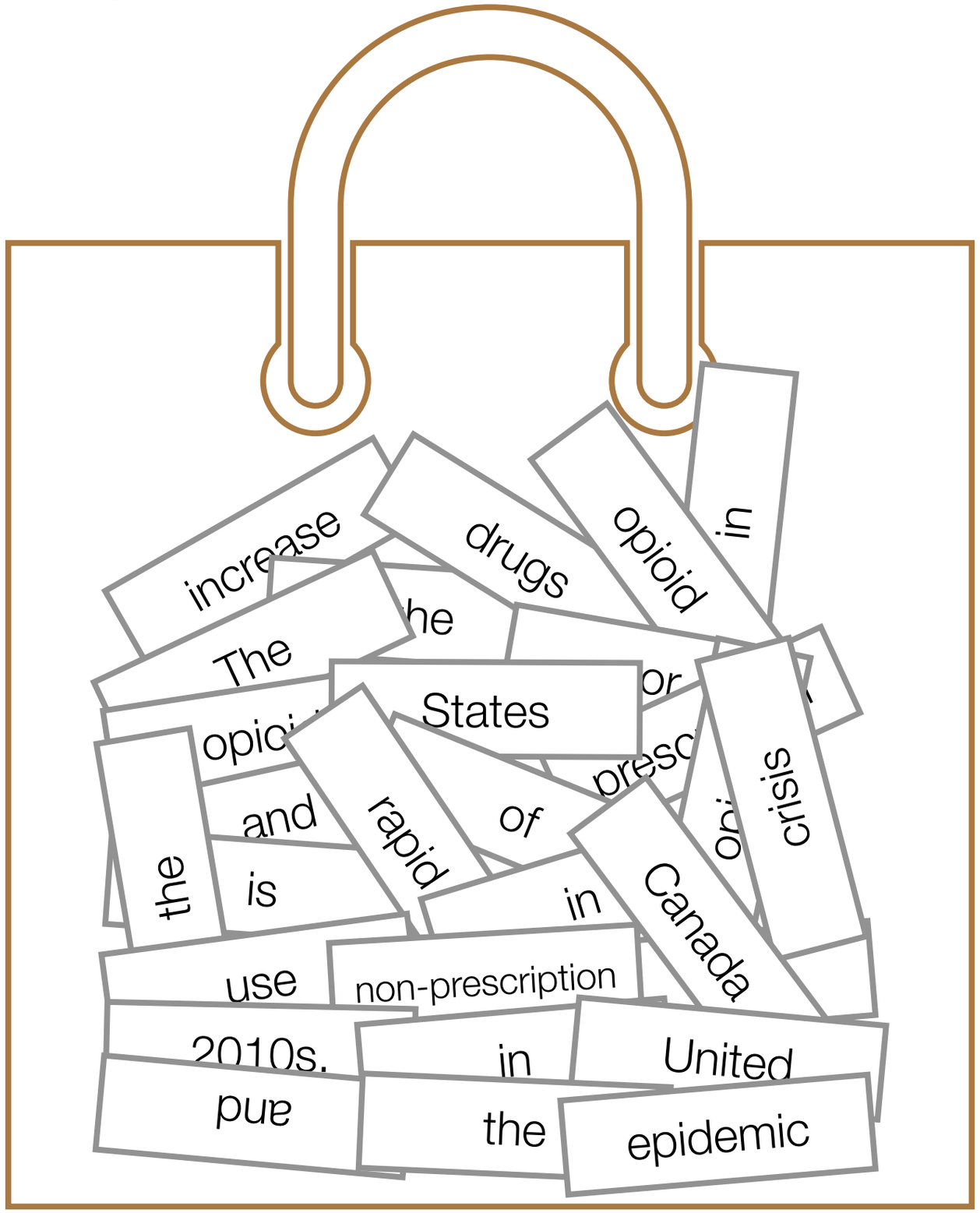

Ordering of words doesn't matter

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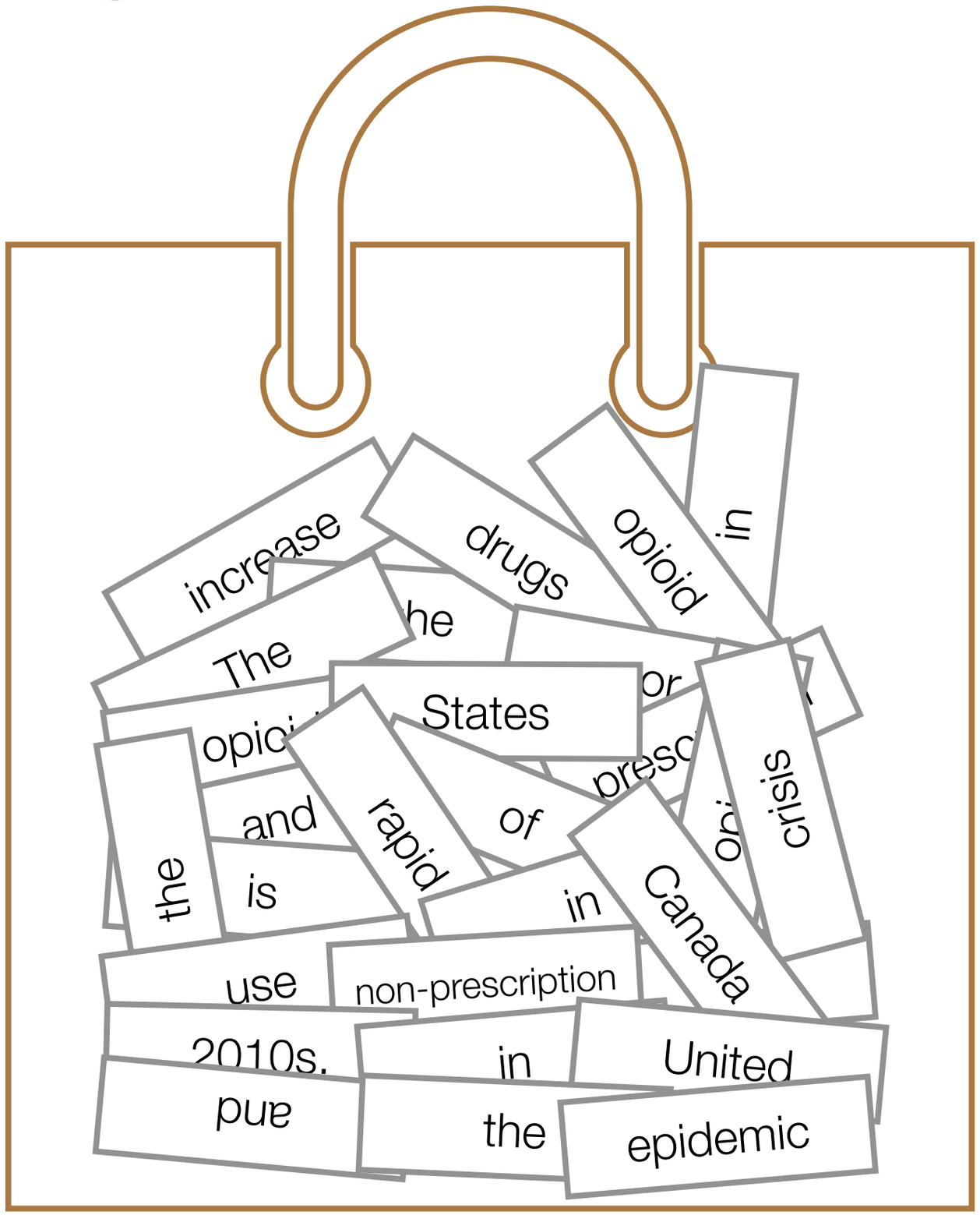

Ordering of words doesn't matter

What is the probability of drawing the word "opioid" from the bag?

Handling Many Documents

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Many natural language processing (NLP) systems are trained on very large collections of text (also called **corpora**) such as the Wikipedia corpus and the Common Crawl corpus

So far did we use anything special about text?

Basic Probability in Disguise

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"Sentence": 

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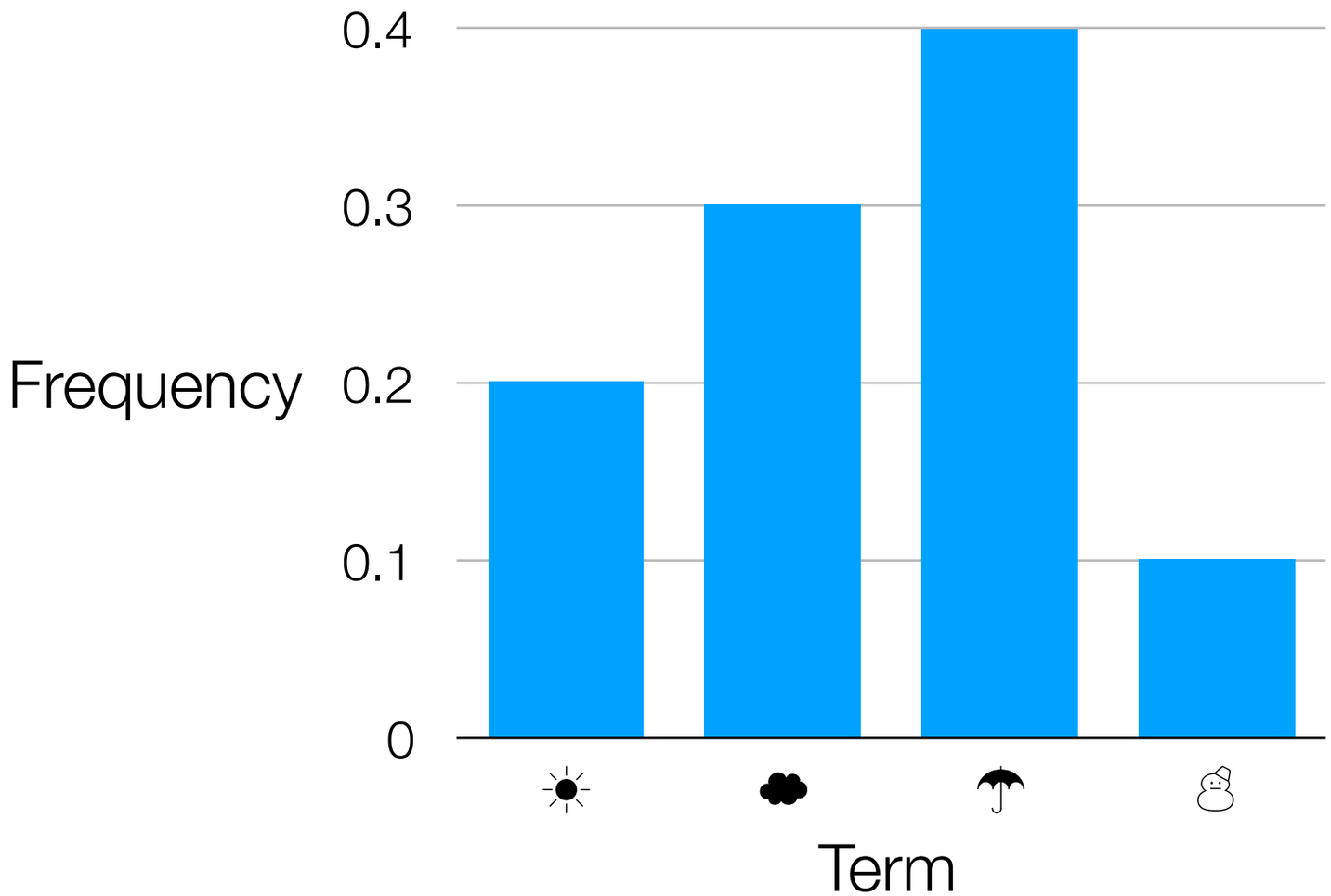

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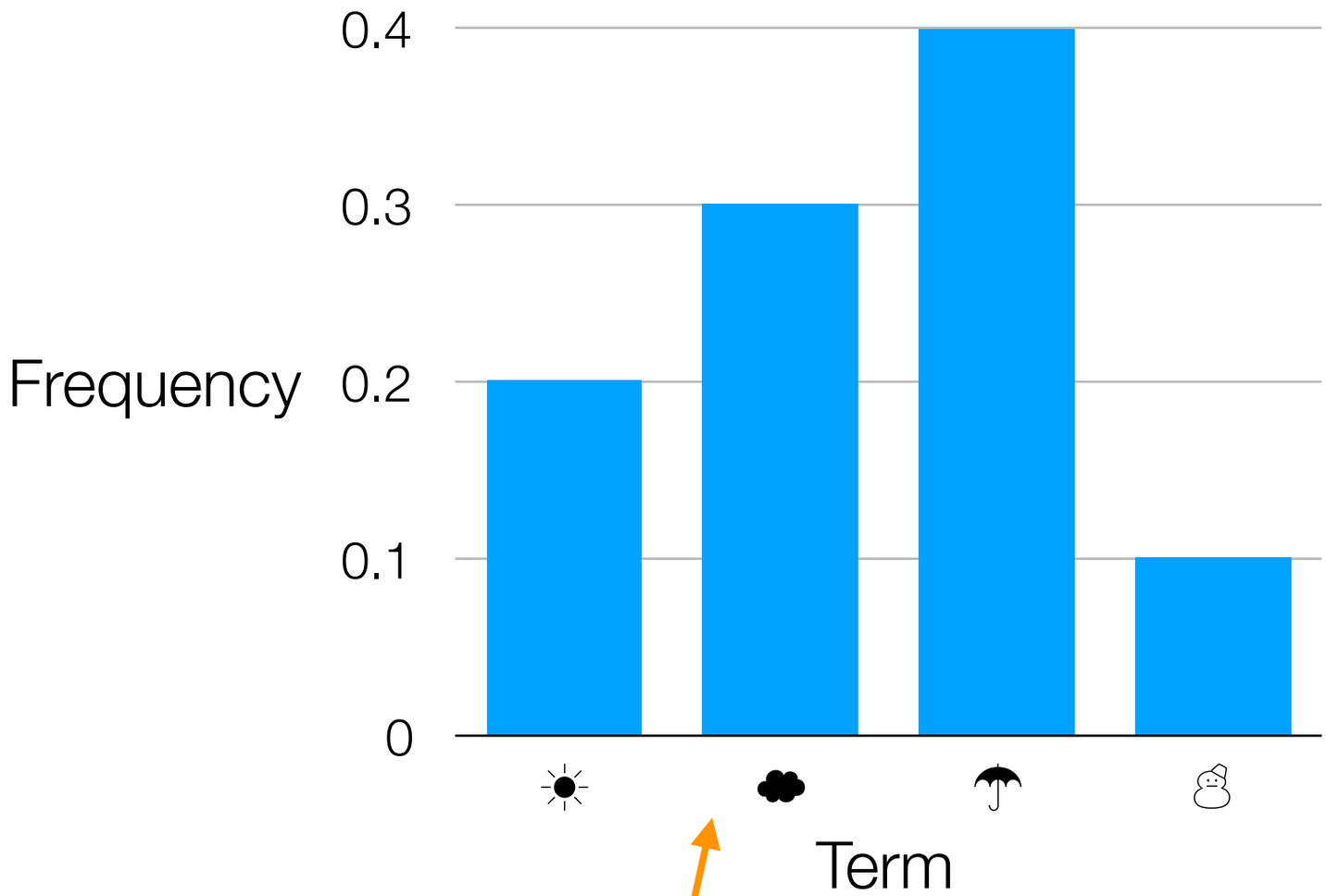

This is an example of a probability distribution

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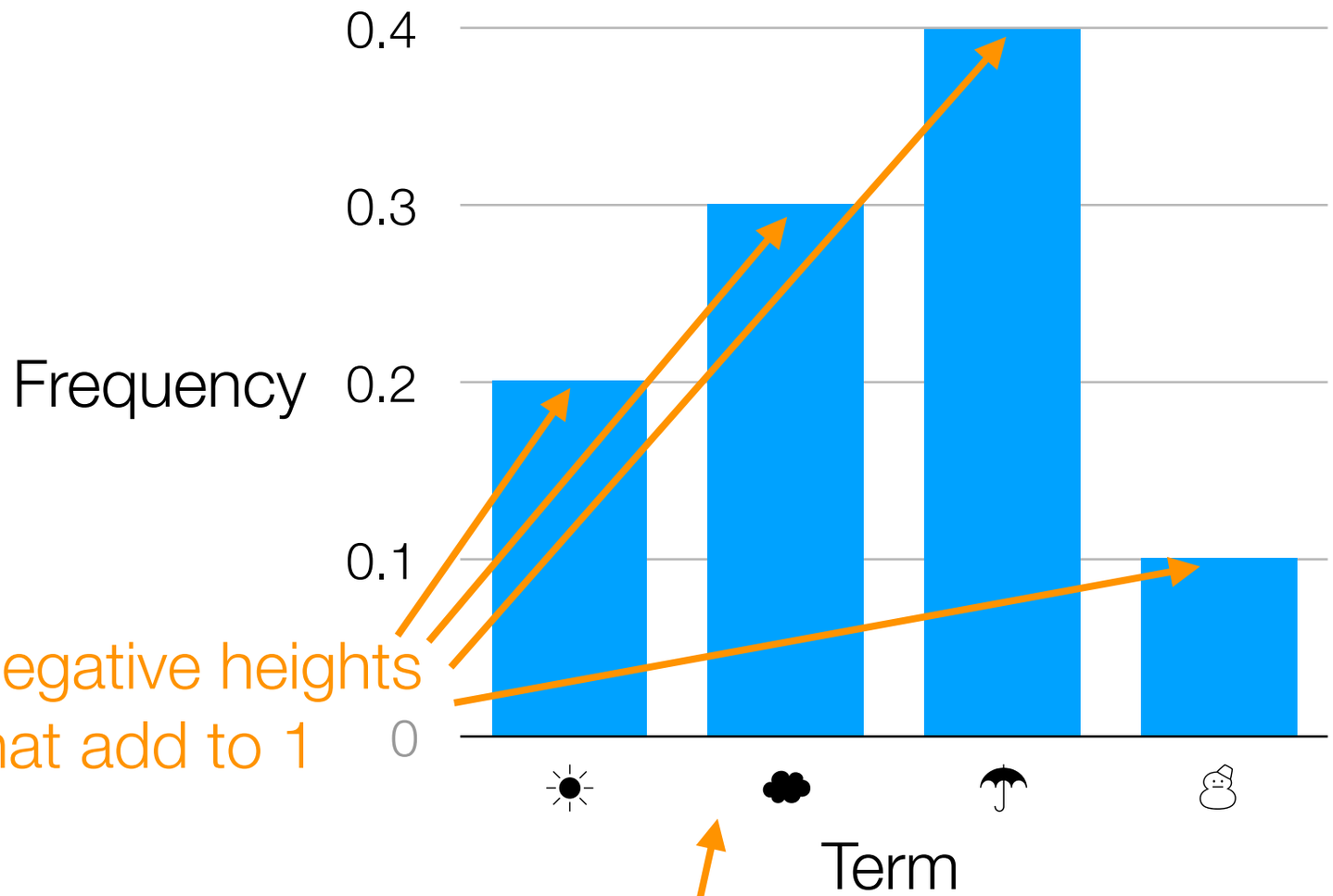

Nonnegative heights that add to 1

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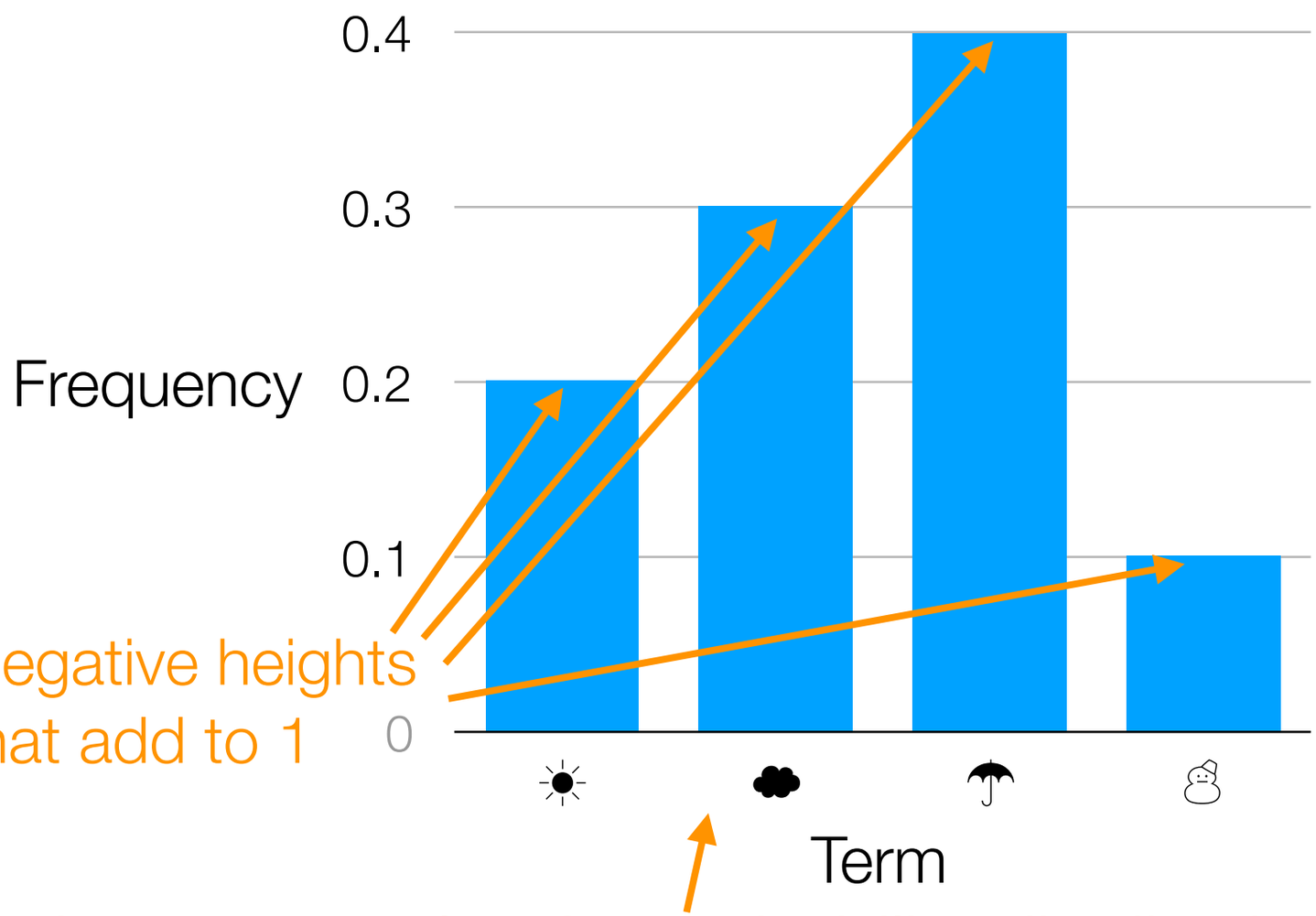

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Probability distributions will appear throughout the course and are a **key component** to the success of many modern AI methods

Now let's take advantage of properties of text

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In other words: natural language humans use has a lot of *structure* that we can exploit

Some Words Don't Help?

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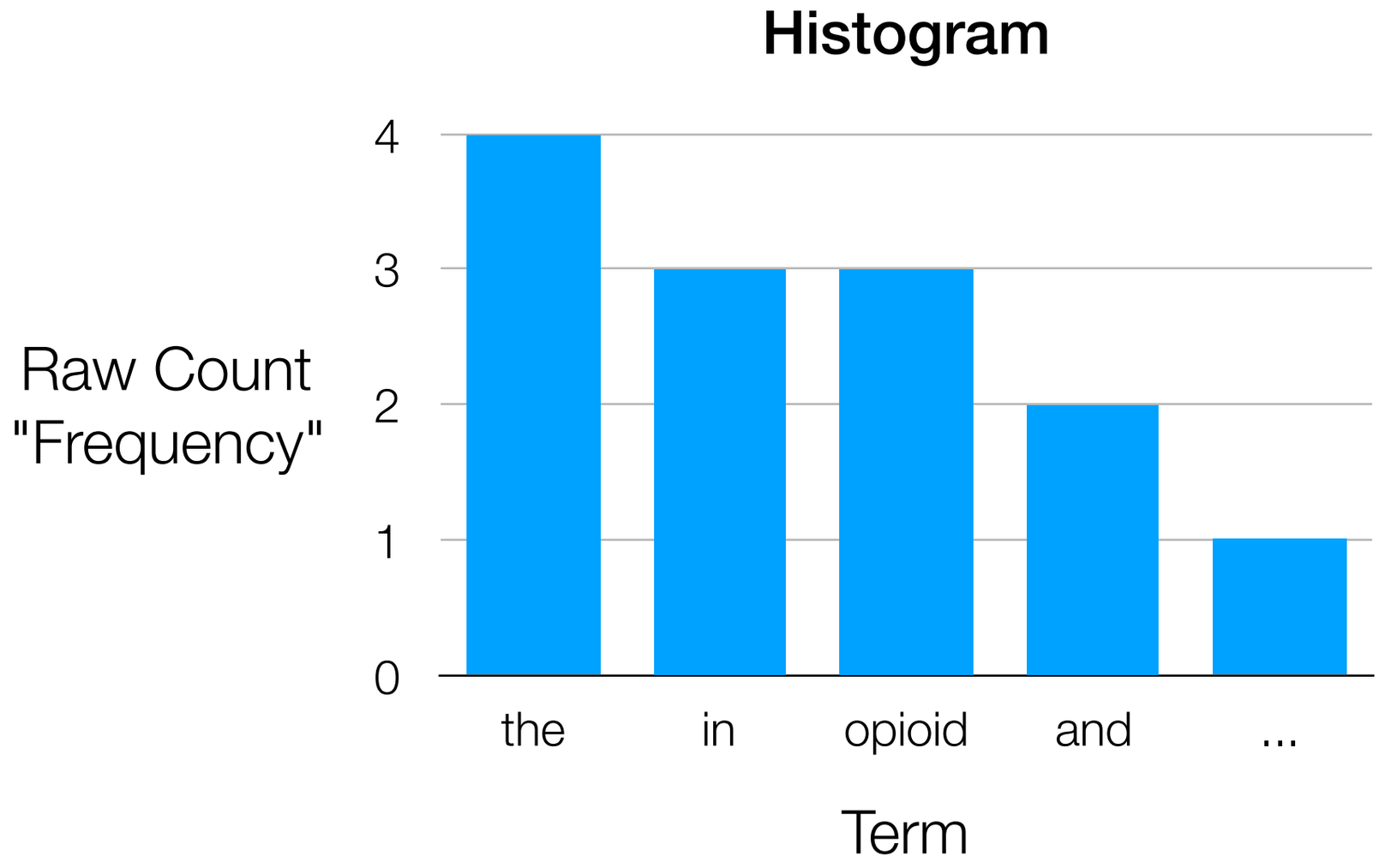

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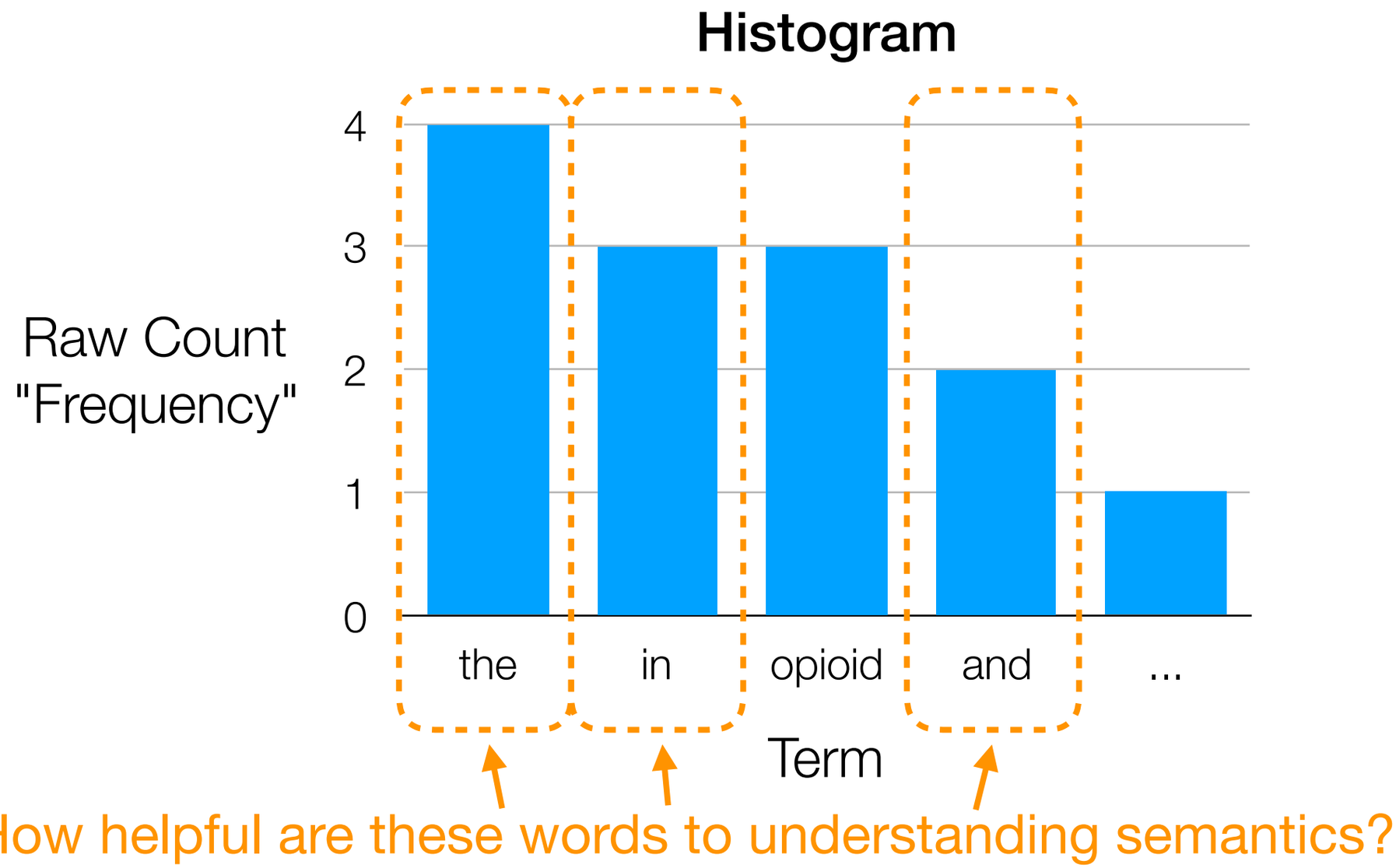

How helpful are these words to understanding semantics?

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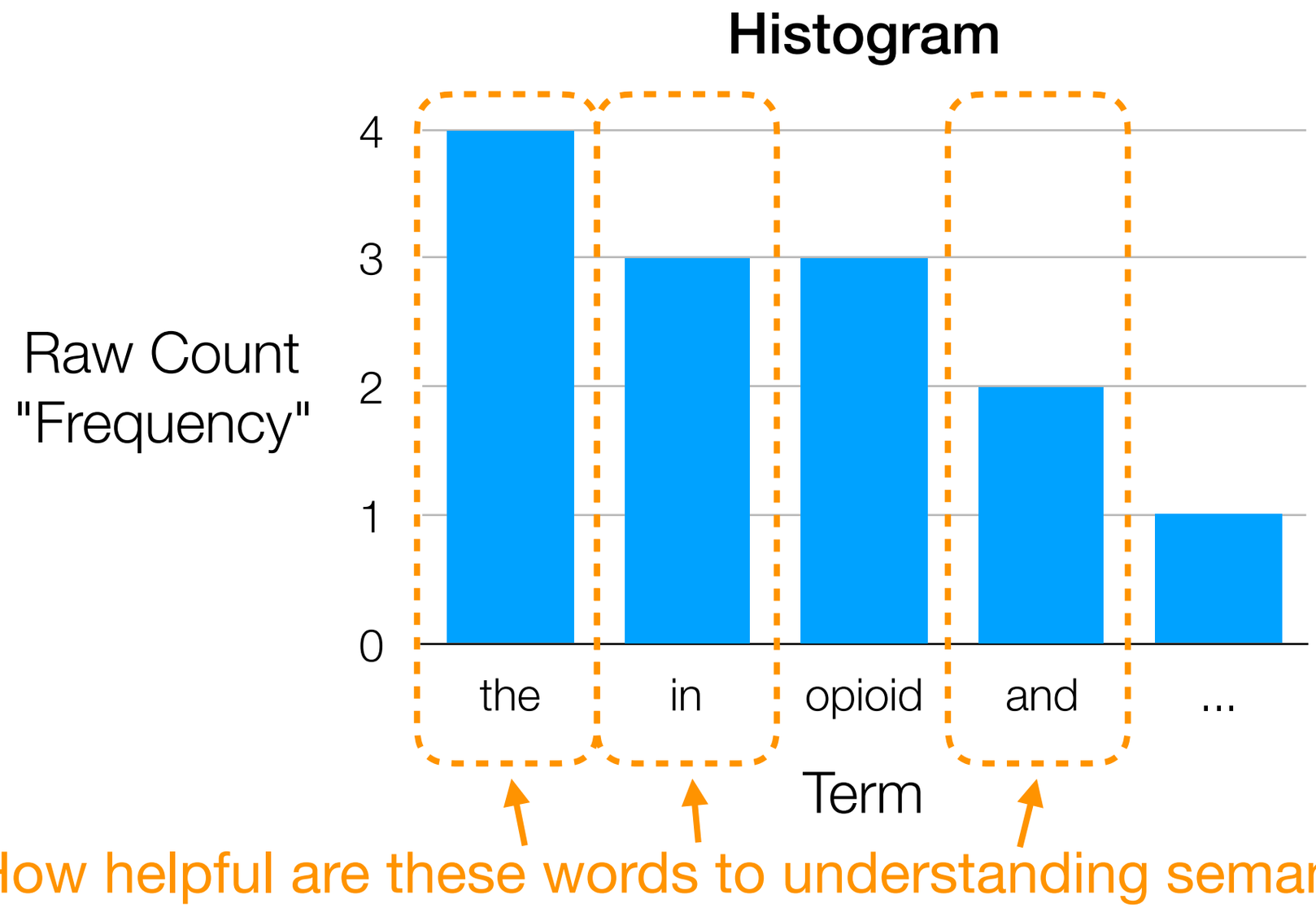

Bag-of-words models: many frequently occurring words unhelpful

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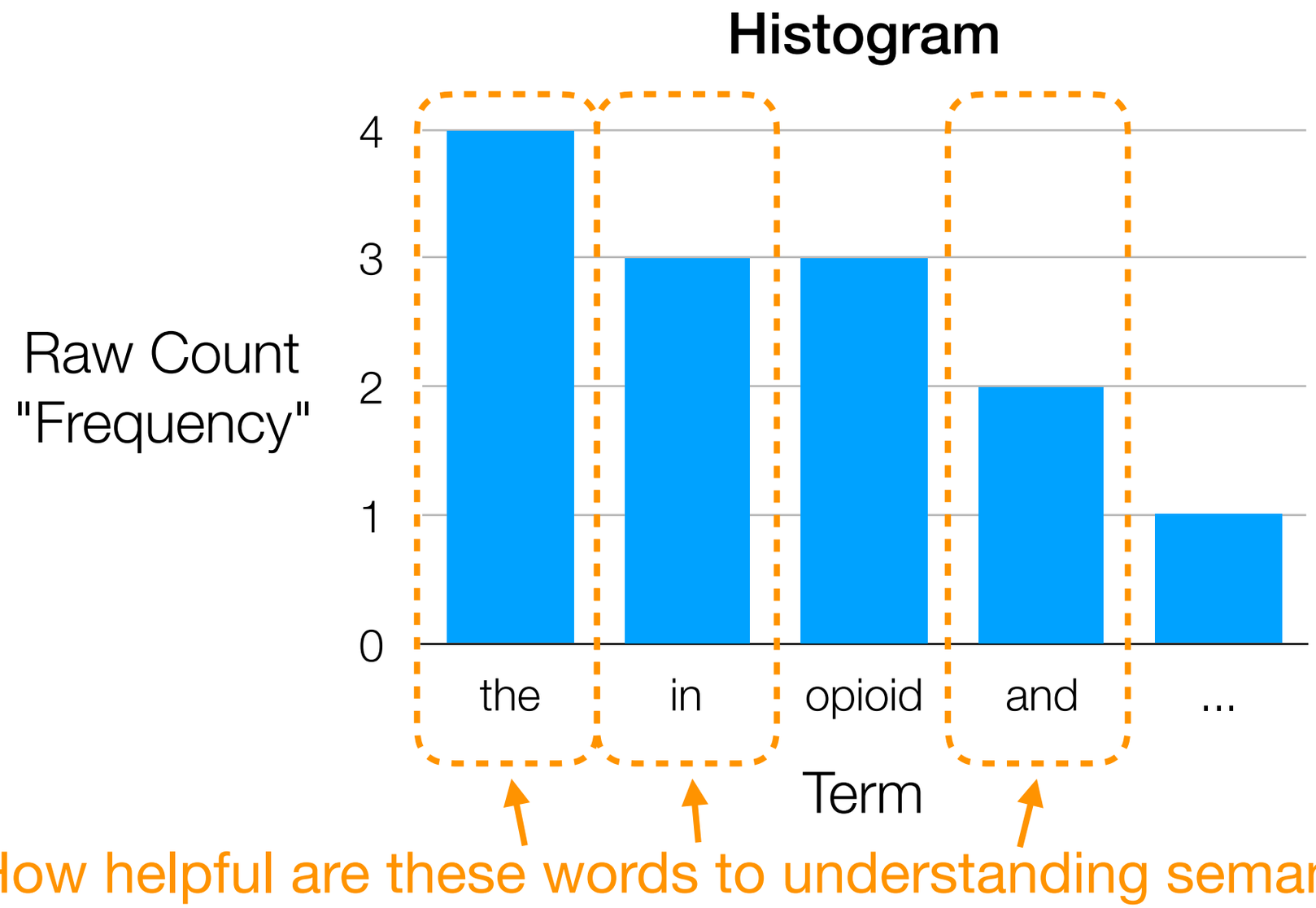

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➔ words that are removed are called **stopwords**

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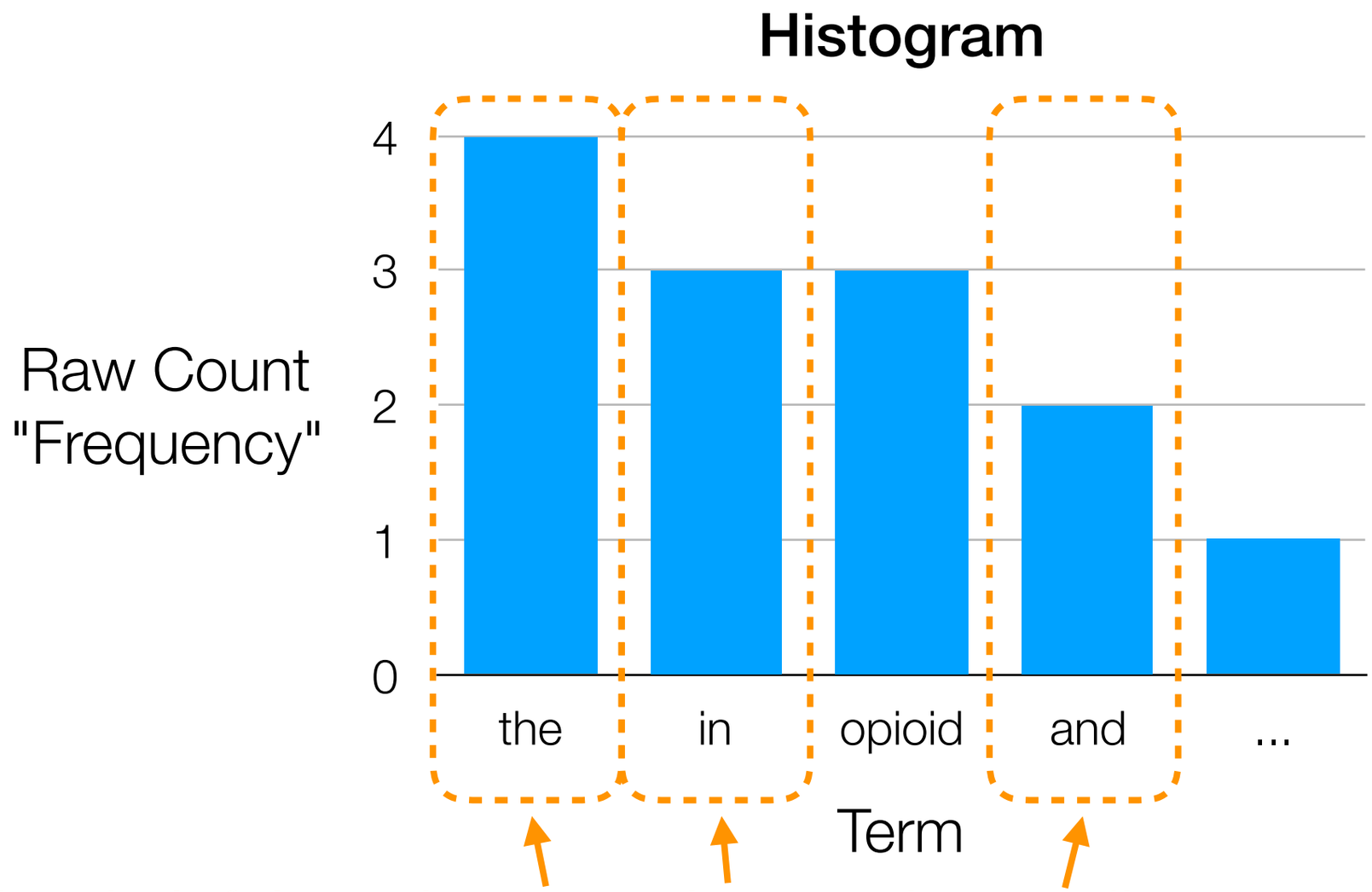

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(determined by removing most frequent words or using curated stopword lists)

Example Stopword List (from spaCy)

'a', 'about', 'above', 'across', 'after', 'afterwards', 'again', 'against', 'all', 'almost', 'alone', 'along', 'already', 'also', 'although', 'always', 'am', 'among', 'amongst', 'amount', 'an', 'and', 'another', 'any', 'anyhow', 'anyone', 'anything', 'anyway', 'anywhere', 'are', 'around', 'as', 'at', 'back', 'be', 'became', 'because', 'become', 'becomes', 'becoming', 'been', 'before', 'beforehand', 'behind', 'being', 'below', 'beside', 'besides', 'between', 'beyond', 'both', 'bottom', 'but', 'by', 'ca', 'call', 'can', 'cannot', 'could', 'did', 'do', 'does', 'doing', 'done', 'down', 'due', 'during', 'each', 'eight', 'either', 'eleven', 'else', 'elsewhere', 'empty', 'enough', 'etc', 'even', 'ever', 'every', 'everyone', 'everything', 'everywhere', 'except', 'few', 'fifteen', 'fifty', 'first', 'five', 'for', 'former', 'formerly', 'forty', 'four', 'from', 'front', 'full', 'further', 'get', 'give', 'go', 'had', 'has', 'have', 'he', 'hence', 'her', 'here', 'hereafter', 'hereby', 'herein', 'hereupon', 'hers', 'herself', 'him', 'himself', 'his', 'how', 'however', 'hundred', 'i', 'if', 'in', 'inc', 'indeed', 'into', 'is', 'it', 'its', 'itself', 'just', 'keep', 'last', 'latter', 'latterly', 'least', 'less', 'made', 'make', 'many', 'may', 'me', 'meanwhile', 'might', 'mine', 'more', 'moreover', 'most', 'mostly', 'move', 'much', 'must', 'my', 'myself', 'name', 'namely', 'neither', 'never', 'nevertheless', 'next', 'nine', 'no', 'nobody', 'none', 'noone', 'nor', 'not', 'nothing', 'now', 'nowhere', 'of', 'off', 'often', 'on', 'once', 'one', 'only', 'onto', 'or', 'other', 'others', 'otherwise', 'our', 'ours', 'ourselves', 'out', 'over', 'own', 'part', 'per', 'perhaps', 'please', 'put', 'quite', 'rather', 're', 'really', 'regarding', 'same', 'say', 'see', 'seem', 'seemed', 'seeming', 'seems', 'serious', 'several', 'she', 'should', 'show', 'side', 'since', 'six', 'sixty', 'so', 'some', 'somehow', 'someone', 'something', 'sometime', 'sometimes', 'somewhere', 'still', 'such', 'take', 'ten', 'than', 'that', 'the', 'their', 'them', 'themselves', 'then', 'thence', 'there', 'thereafter', 'thereby', 'therefore', 'therein', 'thereupon', 'these', 'they', 'third', 'this', 'those', 'though', 'three', 'through', 'throughout', 'thru', 'thus', 'to', 'together', 'too', 'top', 'toward', 'towards', 'twelve', 'twenty', 'two', 'under', 'unless', 'until', 'up', 'upon', 'us', 'used', 'using', 'various', 'very', 'via', 'was', 'we', 'well', 'were', 'what', 'whatever', 'when', 'whence', 'whenever', 'where', 'whereafter', 'whereas', 'whereby', 'wherein', 'whereupon', 'wherever', 'whether', 'which', 'while', 'whither', 'who', 'whoever', 'whole', 'whom', 'whose', 'why', 'will', 'with', 'within', 'without', 'would', 'yet', 'you', 'your', 'yours', 'yourself', 'yourselves'

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“To be or not to be”

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Should capitalization matter?

What about:

- walk, walking
- democracy, democratic, democratization
- good, better

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non-prescription: 1
drugs: 1
United: 1
States: 1
Canada: 1
2010s.: 1

Should capitalization matter?

What about:

- walk, walking
- democracy, democratic, democratization
- good, better

Merging modified versions of "same" word to be analyzed as a single word is called **lemmatization**

Some Words Mean the Same Thing?

Term frequencies

The: 1
opioid: 3
epidemic: 1
or: 1
crisis: 1
is: 1
the: 4
rapid: 1
increase: 1
in: 3
use: 1
of: 1
prescription: 1
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Challenging: try to split up word into multiple words depending on meaning (requires inferring meaning from context)

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This problem is called **word sense disambiguation** (WSD)

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Some Other Basic NLP Tasks

- **Tokenization:** figuring out what are the atomic "words" (including how to treat punctuation)

- **Part-of-speech tagging:** figuring out what are nouns, verbs, adjectives, etc

- **Sentence recognition:** figuring out when sentences actually end rather than there being some acronym with periods in it, etc

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1 word at a time: **unigram** model

2 words at a time: **bigram** model

n words at a time: ***n*-gram** model

The spaCy **Python Package**

Demo

Recap: Basic Text Analysis

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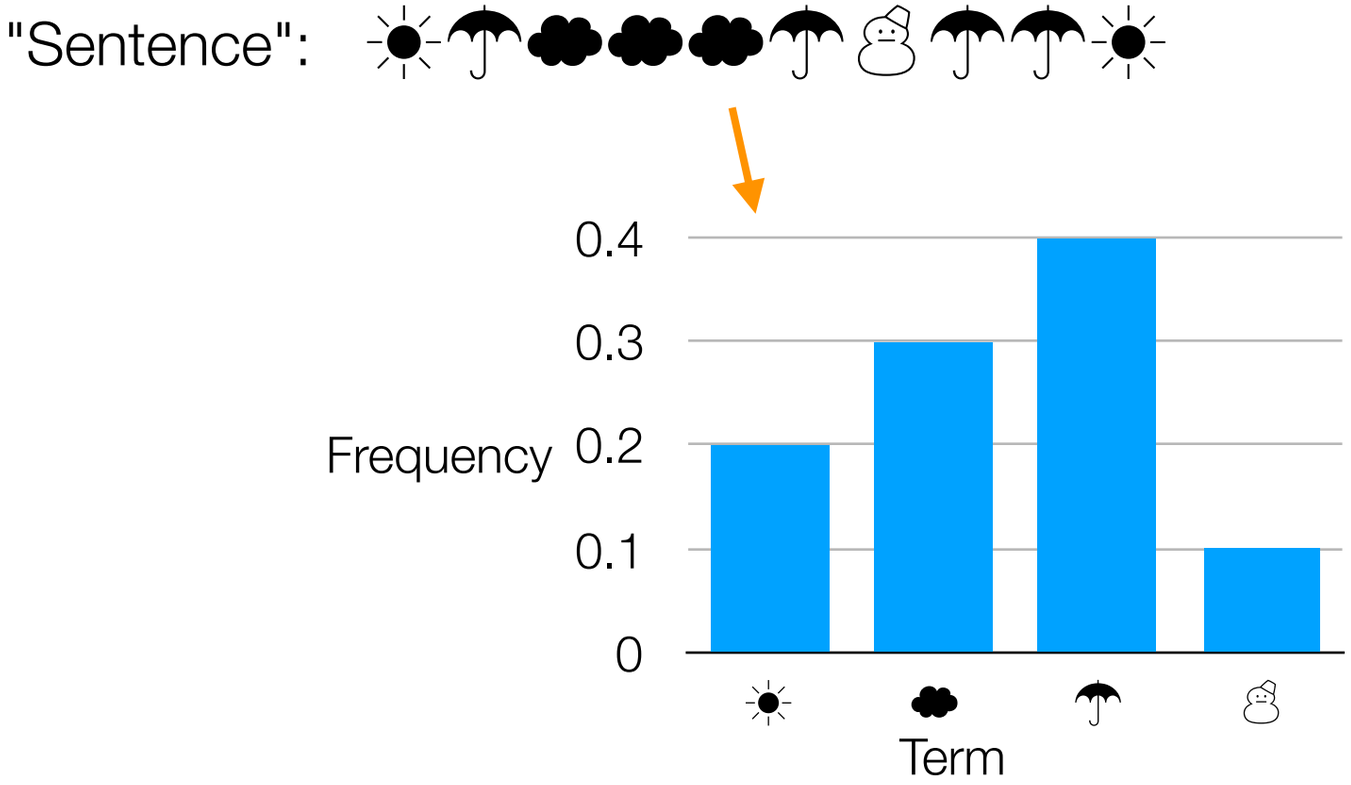

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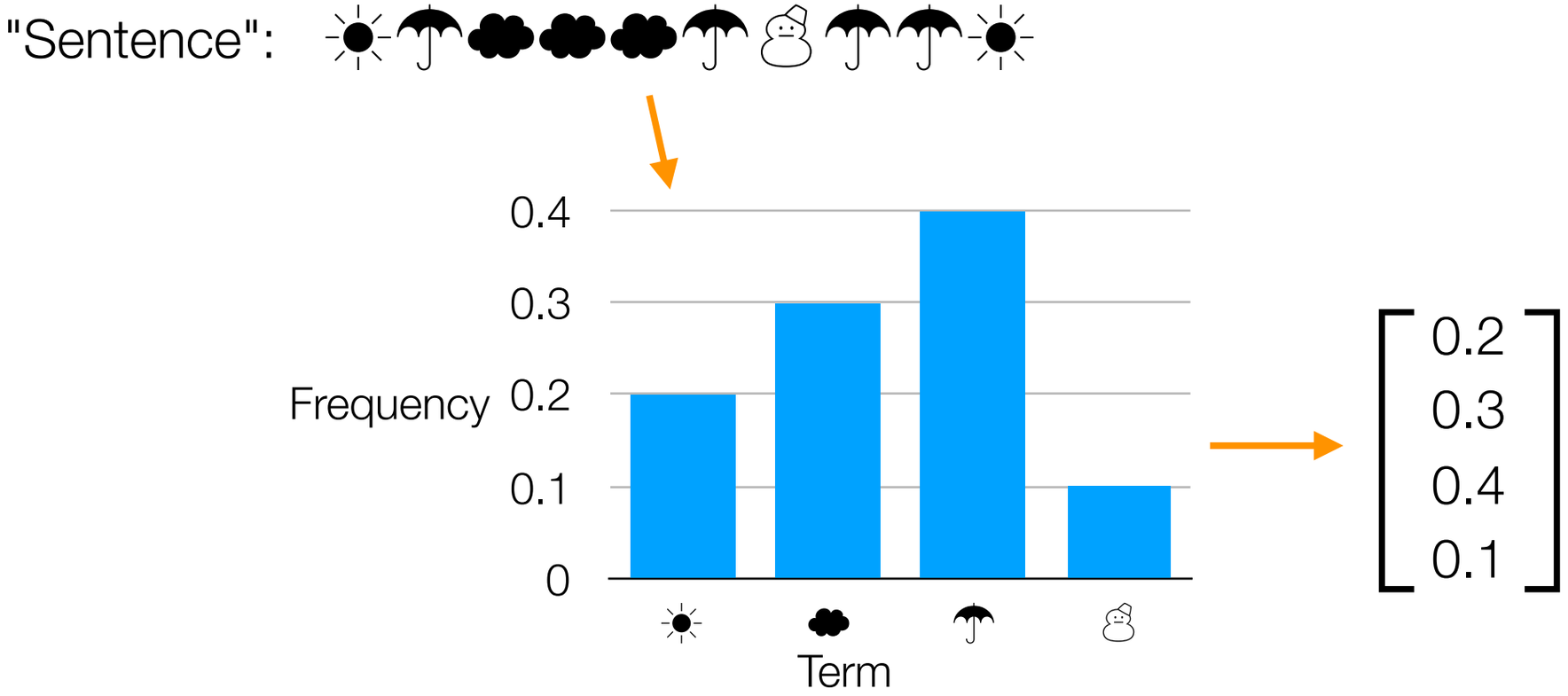

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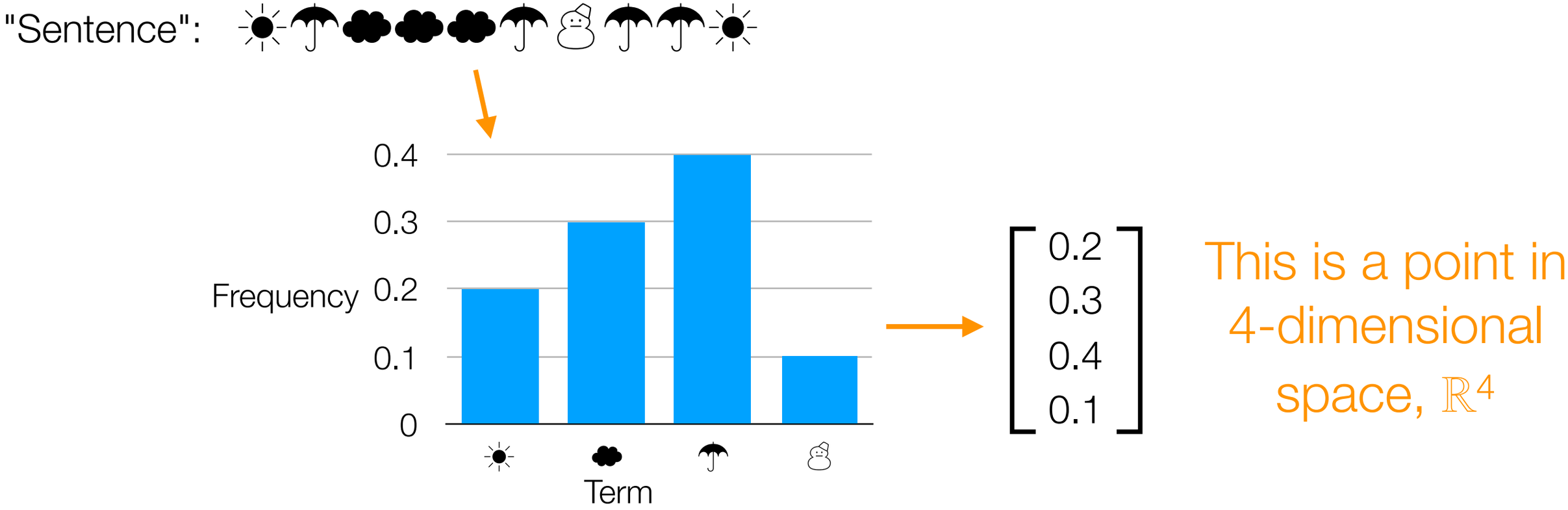

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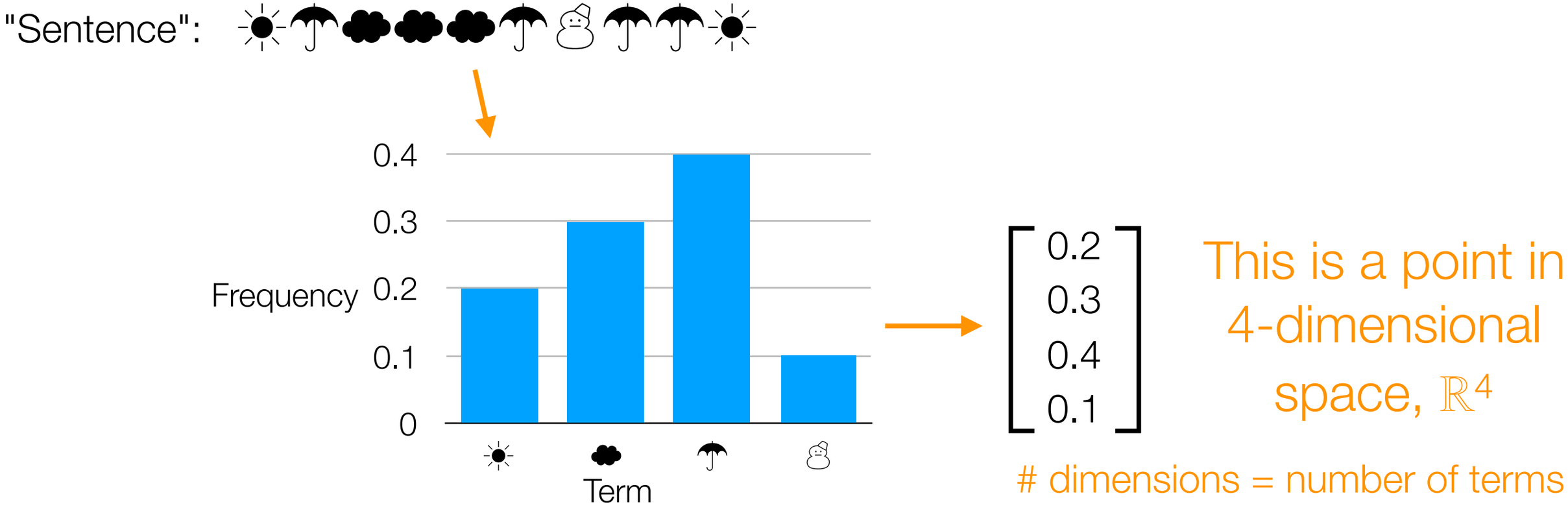

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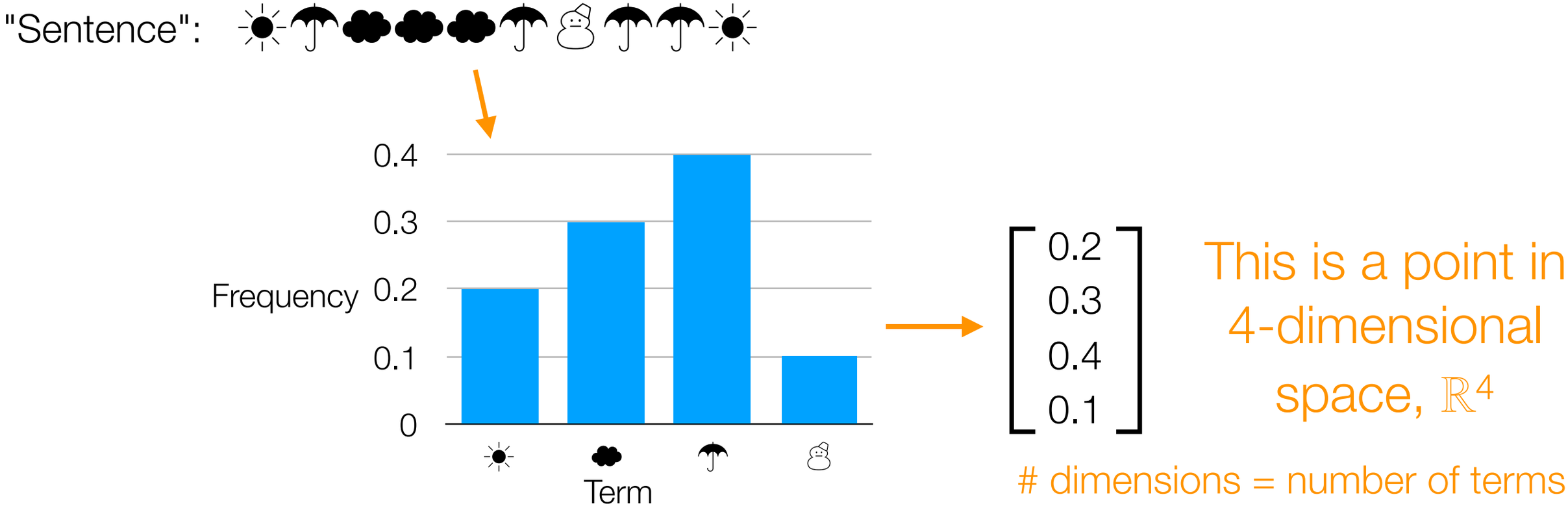

In general (not just text): first represent data as feature vectors

Example: Representing an Image

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Source: http://www.starwars.com/databank/porg

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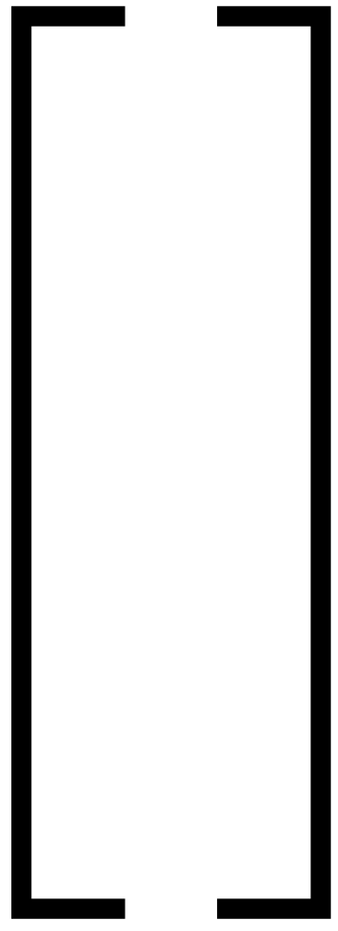

Source: http://www.starwars.com/databank/porg

Example: Representing an Image

0: black
1: white

[ ]

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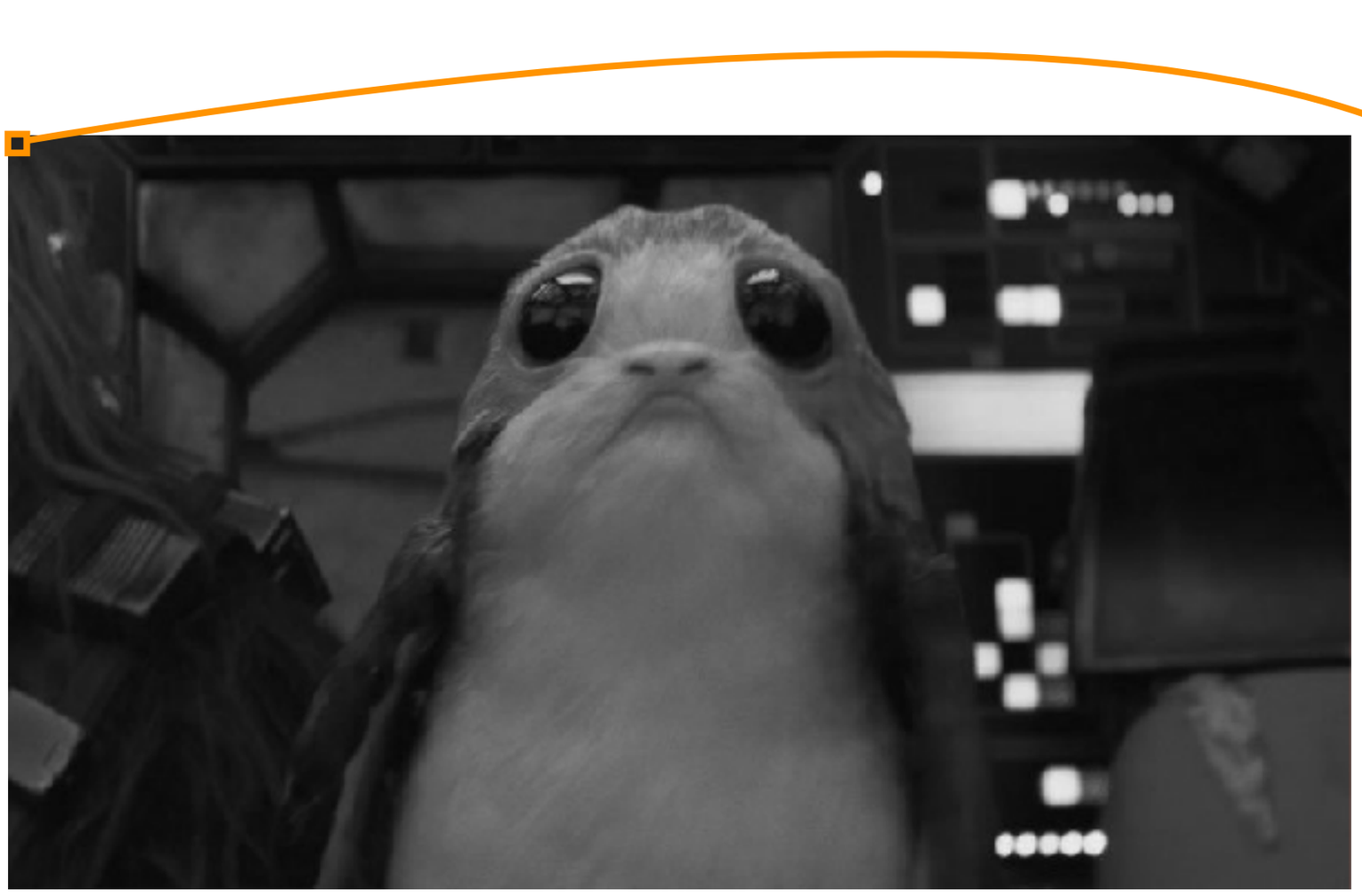

0: black
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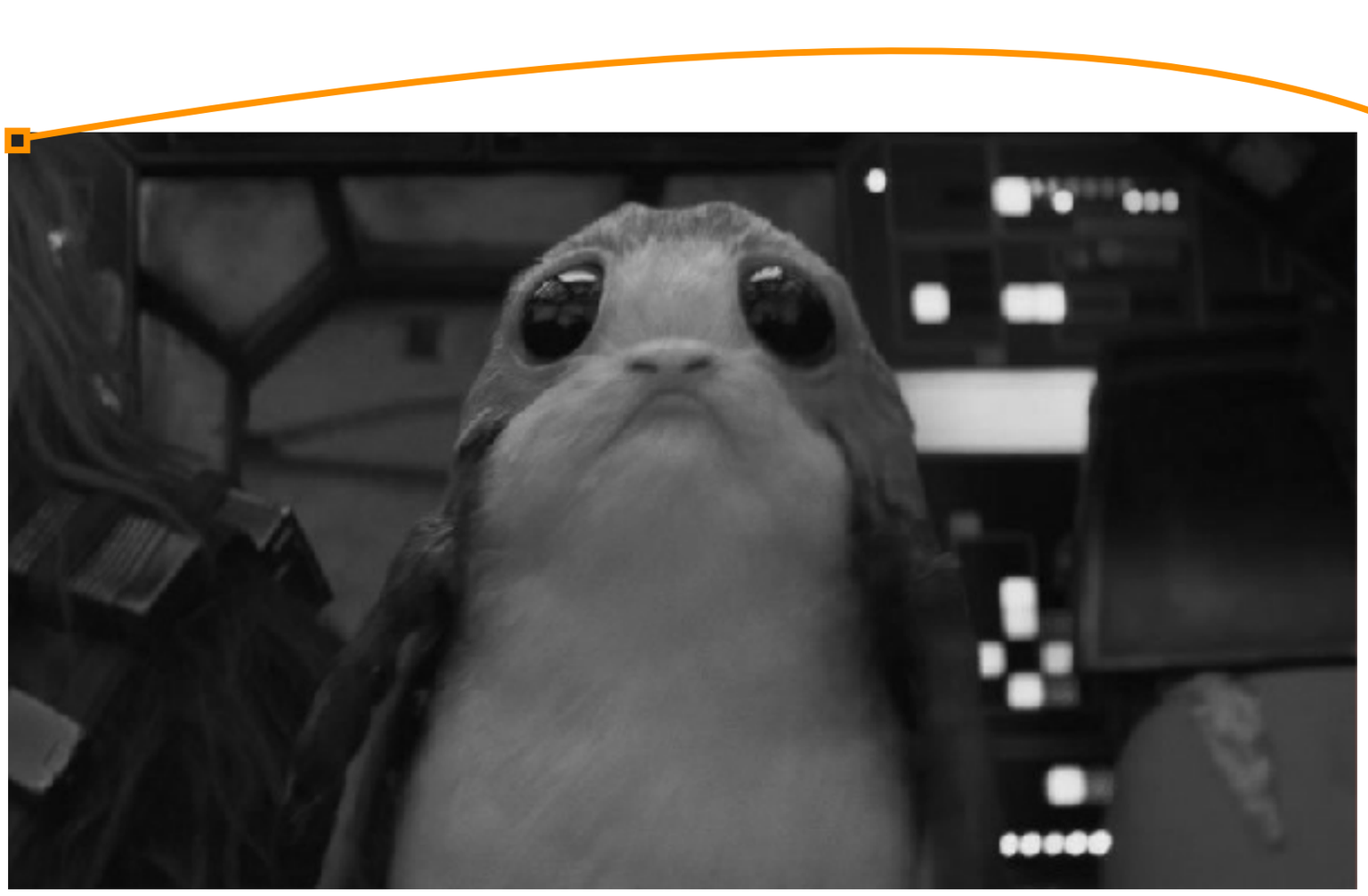

0: black
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0

Go row by row and look at pixel values

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$$\begin{bmatrix} 0 \\ 0 \\ \\ \\ \\ \end{bmatrix}$$

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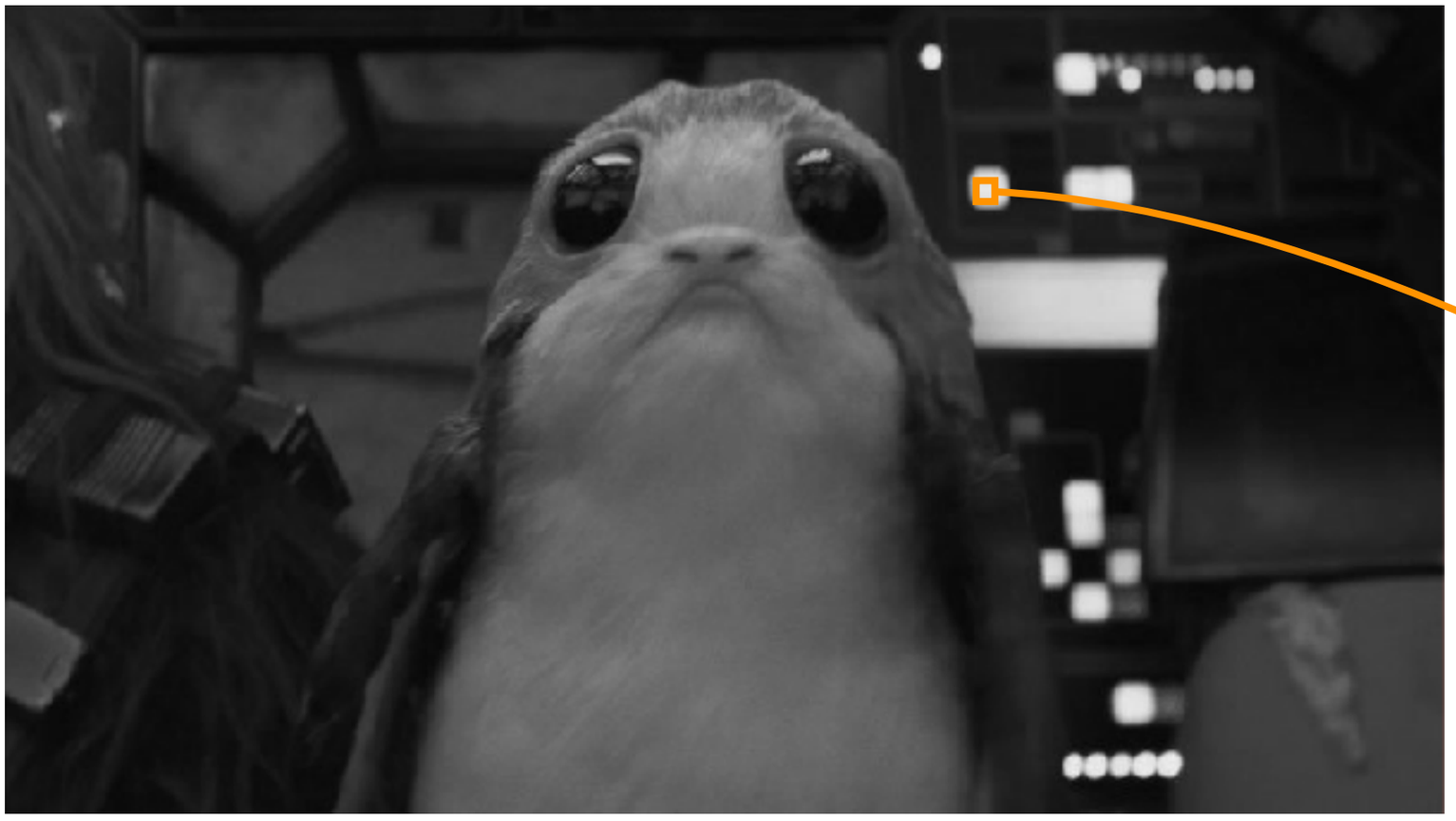

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$$\begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0.9 \\ \vdots \end{bmatrix}$$

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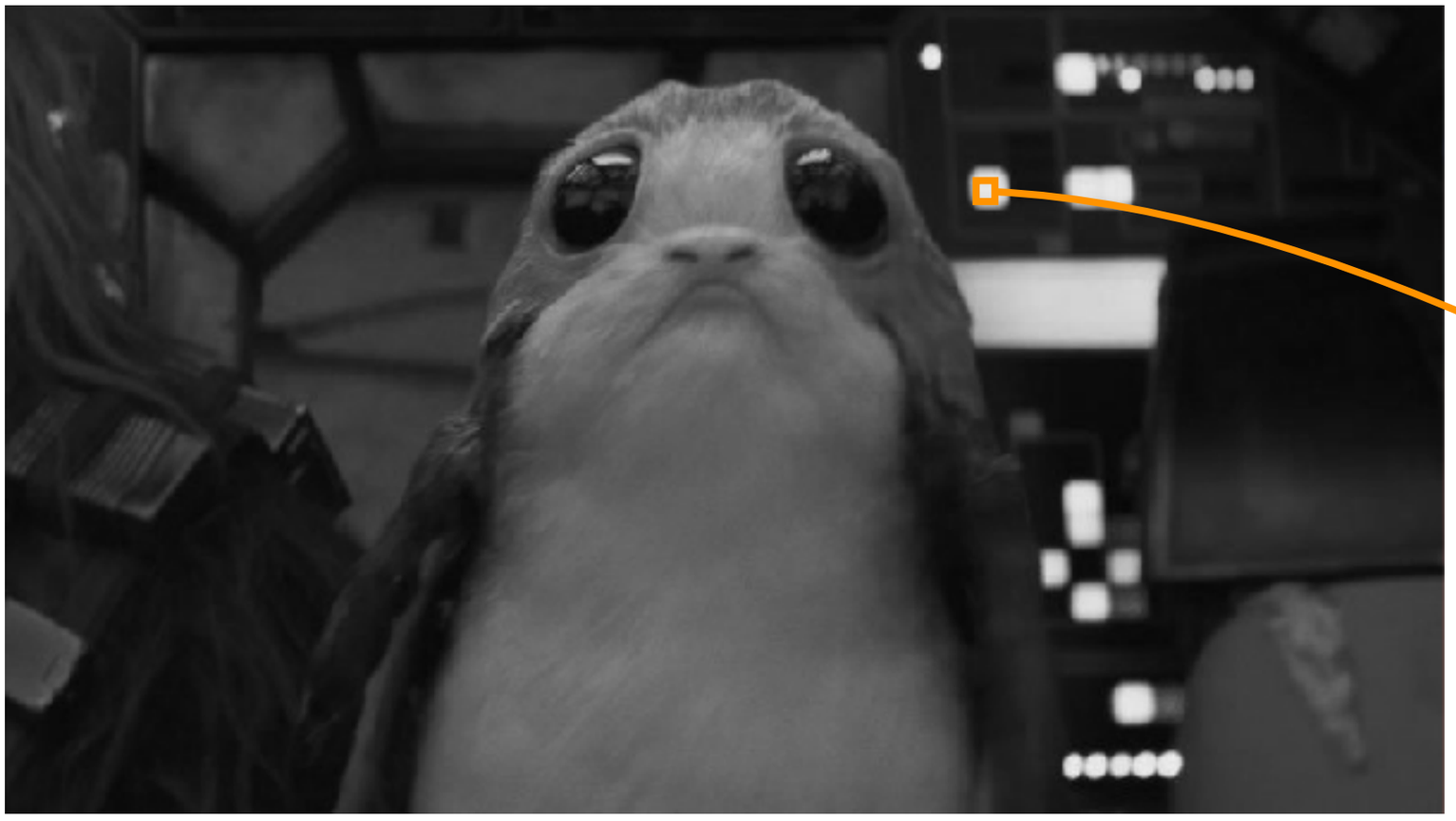

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dimensions = image width × image height

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Very high dimensional!

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- Enough to learn a simple detector for email spam