In [1]:

```
# Install necessary libraries
!pip install wordcloud
!pip install tensorflow
```

```
Requirement already satisfied: wordcloud in c:\users\gabby\anaconda3\lib\site-package
s (1.9.3)
Requirement already satisfied: numpy>=1.6.1 in c:\users\gabby\anaconda3\lib\site-pack
ages (from wordcloud) (1.24.3)
Requirement already satisfied: pillow in c:\users\gabby\anaconda3\lib\site-packages
(from wordcloud) (9.4.0)
Requirement already satisfied: matplotlib in c:\users\gabby\anaconda3\lib\site-packag
es (from wordcloud) (3.7.2)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\gabby\anaconda3\lib\site-
packages (from matplotlib->wordcloud) (1.0.5)
Requirement already satisfied: cycler>=0.10 in c:\users\gabby\anaconda3\lib\site-pack
ages (from matplotlib->wordcloud) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\gabby\anaconda3\lib\site
-packages (from matplotlib->wordcloud) (4.25.0)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\gabby\anaconda3\lib\site
-packages (from matplotlib->wordcloud) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\gabby\anaconda3\lib\site-p
ackages (from matplotlib->wordcloud) (23.1)
Requirement already satisfied: pyparsing<3.1,>=2.3.1 in c:\users\gabby\anaconda3\lib
\site-packages (from matplotlib->wordcloud) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\gabby\anaconda3\lib\s
ite-packages (from matplotlib->wordcloud) (2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\gabby\anaconda3\lib\site-packages
(from python-dateutil>=2.7->matplotlib->wordcloud) (1.16.0)
Requirement already satisfied: tensorflow in c:\users\gabby\anaconda3\lib\site-packag
es (2.17.0)
Requirement already satisfied: tensorflow-intel==2.17.0 in c:\users\gabby\anaconda3\l
ib\site-packages (from tensorflow) (2.17.0)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\gabby\anaconda3\lib\site-pa
ckages (from tensorflow-intel==2.17.0->tensorflow) (2.1.0)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\gabby\anaconda3\lib\site
-packages (from tensorflow-intel==2.17.0->tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=24.3.25 in c:\users\gabby\anaconda3\lib\s
ite-packages (from tensorflow-intel==2.17.0->tensorflow) (24.3.25)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in c:\users\gabby
\anaconda3\lib\site-packages (from tensorflow-intel==2.17.0->tensorflow) (0.6.0)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\gabby\anaconda3\lib\si
te-packages (from tensorflow-intel==2.17.0->tensorflow) (0.2.0)
Requirement already satisfied: h5py>=3.10.0 in c:\users\gabby\anaconda3\lib\site-pack
ages (from tensorflow-intel==2.17.0->tensorflow) (3.11.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\gabby\anaconda3\lib\site-
packages (from tensorflow-intel==2.17.0->tensorflow) (18.1.1)
Requirement already satisfied: ml-dtypes<0.5.0,>=0.3.1 in c:\users\gabby\anaconda3\li
b\site-packages (from tensorflow-intel==2.17.0->tensorflow) (0.4.1)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\gabby\anaconda3\lib\site
-packages (from tensorflow-intel==2.17.0->tensorflow) (3.3.0)
Requirement already satisfied: packaging in c:\users\gabby\anaconda3\lib\site-package
s (from tensorflow-intel==2.17.0->tensorflow) (23.1)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!
=4.21.5,<5.0.0dev,>=3.20.3 in c:\users\gabby\anaconda3\lib\site-packages (from tensor
flow-intel==2.17.0->tensorflow) (4.25.5)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\gabby\anaconda3\lib\si
te-packages (from tensorflow-intel==2.17.0->tensorflow) (2.31.0)
Requirement already satisfied: setuptools in c:\users\gabby\anaconda3\lib\site-packag
es (from tensorflow-intel==2.17.0->tensorflow) (68.0.0)
Requirement already satisfied: six>=1.12.0 in c:\users\gabby\anaconda3\lib\site-packa
ges (from tensorflow-intel==2.17.0->tensorflow) (1.16.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\gabby\anaconda3\lib\site-
packages (from tensorflow-intel==2.17.0->tensorflow) (2.4.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\gabby\anaconda3\l
```

```
ib\site-packages (from tensorflow-intel==2.17.0->tensorflow) (4.7.1)
Requirement already satisfied: wrapt>=1.11.0 in c:\users\gabby\anaconda3\lib\site-pac
kages (from tensorflow-intel==2.17.0->tensorflow) (1.14.1)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\gabby\anaconda3\lib\si
te-packages (from tensorflow-intel==2.17.0->tensorflow) (1.66.1)
Requirement already satisfied: tensorboard<2.18,>=2.17 in c:\users\gabby\anaconda3\li
b\site-packages (from tensorflow-intel==2.17.0->tensorflow) (2.17.1)
Requirement already satisfied: keras>=3.2.0 in c:\users\gabby\anaconda3\lib\site-pack
ages (from tensorflow-intel==2.17.0->tensorflow) (3.5.0)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\gabby
\anaconda3\lib\site-packages (from tensorflow-intel==2.17.0->tensorflow) (0.31.0)
Requirement already satisfied: numpy<2.0.0,>=1.23.5 in c:\users\gabby\anaconda3\lib\s
ite-packages (from tensorflow-intel==2.17.0->tensorflow) (1.24.3)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\gabby\anaconda3\lib\sit
e-packages (from astunparse>=1.6.0->tensorflow-intel==2.17.0->tensorflow) (0.38.4)
Requirement already satisfied: rich in c:\users\gabby\anaconda3\lib\site-packages (fr
om keras>=3.2.0->tensorflow-intel==2.17.0->tensorflow) (13.8.1)
Requirement already satisfied: namex in c:\users\gabby\anaconda3\lib\site-packages (f
rom keras>=3.2.0->tensorflow-intel==2.17.0->tensorflow) (0.0.8)
Requirement already satisfied: optree in c:\users\gabby\anaconda3\lib\site-packages
(from keras>=3.2.0->tensorflow-intel==2.17.0->tensorflow) (0.12.1)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\gabby\anaconda3\l
ib\site-packages (from requests<3,>=2.21.0->tensorflow-intel==2.17.0->tensorflow) (2.
0.4)
Requirement already satisfied: idna<4,>=2.5 in c:\users\gabby\anaconda3\lib\site-pack
ages (from requests<3,>=2.21.0->tensorflow-intel==2.17.0->tensorflow) (3.4)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\gabby\anaconda3\lib\sit
e-packages (from requests<3,>=2.21.0->tensorflow-intel==2.17.0->tensorflow) (1.26.16)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\gabby\anaconda3\lib\sit
e-packages (from requests<3,>=2.21.0->tensorflow-intel==2.17.0->tensorflow) (2023.7.2
2)
Requirement already satisfied: markdown>=2.6.8 in c:\users\gabby\anaconda3\lib\site-p
ackages (from tensorboard<2.18,>=2.17->tensorflow-intel==2.17.0->tensorflow) (3.4.1)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in c:\users\gabb
y\anaconda3\lib\site-packages (from tensorboard<2.18,>=2.17->tensorflow-intel==2.17.0
->tensorflow) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\gabby\anaconda3\lib\site-p
ackages (from tensorboard<2.18,>=2.17->tensorflow-intel==2.17.0->tensorflow) (2.2.3)
Requirement already satisfied: MarkupSafe>=2.1.1 in c:\users\gabby\anaconda3\lib\site
-packages (from werkzeug>=1.0.1->tensorboard<2.18,>=2.17->tensorflow-intel==2.17.0->t
ensorflow) (2.1.1)
Requirement already satisfied: markdown-it-py>=2.2.0 in c:\users\gabby\anaconda3\lib
\site-packages (from rich->keras>=3.2.0->tensorflow-intel==2.17.0->tensorflow) (2.2.
0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in c:\users\gabby\anaconda3\li
b\site-packages (from rich->keras>=3.2.0->tensorflow-intel==2.17.0->tensorflow) (2.1
5.1)
Requirement already satisfied: mdurl~=0.1 in c:\users\gabby\anaconda3\lib\site-packag
es (from markdown-it-py>=2.2.0->rich->keras>=3.2.0->tensorflow-intel==2.17.0->tensorf
low) (0.1.0)
```

In [2]:

```python
# Import Libraries
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import re
import random
import nltk
import tensorflow as tf
```

```
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Embedding, LSTM, Dense, Dropout, BatchNormalizatic
from tensorflow.keras.regularizers import l2
from tensorflow.keras.callbacks import EarlyStopping
from keras.optimizers import Adam
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from wordcloud import WordCloud
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
from nltk.tokenize import word_tokenize
import warnings
```

In [3]:

```
# Download necessary NLTK resources
nltk.download('punkt')
nltk.download('averaged_perceptron_tagger')
nltk.download('wordnet')
nltk.download('stopwords')
```

```
[nltk_data] Downloading package punkt to
[nltk_data]     C:\Users\gabby\AppData\Roaming\nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package averaged_perceptron_tagger to
[nltk_data]     C:\Users\gabby\AppData\Roaming\nltk_data...
[nltk_data]   Package averaged_perceptron_tagger is already up-to-
[nltk_data]       date!
[nltk_data] Downloading package wordnet to
[nltk_data]     C:\Users\gabby\AppData\Roaming\nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\gabby\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

Out[3]:

```
True
```

In [4]:

```
# Suppress all warnings
warnings.filterwarnings("ignore")

# to print out all outputs
from IPython.core.interactiveshell import InteractiveShell
InteractiveShell.ast_node_interactivity = "all"

# Set random seed for reproducibility
random.seed(493)
tf.random.set_seed(493)
```

In [5]:

```
# Read tsv data
colnames = ['text', 'label']
amazon = pd.read_csv(r'C:\Users\gabby\Documents\Masters program\D213\Task 2\sentiment
imdb = pd.read_csv(r'C:\Users\gabby\Documents\Masters program\D213\Task 2\sentiment la
yelp = pd.read_csv(r'C:\Users\gabby\Documents\Masters program\D213\Task 2\sentiment la
```

In [6]:

```
# Combine all reviews into one dataframe
reviews = pd.concat([yelp, amazon, imdb], ignore_index=True)
```

In [7]:

```
# Check for any nulls
print("Null Values in Reviews:\n", reviews.isna().sum())
```

```
Null Values in Reviews:
 text     0
label    0
dtype: int64
```

In [8]:
```
# Print first 5 rows
print(reviews.head())
```

```
                                                text  label
0                           Wow... Loved this place.      1
1                                 Crust is not good.      0
2          Not tasty and the texture was just nasty.      0
3  Stopped by during the late May bank holiday of...      1
4  The selection on the menu was great and so wer...      1
```

In [9]:
```
# Exploratory Data Analysis
print(f"Shape of data: {reviews.shape}")
print(f"Sentiment counts: \n{reviews['label'].value_counts()}")
print(f"Missing values: \n{reviews.isna().sum()}")
```

```
Shape of data: (2748, 2)
Sentiment counts:
label
1    1386
0    1362
Name: count, dtype: int64
Missing values:
text     0
label    0
dtype: int64
```

In [10]:
```
# Check for unusual characters
unusual_chars = reviews['text'].str.extractall(r'([^a-zA-Z0-9\s])')
unusual_chars_count = unusual_chars[0].value_counts()
print(unusual_chars_count)
```

```
0
.    3093
,    1306
'     723
!     503
-     294
"     120
)     103
(      94
/      42
:      39
&      28
?      28
;      25
$      18
*      18
é       7
+       6
%       5
⍰       5
#       2
ê       1
[       1
]       1
å       1
⍰       1
Name: count, dtype: int64
```

In [11]:
```
# Vocabulary Size
vectorizer = CountVectorizer()
vectorizer.fit(reviews['text'])
vocabulary_size = len(vectorizer.vocabulary_)
print("Vocabulary Size:", vocabulary_size)
```

Out[11]:
```
▾ CountVectorizer
CountVectorizer()
```

```
Vocabulary Size: 5155
```

In [12]:
```
# Calculate review lengths
reviews['length'] = reviews['text'].apply(lambda x: len(x.split()))
```

In [13]:
```
# Statistical Justification for Maximum Sequence Length
print(f'Mean Length: {reviews["length"].mean()}')
print(f'Median Length: {reviews["length"].median()}')
print(f'Max Length: {reviews["length"].max()}')
print(f'95th Percentile: {reviews["length"].quantile(0.95)}')
```

```
Mean Length: 13.006550218340612
Median Length: 10.0
Max Length: 1390
95th Percentile: 26.0
```

In [14]:
```
# Make the 95% the max length
max_length = 26
```

In [15]:
```
# Text Normalization
def clean_text(text):
    # Convert all text to lowercase, remove punctuation and single characters
    text = re.sub(r'http\S+|www\S+|https\S+', '', text)  # Remove URLs
    text = re.sub(r'[^a-zA-Z\s]', ' ', text)  # Remove punctuation
    text = re.sub(r'\s+[a-z]\s+', ' ', text)  # Remove single characters
    return text.lower()

reviews['text'] = reviews['text'].apply(clean_text)
```

In [16]:
```
# Initialize lemmatizer and get the list of stopwords
lemmatizer = WordNetLemmatizer()
stop_words = set(stopwords.words('english'))
```

In [17]:
```
reviews.head()
```

Out[17]:

	text	label	length
0	wow loved this place	1	4
1	crust is not good	0	4
2	not tasty and the texture was just nasty	0	8
3	stopped by during the late may bank holiday of...	1	15
4	the selection on the menu was great and so wer...	1	12

In [18]:
```
# Function to clean and lemmatize text
def preprocess_and_clean(text):
    # Remove URLs and special characters
    text = re.sub(r"http\S+|www\S+|https\S+", '', text, flags=re.MULTILINE)
    text = re.sub(r'[^a-zA-Z\s]', '', text)

    # Tokenize and lemmatize
    tokens = word_tokenize(text.lower())
    tokens = [lemmatizer.lemmatize(word) for word in tokens if word not in stop_words]

    return ' '.join(tokens)
```

In [19]:
```
# Apply text cleaning
reviews['text'] = reviews['text'].apply(preprocess_and_clean)
```

In [20]:
```
# Add a column for word count and remove reviews with 3 words or less
reviews['Word_Count'] = reviews['text'].apply(lambda x: len(x.split()))
reviews = reviews[reviews['Word_Count'] > 3]
```

In [21]:
```
# Tokenization and model preparation
tokenizer = Tokenizer()
tokenizer.fit_on_texts(reviews['text'])
sequences = tokenizer.texts_to_sequences(reviews['text'])
```

In [22]:
```
# Padding Process
padded_sequences = pad_sequences(sequences, padding='pre',truncating='pre', maxlen=max
print("Padded Sequences:", padded_sequences[0])
```

```
Padded Sequences: [   0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0  860  861  233 1900 1901 1902  862  863  171]
```

In [23]:
```
# Exporting our prepped data
reviews.to_csv('cleaned_task2.csv', index = False)
```

In [24]:
```
# Train/test split
train_texts, temp_texts, train_labels, temp_labels = train_test_split(
    padded_sequences, reviews['label'], test_size=0.2, random_state=42)  # 80/20 split

# Further split temp into validation and test sets (1/2 of the 20% each = 10% each)
val_texts, test_texts, val_labels, test_labels = train_test_split(
    temp_texts, temp_labels, test_size=0.5, random_state=42)  # 50% of the temp set
```

In [25]:
```
# print shape
print("Training set shape:", train_texts.shape, train_labels.shape)
print("Validation set shape:", val_texts.shape, val_labels.shape)
print("Test set shape:", test_texts.shape, test_labels.shape)
```

```
Training set shape: (1498, 26) (1498,)
Validation set shape: (187, 26) (187,)
Test set shape: (188, 26) (188,)
```

In [26]:
```
# Convert to DataFrames for saving
train_texts_df = pd.DataFrame(train_texts)
val_texts_df = pd.DataFrame(val_texts)
test_texts_df = pd.DataFrame(test_texts)

train_labels_df = pd.DataFrame(train_labels)
val_labels_df = pd.DataFrame(val_labels)
test_labels_df = pd.DataFrame(test_labels)
```

In [27]:
```
# Save to CSV files for B5
train_texts_df.to_csv('train_texts.csv', index=False, header=True)
val_texts_df.to_csv('val_texts.csv', index=False, header=True)
test_texts_df.to_csv('test_texts.csv', index=False, header=True)

train_labels_df.to_csv('train_labels.csv', index=False, header=True)
val_labels_df.to_csv('val_labels.csv', index=False, header=True)
test_labels_df.to_csv('test_labels.csv', index=False, header=True)
```

In [28]:
```
# Build the model
model = Sequential()
model.add(Embedding(input_dim=vocabulary_size, output_dim=128, input_length=max_length
model.add(LSTM(128, return_sequences=True, dropout=0.3, recurrent_dropout=0.3, kernel_
model.add(BatchNormalization())
model.add(LSTM(64, dropout=0.3, recurrent_dropout=0.3, kernel_regularizer=l2(0.001)))
model.add(BatchNormalization())
model.add(Dense(1, activation='sigmoid', kernel_regularizer=l2(0.001)))
```

In [29]:
```
# Compile the model
optimizer = Adam(learning_rate=1e-1)
model.compile(loss='binary_crossentropy', optimizer=optimizer, metrics=['accuracy'])
```

In [30]:
```
# Early stopping to prevent overfitting
early_stopping = EarlyStopping(monitor='val_loss', min_delta=0, patience=3, verbose=0,
model.fit(train_texts, train_labels, validation_split=0.3,
         callbacks= [early_stopping])
```

```
33/33 ━━━━━━━━━━━━━━━━━━━━ 5s 43ms/step - accuracy: 0.5306 - loss: 6.6061 - val_accur
acy: 0.5111 - val_loss: 6.6718
```

Out[30]:
```
<keras.src.callbacks.history.History at 0x172af23e110>
```

In [31]:
```python
# Fit the model
history = model.fit(train_texts, train_labels, epochs=15, batch_size=128, validation_d
```

```
Epoch 1/15
12/12 ━━━━━━━━━━━━━━━━━━━━ 1s 75ms/step - accuracy: 0.5127 - loss: 6.1170 - val_accur
acy: 0.4706 - val_loss: 4.8339
Epoch 2/15
12/12 ━━━━━━━━━━━━━━━━━━━━ 1s 61ms/step - accuracy: 0.4996 - loss: 4.7652 - val_accur
acy: 0.4652 - val_loss: 4.1865
Epoch 3/15
12/12 ━━━━━━━━━━━━━━━━━━━━ 1s 60ms/step - accuracy: 0.5222 - loss: 3.8799 - val_accur
acy: 0.4706 - val_loss: 3.2702
Epoch 4/15
12/12 ━━━━━━━━━━━━━━━━━━━━ 1s 81ms/step - accuracy: 0.5175 - loss: 3.3908 - val_accur
acy: 0.4759 - val_loss: 4.2145
Epoch 5/15
12/12 ━━━━━━━━━━━━━━━━━━━━ 2s 132ms/step - accuracy: 0.5069 - loss: 4.7939 - val_accu
racy: 0.5294 - val_loss: 6.9626
Epoch 6/15
12/12 ━━━━━━━━━━━━━━━━━━━━ 1s 110ms/step - accuracy: 0.5079 - loss: 7.9470 - val_accu
racy: 0.5294 - val_loss: 11.2609
```

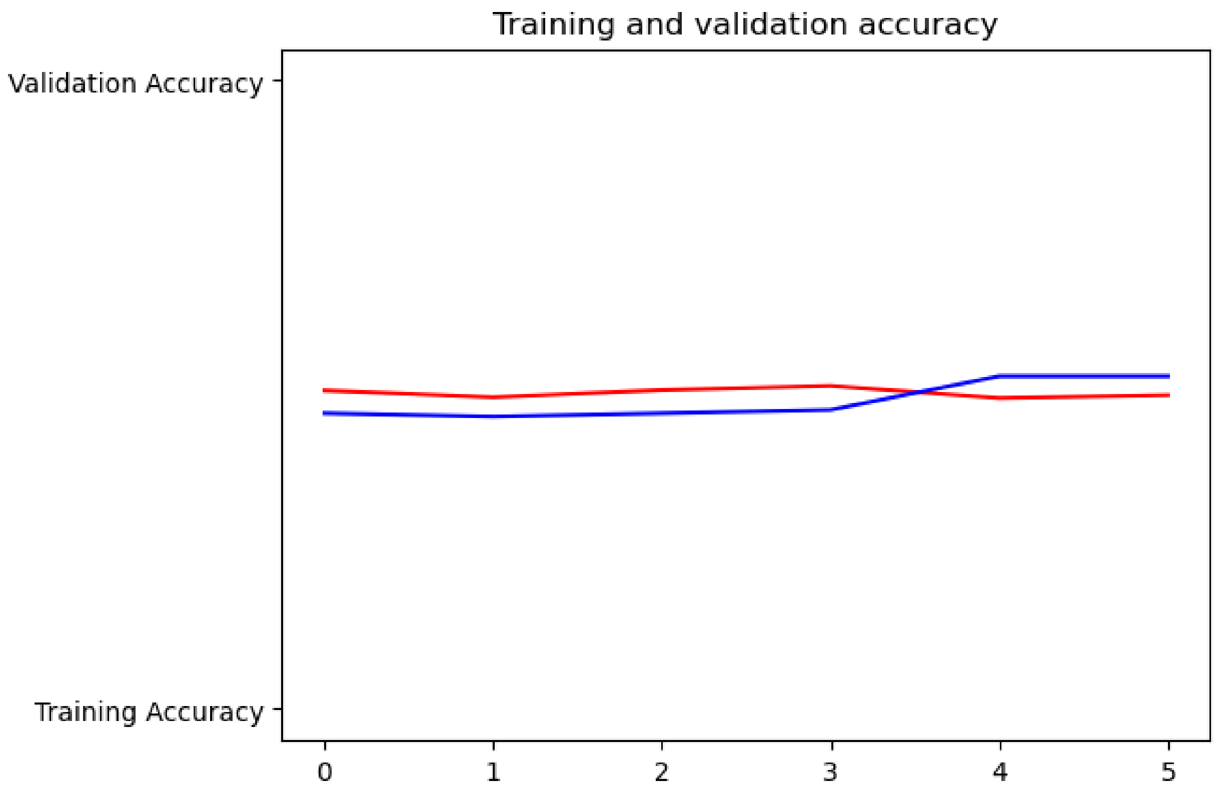
In [32]:
```python
# Get overview of model
print(model.summary())
```

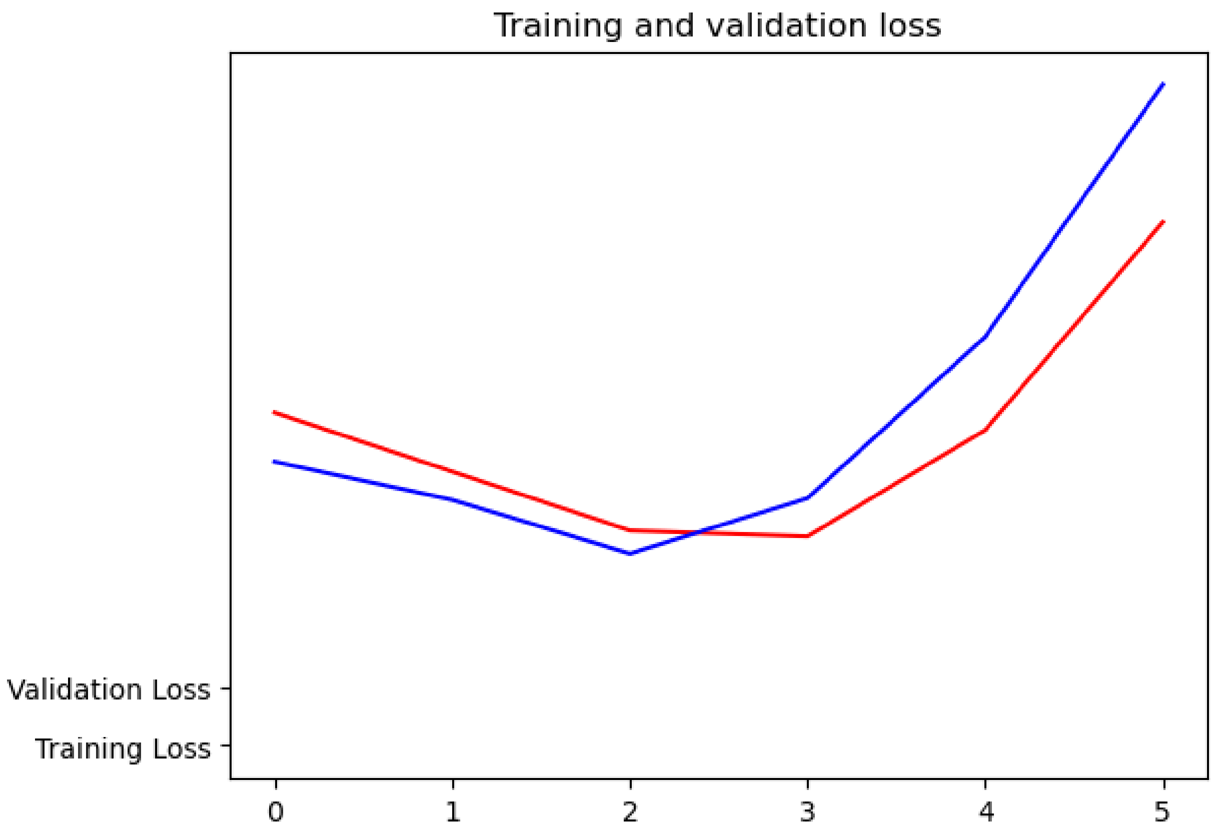
```
Model: "sequential"
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━┓
┃ Layer (type)                     ┃ Output Shape            ┃       Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━┩
│ embedding (Embedding)            │ (None, 26, 128)         │       659,840 │
├──────────────────────────────────┼─────────────────────────┼───────────────┤
│ lstm (LSTM)                      │ (None, 26, 128)         │       131,584 │
├──────────────────────────────────┼─────────────────────────┼───────────────┤
│ batch_normalization              │ (None, 26, 128)         │           512 │
│ (BatchNormalization)             │                         │               │
├──────────────────────────────────┼─────────────────────────┼───────────────┤
│ lstm_1 (LSTM)                    │ (None, 64)              │        49,408 │
├──────────────────────────────────┼─────────────────────────┼───────────────┤
│ batch_normalization_1            │ (None, 64)              │           256 │
│ (BatchNormalization)             │                         │               │
├──────────────────────────────────┼─────────────────────────┼───────────────┤
│ dense (Dense)                    │ (None, 1)               │            65 │
└──────────────────────────────────┴─────────────────────────┴───────────────┘
 Total params: 2,524,229 (9.63 MB)
 Trainable params: 841,281 (3.21 MB)
 Non-trainable params: 384 (1.50 KB)
 Optimizer params: 1,682,564 (6.42 MB)
None
```

In [33]:
```python
# Training and validation accuracy
sns.set
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
```

```
val_loss = history.history['val_loss']
epochs=range(len(acc))
plt.plot(epochs, acc, 'r', 'Training Accuracy')
plt.plot(epochs, val_acc, 'b', 'Validation Accuracy')
plt.title('Training and validation accuracy')
plt.figure()
plt.plot(epochs, loss, 'r', 'Training Loss')
plt.plot(epochs, val_loss, 'b', 'Validation Loss')
plt.title('Training and validation loss')
plt.figure()
```

```
Out[33]: <function seaborn.rcmod.set(*args, **kwargs)>
Out[33]: [<matplotlib.lines.Line2D at 0x172b9223050>,
          <matplotlib.lines.Line2D at 0x172b4da4390>]
Out[33]: [<matplotlib.lines.Line2D at 0x172bb21dd90>,
          <matplotlib.lines.Line2D at 0x172bb22d110>]
Out[33]: Text(0.5, 1.0, 'Training and validation accuracy')
Out[33]: <Figure size 640x480 with 0 Axes>
Out[33]: [<matplotlib.lines.Line2D at 0x172b916f810>,
          <matplotlib.lines.Line2D at 0x172af223790>]
Out[33]: [<matplotlib.lines.Line2D at 0x172bb265f90>,
          <matplotlib.lines.Line2D at 0x172bb266110>]
Out[33]: Text(0.5, 1.0, 'Training and validation loss')
Out[33]: <Figure size 640x480 with 0 Axes>
```





```
<Figure size 640x480 with 0 Axes>
```

```
In [34]: # Save the model
         model.save('D213_T2-model.keras')
```