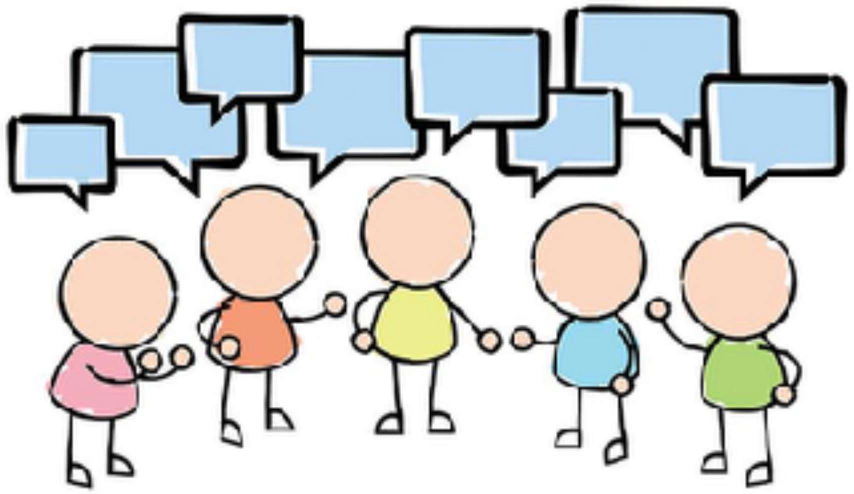
Introduction to Natural Language Processing

Laura Wendlandt
wenlaura@umich.edu

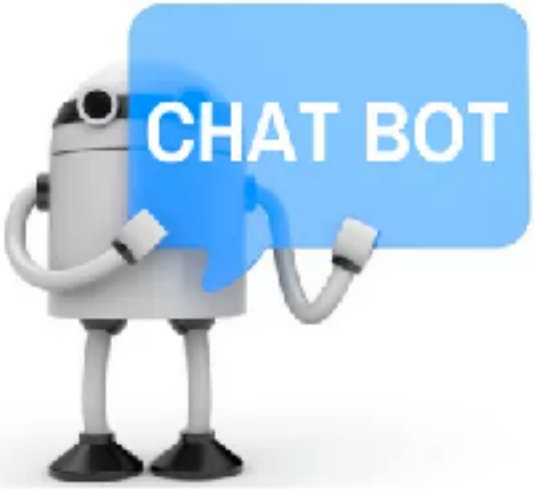
Ideas borrowed liberally from Reed Coke’s slides.

What is NLP?

- Computers understanding language



- Computers generating language



"One margarita has about 195 calories. Is there anything else I can do for you?"
"Successfully logged that food to Track totaling about 453 calories."

Why do I care?

- What do I want to find out?

Do my customers trust my business?

How do people feel about this cultural trend?

- What kind of data do I have?

Social media data

Website comments

Why do I care?

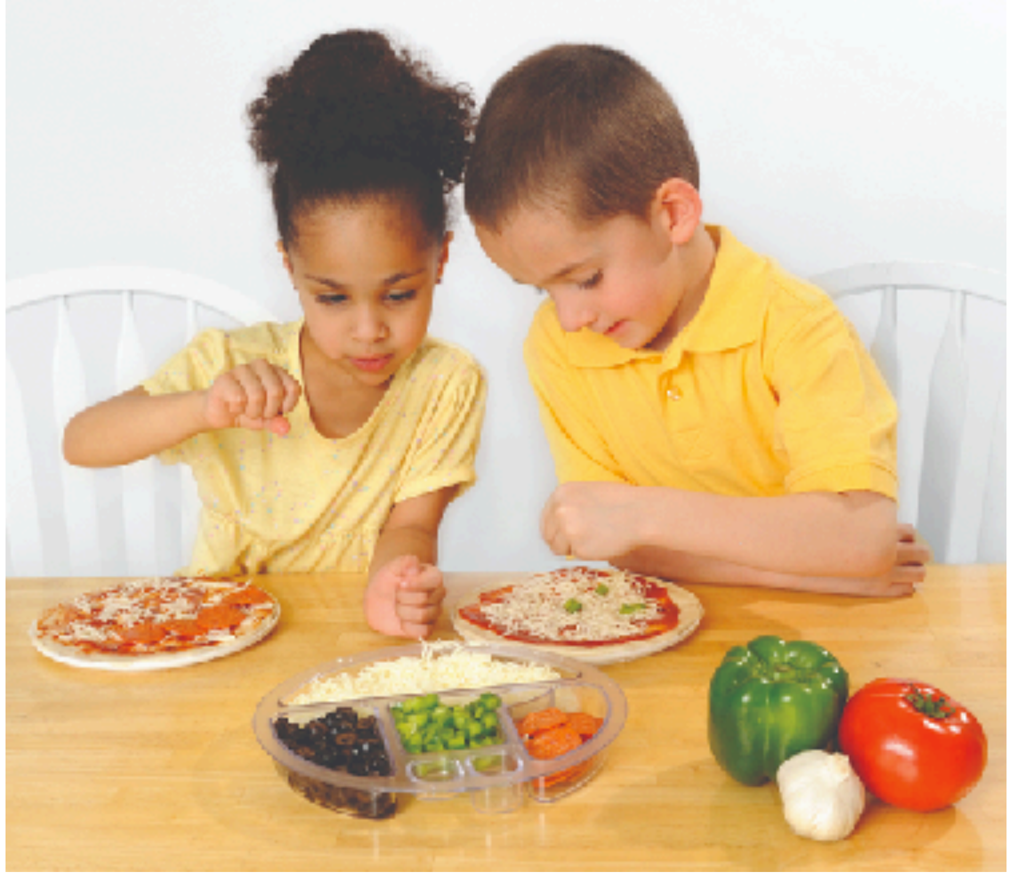
- Is there information in my data that will help me answer these questions?
- How do I extract it?
- Are there tools that do this for me?

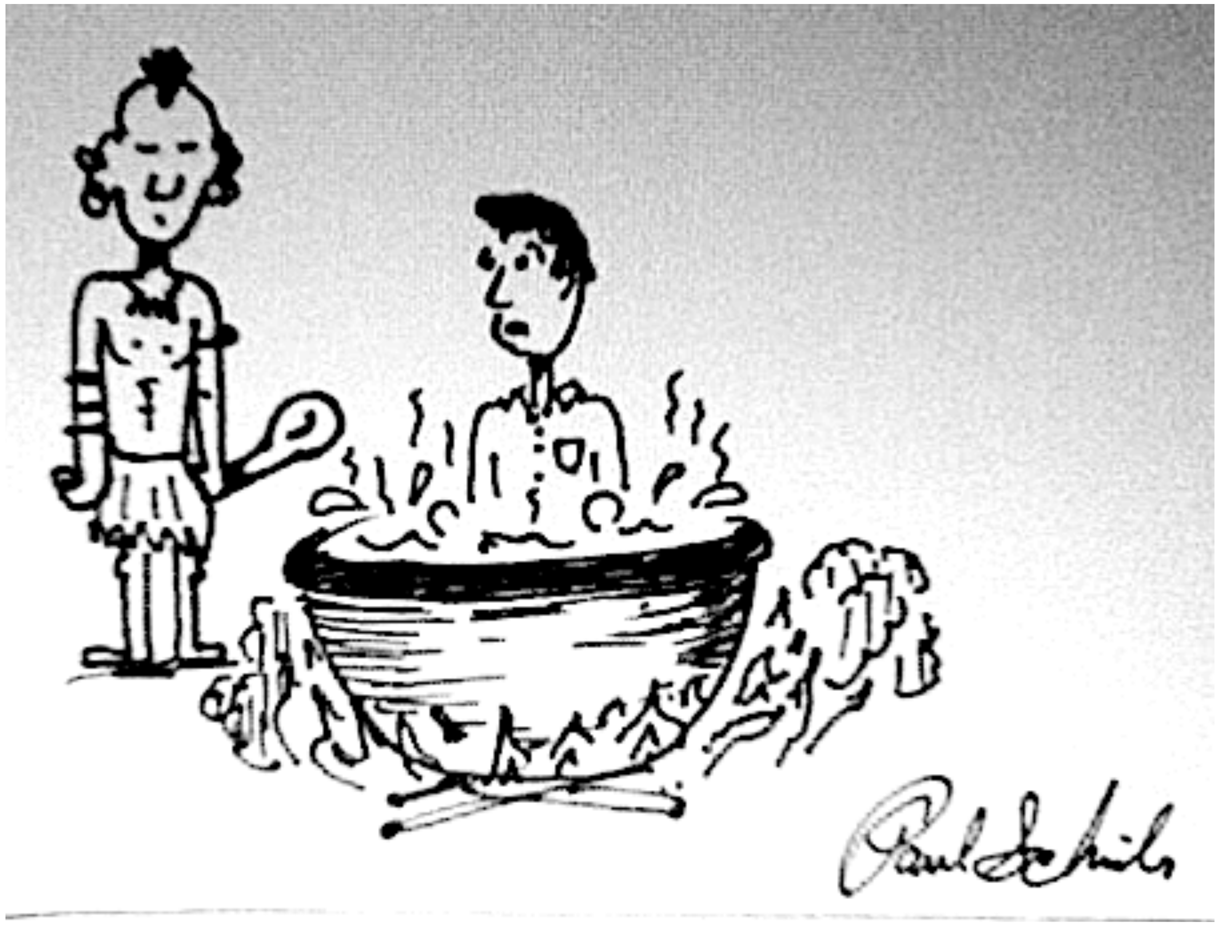
Outline

- **Why is NLP Hard?**
- Twitter data
- Preparing data
- Dataset Statistics
- NLP Tasks
  - Named Entity Recognition (NER)
  - Sentiment Analysis
  - Topic Modeling
  - Word Embeddings

Why is NLP Hard?

- Language is complex!
  - **Ambiguity**: Children make delicious snacks.





Why is NLP Hard?

- Language is complex!
  - **Ambiguity**: I ate a chocolate bar.
I walked into a chocolate bar.

Why is NLP Hard?

- Language is complex!
  - **Humor and Sarcasm**: "Some cause happiness wherever they go; others whenever they go." - Oscar Wilde

Outline

- Why is NLP Hard?
- **Twitter data**
- Preparing data
- Dataset Statistics
- NLP Tasks
    - Named Entity Recognition (NER)
    - Sentiment Analysis
    - Topic Modeling
    - Word Embeddings

Let’s look at some real data!

Here's a cute panda to make your day! :) http://t.co/jeVWqXIK1r http://t.co/DIL4YjCadQ"

I just watched a video about a girl being "allergic" to the sun :(that's depressing

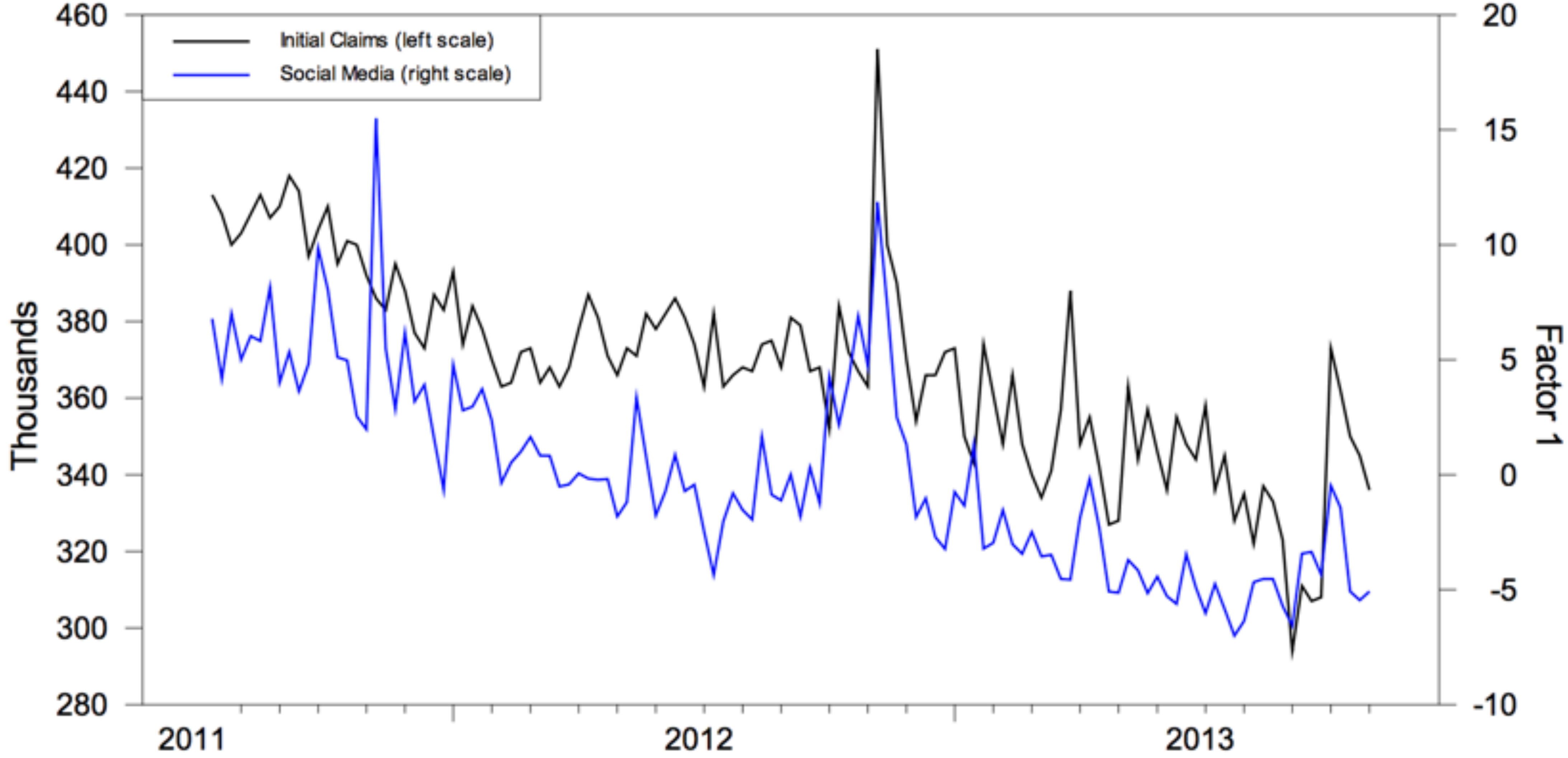
I WANT A WHITE FRENCH BULLDOG :(((

♛♛♛ 》》》》 I LOVE YOU SO MUCH. I BELİEVE THAT HE WİLL FOLLOW. PLEASE FOLLOW ME PLEASE JUSTİN @justinbieber :(x15.337 》》》》SEE ME ♛♛♛

RT @natalieben: #bbcqt - so would Miliband really let David Cameron back in rather than "do a deal" with the SNP?

What can you do with Twitter data?

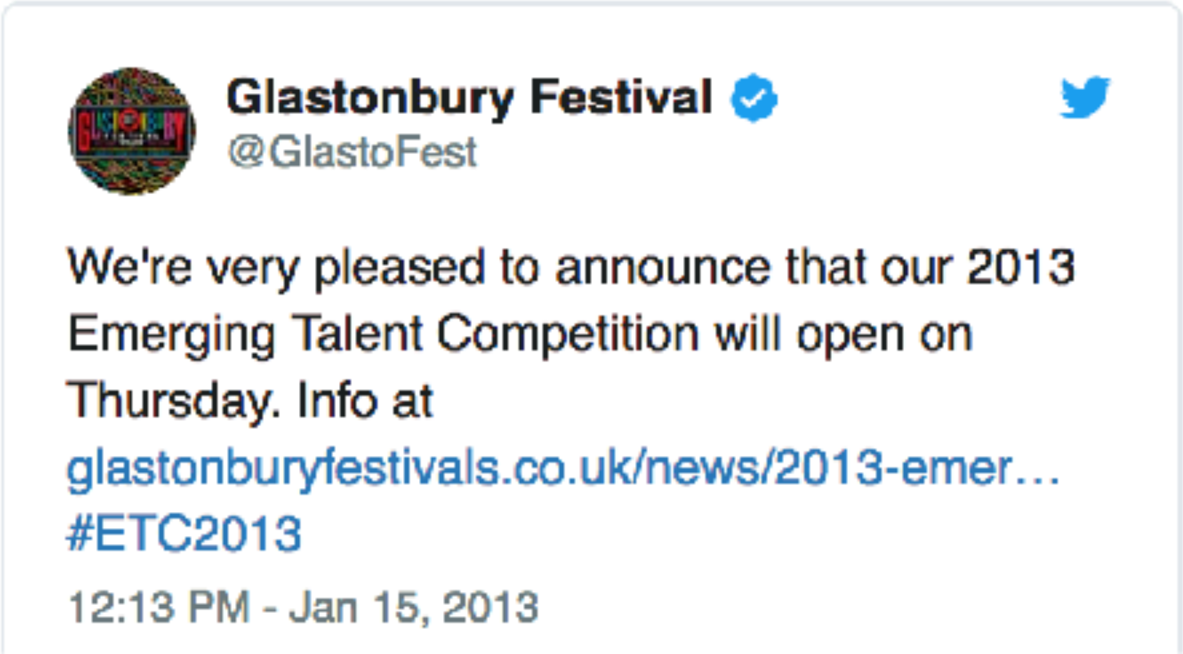
- Predict unemployment



Antenucci, Dolan, et al. *Using social media to measure labor market flows*. No. w20010. National Bureau of Economic Research, 2014.

What can you do with Twitter data?

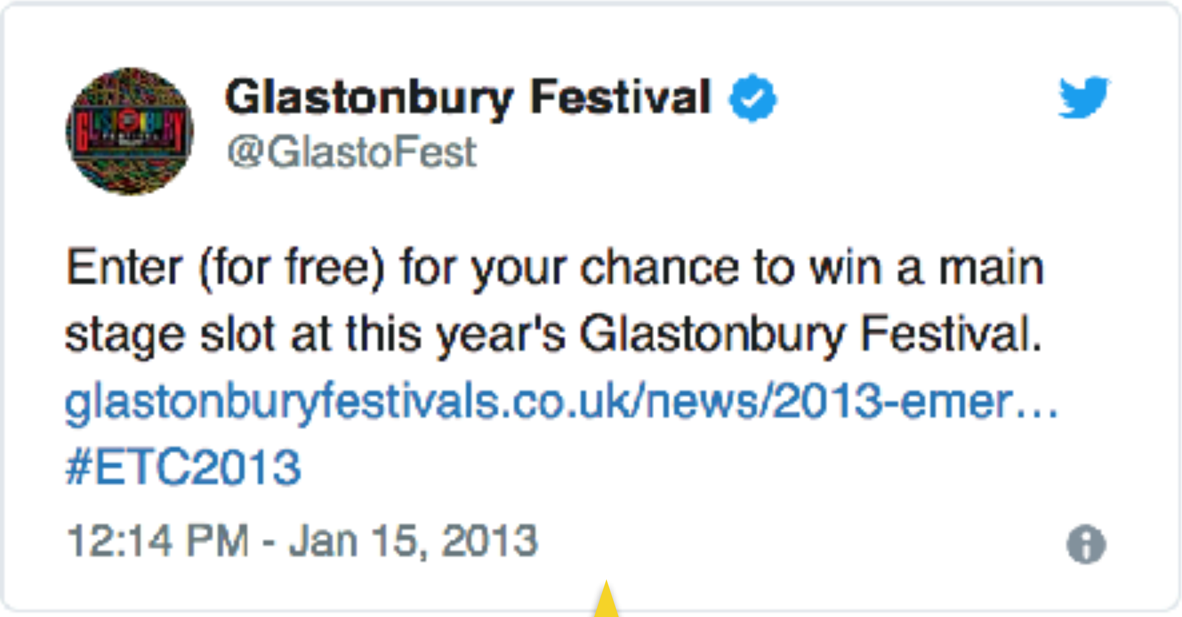
- Predict which tweet will be retweeted more



Glastonbury Festival
@GlastoFest

We're very pleased to announce that our 2013 Emerging Talent Competition will open on Thursday. Info at glastonburyfestivals.co.uk/news/2013-emer… #ETC2013

12:13 PM - Jan 15, 2013



Glastonbury Festival
@GlastoFest

Enter (for free) for your chance to win a main stage slot at this year's Glastonbury Festival. glastonburyfestivals.co.uk/news/2013-emer… #ETC2013

12:14 PM - Jan 15, 2013

★

Tan, Chenhao, Lillian Lee, and Bo Pang. "The effect of wording on message propagation: Topic-and author-controlled natural experiments on Twitter." *ACL* (2014).

Outline

- Why is NLP Hard?
- Twitter data
- **Preparing data**
- Dataset Statistics
- NLP Tasks
  - Named Entity Recognition (NER)
  - Sentiment Analysis
  - Topic Modeling
  - Word Embeddings

Python Libraries

- **NLTK** = Natural Language Toolkit - good for preparing data
  - https://www.nltk.org/
  - Also, good tutorial book: http://www.nltk.org/book/
- **Gensim** - great for topic modeling and word embeddings
  - https://radimrehurek.com/gensim/
- **Stanford Core NLP** (not actually Python, but has Python wrappers available) - good for NER and sentiment analysis, among other things
  - https://nlp.stanford.edu/software/
  - Good Python wrapper: pycorenlp

Python Libraries

tldr;

```
pip install nltk

pip install gensim

pip install pycorenlp

#Go to https://nlp.stanford.edu/software/ and download NER and sentiment analysis packages
```

Preparing Data

- Data is messy!
- How can we clean it up?

	`Here's a cute panda to make your day! :) http://t.co/jeVWqXIK1r http://t.co/DIL4YjCadQ"`
Lowercase	`here's a cute panda to make your day! :) http://t.co/jevwqxik1r http://t.co/dil4yjcadq"`
Tokenize into words	`["here's",'a','cute','panda','to','make','your','day','!',':)','http://t.co/jevwqxik1r','http://t.co/dil4yjcadq']`
Remove links / rare words	`[“here’s",'a','cute','UNK','to','make','your','day','!',':)','LINK',LINK']`

Preparing Data

- Other data cleaning strategies (these depend on the scenario):
    - Tokenize into sentences (as well as tokenize into words)
    - Remove all punctuation
    - Remove digits (or replace digits with #)
    - Remove stop words (e.g., the, and, to, for)
    - Stem words

```
run, running, runner  ⟶  run
```

Outline

- Why is NLP Hard?
- Twitter data
- Preparing data
- **Dataset Statistics**
- NLP Tasks
  - Named Entity Recognition (NER)
  - Sentiment Analysis
  - Topic Modeling
  - Word Embeddings

Dataset Statistics

- What are some ways that we can summarize such a big corpus of text?

Outline

- Why is NLP Hard?
- Twitter data
- Preparing data
- Dataset Statistics
- NLP Tasks
    - **Named Entity Recognition (NER)**
    - Sentiment Analysis
    - Topic Modeling
    - Word Embeddings

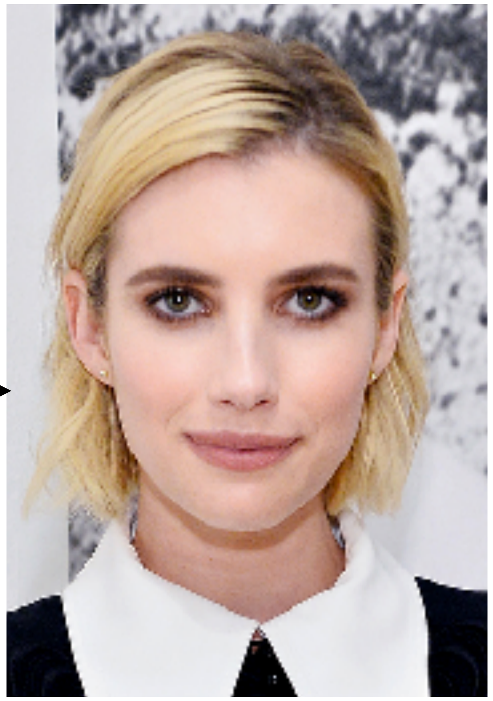
Named Entity Recognition (NER)

- Extract entities in the text
- PERSON, ORGANIZATION, LOCATION (time, date, monetary value, percentage)

```
[('rt', 'O'),
  ('@laboureoin', 'O'),
  (':', 'O'),
  ('the', 'O'),
  ('economy', 'O'),
  ('was', 'O'),
  ('growing', 'O'),
  ('3', 'O'),
  ('times', 'O'),
  ('faster', 'O'),
  ('on', 'O'),
  ('the', 'O'),
  ('day', 'O'),
  (‘david', 'PERSON'),
  ('cameron', 'PERSON'),
  ('became', 'O'),
  ('prime', 'O'),
  ('minister', 'O'),
  ('than', 'O'),
  ('it', 'O'),
  ('is', 'O'),
  ('today', 'O'),
  ('..', 'O'),
  ('#bbcqt', 'O'),
  ('LINK', 'O')]
```

Named Entity Recognition (NER)

jane
miss kang
michael woodford
bush
emma roberts
chris gayle
kath
jonah
jumma mubarak
lewis
miss dubai



Expedia

Named Entity Recognition (NER)

- After identifying all of the entities, you may need to combine some
    - David, Cameron, David Cameron, Mr. Cameron
- There will always be some errors!

Outline

- Why is NLP Hard?
- Twitter data
- Preparing data
- Dataset Statistics
- NLP Tasks
    - Named Entity Recognition (NER)
    - **Sentiment Analysis**
    - Topic Modeling
    - Word Embeddings

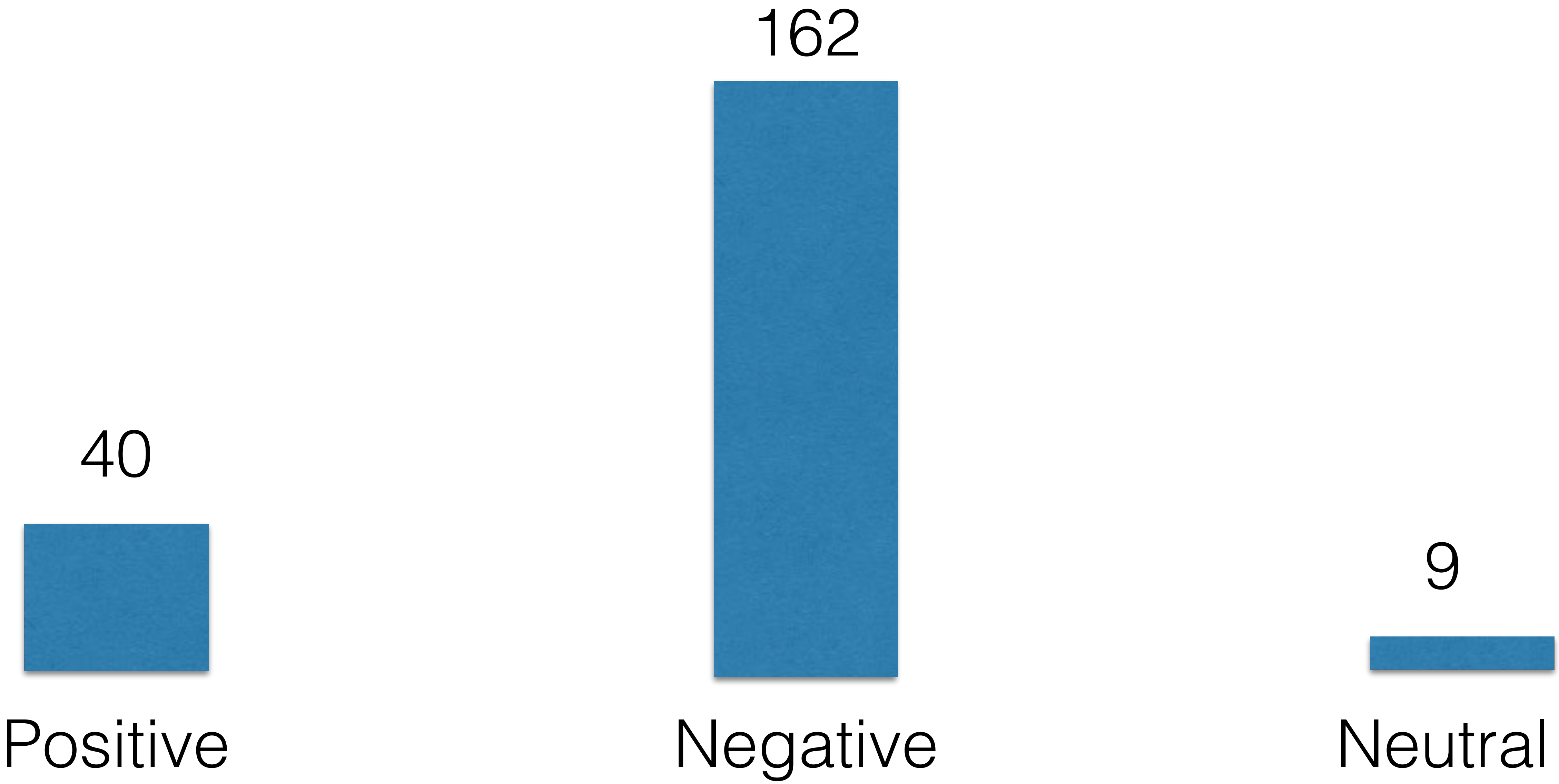
Sentiment Analysis

Sentiment Analysis

-	#followfriday @france_inte @pkuchly57 @milipol_paris for being top engaged members in my community this week :
-	@lamb2ja hey james !
:)	@despiteofficial we had a listen last night : as you bleed is an amazing track .'
:(	we do n't like to keep our lovely customers waiting for long !
:(	having boring time : do n't know what to do ...

Sentiment Analysis + NER!

Sentences including Justin Beiber



Sentiment Analysis

- Domain matters

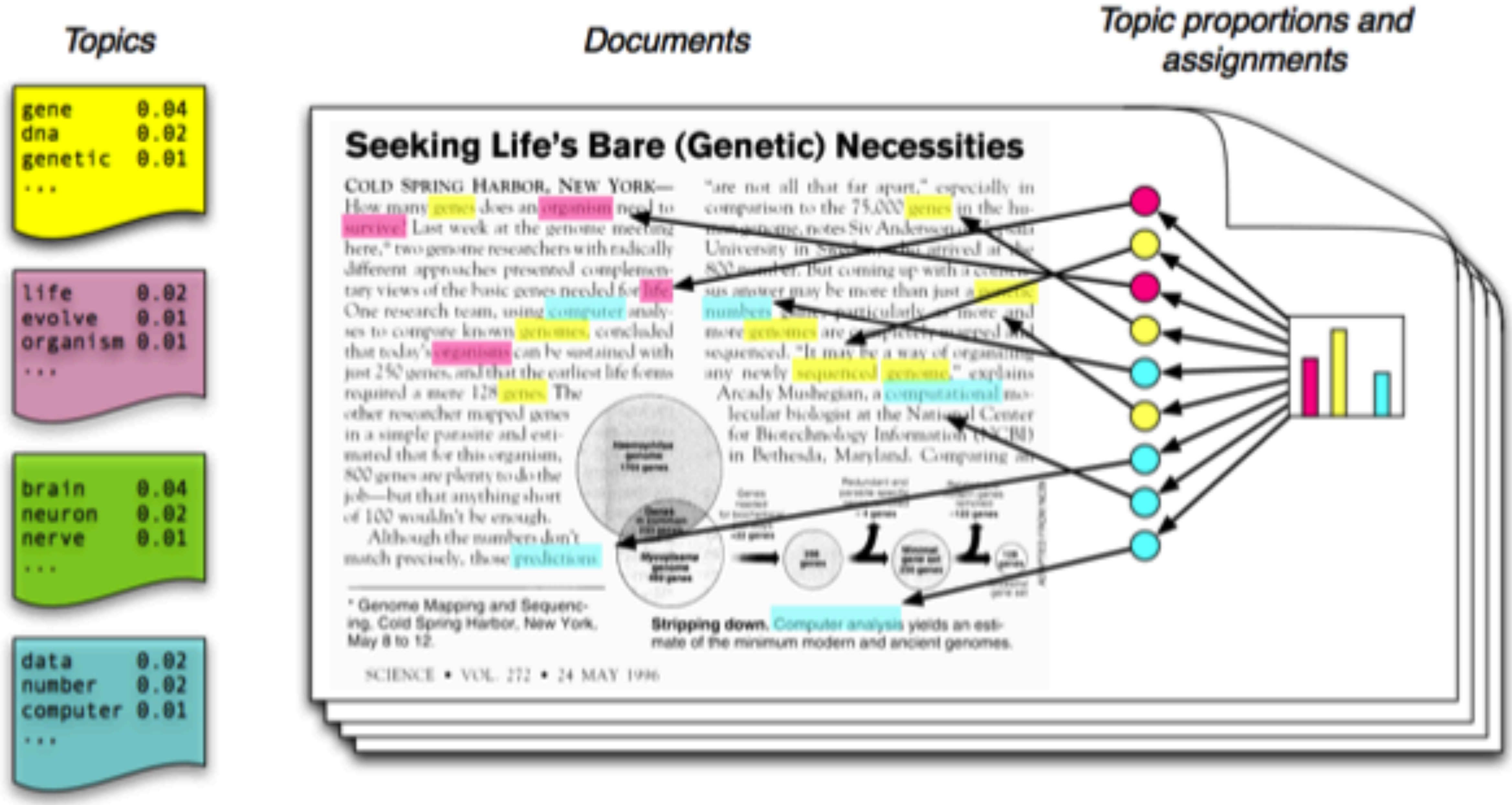
She’s a great athlete and she was not afraid to be aggressive.
This is a terrible restaurant. The wait staff were very aggressive.

Outline

- Why is NLP Hard?
- Twitter data
- Preparing data
- Dataset Statistics
- NLP Tasks
  - Named Entity Recognition (NER)
  - Sentiment Analysis
  - **Topic Modeling**
  - Word Embeddings

Topic Modeling

- Automatically identify topics in a document



Seeking Life's Bare (Genetic) Necessities

COLD SPRING HARBOR, NEW YORK— How many genes does an organism need to survive? Last week at the genome meeting here,* two genome researchers with radically different approaches presented complementary views of the basic genes needed for life. One research team, using computer analyses to compare known genomes, concluded that today's organisms can be sustained with just 250 genes, and that the earliest life forms required a mere 128 genes. The other researcher mapped genes in a simple parasite and estimated that for this organism, 800 genes are plenty to do the job—but that anything short of 100 wouldn't be enough.

Although the numbers don't match precisely, those predictions "are not all that far apart," especially in comparison to the 75,000 genes in the human genome, notes Siv Andersson of Uppsala University in Sweden, who arrived at the 800 number. But coming up with a consensus answer may be more than just a genetic numbers game, particularly as more and more genomes are completely mapped and sequenced. "It may be a way of organizing any newly sequenced genome," explains Arcady Mushegian, a computational molecular biologist at the National Center for Biotechnology Information (NCBI) in Bethesda, Maryland. Comparing an

Stripping down. Computer analysis yields an estimate of the minimum modern and ancient genomes.

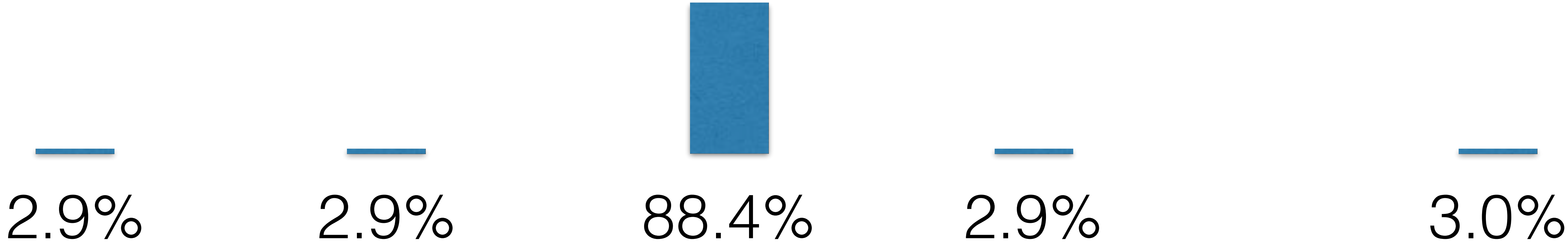
* Genome Mapping and Sequencing, Cold Spring Harbor, New York, May 8 to 12.

SCIENCE • VOL. 272 • 24 MAY 1996

Figure source: Blei, D. M. (2012). Probabilistic topic models. *Communications of the ACM*, *55*(4), 77-84.

Topic Modeling

cant	im	miss	please	im
d	want	sad	follow	followed
like	like	much	u	get
today	kik	cant	》	go
feel	know	get	♛	thanks
want	snapchat	thank	back	still
see	thanks	good	love	3
okay	tired	u	justin bieber	see
im	pls	one	day	wanna
makes	sick	oh	sorry	please



@joyster2012 @cathstaincliffe good for you, girl!!
best wishes :-)

Topic Modeling

- LDA is a common topic modeling algorithm
- Good for exploration
- Sometimes topics are hard to interpret
- The topic model depends heavily on the number of topics you choose

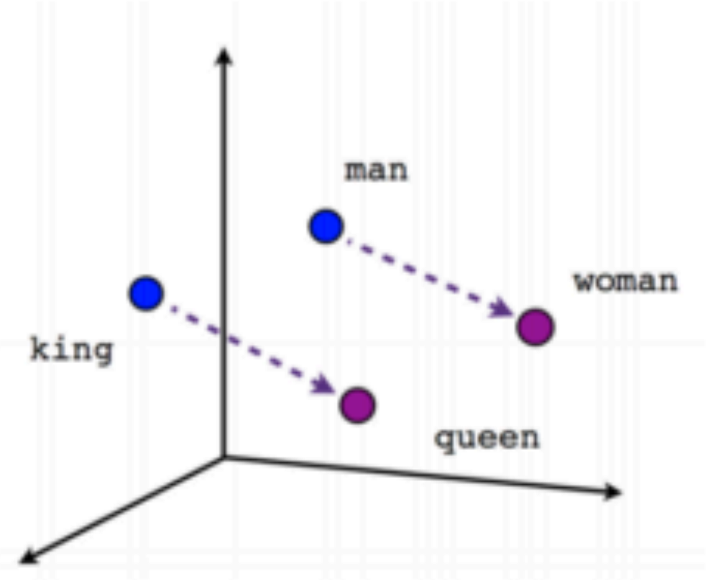
Outline

- Why is NLP Hard?
- Twitter data
- Preparing data
- Dataset Statistics
- NLP Tasks
  - Named Entity Recognition (NER)
  - Sentiment Analysis
  - Topic Modeling
  - **Word Embeddings**

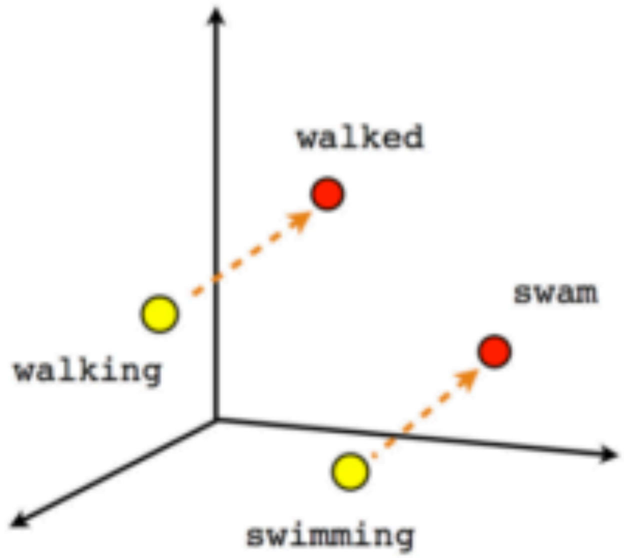
Word Embeddings

- **Word representations** that try to capture some of the meaning of the word

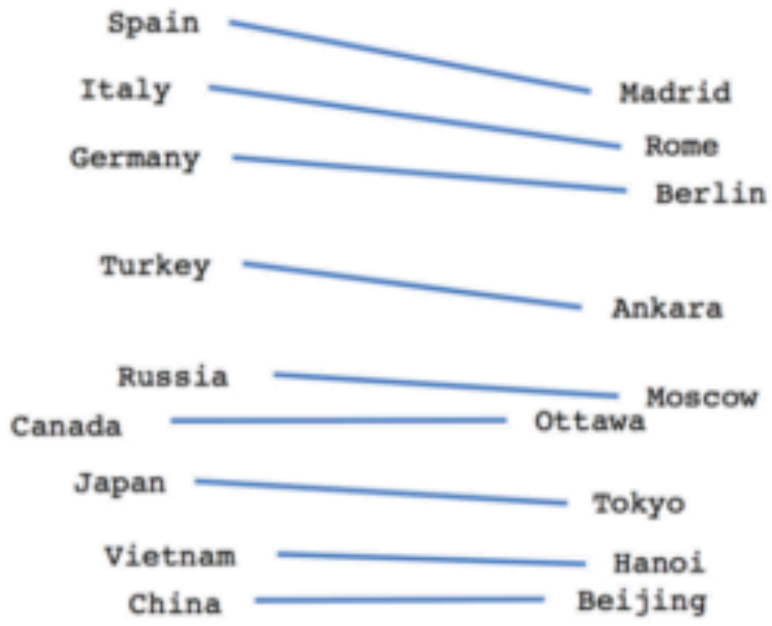
- You can think of them as high-dimensional points for each word (usually dimension = 300)



Male-Female



Verb tense



Country-Capital

Word Embeddings

- What can you do with word embeddings?

1. Use them as features in a machine learning algorithm (e.g., classification, regression)

2. Calculate the similarity between two words

3. Find similar words

Word Embeddings

- A flexible way to represent the meaning of words!
- If you have enough data, you can train your own (see Gensim's word2vec)
- If not, you can download pre-trained word embeddings
  - https://www.quora.com/Where-can-I-find-some-pre-trained-word-vectors-for-natural-language-processing-understanding

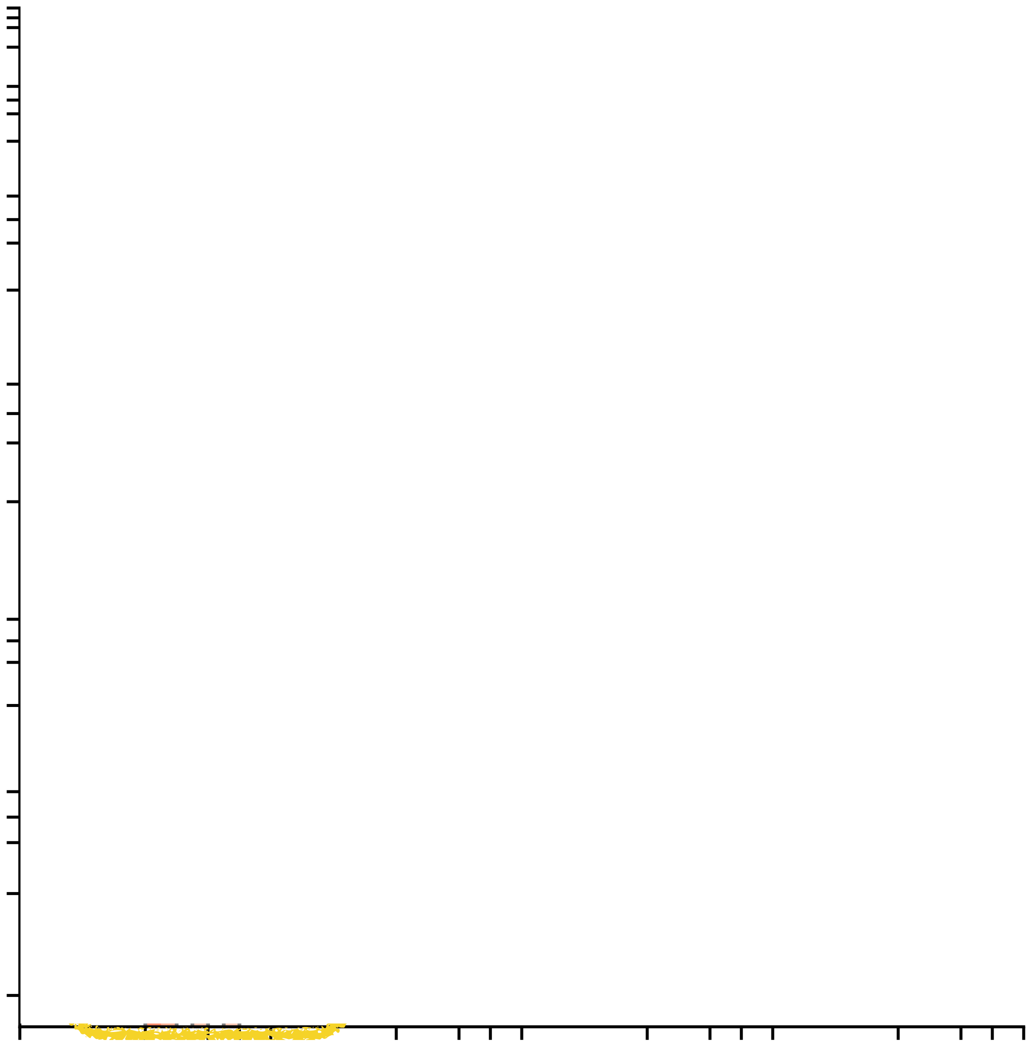
Factors Influencing the Surprising Instability of Word Embeddings

Laura Wendlandt, Jonathan K. Kummerfeld, Rada Mihalcea
University of Michigan

This material is based in part upon work supported by the National Science Foundation (NSF #1344257) and the Michigan Institute for Data Science (MIDAS).

The Problem

Many common embedding algorithms have large amounts of instability.



high frequency =
→ high stability

→ **???**

low frequency =
→ low stability

What is Stability?

Stability = *percent overlap between ten nearest neighbors in an embedding space*

philadelphia
national
metropolitan
egyptian
international
folk
rhode
society
chairwoman
debut
reinstallation

metropolitan
exhibitions
ballet
bard
international
national
chicago
state
society
whitney
rhode

Stability = 40%

Stability within domains is greater than across domains.