# Word Vectors

Princeton AI4ALL: NLP Group

# What’s Next

# Overview of the Week

- Monday (today)
  - 1-3: Introduction to Word Vectors
- Tuesday
  - 1-3: Word Vectors + FNC
- Wednesday
  - 1-3: Lexical Overlaps
- Thursday
  - 9:30-12: Putting together the FNC + Discussion
  - 1-3: Minipresentations (10 minutes per person) + Free time to work on presentation.
- Friday
  - 9:30-10:30: Free time to finish/practice presentation.
  - 10:30-12, 1-3: Presentations with other groups.

# Info about NLP & Ethics/Policy minipresentations

- Find a topic related to NLP and ethics/policy (can be a paper, news article, general topic of debate).
- Prepare either a presentation with slides, or a few questions for debate/discussion.
- Lead a mini-session about this topic!
- We can do sign-ups to avoid overlaps.

# Info about presentations

Friday presentation sessions: 20 min to educate other campers about their project + 10 min for questions

Audience: other campers

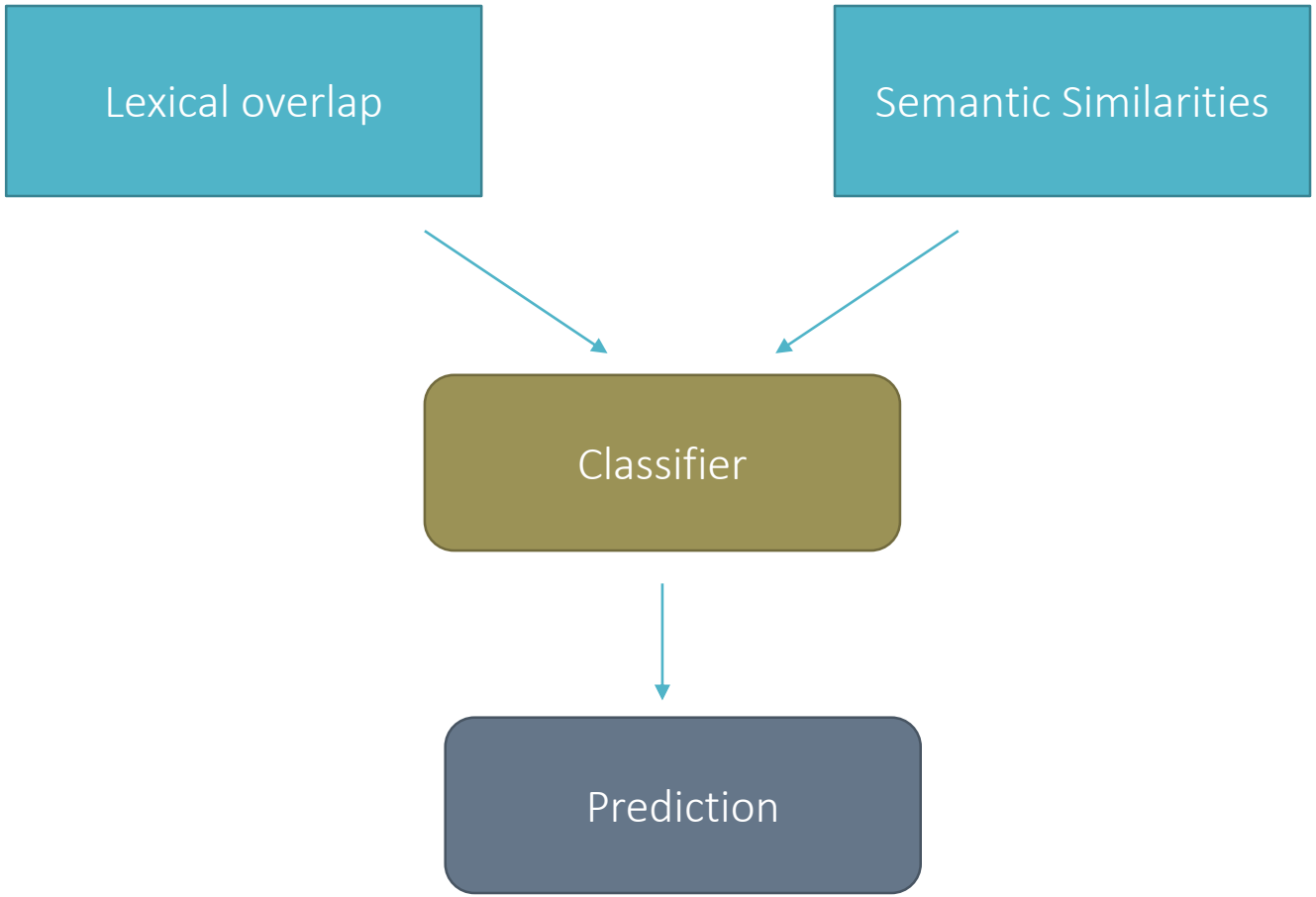
Visuals: Poster/slides/handouts/something creative

Friday banquet: 5 min to give a spotlight about project.

Audience: visitors

No visuals

# Overview of the FNC Classifier



# How should we represent words?


https://www.fluentu.com/blog/educator-english/wp-content/uploads/sites/13/2014/11/beginner-esl-vocabulary-how-to-teach-100-words-in-one-lesson.jpg

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https://foodscapesbristol.files.wordpress.com/2013/07/day-5.jpg
https://antarasdiary.com/30-brilliant-typography-inspirations-featuring-the-word-summer/
https://www.canstockphoto.com/music-word-cloud-34509746.html

# To communicate this information to computers…

To communicate this information to computers…

quantitatively represent words,

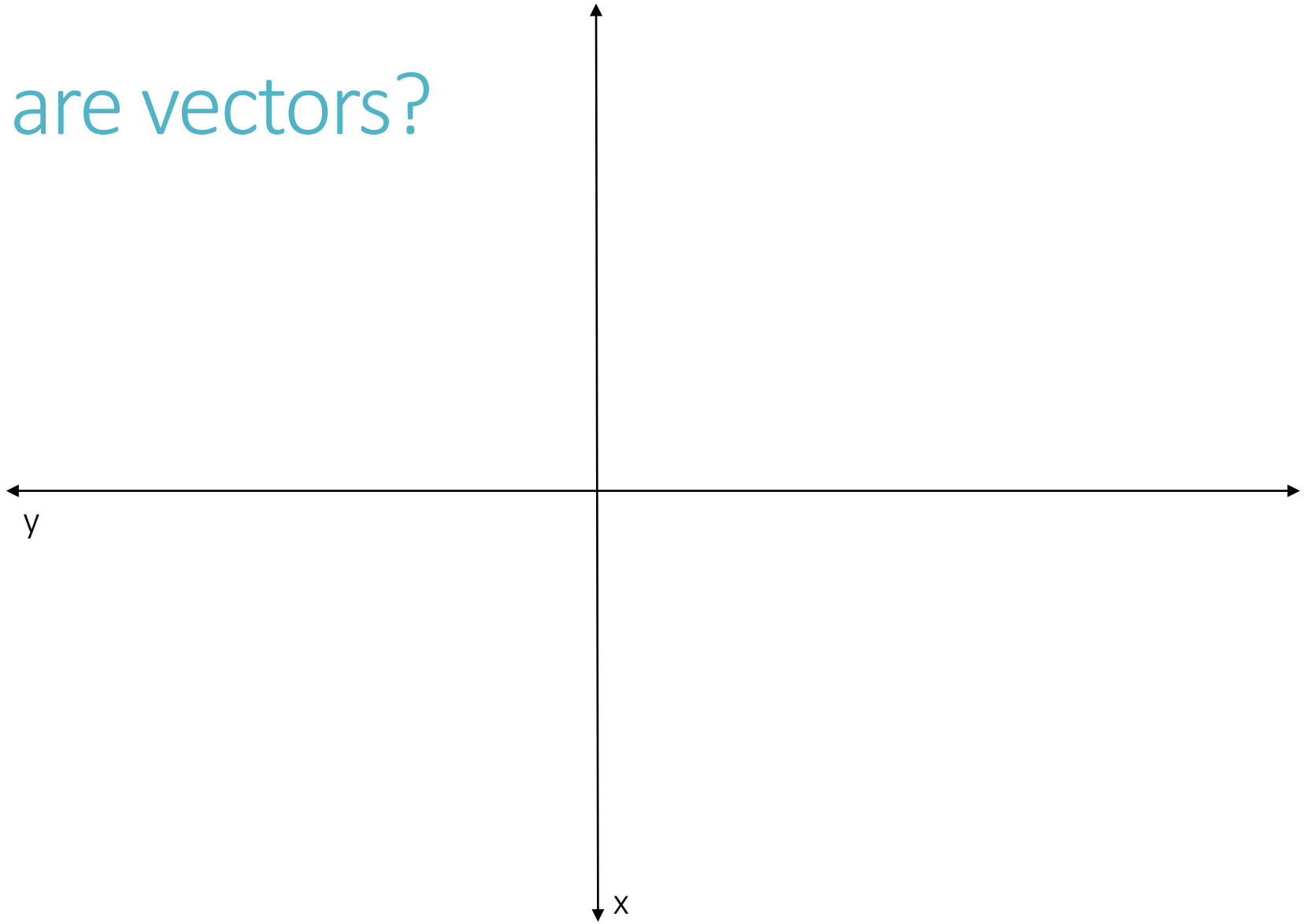
To communicate this information to computers…

quantitatively represent words,

where more similar words have similar representations

# What are word vectors?

# What are vectors?



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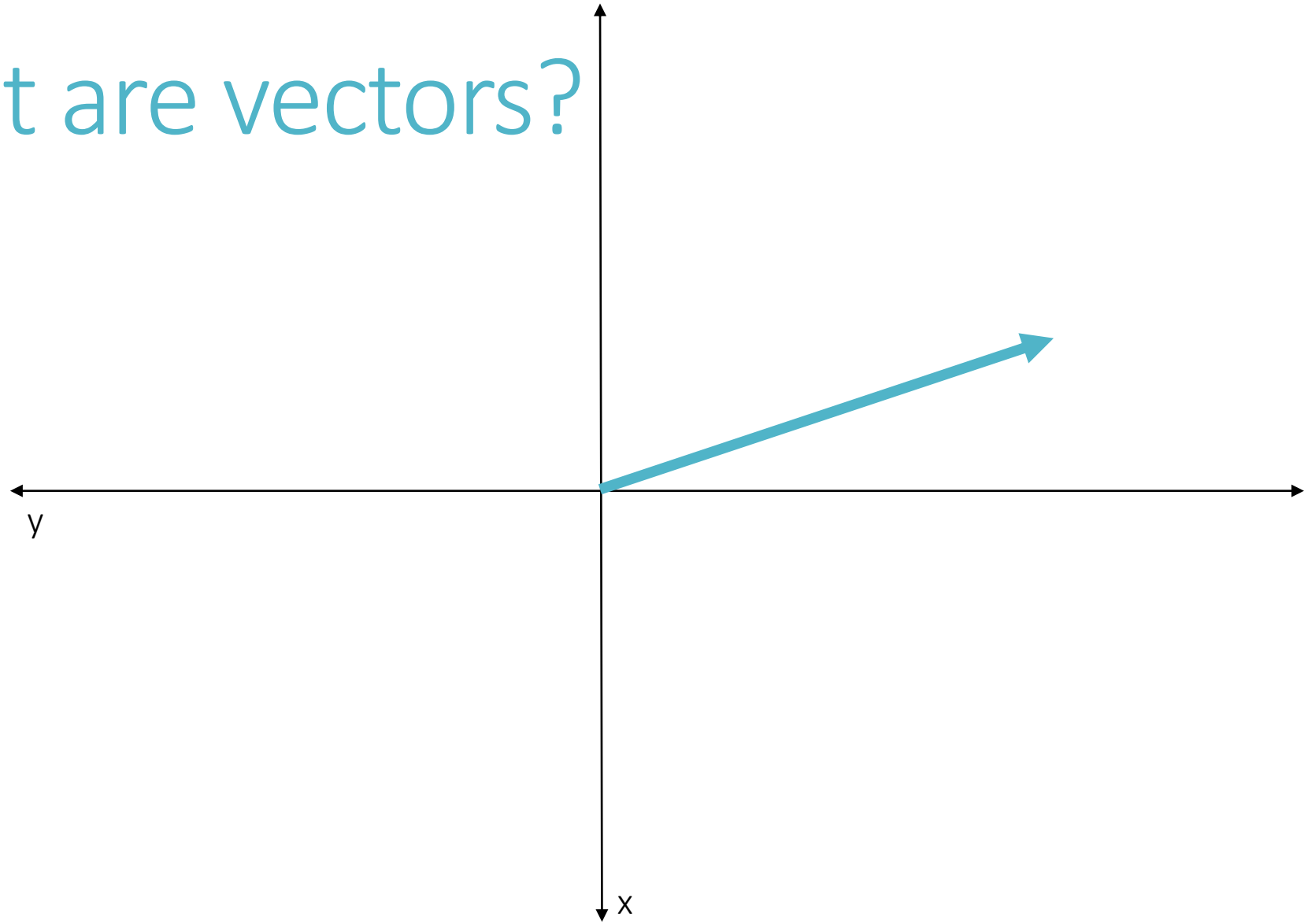

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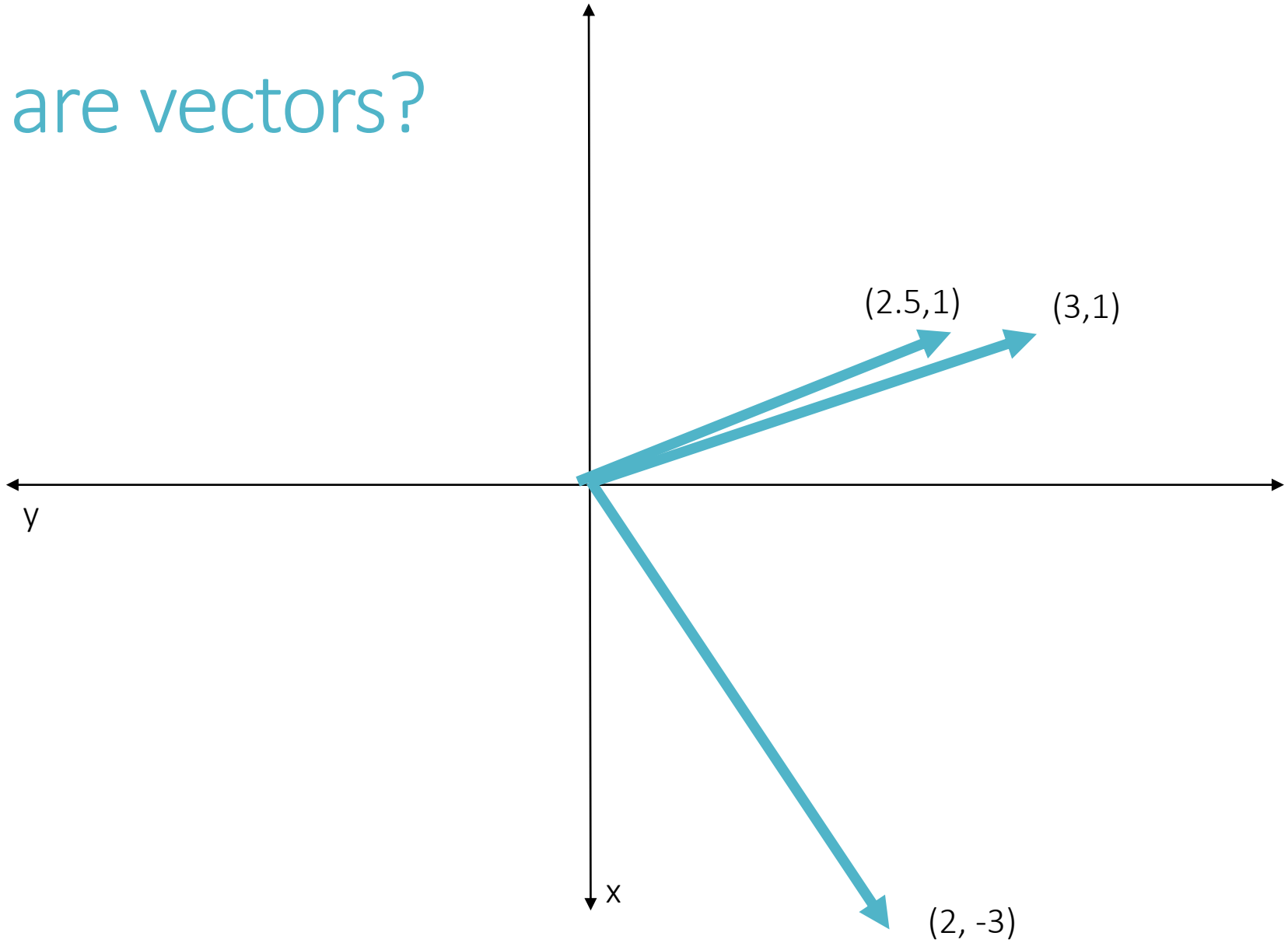
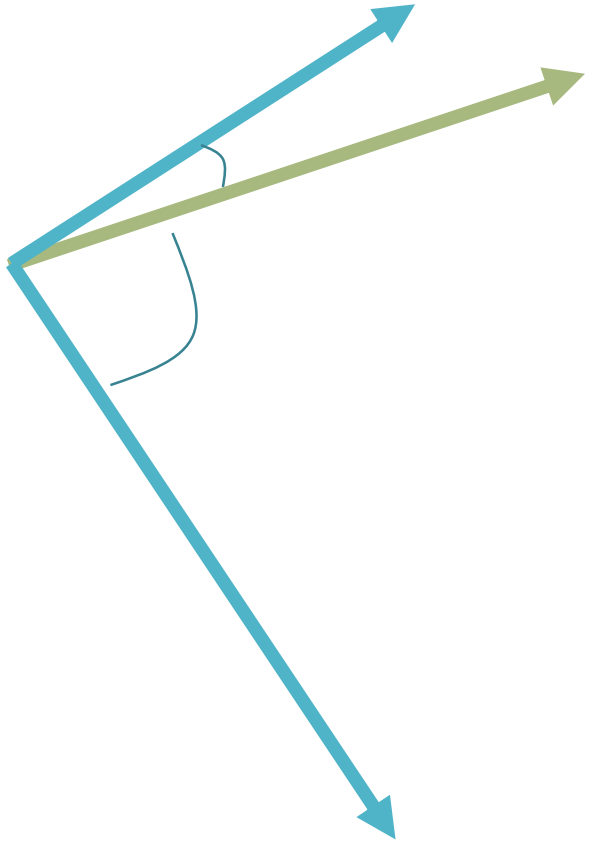


# How do we measure similarity between vectors?



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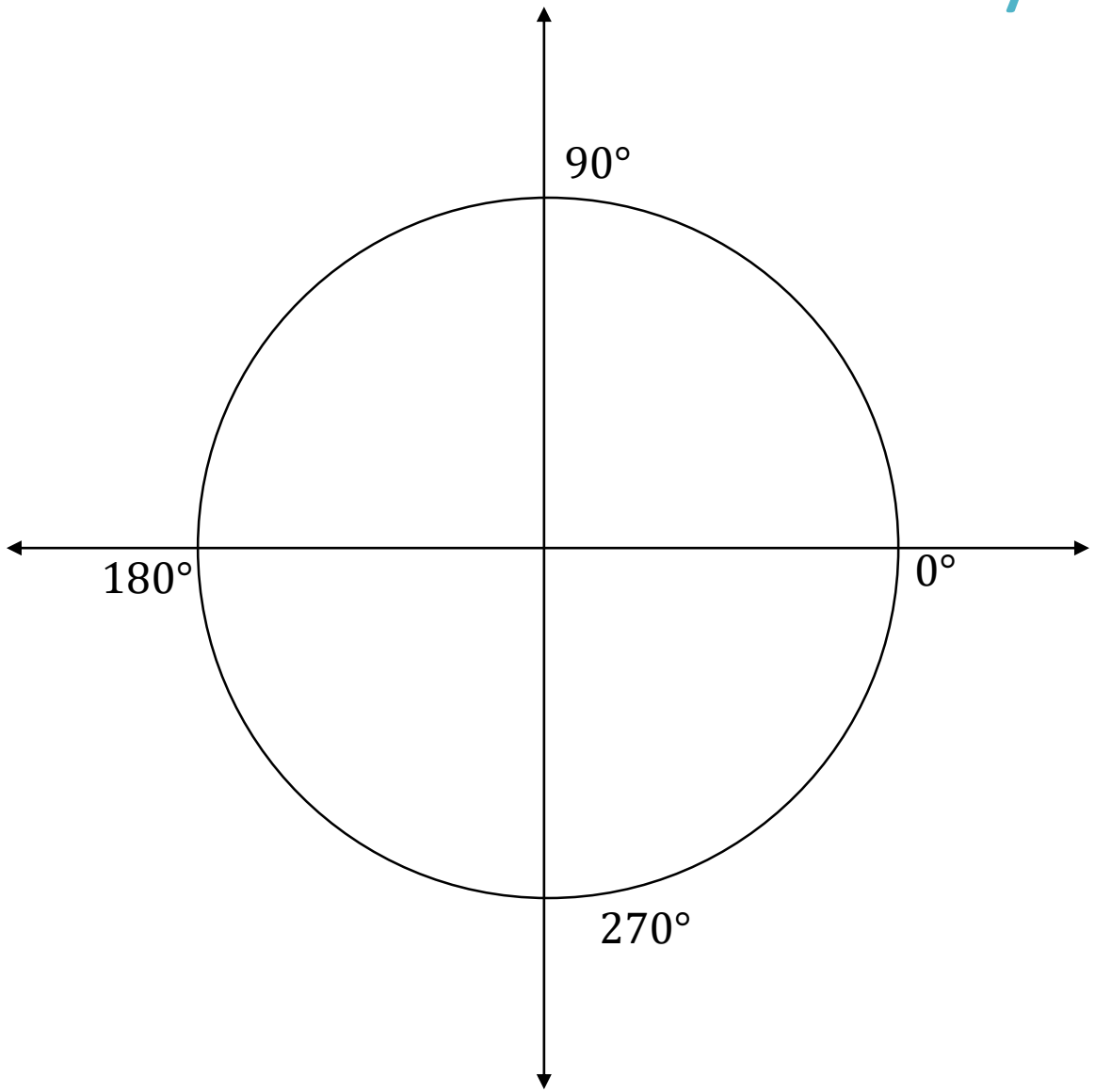

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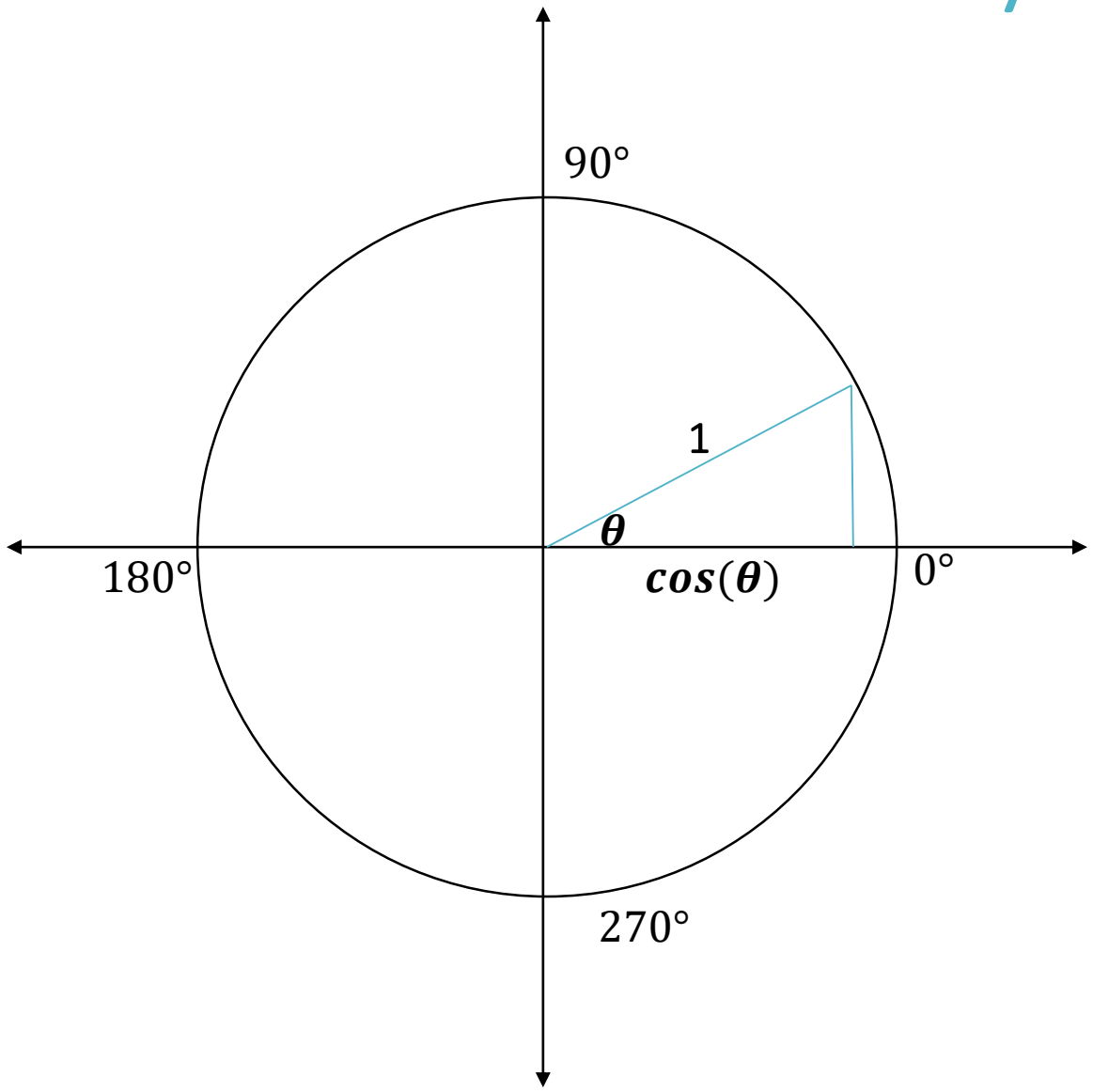

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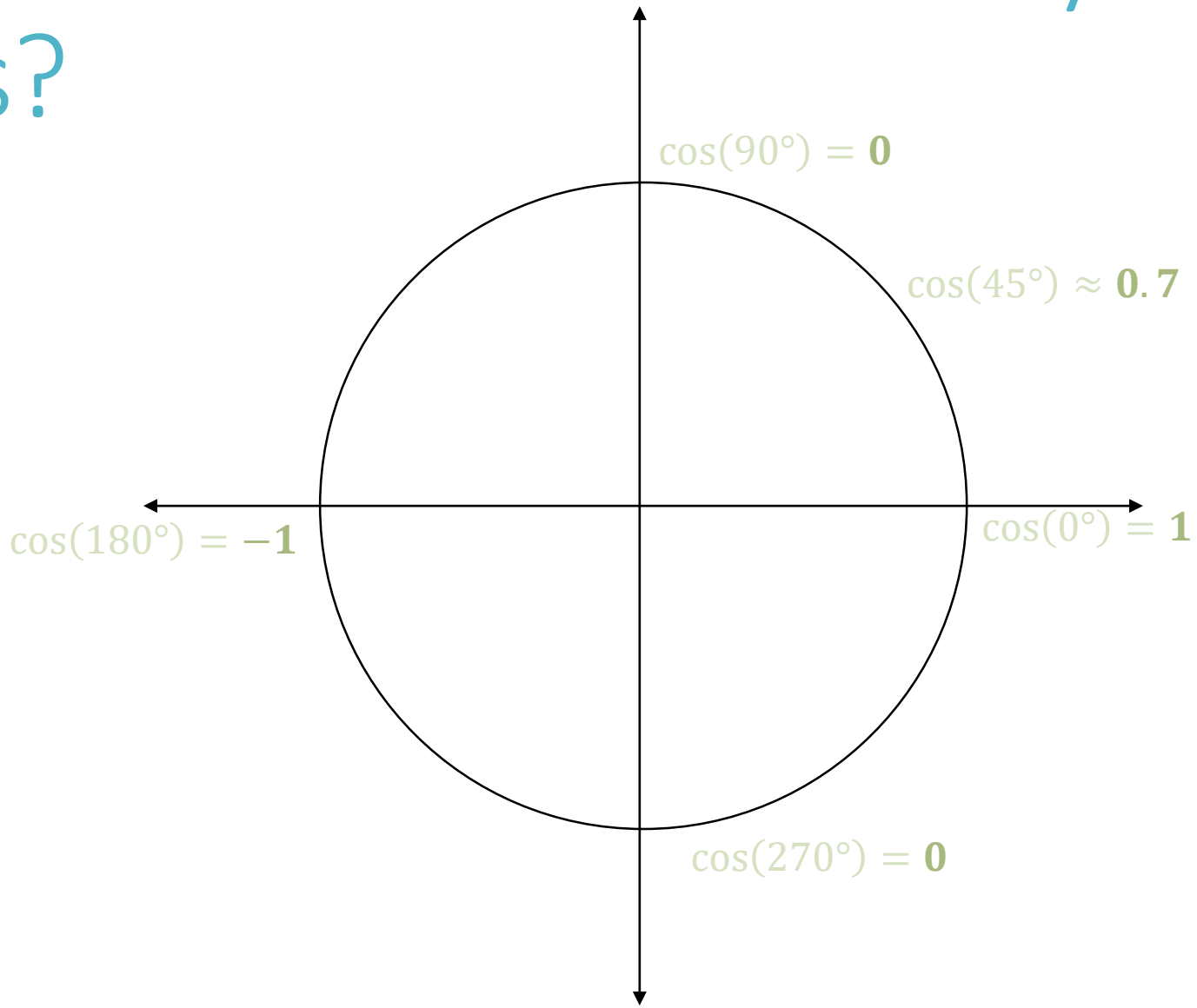

# How do we measure similarity between vectors?

Use the cosine similarity between vectors

# What if we want more information?

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Vectors in 2 dimensions

| | | |
|---|---|---|
| 3 | 2.5 | 2 |
| 1 | 1 | -3 |

Vectors in 6 dimensions

| | |
|---|---|
| 3 | 2.5 |
| 1 | 1 |
| -2 | 0.5 |
| 4 | -2 |
| 1 | 9 |
| 0.7 | 1 |

# What if we want more information?

Vectors in 6 dimensions

| | |
|---|---|
| 3 | 2.5 |
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| -2 | 0.5 |
| 4 | -2 |
| 1 | 9 |
| 0.7 | 1 |

$$\text{cosine similarity (a, b)} = \frac{a \cdot b}{||a|| \cdot ||b||}$$

# How do we create word vectors?

# How do we know if words are similar?

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PRINCETON UNIVERSITY

## WordNet

A Lexical Database for English

- What is WordNet
- People
- News
- Use Wordnet Online
- Download
- Citing WordNet
- License and Commercial Use
- Related Projects
- Documentation
- Publications

### What is WordNet?

*Any opinions, findings, and conclusions or recommendations expressed in this material are those of the creators of WordNet and do not necessarily reflect the views of any funding agency or Princeton University.*

When writing a paper or producing a software application, tool, or interface based on WordNet, it is necessary to properly cite the source. Citation figures are critical to WordNet funding.

### About WordNet

WordNet® is a large lexical database of English. Nouns, verbs, adjectives and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept. Synsets are interlinked by means of conceptual-semantic and lexical relations. The resulting network of meaningfully related words and concepts can be navigated with the browser. WordNet is also freely and publicly available for download. WordNet's structure makes it a useful tool for computational linguistics and natural language processing.


https://wordnet.princeton.edu/
https://www.cs.princeton.edu/courses/archive/fall12/cos226/assignments/wordnet.html

# How do we know if words are similar?

## Natural language processing

From Wikipedia, the free encyclopedia

*This article is about language processing by computers. For the processing of language by the human brain, see Language processing in the brain.*

**Natural language processing** (**NLP**) is an area of computer science and artificial intelligence concerned with the interactions between computers and human (natural) languages, in particular how to program computers to process and analyze large amounts of natural language data.

Challenges in natural language processing frequently involve speech recognition, natural language understanding, and natural language generation.

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# Distributional Hypothesis

“You shall know a word by the company it keeps”

- John Rupert Firth (1957)

# How do we find the distribution of nearby words?

1. Count cooccurrence within a window of size $n$
2. Create a vector cooccurrences

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1. Count cooccurrence within a window of size $n$
2. Create a vector cooccurrences

Any problems with this?

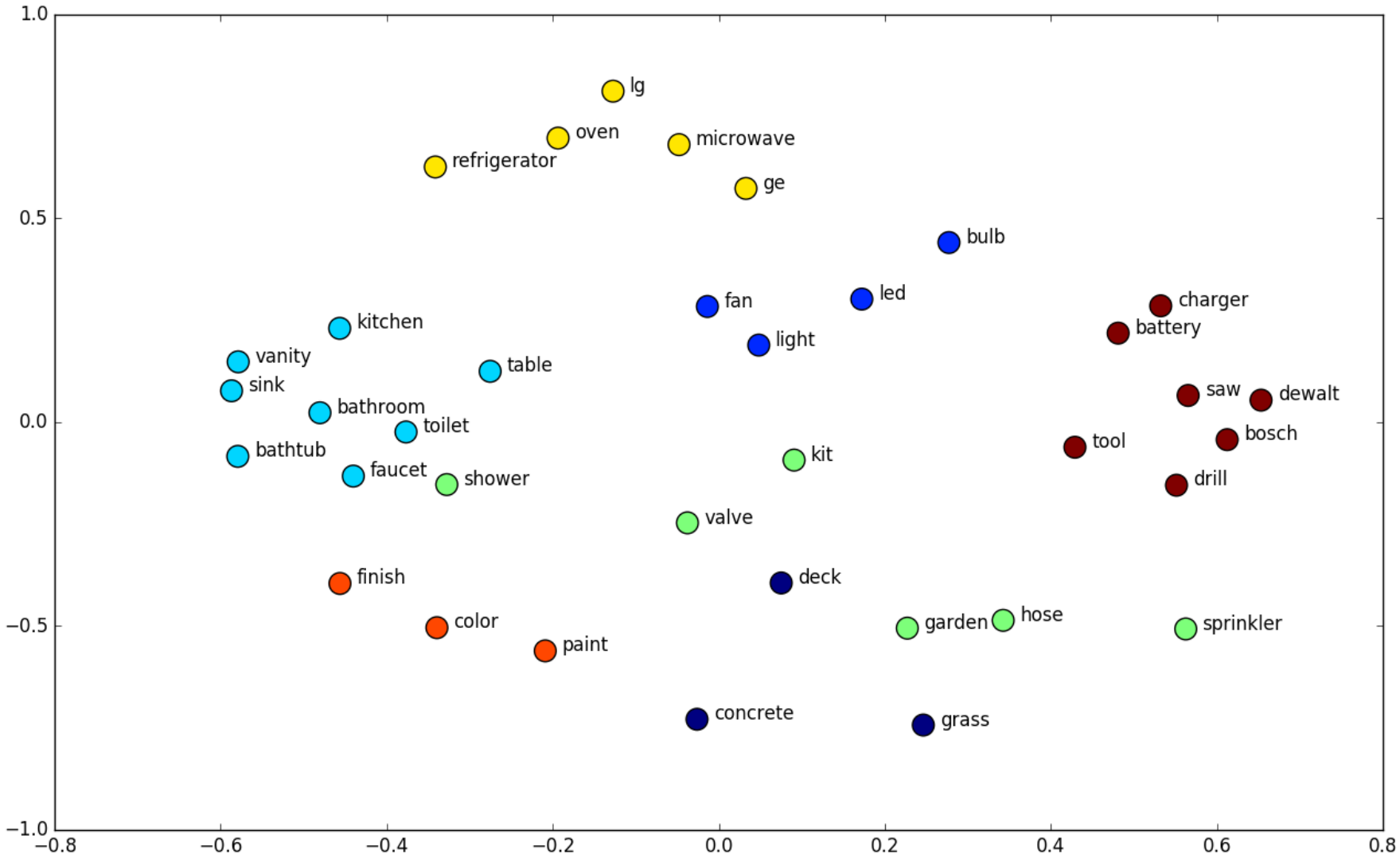
# Some words are more informative than others…

# Pointwise Mutual Information (PMI)

$$PMI(a,b) = \log \frac{P(a,b)}{P(a)P(b)}$$

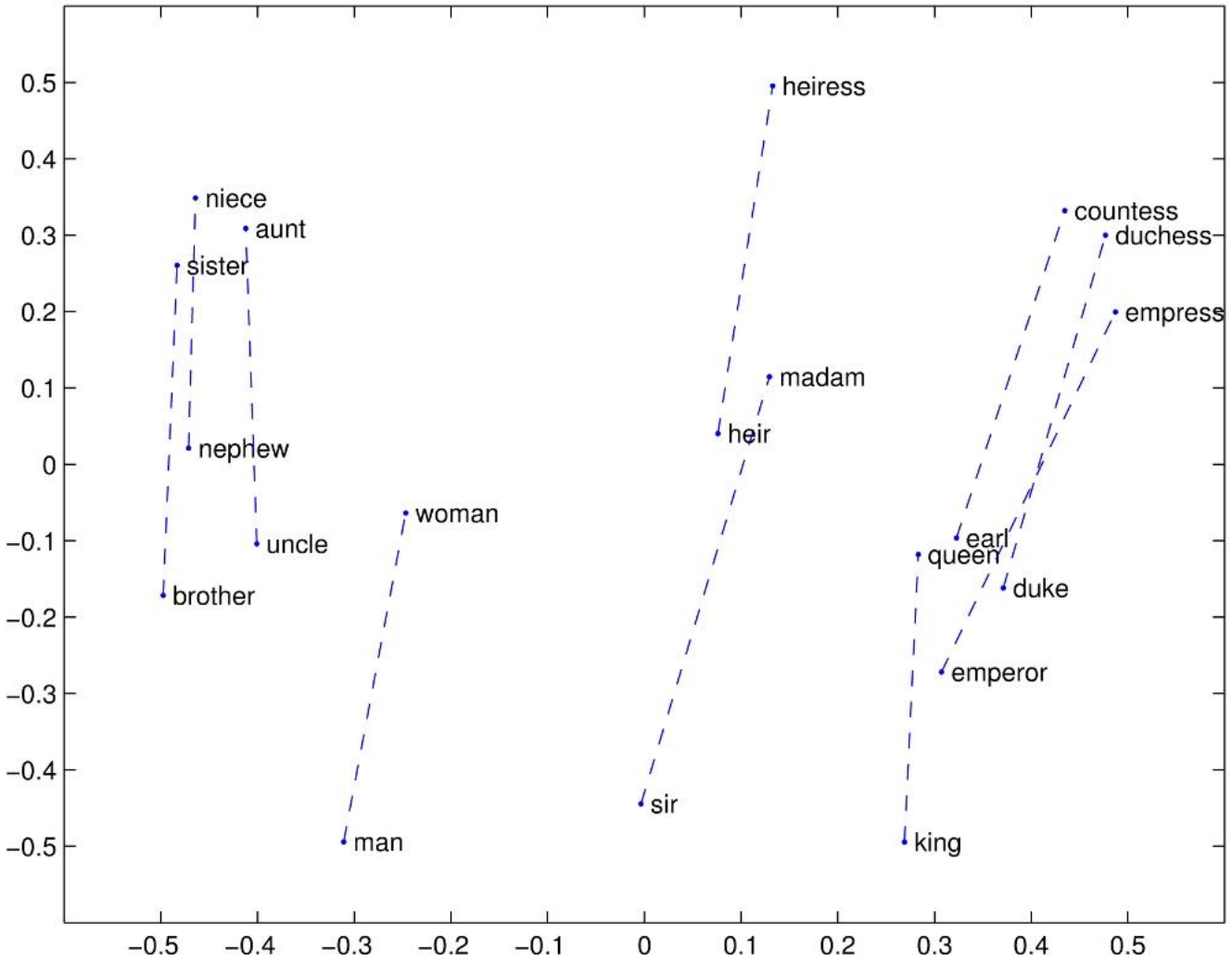
# How can we represent sentences given word embeddings?

# How can we use word vectors?




https://towardsdatascience.com/deep-learning-structured-data-8d6a278f3088


http://ruder.io/word-embeddings-2017/




https://nlp.stanford.edu/projects/glove/images/man_woman.jpg

# Man is to Computer Programmer

**Tolga Bolukbasi**[1], **Kai-Wei Chang**[2], **James Zou**[2], **Venkatesh Saligrama**[1,2], **Adam Kalai**[2]
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[2]Microsoft Research New England, 1 Memorial Drive, Cambridge, MA
tolgab@bu.edu, kw@kwchang.net, jamesyzou@gmail.com, srv@bu.edu, adam.kalai@microsoft.com

$$\overrightarrow{\text{man}} - \overrightarrow{\text{woman}} \approx \overrightarrow{\text{king}} - \overrightarrow{\text{queen}}$$

https://papers.nips.cc/paper/6228-man-is-to-computer-programmer-as-woman-is-to-homemaker-debiasing-word-embeddings.pdf

# Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings

**Tolga Bolukbasi**[1], **Kai-Wei Chang**[2], **James Zou**[2], **Venkatesh Saligrama**[1,2], **Adam Kalai**[2]
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[2]Microsoft Research New England, 1 Memorial Drive, Cambridge, MA
tolgab@bu.edu, kw@kwchang.net, jamesyzou@gmail.com, srv@bu.edu, adam.kalai@microsoft.com

$$\overrightarrow{\text{man}} - \overrightarrow{\text{woman}} \approx \overrightarrow{\text{king}} - \overrightarrow{\text{queen}}.$$

$$\overrightarrow{\text{man}} - \overrightarrow{\text{woman}} \approx \overrightarrow{\text{computer programmer}} - \overrightarrow{\text{homemaker}}.$$

https://papers.nips.cc/paper/6228-man-is-to-computer-programmer-as-woman-is-to-homemaker-debiasing-word-embeddings.pdf

| Extreme *she* | Extreme *he* |
|---|---|
| 1. homemaker | 1. maestro |
| 2. nurse | 2. skipper |
| 3. receptionist | 3. protege |
| 4. librarian | 4. philosopher |
| 5. socialite | 5. captain |
| 6. hairdresser | 6. architect |
| 7. nanny | 7. financier |
| 8. bookkeeper | 8. warrior |
| 9. stylist | 9. broadcaster |
| 10. housekeeper | 10. magician |

**Gender stereotype *she-he* analogies**

| | | |
|---|---|---|
| sewing-carpentry | registered nurse-physician | housewife-shopkeeper |
| nurse-surgeon | interior designer-architect | softball-baseball |
| blond-burly | feminism-conservatism | cosmetics-pharmaceuticals |
| giggle-chuckle | vocalist-guitarist | petite-lanky |
| sassy-snappy | diva-superstar | charming-affable |
| volleyball-football | cupcakes-pizzas | lovely-brilliant |

**Gender appropriate *she-he* analogies**

| | | |
|---|---|---|
| queen-king | sister-brother | mother-father |
| waitress-waiter | ovarian cancer-prostate cancer | convent-monastery |

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Github.com/cchen23/AI4ALL_NLP_Student

Day10_WordVectors.zip

source ~/miniconda3/bin/activate

jupyter notebook

Poll for tomorrow's review:
http://bit.ly/2ANGceX

# Mini-presentation sign-ups

http://bit.ly/2M6dJ8K