

# Using Embeddings to Understand the Variance and Evolution of Data Science Skill Sets

Maryam Jahanshahi Ph.D.  
Research Scientist  
TapRecruit

**tap**Recruit.co

<http://bit.ly/pydatanyc-emb>

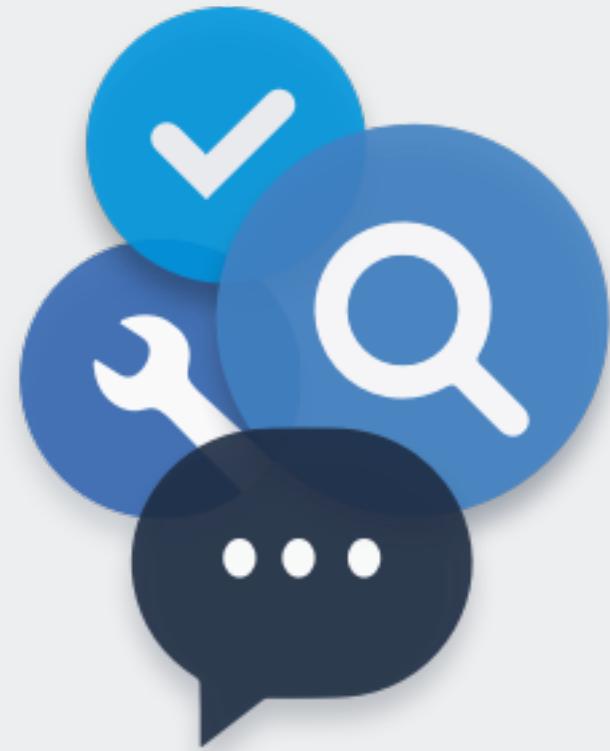
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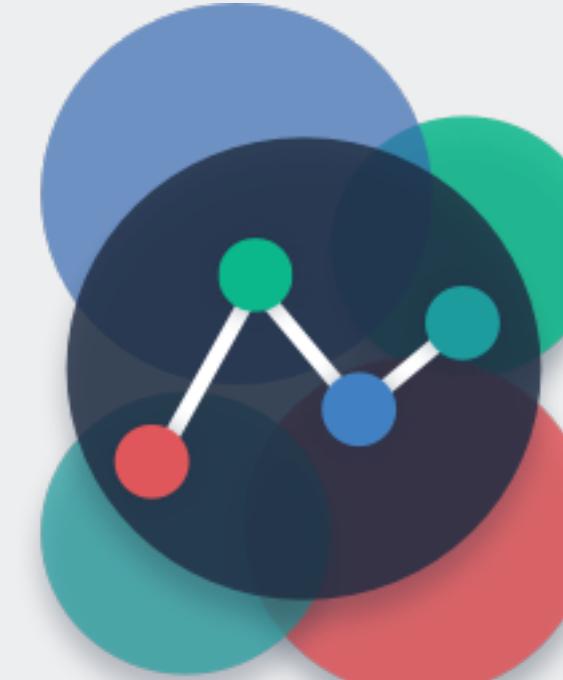


# TapRecruit uses NLP to understand and organize natural language career content

Smart Editor  
for Job Descriptions



Active Pipeline  
Health Monitoring



Multifaceted Salary  
Estimation





28

Job will perform poorly

This job scores **lower than 95%** of Junior Accounting jobs in Los Angeles, CA



- Add preferred qualifications
- Add more "you" statements
- Perks included
- Equal opportunity statement is included

Neutral

Gendered



## Senior Finance Analyst

TapRecruit - Los Angeles

\$76,300 BETA  
 \$65,200      \$98,600

TapRecruit is looking for a smart, detail-oriented person to serve as a senior financial analyst. This person will be responsible for supporting the company's FP&A requirements. Responsibilities will include working on TapRecruit Entertainment Group's FP&A model, supporting analysis for long term planning options, tracking key business operational metrics and producing monthly financial/operational reports. The role will require strong organizational skills to help manage the senior managers across the department and evaluate/implement management. This is a dynamic role that serves the finance department of Finance and will routinely interface with TapRecruit's top management. Language that emphasizes an "intense" or "confusing" environment is known to deter qualified candidates.

>Delete

This is an ideal position for an individual who has gained strong accounting firm and now seeks to apply those skills to a fast-growing entrepreneurial company. Strong quantitative and excel financial modeling skills are a must. The ideal candidate must be comfortable in a dynamic start-up environment, will bring energy and passion to everything he/she does, and will not be afraid to roll up his/her sleeves to tackle challenging analytical assignments.

This job is full-time, based in Los Angeles. We offer competitive compensation and stock option program.

### Responsibilities:

- Provide financial support to News group and overall FP&A / corporate finance department

# Language matters in job descriptions

**Same title,  
Different job**

## Finance Manager

Kraft Foods

**Junior (3 Years)**  
**No Managerial Experience**

## Finance Manager

Kraft Foods

**Senior (6-8 Years)**  
**Division Level Controller**  
**Strategic Finance Role**  
**MBA / CPA**

**Same Title**

**Required Experience**  
**Required Responsibility**  
**Preferred Skill**  
**Required Education**

**Different title,  
Same job**

## Performance Marketing Manager

PocketGems

**Mid-Level**  
**Quantitative Focus**  
**Expertise iBanking**  
**Data Analysis Tools (SQL)**  
**Consulting Experience Preferred**  
**MBA Preferred**

## Senior Analyst, Customer Strategy

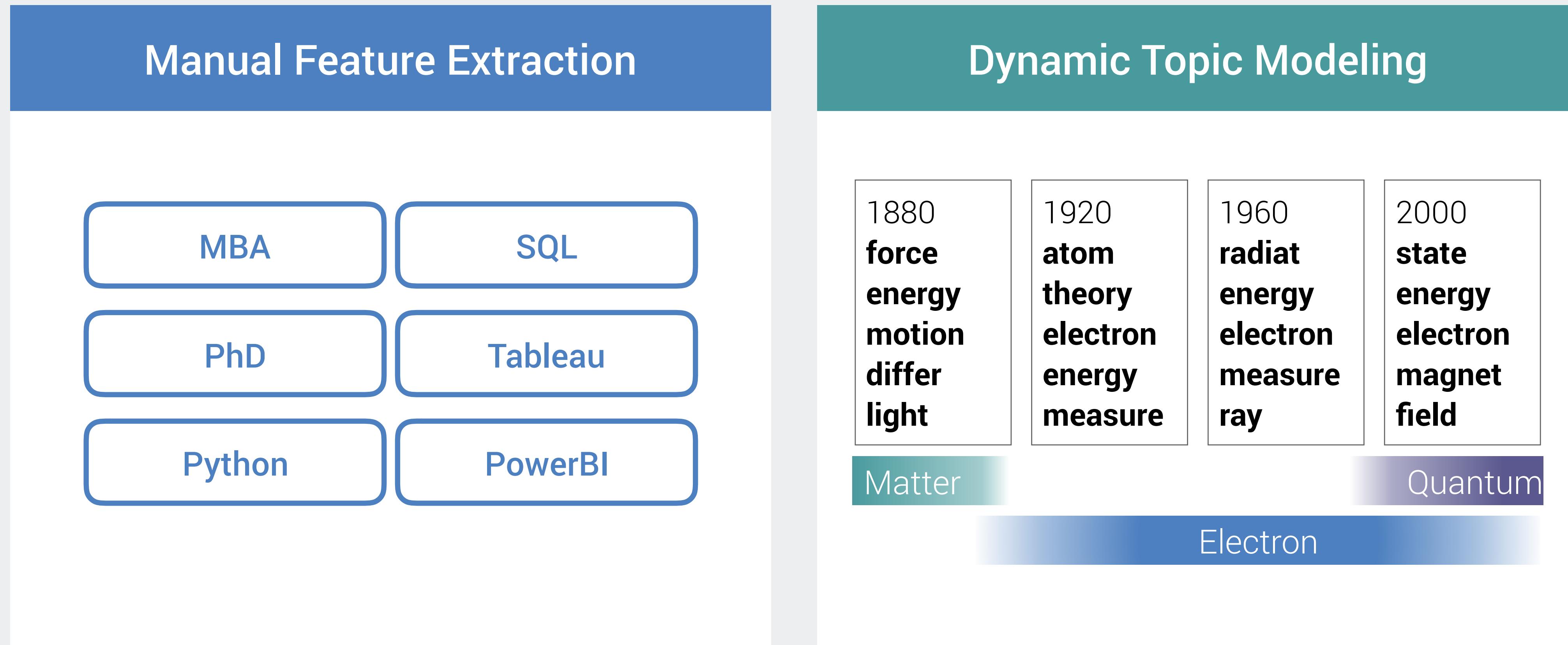
The Gap

**Mid-Level**  
**Quantitative Focus**  
**Expertise iBanking**  
**Relational Database Experience**  
**External Consulting Experience Preferred**  
**BA degree in business, finance, MBA**  
**Preferred**

**Required Experience**  
**Required Skills**  
**Required Experience**  
**Required Skills**  
**Preferred Experience**  
**Required and Preferred Education**

How have data science skills  
changed over time?

# How have data science skills changed over time?

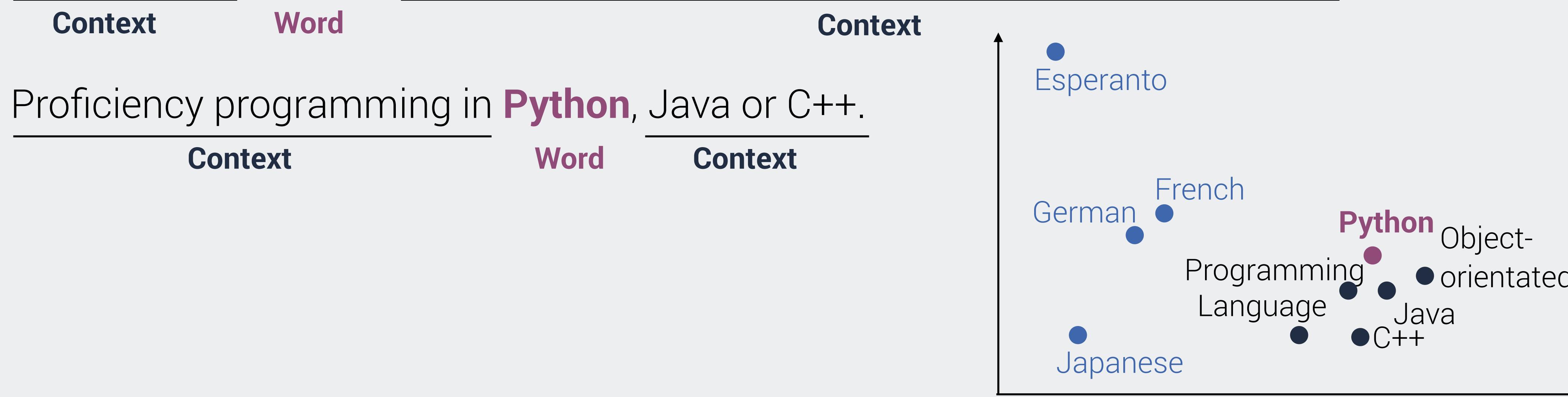


Adapted from Blei and Lafferty, [ICML 2006](#).

# Word embeddings capture semantic similarities

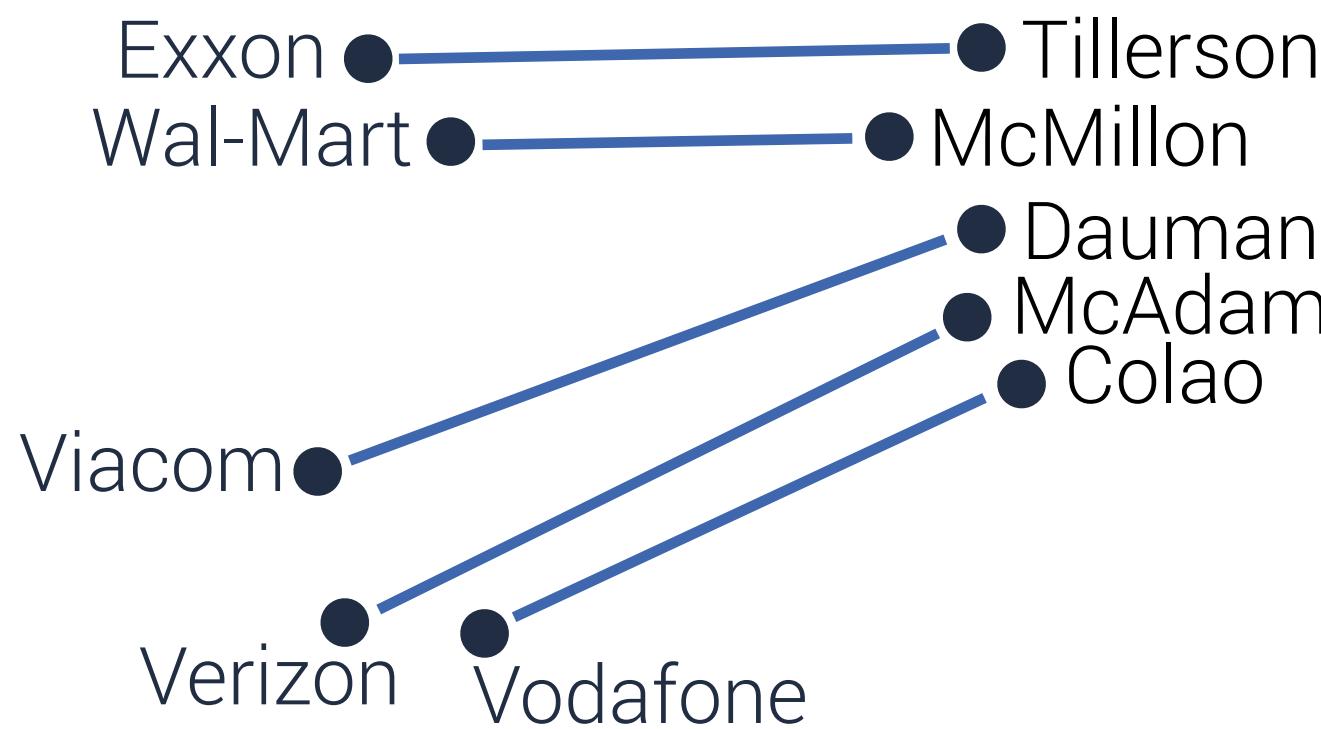
Statistical modeling through software (e.g. SPSS) or programming language (e.g. **Python**)

Experience in **Python**, Java or other object-oriented programming languages

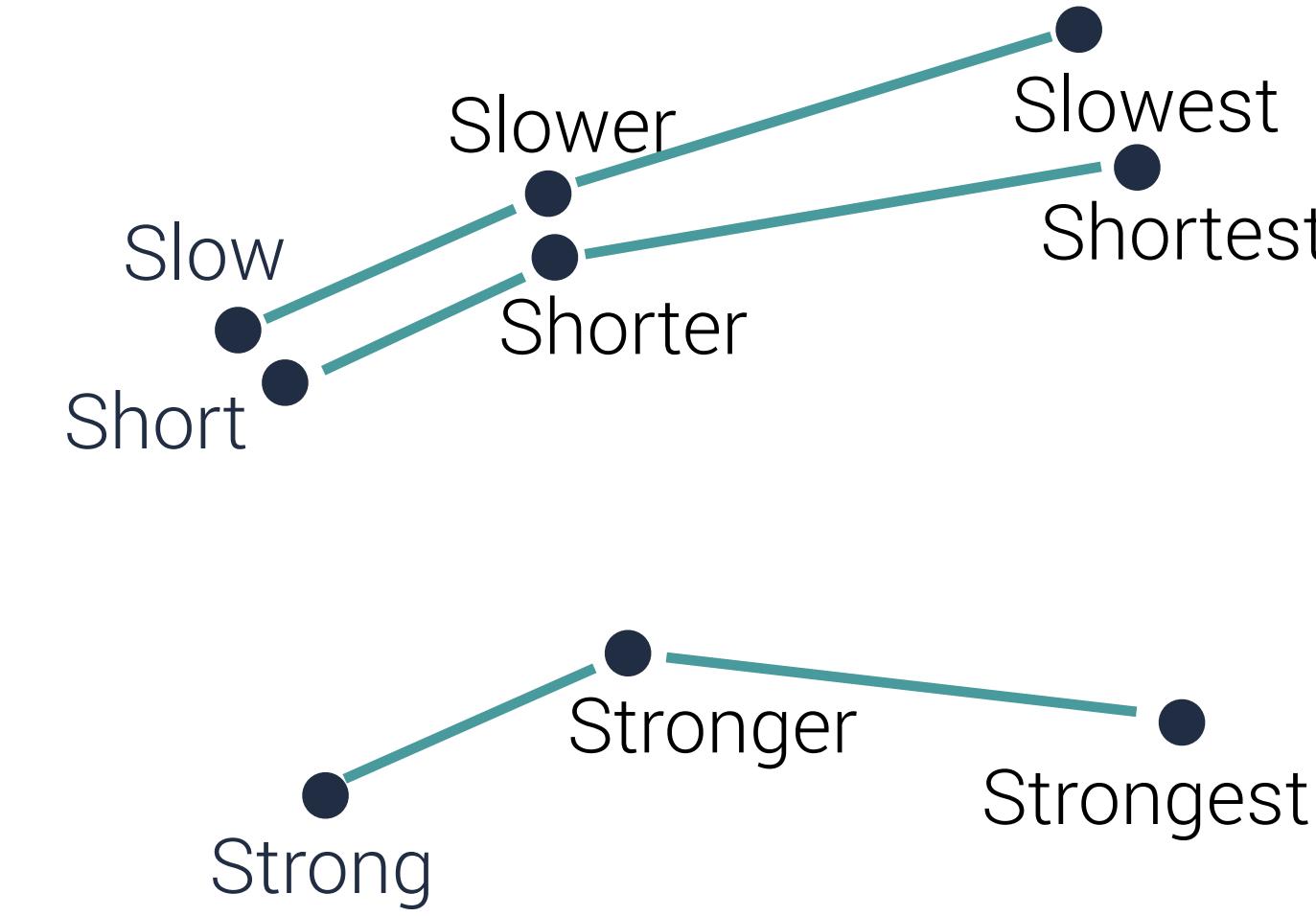


# Embeddings capture entity relationships

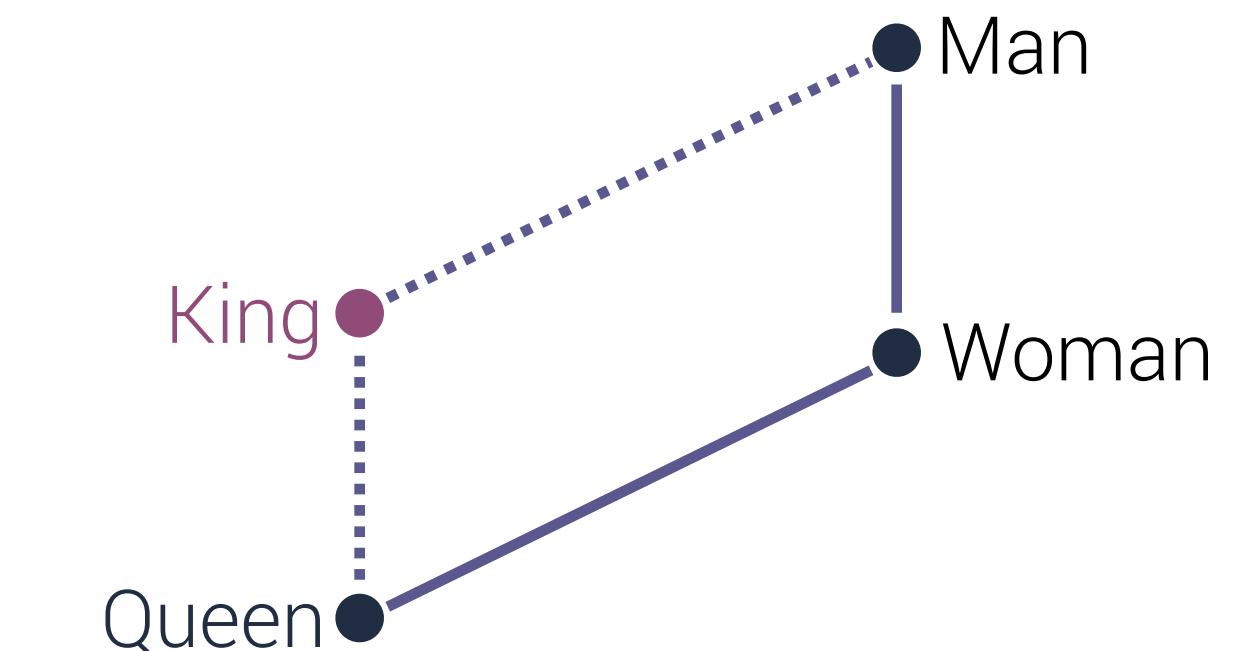
## Hierarchies



## Comparatives and Superlatives



## Woman :: Queen as Man :: ?



# Pretrained embeddings facilitate fast prototyping

<b>Corpus Generation</b>	<b>Corpus Tokens</b>	Twitter 27 B	Common Crawl 42-840 B	GoogleNews 100 B	Wikipedia 6 B
<b>Corpus Processing</b>	<b>Vocabulary Size</b>	1.2 M	1.9-2.2 M	3 M	400 k
<b>Language Model Generation</b>	<b>Algorithm</b> <b>Vector Length</b>	GLoVE 25 - 200 d	GLoVE 300 d	word2vec 300 d	GLoVE 50 - 300 d
<b>Language Model Tuning</b>					
<b>Final Application</b>					

# Problems with pretrained embedding models

Casing	Abbreviations vs Words e.g. IT vs it
Out of Vocabulary Words	Domain Specific Words & Acronyms
Polysemy	Words with multiple meanings e.g. drive (a car) vs drive (results) e.g. Chef (the job) vs Chef (the language)
Multi-word Expressions	Phrases that have new meanings e.g. Front-end vs front + end

# Tools for developing custom language models

## Corpus Processing

Tokenization, POS tagging, Sentence Segmentation, Dependency Parsing



## Language Modeling

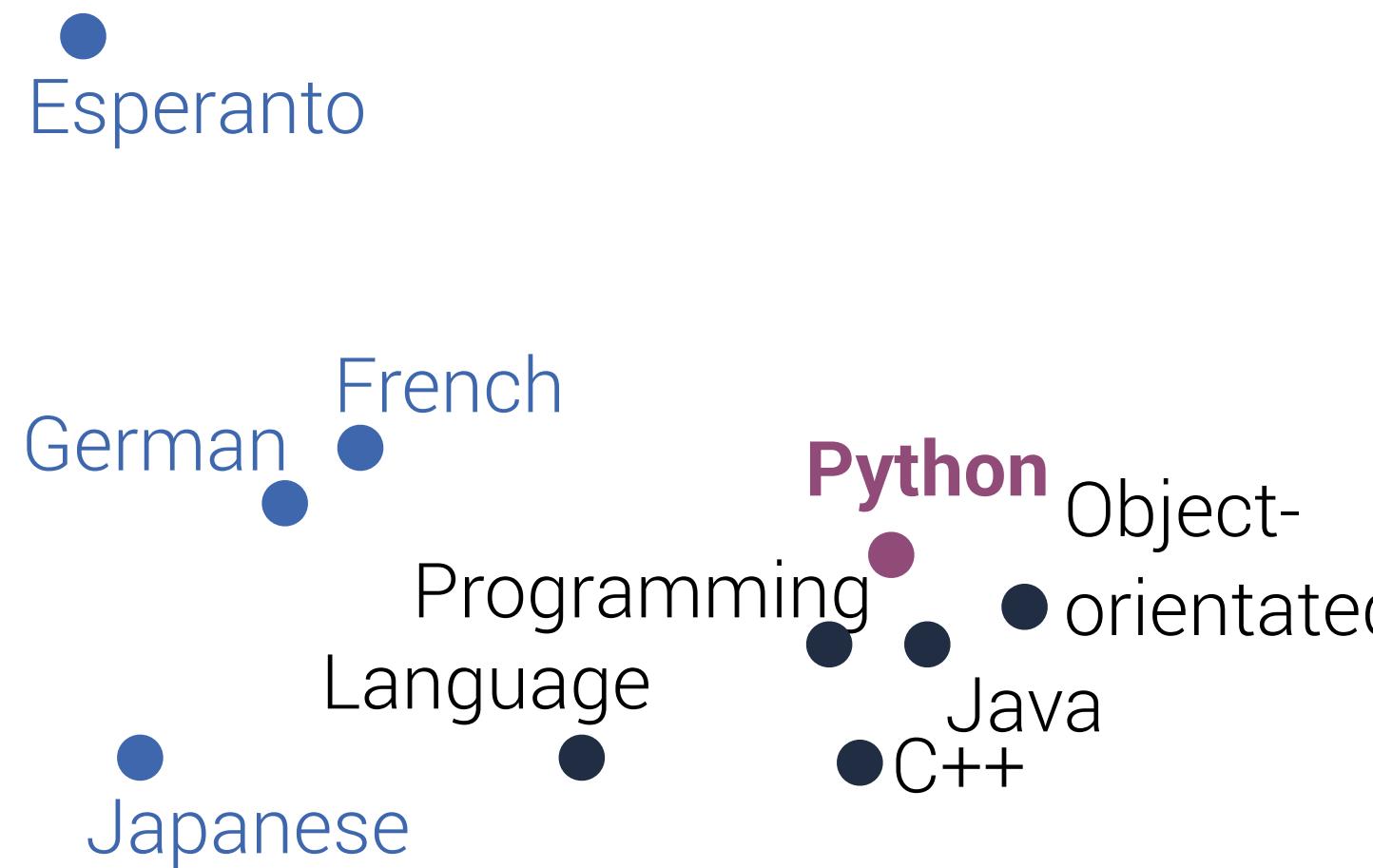
Different word embedding models (GLoVE, word2vec, fastText)



# Windows capture semantic similarity vs relatedness

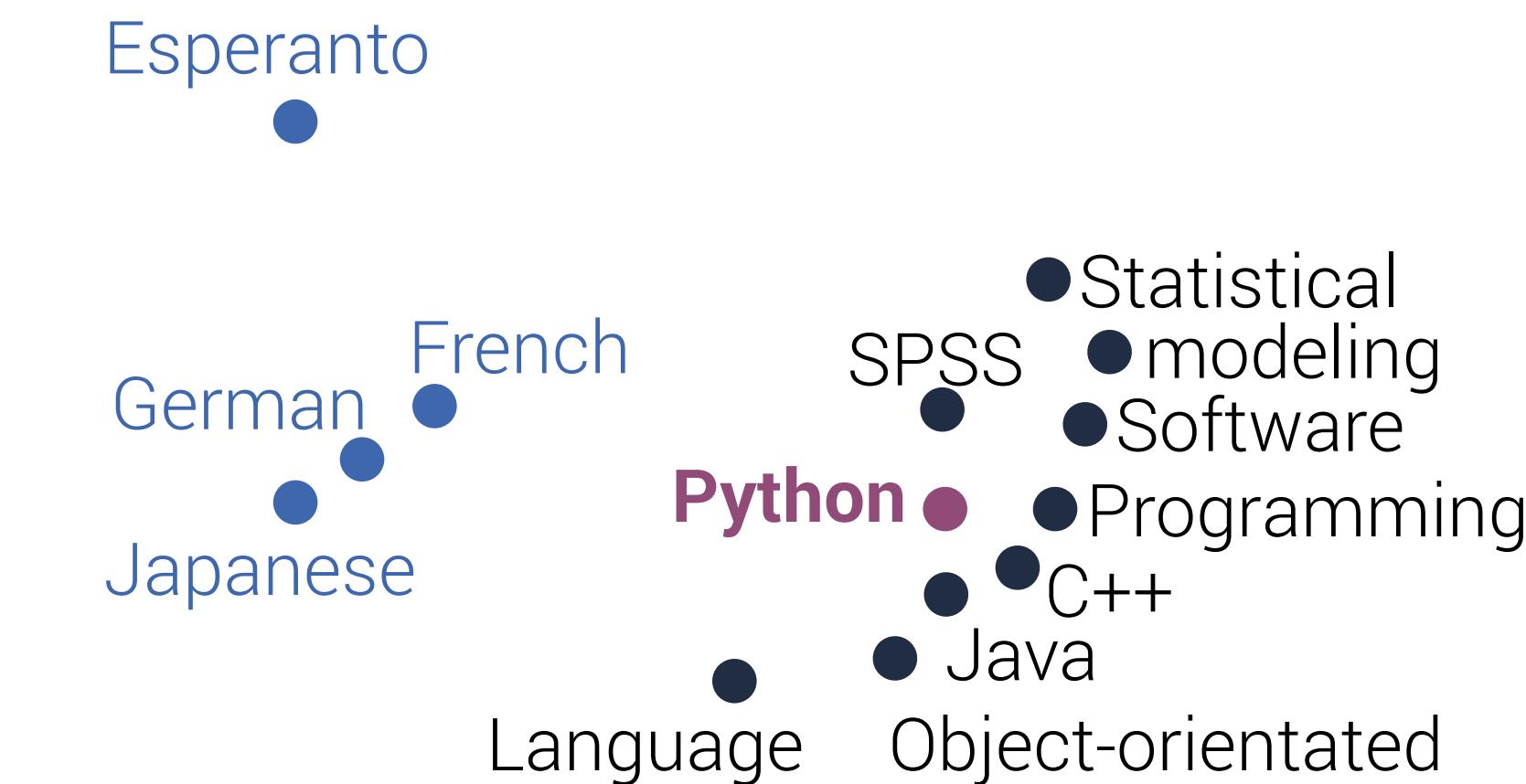
## Small Window Size

Captures Semantic similarity, Substitutes and Word-level differences

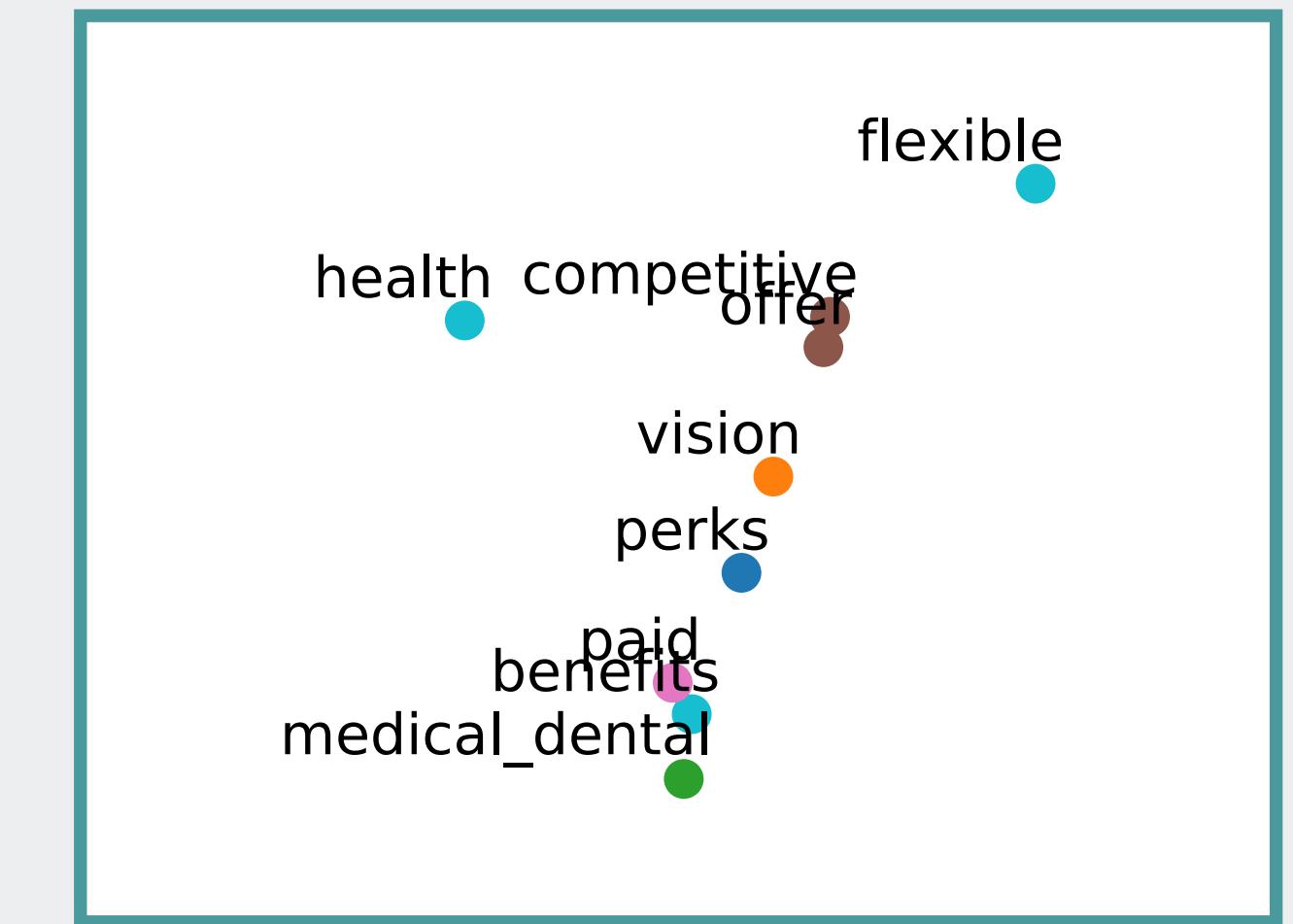
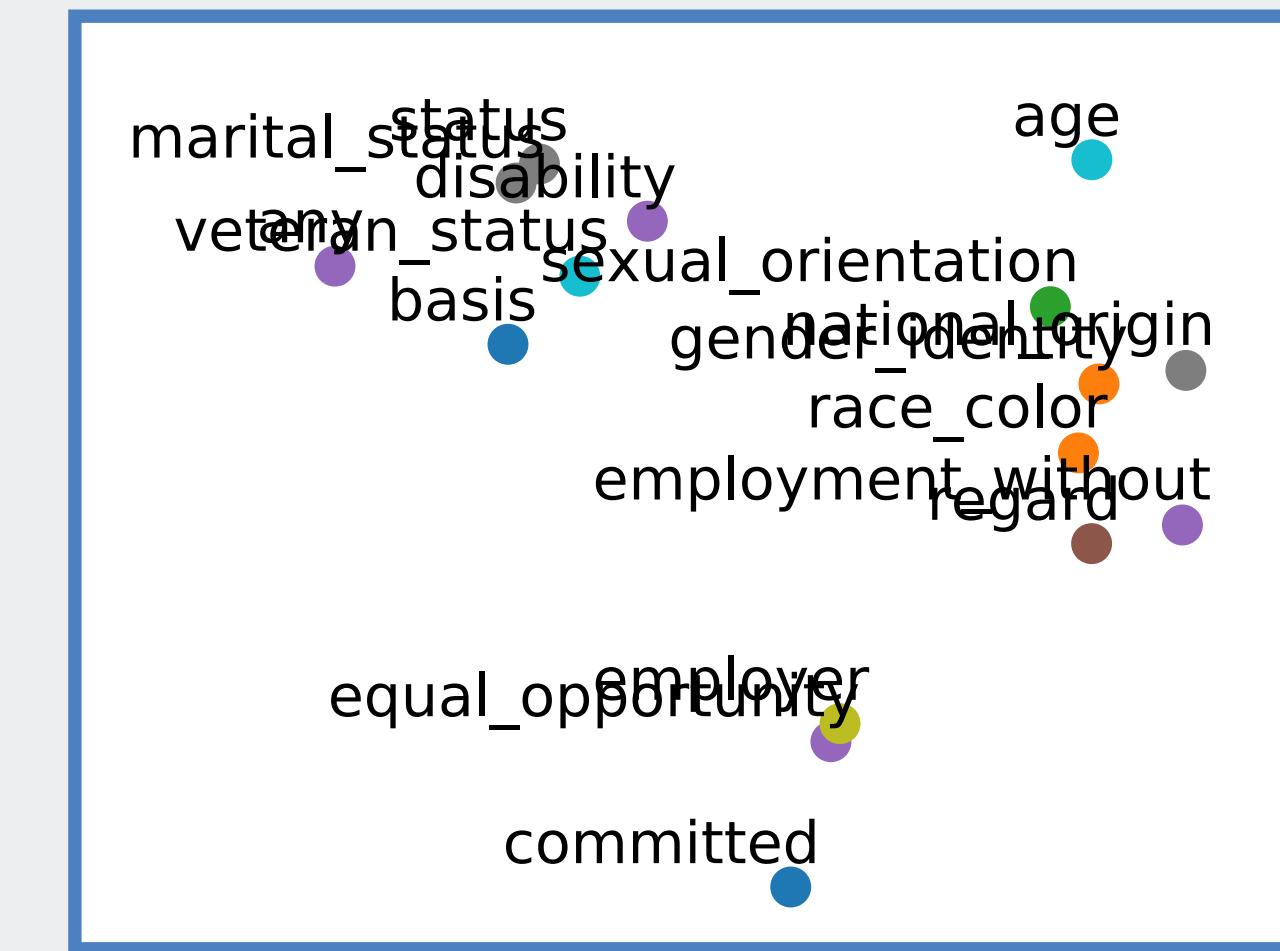
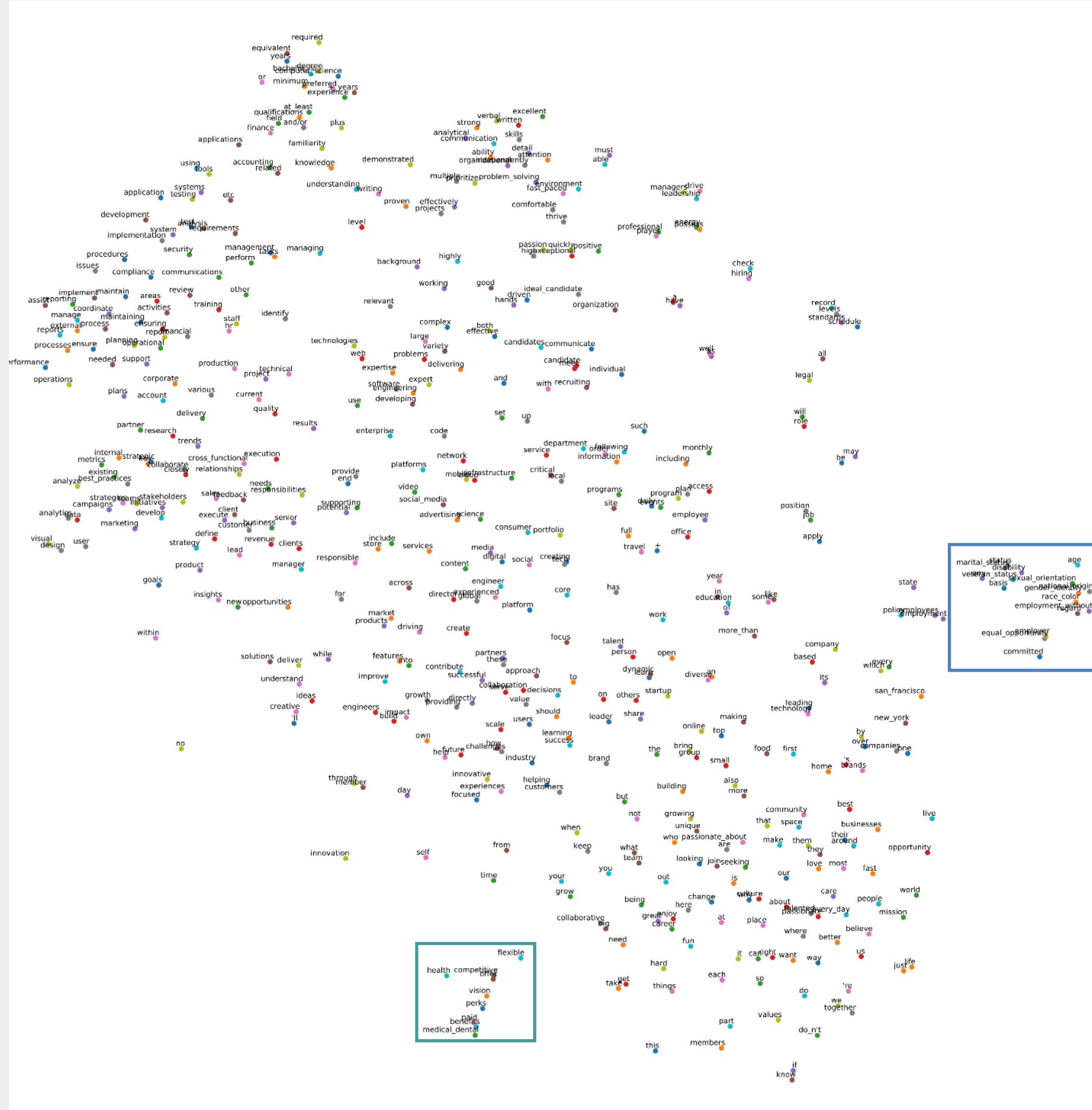


## Large Window Size

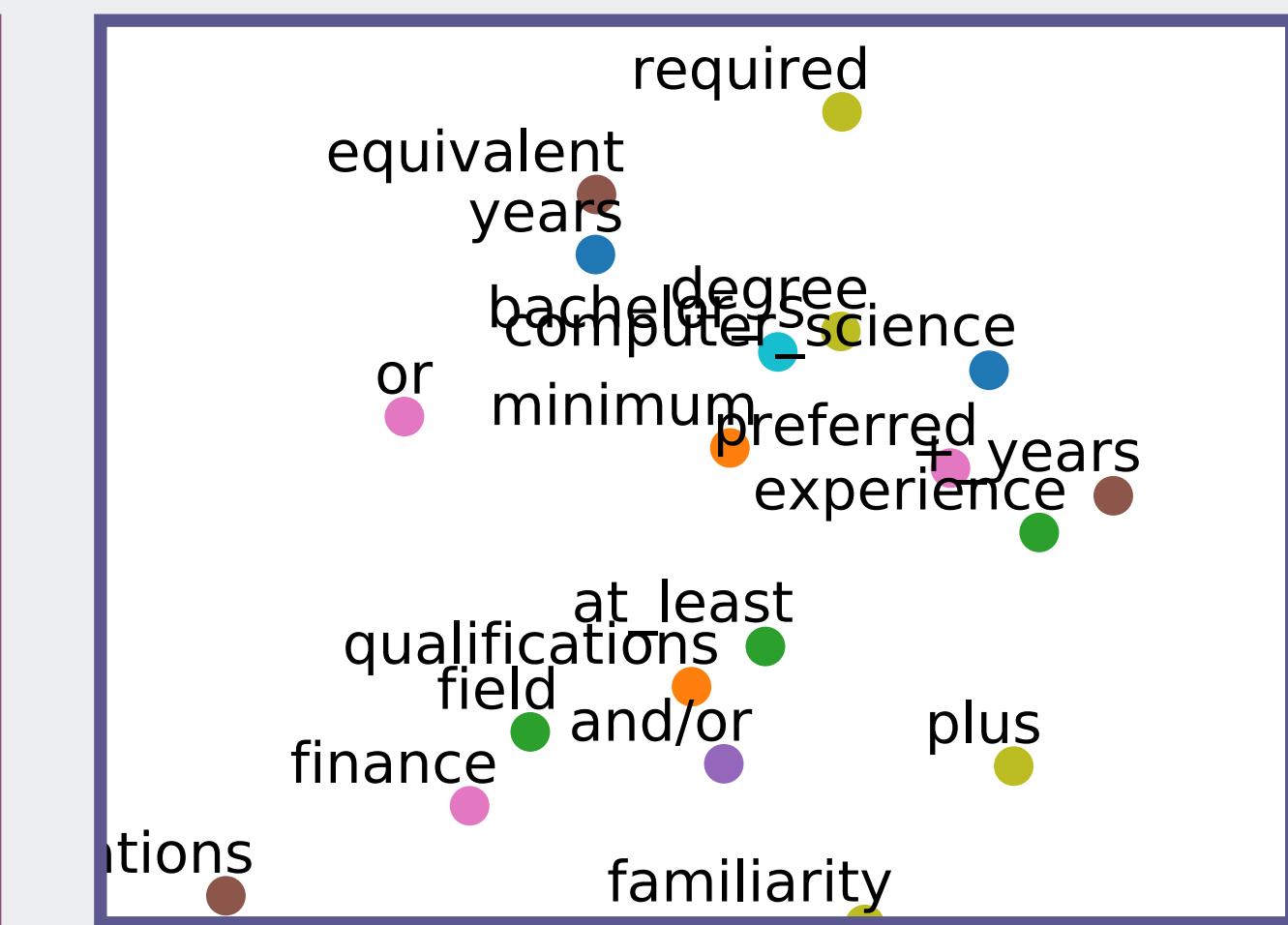
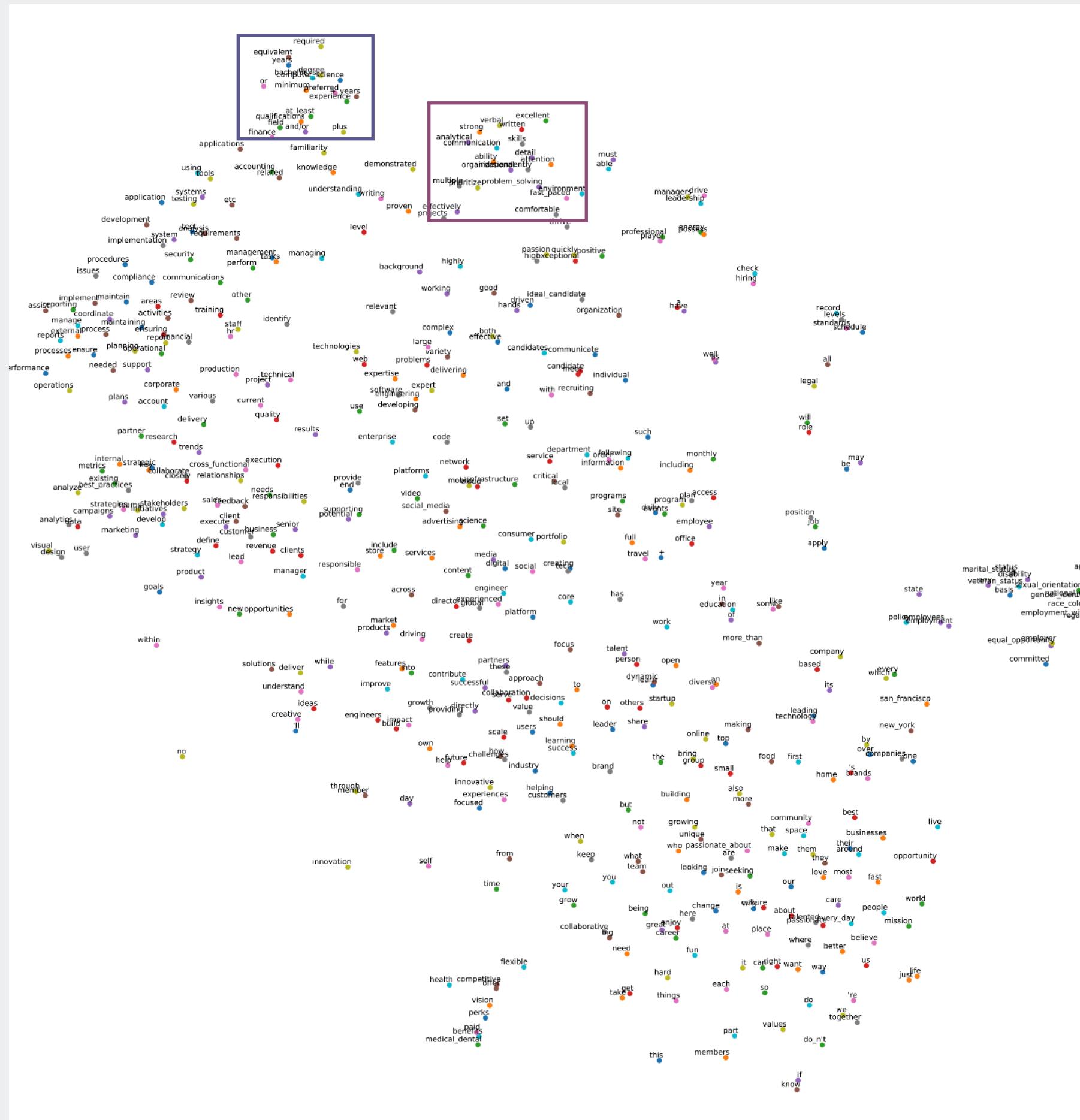
Captures Semantic relatedness, Alternatives and Domain-level differences



# Custom embeddings identified equal opportunity and perks language

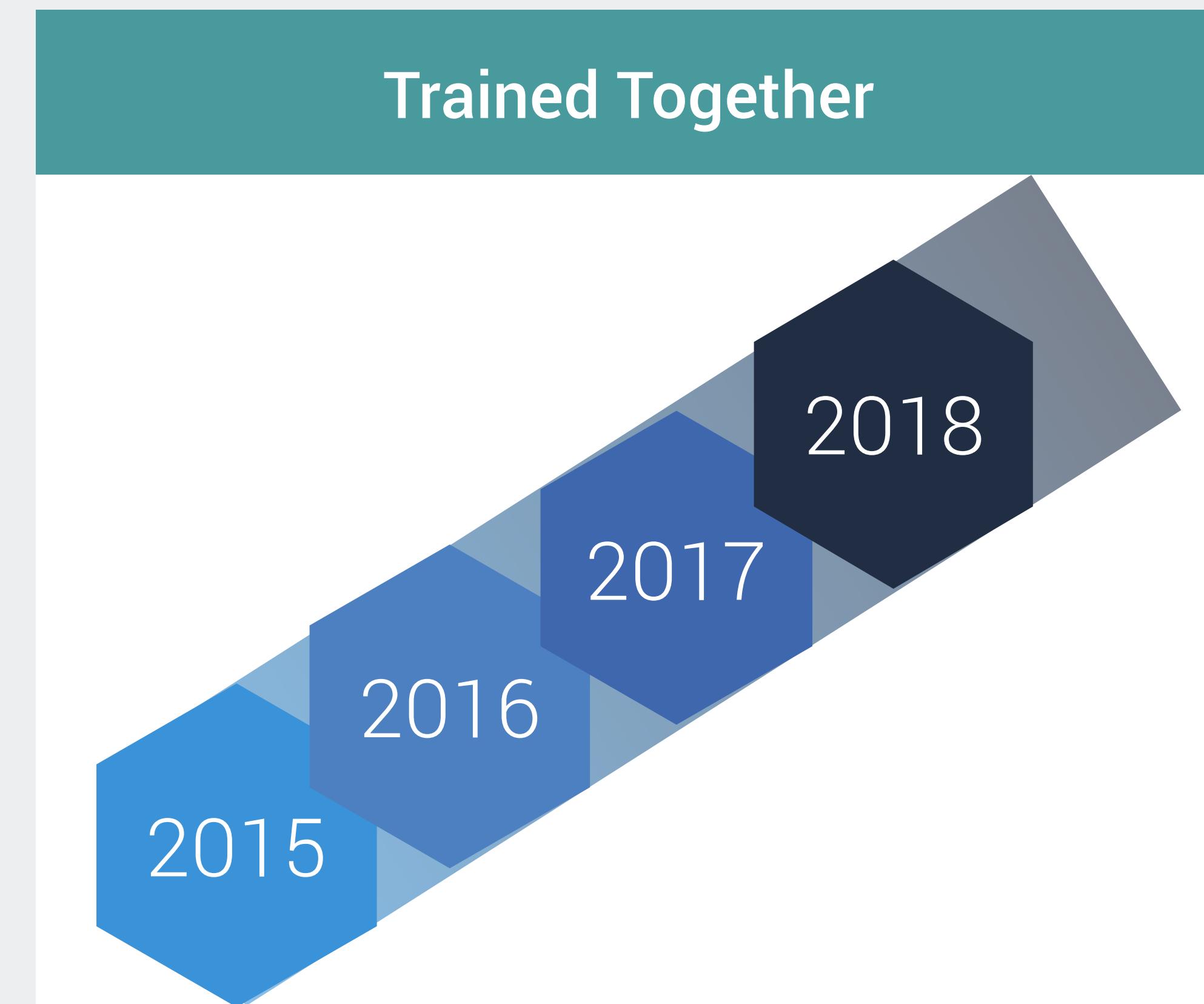
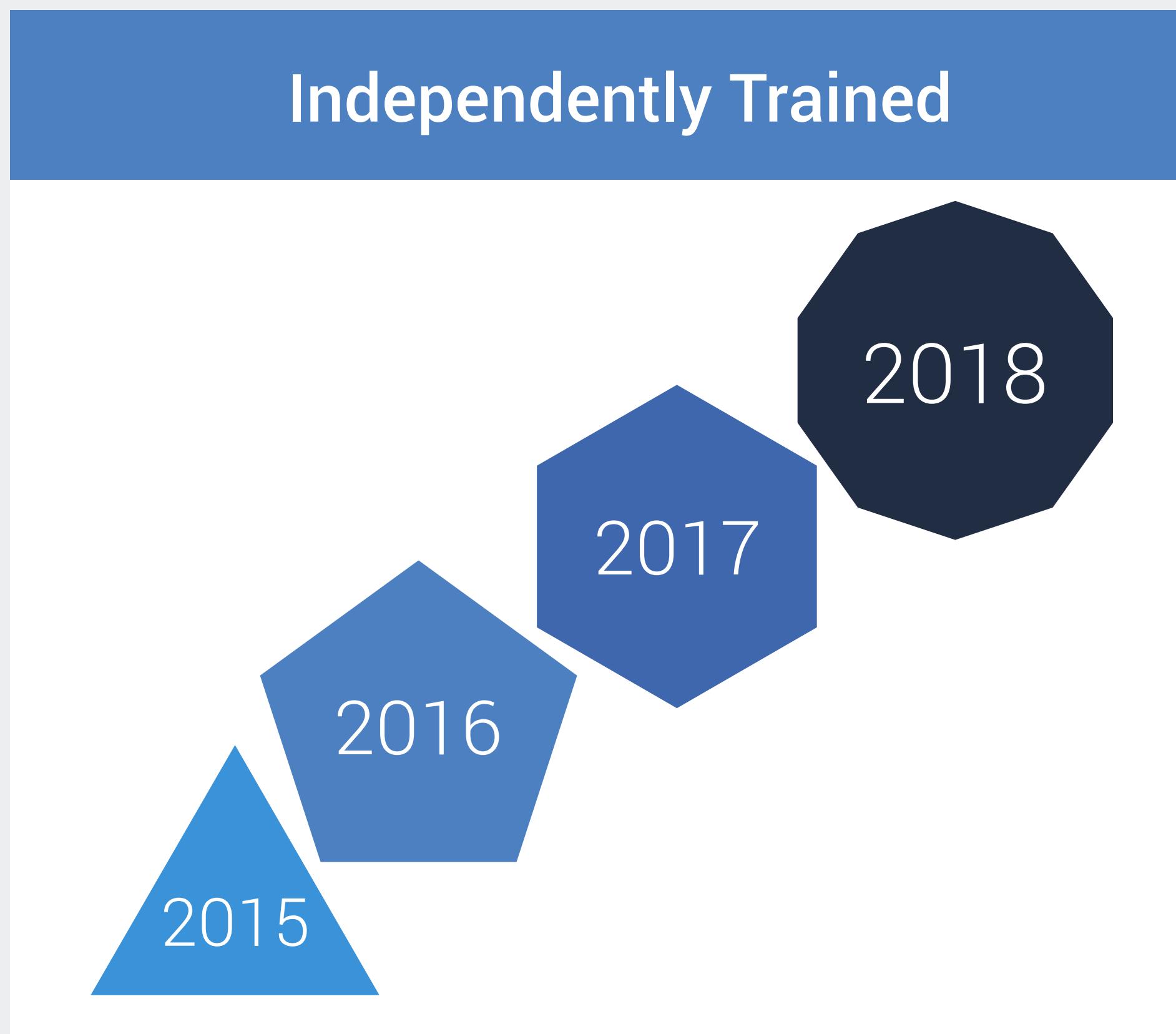


# Custom embeddings identified 'soft' skills and language around experience



I've got 300 dimensions...  
but time ain't one

# Two flavors of dynamic embeddings



Kim, Chiu, Kaneki, Hedge and Petrov, [arXiv: 1405:3515](#).  
Kulkarni, Al-Rfou, Perozzi and Skiena, [arXiv: 1411:3315](#).  
Hamilton, Leskovec and Jurafsky, [arXiv: 1605:09096](#).

Rudolph and Blei, [arXiv: 1703.08052](#).

# The benefits of dynamic Bernoulli embeddings

## Dynamic embeddings

**Data hungry:** Sufficient data for each time slice for a quality embedding.

**Requires stitching:** Each time slice is trained independently, therefore dimensions are not comparable across slices.

## Dynamic Bernoulli embeddings

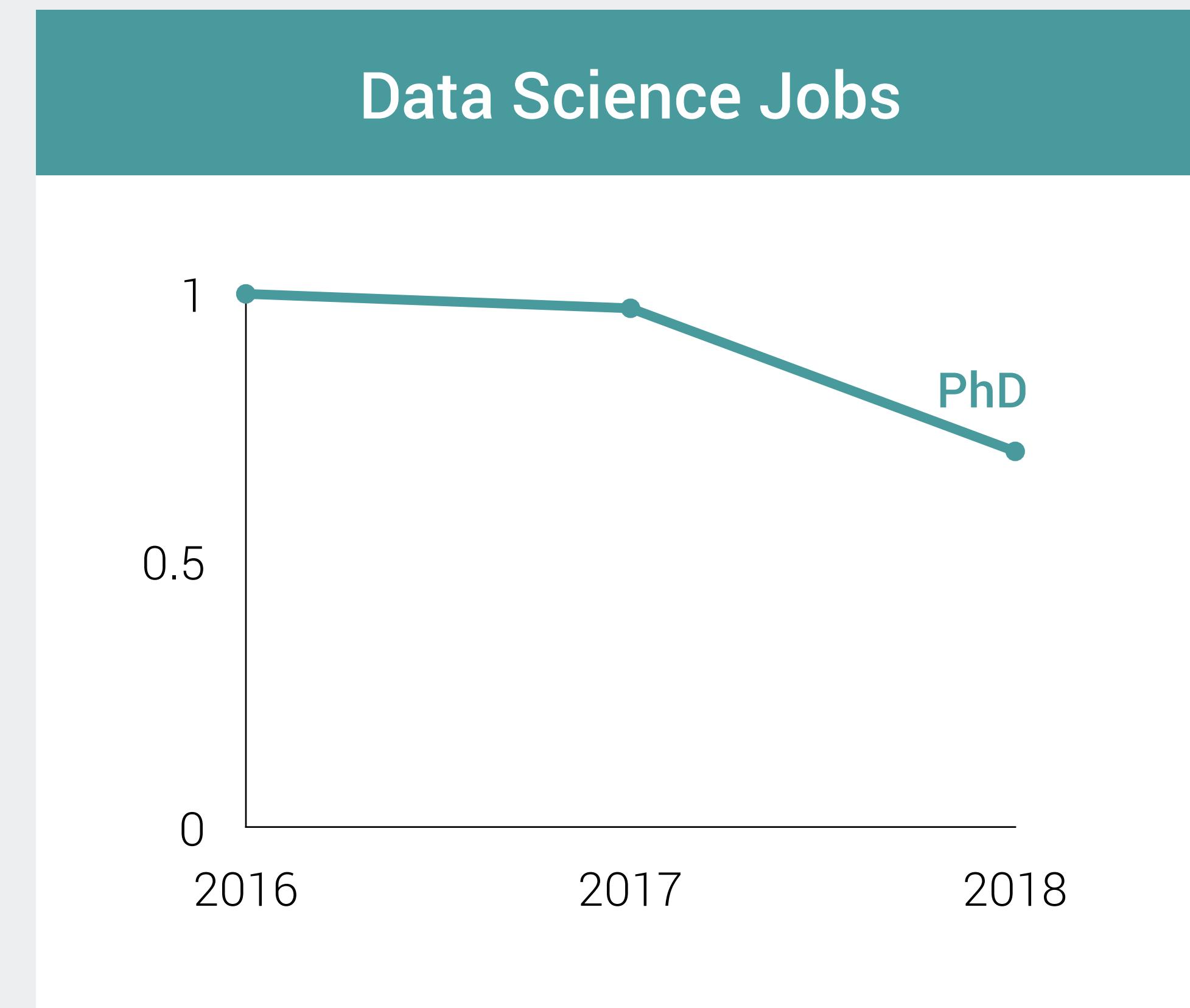
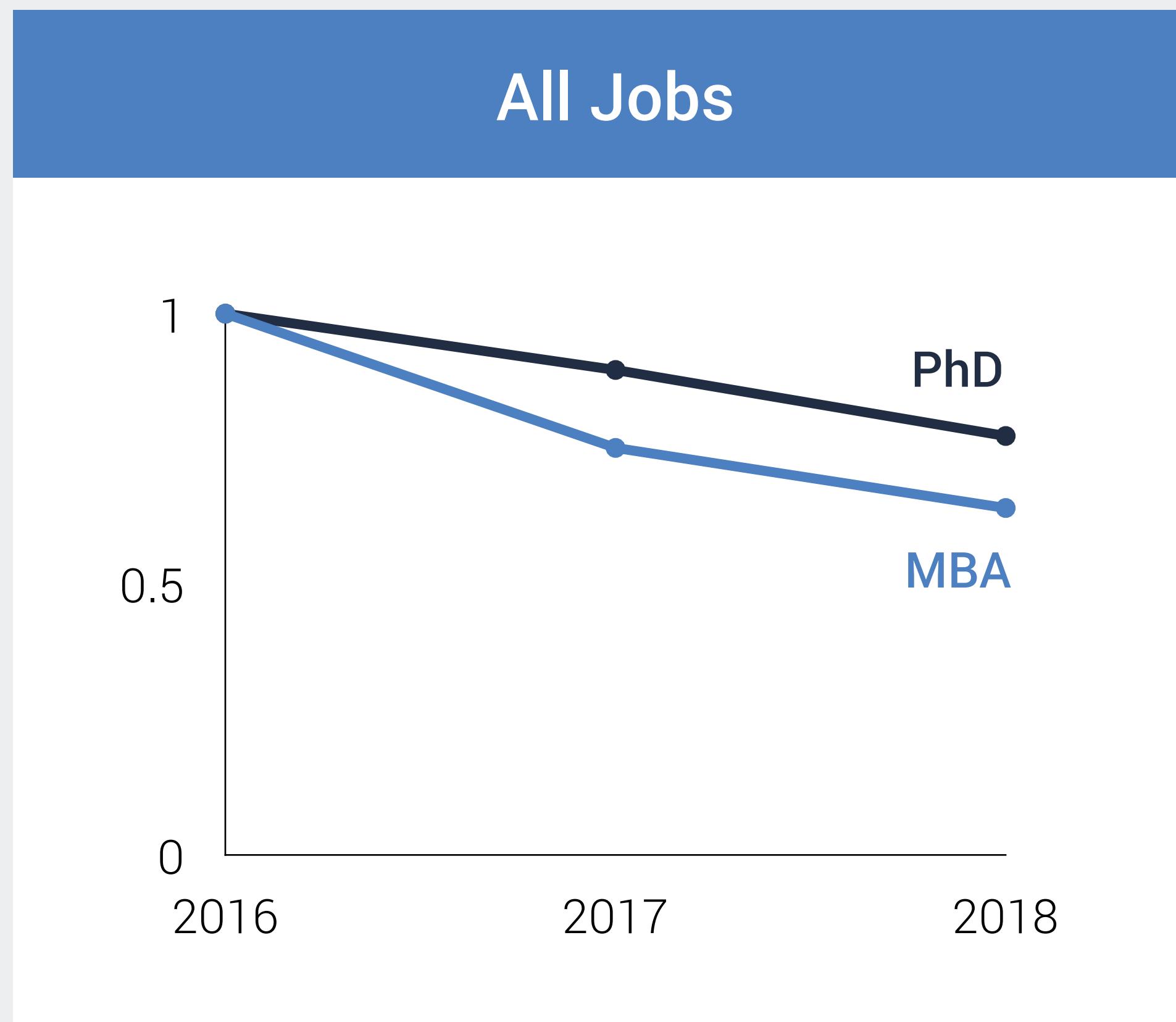
**Data efficient:** Treats each time slice as a sequential latent variable, enabling time slices with sparse data.

**Does not require stitching/alignment:** Treating time slice as a variable ensures embeddings are connected across slices.

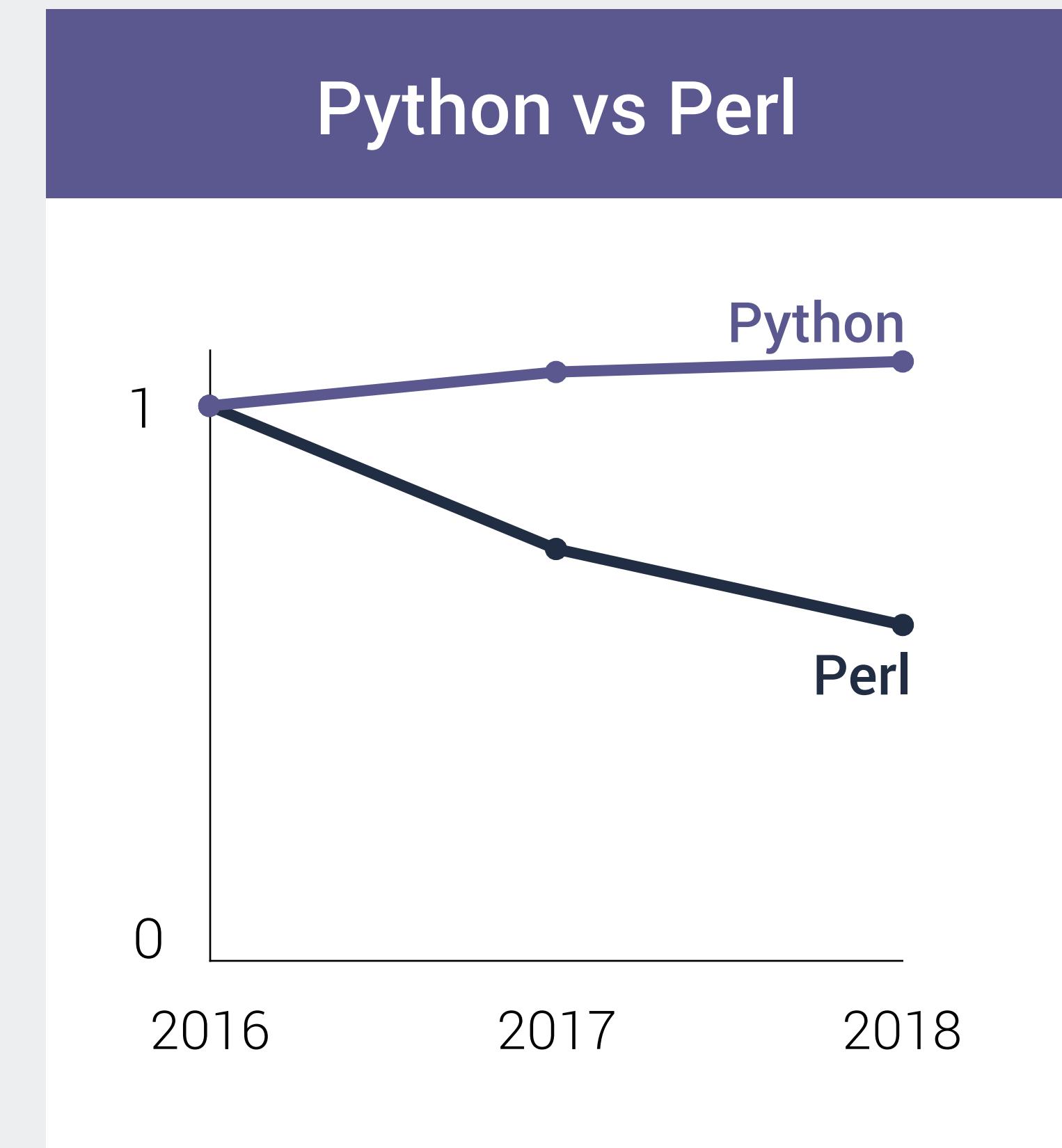
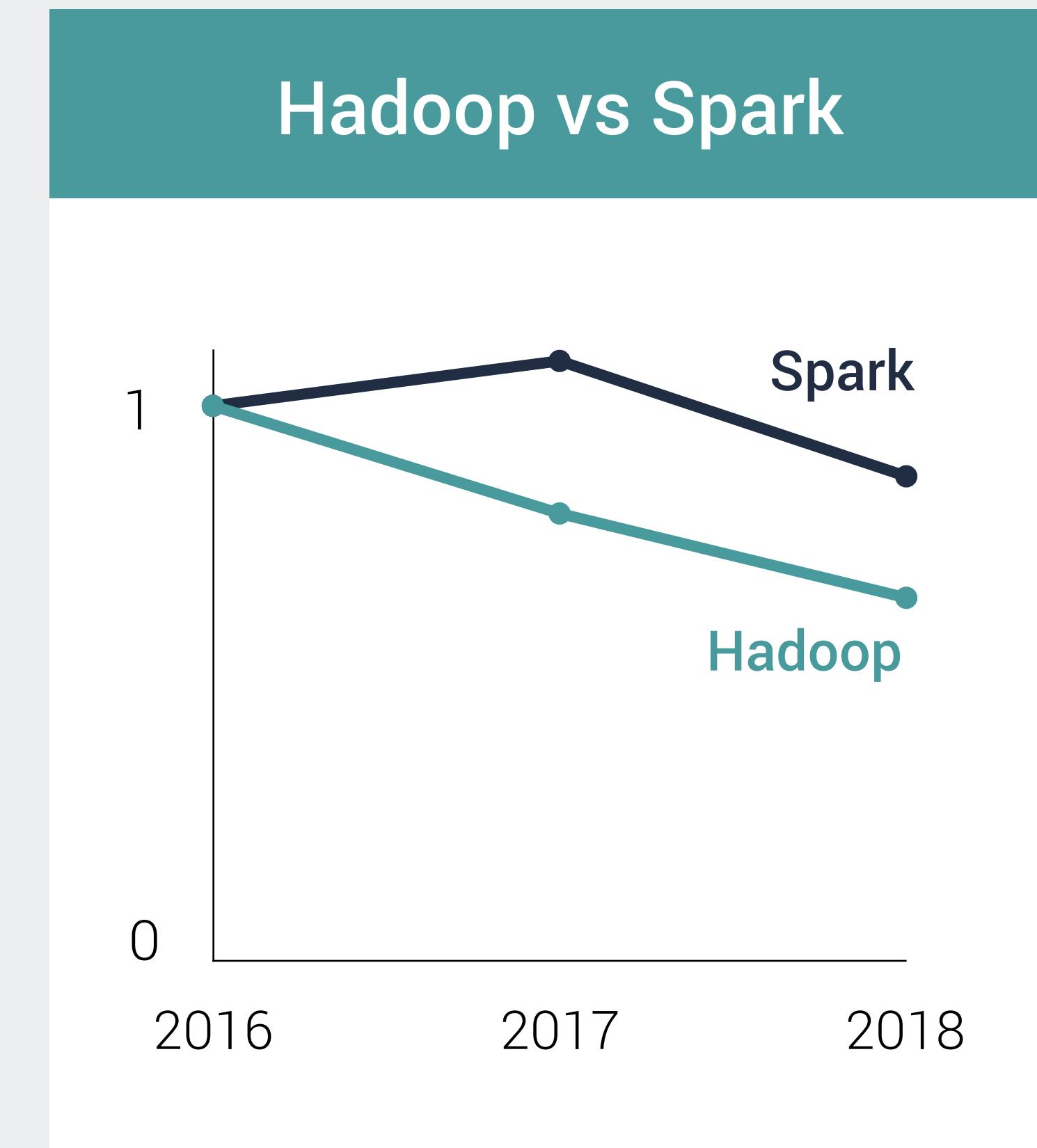
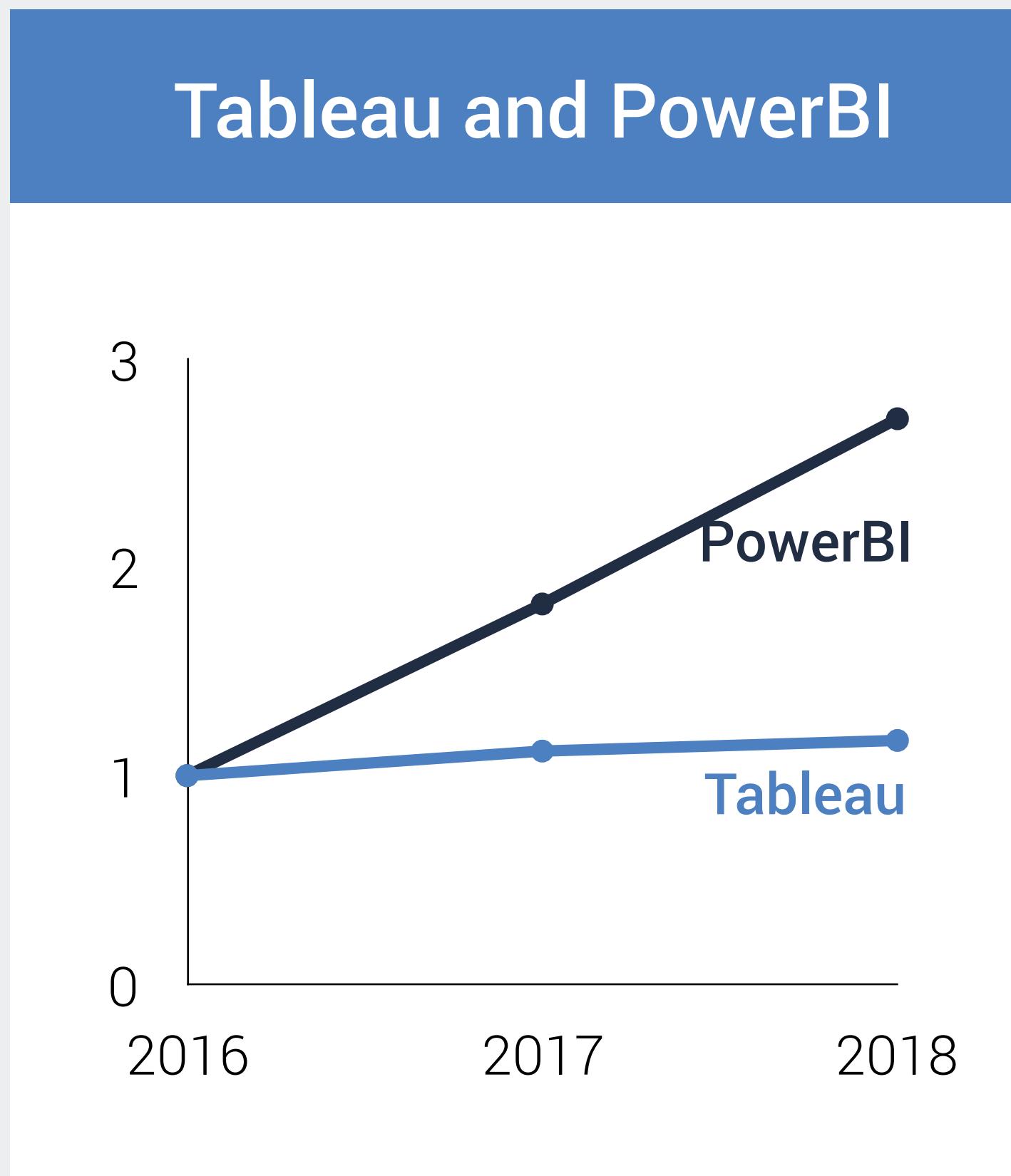
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Hamilton, Leskovec and Jurafsky, [arXiv: 1605:09096](#).

Balmer and Mandt, [arXiv: 1702:08359](#).  
Rudolph and Blei, [arXiv: 1703:08052](#).

# Demand for MBAs and PhDs falling



# Data Science skills showing significant shifts



regression :: Generalized Linear Models as  
word2vec :: Exponential Family Embeddings

# Members of the Exponential Family of Embeddings

Bernoulli Embedding	Poisson Embedding	Gaussian Embedding
Binary Data	Count or Ordinal Data	Continuous Data
Proficiency Context programming Python	Mini Bagels Context Cream cheese Milk	JFK-CDG Context LGA-DCA JFK-DFW
<b>Datapoint Java</b> Context C++	<b>Datapoint Coffee</b> Context Orange Juice	<b>Datapoint LAX-JFK</b> Context LAX-LGA

# Members of the Exponential Family of Embeddings

## Bernoulli Embedding

Binary Data

Proficiency  
Context programming  
Python

## Datapoint Java

Context C++

## Poisson Embedding

Count or Ordinal Data

10 Guidelines for A/B Testing / Emily Robinson  
Context The Value of Null Results / Angel D'az  
Words in Space / Rebecca Bilbro

## Datapoint ... / James Powell

Context Why I Use Julia / Katharine Hyatt

# Poisson embeddings capture item similarities from shopper behavior

## **Maruchan chicken ramen**

Maruchan creamy chicken ramen  
Maruchan oriental flavor ramen  
Maruchan roast chicken ramen

## **Yoplait strawberry yogurt**

Yoplait apricot mango yogurt  
Yoplait strawberry orange smoothie  
Yoplait strawberry banana yogurt

## **High Inner Product Combinations**

Old Dutch potato chips & Budweiser Lager beer  
Lays potato chips & DiGiorno frozen pizza

## **Low Inner Product Combinations**

General Mills cinnamon toast & Tide Plus detergent  
Beef Swanson Broth soup & Campbell Soup cans

# How have data science skills changed over time?

- Flavors of static word embeddings: The Corpus Issue
- Considerations for developing custom embedding models
- Flavors of dynamic models: Dynamic Bernoulli embeddings
- Other members of the Exponential Family of Embeddings

# Thank you PyData NYC!

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<http://bit.ly/pydatanyc-emb>