# BC Stats
# Text Analytics: Quantifying the Responses to Open-Ended Survey Questions

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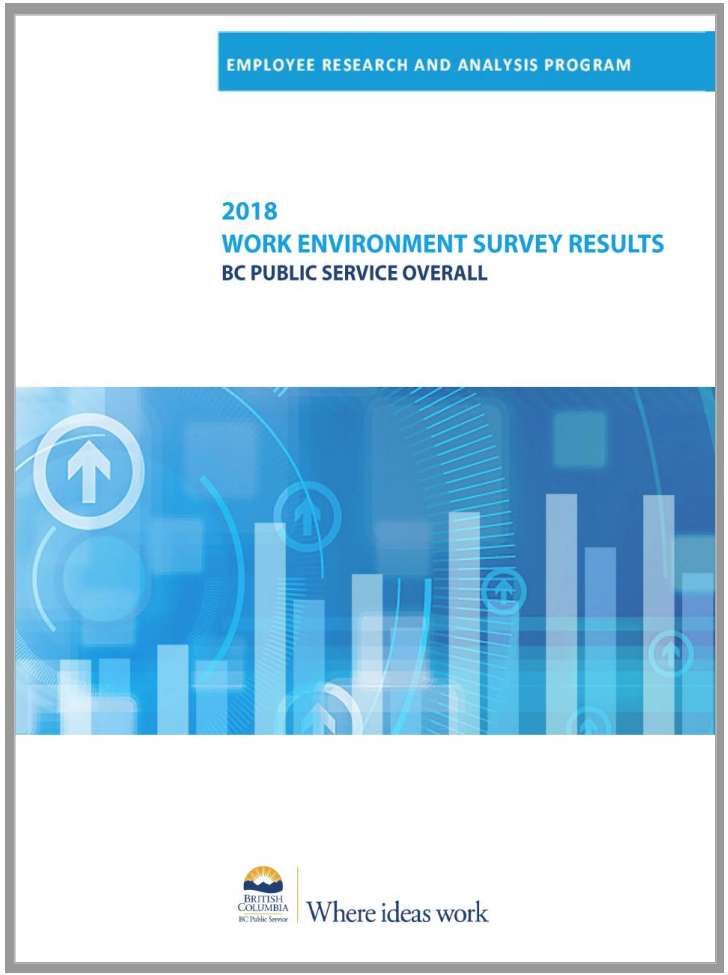
## Introduction

Background
- Work Environment Survey (WES)

Primary Goals:
- Understand employee experiences
- Celebrate successes
- Identify improvements



## Data

- There are over 15,000 respondents across 26 ministries in the 2018 Survey.
- All of the Survey data can be categorized in two:

★ Qualitative data (comments/open ended responses)

- Open ended question:
  *"What one thing would you like your organization to focus on to improve your work environment?"*
- Comment example:
  *"Give us up-to-date equipment and software (not 2010 versions in 2018)."*

  *Theme: Tools, Equipment & Physical Environment*
  *Sub-theme: Provide better computer-based hardware*

★ Quantitative data (Approximately 80 5-point scale questions)

- Example:
  *"The quality of training and development I have received is satisfactory: [1-5]"*

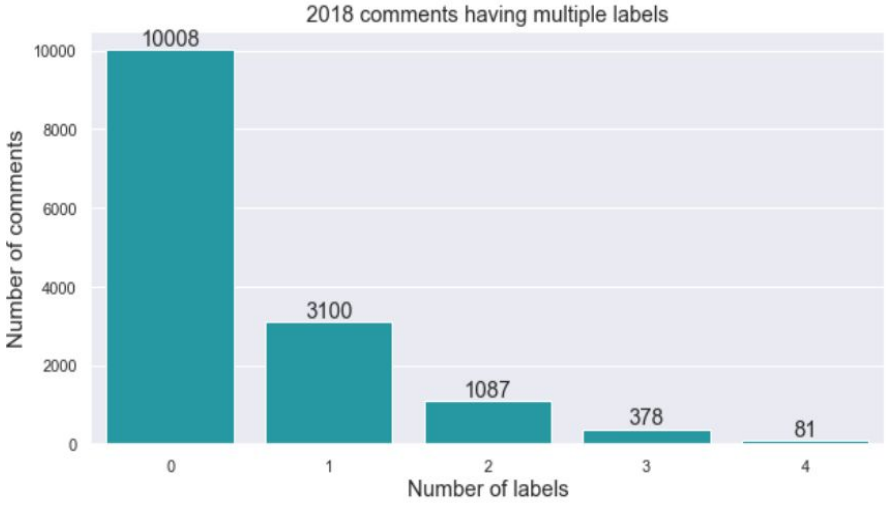
# Research Questions:

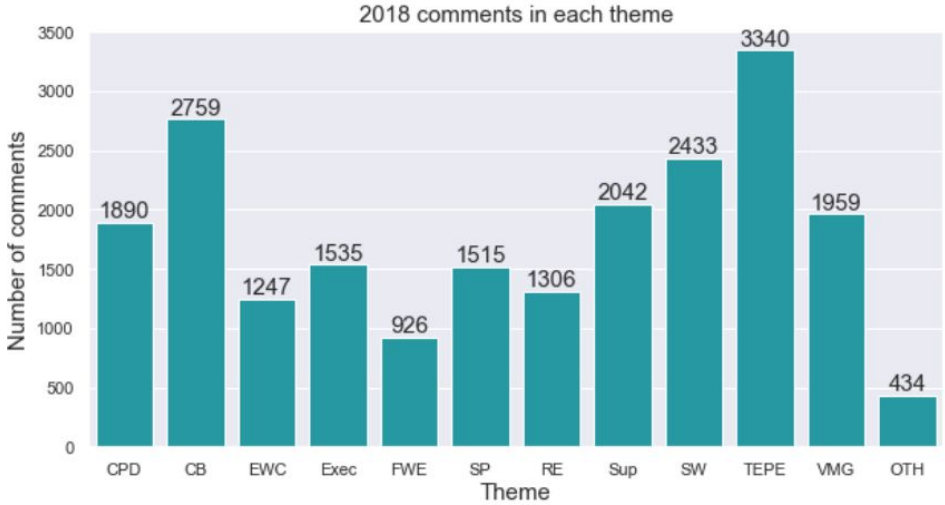
1. Text Classification:
   Automate the written questions labelling to the themes and sub-themes


2. Linking Quantitative to Qualitative:
   How well does the sentiment of the qualitative responses agree with the quantitative responses?

3. Discovery from Text Analysis

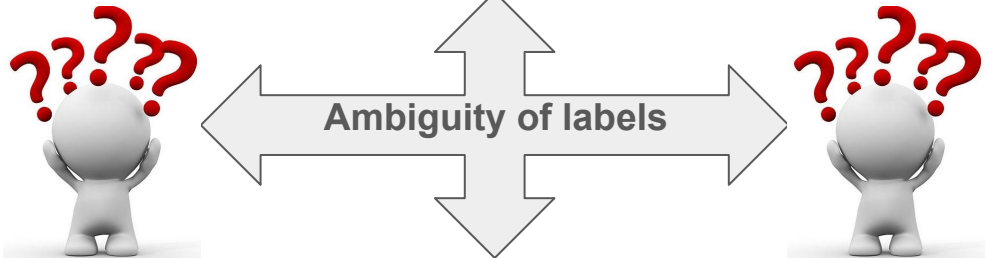
# The challenges we have been facing: Multi-label Text Classification



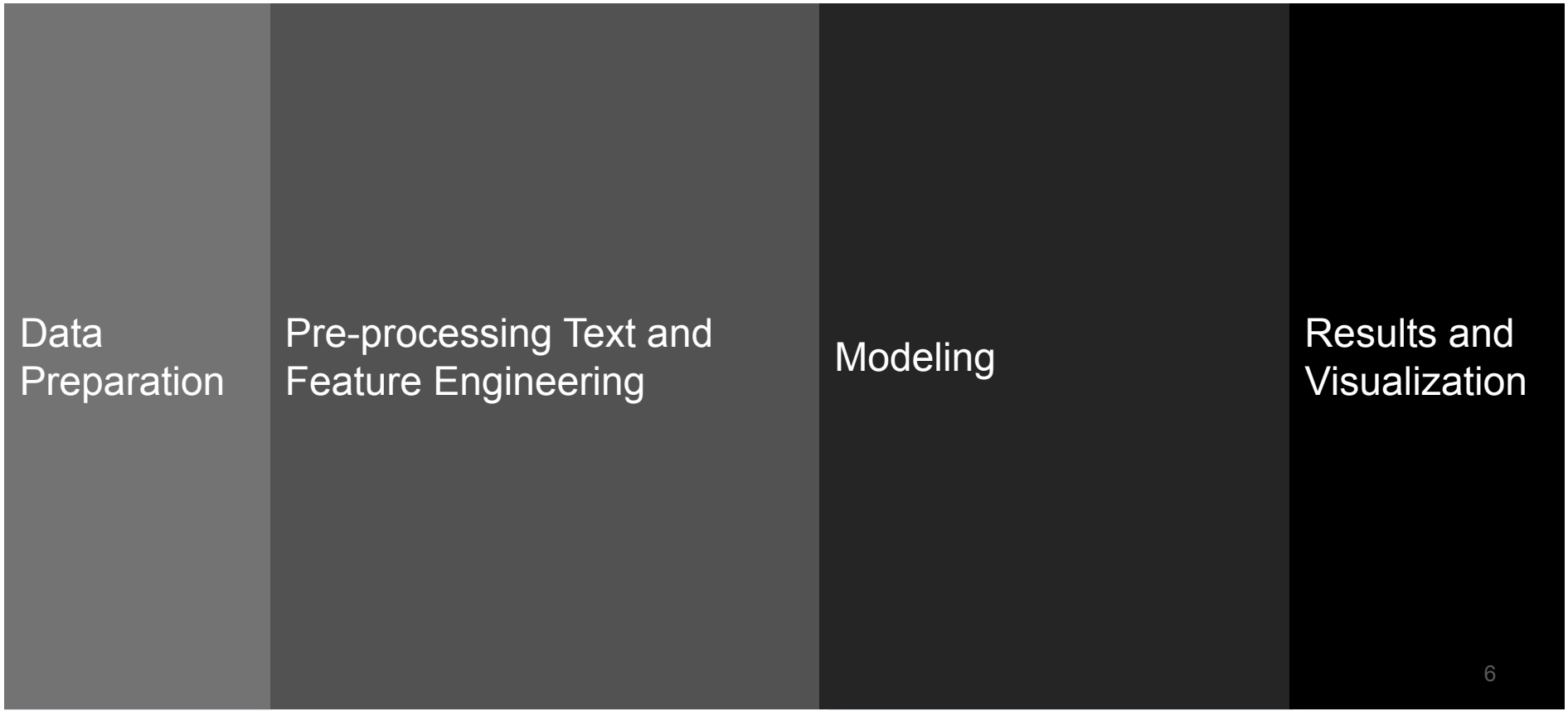




**12 labels (themes) in total and individual comments can be coded up to 5 labels**

**Imbalanced data on each theme**



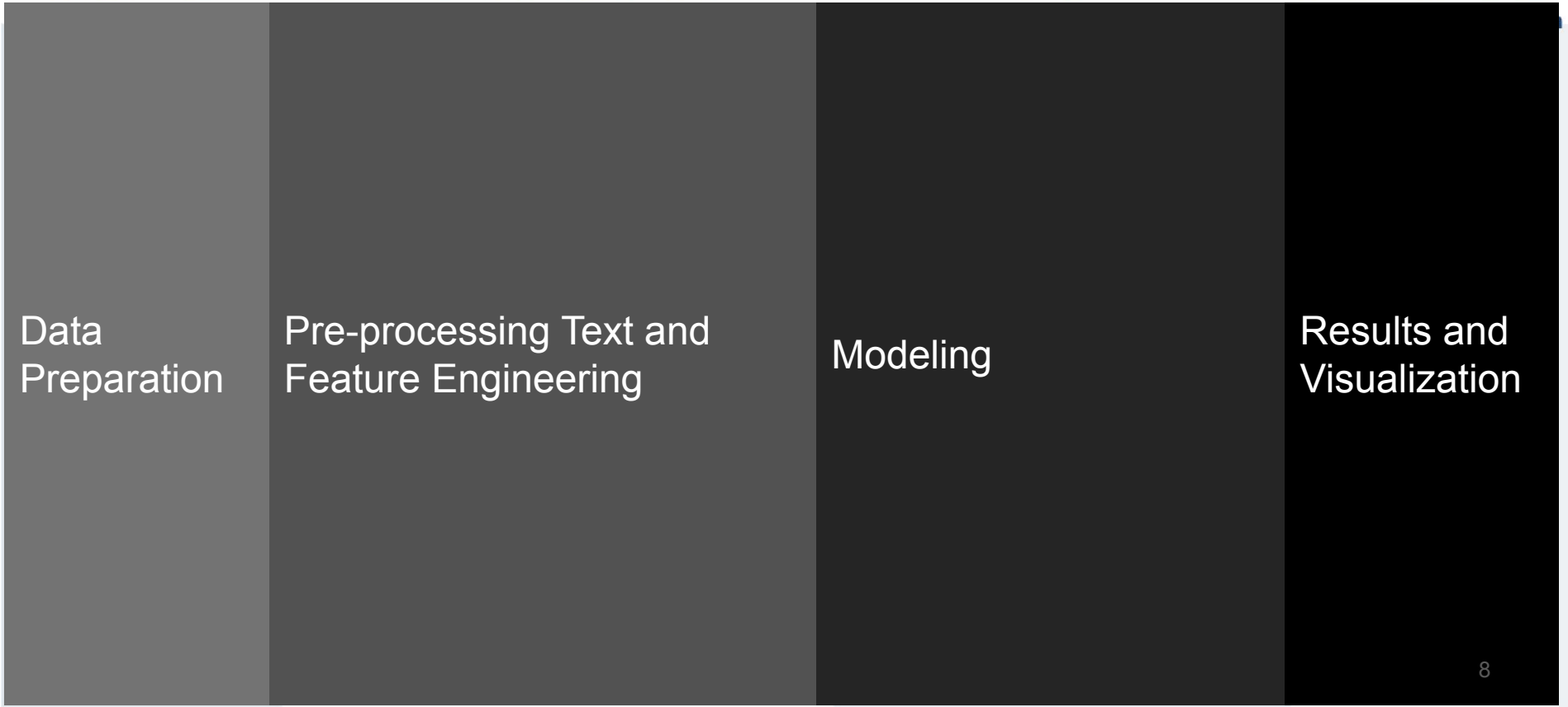
# Text Classification Methodology



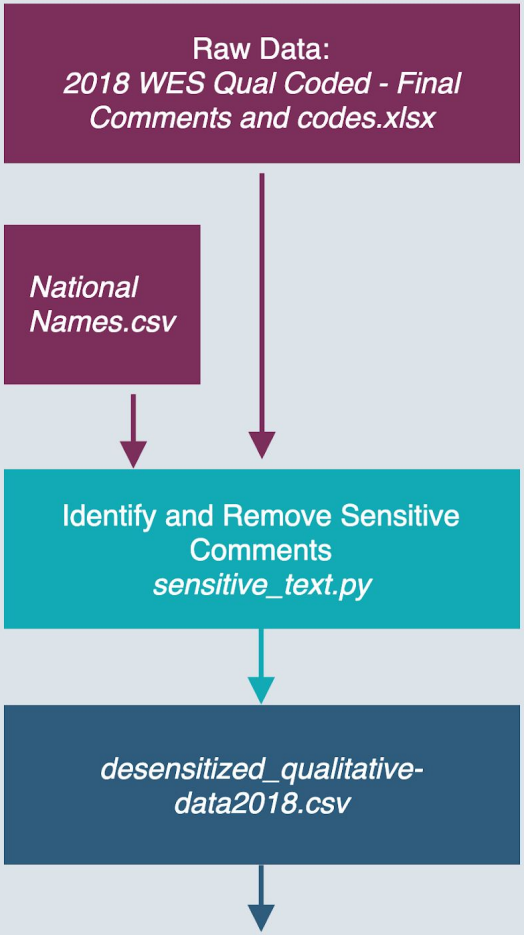
# Flow Chart Legend

| | |
|---|---|
| Prerequisite File | Required files that are input into the pipeline. These are provided by the client or downloaded online |
| Script | A Python or R script used to transform, model, or visualize the data |
| Generated File | A data file or model generated by a script and often used downstream in the analysis |

# Text Classification Methodology



# Data Preparation




Raw Data xlsx file

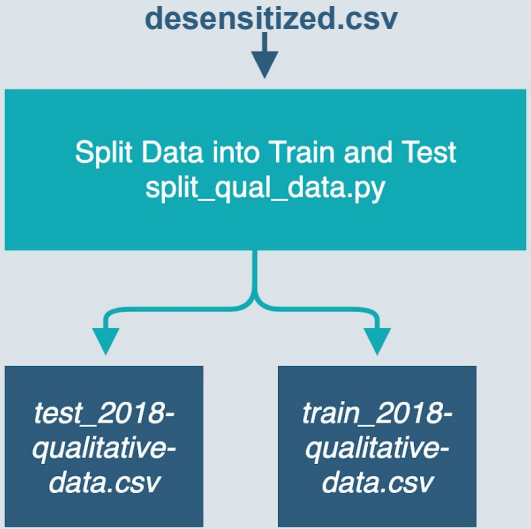
| _telkey | 2018 Comment | Code 1 | ... | Code 5 | CPD | ... |
|---|---|---|---|---|---|---|
| 188273-537556 | Permit more flexible working arrangements… | 53 | ... | | 0 | ... |

- Identify Sensitive Comments using Named Entity Recognition (NER) to look for Person names
- Cross Reference that with csv of baby names published by the US Data.gov
- ~200 of 12,000 removed from dataset

Example Comment that got flagged:

> “To quote Tom Cruise and Cuba Gooding Jr. in the film Jerry Maguire 'show me the money!!!'”

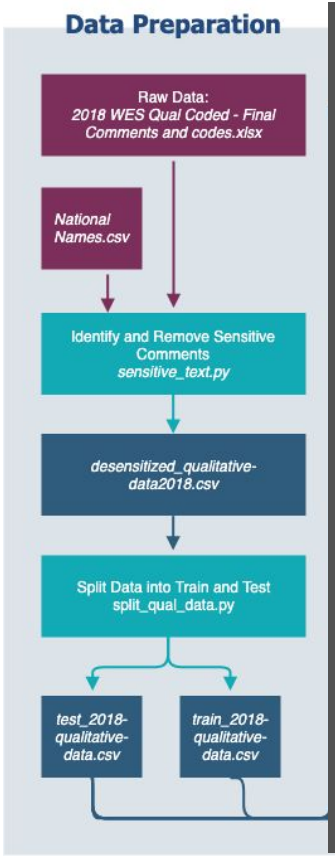
# Data Preparation




One of the Golden Rules of Machine Learning - Don’t touch the test data!

As such, we randomly split the data into 90% Train, and 10% Test

# Text Classification Methodology

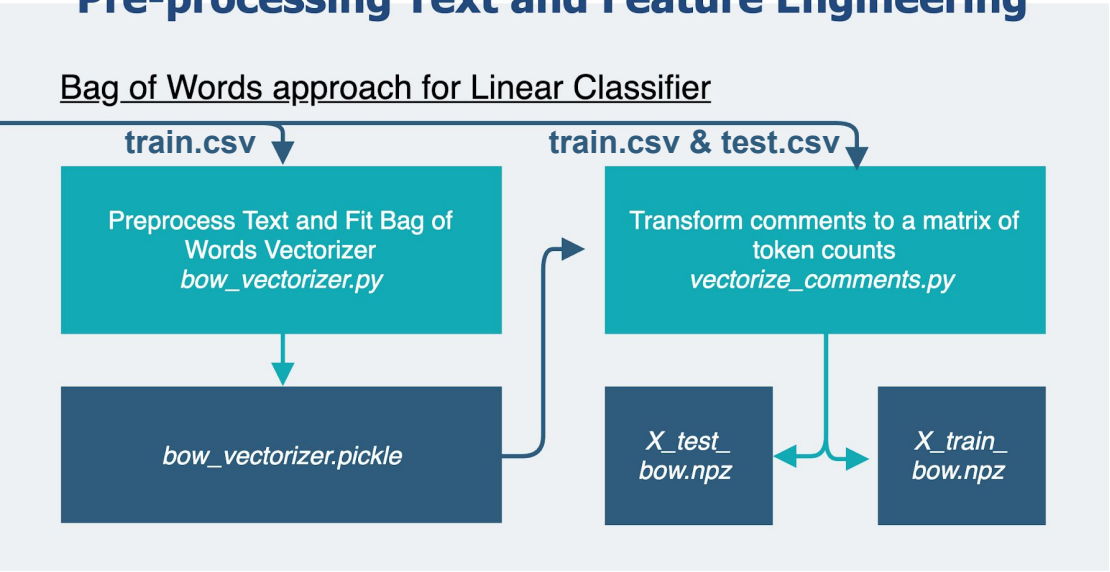



Pre-processing Text and Feature Engineering

Modeling

Results and Visualization

# Pre-processing Text and Feature Engineering




Example Bag of Words (BOW) data

| busy | compensation | flexible work | ... |
|---|---|---|---|
| 0 | 1 | 0 | ... |
| 2 | 0 | 0 | ... |

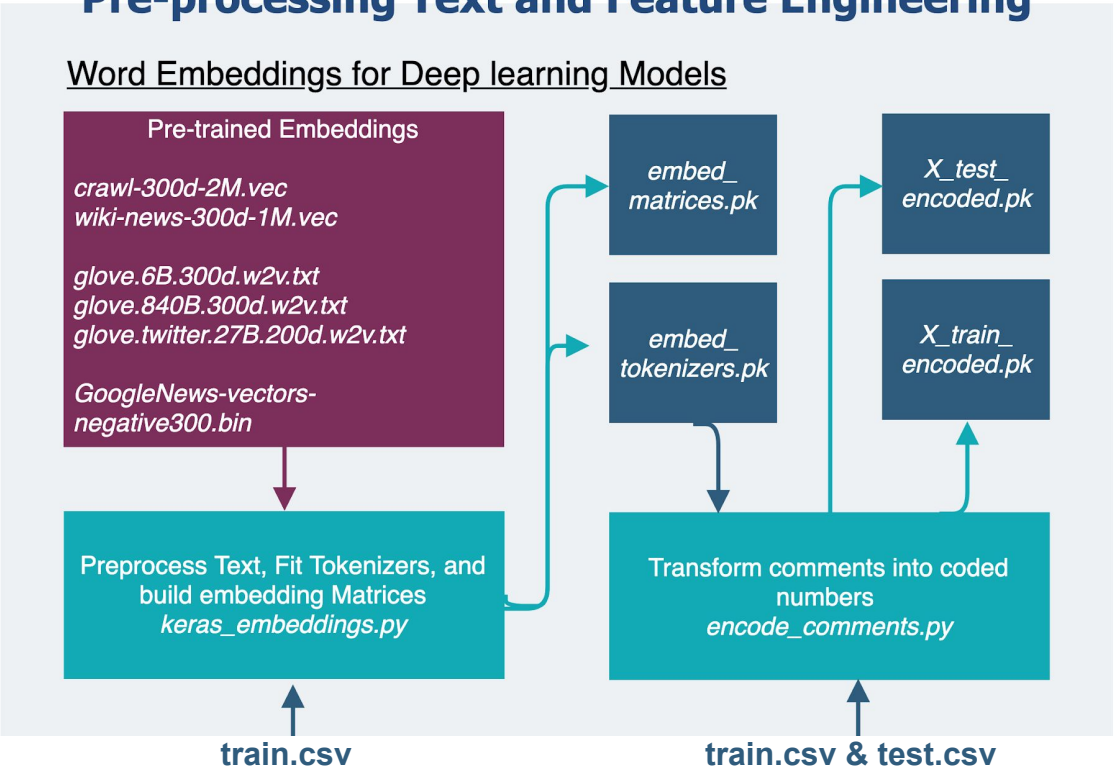
Preprocessing:

- Removed stop words, punct., lowercase, etc.
- Marginal improvements compared to no pre-processing

Bag of Words (BOW) Transform:

- BOW Model used as our Baseline Classifier
- Considered Count Vectorizer with one to five n-grams
- ~ 30,000 features

# Pre-processing Text and Feature Engineering




4705 60 112 35 800

Ex. Comment: “Permit more flexible working arrangements”

Ex. Tokenized Comment: [0, 0, 0, …, 0, 4705, 60, 112, 35, 800]

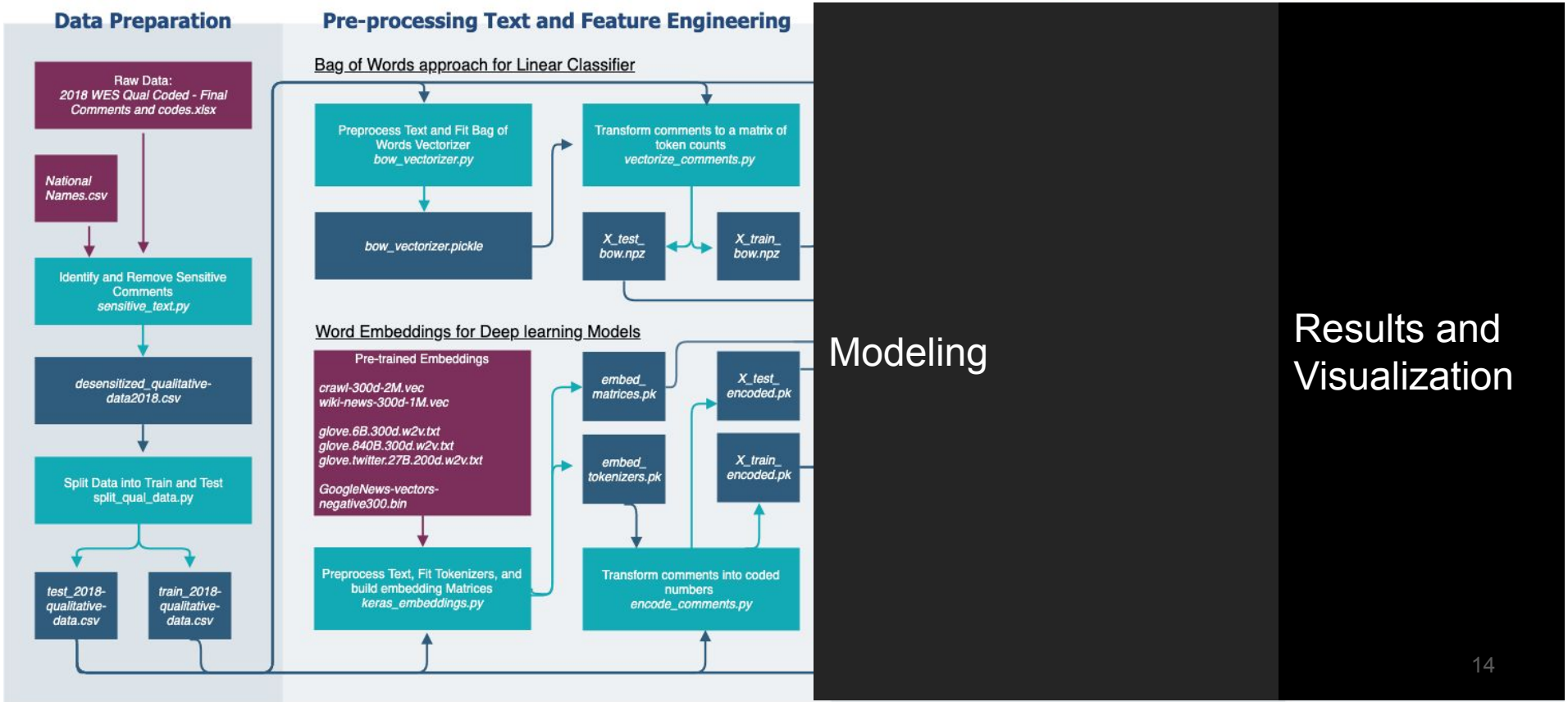
Preprocessing:

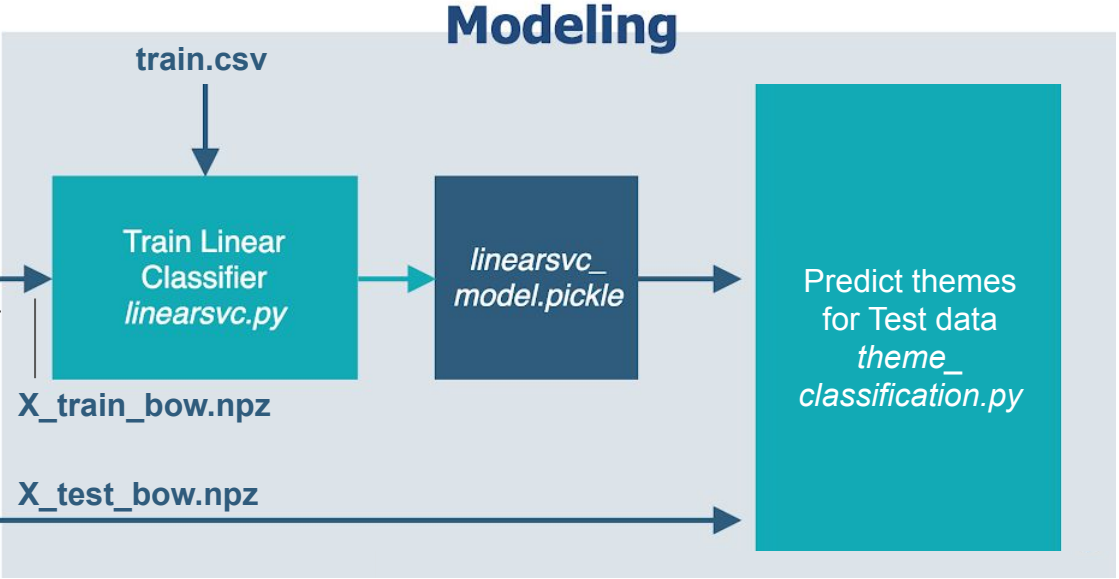
- Minimal pre-processing to capture as much intricacies as possible
- Maximize vocab coverage for each embedding
- Achieved 95 - 98% text coverage

Pre-trained Embeddings and data transformation:

- Explored several embeddings
- Tokenizer maps vocab to indices
- Embed Matrix maps the indices to the embeddings

# Text Classification Methodology






BOW | LinearSVC:

- One vs All Approach
- train/valid split (not shown in img)
- Grid Search used for Hyper Parameter Optimization: Marginal Improvements

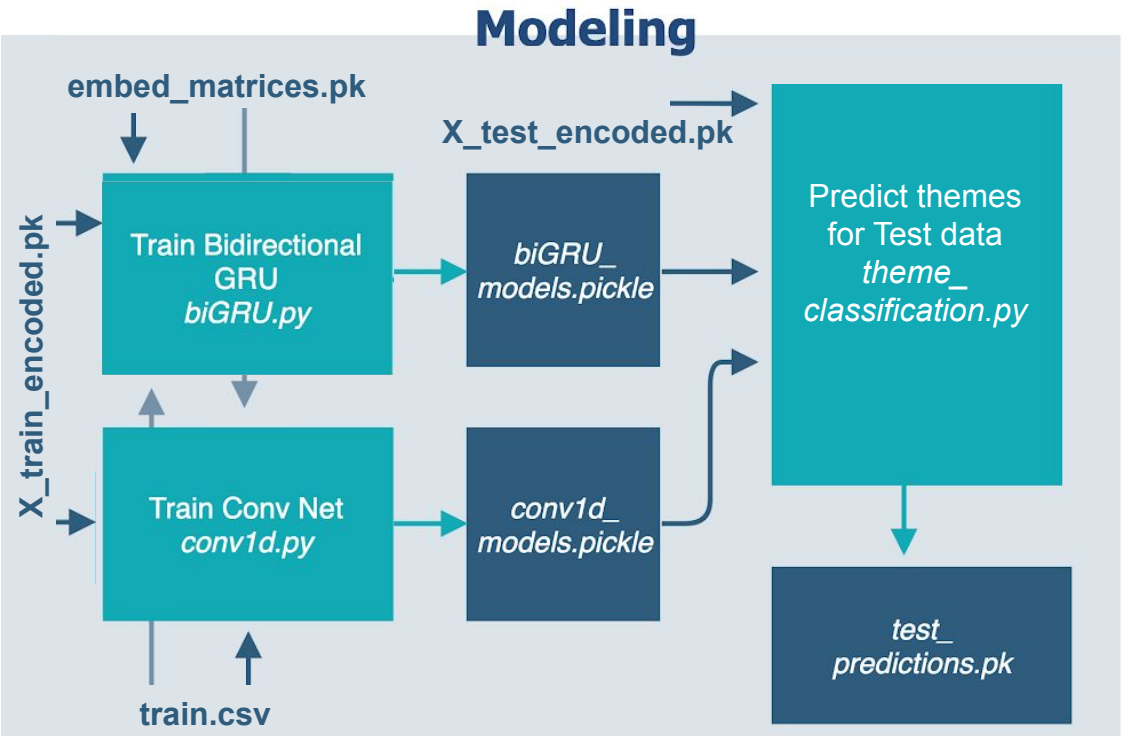
Example Comment Prediction:

| Model | CPD | CB | EWC | Exec | FWE | SP | RE | Sup | SW | TEPE | VMG | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOW \| LinearSVC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

# Predictive BOW features

| CPD | CB | EWC | Exec | FWE | SP |
|---|---|---|---|---|---|
| training | wages | favoritism | communication | lws | succession |
| courses | wage | bullying | executives | teleworking | retention |
| mentoring | pay | diversity | executive | telecommuting | recruiting |
| growth | compensation | harassment | change - management | telework | successional |
| advancement | salary | morale | authenticity | westshore | vacancies |

| RE | Sup | SW | TEPE | VMG | OTH |
|---|---|---|---|---|---|
| recognition | accountability | workload | ergonomics | stewardship | text |
| empowerment | respect - executive | lean | safety | budget | satisfied |
| micro-management | management | bureaucracy | icm | integration | perfect |
| autonomy | supervision | caseloads | technology | funding | happy |
| acknowledgment | communication - improved | workloads | ergonomic | politics | jorpp |



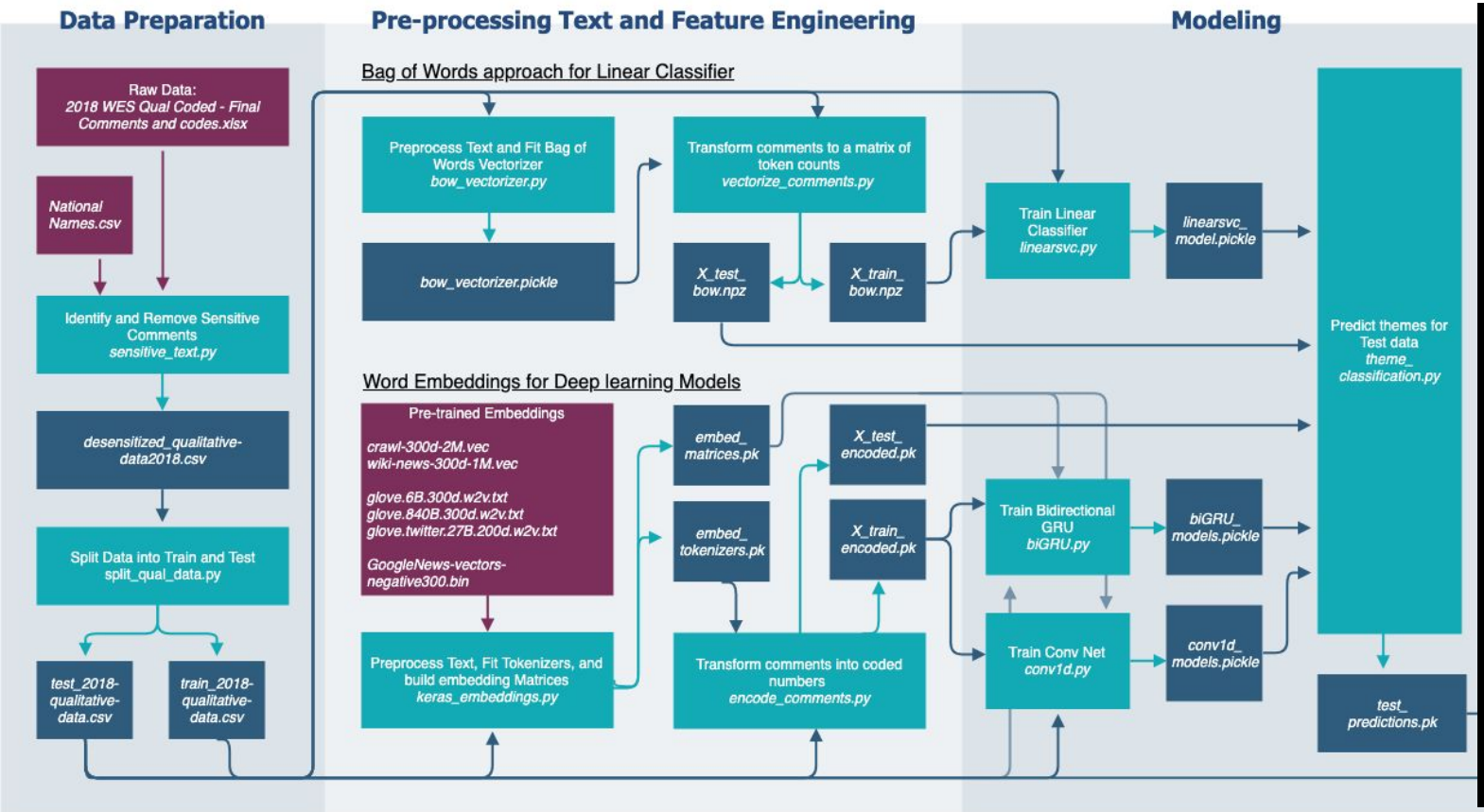

Conv1d & biGRU

- train/valid split (not shown in img)
- Trained each model with each embedding
- Experimenting with Neural Net Architecture made marginal differences
- Ensembled
  - Conv1d | glove_wiki
  - biGRU | glove_wiki
  - biGRU | glove_crawl
  - biGRU | fasttext_crawl

Example Comment Prediction:

| Model | CPD | CB | EWC | Exec | FWE | SP | RE | Sup | SW | TEPE | VMG | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conv1d \| glove_wiki | 0.23 | 0.04 | 0.15 | 0.02 | 0.34 | 0.08 | 0.12 | 0.07 | 0.4 | 0.65 | 0.2 | 0.01 |

# Text Classification Methodology




Results and Visualization

# How do we measure the success of a model:

- Accuracy on individual label/theme vs Overall Accuracy on the 12 labels as a whole

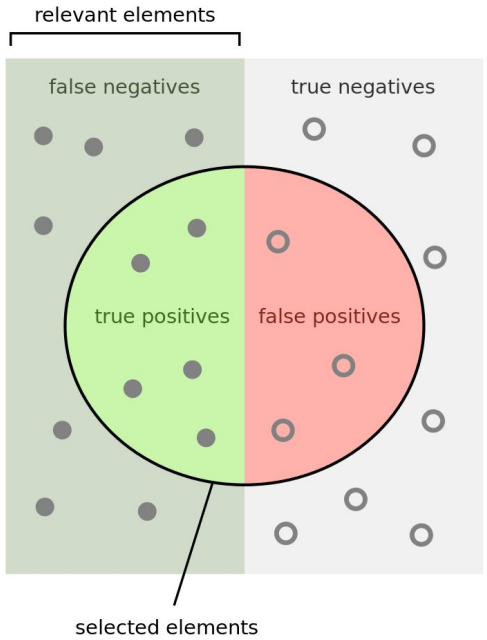
| | Career Development | Compensation | ... | Vision, Mission & Goals | Other |
|---|---|---|---|---|---|
| True Labels | **1** | **0** | | **1** | **0** |
| | **match** | | | | **match** |
| | Career Development | Compensation | ... | Vision, Mission & Goals | Other |
| Predicted Labels | **1** | **1** | | **0** | **0** |

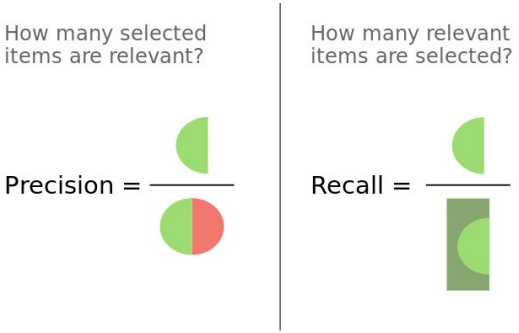
**Overall Accuracy**

**Accuracy on theme level**

# How do we measure the success of a model:

- Precision and Recall



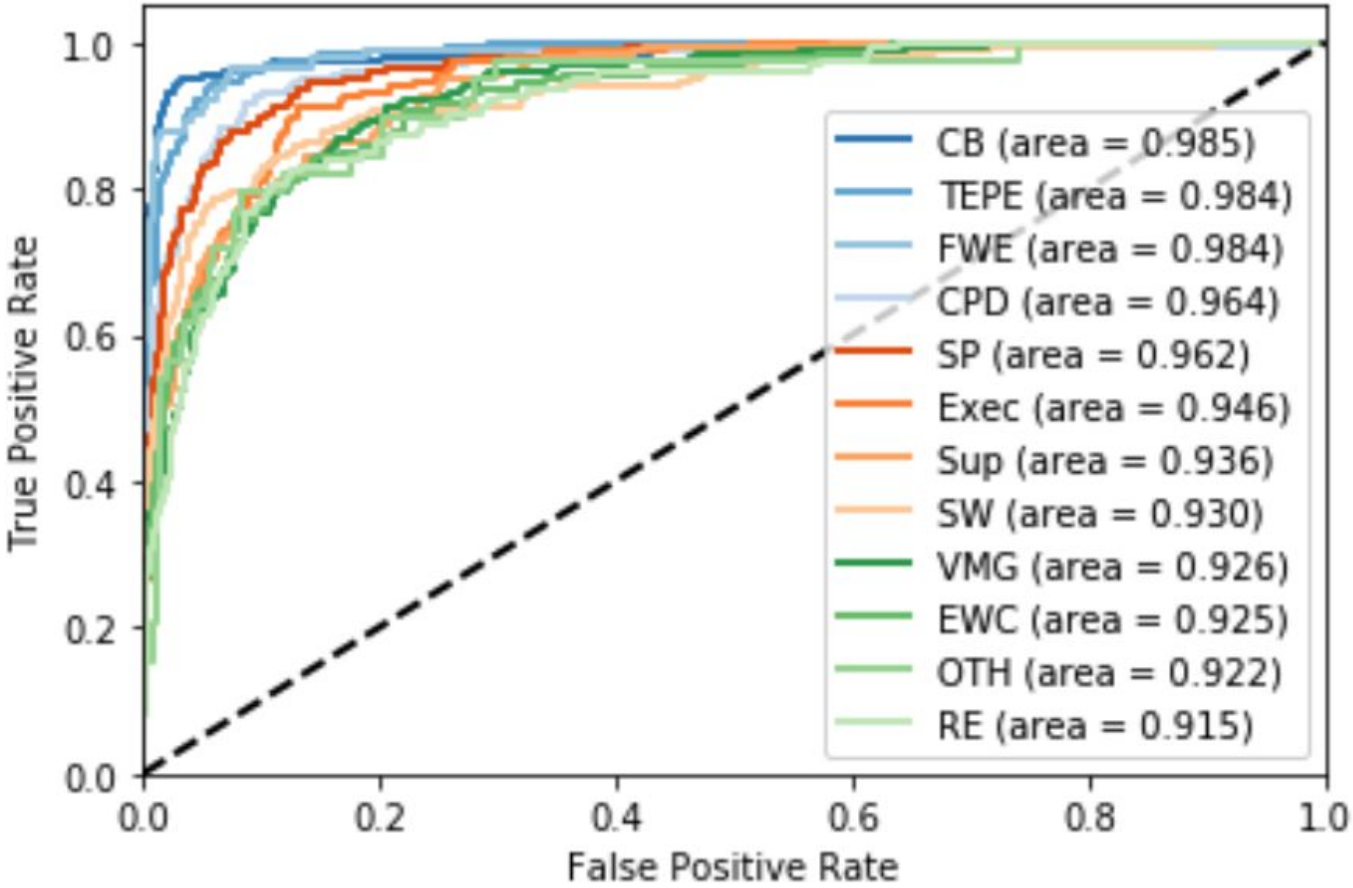




- ROC Curve -- is created by plotting the true positive rate (TPR) against the false positive rate (FPR) at various threshold settings.
- Micro Average -- a weighted average of the precision and recall

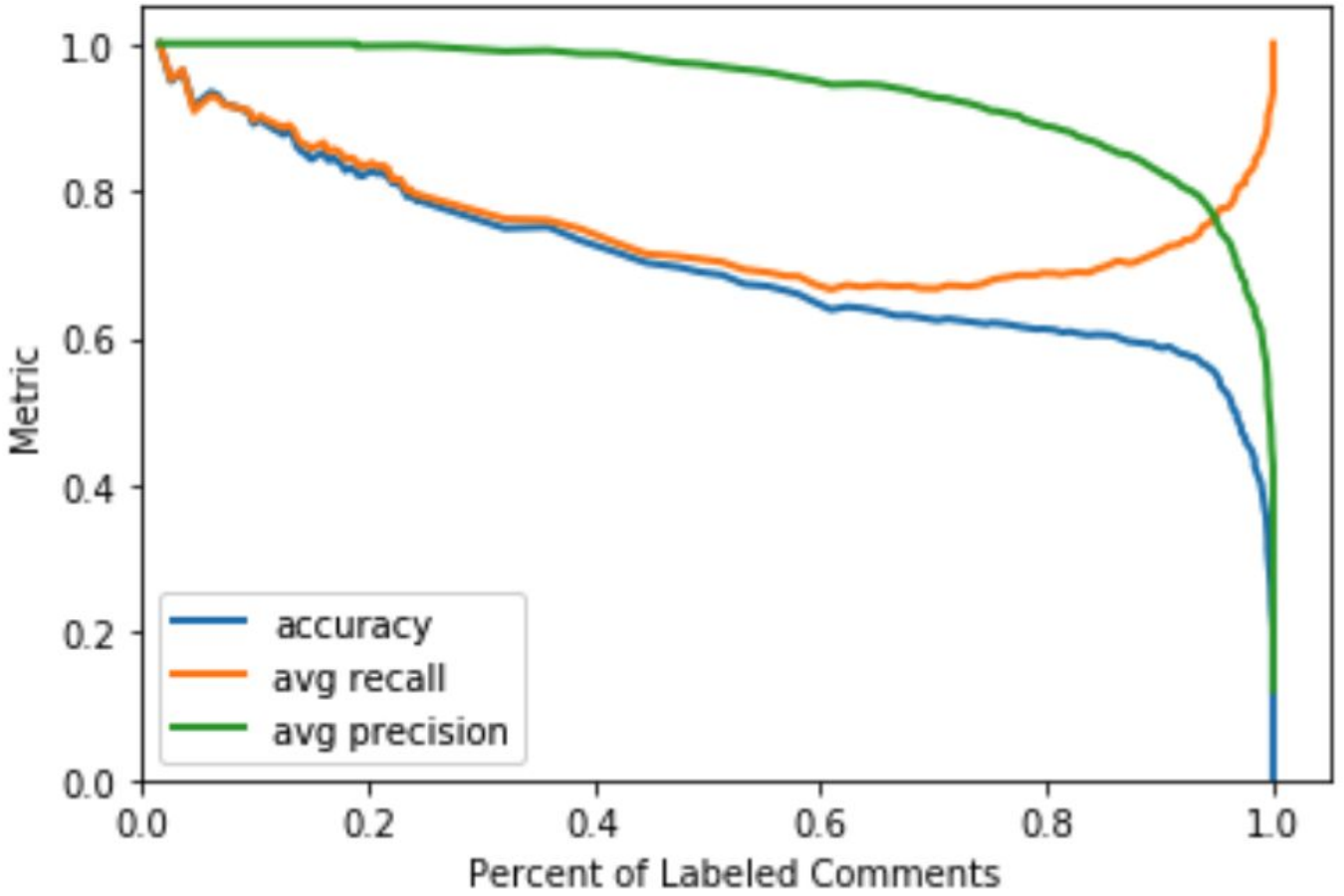
# Theme Classification - Selected Model Results

| Model | Accuracy | Precision | Recall |
|---|---|---|---|
| BOW \| LinearSVC | 45% | 74% | 64% |
| Conv1d \| GloVe Wiki | 51% | 80% | 64% |
| biGRU \| GloVe Wiki | 50% | 79% | 66% |
| biGRU \| fasttext Crawl | 51% | 80% | 66% |
| biGRU \| GloVe Crawl | 50% | 78% | 66% |
| Ensemble | 53% | 83% | 66% |

# Ensemble - ROC curve by Theme



# Ensemble - Adjusting the Probability Threshold



# Methodologies that did not work on our dataset:

-Term Frequency-Inverse Document Frequency (TF-IDF)

- Pre-processing

- Increasing the data (Doubling the data)

- Average Word Vectors per comment

- Intricate Stacking

- Feature selection - adding meta data / m.c questions

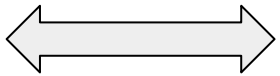
# Google BERT

- Was born in October 2018 at Google AI
- BERT is state-of-the-art NLP pre-trained Model
- Out of box, on a subset of our data, BERT has given the pretty good precision and recall compared to our other models
- Computational and privacy challenges
- On our local computer this model took 3 days to do on a subset of our data (for one theme)

# Relating Open Ended Survey Questions to Multiple-Choice Survey Questions

The computer based tools help me to excel

The computers are so slow and big source of frustration

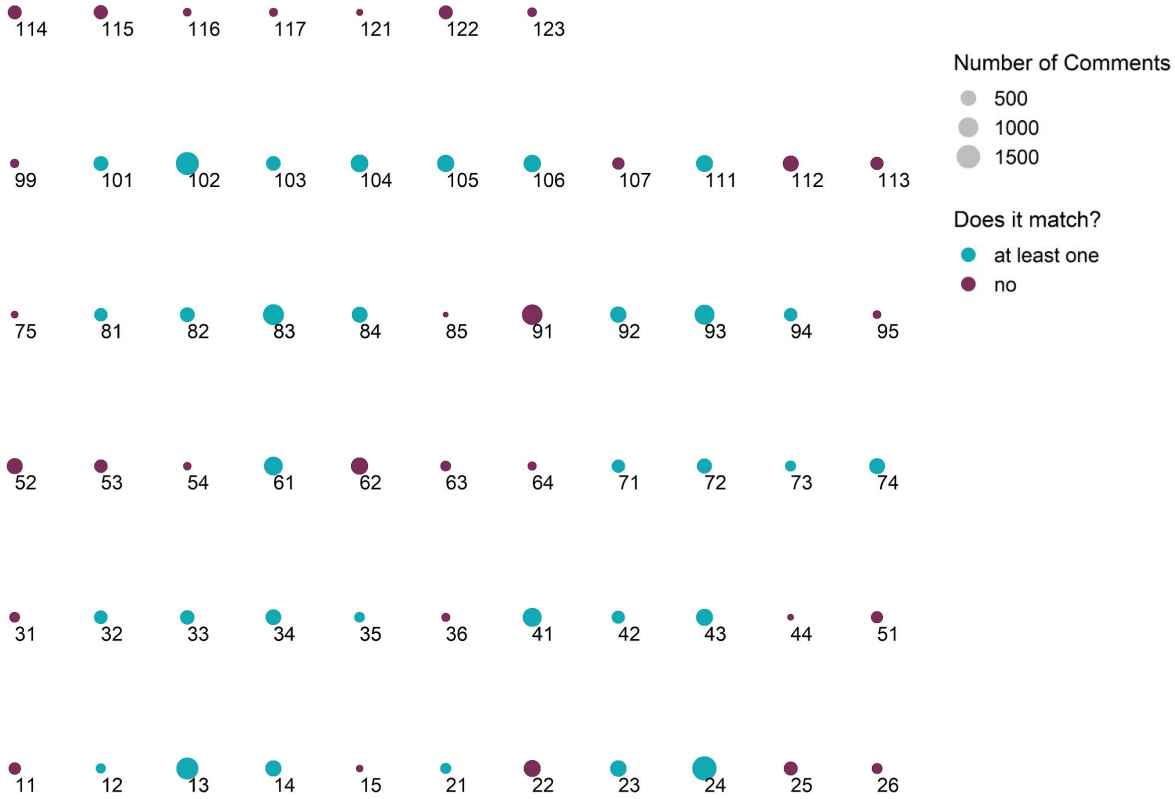


Strong Disagree — Strongly Agree

1 2 3 4 5

- Strength results by agreement between types of survey questions
- Help BC Stats focus on comments not well captured in the mc questions

# Matching Sub-themes & Multiple-choice Questions




| Raters | Percent Agreement |
|---|---|
| All | 0.48 |

## Insights

Create a multiple choice question related to subtheme 91 “Hire more staff”

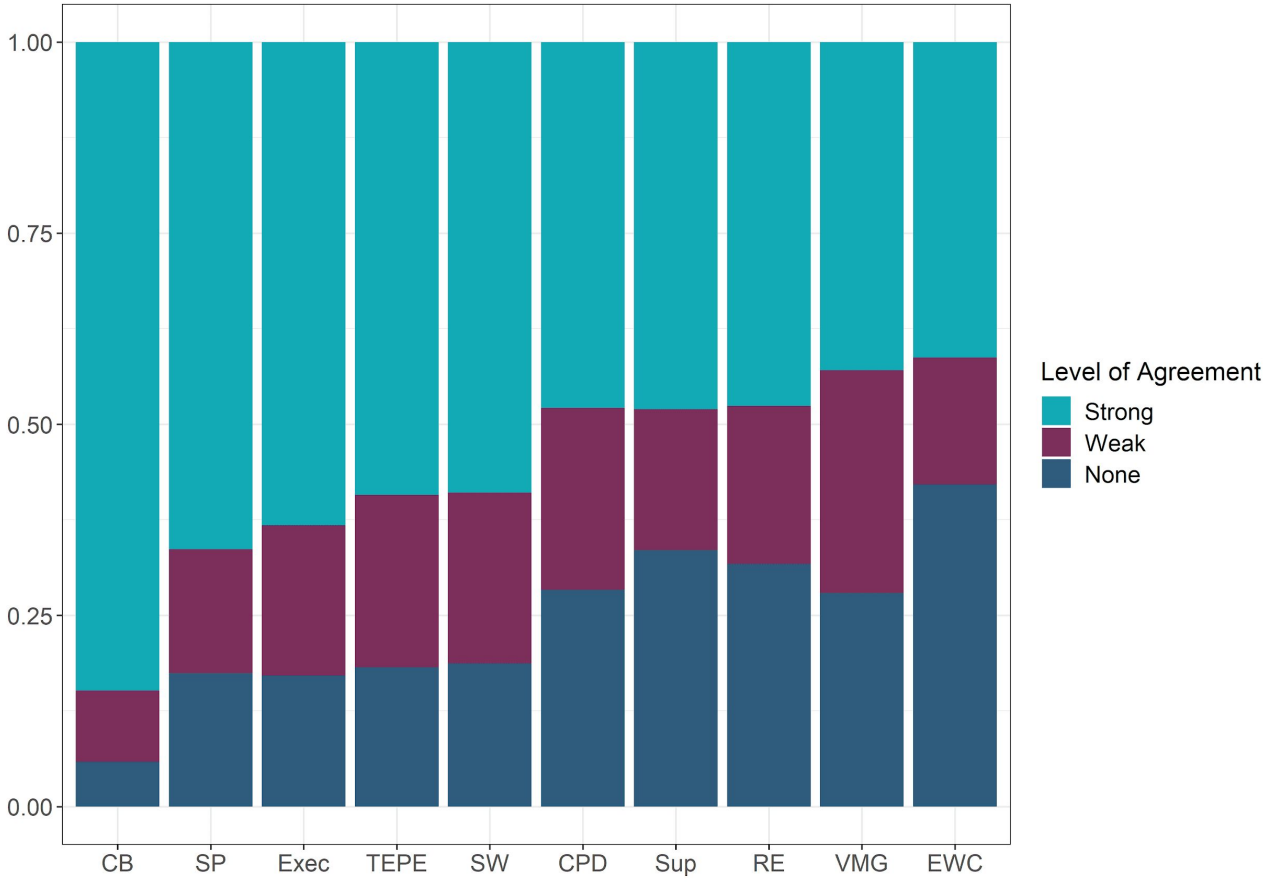
# Methodology

**Challenges**

- There was no mapping between sub-themes & multiple-choice questions
- Not all subthemes matched to a question & vice versa
- Comments could contain more than one topic
- Positive comments weren't coded to a topic

| Comments Sentiment | Multiple-choice Sentiment | Level of Agreement |
|---|---|---|
| negative | negative | strong |
| negative | neutral | weak |
| negative | positive | no |

# Results


1.00
0.75
0.50
0.25
0.00
CB
SP
Exec
TEPE
SW
CPD
Sup
RE
VMG
EWC
Level of Agreement
Strong
Weak
None

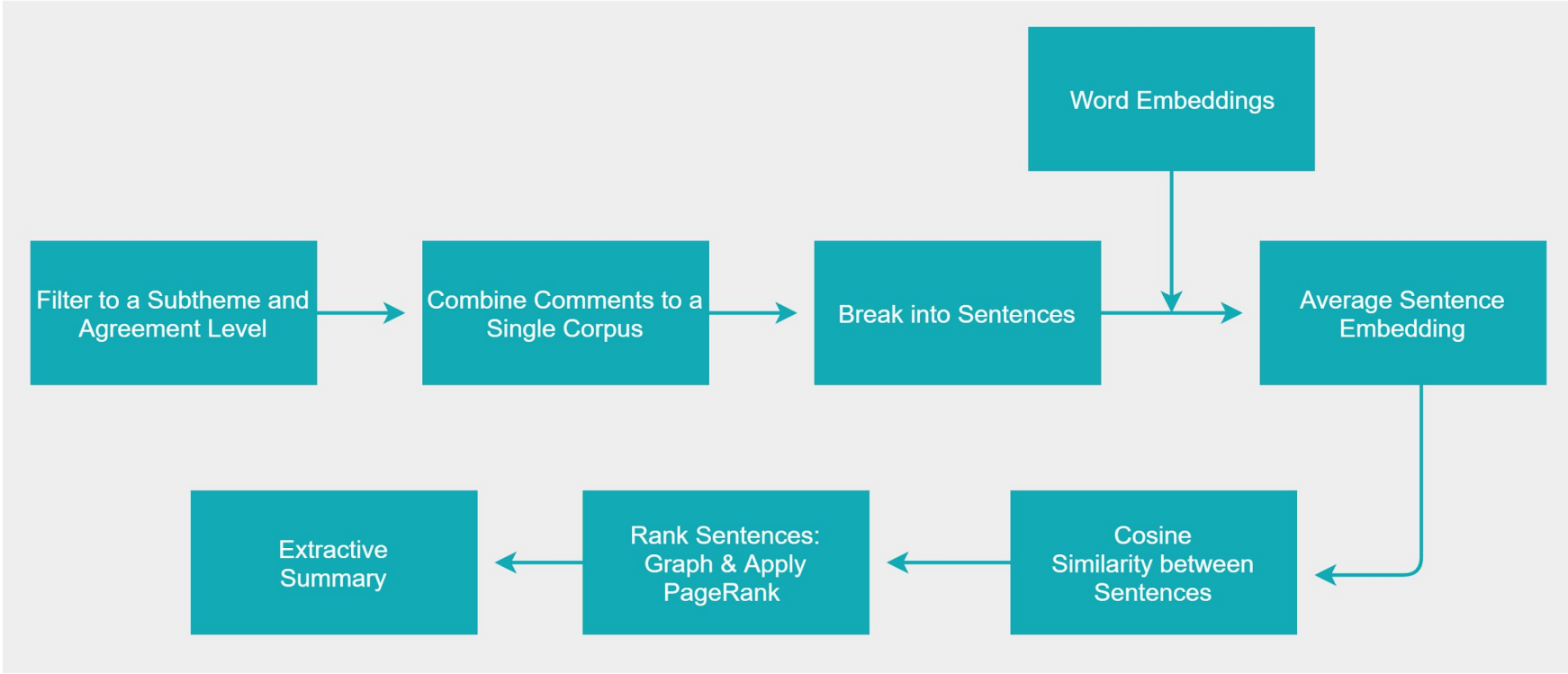
# Text Summarization

**NBA News Articles**

Generate Summary with 4 Sentences

1. This came after the Toronto Raptors clinched their first title with 114 110 win in Game 6 The Finals against the Golden State Warriors at Oracle Arena.
2. Game 6 ended the series while history might suggest the healthier team instead the better team won this title the Raptors did what champions do They pounced on the opportunity sealed the deal.
3. Discouraged irritated by the Raptors past playoff failures that followed successful regular seasons Ujiri traded star guard fan favorite DeMar Derozan for then devalued star Leonard who went rogue on the San Antonio Spurs.
4. The Raptors beat the Golden State Warriors 114 110 in Game 6 the Finals on Thursday win the series 4 2 with commanding performance on the road in Oracle Arenas last game dethrone the leagues reigning dynasty win the Raptors first title.

# Text Summarization




Credit to Prateek Joshi blog https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/

# Emotion of a Comment

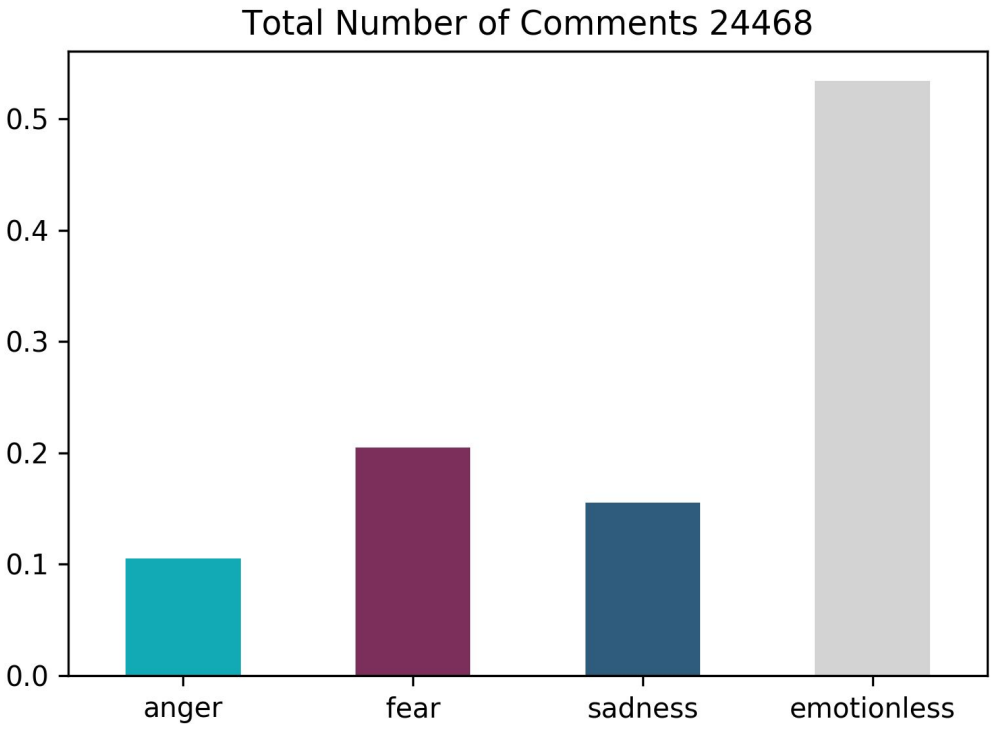
| Theme | Sub-theme Description | Sub-theme Code | Anger | Fear | Sad |
|---|---|---|---|---|---|
| Executive | Improve Stability | 42 | 0.0 | 0.198 + 0.359 = 0.557 | 0.0 |

Comment

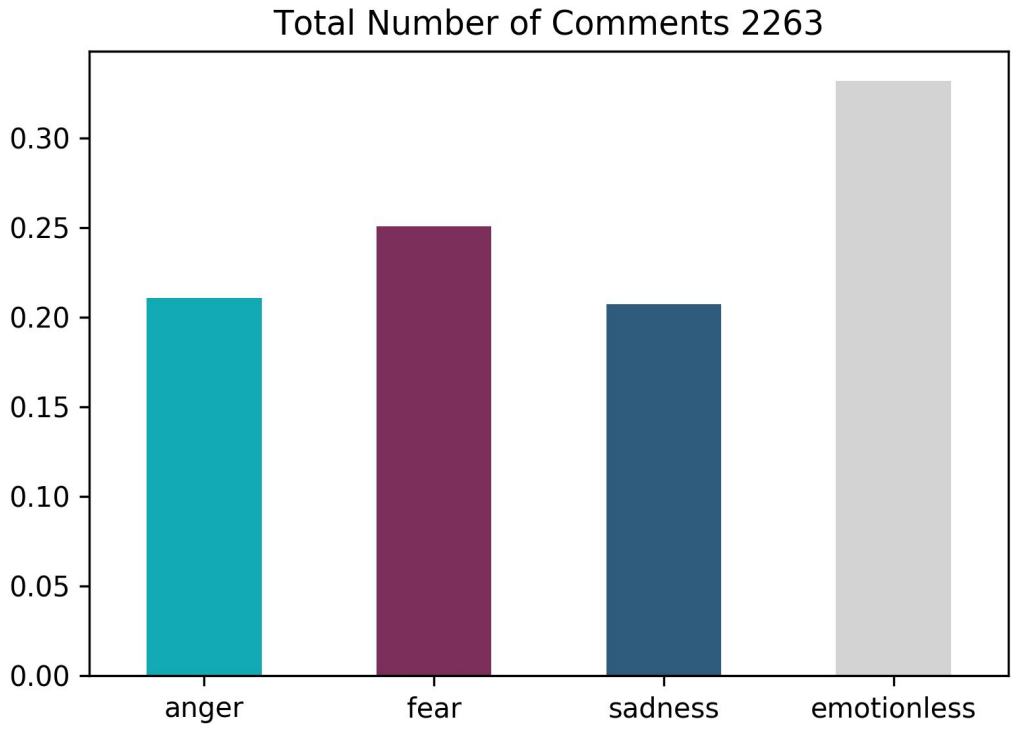

with such a big change-over of priorities and values in government in the past year, it has been somewhat confusing to be a new employee for my organization. some of the changes in organizational structure don't seem to make sense for our line of work.

Credit to The NRC Affect Intensity Lexicon v0.5 by Saif Mohammad

# Overall Emotion



# Emotions about Supervisors



# Data Science & Text

## Supervised

- Multi-label classification
  - Bag of Words
  - Tifid
  - Preprocessing
  - Word Embeddings
  - CNN
  - LSTM
  - BERT

## Discovery Analysis

- Mixed methods
- Text Summarization
- Emotion analysis


Thank you

# Themes

| | |
|---|---|
| CPD | Career & Personal Development |
| CB | Compensation & Benefits |
| EWC | Engagement & Workplace Culture |
| Exec | Executives |
| FWE | Flexible Work Environment |
| SP | Staffing Practices |

| | |
|---|---|
| RE | Recognition & Empowerment |
| Sup | Supervisors |
| SW | Stress & Workload |
| TEPE | Tools, Equipment & Physical Environment |
| VMG | Vision, Mission & Goals |
| Oth | Other |

# Sub-themes

| | | |
|---|---|---|
| Executives | 41 | Improve communication between executives and staff |
| | 42 | Improve stability and/or change management |
| | 43 | Strengthen quality of executive leadership |
| | 44 | Executives - other |
| ⋮ | ⋮ | ⋮ |
| Stress & Workload | 91 | Hire more staff |
| | 92 | Improve productivity and efficiency |
| | 93 | Review workload expectations |
| | 94 | Support a healthy workplace |
| | 95 | Stress & workload - other |