Natural Language Processing

Lecture 05

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Today's Goals

- Know when (and when not) to use **Regular expressions**
- Learn about forms of **TF-IDF** and its possibilities
- Understand how information can be quantified with **entropy**
- Understand **PMI** and see why it can help find collocations

Flexible Matches:
Regular Expressions

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http://xkcd.com/208/

The promise...

Is it an (Email) Address?

- notMyFault@webmail.com ✔
- smithie123@gmx ✗
- Free stuff@unibocconi.it ✗
- mark_my_words@hotmail;com ✗
- truthOrDare@webmail.in ✔
- look@me@twitter.com ✗
- how2GetAnts@aol.dfdsfgfdsgfd ✗

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Simple Matching

sequence	Matches
e	any single occurrence of e
at	**at**, r**at**, m**at**, s**at**, c**at**, **at**tack, **at**tention, l**at**er

Quantifiers

	Means	Example	Matches
*	0 or more	`fr?og`	`fog, frog`
+	1 or more	`hello+`	`hello, helloo, hellooooooo`
?	0 or 1	`cooo*l`	`cool, coool`

Special Characters

	Means	Example	Matches
.	any single character	`.el`	`eel, Nel, gel`
\n	newline character (line break)	`\n+`	One or more line breaks
\t	a tab stop	`\t+`	One or more tabs
\d	a single digit [0-9]	`B\d`	`B0, B1, ..., B9`
\D	a non-digit	`\D.t`	`' t, But, eat`
\w	any alphanumberic character	`\w\w\w`	`Top, WOO, ash, bee, ...`
\W	non-alphanumberic character		
\s	a whitespace character		
\S	a non-whitespace character		
****	"Escapes" special characters to match them	`.+` `\.com`	`abc.com, united.com`
^	the beginning of the input string	`^...`	First word in line
$	the end of the input string	`^\n$`	Empty line

Classes

	Means	Example	Matches
[abc]	Match any of a, b, c	`[bcrms]at`	`bat, cat, rat, mat, sat`
[^abc]	Match anything BUT a, b, c	`te[^ ]+s`	`tens, tests, teens, texts, terrors...`
[a-z]	Match any lowercase character	`[a-z][a-z]t`	`act, ant, not, ... wit`
[A-Z]	Match any uppercase character	`[A-Z]...`	`Ahab, Brit, In a, ..., York`
[0-9]	Match any digit	`DIN A[0-9]`	`DIN A0, DIN A1, ..., DIN A9`

Groups

	Means	Example	Matches
(abc)	Match abc	`[bcrms]at`	`bat, cat, rat, mat, sat`
(ab|c)	Match ab OR c	`te[^ ]+s`	`tens, tests, teens, texts, terrors...`

Matching Addresses


```
^[A-Za-z0-9_\.-]+@[A-Za-z0-9_\.-]+[A-Za-z0-9_][A-Za-z0-9_]$
```

http://xkcd.com/1171/

A (W|w)ord of [Ww]arning

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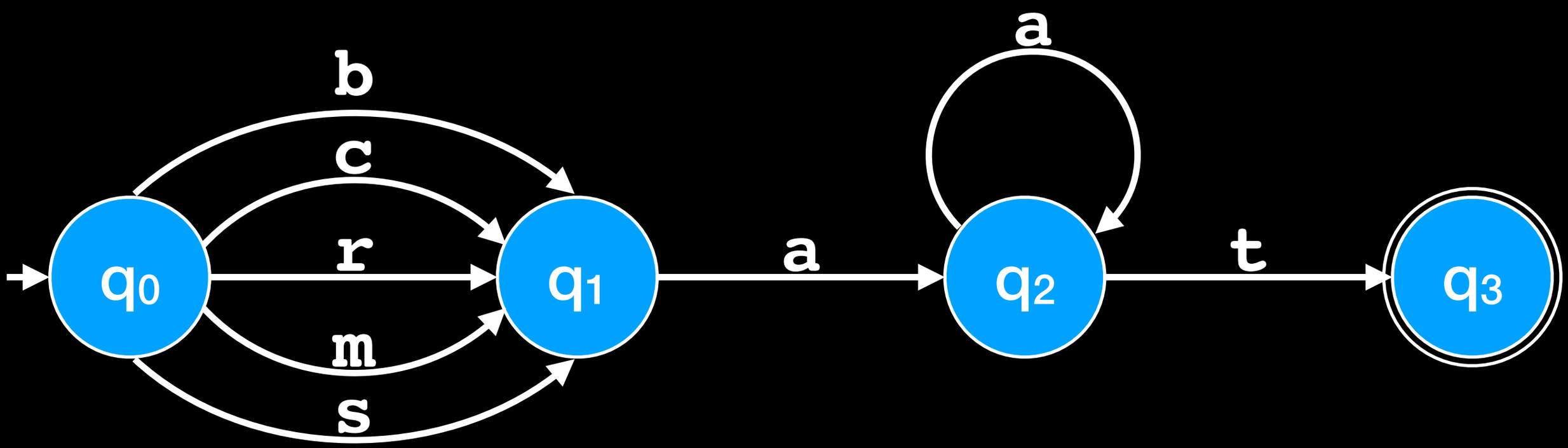
RegEx as Automata




```
[bcrms]a+t
```

Finding Important Words:

TF-IDF

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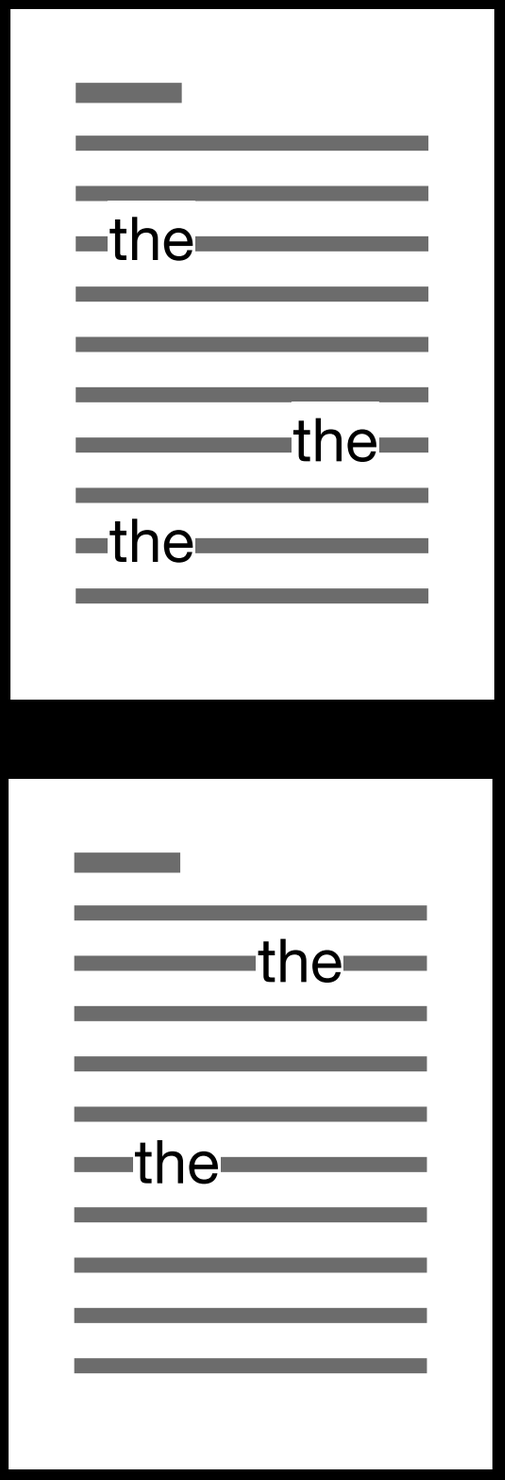
Some Words are Just More Interesting…



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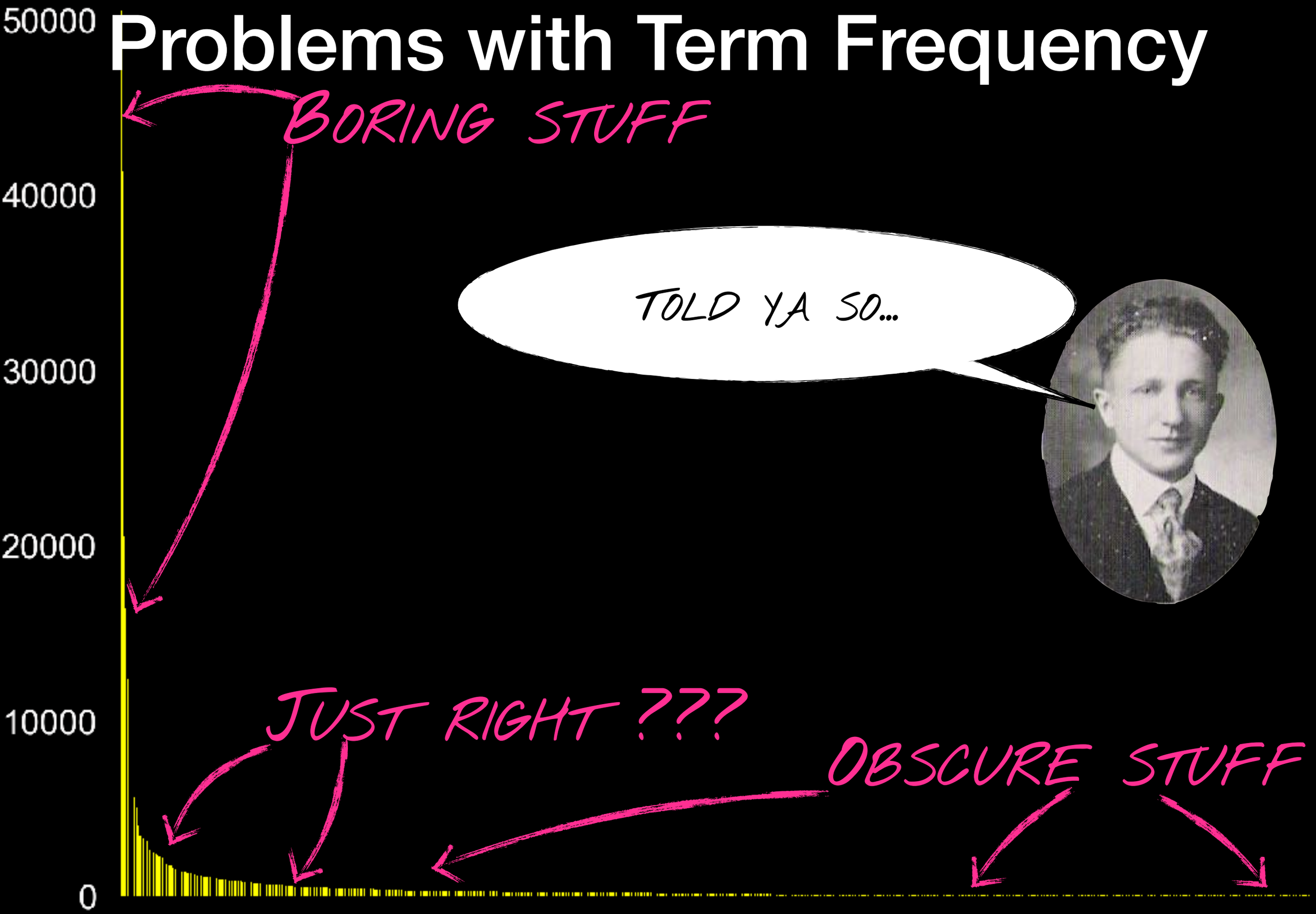
Karen Spärck Jones

1935–2007

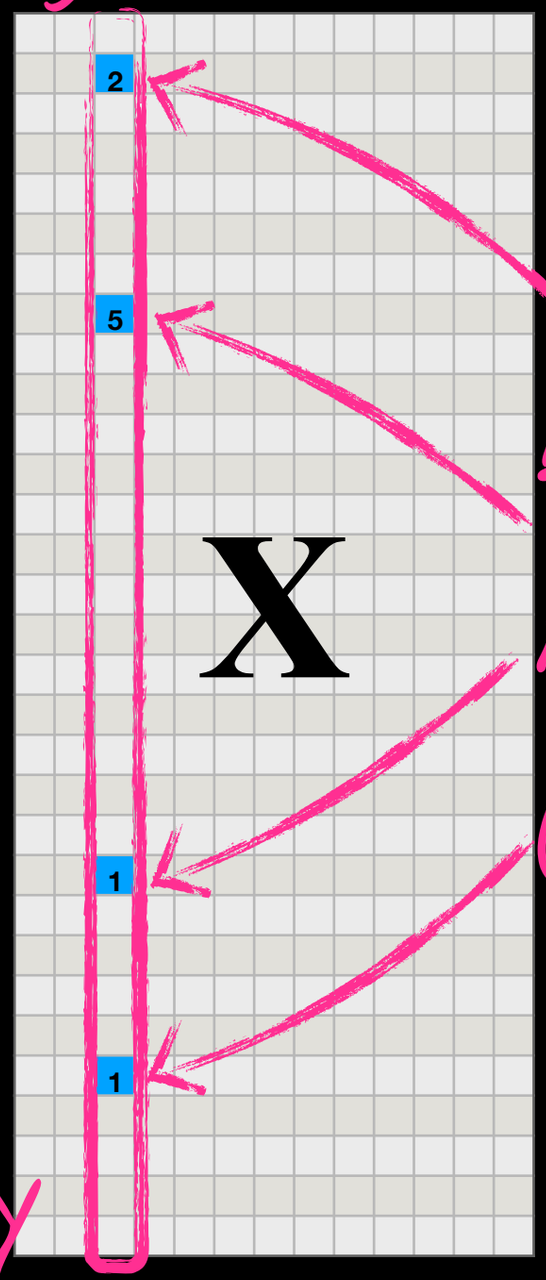
- Became a teacher before starting CS career at Cambridge
- Laid the foundation for modern NLP, Google Search, text classification
- Campaigned for more women in CS
- Namesake of prestigious CS prize

Problems with Term Frequency



Document and Term Frequency

$$IDF = log \frac{N}{df(w)}$$



Putting it Together

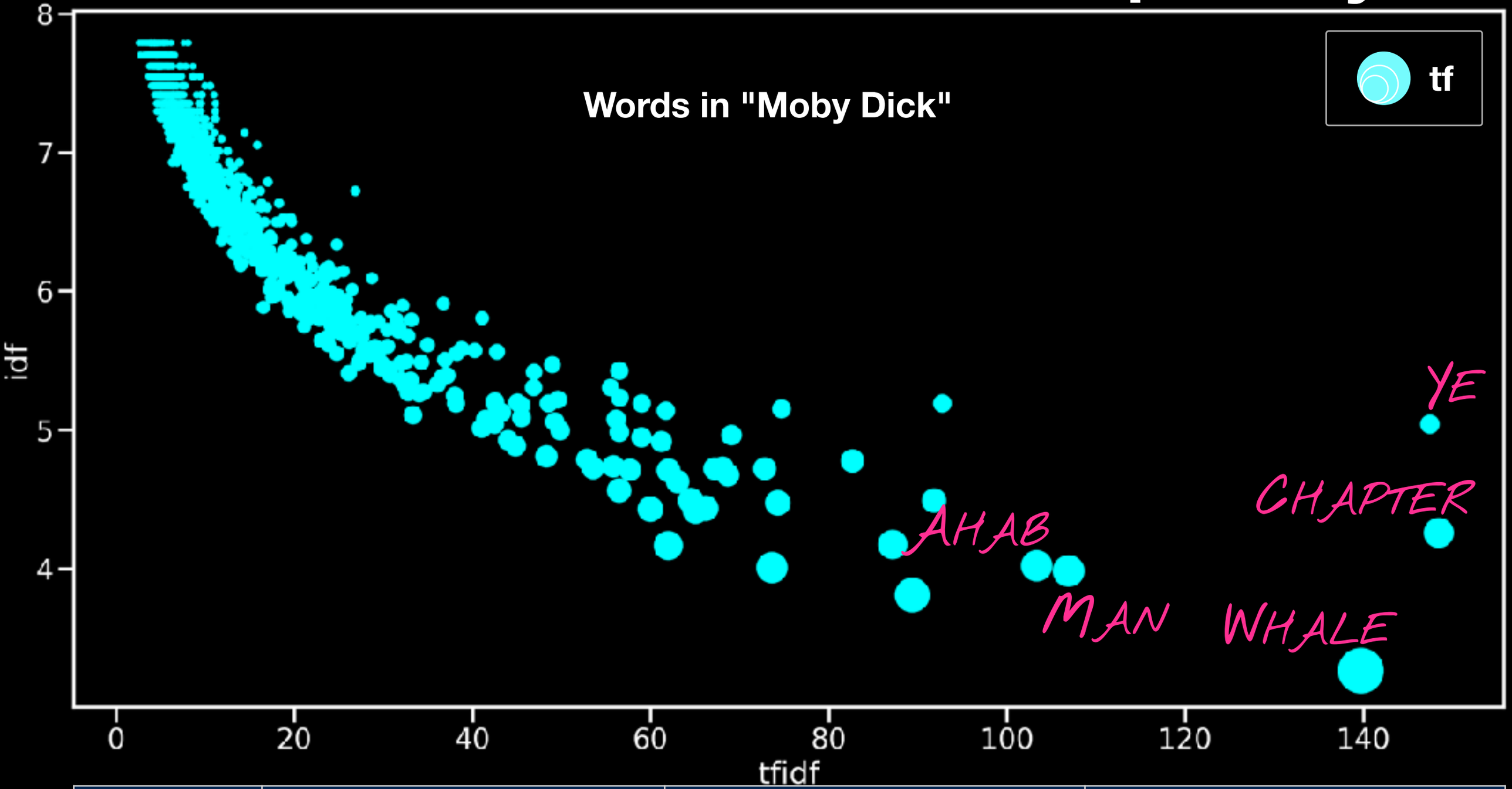
50000
40000
30000
20000
10000
0

How often we saw the word

$$TFIDF(w) = TF(w) \cdot \log \frac{N}{df(w)}$$

adjusted by how many documents

Document and Term Frequency



word	tf	idf	tfidf
ye	467	4.257380	148.497079
chapter	171	5.039475	147.504638
whale	1150	3.262357	139.755743
man	525	3.982412	106.932953
ahab	511	4.019453	103.357774

The Probability of Words: Entropy

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What's More Likely?

We finish each others'

SENTENCES

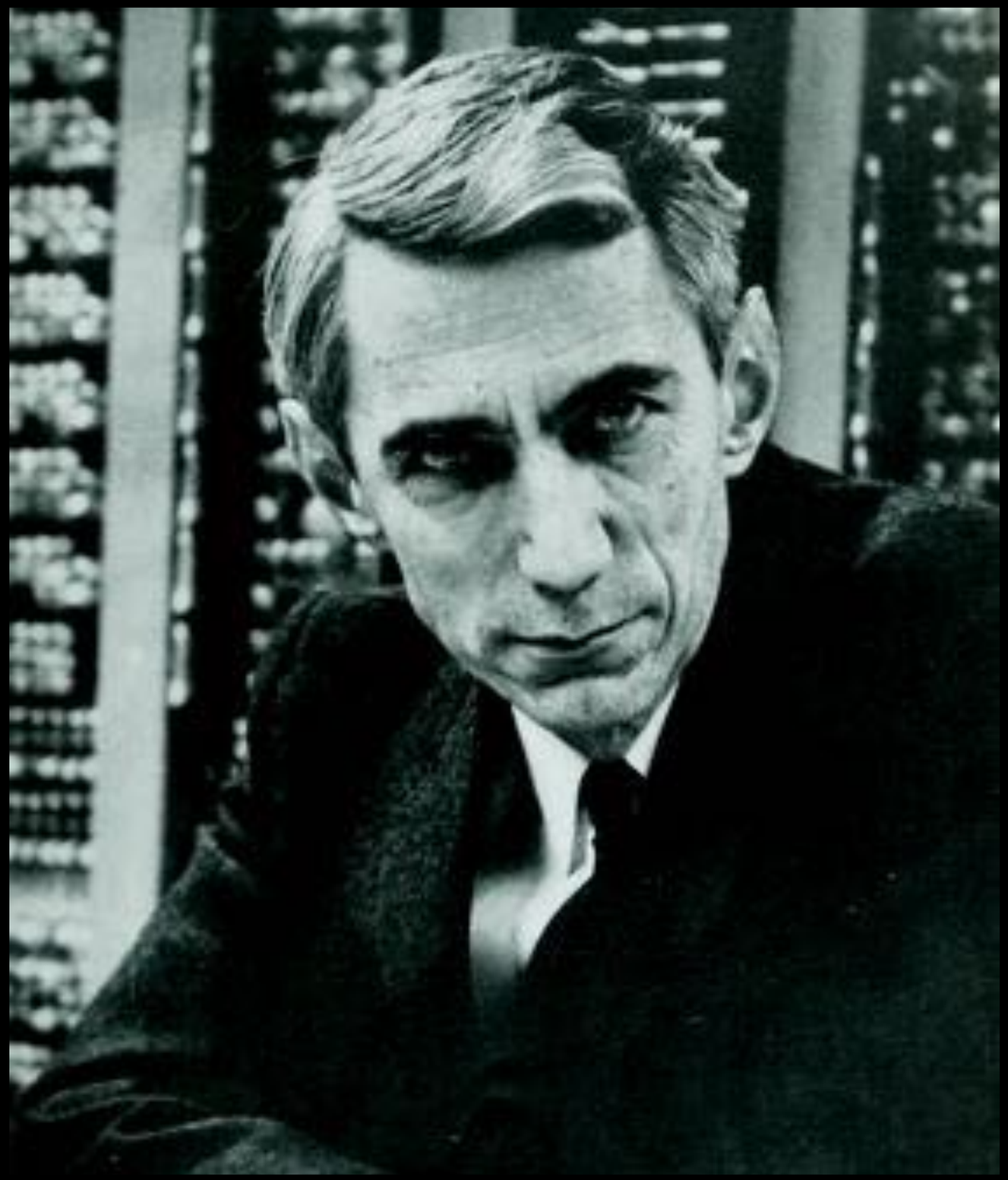
LEFTOVERS

MOVIES

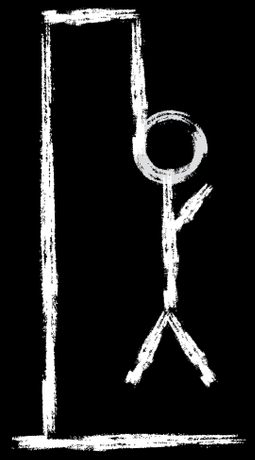
Claude Shannon

1916-2001

- His master's thesis founded a new field: digital circuits
- Invented entropy to quantify language – and a flame-throwing trumpet
- Enabled NLP, cryptography, modern computers…
- Died of Alzheimer's, oblivious to his own inventions' impact



Shannon Game



WHAT'S THE NEXT WORD?

The	house				
A	friend				
Then	dog				
If	car				
When	water			with	water ?
My	**hovercraft**			**of**	**eels**
He	pants			to	air !
You	God			…	…
I	word			HOW MUCH	
…	…			MORE, CLAUDE?	

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Entropy

VERY SURPRISING

entropy

$$H(X) = -\sum_x p(x) \log p(x)$$

Information

$p(x)$

0

1

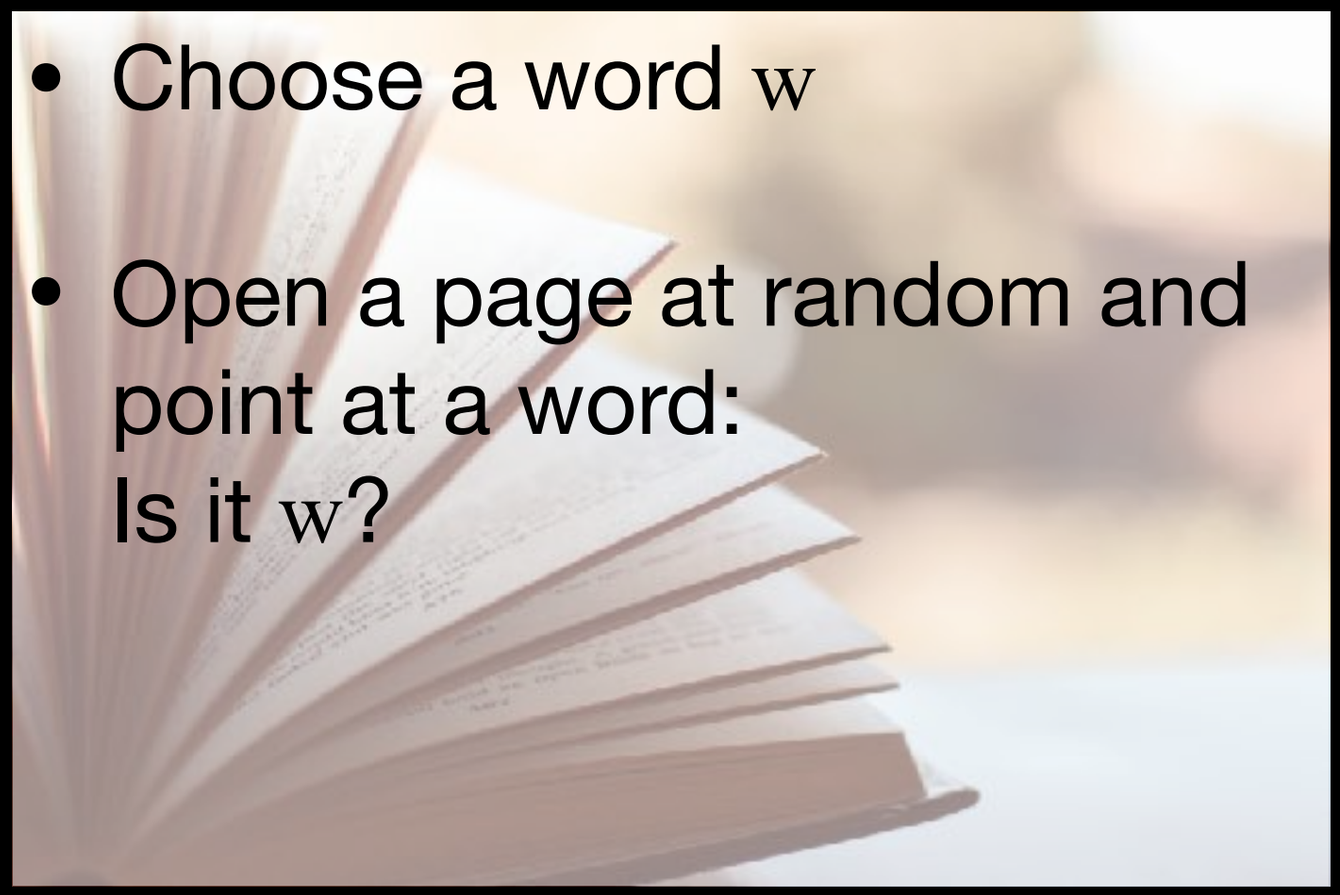
TOTALLY PREDICTABLE

TOTALLY PREDICTABLE

Probability of a Word

"It must be recognized that the notion 'probability of a sentence' is an entirely useless one, under any known interpretation of this term."

Noam Chomsky



- Choose a word w
- Open a page at random and point at a word: Is it w?

HOW OFTEN WE HAVE SEEN W

$$P(w) = \frac{c(w)}{\sum_{v \in V} c(v)}$$

...ALL WORDS

Entropy in Use

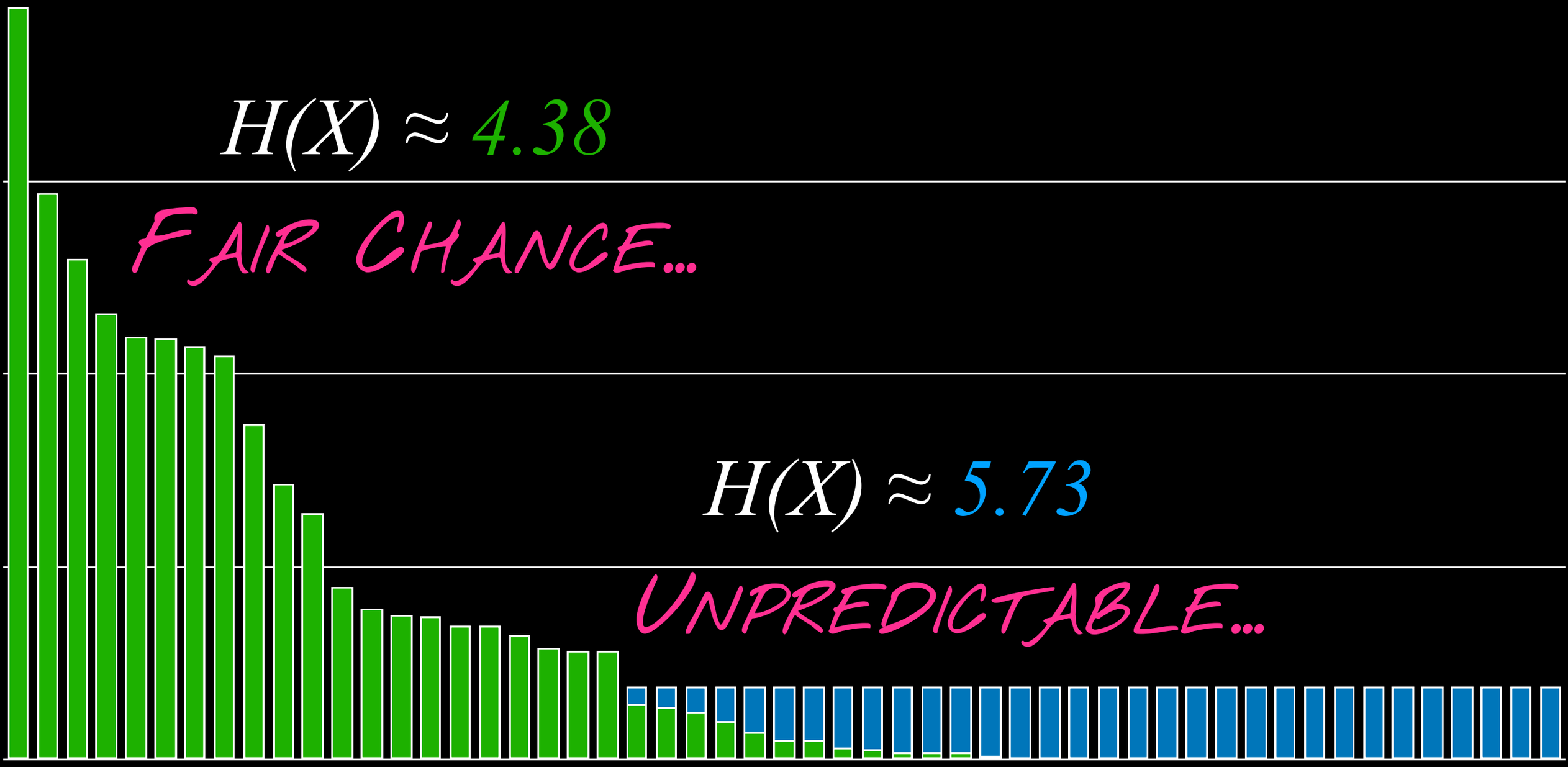
What's the next letter?

$H(X) \approx 4.38$

Fair chance...

$H(X) \approx 5.73$

Unpredictable...



e t a o n i s h r l d u m c w g f , p y b v k , - ; ' ! q j x ? z ( ) : 0 1 2 5 7 8 3 * 4 6 9 _ $ [ ] &

Telling Neighbors: Pointwise Mutual Information

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Some are not like the Others

frying pan

social media

and thought

New York

of the

FREQUENT BIGRAMS

COLLOCATIONS

Mutual Informativity

How well can we guess the blank?

social _____ and _____

_____ media _____ the

Pointwise Mutual Information

CHANCE OF SEEING THEM TOGETHER

$$PMI(x, y) = \log \frac{P(x, y)}{P(x)P(y)}$$

...SEEING EITHER

x	y	c(x)	c(y)	c(xy)	P(x)	P(y)	P(x, y)	PMI(x; y)
moby	**dick**	83	83	82	0.0003	0.0003	0.0003	**3.48**
captain	**ahab**	327	511	61	0.0013	0.0020	0.0002	**1.97**
white	**whale**	280	1150	106	0.0011	0.0045	0.0004	**1.93**
under	**the**	119	14175	45	0.0005	0.0553	0.0002	**0.83**
is	**a**	1690	4636	110	0.0066	0.0181	0.0004	**0.56**

c(X) = 256,149
c(XY) = 256,148

Wrapping up

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Take home points

- **Regular expressions** allow us to search for flexible patterns
- **Entropy** allows us to quantify how surprising/ predictable something is
- **TF-IDF** finds "bursty" words: medium frequency overall, but concentrated in few documents
- **PMI** tells us how likely one word is to occur with/ without another to find **collocations**