In [1]:
```
import os
import pandas as pd
import numpy as np
import spacy
import matplotlib.pyplot as plt
import seaborn as sns
import timeit
import scattertext as st
import collections
from IPython.display import HTML, IFrame
from textblob import TextBlob
from w3lib.html import remove_tags
from wordcloud import WordCloud
from tqdm import tqdm_notebook
from sklearn.preprocessing import MinMaxScaler
from sklearn.manifold import TSNE
from sklearn.decomposition import KernelPCA
import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
import logging
logger = logging.getLogger("spacy")
logger.setLevel(logging.ERROR)
```

In [3]:
```
data1 = pd.read_csv("drugsComTrain_raw.tsv",sep='\t',index_col=0)
data2 = pd.read_csv("drugsComTest_raw.tsv",sep='\t',index_col=0)
data = pd.concat([data1,data2])
data.head()
```

Out[3]:

	drugName	condition	review	rating	date	usefulCount
206461	Valsartan	Left Ventricular Dysfunction	"It has no side effect, I take it in combinati...	9.0	May 20, 2012	27
95260	Guanfacine	ADHD	"My son is halfway through his fourth week of ...	8.0	April 27, 2010	192
92703	Lybrel	Birth Control	"I used to take another oral contraceptive, wh...	5.0	December 14, 2009	17
138000	Ortho Evra	Birth Control	"This is my first time using any form of birth...	8.0	November 3, 2015	10
35696	Buprenorphine / naloxone	Opiate Dependence	"Suboxone has completely turned my life around...	9.0	November 27, 2016	37

In [4]:
```
df = data[['review','rating']]
df.head()
```

Out[4]:

	review	rating
206461	"It has no side effect, I take it in combinati...	9.0
95260	"My son is halfway through his fourth week of ...	8.0
92703	"I used to take another oral contraceptive, wh...	5.0
138000	"This is my first time using any form of birth...	8.0
35696	"Suboxone has completely turned my life around...	9.0

In [5]:
```
def train_val_test_split(df, val_size, test_size, random_state=0):
    """Split data frame into 3 (train/val/test) sets or into 2 (train/

    If you want to split into two datasets, set test_size = 0.

    Parameters
    ----------
    df : pandas.DataFrame
        Pandas.DataFrame to split.
    val_size : float
        Fraction of dataset to include in validation set. Should be fr
    test_size : float
        Fraction of dataset to include in test set. Should be from ran
    random_state: int, optional (default=0)
        The seed used by the random number generator.

    Returns
    -------
    train: pandas.DataFrame
       Training set.
    val: pandas.DataFrame
       Validation set.
    test: pandas.DataFrame
       Test set.

    Raises
    ------
    AssertionError
        If the val_size and test_size sum is greater or equal 1 or the

    """
    assert (val_size + test_size) < 1, 'Validation size and test size
    assert val_size >= 0 and test_size >= 0, 'Negative size is not acc
    train, val, test = np.split(df.sample(frac=1, random_state=random_
                                [int((1-(val_size+test_size))*len(df))
    return train, val, test
```

In [79]:
```
dataset = data1[['review','rating']]
test_dataset = data2[['review','rating']]
```

In [80]:
```
print(dataset.shape)
print(test_dataset.shape)
```

```
(161297, 2)
(53766, 2)
```

In [12]:
```
dataset.rating.value_counts()
```

Out[12]:
```
10.0    50989
9.0     27531
1.0     21619
8.0     18890
7.0      9456
5.0      8013
2.0      6931
3.0      6513
6.0      6343
4.0      5012
Name: rating, dtype: int64
```

In [13]:
```
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 161297 entries, 206461 to 215220
Data columns (total 2 columns):
review    161297 non-null object
rating    161297 non-null float64
dtypes: float64(1), object(1)
memory usage: 3.7+ MB
```

In [14]:
```
# Get indices of duplicate data (excluding first occurrence)
duplicate_indices = dataset.loc[dataset.duplicated(keep='first')].inde

# Count and print the number of duplicates
print('Number of duplicates in the dataset: {}'.format(dataset.loc[dup
```

```
Number of duplicates in the dataset: 48879
```

In [15]:
```
dataset.loc[duplicate_indices, :].head()
```

Out[15]:

	review	rating
109101	"First had implanon then got Nexplanon, had a ...	9.0
183531	"Prescribed via a Psychiatrist for severe Pani...	1.0
5154	"I have only been on orsythia for about 1 mont...	2.0
186190	"I have suffered from severe anxiety (GAD) and...	8.0
73940	"I have been taking my first pack of Lo Loestr...	8.0

In [16]:
```
# Drop duplicates
dataset.drop_duplicates(keep='first', inplace=True)
```

In [81]:
```
test_dataset.drop_duplicates(keep='first', inplace=True)
```

In [82]:
```
# Print the shape of dataset after removing duplicate rows
print('Dataset shape after removing duplicates: {}'.format(dataset.sha
print('Test Dataset shape after removing duplicates: {}'.format(test_d
```

```
Dataset shape after removing duplicates: (161297, 2)
Test Dataset shape after removing duplicates: (48302, 2)
```

In [18]:
```
dataset = dataset.dropna()
```

In [83]:
```
test_dataset = test_dataset.dropna()
```

In [24]:
```
# Save raw dataset as a CSV file
dataset.to_csv(os.path.join('drugreview/drugreview_raw.csv'), index=Fa
```

In [86]:
```
test_dataset.to_csv(os.path.join('drugreview/drugreview_test_raw.csv')
```

In [88]:
```
path = 'drugreview/'

# Load raw dataset from CSV file
dataset = pd.read_csv(os.path.join(path, 'drugreview_raw.csv'))
```

In [89]:
```
test_dataset = pd.read_csv(os.path.join(path, 'drugreview_test_raw.csv
```

In [90]:
```
def polarity(text):
    """Calculate the polarity score of the input text.

    """
    return TextBlob(text).sentiment.polarity
```

In [91]:
```
def subjectivity(text):
    """Calculate the subjectivity score of the input text.

    """
    return TextBlob(text).sentiment.subjectivity
```

In [92]:
```
def pos(df, batch_size, n_threads, required_tags):
    """Count the number of peculiar POS tags in data series of strings

    Parameters
    ----------
    df : pandas.Series
        Pandas.Series containing strings to process.
    batch_size: int
        Size of text batch (recommended to be the power of 2).
    n_threads: int
        Number of threads in multiprocessing.
    required_tags: list
        List containing spacy's POS tags to count.

    Returns
    -------
    pandas.DataFrame
       DataFrame of a shape (index, len(required_tags)).

    """
    # Add index column to reviews frame and change column order
    reviews = df.reset_index(drop=False)[['review', 'index']]
    # Convert dataframe to list of tuples (review, index)
    review_list = list(zip(*[reviews[c].values.tolist() for c in revie
    # Create empty dictionary
    review_dict = collections.defaultdict(dict)

    for doc, context in list(nlp.pipe(review_list, as_tuples=True, bat
        review_dict[context] = {}
        for token in doc:
            pos = token.pos_
            if pos in required_tags:
                review_dict[context].setdefault(pos, 0)
                review_dict[context][pos] = review_dict[context][pos]
    # Transpose data frame to shape (index, tags)
    return pd.DataFrame(review_dict).transpose()
```

In [93]:
```
def pos2(df, batch_size, n_threads, required_tags):
    """Count the number of peculiar POS tags in data series of strings

    Parameters
    ----------
    df : pandas.Series
        Pandas.Series containing strings to process.
    batch_size: int
        Size of text batch (recommended to be the power of 2).
    n_threads: int
        Number of threads in multiprocessing.
    required_tags: list
        List containing spacy's POS tags to count.

    Returns
    -------
    pandas.DataFrame
       DataFrame of a shape (index, len(required_tags)).

    """
    # Create empty dictionary
    review_dict = collections.defaultdict(dict)
    for i, doc in enumerate(nlp.pipe(df, batch_size=batch_size)):
         for token in doc:
            pos = token.pos_
            if pos in required_tags:
                review_dict[i].setdefault(pos, 0)
                review_dict[i][pos] = review_dict[i][pos] + 1
    # Transpose data frame to shape (index, tags)
    return pd.DataFrame(review_dict).transpose()
```

In [94]:
```
def pos3(df, required_tags):
    """Count the number of peculiar POS tags in data series of strings

    Parameters
    ----------
    df : pandas.Series
        Pandas.Series containing strings to process.
    required_tags: list
        List containing spacy's POS tags to count.

    Returns
    -------
    pandas.DataFrame
       DataFrame of a shape (index, len(required_tags)).

    """
    pos_list = []
    for i in range(df.shape[0]):
        doc = nlp(df[i])
        pos_dict = {}
        for token in doc:
            pos = token.pos_
            if pos in required_tags:
                pos_dict.setdefault(pos, 0)
                pos_dict[pos] = pos_dict[pos] + 1
        pos_list.append(pos_dict)
    return pd.DataFrame(pos_list)
```

In [31]:
```
# Load language model and disable unnecessary components of processing
nlp = spacy.load('en_core_web_sm', disable = ['ner', 'parser', 'textca
required_tags = ['PROPN', 'PUNCT', 'NOUN', 'ADJ', 'VERB']

# Define batch_size and n_threads
batch_size = 512
n_threads = 2

# Test the processing time on a part of the dataset, given batch_size
start_time = timeit.default_timer()
print('Start processing 1000 examples using batch_size: {} and n_threa
pos(dataset.loc[:1000, 'review'], required_tags=required_tags, batch_s
print('Function 1 processing time: {:.2f} sec'.format(timeit.default_t
```

```
Start processing 1000 examples using batch_size: 512 and n_threads: 2
Function 1 processing time: 5.35 sec
```

In [32]:
```
# Define batch_size and n_threads
batch_size = 512
n_threads = 2

# Test the processing time on a part of the dataset, given batch_size
start_time = timeit.default_timer()
print('Start processing 1000 examples using batch_size: {} and n_threa
pos2(dataset.loc[:1000, 'review'],  batch_size=batch_size, n_threads=2
print('Function 2 processing time: {:.2f} sec'.format(timeit.default_t
```

```
Start processing 1000 examples using batch_size: 512 and n_threads: 2
Function 2 processing time: 4.38 sec
```

In [33]:
```
# Test the processing time on a part of the dataset, given batch_size
start_time = timeit.default_timer()
print('Start processing 1000 examples')
pos3(dataset.loc[:1000, 'review'], required_tags=required_tags)
print('Function 3 processing time: {:.2f} sec'.format(timeit.default_t
```

```
Start processing 1000 examples
Function 3 processing time: 4.91 sec
```

In [34]:
```
def extract_features(df, batch_size, n_threads, required_tags):
    """Extract the following features from the data frame's 'review' c
    polarity, subjectivity, word_count, UPPERCASE, DIGITS, and POS tag

    Convert extracted features to int16 or float16 data types.

    Parameters
    ----------
    df : pandas.DataFrame
        Pandas.DataFrame containing 'review' column to which extractio
    batch_size: int
        Size of text batch (recommended to be the power of 2).
    n_threads: int
        Number of threads in multiprocessing.
    required_tags: list
        List containing spacy's POS tags to count.

    Returns
    -------
    pandas.DataFrame
       Concatenation of the original data frame and data frame contain

    """
    # Calculate polarity
    df['polarity'] = df.review.apply(polarity).astype('float16')
    # Calculate subjectivity
    df['subjectivity'] = df.review.apply(subjectivity).astype('float16
    # Calculate number of words in review
    df['word_count'] = df.review.apply(lambda text: len(text.split()))
    # Count number of uppercase words, then divide by word_count
    df['UPPERCASE'] = df.review.apply(lambda text: len([word for word
                                                        if word.isuppe
    # Change data type to float16
    df.UPPERCASE = df.UPPERCASE.astype('float16')
    # Count number of digits, then divide by word_count
    df['DIGITS'] = df.review.apply(lambda text: len([word for word in
                                                    if word.isdigit()
    # Change data type to float16
    df.DIGITS = df.DIGITS.astype('float16')
    # Perform part-of-speech taging
    pos_data = pos2(df.review, batch_size=batch_size, n_threads=n_thre
    # Divide POS tags count by word_count
    pos_data = pos_data.div(df.word_count, axis=0).astype('float16')
    # Concatenate pandas data frames horizontaly
    return pd.concat([df, pos_data], axis=1)
```

In [35]:
```
# Load language model and disable unnecessary components of processing
nlp = spacy.load('en_core_web_sm', disable = ['ner', 'parser', 'textca
required_tags = ['PROPN', 'PUNCT', 'NOUN', 'ADJ', 'VERB']

batch_size = 512
n_threads = 2

# Test the processing time on a part of the trainig set, given batch_s
start_time = timeit.default_timer()
print('Start processing 1000 examples using batch_size: {} and n_threa
extract_features(dataset.loc[:1000, :], batch_size=batch_size, n_threa
print('Feature extraction function processing time: {:.2f} sec'.format
```

```
Start processing 1000 examples using batch_size: 512 and n_threads: 2
Feature extraction function processing time: 5.94 sec
```

In [36]:
```
from tqdm.notebook import tqdm
def split_extract_save(df, name, path, part_size, batch_size, n_thread
    """Split data frame into chunks of size equal: part_size and perfo
    Extract the following features from the data frame part's 'review'
    UPPERCASE, DIGITS, and POS tags specified by required_tags.

    Parameters
    ----------
    df : pandas.DataFrame
        Pandas.DataFrame containing 'review' column to which extractio
    name : str
        Name of the CSV file to which export the data.
    path : str
        Absolute or relative path to directory where to save the data.
    part_size: int
        Size of the chunk to process (number of strings it contains).
    batch_size: int
        Size of text batch (recommended to be the power of 2).
    n_threads: int
        Number of threads in multiprocessing.
    required_tags: list
        List containing spacy's POS tags to count.
    nlp: spacy.lang.<language>
        Spacy language model (for example spacy.lang.en.English)

    Returns
    -------
    pandas.DataFrame
       Concatenation of the original data frame and data frame contain

    """
    if name not in os.listdir(path):
        dataset_parts = []
        N = int(len(df)/part_size)
```

```
        N = int(len(df)/part_size)
        # Create list of dataframe chunks
        data_frames = [df.iloc[i*part_size:(i+1)*part_size].copy() for
        # Process dataset partialy
        i = 0
        for frame in tqdm(data_frames):
            print(i)
            i += 1
            # Extract features from dataset chunk
            dataset_part = extract_features(frame, batch_size=batch_si
                                            required_tags=required_tag
            dataset_parts.append(dataset_part)
            # Reload nlp
            nlp = spacy.load('en_core_web_sm', disable = ['ner', 'pars

        # Concatenate all parts into one dataset
        dataset_feat = pd.concat(dataset_parts, axis=0, sort=False)
        # Replace missing values NaN with 0
        dataset_feat.fillna(0, inplace=True)
        # Convert label values to int16
        dataset_feat.rating = dataset_feat.rating.astype('int16')
        # Export data frame to CSV file
        dataset_feat.to_csv(path + name, index=False)
    else:
        print('File {} already exists in given directory.'.format(name
```

In [39]:
```
# Define all required variables
nlp = spacy.load('en_core_web_sm', disable = ['ner', 'parser', 'textca
required_tags = ['PROPN', 'PUNCT', 'NOUN', 'ADJ', 'VERB']
batch_size = 512
n_threads = 2
part_size = 5000
path = os.path.join(os.getcwd(), 'drugreview/datasets_feat/')
name = 'drugreview_feat.csv'

# Perform feature extraction and export resulted file into CSV
split_extract_save(dataset, name, path, part_size, batch_size, n_threa
```

```
100%                                                  12/12 [05:06<00:00, 21.60s/it]

0
1
2
3
4
5
6
7
8
9
10
11
```

In [99]:
```
# Define all required variables
nlp = spacy.load('en_core_web_sm', disable = ['ner', 'parser', 'textca
required_tags = ['PROPN', 'PUNCT', 'NOUN', 'ADJ', 'VERB']
batch_size = 512
n_threads = 2
part_size = 5000
path = os.path.join(os.getcwd(), 'drugreview/datasets_feat/')
name = 'drugreview_test_feat.csv'

# Perform feature extraction and export resulted file into CSV
split_extract_save(test_dataset, name, path, part_size, batch_size, n_
```

```
100%                                                  10/10 [04:21<00:00, 24.18s/it]

0
1
2
3
4
5
6
7
8
9
```

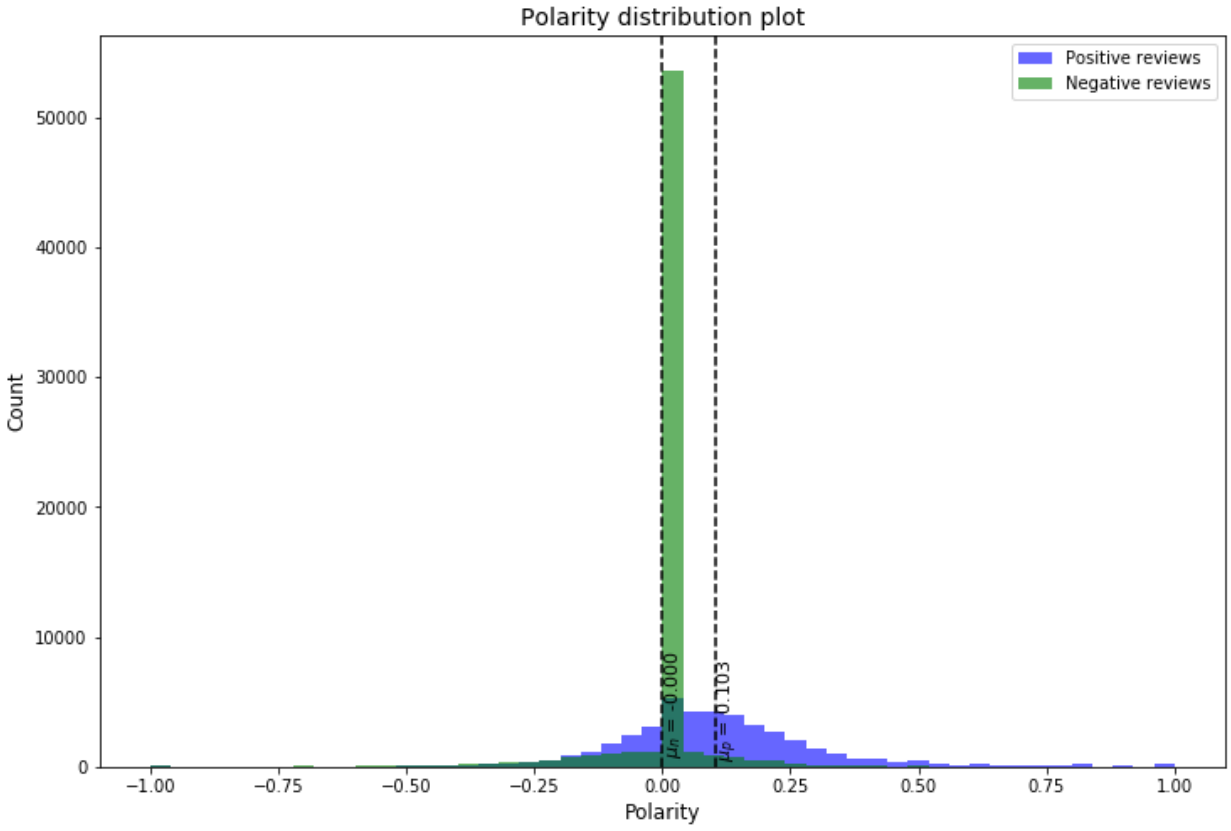
In [100]:
```
# Dictionary of {column: dtype} pairs
col_types = {'review': str,'rating': np.int16, 'polarity': np.float16,
             'word_count': np.int16, 'UPPERCASE': np.float16, 'DIGITS'
             'VERB': np.float16, 'NOUN': np.float16, 'PUNCT': np.float

# Import dataset from the CSV file
dataset_feat = pd.read_csv('drugreview/datasets_feat/drugreview_feat.c
```

In [101]:
```
test_dataset_feat = pd.read_csv('drugreview/datasets_feat/drugreview_t
```

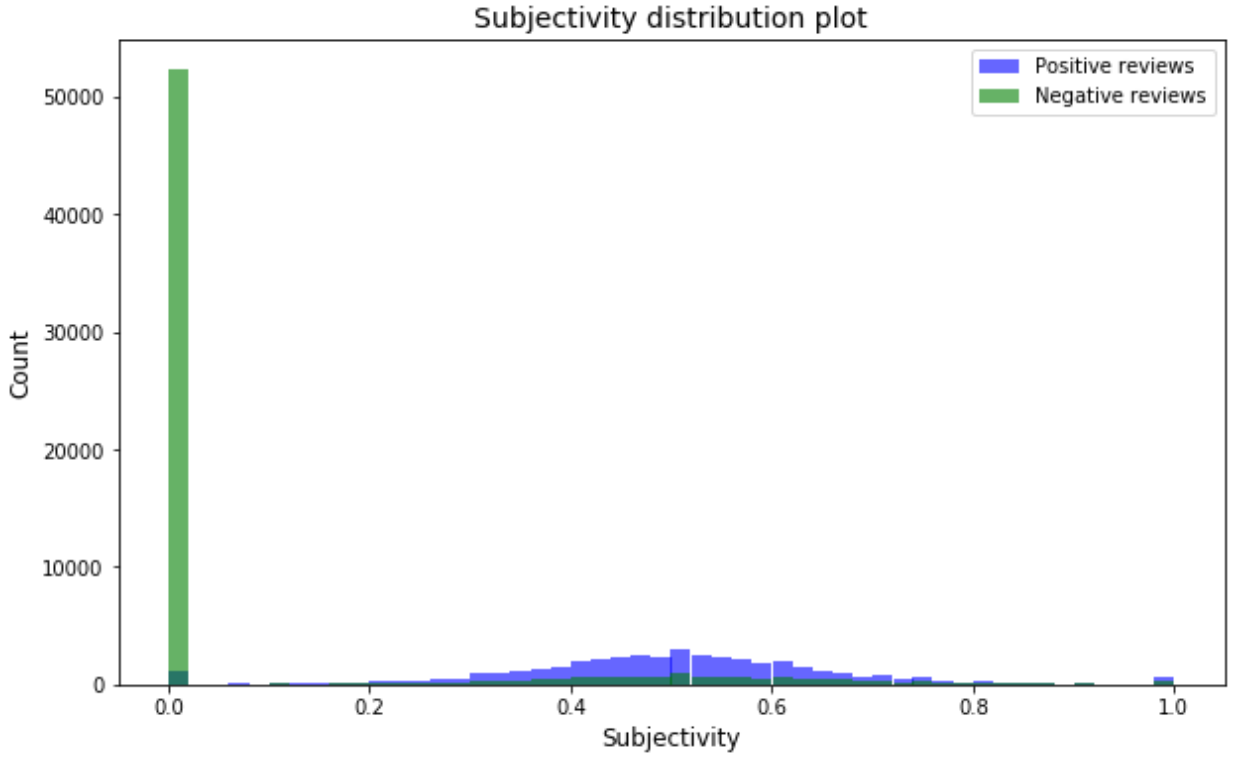
In [41]:
```
dataset_feat.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 108368 entries, 0 to 108367
Data columns (total 12 columns):
review          108368 non-null object
rating          108368 non-null int16
polarity        108368 non-null float16
subjectivity    108368 non-null float16
word_count      108368 non-null int16
UPPERCASE       108368 non-null float16
DIGITS          108368 non-null float16
PUNCT           108368 non-null float16
VERB            108368 non-null float16
PROPN           108368 non-null float16
NOUN            108368 non-null float16
ADJ             108368 non-null float16
dtypes: float16(9), int16(2), object(1)
memory usage: 3.1+ MB
```

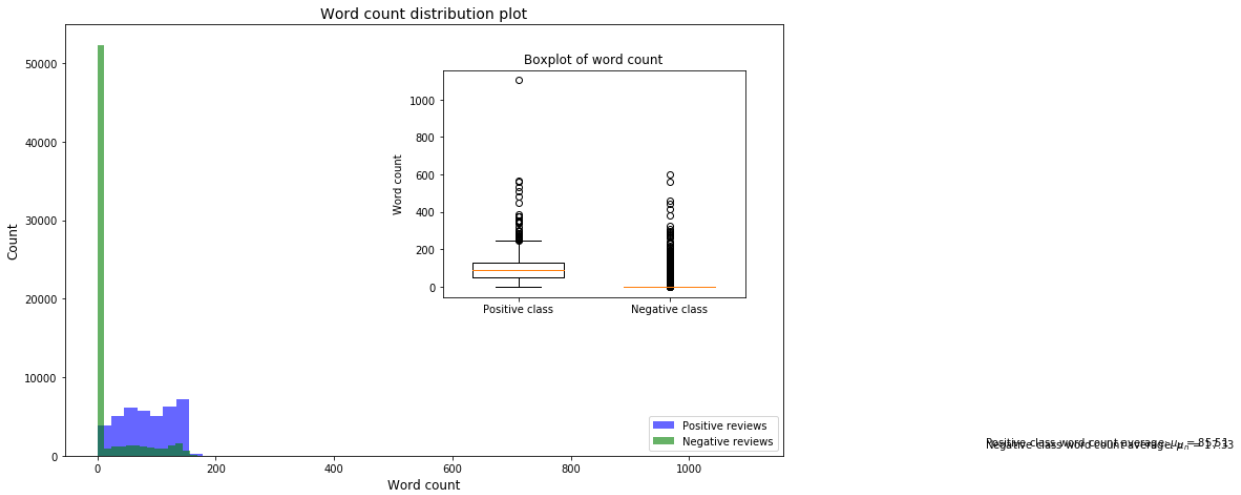
In [42]:
```
# Separate polarity score for positive and nagative reviews
pos_reviews_pol = dataset_feat.loc[dataset_feat.rating >= 5, 'polarity
neg_reviews_pol = dataset_feat.loc[dataset_feat.rating < 5, 'polarity'

# Create a new figure
plt.figure(figsize=(12,8))

# Create a histogram of polarity for positive reviews (color=blue, tra
plt.hist(pos_reviews_pol, bins=50, label='Positive reviews', alpha=0.6
# Create a histogram of polarity for negative reviews (color=green, tr
plt.hist(neg_reviews_pol, bins=50, label='Negative reviews', alpha=0.6
# Create the title, horizontal axis label, vertical axis label and leg
plt.title('Polarity distribution plot', size=14)
plt.xlabel('Polarity', size=12)
plt.ylabel('Count', size=12)
plt.legend(loc='upper right')

# Calculate the mean value of polarity for positive and negative revie
pos_pol_mean = pos_reviews_pol.mean()
neg_pol_mean = neg_reviews_pol.mean()

# Add vertical lines that represent the average polarity of each class
plt.axvline(pos_pol_mean, c='k', linestyle='--', linewidth=1.5)
plt.axvline(neg_pol_mean, c='k', linestyle='--', linewidth=1.5)
# Add annotations
plt.text(pos_pol_mean, 1200, r'$\mu_p$ = {:.3f}'.format(pos_pol_mean),
plt.text(neg_pol_mean, 1200, r'$\mu_n$ = {:.3f}'.format(neg_pol_mean),

plt.show()
```


Polarity distribution plot
Positive reviews
Negative reviews
Count
50000
40000
30000
20000
10000
0
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
Polarity
μ_n = 0.000
μ_p = 0.103

In [43]:
```
# Separate subjectivity score for positive and nagative reviews
pos_reviews_subj = dataset_feat.loc[dataset_feat.rating >=5, 'subjecti
neg_reviews_subj = dataset_feat.loc[dataset_feat.rating < 5, 'subjecti

# Create a new figure
plt.figure(figsize=(10,6))

# Create histograms of subjectivity for positive and negative reviews
plt.hist(pos_reviews_subj, bins=50, label='Positive reviews', alpha=0.
plt.hist(neg_reviews_subj, bins=50, label='Negative reviews', alpha=0.
plt.title('Subjectivity distribution plot', size=14)
plt.xlabel('Subjectivity', size=12)
plt.ylabel('Count', size=12)
plt.legend(loc='upper right')

plt.show()
```



In [44]:
```
# Separate word count distributions for positive and nagative reviews
# Violinplots or boxplots better deal with numpy arrays
pos_reviews_w_count = np.array(dataset_feat.loc[dataset_feat.rating >+
neg_reviews_w_count = np.array(dataset_feat.loc[dataset_feat.rating <

# Create a new figure instance
fig = plt.figure(figsize=(10,6))

# Add axes to the figure. Create the first main window
ax1 = fig.add_axes([0, 0, 0.95, 0.95]) # window coord: (left, bottom,
ax1.hist(pos_reviews_w_count, bins=50, label='Positive reviews', alpha
ax1.hist(neg_reviews_w_count, bins=50, label='Negative reviews', alpha
# Create the title, horizontal axis label, vertical axis label and leg
ax1.set_title('Word count distribution plot', size=14)
ax1.set_xlabel('Word count', size=12)
ax1.set_ylabel('Count', size=12)
ax1.legend(loc='lower right')
# Add descriptions
ax1.text(1500, 1200, r'Positive class word count average: $\mu_p$ = {:
ax1.text(1500, 1000, r'Negative class word count average: $\mu_n$ = {:

# Add axes to the figure. Create the second boxplots window
ax2 = fig.add_axes([0.5, 0.35, 0.40, 0.50]) # window coord: (left, bot
# Create boxplots
ax2.boxplot([pos_reviews_w_count, neg_reviews_w_count], widths=0.6)
ax2.set_title('Boxplot of word count')
ax2.set_ylabel('Word count')
# Set the x axis labels
ax2.set_xticks([1, 2])
ax2.set_xticklabels(['Positive class', 'Negative class'])

plt.show()
```



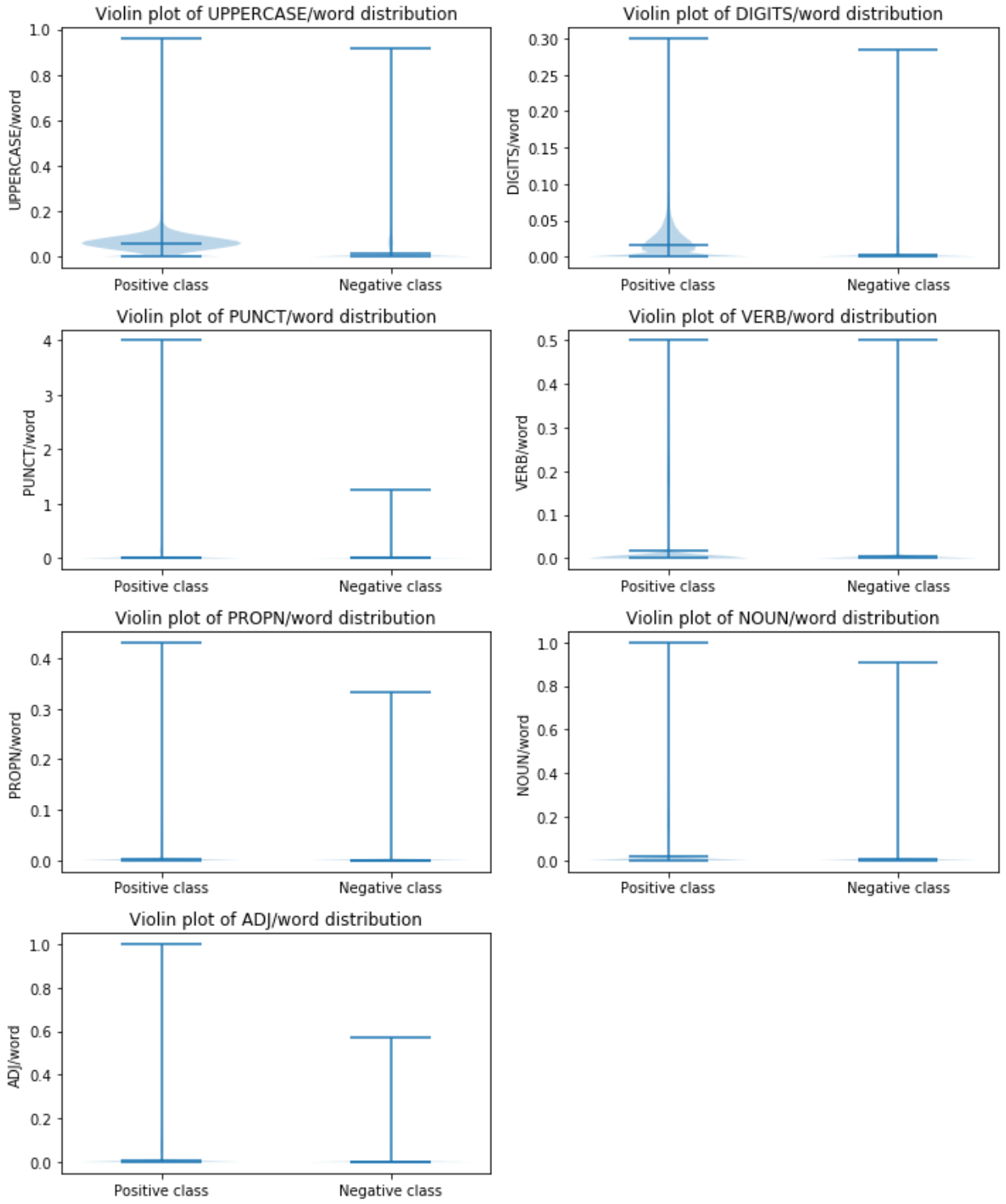
In [45]:
```
dataset_feat.groupby(by='rating').word_count.describe()
```

Out[45]:

rating	count	mean	std	min	25%	50%	75%	max
0	51684.0	0.000000	0.000000	0.0	0.0	0.0	0.0	0.0
1	7592.0	78.323235	45.445657	1.0	41.0	73.0	119.0	601.0
2	2423.0	82.860091	42.835462	2.0	47.0	82.0	122.5	298.0
3	2281.0	83.859272	42.044149	2.0	49.0	83.0	124.0	216.0
4	1788.0	85.553691	42.035119	1.0	51.0	85.0	125.0	287.0
5	2825.0	88.042832	42.066123	2.0	53.0	89.0	127.0	375.0
6	2259.0	86.830899	42.652547	1.0	52.0	87.0	127.0	260.0
7	3330.0	89.367267	43.465768	1.0	54.0	91.0	129.0	566.0
8	6515.0	88.872141	43.677508	1.0	54.0	91.0	129.0	558.0
9	9633.0	88.069553	45.389299	1.0	52.0	90.0	129.0	1103.0
10	18038.0	82.061759	44.933570	1.0	45.0	80.0	124.0	532.0

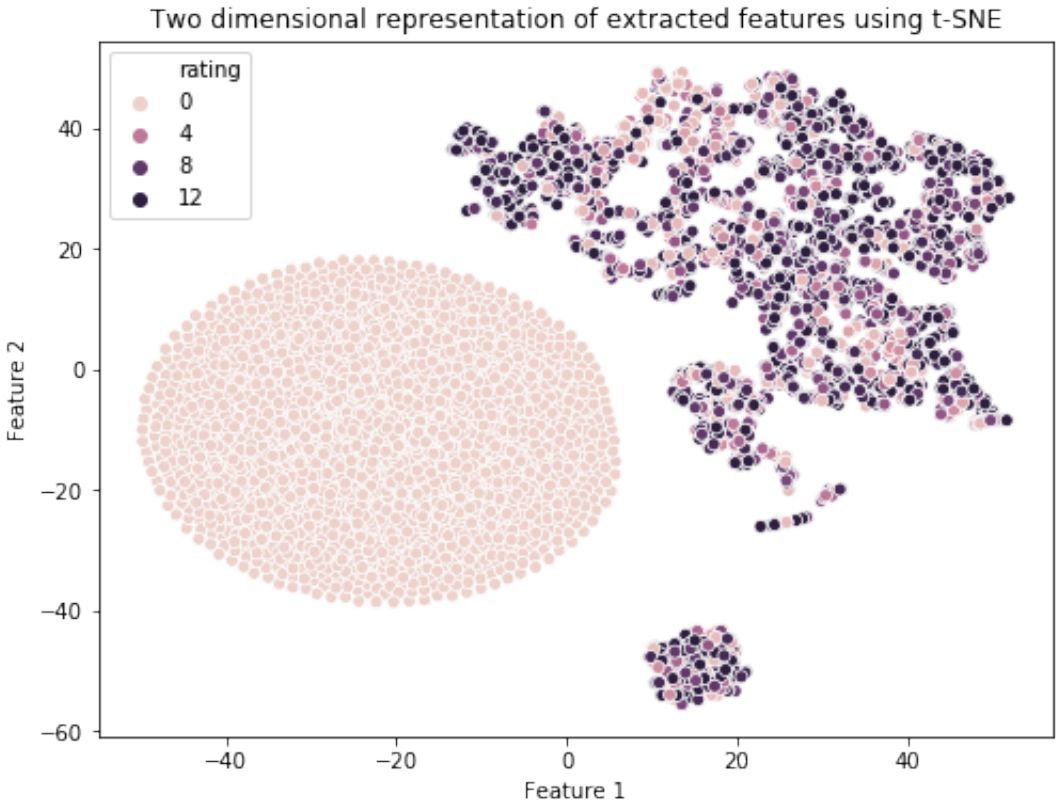
In [46]:
```
# Create the figure and axes instances
fig, axes = plt.subplots(4, 2, figsize=(10,12), sharex=False)
# Take the last 7 columns labels from the data frame
data_labels = dataset_feat.columns[-7:]
data_idx = 0

# Iterate through the plots rows and columns
for row in range(4):
    for col in range(2):
        if data_idx <= 6:
            # Create the violinplot of given feature for positive and
            axes[row, col].violinplot([np.array(dataset_feat.loc[datas
                                       np.array(dataset_feat.loc[datase
                                       widths=0.7, showmeans=True)
            # Set the title and vertical axis labels
            axes[row, col].set_title('Violin plot of {}/word distribut
            axes[row, col].set_ylabel('{}/word'.format(data_labels[dat
            # Set the x axis labels
            axes[row, col].set_xticks([1, 2])
            axes[row, col].set_xticklabels(['Positive class', 'Negativ
        else:
            # Delete unnecessary axes
            fig.delaxes(axes[row, col])
        data_idx += 1

# Automatically adjusts subplot params to fit in figure
```

```
plt.tight_layout()
```



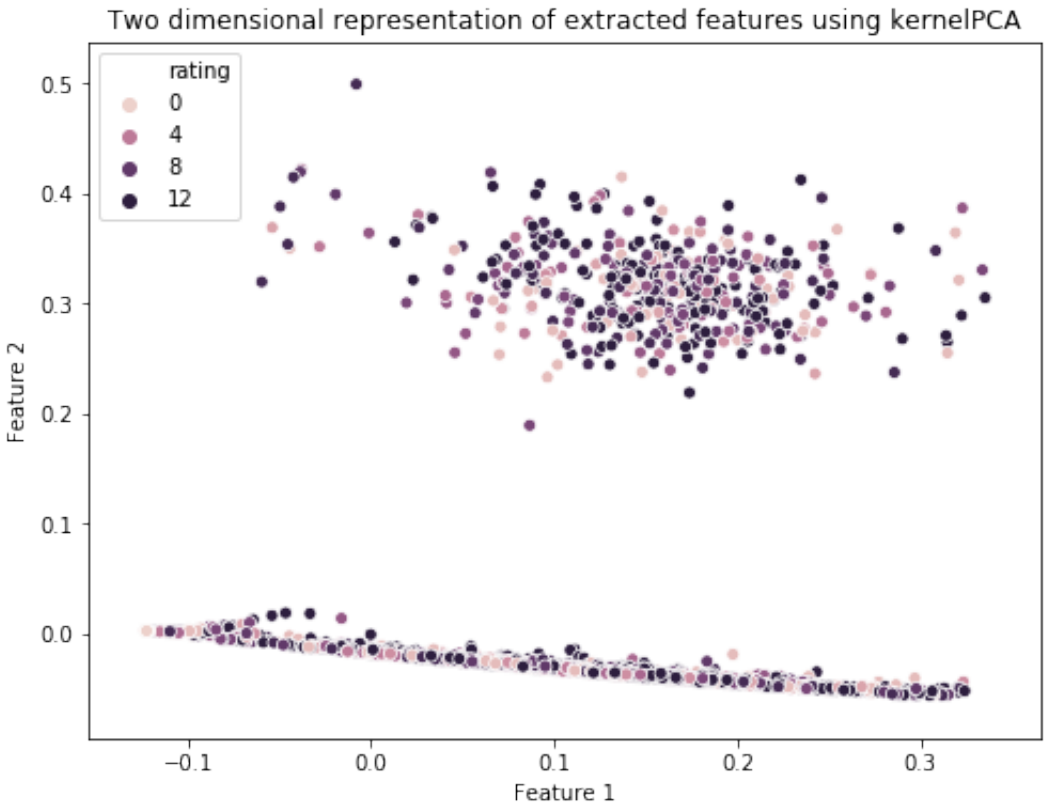
In [47]:
```
# Choose at random a sample of 10,000 examples to visualize
data_to_vis = dataset_feat.iloc[:, -11:].sample(n=10000)
feat_to_vis = data_to_vis.iloc[:, -10:]
label_to_vis = data_to_vis.iloc[:, 0]

# Perform MinMax feature scaling
feat_to_vis = MinMaxScaler().fit_transform(feat_to_vis)

# Perform dimensionality reduction using t-SNE
emb_vectors = TSNE(n_components=2, n_iter=1000).fit_transform(feat_to_
```

In [48]:
```
#Visualize data in lower-dimensional space
plt.figure(figsize=(8,6))
# Create seaborn scatterplot
sns.scatterplot(x=emb_vectors[:, 0], y=emb_vectors[:, 1], hue=label_to
plt.title('Two dimensional representation of extracted features using
plt.xlabel('Feature 1')
plt.ylabel('Feature 2')
plt.show()
```

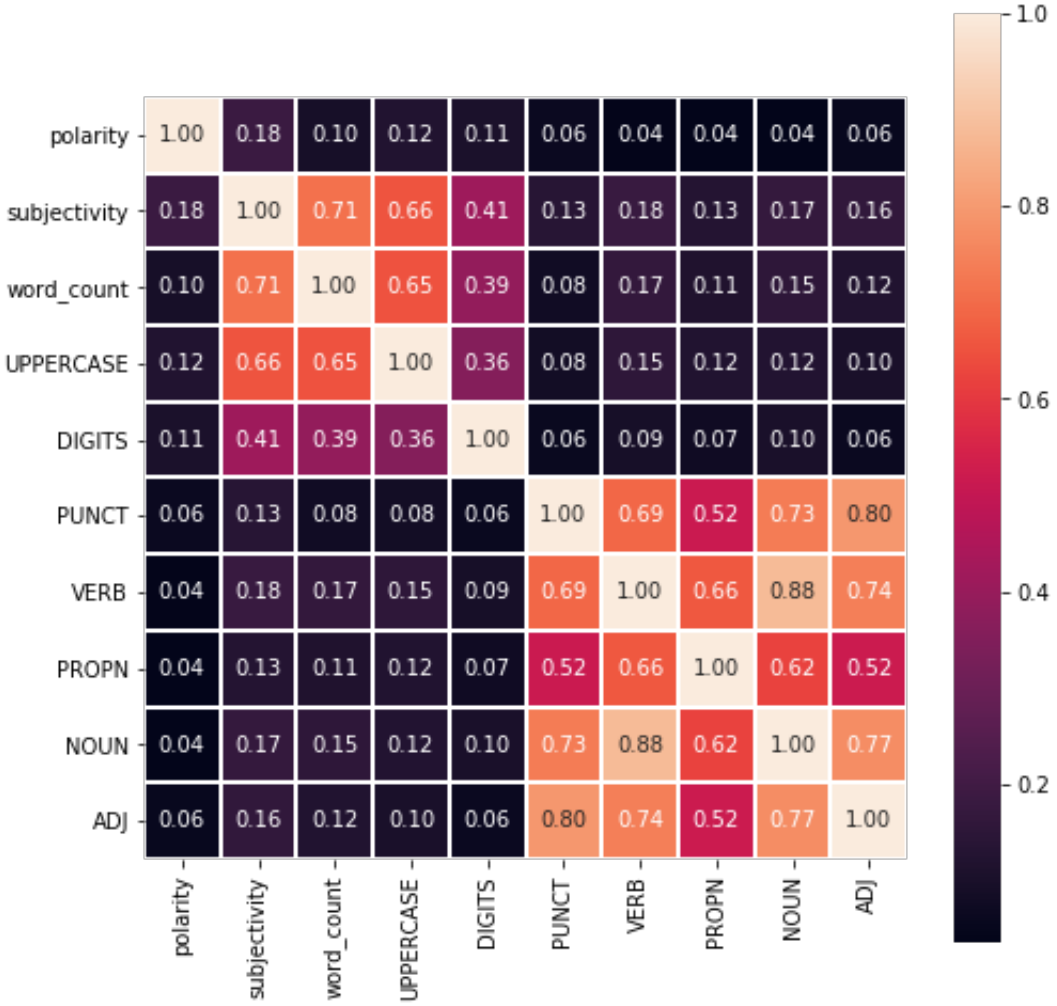


In [49]:
```
# Perform dimensionality reduction using kernel PCA
emb_vectorsPCA = KernelPCA(n_components=2, kernel='rbf').fit_transform
```

In [50]:
```
# Visualize data in lower-dimensional space
plt.figure(figsize=(8,6))
sns.scatterplot(x=emb_vectorsPCA[:, 0], y=emb_vectorsPCA[:, 1], hue=la
plt.title('Two dimensional representation of extracted features using
plt.xlabel('Feature 1')
plt.ylabel('Feature 2')
plt.show()
```



In [51]:
```
# Calculate correlations between the features
corr_matrix = dataset_feat.iloc[:, 2:].corr()

# Plot correlation matrix
plt.figure(figsize=(8,8))
ax = sns.heatmap(corr_matrix, annot=True, fmt='.2f', linewidths=1, squ
# Set limit of y axis. To check current settings use: ax.get_ylim()
ax.set_ylim(10,0)
plt.show()
```



In [102]:
```
# Import the dataset
dataset_feat = pd.read_csv('drugreview/datasets_feat/drugreview_feat.c
dataset_test_feat = pd.read_csv('drugreview/datasets_feat/drugreview_t
```

In [103]:
```
def token_filter(token):
    """Filter the token for text_preprocessing function.
    Check if the token is not: punctuation, whitespace, stopword or di

    Parameters
    ----------
    token : spacy.Token
        Token passed from text_preprocessing function.

    Returns
    -------
    Bool
       True if token meets the criteria, otherwise False.

    """
    return not (token.is_punct | token.is_space | token.is_stop | toke

def text_preprocessing(df, batch_size, n_threads):
    """Perform text preprocessing using the following methods: removin
    lemmatization and removing stopwords, whitespaces, punctuations, d

    Parameters
    ----------
    df : pandas.Series
        Pandas.Series containing strings to process.
    batch_size: int
        Size of text batch (recommended to be the power of 2).
    n_threads: int
        Number of threads in multiprocessing.

    Returns
    -------
    pandas.Series
       Pandas.Series containing processed strings.

    """
    # Remove HTML tags
    df = df.apply(remove_tags)
    # Make lowercase
    df = df.str.lower()
    processed_docs = []
    for doc in list(nlp.pipe(df, batch_size=batch_size)):
        # Remove stopwords, spaces, punctutations and digits
        text = [token for token in doc if token_filter(token)]
        # Lemmatization
        text = [token.lemma_ for token in text if token.lemma_ != '-PR
        processed_docs.append(' '.join(text))
    return pd.Series(processed_docs, name='clean_review', index=df.ind
```

In [54]:
```
# Define the variables
import warnings
warnings.filterwarnings('ignore')
warnings.simplefilter('ignore')
nlp = spacy.load('en_core_web_sm', disable = ['ner', 'parser', 'textca
batch_size = 512
n_threads = 2

# Test the processing time on a part of the trainig set, given batch_s
print('Start processing 1000 examples using batch_size: {} and n_threa
start_time = timeit.default_timer()
text_preprocessing(dataset_feat.loc[:1000, 'review'], batch_size=batch
print('Processing time: {:.2f} sec'.format(timeit.default_timer() - st
```

```
Start processing 1000 examples using batch_size: 512 and n_threads: 2
Processing time: 4.39 sec
```

In [104]:
```
def split_norm_save(df, name, path, part_size, batch_size, n_threads,
    """Split data frame into chunks of size equal: part_size and perfo
    Preprocess strings using the following methods: removing HTML tags
    removing stopwords, whitespaces, punctuations, digits.

    Parameters
    ----------
    df : pandas.DataFrame
        Pandas.DataFrame containing 'review' column to preprocess.
    name : str
        Name of the CSV file to which export the data.
    path : str
        Absolute or relative path to directory where to save the data.
    part_size: int
        Size of the chunk to process (number of strings it contains).
    batch_size: int
        Size of text batch (recommended to be the power of 2).
    n_threads: int
        Number of threads in multiprocessing.
    nlp: spacy.lang.<language>
        Spacy language model (for example spacy.lang.en.English)

    Returns
    -------
    pandas.DataFrame
       Concatenation of the original data frame and pandas series of n

    """
    from tqdm.notebook import tqdm
    if name not in os.listdir(path):
        dataset_parts = []
        N = int(len(df)/part_size)
        # Create list of dataframe chunks
```

```
        # create list of dataframe chunks
        data_frames = [df.iloc[i*part_size:(i+1)*part_size, 0].copy()
        print(len(data_frames))
        # Process dataset partialy
        i = 0
        for frame in tqdm(data_frames):
            # Normalize dataset chunk
            print(i)
            i += 1
            dataset_part = text_preprocessing(frame, batch_size=batch_
            dataset_parts.append(dataset_part)
            # Reload nlp
            nlp = spacy.load('en_core_web_sm', disable = ['ner', 'pars

        # Concatenate all parts into one series
        concat_clean = pd.concat(dataset_parts, axis=0, sort=False)
        # Concatenate dataset and cleaned review seires
        dataset_clean = pd.concat([df, concat_clean], axis=1)
        # Export data frame to CSV file
        dataset_clean.to_csv(path + name, index=False)
    else:
        print('File {} already exists in given directory.'.format(name
```

In [56]:
```
# Define variables
nlp = spacy.load('en_core_web_sm', disable = ['ner', 'parser', 'textca
batch_size = 512
n_threads = 2
part_size = 5000
path = os.path.join(os.getcwd(), 'drugreview/datasets_feat_clean/')
name = 'drugreview_feat_clean.csv'

# Perform text preprocessing and save the resulted frame to CSV file
split_norm_save(dataset_feat, name, path, part_size, batch_size, n_thr
```

```
22

100%                                                 22/22 [04:01<00:00, 10.98s/it]

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```

In [105]:
```
# Define variables
nlp = spacy.load('en_core_web_sm', disable = ['ner', 'parser', 'textca
batch_size = 512
n_threads = 2
part_size = 5000
path = os.path.join(os.getcwd(), 'drugreview/datasets_feat_clean/')
name = 'drugreview_test_feat_clean.csv'

# Perform text preprocessing and save the resulted frame to CSV file
split_norm_save(dataset_test_feat, name, path, part_size, batch_size,
```

```
19

100%                                                19/19 [03:25<00:00, 9.69s/it]

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```

In [109]:
```
# Import preprocessed dataset from CSV file
dataset_feat_clean = pd.read_csv('drugreview/datasets_feat_clean/drugr
dataset_test_feat_clean = pd.read_csv('drugreview/datasets_feat_clean/
```

In [59]:
```
# Display the random review before normalization
idx = np.random.randint(dataset_feat_clean.shape[0])
HTML(dataset_feat_clean.loc[idx, 'review'])
```

Out[59]: "Hello! I am a nurse and I suffer from anxiety and depression from very early age. I used many antidepressants through the years, but nothing was as helpful such as diazepam. It's a miracle drug.Finaly, maby in first timemy life I am filling calm and so secure Because I am a nurse I was very afraid to take this kind of drugs, because I listened many times that this kind of drugs, called benzodiazepines can create an addiction in a very short time, but my psychotherapist told me: "yes, that's kind of drugs can be addictive, but who cares if it make you to feel good? It not working such narcotic drugs- usually you don't need to take larger amounts of drug through the years in order to receive the same influence.""

In [60]:
```
# Display normalized review
HTML(dataset_feat_clean.loc[idx, 'clean_review'])
```

Out[60]: hello nurse suffer anxiety depression early age antidepressants years helpful diazepam it's miracle drug.finaly maby timemy life I filling calm secure nurse afraid kind drugs listened times kind drugs called benzodiazepines create addiction short time psychotherapist told quot;yes that's kind drugs addictive cares feel good working narcotic drugs- usually don't need larger amounts drug years order receive influence."

In [61]:
```
# Load the language model
nlp = spacy.load('en_core_web_sm')

# Create the data frame that contains positive and neagtive reviews to
pos_to_visual = dataset_feat_clean.loc[dataset_feat_clean.rating >= 5,
neg_to_visual = dataset_feat_clean.loc[dataset_feat_clean.rating < 5,
data_to_visual = pd.concat([pos_to_visual, neg_to_visual], axis=0)
# Replace numerical labels by strings (required by scattertext)
data_to_visual.rating = data_to_visual.rating.replace([10,9,8,7,6,5,4,
```

In [62]:
```
# Create the Scattertext corpus
corpus = st.CorpusFromPandas(data_to_visual,
                             category_col='rating',
                             text_col='clean_review',
                             nlp=nlp).build()
```

In [63]:
```
# Create the scattertext plot
html = st.produce_scattertext_explorer(corpus,
          category='pos',
          category_name='Positive reviews',
          not_category_name='Negative reviews',
          width_in_pixels=600,
          height_in_pixels=500)
# Save the visualization as HTML file
open('assets/scattertext_visualization.html', 'wb').write(html.encode(
```

Out[63]:
```
1621173
```

In [64]:
```
data_to_visual.loc[data_to_visual.rating =='neg', 'clean_review']
```

Out[64]:
```
17      irregular inconsistency pain control break pai...
20            breo didn&#039;t help asthma bright effects
23      life blood pressure medication horror story ba...
25      months taking drug stop effects painful weakne...
27      i&#039;ve bad reactions mood stabilizer i&#039...
                              ...
5280                                                  NaN
5281                                                  NaN
5282                                                  NaN
5283                                                  NaN
5284                                                  NaN
Name: clean_review, Length: 1500, dtype: object
```

In [65]:
```
data_to_visual.shape
```

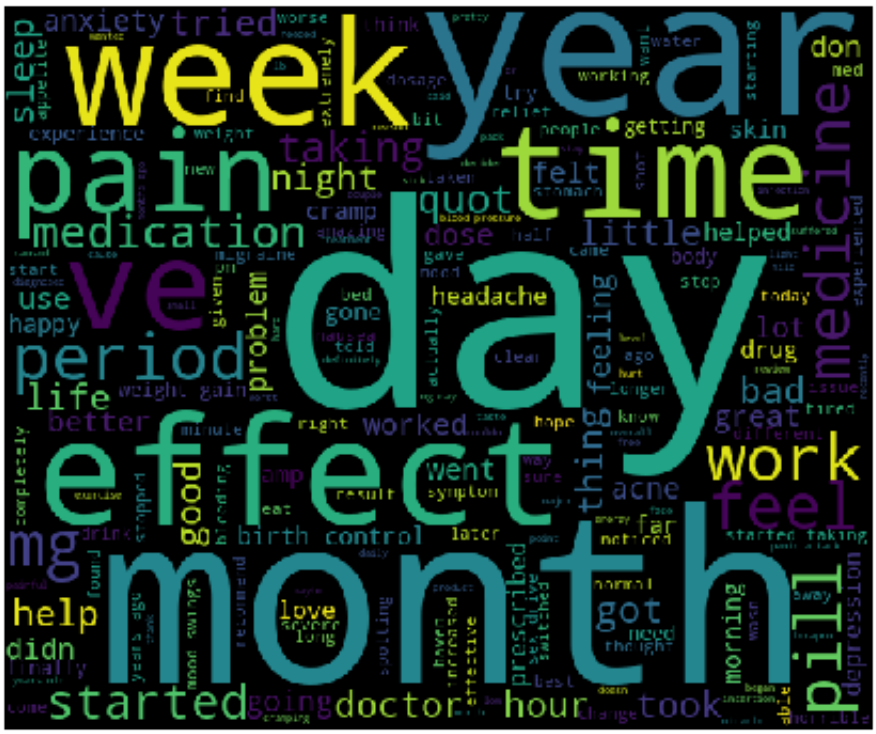
Out[65]:
```
(3000, 2)
```

In [66]:
```
data_to_visual = data_to_visual.dropna()
```

In [67]:
```
# Separate positive and negative reviews and then concatenate all revi
pos_reviews = ' '.join(data_to_visual.loc[data_to_visual.rating =='pos
neg_reviews = ' '.join(data_to_visual.loc[data_to_visual.rating =='neg
```

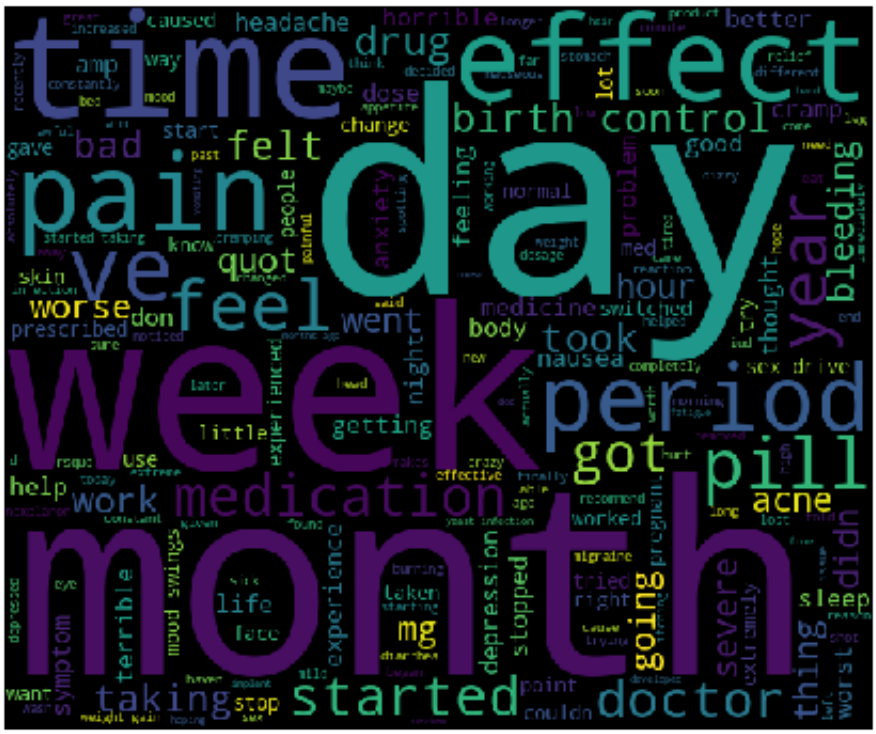
In [68]:
```
# Create wordcloud for positive reviews
wordcloud_pos = WordCloud(background_color='black',
                      width=600,
                      height=500).generate(pos_reviews)
```

In [69]:
```
# Depict wordcloud for positive reviews
plt.figure(figsize=(8,5))
plt.imshow(wordcloud_pos)
plt.axis('off')
plt.tight_layout()
```



In [70]:
```
# Create wordcloud for negative reviews
wordcloud_neg = WordCloud(background_color='black',
                          width=600,
                          height=500).generate(neg_reviews)
```

In [71]:
```
# Depict wordcloud for negative reviews
plt.figure(figsize=(8,5))
plt.imshow(wordcloud_neg)
plt.axis('off')
plt.tight_layout()
```



In [107]:
```
# Split entire raw dataset into training, validation and test sets
train_set, val_set, test1_set = train_val_test_split(dataset_feat_clea
```

In [110]:
```
# Check training, validation and test sets shapes
print('Training set shape: {}'.format(train_set.shape))
print('Validation set shape: {}'.format(val_set.shape))
print('Test set shape: {}'.format(dataset_test_feat_clean.shape))
```

```
Training set shape: (86694, 13)
Validation set shape: (21674, 13)
Test set shape: (91604, 13)
```

In [112]:
```
# Save training, validation and test sets to CSV files
train_set.to_csv('drugreview/drugreview_feat_clean/train_feat_clean.cs
val_set.to_csv('drugreview/drugreview_feat_clean/val_feat_clean.csv',
dataset_test_feat_clean.to_csv('drugreview/drugreview_feat_clean/test_
```

In [113]:
```
dataset_feat_clean.head()
```

Out[113]:

	review	rating	polarity	subjectivity	word_count	UPPERCASE	DIGITS	PUNCT	VE
0	"I have been taking Seroquel for a number of y...	10	0.10190	0.5825	133.0	0.04510	0.00000	0.09020	0.2
1	"I tried the MYLAN 5% patches that the VA pres...	7	0.29150	0.4507	140.0	0.12140	0.00000	0.12850	0.1
2	"I have been on 10 MG Norco for four years due...	9	-0.00238	0.5100	106.0	0.09436	0.01888	0.09436	0.1
3	"I went to my dermatologist after suffering th...	9	-0.03268	0.3108	143.0	0.05594	0.00000	0.13990	0.1
4	"Works great for me, very effective."	10	0.79000	0.8750	6.0	0.00000	0.00000	0.66650	0.1