Analysis and Classification of Tweets to investigate COVID response

Load in libraries which we will use for analysis

In [188…

```
#!pip install textblob
import nltk
from nltk.tokenize import word_tokenize
from nltk.stem import WordNetLemmatizer
from nltk.stem.snowball import SnowballStemmer
from nltk.stem.porter import *
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from textblob import TextBlob
import re
from nltk.corpus import stopwords
from nltk.stem.wordnet import WordNetLemmatizer
from sklearn.feature_extraction.text import CountVectorizer, TfidfTransformer
from sklearn.naive_bayes import MultinomialNB
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline
from sklearn.metrics import confusion_matrix, classification_report,accuracy_score
```

Read in the data and show some sample tweets

In [189…

```
import pandas as pd
df = pd.read_csv('Data/ms4h05_data_anon.csv')
#print(df.to_string())
```

Task A: Pre-Processing

1. Change @twitterhandle to @user

Example of a tweet with a mention:

In [190…

```
df["text"][0] #example of a tweet with @username
```

Out[190…

```
'PAGS PARODY! Plus, Joe talks coronavirus and has special guest Peter J Hasson on his new book. - @JoeTalkShow https://t.co/IJE4gZwI0V'
```

Use regular expression to pick up any mention and replace it with @user

In [191…

```
import re
df['text'] = [re.sub(r'@\w+', '@User', x) for x in df["text"]] # eliminate usernames and replace with @User
```

Now look at the same tweet above and how the mention @JoeTalkShow has changed to @User

In [192…

```
df['text'][0] #above changes @JoeTalkShow to @User
```

Out[192…

```
'PAGS PARODY! Plus, Joe talks coronavirus and has special guest Peter J Hasson on his new book. - @User https://t.co/IJE4gZwI0V'
```

2. Clean tweets

Now we clean the tweets so they don't impact the analysis.

1. Convert html expressions such as \n and & to characters
2. Delete any html tags such as <'tab'>
3. We will keep URLS as they may help for the classification in Task D
4. Eliminate any brackets
5. Clean up hashes that don't form a hashtag
6. Clean up hyphens
7. Clean up white spaces to just one white space

Here is a program that will clean up the text:

In [193…

```
import html

def clean(text):
    # convert html escapes like &amp; to characters.
    text = html.unescape(text)
    # tags like <tab>
    text = re.sub(r'<[^<>]*>', ' ', text)
    # markdown URLs like [Some text](https://....)
    #text = re.sub(r'\[([^\[\]]*)\]\([^\(\)]*\)', r'\1', text)
    # text or code in brackets like [0]
    text = re.sub(r'\[[^\[\]]*\]', ' ', text)
    # standalone sequences of specials, matches &# but not #cool
    text = re.sub(r'(?:^|\s)[&#<>{}\[\]+|\\:-]{1,}(?:\s|$)', ' ', text)
    # standalone sequences of hyphens like --- or ==
    text = re.sub(r'(?:^|\s)[\-=\+]{2,}(?:\s|$)', ' ', text)
    # sequences of white spaces
    text = re.sub(r'\s+', ' ', text)
    #no hashtags
    #text = re.sub('\#[\w\_]+',' ', text)
    return text.strip()
```

Apply the cleaning program to our text and call it "clean_text"

In [194…

```
df['clean_text'] = df['text'].map(clean)
```

Example tweet before clean:

In [195…

```
df['text'][352]
```

Out[195…

```
"Hey @User if you are done with cocaine and gay orgies, take some similar diplomatic initiatives..\n\nStop being Bajwa's bitch for once and show your balls, if you have
 any..\n\n#imrankhanPTI #Pakistan #CoronaAlert \n#CoronaOutbreak #CoronavirusPandemic #CoronaVirus #SAARC https://t.co/55n0bN9ZRv"
```

Same tweet but now cleaned up.

In [196…

```
df['clean_text'][352]
```

Out[196… "Hey @User if you are done with cocaine and gay orgies, take some similar diplomatic initiatives.. Stop being Bajwa's bitch for once and show your balls, if you have an y.. #imrankhanPTI #Pakistan #CoronaAlert #CoronaOutbreak #CoronavirusPandemic #CoronaVirus #SAARC https://t.co/55n0bN9ZRv"

3. We do not remove hashtags - the code below is not used, we will keep the hashtags because it can be used in our classifier later on.

In [197…

```
# def remove_hash(text):
#     text = re.sub('\#[\w\_]+',' ', text)
#     return text.strip()
```

In [198…

```
#df['ctext_nh'] = df['clean_text'].map(remove_hash) #decide to keep the hashtags as may help in future prediction for classifier
df['ctext_nh'] = df['clean_text']
```

4. Convert all tweets to lowercase for tokenisation

We convert to lowercase so words like "corona" and "Corona" which means in the analysis both words come under the label "corona"

In [199…

```
df = df.applymap(lambda s:s.lower() if type(s) == str else s) #convert all to lowercase
```

5. Keep URLS - may be useful in classification later

In [200…

```
df['text5'] = df['ctext_nh']
#.map(form_sentence)
```

Normalisation

Furhter cleaning of the text.

1. Eliminate hyphens in hyphenated words
2. Delete quotation marks
3. Delete unicode
4. Remove accents (such as accented vowels)

In [201…

```
from  textacy import preprocessing as tprep
def normalise(text):
    text = tprep.normalize.hyphenated_words(text)
    text = tprep.normalize.quotation_marks(text)
    text = tprep.normalize.unicode(text)
    text = tprep.remove.accents(text)
    return text
```

In [202…

```
df['text6'] = df['text5'].map(normalise)
```

Using Spacy for Tokenisation

Load in spacy which is a package used for text analysis. First we tokenise the tweets, which means splitting the tweets up into individual words and also split into nouns and verbs and other word types.

In [203…

```
import spacy
nlp = spacy.load('en_core_web_sm')
```

In [204…

```
#disable stuff we don't need
#nlp = spacy.load("en_core_web_sm", disable=["parser", "ner"])
```

In [205…

```
df['text7'] = df['text6'].map(nlp)
```

You can now see the tweets are split into individual words

In [206…

```
df['text7']
```

Out[206…

```
0       (pags, parody, !, plus, ,, joe, talks, coronav...
1       (#, coronavirus, shows, that, racists, have, a...
2       (@user, @user, i, would, expect, front, line, ...
3       (the, coronavirus, is, not, only, affecting, t...
4       (i, hope, your, father, recovers, from, the, v...
                                ...
3637    (da, fark, is, wrong, with, these, people, ?, ...
3638    (doctor, finds, cure, to, covid-19, (, without...
3639    (i, ca, n't, believe, people, legitimately, th...
3640    (..., (, wrong, with, trump, continues, ), ,, ...
3641    (for, anyone, who, still, believes, that, covi...
Name: text7, Length: 3642, dtype: object
```

Create a program that tells us the word type for each word in the tweet:

In [207…

```
def display_nlp(doc, include_punct=False):
    """Generate data frame for visualization of spaCy tokens."""
    rows = []
    for i, t in enumerate(doc):
        if not t.is_punct or include_punct:
            row = {'token': i,  'text': t.text, 'lemma_': t.lemma_,
                   'is_stop': t.is_stop, 'is_alpha': t.is_alpha,
                   'pos_': t.pos_, 'dep_': t.dep_,
                   'ent_type_': t.ent_type_, 'ent_iob_': t.ent_iob_}
            rows.append(row)

    df = pd.DataFrame(rows).set_index('token')
    df.index.name = None
    return df
```

Here's a table of word types (see column pos_) of one tweet.

In [208…

```
display_nlp(df['text7'][1])
```

Out[208…

	text	lemma_	is_stop	is_alpha	pos_	dep_	ent_type_	ent_iob_
1	coronavirus	coronavirus	False	True	NOUN	compound		O
2	shows	show	False	True	VERB	advcl		O
3	that	that	True	True	SCONJ	mark		O

	text	lemma_	is_stop	is_alpha	pos_	dep_	ent_type_	ent_iob_
4	racists	racist	False	True	NOUN	nsubj		O
5	have	have	True	True	VERB	ccomp		O
6	absolutely	absolutely	False	True	ADV	advmod		O
7	2	2	False	False	NUM	nummod	CARDINAL	B
8	much	much	True	True	ADJ	amod		O
9	time	time	False	True	NOUN	dobj		O
10	on	on	True	True	ADP	prep		O
11	their	their	True	True	PRON	poss		O
12	hands	hand	False	True	NOUN	pobj		O
13	firstly	firstly	False	True	ADV	advmod		O
15	those	those	True	True	DET	det		O
16	racists	racist	False	True	NOUN	nsubj		O
17	who	who	True	True	PRON	nsubj		O
18	hate	hate	False	True	VERB	relcl		O
19	poc	poc	False	True	NOUN	compound		O
20	r	r	False	True	NOUN	nsubj		O
21	stuck	stick	False	True	VERB	ccomp		O
22	in	in	True	True	ADP	prep		O
24	xenophobicworld	xenophobicworld	False	True	NOUN	pobj		O
25	are	be	True	True	AUX	ROOT		O
26	proud	proud	False	True	ADJ	amod		O
28	deplorables	deplorable	False	True	NOUN	attr		O
29	which	which	True	True	DET	nsubj		O
30	means	mean	False	True	VERB	relcl		O
31	they	they	True	True	PRON	nsubj		O
32	did	do	True	True	AUX	aux		O
33	n't	n't	True	False	PART	neg		O
34	even	even	True	True	ADV	advmod		O
35	beleev	beleev	False	True	NOUN	ccomp		O
37	coronavirus	coronavirus	False	True	NOUN	nsubj		O
38	existed	exist	False	True	VERB	advcl		O
39	until	until	True	True	ADP	prep		O
40	a	a	True	True	DET	det		O
41	day	day	False	True	NOUN	pobj	DATE	B
42	or	or	True	True	CCONJ	cc		O
43	2	2	False	False	NUM	nummod	DATE	B
44	ago	ago	False	True	ADV	advmod	DATE	I
45	when	when	True	True	ADV	advmod		O
46	trump	trump	False	True	NOUN	advmod		O
47	did	do	True	True	AUX	aux		O
48	they	they	True	True	PRON	nsubj		O
49	're	be	True	False	VERB	advcl		O
50	quick	quick	False	True	ADJ	amod		O
51	studies	study	False	True	NOUN	attr		O
52	https://t.co/p22j3ti6kk	https://t.co/p22j3ti6kk	False	False	VERB	ROOT		O

Get rid of stop words - words that don't help the analysis such as "that", "there" etc.

These words don't help predict or tell us the opinion of a tweet, so we don't need them and they just add noise to the data if we keep them. Here's a program that deletes stop words.

In [209…

```
def stop_words(doc):
    non_stop = [t for t in doc if not t.is_stop and not t.is_punct]
    return non_stop
```

Use the program on our tweets:

In [210…

```
df['text8'] = df['text7'].map(stop_words)
```

Lemmatisation

This process makes words such as "closed", "closing", "closes" all the same, "closes". Tense doesn't tell us anything about the tweet so we make these words the same as they have the same meaning.

See how in the following tweet, the 2nd word is "show". The original tweet has "shows" but with lemmatisation this changes to "show"

In [211…

```
test = [t.lemma_ for t in df['text8'][1]]
test
```

Out[211…

```
['coronavirus',
 'show',
 'racist',
 'absolutely',
 '2',
 'time',
 'hand',
 'firstly',
 'racist',
```

```
 'hate',
 'poc',
 'r',
 'stick',
 'xenophobicworld',
 'proud',
 'deplorable',
 'mean',
 'beleev',
 'coronavirus',
 'exist',
 'day',
 '2',
 'ago',
 'trump',
 'quick',
 'study',
 'https://t.co/p22j3ti6kk']
```

Create a program that does the lemmatisation to our tweets.

In [212…

```
def lemma(doc):
    doclems = [t.lemma_ for t in doc]
    return doclems
```

In [213…

```
df['text9'] = df['text8'].map(lemma)
```

Here we have our tweets lemmatised.

In [214…

```
df['text9']
```

Out[214…

```
0       [pag, parody, plus, joe, talk, coronavirus, sp...
1       [coronavirus, show, racist, absolutely, 2, tim...
2       [@user, @user, expect, line, staff, risk, have...
3       [coronavirus, affect, way, live, dramatically,...
4       [hope, father, recover, virus, soona, possible...
                                   ...
3637    [da, fark, wrong, people, https://t.co/dxmbsob...
3638    [doctor, find, cure, covid-19, vaccine, https:...
3639    [believe, people, legitimately, think, covid, ...
3640    [wrong, trump, continue, -will, push, pressure...
3641    [believe, covid-19, conspiracy, people, die, s...
Name: text9, Length: 3642, dtype: object
```

Finished pre-processing. Finding word types follows

Below we make a program that allows us to extract the word types from a tweet. We use a packages called textacy for this. We can use this program and tell it to give us adjectives, nouns, verbs and more.

In [215…

```
import textacy

tokens = textacy.extract.words(doc,
            filter_stops = True,           # default True, no stopwords
            filter_punct = True,           # default True, no punctuation
            filter_nums = True,            # default False, no numbers
            include_pos = ['ADJ', 'NOUN'], # default None = include all
            exclude_pos = None,            # default None = exclude none
            min_freq = 1)                  # minimum frequency of words
```

A program to extract lemmas.

In [216…

```
#program to extract lemmas
def extract_lemmas(doc, **kwargs):
    return [t.lemma_ for t in textacy.extract.words(doc, **kwargs)]
```

So we use use program to extract lemmas. These are adjectives, nouns and verbs.

Noun phrases

We create the following program which extracts noun phrases, that is, where a noun appears with a noun before it.

In [217…

```
def extract_noun_phrases(doc, preceding_pos=['NOUN'], sep='_'):
    patterns = []
    for pos in preceding_pos:
        patterns.append(f"POS:{pos} POS:NOUN:+")
    spans = textacy.extract.matches.token_matches(doc, patterns=patterns)
    return [sep.join([t.lemma_ for t in s]) for s in spans]

print(*extract_noun_phrases(df['text7'][7], ['NOUN']), sep='|')
```

```
health_authority|human_transmission
```

Creata program doing the same but for verbs. So a verb with a verb before it.

In [218…

```
def extract_verb_phrases(doc, preceding_pos=['VERB'], sep='_'):
    patterns = []
    for pos in preceding_pos:
        patterns.append(f"POS:{pos} POS:VERB:+")
    spans = textacy.extract.matches.token_matches(doc, patterns=patterns)
    return [sep.join([t.lemma_ for t in s]) for s in spans]

print(*extract_verb_phrases(df['text7'][12], ['VERB']), sep='|')
```

```
drink_boil
```

Now we create a program that extracts entities from the tweets. Entities are names and organisations and places.

In [219…

```
def extract_entities(doc, include_types=None, sep='_'):

    ents = textacy.extract.entities(doc,
             include_types=include_types,
             exclude_types=None,
             drop_determiners=True,
             min_freq=1)

    return [sep.join([t.lemma_ for t in e])+'/'+e.label_ for e in ents]
```

Create a program that extracts hashtags from the tweets

In [220…

```
import re
def extract_hashtags(text):
    # the regular expression
    regex = "#(\w+)"
    # extracting the hashtags
    hashtag_list = re.findall(regex, text)
    return [t for t in hashtag_list]
```

Use all the programs above and put it into one program so you can extract all these features just using one piece of code

In [221…

```
def extract_nlp(doc):
    return {
    'lemmas'          : extract_lemmas(doc,
                                       exclude_pos = ['PART', 'PUNCT',
                                          'DET', 'PRON', 'SYM', 'SPACE'],
                                       filter_stops = True),
    'adjs'      : extract_lemmas(doc, include_pos = ['ADJ', 'VERB']),
    'verbs'      : extract_lemmas(doc, include_pos = ['VERB']),
    'nouns'           : extract_lemmas(doc, include_pos = ['NOUN', 'PROPN']),
    'noun_phrases'    : extract_noun_phrases(doc, ['NOUN']),
    'verb_phrases'    : extract_verb_phrases(doc, ['ADV']),
    'adj_noun_phrases': extract_noun_phrases(doc, ['ADJ']),
    'entities'        : extract_entities(doc, ['PERSON', 'ORG', 'GPE', 'LOC']),
    #'hashtags'        : extract_hashtags(text)
    }
```

Create a dataset extracting these features from the tweets. But first we remove hashtags because this interferes with the extractions.

In [222…

```
def remove_hash(text):
    text = re.sub('\#[\w\_]+',' ', text)
    return text.strip()
```

In [223…

```
df['ctext_nh2'] = df['ctext_nh'].map(remove_hash)
```

In [224…

```
nlp_columns = list(extract_nlp(nlp.make_doc('')).keys())
print(nlp_columns)
```

```
['lemmas', 'adjs', 'verbs', 'nouns', 'noun_phrases', 'verb_phrases', 'adj_noun_phrases', 'entities']
```

In [225…

```
for col in nlp_columns:
    df[col] = None
```

In [226…

```
batch_size = 50

for i in range(0, len(df), batch_size):
    docs = nlp.pipe(df['ctext_nh'][i:i+batch_size])

    for j, doc in enumerate(docs):
        for col, values in extract_nlp(doc).items():
            df[col].iloc[i+j] = values
```

```
C:\Users\T430\Anaconda3\lib\site-packages\pandas\core\indexing.py:1637: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  self._setitem_single_block(indexer, value, name)
```

Extract all hastags from original tweets

In [227…

```
#make hashtags column
df['hashtags_orig'] = df['text'].map(extract_hashtags)
#extract hashtags but where the hashtags we don't want are deleted

import re
#store stated hashtags
remove_words = ['ncov20199',
'coronaoutbreak',
'coronavirus',
'coronaviruscoverup',
'coronavirusoutbreak',
'covid19',
'coronavirus',
'wuhancoronavirus',
'coronaviris',
'wuhan']
```

Make a new variable that lists the hashtags but excluding the ones listed in the assignment.

In [228…

```
#this removes the hashtags stated from the hashtag column
df['hashtags_del'] = df.hashtags_orig.apply(lambda x: [i for i in x if i not in remove_words])
```

Task B

1. Distribution of word types in corpus and each category

Create a column that tells us the amount of each word type for each tweet

In [229…

```
nlp_columns

for column in nlp_columns:
    df[f'{column}_num'] = [len(x) for x in df[column]]
```

Here we have a chart of the frequency of word types in the entire dataset.

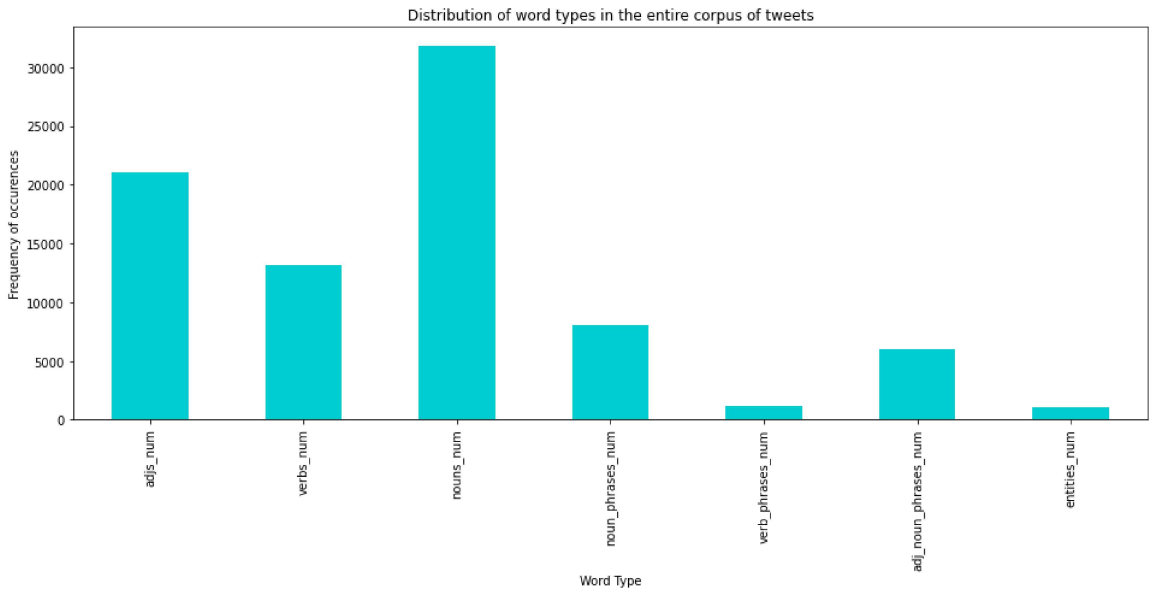
In [230…

```
from matplotlib import pyplot as plt
df[df.columns[22:29]].sum().plot.bar(rot=90, color='DarkTurquoise')
# Custom x axis

plt.xlabel("Word Type")
```

```
plt.ylabel("Frequency of occurences")
plt.title('Distribution of word types in the entire corpus of tweets')
```

Out[230…

```
Text(0.5, 1.0, 'Distribution of word types in the entire corpus of tweets')
```



Do this same analysis but for each group of tweets, so we sum up the number of word types by the groups.

In [231…

```
#get dataframe to sum over
import numpy as np
df1 = df[df.columns[np.concatenate([range(2,3),range(22,29)])]]
```

In [232…

```
df2 = df1.groupby('annontation', as_index=False).sum()
```

In [233…

```
df2
```

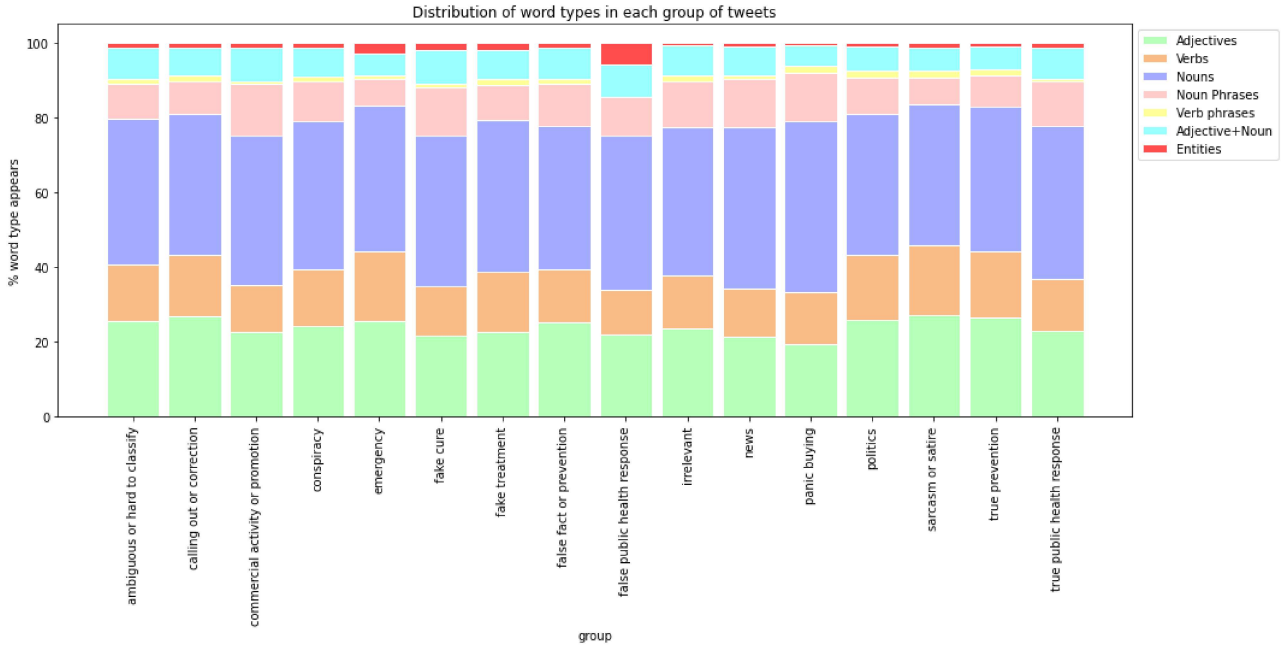
Out[233…

	annontation	adjs_num	verbs_num	nouns_num	noun_phrases_num	verb_phrases_num	adj_noun_phrases_num	entities_num
0	ambiguous or hard to classify	647	380	977	231	32	211	37
1	calling out or correction	7085	4396	9989	2291	408	1930	396
2	commercial activity or promotion	189	103	330	116	4	77	10
3	conspiracy	2791	1727	4526	1238	157	885	141
4	emergency	125	90	190	34	6	28	14
5	fake cure	381	229	706	226	17	155	35
6	fake treatment	107	75	191	45	7	36	10
7	false fact or prevention	1639	911	2465	730	76	548	84
8	false public health response	15	8	28	7	0	6	4
9	irrelevant	600	364	1005	312	39	201	22
10	news	386	227	775	232	13	138	21
11	panic buying	278	193	648	184	26	78	11
12	politics	2812	1859	4103	1034	188	713	112
13	sarcasm or satire	2043	1379	2825	545	140	452	105
14	true prevention	1085	727	1569	340	67	247	48
15	true public health response	847	516	1514	439	27	305	54

In [234…

```
# Libraries
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import rc
import pandas as pd

# Data
r = list(df2['annontation'])

# From raw value to percentage
totals = [i+j+k+l+m+n+o for i,j,k,l,m,n,o in zip(df2['adjs_num'], df2['verbs_num'],
                                        df2['nouns_num'], df2['noun_phrases_num'], df2['verb_phrases_num'], df2['adj_noun_phrases_num'], df2['entities_num'])]

adjs_num = [i / j * 100 for i,j in zip(df2['adjs_num'], totals)]
verbs_num = [i / j * 100 for i,j in zip(df2['verbs_num'], totals)]
nouns_num = [i / j * 100 for i,j in zip(df2['nouns_num'], totals)]
noun_phrases_num = [i / j * 100 for i,j in zip(df2['noun_phrases_num'], totals)]
verb_phrases_num = [i / j * 100 for i,j in zip(df2['verb_phrases_num'], totals)]
adj_noun_phrases_num = [i / j * 100 for i,j in zip(df2['adj_noun_phrases_num'], totals)]
entities_num = [i / j * 100 for i,j in zip(df2['entities_num'], totals)]

# plot
barWidth = 0.85
names = tuple(list(df2['annontation']))
# Create green Bars
plt.bar(r, adjs_num, color='#b5ffb9', edgecolor='white', width=barWidth, label="Adjectives")
#Create orange Bars
plt.bar(r, verbs_num, bottom=adjs_num, color='#f9bc86', edgecolor='white', width=barWidth, label="Verbs")
# Create blue Bars
plt.bar(r, nouns_num, bottom=[i+j for i,j in zip(adjs_num, verbs_num)], color='#a3acff', edgecolor='white', width=barWidth, label="Nouns")
plt.bar(r, noun_phrases_num, bottom=[i+j+k for i,j,k in zip(adjs_num, verbs_num, nouns_num)], color='#ffcccc', edgecolor='white', width=barWidth, label="Noun Phrases")
plt.bar(r, verb_phrases_num, bottom=[i+j+k+l for i,j,k,l in zip(adjs_num, verbs_num, nouns_num, noun_phrases_num)], color='#ffff99', edgecolor='white', width=barWidth, l
plt.bar(r, adj_noun_phrases_num, bottom=[i+j+k+l+m for i,j,k,l,m in zip(adjs_num, verbs_num, nouns_num, noun_phrases_num,verb_phrases_num)], color='#99ffff', edgecolor='
plt.bar(r, entities_num, bottom=[i+j+k+l+m+n for i,j,k,l,m,n in zip(adjs_num, verbs_num, nouns_num, noun_phrases_num,verb_phrases_num,adj_noun_phrases_num)], color='#ff4
```

```
# Custom x axis
plt.xticks(r, names, rotation=90)
plt.xlabel("group")

# Add a Legend
plt.legend(loc='upper left', bbox_to_anchor=(1,1), ncol=1)

plt.ylabel("% word type appears")
plt.title('Distribution of word types in each group of tweets')
# Show graphic
plt.rcParams["figure.figsize"] = (16,6)
plt.show()
```



2. Similarities

First we take all the text for each group and put it into one row.

In [235…

```
dfg = df.groupby("annontation")
# for x , y in dfg:
#      print(x)
#      print(y)
```

In [236…

```
column_names= ["Annontation", "Text"]
df_groups = pd.DataFrame(columns = column_names)
annots = []
fulltexts = []

for x, y in dfg:
    #print(x)
    #print(y['text'].str.cat(sep=', '))
    annots.append(x)
    fulltexts.append(y['text'].str.cat(sep=', '))
```

In [237…

```
dfg2 = pd.DataFrame({"Annontation": annots, "Text": fulltexts})
```

In [238…

```
dfg2
```

Out[238…

	Annontation	Text
0	ambiguous or hard to classify	are hand dryers effective in killing the new c...
1	calling out or correction	no, lime juice won't immunize you: some people...
2	commercial activity or promotion	visit https://t.co/gqrtz87i0w for new jersey #...
3	conspiracy	do you think the coronavirus is a natural occu...
4	emergency	bfhp is in need of essential supplies due to c...
5	fake cure	“anti-vaxxers have the cure to the coronavirus...
6	fake treatment	i currently have the flu (haven't been tested ...
7	false fact or prevention	if you went to dr. ricciardi in east orange as...
8	false public health response	italy allows malaria and hiv drugs for coronav...
9	irrelevant	pags parody! plus, joe talks coronavirus and h...
10	news	health authorities have identified a new coron...
11	panic buying	as the demand for hand sanitisers soars in the...
12	politics	i hope your father recovers from the virus as ...
13	sarcasm or satire	i protected myself from the coronavirus by wea...
14	true prevention	wash your hands as often as possible #cureforc...
15	true public health response	delhi hc restrains publication of certain adve...

Then we convert the text into a matrix where each word is a column and it gets a value 1 if it appears in the group.

In [239…
```
dt2 = CountVectorizer().fit_transform(dfg2['Text'])
```

We use cosine similarity to produce a correlation matrix

In [240…
```
from sklearn.metrics.pairwise import cosine_similarity
simi = pd.DataFrame(cosine_similarity(dt2,dt2))
```

In [241…
```
simi
```

Out[241…

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1.000000	0.951407	0.710882	0.928218	0.762031	0.781331	0.755302	0.888132	0.374929	0.894340	0.764297	0.821555	0.894777	0.935070	0.845954	0.819947
1	0.951407	1.000000	0.768467	0.929981	0.811118	0.807141	0.771616	0.914836	0.447666	0.898867	0.809751	0.855873	0.918822	0.953431	0.885512	0.867512
2	0.710882	0.768467	1.000000	0.719620	0.725741	0.647337	0.653725	0.824105	0.573720	0.742712	0.811023	0.781266	0.739685	0.717877	0.832002	0.838570
3	0.928218	0.929981	0.719620	1.000000	0.757918	0.796624	0.731955	0.858089	0.415083	0.893473	0.834459	0.854849	0.901658	0.914212	0.817155	0.874116
4	0.762031	0.811118	0.725741	0.757918	1.000000	0.678575	0.672576	0.814522	0.436440	0.734060	0.733205	0.733672	0.778550	0.789106	0.819130	0.813748
5	0.781331	0.807141	0.647337	0.796624	0.678575	1.000000	0.785798	0.747627	0.487822	0.735319	0.722016	0.716538	0.788127	0.786461	0.689336	0.787059
6	0.755302	0.771616	0.653725	0.731955	0.672576	0.785798	1.000000	0.744831	0.435436	0.693030	0.693619	0.682270	0.737589	0.725426	0.684972	0.741265
7	0.888132	0.914836	0.824105	0.858089	0.814522	0.747627	0.744831	1.000000	0.463483	0.864897	0.804748	0.837533	0.854271	0.890421	0.905747	0.871630
8	0.374929	0.447666	0.573720	0.415083	0.436440	0.487822	0.435436	0.463483	1.000000	0.373890	0.574430	0.450327	0.408884	0.376851	0.442588	0.549838
9	0.894340	0.898867	0.742712	0.893473	0.734060	0.735319	0.693030	0.864897	0.373890	1.000000	0.813790	0.897840	0.878635	0.913416	0.832903	0.858732
10	0.764297	0.809751	0.811023	0.834459	0.733205	0.722016	0.693619	0.804748	0.574430	0.813790	1.000000	0.862492	0.800070	0.762752	0.769123	0.920379
11	0.821555	0.855873	0.781266	0.854849	0.733672	0.716538	0.682270	0.837533	0.450327	0.897840	0.862492	1.000000	0.846982	0.856568	0.815039	0.878355
12	0.894777	0.918822	0.739685	0.901658	0.778550	0.788127	0.737589	0.854271	0.408884	0.878635	0.800070	0.846982	1.000000	0.929048	0.839155	0.869537
13	0.935070	0.953431	0.717877	0.914212	0.789106	0.786461	0.725426	0.890421	0.376851	0.913416	0.762752	0.856568	0.929048	1.000000	0.865442	0.839416
14	0.845954	0.885512	0.832002	0.817155	0.819130	0.689336	0.684972	0.905747	0.442588	0.832903	0.769123	0.815039	0.839155	0.865442	1.000000	0.849693
15	0.819947	0.867512	0.838570	0.874116	0.813748	0.787059	0.741265	0.871630	0.549838	0.858732	0.920379	0.878355	0.869537	0.839416	0.849693	1.000000

We display this in a heat map, with lighter colours representing a higher similarity. For example, 13 and 1 have a value of 0.95. These groups of tweets are very similar. What groups are they?

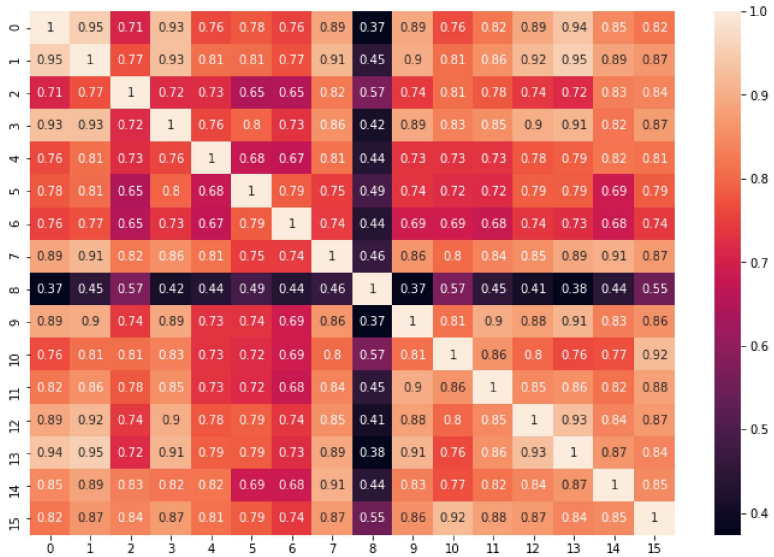
In [242…
```
annots[1], annots[13]
```

Out[242…
```
('calling out or correction', 'sarcasm or satire')
```

So calling out/correction and sarcasm tweets are similar.

In [243…
```
plt.figure(figsize=(12, 8))
sns.heatmap(simi, annot=True)
```

Out[243…
```
<AxesSubplot:>
```



3. Distribution of word types in entire distribution.

We sum up the number of each word type and display as a percentage of the entire dataset

In [244…
```
dfb3 = df1.sum()
dfb3
```

Out[244…
```
annontation             irrelevantirrelevantirrelevantirrelevantpoliti...
adjs_num                                                            21030
verbs_num                                                           13184
nouns_num                                                           31841
noun_phrases_num                                                     8004
verb_phrases_num                                                     1207
adj_noun_phrases_num                                                 6010
entities_num                                                         1104
dtype: object
```

In [245…
```
dfb3[1:8]
```

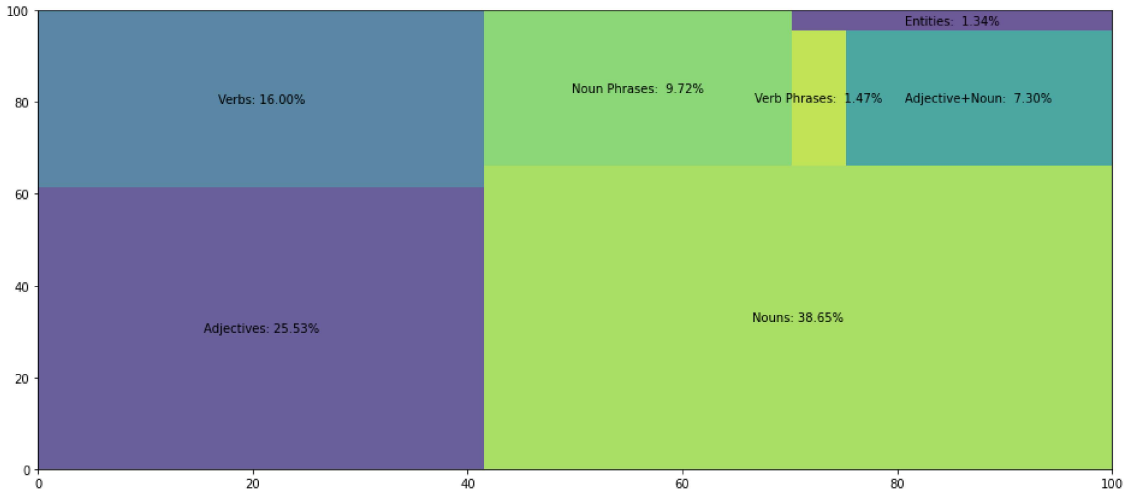
Out[245…
```
adjs_num                21030
verbs_num               13184
nouns_num               31841
noun_phrases_num         8004
verb_phrases_num         1207
adj_noun_phrases_num     6010
entities_num             1104
dtype: object
```

In [246…

```
#!pip install squarify
import squarify
label= ["Adjectives", "Verbs", "Nouns", "Noun Phrases", "Verb Phrases", "Adjective+Noun", "Entities"]

perc = [f'{i/dfb3[1:8].sum()*100:5.2f}%' for i in dfb3[1:8]]
lbl = [f'{el[0]}: {el[1]}' for el in zip(label, perc)]
plt.figure(figsize=(16, 7))
squarify.plot(sizes=dfb3[1:8], label=lbl, alpha=.8 )
#squarify.plot(sizes=dfb3[1:6], label =["Adjectives", "Verbs", "Nouns", "Noun Phrases", "Verb Phrases", "Adjective+Noun"], alpha=.8 )
#plt.axis('off')
#plt.show()
```

Out[246…

```
<AxesSubplot:>
```



4. Which annotated category has the highest number of user mentions?

We count the number of mentions per tweet then aggregate up for each group of tweets to see which has the most mentions

In [247…

```
df['numuser'] = df.text.str.count("@user")
```

In [248…

```
dfb4 = df[df.columns[np.concatenate([range(2,3),range(29,30)])]]
```

In [249…

```
dfb4a = dfb4.groupby('annontation', as_index=False).sum()
dfb4a
```

Out[249…

	annontation	numuser
0	ambiguous or hard to classify	38
1	calling out or correction	381
2	commercial activity or promotion	6
3	conspiracy	166
4	emergency	8
5	fake cure	71
6	fake treatment	22
7	false fact or prevention	51
8	false public health response	0
9	irrelevant	22
10	news	31
11	panic buying	17
12	politics	190
13	sarcasm or satire	78
14	true prevention	32
15	true public health response	53

In [250…

```
totals = dfb4.groupby('annontation', as_index=False).agg('count')
dfb4a['percent'] = (dfb4a['numuser']/totals['numuser'])*100
```

From the table below, fake treatment has the most mentions per tweet with ~105%.

In [251…

```
dfb4a # one entry can have more than mention, hence fake treatment has more mentions than individual tweets so it's >100%
```

Out[251…

	annontation	numuser	percent
0	ambiguous or hard to classify	38	33.628319
1	calling out or correction	381	31.936295
2	commercial activity or promotion	6	20.689655
3	conspiracy	166	32.549020
4	emergency	8	50.000000
5	fake cure	71	77.173913
6	fake treatment	22	104.761905
7	false fact or prevention	51	20.158103
8	false public health response	0	0.000000
9	irrelevant	22	20.183486

	annontation	numuser	percent
10	news	31	33.695652
11	panic buying	17	26.153846
12	politics	190	43.378995
13	sarcasm or satire	78	19.647355
14	true prevention	32	20.000000
15	true public health response	53	35.099338

5. Which annotated category uses the most hashtags in a tweet on average?

In [252…

```
df['hash_count'] = df['hashtags_orig'].str.len()
```

In [253…

```
dfb5 = df[df.columns[np.concatenate([range(2,3),range(30,31)])]]
dfb5
dfb5a = dfb5.groupby('annontation', as_index=False).sum()
totals = dfb5.groupby('annontation', as_index=False).agg('count')
dfb5a['totals'] = totals['hash_count']
dfb5a['percent'] = (dfb5a['hash_count']/totals['hash_count'])*100
```

Commercial activity has the most hash tags per tweet at ~241% (that's 2.4 hashtags per tweet)

In [254…

```
dfb5a
```

Out[254…

	annontation	hash_count	totals	percent
0	ambiguous or hard to classify	116	113	102.654867
1	calling out or correction	1017	1193	85.247276
2	commercial activity or promotion	70	29	241.379310
3	conspiracy	739	510	144.901961
4	emergency	16	16	100.000000
5	fake cure	109	92	118.478261
6	fake treatment	16	21	76.190476
7	false fact or prevention	365	253	144.268775
8	false public health response	0	3	0.000000
9	irrelevant	184	109	168.807339
10	news	72	92	78.260870
11	panic buying	100	65	153.846154
12	politics	534	438	121.917808
13	sarcasm or satire	238	397	59.949622
14	true prevention	210	160	131.250000
15	true public health response	183	151	121.192053

6. What are the top 3 hashtags for each category, including and excluding the hashtags used to filter the tweets?

Create a program that counts the frequency of word appearance.

In [255…

```
from collections import Counter
def count_words(df, column='tokens', preprocess=None, min_freq=2):

    # process tokens and update counter
    def update(doc):
        tokens = doc if preprocess is None else preprocess(doc)
        counter.update(tokens)

    # create counter and run through all data
    counter = Counter()
    df[column].map(update)

    # transform counter into a DataFrame
    freq_df = pd.DataFrame.from_dict(counter, orient='index', columns=['freq'])
    freq_df = freq_df.query('freq >= @min_freq')
    freq_df.index.name = 'token'

    return freq_df.sort_values('freq', ascending=False)
```

In [256…

```
hash_freq_tab =count_words(df, 'hashtags_orig').head(3)
#count_words(df, 'noun_p').head(10).plot(kind='barh').invert_yaxis()
```

Top 3 hashtags per category including all tweets

In [257…

```
for x in dfb5a['annontation']:
    print(x)
    print(count_words(df.loc[df['annontation'] == x], 'hashtags_orig').head(3))
    print('\n')
```

```
ambiguous or hard to classify
             freq
token
covid19         17
coronavirus     14
bioweapon        4


calling out or correction
                   freq
token
coronavirus         179
covid19             167
coronavirusfacts     23


commercial activity or promotion
```

```
             freq
token
covid19         9
coronavirus     8
covidscams      2


conspiracy
             freq
token
coronavirus   111
covid19        63
bioweapon      62


emergency
                        freq
token
coronavirus                4
covid19                    2
donateplasmarescuealife    2


fake cure
             freq
token
coronil         8
covid19         8
coronavirus     6


fake treatment
                   freq
token
hydroxychloroquine     2
coronavirus            2


false fact or prevention
             freq
token
coronavirus    39
covid19        35
covid_19       18


false public health response
Empty DataFrame
Columns: [freq]
Index: []


irrelevant
             freq
token
coronavirus    29
covid19        21
cooking         4


news
             freq
token
coronavirus    18
covid19         8
covid           3


panic buying
             freq
token
coronavirus    20
covid19         7
covid—19        4


politics
             freq
token
coronavirus    60
covid19        54
trump          37


sarcasm or satire
                  freq
token
coronavirus         38
covid19             34
socialdistancing     6


true prevention
             freq
token
covid19        48
coronavirus    26
covid_19        6


true public health response
                   freq
token
covid19               28
coronavirus           23
hydroxychloroquine     6
```

Top 3 hashtags per category excluding tweets quoted in the assignment

In [258…

```
for x in dfb5a['annontation']:
    print(x)
    print(count_words(df.loc[df['annontation'] == x], 'hashtags_del').head(3))
    print('\n')
```

```
ambiguous or hard to classify
           freq
token
bioweapon     4
billgates     3
covid         3
```

```
calling out or correction
                  freq
token
coronavirusfacts    23
lie                 23
covidiots           22


commercial activity or promotion
              freq
token
covidscams       2
disinfectant     2
cleaning         2


conspiracy
          freq
token
bioweapon    62
china        26
5g           14


emergency
                        freq
token
donateplasmarescuealife     2


fake cure
                    freq
token
coronil                8
covid                  6
hydroxychloroquine     6


fake treatment
                    freq
token
hydroxychloroquine     2


false fact or prevention
                    freq
token
covid_19              18
hydroxychloroquine     7
health                 6


false public health response
Empty DataFrame
Columns: [freq]
Index: []


irrelevant
                freq
token
cooking            4
quarantinelife     4
covid—19           3


news
            freq
token
covid           3
saudiarabia     2
icis            2


panic buying
            freq
token
covid—19        4
toiletpaper     3
covid2019       3


politics
            freq
token
trump          37
trumpvirus     12
donaldtrump     8


sarcasm or satire
                  freq
token
socialdistancing     6
trump                6
covid_19             4


true prevention
              freq
token
covid_19         6
disinfectant     4
staysafe         4


true public health response
                    freq
token
hydroxychloroquine     6
covidscams             4
who                    4
```

Task C - Affect Analysis

In [259…

```
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()
```

In [260…

```
dfg2['Text'] ####here is the column we'll do the analysis on
```

Out[260…

```
0     are hand dryers effective in killing the new c...
1     no, lime juice won't immunize you: some people...
2     visit https://t.co/gqrtz87i0w for new jersey #...
3     do you think the coronavirus is a natural occu...
4     bfhp is in need of essential supplies due to c...
5     “anti-vaxxers have the cure to the coronavirus...
6     i currently have the flu (haven't been tested ...
7     if you went to dr. ricciardi in east orange as...
8     italy allows malaria and hiv drugs for coronav...
9     pags parody! plus, joe talks coronavirus and h...
10    health authorities have identified a new coron...
11    as the demand for hand sanitisers soars in the...
12    i hope your father recovers from the virus as ...
13    i protected myself from the coronavirus by wea...
14    wash your hands as often as possible #cureforc...
15    delhi hc restrains publication of certain adve...
Name: Text, dtype: object
```

This prepares a dataset with the group and all the text within the group.

In [261…

```
column_names= ["Annontation", "Text"]
df_groups = pd.DataFrame(columns = column_names)
annots = []
fulltexts = []

for x, y in dfg:
    #print(x)
    #print(y['text'].str.cat(sep=', '))
    annots.append(x)
    fulltexts.append(y['text5'].str.cat(sep=', '))

dfg2 = pd.DataFrame({"Annontation": annots, "Text": fulltexts})
```

We now use the vader dictionary on the text. This matches up words in the dictionary with the words in the tweets and gives it a score based on those words. For example, if the text contains the word "good" then it will receive +1, if it contains the word "bad" it will receive -1 points. If it contains "very bad" it will get -2, for example. Depending on how positive/negative the word/phrase it, it gets more/less points. From this we can give each body of a text a score for positive or negative to see if each groups' tweets are positive or negative.

In [262…

```
dfg2['scores'] = dfg2['Text'].apply(lambda review: sid.polarity_scores(review))
dfg2
```

Out[262…

	Annontation	Text	scores
0	ambiguous or hard to classify	are hand dryers effective in killing the new c...	{'neg': 0.129, 'neu': 0.754, 'pos': 0.117, 'co...
1	calling out or correction	no, lime juice won't immunize you: some people...	{'neg': 0.178, 'neu': 0.719, 'pos': 0.103, 'co...
2	commercial activity or promotion	visit https://t.co/gqrtz87i0w for new jersey #...	{'neg': 0.068, 'neu': 0.799, 'pos': 0.133, 'co...
3	conspiracy	do you think the coronavirus is a natural occu...	{'neg': 0.14, 'neu': 0.766, 'pos': 0.094, 'com...
4	emergency	bfhp is in need of essential supplies due to c...	{'neg': 0.084, 'neu': 0.79, 'pos': 0.126, 'com...
5	fake cure	“anti-vaxxers have the cure to the coronavirus...	{'neg': 0.075, 'neu': 0.836, 'pos': 0.09, 'com...
6	fake treatment	i currently have the flu (haven't been tested ...	{'neg': 0.025, 'neu': 0.808, 'pos': 0.167, 'co...
7	false fact or prevention	if you went to dr. ricciardi in east orange as...	{'neg': 0.087, 'neu': 0.716, 'pos': 0.197, 'co...
8	false public health response	italy allows malaria and hiv drugs for coronav...	{'neg': 0.0, 'neu': 0.947, 'pos': 0.053, 'comp...
9	irrelevant	pags parody! plus, joe talks coronavirus and h...	{'neg': 0.108, 'neu': 0.781, 'pos': 0.112, 'co...
10	news	health authorities have identified a new coron...	{'neg': 0.118, 'neu': 0.813, 'pos': 0.069, 'co...
11	panic buying	as the demand for hand sanitisers soars in the...	{'neg': 0.114, 'neu': 0.821, 'pos': 0.065, 'co...
12	politics	i hope your father recovers from the virus as ...	{'neg': 0.156, 'neu': 0.731, 'pos': 0.112, 'co...
13	sarcasm or satire	i protected myself from the coronavirus by wea...	{'neg': 0.112, 'neu': 0.752, 'pos': 0.136, 'co...
14	true prevention	wash your hands as often as possible #cureforc...	{'neg': 0.06, 'neu': 0.758, 'pos': 0.182, 'com...
15	true public health response	delhi hc restrains publication of certain adve...	{'neg': 0.087, 'neu': 0.798, 'pos': 0.116, 'co...

Can see from this table if a category is negative or positive. Positive are any scored >0, negative are any scored <0. "comp_score" column tells us if the category is positive or negative.

In [263…

```
dfg2['compound']  = dfg2['scores'].apply(lambda score_dict: score_dict['compound'])
dfg2['comp_score'] = dfg2['compound'].apply(lambda c: 'pos' if c >=0 else 'neg')
dfg2
```

Out[263…

	Annontation	Text	scores	compound	comp_score
0	ambiguous or hard to classify	are hand dryers effective in killing the new c...	{'neg': 0.129, 'neu': 0.754, 'pos': 0.117, 'co...	-0.9973	neg
1	calling out or correction	no, lime juice won't immunize you: some people...	{'neg': 0.178, 'neu': 0.719, 'pos': 0.103, 'co...	-1.0000	neg
2	commercial activity or promotion	visit https://t.co/gqrtz87i0w for new jersey #...	{'neg': 0.068, 'neu': 0.799, 'pos': 0.133, 'co...	0.9941	pos
3	conspiracy	do you think the coronavirus is a natural occu...	{'neg': 0.14, 'neu': 0.766, 'pos': 0.094, 'com...	-1.0000	neg
4	emergency	bfhp is in need of essential supplies due to c...	{'neg': 0.084, 'neu': 0.79, 'pos': 0.126, 'com...	0.9764	pos
5	fake cure	“anti-vaxxers have the cure to the coronavirus...	{'neg': 0.075, 'neu': 0.836, 'pos': 0.09, 'com...	0.9915	pos
6	fake treatment	i currently have the flu (haven't been tested ...	{'neg': 0.025, 'neu': 0.808, 'pos': 0.167, 'co...	0.9981	pos
7	false fact or prevention	if you went to dr. ricciardi in east orange as...	{'neg': 0.087, 'neu': 0.716, 'pos': 0.197, 'co...	1.0000	pos
8	false public health response	italy allows malaria and hiv drugs for coronav...	{'neg': 0.0, 'neu': 0.947, 'pos': 0.053, 'comp...	0.4404	pos
9	irrelevant	pags parody! plus, joe talks coronavirus and h...	{'neg': 0.108, 'neu': 0.781, 'pos': 0.112, 'co...	-0.7671	neg
10	news	health authorities have identified a new coron...	{'neg': 0.118, 'neu': 0.813, 'pos': 0.069, 'co...	-0.9989	neg
11	panic buying	as the demand for hand sanitisers soars in the...	{'neg': 0.114, 'neu': 0.821, 'pos': 0.065, 'co...	-0.9970	neg
12	politics	i hope your father recovers from the virus as ...	{'neg': 0.156, 'neu': 0.731, 'pos': 0.112, 'co...	-1.0000	neg
13	sarcasm or satire	i protected myself from the coronavirus by wea...	{'neg': 0.112, 'neu': 0.752, 'pos': 0.136, 'co...	0.9998	pos
14	true prevention	wash your hands as often as possible #cureforc...	{'neg': 0.06, 'neu': 0.758, 'pos': 0.182, 'com...	1.0000	pos
15	true public health response	delhi hc restrains publication of certain adve...	{'neg': 0.087, 'neu': 0.798, 'pos': 0.116, 'co...	0.9992	pos

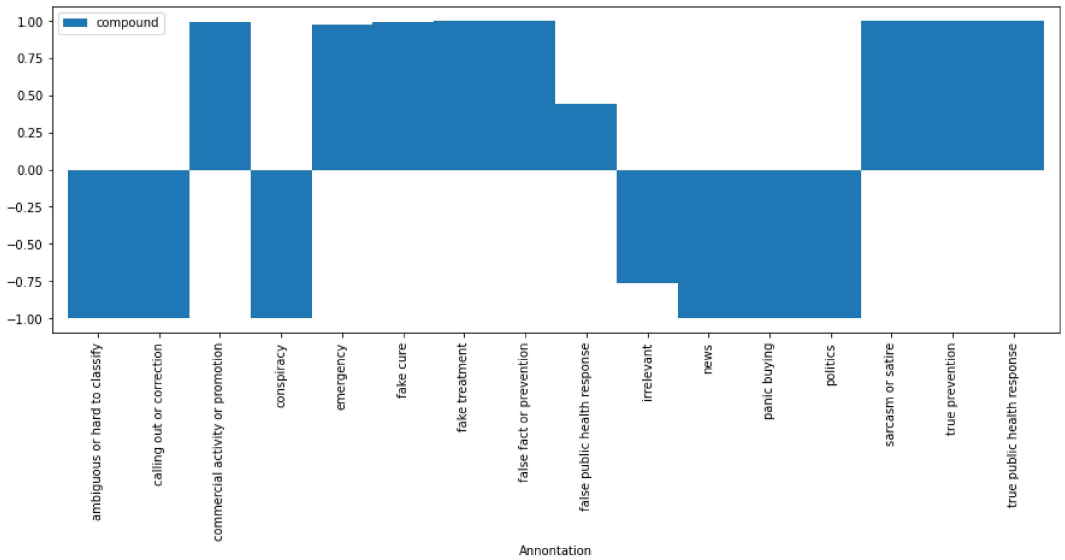
We plot this on a bar chart

In [264…

```
# Custom x axis
dfg2.plot.bar(figsize=(15,5),width=1, x='Annontation')
```

Out[264…

```
<AxesSubplot:xlabel='Annontation'>
```



Task D. Text Classification

We want to create a binary classifier of "misinformation" and "no misinformation". First we combined tweets. We exclude "sarcasm" and "irrelevant" from this analysis. Sarcasm could confuse the classifier as the classifier probably won't be able to pick up on a sarcastic tone. Irrelevant is excluded because it's not relevant.

In [265…

```
## merge tweets
df

misinfo = ["conspiracy", "fake cure", "fake treatment", "false fact or prevention"]
no_misinfo = ["true treatment", "true prevention", "true public health response", "calling out or correction", "emergency", "news",
              "irrelevant", "commercial activity or promotion", "panic buying", "politics"]
```

Assign each tweet a misinfo or no misinfo label

In [266…

```
# create a list of our conditions
conditions = [
    (df["annontation"].isin(misinfo)),
    (df["annontation"].isin(no_misinfo)),
    (~df["annontation"].isin(misinfo)) & (~df["annontation"].isin(no_misinfo))
    ]

# create a list of the values we want to assign for each condition
values = ['misinfo', 'no_misinfo', 'n/a']

# create a new column and use np.select to assign values to it using our lists as arguments
df['class1'] = np.select(conditions, values)
```

In [267…

```
with pd.option_context('display.max_rows', None, 'display.max_columns', None):
    print(df[['annontation', 'class1']].head())
```

```
  annontation      class1
0  irrelevant  no_misinfo
1  irrelevant  no_misinfo
2  irrelevant  no_misinfo
3  irrelevant  no_misinfo
4    politics  no_misinfo
```

Drop the tweets we don't deem relevant to the analysis.

In [268…

```
#drop n/a
dfd1 = df[df.class1 != 'n/a']
```

The column 'text9' is after our pre-processing steps. We change it to a list to a string so it can be used in the classifier.

In [269…

```
#hello = ' '.join(dfd1['text9'])
#dfd1['text9']
dfd1['text10'] = [' ' .join(x) for x in dfd1['text9']]
```

```
<ipython-input-269-59c8dd610ef5>:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  dfd1['text10'] = [' ' .join(x) for x in dfd1['text9']]
```

Split the data into train and test. Train data is used to create the model. We then use the test data to see if the model is accurate on data we didn't use in the model to see if it can make predictions on new data.

In [270…

```
#use text6
X_train, X_test, Y_train, Y_test = train_test_split(dfd1['text10'],
                                                    dfd1['class1'],
                                                    test_size=0.2,
                                                    random_state=42,
                                                    stratify=dfd1['class1']
                                                   )

print('Size of Training Data ', X_train.shape[0])
print('Size of Test Data ', X_test.shape[0])
```

```
Size of Training Data  2503
Size of Test Data  626
```

Transform the test data into a matrix of numbers, where each word gets a number of how frequently it appears in each class of info and misinfo. The grid search below, which tells us the best parameters to use for this model, tells us that an ngram range of 1,3 is the best. That means we include phrases of 1, 2 and 3 words long in the analysis. For example for a 3 gram phrase,

"coronavirus is bad" would be included. For a 2 gram phrase "go away" would be included.

In [271…

```
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf = TfidfVectorizer(min_df = 10, ngram_range=(1,3), stop_words="english")
X_train_tf = tfidf.fit_transform(X_train)
```

We use a Support Vector Machine to classify as this is better with text data as it's sparse data (the matrix has a lot of 0s in, hence it is sparse).

In [272…

```
#from sklearn.svm.LinearSVC import LinearSVC
from sklearn.svm import LinearSVC
from sklearn.pipeline import make_pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.datasets import make_classification
model1 = LinearSVC(random_state=0, tol=1e-5)
model1.fit(X_train_tf, Y_train)
```

Out[272…

```
LinearSVC(random_state=0, tol=1e-05)
```

In [273…

```
LinearSVC(C=1.0, class_weight=None, dual=True, fit_intercept=True,
          intercept_scaling=1, loss='squared_hinge', max_iter=10000,
          multi_class='ovr', penalty='l2', random_state=0, tol=1e-05,
          verbose=0)
```

Out[273…

```
LinearSVC(max_iter=10000, random_state=0, tol=1e-05)
```

We test the model on our test data to see how accurate it is. For each tweet we let the model predict if it's information or misinformation and we compare it to the actual label. What percentage of the time is it correct, the accuracy score tells us that, 82.4%

In [274…

```
X_test_tf = tfidf.transform(X_test)

Y_pred = model1.predict(X_test_tf)
print ('Accuracy Score - ', accuracy_score(Y_test, Y_pred))
```

```
Accuracy Score -  0.8242811501597445
```

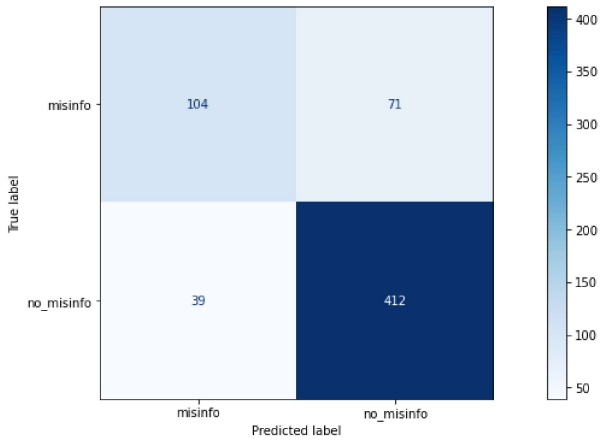
This is a confusion matrix which tells us how well the model performs.

For the test data, and for the misinformation tweets, the model gets it right 104 times, but gets it wrong 71 times. That's not so good.

For the no_information, it gets it wrong 39 times but gets it right 412 times. That's good. So it's good at detecting tweets with no_misinformation but not as good det picking up tweets with misinformation.

In [275…

```
from sklearn.metrics import plot_confusion_matrix
plot_confusion_matrix(model1,X_test_tf,
                      Y_test, values_format='d',
                      cmap=plt.cm.Blues)
plt.show()
```



Here are some examples where the model gets it right

In [276…

```
# Create a DataFrame combining the Title and Description,
# Actual and Predicted values that we can explore
frame = { 'text': X_test, 'actual': Y_test, 'predicted': Y_pred }
result = pd.DataFrame(frame)


result[((result['actual'] == 'no_misinfo') | (result['actual'] == 'misinfo')) &(result['actual'] == result['predicted'])].sample(4)
```

Out[276…

	text	actual	predicted
1267	wash hand properly 20 sec prior wash fruit luk...	no_misinfo	no_misinfo
2435	aunt friend tell coronavirus fake create democ...	no_misinfo	no_misinfo
741	@user talk malaria drug miracle cure covid19	no_misinfo	no_misinfo
200	@user flu shot increase risk respiratory virus...	misinfo	misinfo

Here are some examples where the model gets it wrong.

In [277…

```
result[((result['actual'] == 'misinfo')) &(result['actual'] != result['predicted'])].sample(4)
```

Out[277…

	text	actual	predicted
3069	church phony covid-19 cure sell north texas gr...	misinfo	no_misinfo
3589	cure covid-19 popolo plant try manomano ka ike...	misinfo	no_misinfo
556	@user @user simple trick kill coronavirus hair...	misinfo	no_misinfo
3588	expect cure covid god know come lockdown weapo...	misinfo	no_misinfo

In [278…

```
dfd1['text'][85]
```

Out[278…

```
"chinese wet market a farmer's market on steroids, spread all sorts of viruses, world now condemns!  chlorinated chicken safer than the fresh chicken that caused coronav
irus says dominic lawson https://t.co/lkzgf0bmbj…  #borisjohnson  @user #backboris #johnson #boris https://t.co/mkazelksvc"
```

This is a grid search which tells us the best parameters to use.

In [279…

```
from sklearn.pipeline import Pipeline
from sklearn.model_selection import GridSearchCV
training_pipeline = Pipeline(
    steps=[('tfidf', TfidfVectorizer(stop_words="english")),
            ('model', LinearSVC(random_state=42, tol=1e-5))])

grid_param = [{
    'tfidf__min_df': [5, 10],
    'tfidf__ngram_range': [(1, 3), (1, 6)],
    'model__penalty': ['l2'],
    'model__loss': ['hinge'],
    'model__max_iter': [10000]
}, {
    'tfidf__min_df': [5, 10],
    'tfidf__ngram_range': [(1, 3), (1, 6)],
    'model__C': [1, 10],
    'model__tol': [1e-2, 1e-3]
}]

gridSearchProcessor = GridSearchCV(estimator=training_pipeline,
                                   param_grid=grid_param,
                                   cv=5)
gridSearchProcessor.fit(dfd1['text10'], dfd1['class1'])

best_params = gridSearchProcessor.best_params_
print("Best alpha parameter identified by grid search ", best_params)

best_result = gridSearchProcessor.best_score_
print("Best result identified by grid search ", best_result)
```

```
Best alpha parameter identified by grid search  {'model__loss': 'hinge', 'model__max_iter': 10000, 'model__penalty': 'l2', 'tfidf__min_df': 10, 'tfidf__ngram_range': (1,
3)}
Best result identified by grid search  0.8117648562300319
```