01to06_core_analysis

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1 01to06_core_analysis

Hardware and runtime All experiments were run locally on a MacBook Pro (16-inch, November 2024) with an Apple M4 Pro chip (14 CPU cores: 10 performance and 4 efficiency cores) and 24 GB unified memory, running macOS Tahoe 26.2. All steps were executed on CPU, and no distributed computing frameworks (for example SLURM or OpenPBS) were used.

Runtime: On the hardware above, the notebook completes in approximately **3-5 minutes**. Runtime may vary slightly depending on installed package versions and whether optional diagnostics are enabled.

1.1 Table of contents

Section	Description
04b_emotion_analysis_bert_base_uncased	Repeats the same emotion pipeline for comparison using the second model in `EmotionParams` (defined in this notebook), reusing `Initialiser`, `EmotionModelDataCompiler`, and `bar_plot` (all defined in this notebook).
05_topic_modelling_bertopic_per_emotion_neg_reviews	Runs BERTopic per emotion on negative reviews (for example sadness) using `BERTopicRunner` (imported), enforcing a minimum document threshold and exporting topic summaries and visualisations.
06_topic_modelling_lda_gensim	Trains and evaluates Gensim LDA baselines and exports pyLDAvis artefacts using the in-notebook pipeline `LDAConfig`, `LDARunner`, `LDAEvaluator`, `PreprocessedTokeniser`, `GensimCorpusBuilder`, and `run_emotion_subset` (all defined in this notebook).

Reproducibility note (BERTopic plots and top topics)

- BERTopic visualisations in this notebook (for example intertopic distance maps) rely on a UMAP projection. UMAP can yield slightly different embeddings across hardware/OS and execution settings (particularly when parallelism differs), so plots generated on a different device from the one specified above may not exactly match the reported figures even when the same random seed is used. On the device used for this project, the plots are reproducible for the fixed seed (**901**).
- This sensitivity to execution environment is one reason LDA was also explored in this project, as a complementary topic modelling approach with more straightforward reproducibility characteristics.
- Documentation: https://umap-learn.readthedocs.io/en/latest/reproducibility.html
- The reported plots are pre-saved in the folders for this reason. However, executing all notebooks will overwrite them.

[100]:
```python
from pathlib import Path
import sys
import ast
from configparser import ConfigParser

import numpy as np
import random
import pandas as pd

import re
```

```
# Resolve project root as the parent of the folder the notebook is currently in
CWD = Path.cwd().resolve()
PROJECT_ROOT = CWD.parent

# Safety fallback
if not (PROJECT_ROOT / "config.ini").exists():
    PROJECT_ROOT = next((p for p in (CWD, *CWD.parents) if (p / "config.ini").
 ↪exists()), None)
    if PROJECT_ROOT is None:
        raise FileNotFoundError("Could not locate 'config.ini' in the current␣
 ↪directory or its parents.")

if str(PROJECT_ROOT) not in sys.path:
    sys.path.insert(0, str(PROJECT_ROOT))

CONFIG = ConfigParser()
CONFIG.read(PROJECT_ROOT / "config.ini")

print("CONFIG used:")
for section in CONFIG.sections():
    print(f"\n[{section}]")
    for key, value in CONFIG[section].items():
        print(f"{key} = {value}")
```

```
CONFIG used:

[DATA]
data_dir = data
raw_filename = PureGym Customer Reviews.csv
raw_filename_filtered = PureGym Customer Reviews_raw_filtered.csv
preprocessed_filename = PureGym Customer Reviews_preprocessed.csv
preprocessed_filename_sentiment = PureGym Customer
Reviews_preprocessed_sentiment.csv
preprocessed_filename_negative = PureGym Customer
Reviews_preprocessed_negative.csv
preprocessed_filename_non_negative = PureGym Customer
Reviews_preprocessed_non_negative.csv
preprocessed_filename_emotion = PureGym Customer
Reviews_preprocessed_emotion.csv
preprocessed_filename_negative_emotion = PureGym Customer
Reviews_preprocessed_negative_emotion.csv
preprocessed_filename_non_negative_emotion = PureGym Customer
Reviews_preprocessed_non_negative_emotion.csv

[OUTPUT]
plot_dir = output/plots
```

```
table_dir = output/tables
model_dir = output/models

[FILTERING]
selected_cols = ["Rating", "Date Experienced", "Review Title", "Review"]
country_code = GB
text_col = Review
detect_language = en
negative_ratings = [1, 2]
emotion_col = Dominant Emotion

[ANALYSIS_DATES]
start_date = 2022-12-17
end_date = 2023-12-17
date_col = Date Experienced

[REPRODUCIBILITY]
seed = 901

[MODELS]
bertopic_negative = bertopic_negative
bertopic_non_negative = bertopic_non_negative
bertopic_emotion_negative_anger = bertopic_emotion_negative_anger
bertopic_emotion_negative_sadness = bertopic_emotion_negative_sad
bertopic_emotion_negative_joy = bertopic_emotion_negative_joy
bertopic_llm_topics_negative = bertopic_llm_topics_negative
bertopic_negative_reviews_llm_filtered = bertopic_negative_reviews_llm_filtered
```

[101]:
```python
SEED = CONFIG["REPRODUCIBILITY"].getint("SEED")
random.seed(SEED)
np.random.seed(SEED)
```

[102]:
```python
import time

NOTEBOOK_TO_GLOBAL = time.perf_counter()
print("Notebook timer started.")
```

```
Notebook timer started.
```

2 01_preprocessing

This section performs all preprocessing required prior to modelling and analysis:

- Filters the raw Trustpilot dataset by country (UK), date range, language, and selected variables.
- Applies text preprocessing (normalisation, contraction handling, lemmatisation, punctuation and digit removal, stopword filtering).

- Produces separate preprocessed datasets for topic modelling and for sentiment or emotion analysis.

Outputs (data/):

- `PureGym Customer Reviews_raw_filtered.csv`
- `PureGym Customer Reviews_preprocessed.csv`
- `PureGym Customer Reviews_preprocessed_sentiment.csv`

Compute and reproducibility:

- Local run on MacBook Pro (16-inch, Nov 2024), Apple M4 Pro (14 CPU cores), 24 GB unified memory, macOS Tahoe 26.2.
- CPU-only execution, no distributed frameworks.
- Fixed random seed: **901**.

[103]:
```
NOTEBOOK_T0 = time.perf_counter()
print("Section timer started.")
```

```
Section timer started.
```

[104]:
```
from typing import Iterable, Optional, Callable

from utils.data_management.data_io import load_csv, save_csv
from utils.processing.text_preprocessor import TextPreprocessor

from langdetect import detect, DetectorFactory
from langdetect.lang_detect_exception import LangDetectException
```

[105]:
```
# FILTERING
SELECTED_COLS = ast.literal_eval(CONFIG["FILTERING"]["SELECTED_COLS"])

COUNTRY_CODE = CONFIG["FILTERING"]["COUNTRY_CODE"]
TEXT_COL = CONFIG["FILTERING"]["TEXT_COL"]
DETECT_LANGUAGE = CONFIG["FILTERING"]["DETECT_LANGUAGE"]

# ANALYSIS DATES
DATE_COL = CONFIG["ANALYSIS_DATES"]["DATE_COL"]
START_DATE = CONFIG["ANALYSIS_DATES"]["START_DATE"]
END_DATE = CONFIG["ANALYSIS_DATES"]["END_DATE"]

# REPRODUCIBILITY
DetectorFactory.seed = SEED  # Configure langdetect RNG once

# DATA
DATA_DIR = (PROJECT_ROOT / CONFIG["DATA"]["DATA_DIR"]).resolve()
DATA_DIR.mkdir(parents=True, exist_ok=True)
```

```python
RAW_FILENAME = CONFIG["DATA"]["RAW_FILENAME"]
RAW_PATH = f"{DATA_DIR}/{RAW_FILENAME}"

# PREPROCESSING
STOPWORD_LANGUAGE = "english"
EXTRA_STOPWORDS = ["pure", "gym", "puregym", "equipment"]

PUNCTUATION_PATTERN_TOPIC = r"[-.,\"'’`;:!?()/&%]+"
USE_POS_TAGGING_TOPIC = False

PUNCTUATION_PATTERN_SENTIMENT = r"[-.,\"'’`;:()/&%]+"
USE_POS_TAGGING_SENTIMENT = True
```

[106]:
```python
def detect_language(text: Optional[str]) -> str:
    """
    Detect the language of a text string.

    Parameters
    ----------
    text : str or None
        Input text.

    Returns
    -------
    str
        ISO 639-1 language code or ``"unknown"`` if detection fails.
    """
    if not isinstance(text, str) or not text.strip():
        return "unknown"

    try:
        return detect(text)
    except LangDetectException:
        return "unknown"
```

[107]:
```python
class TrustpilotDataFilter:
    """
    Apply standardised filtering operations to Trustpilot review data.

    Parameters
    ----------
    selected_columns : list[str]
        Columns to retain in the final output DataFrame.
    date_column : str
        Name of the column containing review dates.
    start_date : str or pandas.Timestamp
        Inclusive start date for filtering.
    end_date : str or pandas.Timestamp
        Inclusive end date for filtering.
    country_code : str or None, optional
        Country code to filter on. If ``None``, no country filtering is applied.
    language_detector : Callable[[str | None], str], optional
        Function used to detect language from text.
    text_column : str
        Column used for language detection.
    allowed_languages : Iterable[str] or None, optional
        Languages to retain. If ``None``, no language filtering is applied.
    """

    def __init__(
        self,
        selected_columns: list[str],
        date_column: str,
        start_date,
        end_date,
        country_code: Optional[str] = None,
        language_detector: Callable[[Optional[str]], str] = detect_language,
        text_column: str = "Review",
        allowed_languages: Optional[Iterable[str]] = ("en",),
    ) -> None:
        self.selected_columns = selected_columns
        self.date_column = date_column
        self.start_date = pd.Timestamp(start_date)
        self.end_date = pd.Timestamp(end_date)
        self.country_code = country_code
        self.language_detector = language_detector
        self.text_column = text_column
        self.allowed_languages = allowed_languages

    def apply(self, df: pd.DataFrame) -> pd.DataFrame:
        """
        Apply all configured filters to the dataset.

        Parameters
        ----------
        df : pandas.DataFrame
            Raw Trustpilot dataset.

        Returns
        -------
        pandas.DataFrame
            Filtered dataset containing only the selected columns.
        """
        df_filtered = df.copy()
        df_filtered = self._filter_country(df_filtered)
        df_filtered = self._parse_dates(df_filtered)
        df_filtered = self._filter_date_range(df_filtered)
        df_filtered = self._filter_language(df_filtered)
        df_filtered = self._select_columns(df_filtered)

        return df_filtered

    def _filter_country(self, df: pd.DataFrame) -> pd.DataFrame:
        """
        Filter reviews by country code.
        """
        if self.country_code is None:
            return df

        return df[df["Country Code"] == self.country_code]

    def _parse_dates(self, df: pd.DataFrame) -> pd.DataFrame:
        """
        Parse the date column into pandas datetime format.
        """
        df = df.copy()
        df[self.date_column] = pd.to_datetime(df[self.date_column],␣
↪errors="coerce")
        return df

    def _filter_date_range(self, df: pd.DataFrame) -> pd.DataFrame:
        """
        Filter reviews within the specified date range.
        """
        mask = (
            (df[self.date_column] >= self.start_date) &
            (df[self.date_column] <= self.end_date)
        )
        return df[mask]

    def _filter_language(self, df: pd.DataFrame) -> pd.DataFrame:
        """
        Filter reviews by detected language.
        Language detection is performed temporarily and the helper
        column is dropped before returning the dataset.
        """
        if self.allowed_languages is None:
            return df

        df = df.copy()
        df["_detected_language"] = df[self.text_column].apply(self.
↪language_detector)

        df = df[df["_detected_language"].isin(self.allowed_languages)]
        df = df.drop(columns="_detected_language")

        return df

    def _select_columns(self, df: pd.DataFrame) -> pd.DataFrame:
        """
        Select the final output columns.
        """
        return df[self.selected_columns].copy()
```

2.0.1 Load raw data

[ ]:
```
df_trustpilot = load_csv(RAW_PATH)
```

2.0.2 Data Quality Checks

[109]:
```
print("Number of Missing Comments in Trustpilot Reviews Dataset:",␣
↪df_trustpilot[TEXT_COL].isna().sum())
print("Number of duplicates in Trustpilot Reviews Dataset:", df_trustpilot.
↪duplicated().sum())
```

```
Number of Missing Comments in Trustpilot Reviews Dataset: 0
Number of duplicates in Trustpilot Reviews Dataset: 0
```

2.0.3 Apply Filters

[110]:
```
trustpilot_filter = TrustpilotDataFilter(
    selected_columns=SELECTED_COLS,   # Columns to keep in final dataset
    date_column=DATE_COL,           # Review date field
    start_date=START_DATE,               # Inclusive start date
    end_date=END_DATE,                   # Inclusive end date
    country_code=COUNTRY_CODE,           # Filter to UK reviews only
    text_column=TEXT_COL,                # Text used for language detection
    allowed_languages=(DETECT_LANGUAGE ,)   # Keep English-language reviews
)

df_trustpilot = trustpilot_filter.apply(df_trustpilot)
```

[ ]:
```
# Validate language filtering
VALIDATE_LANGUAGE = True
if VALIDATE_LANGUAGE:
    language_check = df_trustpilot[TEXT_COL].apply(detect_language)
    language_counts = (
        pd.Series(language_check)
        .value_counts(dropna=False)
        .sort_index()
    )
    display(language_counts)
```

```
Review
en    11300
Name: count, dtype: int64
```

[112]:
```
# Save raw filtered (no text preprocessing yet)
save_csv(
    df_trustpilot,
    RAW_PATH,
    suffix="_raw_filtered",
)

print("Saved raw filtered dataset to:", Path(RAW_PATH).
 ↪with_name(f"{Path(RAW_PATH).stem}_raw_filtered{Path(RAW_PATH).suffix}"))
display(df_trustpilot.head(4))
```

```
Saved raw filtered dataset to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_raw_filtered.csv

   Rating Date Experienced                              Review Title  \
0       4       2023-12-17  A well equipped gym, lacked cleaning facilities
1       4       2023-12-13                      Overall a good experience
2       5       2023-12-12                                  Excellent gym
3       5       2023-11-12                            I'm going to be so fit

                                                                          ␣
 ↪                                                                         ␣
 ↪                                                                         ␣
 ↪                                                                         ␣
 ↪                                                                         ␣
 ↪                      Review
0                                                                         ␣
 ↪                                                                         ␣
 ↪  a well equipped gym and only noticed one machine out of order. disappointed␣
 ↪with the lack of blue towel and sanitizer spray for customers to use once they␣
 ↪have finished with equipment. and notices asking customers to do so as a␣
 ↪matter of respect for other users
1  overall a good experience. its still too cramped compared with the old␣
 ↪redditch gym, but numbers seem to be reducing a little so equipment is a␣
 ↪little more readily available. the changing rooms are far too small though␣
 ↪(take a look at sunderland pure gym for comparison). one jewel in the crown is␣
 ↪mark fisher. this guys classes are "insane" (in the nicest possible way!).␣
 ↪book his classes early to avoid disappointment.
```

```
2                                                                               ␣
 ↪                                                          excellent␣
 ↪gym, friendly environment, plenty of choice of equipment and space to do your␣
 ↪exercise. personal trainers at hand. excellent opening hours, basically you␣
 ↪can go whenever you want  can get busy at times, but you can always get on␣
 ↪something. classes are also very good
3                                                                               ␣
 ↪                                                                               ␣
 ↪                                                                               ␣
 ↪                                         havnt been a gym member for 20␣
 ↪years but this is state of the art, brand new with friendly staff and at␣
 ↪really good competitive monthly price
```

2.0.4 Apply Text Preprocessor for Topic Modelling

[113]:
```python
# Apply text preprocessor for topic modelling
df_trustpilot[TEXT_COL] = TextPreprocessor(
    punctuation_pattern=PUNCTUATION_PATTERN_TOPIC,
    extra_stopwords=EXTRA_STOPWORDS,
    use_pos_tagging=USE_POS_TAGGING_TOPIC,
    language=STOPWORD_LANGUAGE,
).transform_many(df_trustpilot[TEXT_COL])
```

[114]:
```python
display(df_trustpilot.head(4))
```

```
   Rating Date Experienced                                    Review Title  \
0       4       2023-12-17  A well equipped gym, lacked cleaning facilities
1       4       2023-12-13                        Overall a good experience
2       5       2023-12-12                                    Excellent gym
3       5       2023-11-12                             I'm going to be so fit


                                                                                ␣
 ↪                                                                               ␣
 ↪                                                                               ␣
 ↪                                       Review
0                                                                               ␣
 ↪                                               well equipped noticed one␣
 ↪machine order disappointed lack blue towel sanitizer spray customer use␣
 ↪finished notice asking customer matter respect user
1  overall good experience still cramped compared old redditch number seem␣
 ↪reducing little little readily available changing room far small though take␣
 ↪look sunderland comparison one jewel crown mark fisher guy class insane nicest␣
 ↪possible way book class early avoid disappointment
2                                                                               ␣
 ↪                excellent friendly environment plenty choice space exercise␣
 ↪personal trainer hand excellent opening hour basically go whenever want  get␣
 ↪busy time always get something class also good
```

```
3                                                                                     ␣
 ↪                                                                                    ␣
 ↪                                      havnt member year state art brand new friendly␣
 ↪staff really good competitive monthly price
```

2.0.5 Save Processed Data for Topic Modelling

```
[115]: save_csv(
           df_trustpilot,
           RAW_PATH,
           suffix="_preprocessed"
       )
```

```
[115]: PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
       Analysis/PureGym-NLP-UDA/data/PureGym Customer Reviews_preprocessed.csv')
```

2.0.6 Apply Text Preprocessor for Sentiment/Emotion Data

```
[116]: # Apply text preprocessor for sentiment/emotion data
       df_trustpilot_sentiment = df_trustpilot.copy()

       df_trustpilot_sentiment[TEXT_COL] = TextPreprocessor(
           punctuation_pattern=PUNCTUATION_PATTERN_SENTIMENT,
           extra_stopwords=EXTRA_STOPWORDS,
           use_pos_tagging=USE_POS_TAGGING_SENTIMENT,
           language=STOPWORD_LANGUAGE,
       ).transform_many(df_trustpilot_sentiment[TEXT_COL])
```

2.0.7 Save Processed Sentiment/Emotion Data

```
[117]: sentiment_save_path = save_csv(
           df_trustpilot_sentiment,
           RAW_PATH,
           suffix="_preprocessed_sentiment",
       )

       print("Saved sentiment/emotion preprocessed dataset to:", sentiment_save_path)
```

```
Saved sentiment/emotion preprocessed dataset to:
/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/PureGym-NLP-
UDA/data/PureGym Customer Reviews_preprocessed_sentiment.csv
```

```
[118]: elapsed_s = time.perf_counter() - NOTEBOOK_T0
       elapsed_m = elapsed_s / 60

       print(f"\nTotal runtime: {elapsed_s:,.1f} seconds ({elapsed_m:,.2f} minutes)")
```

```

Total runtime: 43.9 seconds (0.73 minutes)
```

3 02_eda_and_split_negative_review_data

This section performs exploratory analysis on the preprocessed dataset and prepares modelling subsets:

- Produces word-frequency tables and word clouds for all reviews, negative reviews, and non-negative reviews.
- Splits the dataset into negative and non-negative subsets using rating thresholds from the configuration.

Outputs (data/):

- `PureGym Customer Reviews_preprocessed_negative.csv`
- `PureGym Customer Reviews_preprocessed_non_negative.csv`

Additional outputs: plots and tables under `output/plots/02_eda_and_split_negative_review_data/` and `output/tables/02_eda_and_split_negative_review_data/`.

Compute and reproducibility: CPU-only local execution, fixed random seed **901**.

[119]:
```
import time

NOTEBOOK_T0 = time.perf_counter()
print("Notebook timer started.")
```

```
Notebook timer started.
```

[120]:
```
PLOT_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["PLOT_DIR"] /␣
  ↪"02_eda_and_split_negative_review_data"
TABLE_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["TABLE_DIR"] /␣
  ↪"02_eda_and_split_negative_review_data"

PLOT_DIR.mkdir(parents=True, exist_ok=True)
TABLE_DIR.mkdir(parents=True, exist_ok=True)

# DATA
DATA_DIR = (PROJECT_ROOT / CONFIG["DATA"]["DATA_DIR"]).resolve()
DATA_DIR.mkdir(parents=True, exist_ok=True)
RAW_FILENAME = CONFIG["DATA"]["RAW_FILENAME"]
PREPROCESSED_FILENAME = CONFIG["DATA"]["PREPROCESSED_FILENAME"]
PREPROCESSED_PATH = f"{DATA_DIR}/{PREPROCESSED_FILENAME}"


TEXT_COL = CONFIG["FILTERING"]["TEXT_COL"]
SEED = CONFIG["REPRODUCIBILITY"].getint("SEED")


TOP_N = 10 # Number of words to show in bar plots
```

[121]:
```python
# Standard
import ast
import warnings
from collections import Counter
from typing import Iterable, Sequence, Optional

# Data handling
import pandas as pd
import numpy as np
pd.set_option("display.max_colwidth", None)

# Visualisation
import matplotlib.pyplot as plt
import seaborn as sns
import matplotlib.pyplot as plt
from wordcloud import WordCloud

# Project utilities
from utils.data_management.data_io import load_csv, save_csv

warnings.filterwarnings("ignore")
```

[122]:
```python
# Load preprocessed Trustpilot data
df_trustpilot = load_csv(PREPROCESSED_PATH)
```

3.0.1 Plotter Class

[123]:
```python
class Plotter:
    """
    Create, display, and save common NLP plots.
    """

    def __init__(self, output_dir: str | Path = "output/plots") -> None:
        self._output_dir = Path(output_dir)
        self._output_dir.mkdir(parents=True, exist_ok=True)

    @property
    def output_dir(self) -> Path:
        return self._output_dir

    def _save_figure(self, fig: plt.Figure, filename: str) -> Path:
        save_path = self._output_dir / filename
        fig.savefig(save_path, bbox_inches="tight")
        return save_path

    def plot_word_frequencies(
        self,
        words: Sequence[str],
        counts: Sequence[int],
        *,
        title: str,
        filename: str,
        rotation: int = 45,
        figsize: float = 6.0,
        show: bool = True,
    ) -> Path:
        """
        Plot, display, and save a word frequency bar chart.
        """
        if len(words) != len(counts):
            raise ValueError("words and counts must have the same length")

        fig, ax = plt.subplots(figsize=(figsize, figsize))
        ax.bar(words, counts)
        ax.set_title(title)
        ax.set_xlabel("Words")
        ax.set_ylabel("Frequency")
        ax.tick_params(axis="x", rotation=rotation)
        fig.tight_layout()

        if show:
            plt.show()

        path = self._save_figure(fig, filename)
        plt.close(fig)
        return path

    def plot_wordcloud(
        self,
        tokens: Iterable[str],
        *,
        title: str,
        filename: str,
        seed: Optional[int] = None,
        width: int = 800,
        height: int = 800,
        background_color: str = "white",
        max_words: int = 200,
        figsize: float = 6.0,
        show: bool = True,
    ) -> Path:
        """
        Plot, display, and save a word cloud.
        Parameters
        ----------
        seed
            Random seed for word cloud layout. If ``None``, randomness is␣
↪uncontrolled.
        """
        text = " ".join(str(t) for t in tokens if t is not None)

        wc = WordCloud(
            width=width,
            height=height,
            background_color=background_color,
            max_words=max_words,
            random_state=seed,
        ).generate(text)

        fig, ax = plt.subplots(figsize=(figsize, figsize))
        ax.imshow(wc, interpolation="bilinear")
        ax.set_title(title)
        ax.axis("off")
        fig.tight_layout()

        if show:
            plt.show()

        path = self._save_figure(fig, filename)
        plt.close(fig)
        return path
```

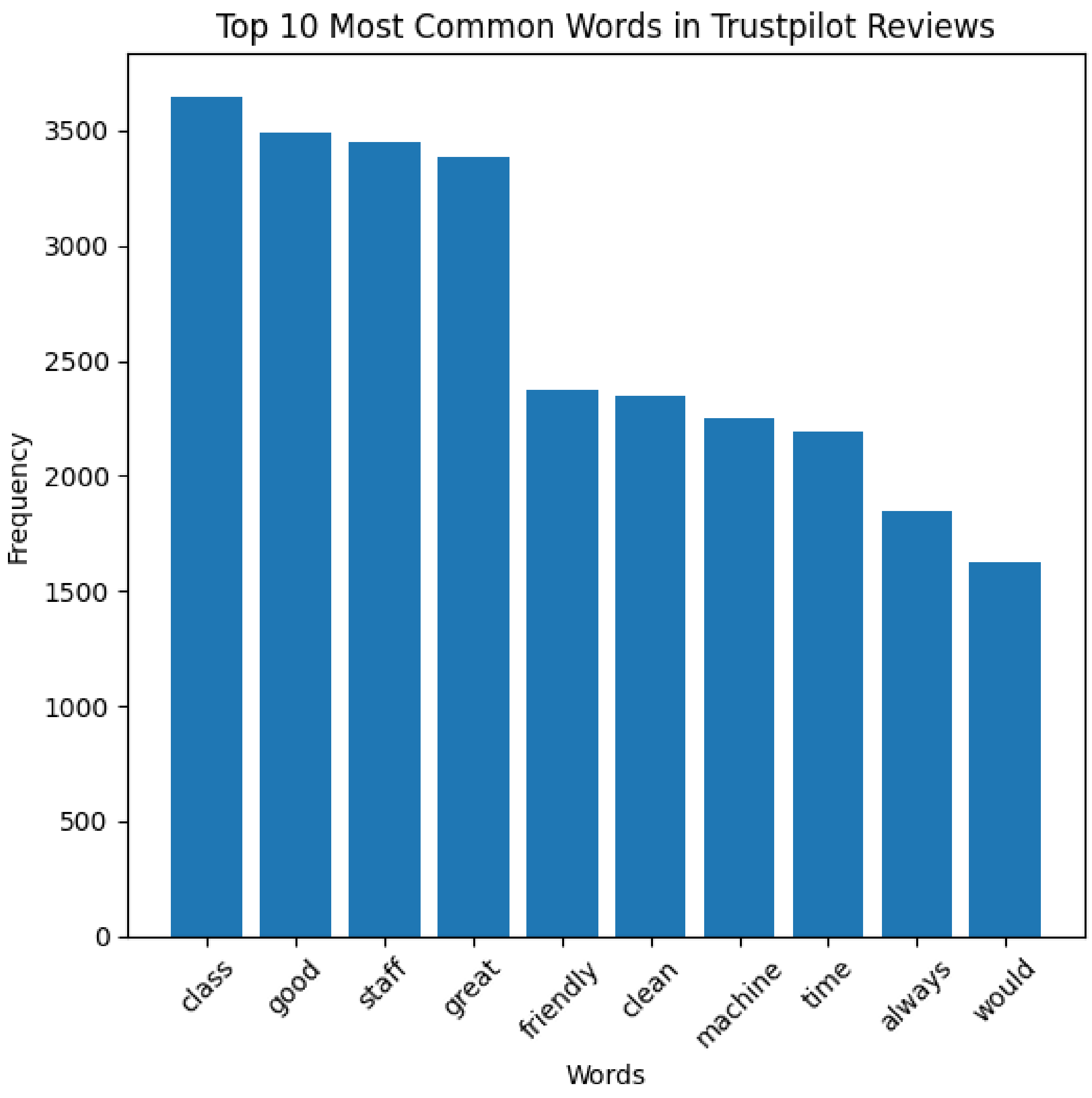
[124]:
```
# Instantiate plotter
plotter = Plotter(output_dir=PLOT_DIR)
```

3.0.2 Plots: All Reviews

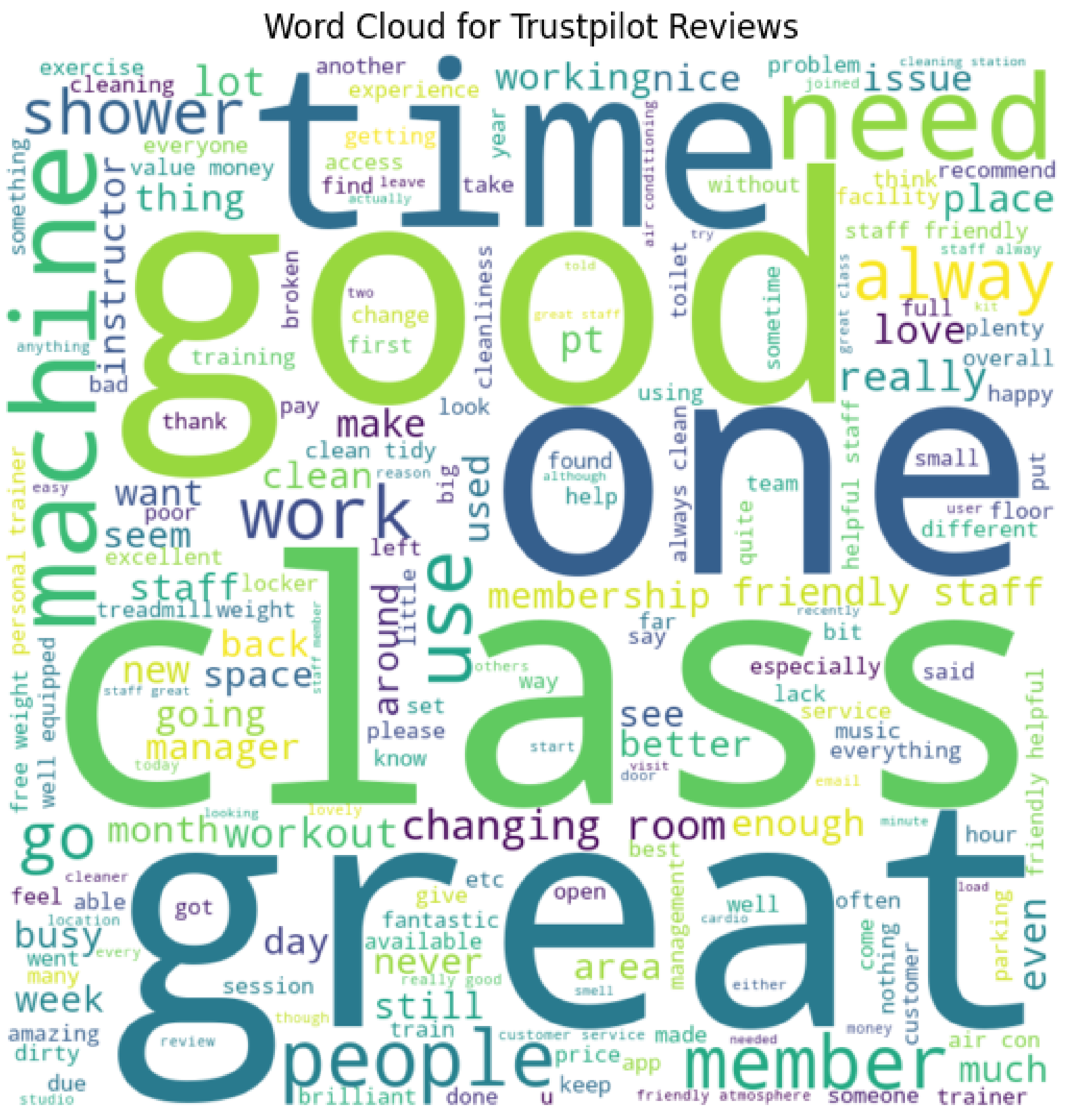
[125]:
```
# Tokenise preprocessed text
tokens_trustpilot = (
    df_trustpilot[TEXT_COL]
    .dropna()
    .astype(str)
    .str.split()
    .explode()
)
```

[126]:
```
# Word frequency calculation
token_counts = Counter(tokens_trustpilot)
common_words = token_counts.most_common(TOP_N)
```

```python
# Save top words table
df_top_words_all = pd.DataFrame(common_words, columns=["word", "count"])
df_top_words_all.to_csv(TABLE_DIR / "trustpilot_top10_words.csv", index=False)

words, counts = zip(*common_words) if common_words else ([], [])

# Plot and save word frequencies
freq_plot_path = plotter.plot_word_frequencies(
    words=words,
    counts=counts,
    title="Top 10 Most Common Words in Trustpilot Reviews",
    filename="trustpilot_top10_words.png",
)

print(f"Saved frequency plot to: {freq_plot_path}")

# Plot and save wordcloud
wordcloud_path = plotter.plot_wordcloud(
    tokens=tokens_trustpilot,
    title="Word Cloud for Trustpilot Reviews",
    filename="trustpilot_wordcloud.png",
    seed=SEED,
)

print(f"Saved wordcloud to: {wordcloud_path}")
print(f"Saved top words table to: {TABLE_DIR / 'trustpilot_top10_words.csv'}")
```



```
Saved frequency plot to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/02_eda_and_split_negative_review_data/trus
tpilot_top10_words.png
```



```
Saved wordcloud to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-
UDA/output/plots/02_eda_and_split_negative_review_data/trustpilot_wordcloud.png
Saved top words table to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured
Data Analysis/PureGym-NLP-UDA/output/tables/02_eda_and_split_negative_review_dat
a/trustpilot_top10_words.csv
```

3.0.3 Create and Save Sub-dataframes

[127]:
```python
# View counts for each Rating level
df_trustpilot["Rating"].value_counts()
```

[127]:
```
Rating
5    5237
4    2177
1    1524
3    1518
2     844
Name: count, dtype: int64
```

[128]:
```
# Split into negative / non-negative
NEGATIVE_RATINGS = ast.literal_eval(CONFIG["FILTERING"].get("NEGATIVE_RATINGS",␣
↪"[]"))

df_negative = df_trustpilot[df_trustpilot["Rating"].isin(NEGATIVE_RATINGS)].
↪copy()
df_non_negative = df_trustpilot[~df_trustpilot["Rating"].
↪isin(NEGATIVE_RATINGS)].copy()

print("Negative ratings:", NEGATIVE_RATINGS)
print("All reviews:", len(df_trustpilot))
print("Negative reviews:", len(df_negative))
print("Non-negative reviews:", len(df_non_negative))
```

```
Negative ratings: [1, 2]
All reviews: 11300
Negative reviews: 2368
Non-negative reviews: 8932
```

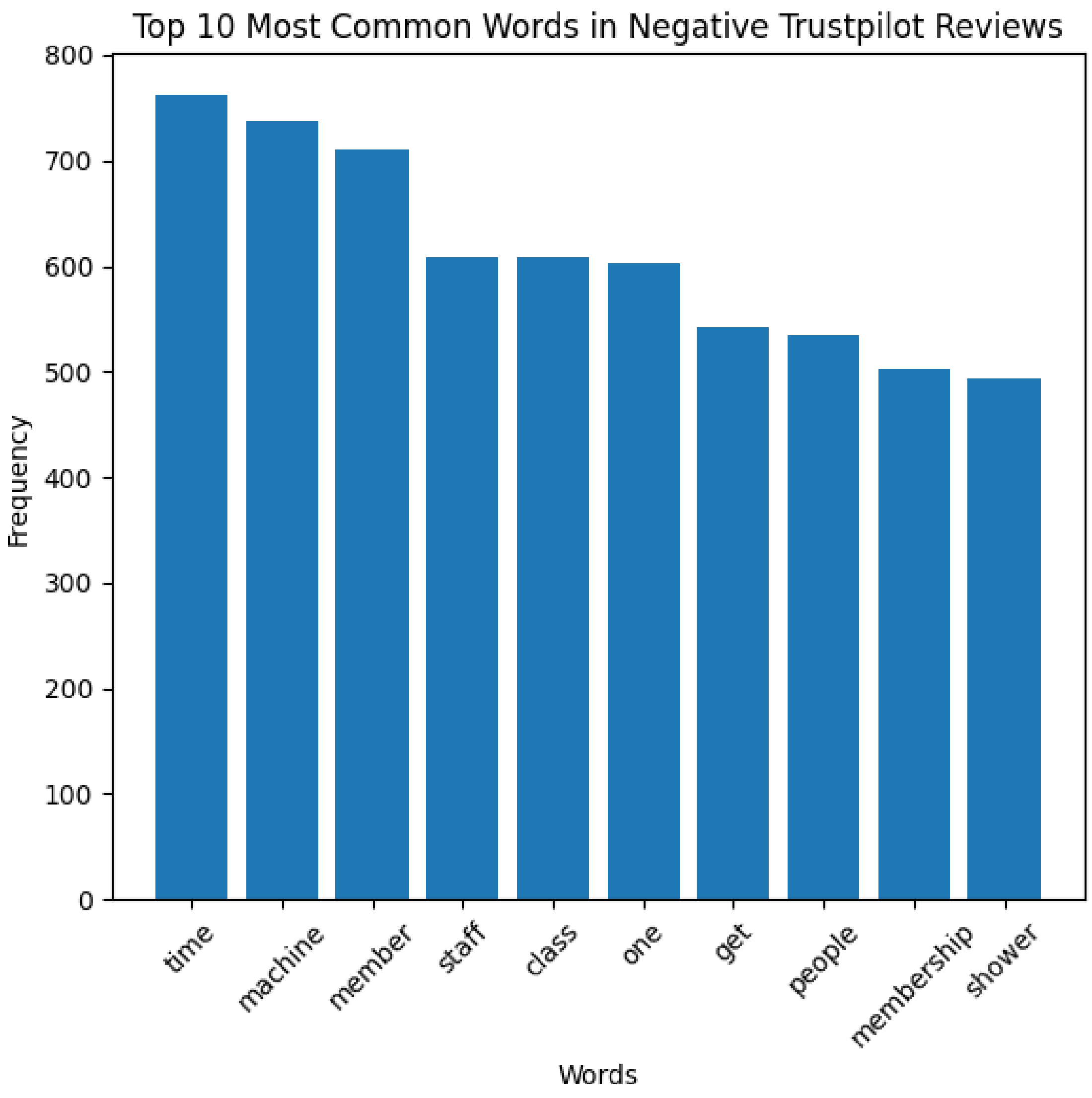
[129]:
```
# Save split datasets to data folder
negative_suffix = "_negative"
non_negative_suffix = "_non_negative"

negative_save_path = save_csv(
    df_negative,
    PREPROCESSED_PATH,
    suffix=negative_suffix,
)

non_negative_save_path = save_csv(
    df_non_negative,
    PREPROCESSED_PATH,
    suffix=non_negative_suffix,
)

print(f"Saved negative reviews to: {negative_save_path}")
print(f"Saved non-negative reviews to: {non_negative_save_path}")
```

```
Saved negative reviews to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured
Data Analysis/PureGym-NLP-UDA/data/PureGym Customer
```

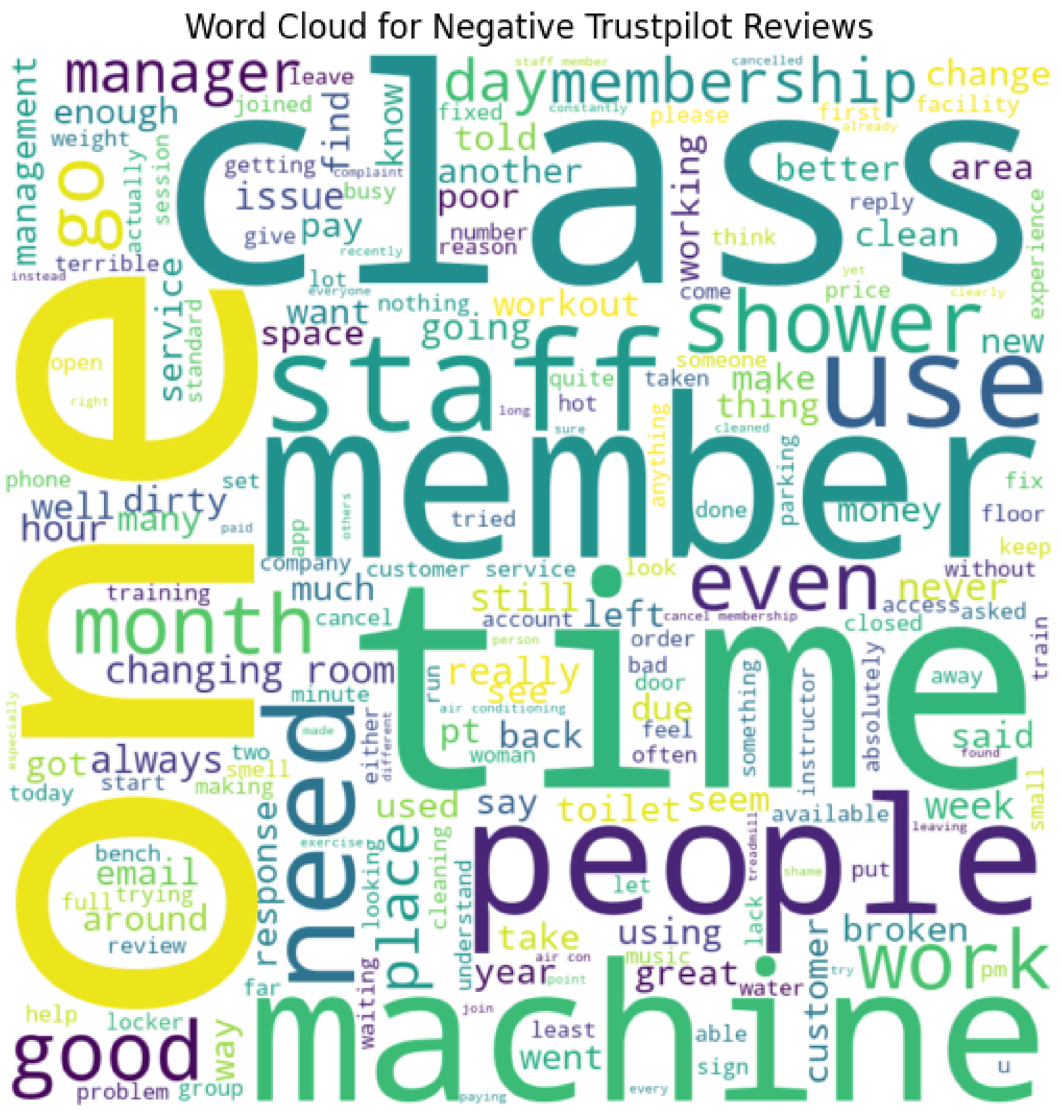
```
Reviews_preprocessed_negative.csv
Saved non-negative reviews to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_non_negative.csv
```

3.0.4 Plots: Negative Reviews

[130]:
```python
tokens_negative = (
    df_negative[TEXT_COL]
    .dropna()
    .astype(str)
    .str.split()
    .explode()
)

token_counts_negative = Counter(tokens_negative)
common_words_negative = token_counts_negative.most_common(TOP_N)

# Save top words table
df_top_words_negative = pd.DataFrame(common_words_negative, columns=["word",␣
 ↪"count"])
df_top_words_negative.to_csv(TABLE_DIR / "trustpilot_negative_top10_words.csv",␣
 ↪index=False)

words_neg, counts_neg = zip(*common_words_negative) if common_words_negative␣
 ↪else ([], [])

freq_plot_path_negative = plotter.plot_word_frequencies(
    words=words_neg,
    counts=counts_neg,
    title="Top 10 Most Common Words in Negative Trustpilot Reviews",
    filename="trustpilot_negative_top10_words.png",
)

print(f"Saved negative frequency plot to: {freq_plot_path_negative}")

wordcloud_path_negative = plotter.plot_wordcloud(
    tokens=tokens_negative,
    title="Word Cloud for Negative Trustpilot Reviews",
    filename="trustpilot_negative_wordcloud.png",
    seed=SEED,
)

print(f"Saved negative wordcloud to: {wordcloud_path_negative}")
print(f"Saved negative top words table to: {TABLE_DIR /␣
 ↪'trustpilot_negative_top10_words.csv'}")
```



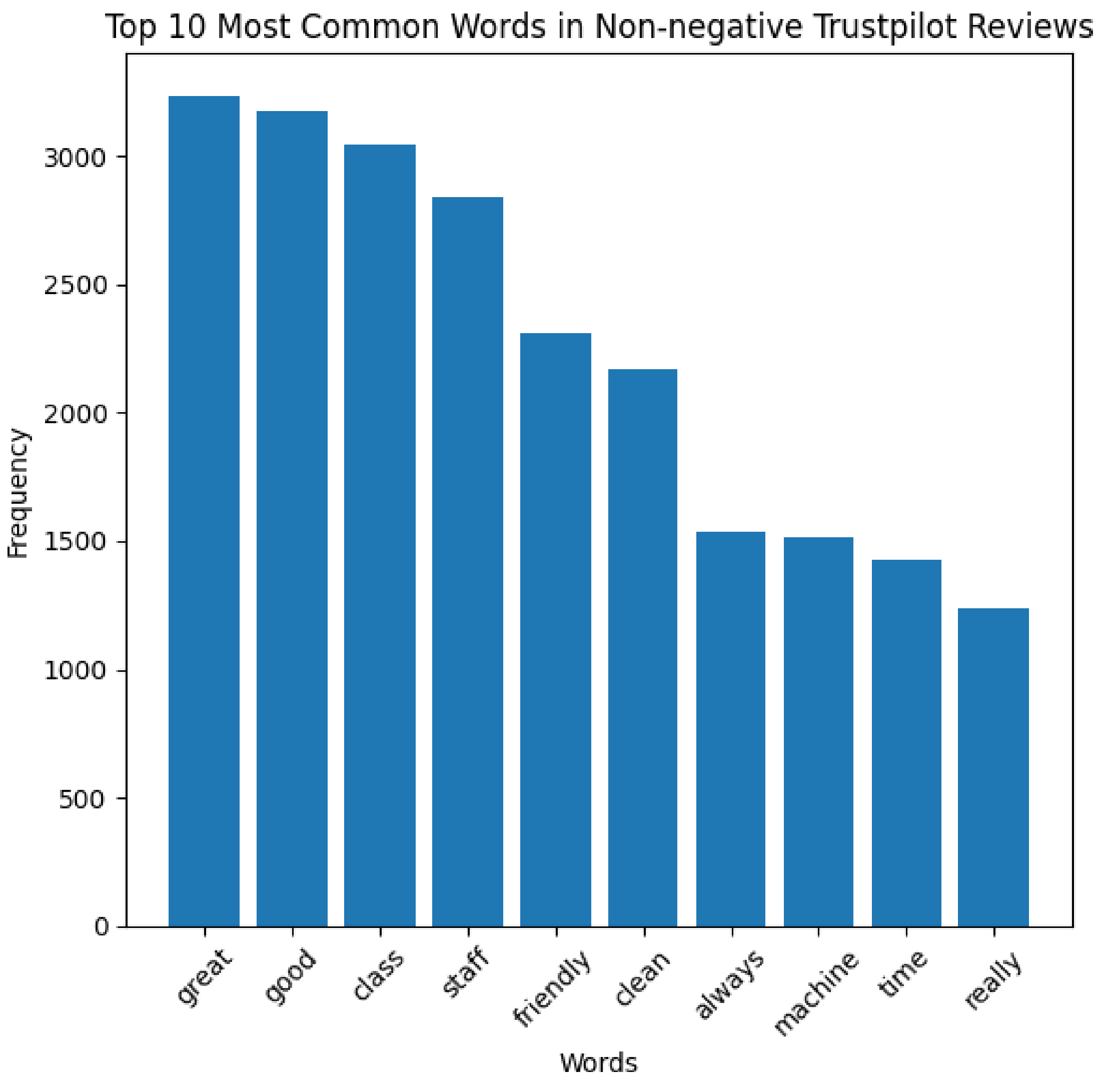
```
Saved negative frequency plot to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/02_eda_and_split_negativ
e_review_data/trustpilot_negative_top10_words.png
```



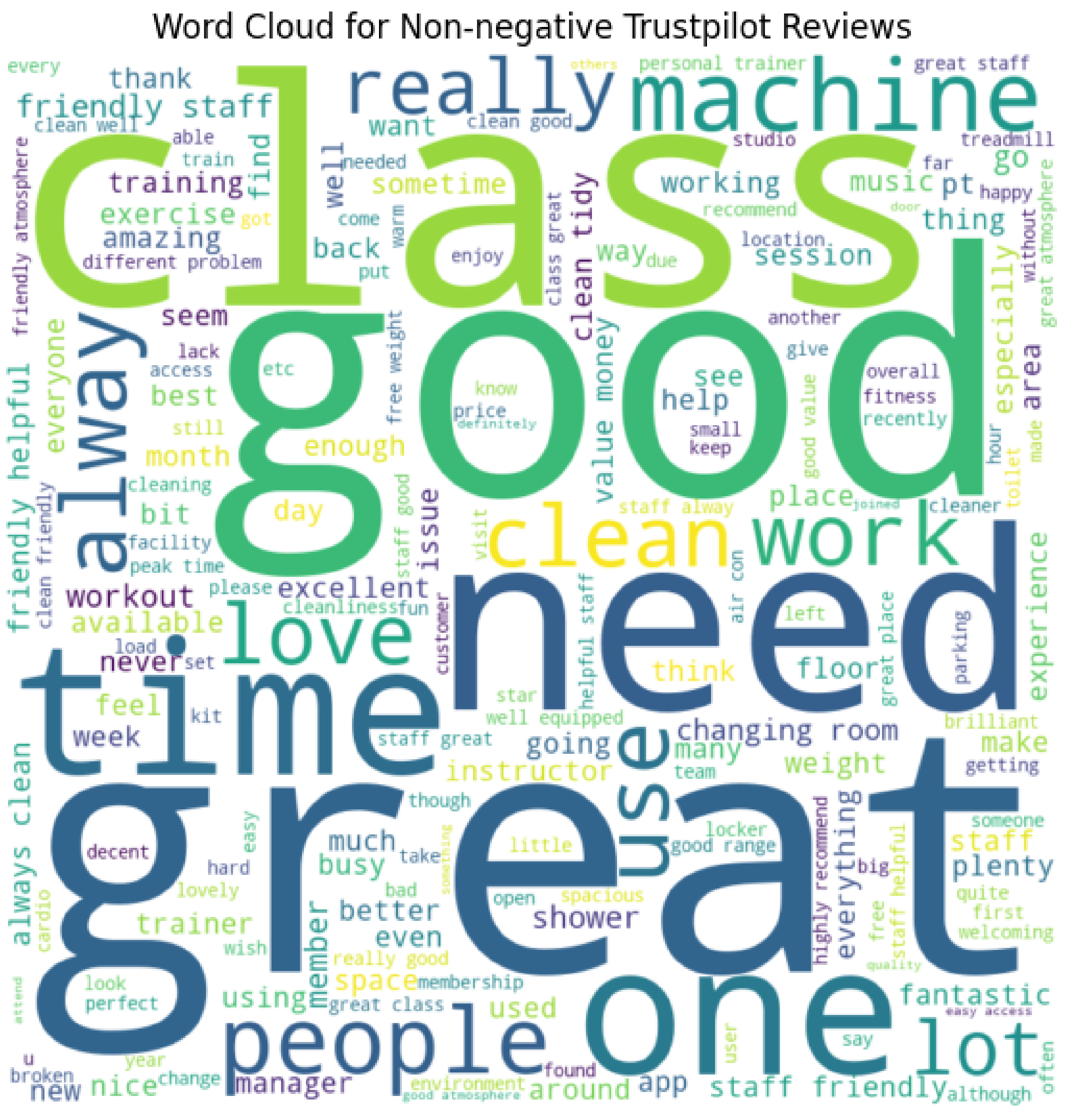
```
Saved negative wordcloud to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured
Data Analysis/PureGym-NLP-UDA/output/plots/02_eda_and_split_negative_review_data
/trustpilot_negative_wordcloud.png
Saved negative top words table to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/tables/02_eda_and_split_negati
ve_review_data/trustpilot_negative_top10_words.csv
```

3.0.5 Plots: Non-negative Reviews

[131]:
```
tokens_non_negative = (
    df_non_negative[TEXT_COL]
    .dropna()
    .astype(str)
    .str.split()
    .explode()
)

token_counts_non_negative = Counter(tokens_non_negative)
common_words_non_negative = token_counts_non_negative.most_common(TOP_N)

# Save top words table
df_top_words_non_negative = pd.DataFrame(common_words_non_negative,␣
↪columns=["word", "count"])
df_top_words_non_negative.to_csv(TABLE_DIR /␣
↪"trustpilot_non_negative_top10_words.csv", index=False)

words_non_neg, counts_non_neg = zip(*common_words_non_negative) if␣
↪common_words_non_negative else ([], [])

freq_plot_path_non_negative = plotter.plot_word_frequencies(
    words=words_non_neg,
    counts=counts_non_neg,
    title="Top 10 Most Common Words in Non-negative Trustpilot Reviews",
    filename="trustpilot_non_negative_top10_words.png",
)

print(f"Saved non-negative frequency plot to: {freq_plot_path_non_negative}")

wordcloud_path_non_negative = plotter.plot_wordcloud(
    tokens=tokens_non_negative,
    title="Word Cloud for Non-negative Trustpilot Reviews",
    filename="trustpilot_non_negative_wordcloud.png",
    seed=SEED,
)

print(f"Saved non-negative wordcloud to: {wordcloud_path_non_negative}")
print(f"Saved non-negative top words table to: {TABLE_DIR /␣
↪'trustpilot_non_negative_top10_words.csv'}")
```



```
Saved non-negative frequency plot to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/02_eda_and_split_negativ
e_review_data/trustpilot_non_negative_top10_words.png
```



```
Saved non-negative wordcloud to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/02_eda_and_split_negativ
e_review_data/trustpilot_non_negative_wordcloud.png
Saved non-negative top words table to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/tables/02_eda_and_split_negati
ve_review_data/trustpilot_non_negative_top10_words.csv
```

[132]:
```python
elapsed_s = time.perf_counter() - NOTEBOOK_T0
elapsed_m = elapsed_s / 60

print(f"\nTotal runtime: {elapsed_s:,.1f} seconds ({elapsed_m:,.2f} minutes)")
```

```
Total runtime: 2.9 seconds (0.05 minutes)
```

4 03_topic_modelling_bertopic

This section applies BERTopic topic modelling to:

- Negative reviews

UMAP is used for dimensionality reduction and visualisation, and summary tables and plots are saved for reporting.

Outputs:

- Models: `output/models/03_topic_modelling_bertopic/`
- Tables: `output/tables/03_topic_modelling_bertopic/`
- Plots: `output/plots/03_topic_modelling_bertopic/`

Compute and reproducibility: CPU-only local execution, fixed random seed **901**.

[133]:
```
import os
os.environ["TOKENIZERS_PARALLELISM"] = "false"
```

[134]:
```
NOTEBOOK_T0 = time.perf_counter()
print("Notebook timer started.")
```

```
Notebook timer started.
```

[135]:
```
# BERTopic Runner
from modelling.bertopic.bertopic_runner import BERTopicRunner
```

[136]:
```
DATA_DIR = (PROJECT_ROOT / CONFIG["DATA"]["DATA_DIR"])
DATA_DIR.mkdir(parents=True, exist_ok=True)

PREPROCESSED_FILENAME = CONFIG["DATA"]["PREPROCESSED_FILENAME"]
PREPROCESSED_PATH = f"{DATA_DIR}/{PREPROCESSED_FILENAME}"

TEXT_COL = CONFIG["FILTERING"]["TEXT_COL"]
NEGATIVE_RATINGS = ast.literal_eval(CONFIG["FILTERING"].get("NEGATIVE_RATINGS",␣
 ↪"[]"))
SEED = CONFIG["REPRODUCIBILITY"].getint("SEED")

PLOT_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["PLOT_DIR"] /␣
 ↪"03_topic_modelling_bertopic"
TABLE_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["TABLE_DIR"] /␣
 ↪"03_topic_modelling_bertopic"
MODEL_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["MODEL_DIR"] /␣
 ↪"03_topic_modelling_bertopic"
```

[137]:
```
TOP_N_TOPICS = 4
N_WORDS_BARCHART = 5
SHOW_PLOTS = True
SAVE_PNG = True
```

```
PNG_SCALE = 2

UMAP_N_NEIGHBOURS = 15
UMAP_N_COMPONENTS = 5
UMAP_MIN_DIST = 0
UMAP_METRIC = "cosine"
```

[138]:
```
df = load_csv(PREPROCESSED_PATH)
df_negative = df[df["Rating"].isin(NEGATIVE_RATINGS)].copy()
df_non_negative = df[~df["Rating"].isin(NEGATIVE_RATINGS)].copy()
```

[139]:
```
runner = BERTopicRunner(
    model_dir=MODEL_DIR,
    plot_dir=PLOT_DIR,
    table_dir=TABLE_DIR,
    seed=SEED,
    min_topic_size=40,

    # Topic-level controls
    top_n_topics=TOP_N_TOPICS,
    n_words_barchart=N_WORDS_BARCHART,

    # Plotting controls
    show_plots=SHOW_PLOTS,
    save_png=SAVE_PNG,
    png_scale=PNG_SCALE,

    # UMAP controls
    umap_n_neighbors=UMAP_N_NEIGHBOURS,
    umap_n_components=UMAP_N_COMPONENTS,
    umap_min_dist=UMAP_MIN_DIST,
    umap_metric=UMAP_METRIC,
)
```

[140]:
```
neg_result = runner.run(df_negative, label="negative", text_col=TEXT_COL,␣
 ↪verbose=True)
print(neg_result.plot_paths)
display(neg_result.topic_info.head(3))
display(neg_result.top_topics_table.head(5))
```

```
2026-01-21 17:29:45,893 - BERTopic - Embedding - Transforming documents to
embeddings.
Batches: 100%|      | 74/74 [00:01<00:00, 66.10it/s]
2026-01-21 17:29:49,263 - BERTopic - Embedding - Completed
2026-01-21 17:29:49,263 - BERTopic - Dimensionality - Fitting the dimensionality
reduction algorithm
2026-01-21 17:29:52,946 - BERTopic - Dimensionality - Completed
2026-01-21 17:29:52,946 - BERTopic - Cluster - Start clustering the reduced
```

```
embeddings
2026-01-21 17:29:52,983 - BERTopic - Cluster - Completed
2026-01-21 17:29:52,985 - BERTopic - Representation - Fine-tuning topics using
representation models.
2026-01-21 17:29:53,016 - BERTopic - Representation - Completed
2026-01-21 17:29:53,043 - BERTopic - WARNING: When you use `pickle` to save/load
a BERTopic model,please make sure that the environments in which you saveand
load the model are **exactly** the same. The version of BERTopic,its
dependencies, and python need to remain the same.
```

```
{'intertopic_distance_html': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_berto
pic/bertopic_negative_intertopic_distance.html'), 'intertopic_distance_png':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_bertopic/bertopic_negat
ive_intertopic_distance.png'), 'barchart_top_topics_html':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_bertopic/bertopic_negat
ive_barchart_top4.html'), 'barchart_top_topics_png':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_bertopic/bertopic_negat
ive_barchart_top4.png'), 'heatmap_all_topics_html':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_bertopic/bertopic_negat
ive_heatmap_all_topics.html'), 'heatmap_all_topics_png':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_bertopic/bertopic_negat
ive_heatmap_all_topics.png'), 'heatmap_top_topics_html':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_bertopic/bertopic_negat
ive_heatmap_top4.html'), 'heatmap_top_topics_png':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/03_topic_modelling_bertopic/bertopic_negat
ive_heatmap_top4.png'), 'topic_info_csv':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/03_topic_modelling_bertopic/bertopic_nega
tive_topic_info.csv'), 'top_topics_csv':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/03_topic_modelling_bertopic/bertopic_nega
tive_top_topics.csv')}
```

```
   Topic  Count                              Name  \
0     -1    717        -1_machine_time_staff_people
1      0    512          0_shower_toilet_room_dirty
2      1    337  1_membership_email_cancel_customer

                                                                      ␣
 ↪Representation  \
0                    [machine, time, staff, people, member, get, one, use, good,␣
 ↪like]
1       [shower, toilet, room, dirty, cleaning, changing, water, cold, clean,␣
 ↪machine]
2  [membership, email, cancel, customer, service, account, month, payment,␣
 ↪money, app]
```

```
0  [hi happy actually time remodelling supposed get better came back couple␣
 ↪month work finished machine also working take long time routine work also need␣
 ↪make time another exercise pay money work machine working one many people␣
 ↪disappointed please would love manager resolve problem, kit bad albeit skewed␣
 ↪towards weight rather cardio busy period lack cardio kit prove achilles heel␣
 ↪wait frustrating little thought towards layout could actually fit cross␣
 ↪trainer bike something would improve place free weight area good plenty␣
 ↪selection kit people mostly tidy put kit back back per always case however␣
 ↪fairly big issue hence two star could easily resolved site staff company seem␣
 ↪reluctant * male changing room consistently dirty even cleaner cleaned ever␣
 ↪witness cleaner job see poor shower also bone contention three begin fact one␣
 ↪shower entire male changing room busy unacceptable one order shower broken␣
 ↪door week unacceptable inside locker consistently dirty many locker lock left␣
 ↪week enforced staff * rule enforced multiple printed sheet telling love␣
 ↪laminated document blu tac little enforcement group young male training␣
 ↪vocally putting kit back half clothed create inviting environment say rule␣
 ↪enforced multiple laminated sheet printed telling people banned training semi␣
 ↪clothed putting kit back = nothing actually happens *maintenance time kit␣
 ↪break take week month fix appreciate big company bangor stick speak still␣
 ↪pretty shoddy leg extender machine nice laminated notice push beyond point␣
 ↪month actually fixed shower door cross trainer took week + fix… something␣
 ↪break appears sense urgency site staff particularly company urinal male␣
 ↪changing room full urine month long ago fixed * water water whole issue site␣
 ↪issue plumber know looking water fountain pressure barely dribble shower␣
 ↪pressure work also barely dribble male urinal flush never stop nothing saving␣
 ↪water regard low pressure site issue going month sorted air con pace stuffy␣
 ↪need good reliable air circulation consequence place warmer plethora member␣
 ↪smell every nice make warm sticky environment little bit worse place smell␣
 ↪pleasant lot time really need get act together end member student want cheap␣
 ↪membership mostly student put weight back throw litter away train half clothed␣
 ↪think one second also need employ management team site proactive get stuff␣
 ↪done site gone massively hill last three month continues go time go get worse␣
 ↪management team place beginning year prone challenging member keeping top kit␣
 ↪repair rather laminating sheet saying actually getting done offence current␣
 ↪team lovely people meek reserved follow promise get issue sorted reported␣
 ↪waiting engineer hold much water report chase done customer service customer␣
 ↪satisfaction site missing shame lack experience management summarised␣
 ↪instagram post manager week ago odd degree outside warm water went toilet␣
 ↪water fountain shower tap manager put instagram post saying people still come␣
 ↪drink pee shower mind boggles customer focussed business savvy manager better␣
 ↪enforcement rule urgency regarding repair would sort place moment mess que pg␣
 ↪copy paste reply, floor underground took advantage day pas january␣
 ↪unfortunately hour signed midnight would already lost day signed another month␣
 ↪cancelling found atmosphere weird number staff seemed obsessed activity␣
 ↪whereabouts could use pin front entrance think done purpose could give staff␣
 ↪something week rectify tanoy system sometimes put loud quite offputting␣
 ↪getting zone music controlled staff seemingly either treadmill mat big␣
 ↪membership price lowest market really push shyier nature get past staff␣
 ↪generally goer respectful keep big enough always space want get impression␣
 ↪staff like allowed want restarted membership half price joining fee paid␣
 ↪another month last week purchasing day pass friday leak bit waste money closed␣
 ↪massive section floor completely flooded sewage water female changing room␣
 ↪section running machine closed prior pm shortly would arrived know clearly␣
```

1

[good locker room shower
need better cleaning often stench toilet dirt shower disgusting, member sutton

```
2
                    [great shop floor staff company morally bankrupt claw much
money customer possible website talk flexible package ability change required
reality want upgrade give money process simple downgrading possible without
cancelling direct debit experienced quick google tell one try downgrading
website take circle web page right back started contacted customer service
received response easy downgrade click taking straight back circular process
caveat message process work cancel direct debit" need tell another really sad
example corporate greed trying get one loyal customer frankly better thing
mess around cancelling direct debit go whole sign process setting fee take
advantage update following response copied part email chain customer service
demonstrates easily downgrade membership customer request recommend cancelling
direct debit "thank message sorry feel spouting lie informing cancellation
process also mentioned previous email information issue way nothing worry also
cancel ending direct debit agreement bank issue resolved contacting bank
directly cancelling direct debit unable cancel membership behalf member
```

```
   Topic  Count  \
0      0    512
1      1    337
2      2    223
3      3    132


                                                                            ␣
↪TopWords
0       shower, toilet, room, dirty, cleaning, changing, water, cold, clean,␣
↪machine
1  membership, email, cancel, customer, service, account, month, payment, money,␣
↪app
2            machine, weight, bench, one, space, need, cardio, enough, area,␣
↪workout
3        class, instructor, cancelled, booked, booking, book, time, attend, get,␣
↪one
```

[141]:
```python
elapsed_s = time.perf_counter() - NOTEBOOK_T0
elapsed_m = elapsed_s / 60

print(f"\nTotal runtime: {elapsed_s:,.1f} seconds ({elapsed_m:,.2f} minutes)")
```

```
Total runtime: 12.6 seconds (0.21 minutes)
```

5 04a_emotion_analysis_roberta

This section performs transformer-based emotion classification using a DistilRoBERTa emotion model:

- Runs token-length diagnostics to inform a conservative `max_length` choice.
- Performs batched inference to assign a dominant emotion label and confidence score to each review.
- Splits emotion-annotated data into negative and non-negative subsets.
- Produces emotion distribution tables and bar plots for all, negative, and non-negative reviews.

Outputs (data/): - `PureGym Customer Reviews_preprocessed_emotion.csv`

- `PureGym Customer Reviews_preprocessed_negative_emotion.csv`
- `PureGym Customer Reviews_preprocessed_non_negative_emotion.csv`

Additional outputs: plots and tables under `output/plots/04a_emotion_analysis/` and `output/tables/04a_emotion_analysis/`.

Compute and reproducibility: CPU-only local execution, fixed random seed **901**.

5.0.1 Emotion Classes

[142]:
```python
from transformers import AutoModelForSequenceClassification, AutoTokenizer
class Initialiser:
    """Initialise tokenizer and model for emotion sequence classification."""

    @staticmethod
    def init_tokenizer(model_name: str) -> AutoTokenizer:
        return AutoTokenizer.from_pretrained(model_name)

    @staticmethod
    def init_model(model_name: str) -> AutoModelForSequenceClassification:
        return AutoModelForSequenceClassification.from_pretrained(model_name)
```

[143]:
```python
from dataclasses import dataclass


@dataclass(frozen=True)
class EmotionParams:
    """
    Central config for the emotion classification model run.
    """

    MODEL_NAME_V1: str = "j-hartmann/emotion-english-distilroberta-base"
    MODEL_NAME_V2: str = "bhadresh-savani/bert-base-uncased-emotion"

    DEVICE: str = "cpu"

    BATCH_SIZE: int = 16
    MAX_LENGTH: int = 192

    PADDING: bool = True
    TRUNCATION: bool = True

    LABEL_COL: str = "Dominant Emotion"
    SCORE_COL: str = "Confidence Score"
```

[144]:
```python
from typing import Tuple, Any

import pandas as pd
import torch
from transformers import AutoModelForSequenceClassification, AutoTokenizer


class EmotionModelDataCompiler:
    """
    Apply a Hugging Face emotion sequence classification model to a DataFrame␣
 ↪text column.
```

```
    The compiler tokenises text in batches, runs the model in inference mode,␣
↪and
    appends two columns to the returned DataFrame:
    - predicted label (string)
    - confidence score (float, max softmax probability)

    Parameters
    ----------
    df
        Input DataFrame containing the text to classify.
    text_col
        Name of the column in ``df`` containing the text.
    tokenizer
        Hugging Face tokenizer used to encode text.
    model
        Hugging Face sequence classification model.
    device
        Torch device string, for example "cpu" or "cuda".
    batch_size
        Number of texts per inference batch.
    max_length
        Maximum token length for truncation.
    label_col
        Output column name for predicted labels.
    score_col
        Output column name for confidence scores.
    padding
        Whether to pad sequences in a batch (passed to the tokenizer).
    truncation
        Whether to truncate sequences to ``max_length`` (passed to the␣
↪tokenizer).
    """

    def __init__(
        self,
        *,
        df: pd.DataFrame,
        text_col: str,
        tokenizer: AutoTokenizer,
        model: AutoModelForSequenceClassification,
        device: str,
        batch_size: int,
        max_length: int,
        label_col: str,
        score_col: str,
        padding: bool,
        truncation: bool,
    ) -> None:

        if text_col not in df.columns:
            raise KeyError(f"'{text_col}' not found in DataFrame")

        # Store core inputs for later use
        self._df = df
        self._text_col = text_col

        self._tokenizer = tokenizer
        self._model = model
        self._device = torch.device(device)

        # Store inference settings (batching + tokenisation behaviour)
        self._batch_size = batch_size
        self._max_length = max_length
        self._padding = padding
        self._truncation = truncation

        # Store output column names
        self._label_col = label_col
        self._score_col = score_col

        # Ensure model is on the correct device and set to inference mode
        self._model.to(self._device)
        self._model.eval()

        # Map numeric class ids to human-readable labels (falls back to id if␣
↪missing)
        id2label = getattr(self._model.config, "id2label", None) or {}
        self._id2label = {int(k): str(v) for k, v in id2label.items()}

    def apply(self) -> pd.DataFrame:
        """
        Run inference over the configured DataFrame and append label and score␣
↪columns.

        Returns
        -------
        pandas.DataFrame
            Copy of the input DataFrame with two additional columns.
        """

        df_out = self._df.copy()
        # Clean text inputs (avoid NaNs, enforce string type, remove␣
↪surrounding whitespace)
        texts = (
            df_out[self._text_col]
            .fillna("")
            .astype(str)
            .str.strip()
            .tolist()
        )

        # Run model inference to obtain labels and confidence scores
        labels, scores = self._predict(texts)

        # Append outputs back onto the DataFrame in the same row order
        df_out[self._label_col] = labels
        df_out[self._score_col] = scores
        return df_out

    def _predict(self, texts: list[str]) -> Tuple[list[str], list[float]]:
        """
        Predict labels and confidence scores for a list of texts.

        Parameters
        ----------
        texts
            List of input texts.

        Returns
        -------
        tuple[list[str], list[float]]
            Predicted labels and confidence scores aligned to ``texts``.
        """
        out_labels: list[str] = []
        out_scores: list[float] = []

        # Handle empty input explicitly (keeps behaviour predictable for␣
↪callers)
        if not texts:
            return out_labels, out_scores

        # Process texts in batches
        for start in range(0, len(texts), self._batch_size):
            batch = texts[start : start + self._batch_size]

            # Tokenise the batch using the configured padding/truncation␣
↪strategy
            enc = self._tokenizer(
                batch,
                padding=self._padding,
                truncation=self._truncation,
                max_length=self._max_length,
                return_tensors="pt",
            )

            # Move tokenised tensors onto the same device as the model
            enc = {k: v.to(self._device) for k, v in enc.items()}

            # Inference only: disable gradients to reduce memory and improve␣
 ↪speed
            with torch.no_grad():
                logits = self._model(**enc).logits

            # Convert logits to probabilities, then pick the␣
 ↪highest-probability class
            probs = torch.softmax(logits, dim=-1)
            best_scores, best_ids = torch.max(probs, dim=-1)

            # Convert tensors to plain Python types and map ids to label strings
            for label_id, score in zip(
                best_ids.detach().cpu().numpy(),
                best_scores.detach().cpu().numpy(),
            ):
                label = self._id2label.get(int(label_id), str(int(label_id)))
                out_labels.append(label)
                out_scores.append(float(score))

        return out_labels, out_scores
```

[145]:
```
# Single helper function for bar charts
def bar_plot(
    counts: pd.Series,
    *,
    title: str,
    x_label: str,
    y_label: str,
    figsize: tuple[float, float] = (7.0, 7.0),
    rotation: int = 45,
    show: bool = True,
    save: bool = False,
    output_dir: Optional[Path] = None,
    filename: Optional[str] = None,
    dpi: int = 150,
    print_path: bool = True,
) -> None:
```

```
"""
Plot a categorical bar chart from a frequency Series.

Parameters
----------
counts
    Counts indexed by category (x-axis labels).
title
    Plot title.
x_label
    X-axis label.
y_label
    Y-axis label.
figsize
    Figure size in inches.
rotation
    Rotation for x tick labels.
show
    If True, display the figure.
save
    If True, save the figure to disk.
output_dir
    Output directory used when ``save=True``.
filename
    Output filename used when ``save=True``.
dpi
    Resolution used when saving.
print_path
    If True and ``save=True``, print the saved path.

Returns
-------
None

Raises
------
ValueError
    If ``save=True`` and ``output_dir`` or ``filename`` is not provided.
"""
fig, ax = plt.subplots(figsize=figsize)

x = counts.index.astype(str)
y = counts.to_numpy()
ax.bar(x, y)

ax.set_title(title)
ax.set_xlabel(x_label)
```

```
    ax.set_ylabel(y_label)
    ax.tick_params(axis="x", rotation=rotation)
    fig.tight_layout()

    if save:
        if output_dir is None or filename is None:
            plt.close(fig)
            raise ValueError("When save=True, both output_dir and filename must␣
 ↪be provided.")
        output_dir.mkdir(parents=True, exist_ok=True)
        out_path = output_dir / filename
        fig.savefig(out_path, dpi=dpi, bbox_inches="tight")
        if print_path:
            print("Saved plot to:", out_path)

    if show:
        plt.show()

    plt.close(fig)
```

[146]:
```
NOTEBOOK_T0 = time.perf_counter()
print("Notebook timer started.")
```

```
Notebook timer started.
```

[147]:
```
from utils.data_management.data_io import load_csv, save_csv

DATA_DIR = (PROJECT_ROOT / CONFIG["DATA"]["DATA_DIR"])
DATA_DIR.mkdir(parents=True, exist_ok=True)

PREPROCESSED_FILENAME = CONFIG["DATA"]["PREPROCESSED_FILENAME_SENTIMENT"]
PREPROCESSED_PATH = f"{DATA_DIR}/{PREPROCESSED_FILENAME}"

TEXT_COL = CONFIG["FILTERING"]["TEXT_COL"]
NEGATIVE_RATINGS = ast.literal_eval(CONFIG["FILTERING"].get("NEGATIVE_RATINGS",␣
 ↪"[]"))
SEED = CONFIG["REPRODUCIBILITY"].getint("SEED")

PLOT_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["PLOT_DIR"] / "04a_emotion_analysis"
TABLE_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["TABLE_DIR"] /␣
 ↪"04a_emotion_analysis"

PLOT_DIR.mkdir(parents=True, exist_ok=True)
TABLE_DIR.mkdir(parents=True, exist_ok=True)

SEED = CONFIG["REPRODUCIBILITY"].getint("SEED")
```

[148]:
```
FIGSIZE = (7, 7)
DPI = 150
```

[149]:
```
# Paths
preprocessed_path = Path(DATA_DIR / PREPROCESSED_FILENAME)
PREPROCESSED_PATH = str(preprocessed_path)
print("PREPROCESSED_PATH:", PREPROCESSED_PATH)
```

```
PREPROCESSED_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_sentiment.csv
```

[150]:
```
PREPROCESSED_FILENAME_EMOTION = CONFIG["DATA"]["PREPROCESSED_FILENAME_EMOTION"]
PREPROCESSED_FILENAME_NEGATIVE_EMOTION =␣
  ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NEGATIVE_EMOTION"]
PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION =␣
  ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION"]

ALL_EMOTION_PATH = Path(DATA_DIR) / PREPROCESSED_FILENAME_EMOTION
NEG_EMOTION_PATH = Path(DATA_DIR) / PREPROCESSED_FILENAME_NEGATIVE_EMOTION
NON_NEG_EMOTION_PATH = Path(DATA_DIR) /␣
  ↪PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION

print("ALL_EMOTION_PATH:", ALL_EMOTION_PATH)
print("NEG_EMOTION_PATH:", NEG_EMOTION_PATH)
print("NON_NEG_EMOTION_PATH:", NON_NEG_EMOTION_PATH)
```

```
ALL_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer Reviews_preprocessed_emotion.csv
NEG_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_negative_emotion.csv
NON_NEG_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_non_negative_emotion.csv
```

[151]:
```
# Load preprocessed dataset only (single inference run)

df_all = load_csv(PREPROCESSED_PATH)
print("All reviews:", len(df_all))
display(df_all.head(4))
```

```
All reviews: 11300

   Rating Date Experienced                                       Review Title  \
0       4       2023-12-17  A well equipped gym, lacked cleaning facilities
1       4       2023-12-13                         Overall a good experience
2       5       2023-12-12                                     Excellent gym
3       5       2023-11-12                               I'm going to be so fit
```

```
                                                                                    ␣
↪                                                                                   ␣
↪                                                                                   ␣
↪                            Review
0                                                                                   ␣
↪                                                    well equipped notice one␣
↪machine order disappoint lack blue towel sanitizer spray customer use finish␣
↪notice ask customer matter respect user
1  overall good experience still cramp compare old redditch number seem reduce␣
↪little little readily available change room far small though take look␣
↪sunderland comparison one jewel crown mark fisher guy class insane nice␣
↪possible way book class early avoid disappointment
2                                                                                   ␣
↪       excellent friendly environment plenty choice space exercise personal␣
↪trainer hand excellent opening hour basically go whenever want   get busy time␣
↪always get something class also good
3                                                                                   ␣
↪                                                                                   ␣
↪                      havnt member year state art brand new friendly staff␣
↪really good competitive monthly price
```

5.1 Token Length EDA

- The max_length has been conservatively set to 192 in the EmotionParams file based on the above (see import path in cell above). This has been kept constant for emotion based models..

[152]:
```python
## Token Length EDA
RUN_TOKEN_LENGTH_DIAGNOSTICS = True  # set True to run diagnostics

if RUN_TOKEN_LENGTH_DIAGNOSTICS:
    MAXLEN_CANDIDATES = [64, 96, 128, 160, 192, 256, 320, 384, 448, 512]
    df_for_profile = df_all

    texts = (df_for_profile[TEXT_COL].fillna("").astype(str).str.strip())
    texts = texts.loc[texts.ne("")]

    model_name_v1 = EmotionParams.MODEL_NAME_V1
    model_name_v2 = EmotionParams.MODEL_NAME_V2

    print(f"Tokenizer/model V1: {model_name_v1}")
    print(f"Tokenizer/model V2: {model_name_v2}")

    # Initialise both tokenisers based on model names
    tokenizer_v1 = Initialiser.init_tokenizer(model_name_v1)
    tokenizer_v2 = Initialiser.init_tokenizer(model_name_v2)

    # Compute token lengths without truncation for each tokeniser
    token_lengths_v1 = texts.apply(lambda t: len(tokenizer_v1.encode(t,␣
↪add_special_tokens=True))).to_numpy()
    token_lengths_v2 = texts.apply(lambda t: len(tokenizer_v2.encode(t,␣
↪add_special_tokens=True))).to_numpy()

    # Worst-case length per text across both tokenisers (safe choice for later␣
↪max_length)
    token_lengths_worst = np.maximum(token_lengths_v1, token_lengths_v2)

    # % fully captured for each candidate max length
    captured_pct_v1 = [(token_lengths_v1 <= L).mean() * 100 for L in␣
↪MAXLEN_CANDIDATES]
    captured_pct_v2 = [(token_lengths_v2 <= L).mean() * 100 for L in␣
↪MAXLEN_CANDIDATES]
    captured_pct_worst = [(token_lengths_worst <= L).mean() * 100 for L in␣
↪MAXLEN_CANDIDATES]

    # Summary stats
    percentiles = [50, 75, 90, 95, 97, 99]
    pvals_v1 = np.percentile(token_lengths_v1, percentiles)
    pvals_v2 = np.percentile(token_lengths_v2, percentiles)

    p99_v1 = float(np.percentile(token_lengths_v1, 99))
    p99_v2 = float(np.percentile(token_lengths_v2, 99))
    p99_max = max(p99_v1, p99_v2)

    print("Token length percentiles (V1):")
    for p, v in zip(percentiles, pvals_v1):
        print(f"{p:>2}%: {int(v)} tokens")

    print("\nToken length percentiles (V2):")
    for p, v in zip(percentiles, pvals_v2):
        print(f"{p:>2}%: {int(v)} tokens")

    print(f"\n99th percentile (V1): {int(p99_v1)} tokens")
    print(f"99th percentile (V2): {int(p99_v2)} tokens")
    print(f"Using larger 99th percentile across V1/V2: {int(p99_max)} tokens")

    print("\nCapture by candidate max_length (%):")
    for L, p1, p2, pw in zip(MAXLEN_CANDIDATES, captured_pct_v1,␣
↪captured_pct_v2, captured_pct_worst):
        print(f"{L:>3}: V1={p1:6.2f}% | V2={p2:6.2f}% | worst-case={pw:6.2f}%")

    best_L = next((L for L, p in zip(MAXLEN_CANDIDATES, captured_pct_worst) if␣
↪p >= 99), None)
```

```
    if best_L is not None:
        print(f"\nFirst candidate max_length capturing  99% for BOTH tokenisers␣
↪(worst-case): {best_L}.")
    else:
        print("\nNo candidate max_length reached 99% capture for BOTH␣
↪tokenisers (consider adding larger values).")
```

```
Tokenizer/model V1: j-hartmann/emotion-english-distilroberta-base
Tokenizer/model V2: bhadresh-savani/bert-base-uncased-emotion
Token length percentiles (V1):
50%: 16 tokens
75%: 28 tokens
90%: 49 tokens
95%: 68 tokens
97%: 83 tokens
99%: 126 tokens

Token length percentiles (V2):
50%: 16 tokens
75%: 28 tokens
90%: 49 tokens
95%: 68 tokens
97%: 84 tokens
99%: 127 tokens

99th percentile (V1): 126 tokens
99th percentile (V2): 127 tokens
Using larger 99th percentile across V1/V2: 127 tokens

Capture by candidate max_length (%):
 64: V1= 94.24% | V2= 94.19% | worst-case= 94.00%
 96: V1= 97.91% | V2= 97.89% | worst-case= 97.84%
128: V1= 99.07% | V2= 99.02% | worst-case= 99.00%
160: V1= 99.50% | V2= 99.46% | worst-case= 99.45%
192: V1= 99.65% | V2= 99.65% | worst-case= 99.65%
256: V1= 99.87% | V2= 99.85% | worst-case= 99.85%
320: V1= 99.93% | V2= 99.93% | worst-case= 99.93%
384: V1= 99.96% | V2= 99.96% | worst-case= 99.96%
448: V1= 99.97% | V2= 99.97% | worst-case= 99.97%
512: V1=100.00% | V2=100.00% | worst-case=100.00%

First candidate max_length capturing  99% for BOTH tokenisers (worst-case): 128.
```

[153]:
```
tokenizer = Initialiser.init_tokenizer(EmotionParams.MODEL_NAME_V1)
model = Initialiser.init_model(EmotionParams.MODEL_NAME_V1)

compiler = EmotionModelDataCompiler(
    df=df_all,
    text_col=TEXT_COL,
    tokenizer=tokenizer,
    model=model,
    device=EmotionParams.DEVICE,
    batch_size=EmotionParams.BATCH_SIZE,
    max_length=EmotionParams.MAX_LENGTH,
    label_col=EmotionParams.LABEL_COL,
    score_col=EmotionParams.SCORE_COL,
    padding=EmotionParams.PADDING,
    truncation=EmotionParams.TRUNCATION,
)
```

[154]:
```
MODEL_TAG = re.sub(r"[^A-Za-z0-9]+", "_", EmotionParams.MODEL_NAME_V1).
 ↪strip("_")

# Print params
print("\nEmotionParams used:")
print("MODEL_NAME:", EmotionParams.MODEL_NAME_V1)
print("DEVICE:", EmotionParams.DEVICE)
print("BATCH_SIZE:", EmotionParams.BATCH_SIZE)
print("MAX_LENGTH:", EmotionParams.MAX_LENGTH)
print("PADDING:", EmotionParams.PADDING)
print("TRUNCATION:", EmotionParams.TRUNCATION)
print("LABEL_COL:", EmotionParams.LABEL_COL)
print("SCORE_COL:", EmotionParams.SCORE_COL)
print("TEXT_COL:", TEXT_COL)
print("Rows:", len(df_all))

print("Tokenizer class:", type(tokenizer).__name__)
print("Is fast tokenizer:", getattr(tokenizer, "is_fast", False))
print("Vocab size:", tokenizer.vocab_size)
print("Model max length:", tokenizer.model_max_length)
print("Pad token:", tokenizer.pad_token, tokenizer.pad_token_id)
print("EOS token:", tokenizer.eos_token, tokenizer.eos_token_id)
```

```
EmotionParams used:
MODEL_NAME: j-hartmann/emotion-english-distilroberta-base
DEVICE: cpu
BATCH_SIZE: 16
MAX_LENGTH: 192
PADDING: True
TRUNCATION: True
LABEL_COL: Dominant Emotion
SCORE_COL: Confidence Score
TEXT_COL: Review
Rows: 11300
```

```
Tokenizer class: RobertaTokenizerFast
Is fast tokenizer: True
Vocab size: 50265
Model max length: 512
Pad token: <pad> 1
EOS token: </s> 2
```

[155]:
```
# Apply: All reviews (single inference run)
df_all_emotion = compiler.apply()

display(df_all_emotion[[TEXT_COL, EmotionParams.LABEL_COL, EmotionParams.
 ↪SCORE_COL]].head(4))

all_save_path = save_csv(df_all_emotion, f"{DATA_DIR}/
 ↪{PREPROCESSED_FILENAME_EMOTION}", suffix=None)
print(f"Saved emotion-annotated all reviews to: {all_save_path}")
```

```
                                                                             ␣
 ↪                                                                            ␣
 ↪                                                                            ␣
 ↪                               Review  \
0                                                                            ␣
 ↪                                                   well equipped notice one␣
 ↪machine order disappoint lack blue towel sanitizer spray customer use finish␣
 ↪notice ask customer matter respect user
1  overall good experience still cramp compare old redditch number seem reduce␣
 ↪little little readily available change room far small though take look␣
 ↪sunderland comparison one jewel crown mark fisher guy class insane nice␣
 ↪possible way book class early avoid disappointment
2                                                                            ␣
 ↪       excellent friendly environment plenty choice space exercise personal␣
 ↪trainer hand excellent opening hour basically go whenever want   get busy time␣
 ↪always get something class also good
3                                                                            ␣
 ↪                                                                            ␣
 ↪                        havnt member year state art brand new friendly staff␣
 ↪really good competitive monthly price

  Dominant Emotion  Confidence Score
0          neutral          0.340861
1          sadness          0.545070
2              joy          0.895917
3              joy          0.539196

Saved emotion-annotated all reviews to: /Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_emotion.csv
```

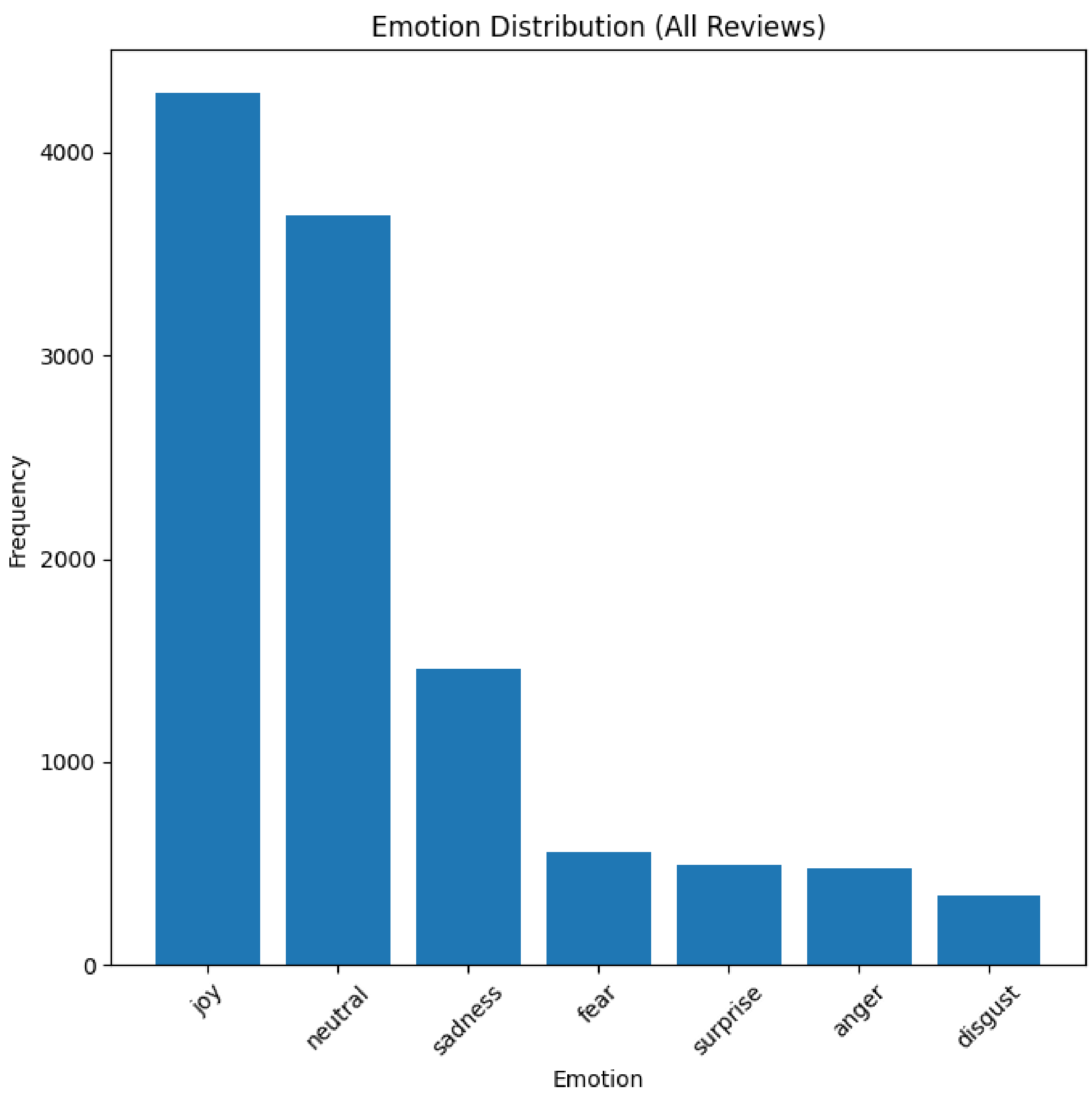
```
[156]: # Split from annotated dataset
df_negative_emotion = df_all_emotion[df_all_emotion["Rating"].
  ↪isin(NEGATIVE_RATINGS)].copy()
df_non_negative_emotion = df_all_emotion[~df_all_emotion["Rating"].
  ↪isin(NEGATIVE_RATINGS)].copy()

print("Negative reviews:", len(df_negative_emotion))
print("Non-negative reviews:", len(df_non_negative_emotion))

display(df_negative_emotion[[TEXT_COL, EmotionParams.LABEL_COL, EmotionParams.
  ↪SCORE_COL]].head(4))
display(df_non_negative_emotion[[TEXT_COL, EmotionParams.LABEL_COL,␣
  ↪EmotionParams.SCORE_COL]].head(4))

neg_save_path = save_csv(df_negative_emotion, f"{DATA_DIR}/
  ↪{PREPROCESSED_FILENAME_NEGATIVE_EMOTION}", suffix=None)
print(f"Saved emotion-annotated negative reviews to: {neg_save_path}")

non_neg_save_path = save_csv(df_non_negative_emotion, PREPROCESSED_PATH,␣
  ↪suffix="_non_negative_emotion")
non_neg_save_path = save_csv(df_non_negative_emotion, f"{DATA_DIR}/
  ↪{PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION}", suffix=None)
```

```
Negative reviews: 2368
Non-negative reviews: 8932

                                                                                ␣
 ↪                                                                              ␣
 ↪                                                                              ␣
 ↪                                                               Review  \
10                                                                              ␣
 ↪                 historically upkeep machine facility slow ok last month men␣
 ↪shower lukewarm best know member notice pay membership every month cold shower␣
 ↪good enough let worry carbon footprint cost go increase membership fee
16  joined local zero join fee except local exempt charge £ join fee ready train␣
 ↪festive period local close festive period due staff shortage company thay␣
 ↪adverises day access yet access want close make sence policy place manager␣
 ↪abuse futher conversion manager team stay u conversion transcript share staff
17        almost week shut still receive single email update proceed go like␣
 ↪finsbury park near one hence join local seven sister one keep come check open␣
 ↪every day absolutely commitment keep u loop maintenance carry try solve␣
 ↪problem make think catch £ first month offer want u cancel membership go £␣
 ↪month
21                                                                              ␣
 ↪                                                                              ␣
 ↪                            dirty almost never cleaning staff enforce use towel␣
 ↪bench full sweat hair gel handwash toilet urine excrement toilet time
```

```
   Dominant Emotion  Confidence Score
10          sadness          0.536304
16          sadness          0.570133
17          sadness          0.600498
21          disgust          0.943677

                                                                              ␣
 ↪                                                                             ␣
 ↪                                                                             ␣
 ↪                            Review  \
0                                                                             ␣
 ↪                                                 well equipped notice one␣
 ↪machine order disappoint lack blue towel sanitizer spray customer use finish␣
 ↪notice ask customer matter respect user
1  overall good experience still cramp compare old redditch number seem reduce␣
 ↪little little readily available change room far small though take look␣
 ↪sunderland comparison one jewel crown mark fisher guy class insane nice␣
 ↪possible way book class early avoid disappointment
2                                                                             ␣
 ↪       excellent friendly environment plenty choice space exercise personal␣
 ↪trainer hand excellent opening hour basically go whenever want   get busy time␣
 ↪always get something class also good
3                                                                             ␣
 ↪                                                                             ␣
 ↪                     havnt member year state art brand new friendly staff␣
 ↪really good competitive monthly price

  Dominant Emotion  Confidence Score
0          neutral          0.340861
1          sadness          0.545070
2              joy          0.895917
3              joy          0.539196

Saved emotion-annotated negative reviews to:
/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/PureGym-NLP-
UDA/data/PureGym Customer Reviews_preprocessed_negative_emotion.csv
```

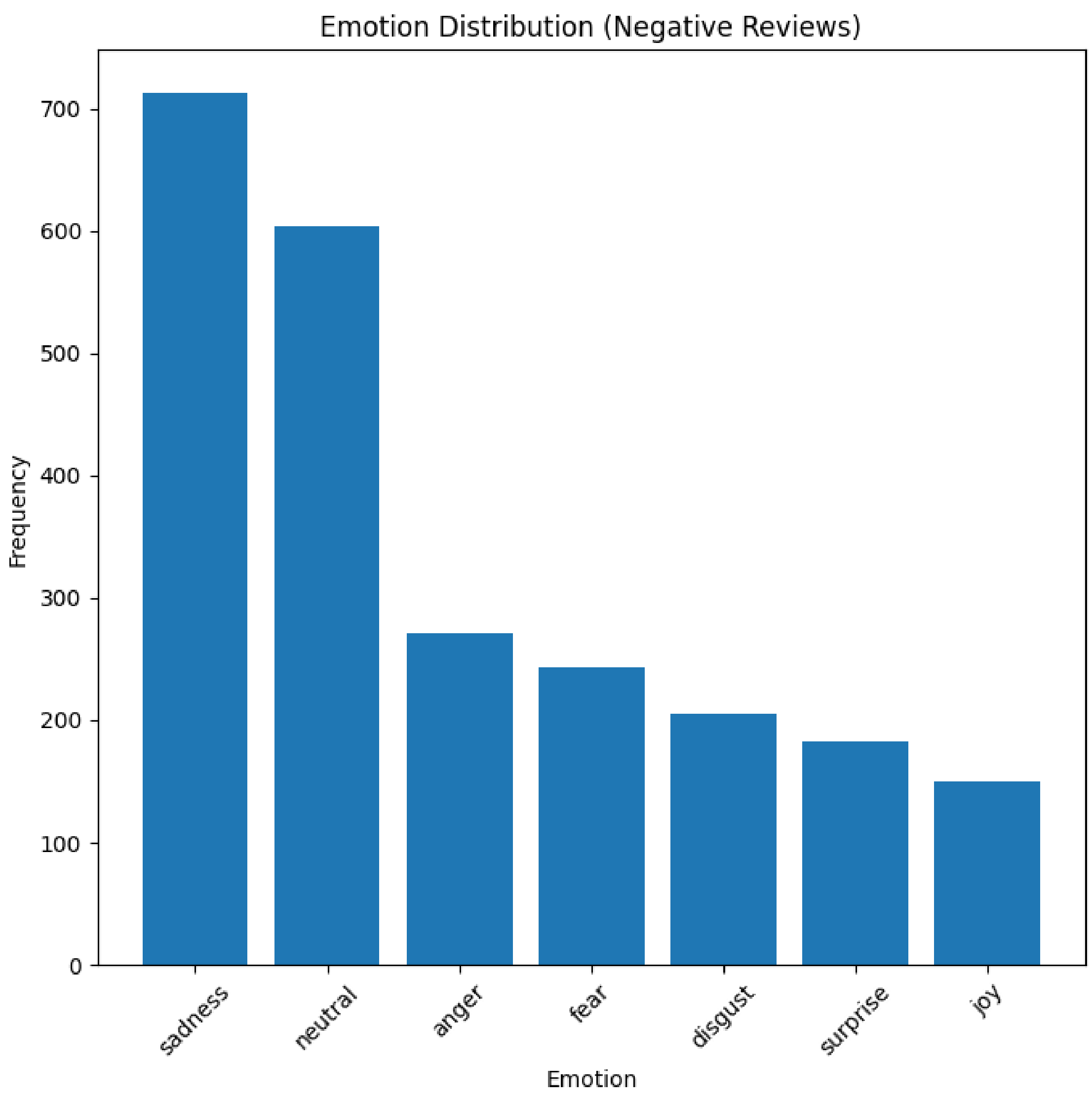
[157]:
```python
# Tables and Plots: All reviews
counts_all = df_all_emotion[EmotionParams.LABEL_COL].value_counts(dropna=False)
counts_all_df = counts_all.rename_axis("Emotion").reset_index(name="Count")
display(counts_all_df)

out_path = TABLE_DIR / f"emotion_counts_all_reviews_{MODEL_TAG}.csv"
counts_all_df.to_csv(out_path, index=False)
print("Saved table to:", out_path)

bar_plot(
    counts_all,
    title="Emotion Distribution (All Reviews)",
    x_label="Emotion",
    y_label="Frequency",
    figsize=FIGSIZE,
    show=True,
    save=True,
    output_dir=PLOT_DIR,
    filename=f"emotion_distribution_all_reviews_{MODEL_TAG}.png",
    dpi=DPI,
)
```

```
    Emotion  Count
0       joy   4289
1   neutral   3691
2   sadness   1458
3      fear    554
4  surprise    490
5     anger    477
6   disgust    341

Saved table to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/04a_emotion_analysis/emotion_counts_all_r
eviews_j_hartmann_emotion_english_distilroberta_base.csv
Saved plot to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/04a_emotion_analysis/emotion_distribution_
all_reviews_j_hartmann_emotion_english_distilroberta_base.png
```



[158]:
```
# Tables and Plots: Negative reviews
counts_neg = df_negative_emotion[EmotionParams.LABEL_COL].
  ↪value_counts(dropna=False)
counts_neg_df = counts_neg.rename_axis("Emotion").reset_index(name="Count")
display(counts_neg_df)

out_path = TABLE_DIR / f"emotion_counts_negative_reviews_{MODEL_TAG}.csv"
counts_neg_df.to_csv(out_path, index=False)
print("Saved table to:", out_path)

bar_plot(
    counts_neg,
    title="Emotion Distribution (Negative Reviews)",
    x_label="Emotion",
    y_label="Frequency",
    figsize=FIGSIZE,
    show=True,
    save=True,
    output_dir=PLOT_DIR,
    filename=f"emotion_distribution_negative_reviews_{MODEL_TAG}.png",
    dpi=DPI,
)
```

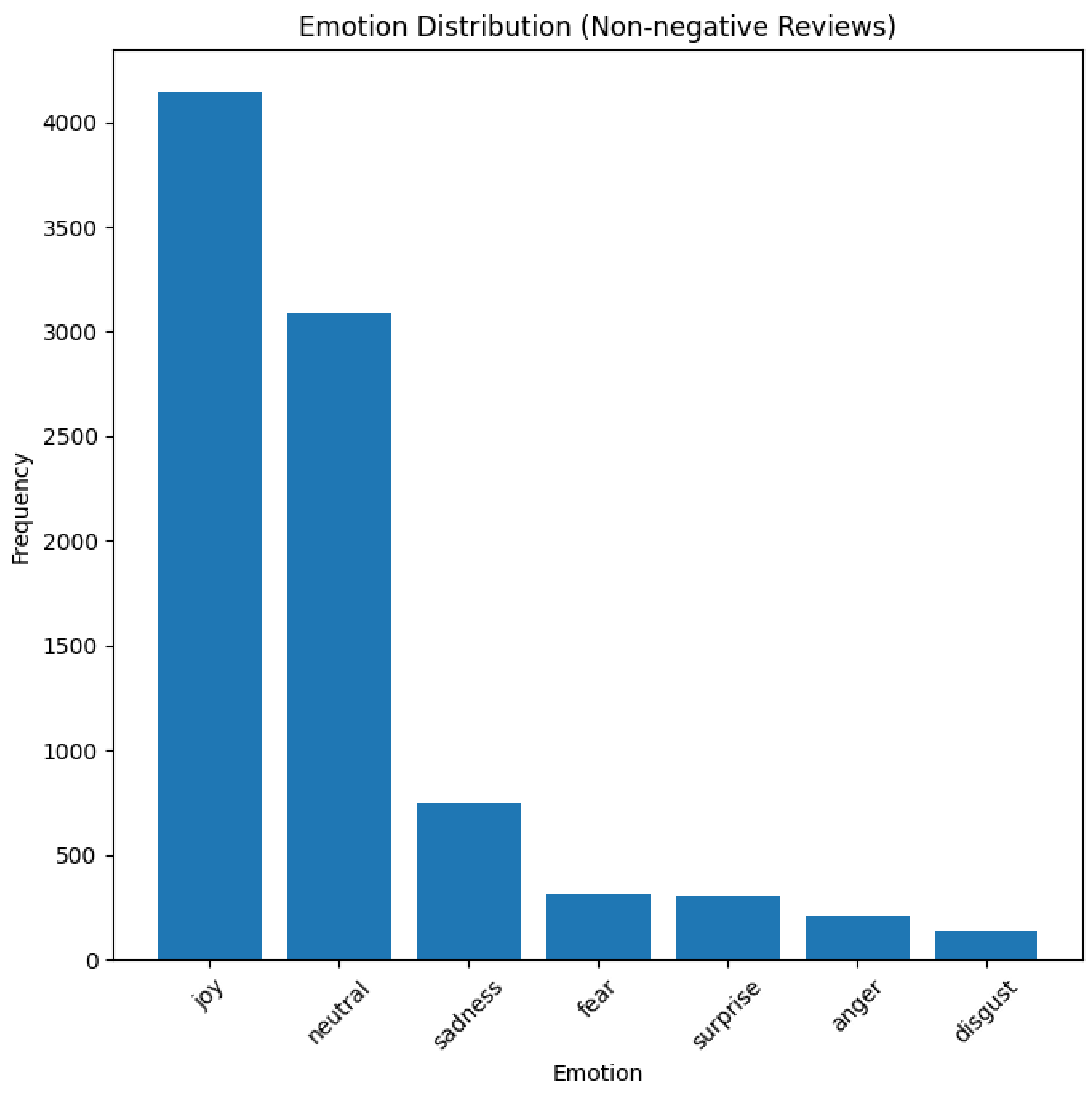
```
    Emotion  Count
0   sadness    712
1   neutral    604
2     anger    271
3      fear    243
4   disgust    205
5  surprise    183
6       joy    150

Saved table to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/04a_emotion_analysis/emotion_counts_negat
ive_reviews_j_hartmann_emotion_english_distilroberta_base.csv
Saved plot to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/04a_emotion_analysis/emotion_distribution_
negative_reviews_j_hartmann_emotion_english_distilroberta_base.png
```



[159]:
```
# Tables and Plots: Non-negative reviews
counts_non_neg = df_non_negative_emotion[EmotionParams.LABEL_COL].
 ↪value_counts(dropna=False)
counts_non_neg_df = counts_non_neg.rename_axis("Emotion").
 ↪reset_index(name="Count")
display(counts_non_neg_df)

out_path = TABLE_DIR / f"emotion_counts_non_negative_reviews_{MODEL_TAG}.csv"
counts_non_neg_df.to_csv(out_path, index=False)
print("Saved table to:", out_path)

bar_plot(
    counts_non_neg,
    title="Emotion Distribution (Non-negative Reviews)",
    x_label="Emotion",
    y_label="Frequency",
    figsize=FIGSIZE,
    show=True,
    save=True,
    output_dir=PLOT_DIR,
    filename=f"emotion_distribution_non_negative_reviews_{MODEL_TAG}.png",
    dpi=DPI,
)
```

```
    Emotion  Count
0       joy   4139
1   neutral   3087
2   sadness    746
3      fear    311
4  surprise    307
5     anger    206
6   disgust    136
```

```
Saved table to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/04a_emotion_analysis/emotion_counts_non_n
egative_reviews_j_hartmann_emotion_english_distilroberta_base.csv
Saved plot to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/04a_emotion_analysis/emotion_distribution_
non_negative_reviews_j_hartmann_emotion_english_distilroberta_base.png
```



```
[160]: elapsed_s = time.perf_counter() - NOTEBOOK_T0
       elapsed_m = elapsed_s / 60

       print(f"\nTotal runtime: {elapsed_s:,.1f} seconds ({elapsed_m:,.2f} minutes)")
```

```
Total runtime: 44.2 seconds (0.74 minutes)
```

6 04b__emotion__analysis__bert__base__uncased

This section repeats emotion classification with a second model (BERT base uncased emotion) to support model comparison:

- Runs batched inference to assign a dominant emotion label and confidence score.

- Splits results into negative and non-negative subsets.
- Produces summary tables and bar plots for all, negative, and non-negative reviews.

Outputs: plots and summary tables under `output/plots/04b_emotion_analysis/` and `output/tables/04b_emotion_analysis/`.

Compute and reproducibility: CPU-only local execution, fixed random seed **901**.

[161]:
```python
import time

NOTEBOOK_T0 = time.perf_counter()
print("Notebook timer started.")
```

```
Notebook timer started.
```

[162]:
```python
PLOT_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["PLOT_DIR"] / "04b_emotion_analysis"
TABLE_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["TABLE_DIR"] /␣
  ↪"04b_emotion_analysis"

PLOT_DIR.mkdir(parents=True, exist_ok=True)
TABLE_DIR.mkdir(parents=True, exist_ok=True)
```

[163]:
```python
FIGSIZE = (7, 7)
DPI = 150
```

[164]:
```python
# Paths
preprocessed_path = Path(DATA_DIR / PREPROCESSED_FILENAME)
PREPROCESSED_PATH = str(preprocessed_path)
print("PREPROCESSED_PATH:", PREPROCESSED_PATH)
```

```
PREPROCESSED_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_sentiment.csv
```

[165]:
```python
PREPROCESSED_FILENAME_EMOTION = CONFIG["DATA"]["PREPROCESSED_FILENAME_EMOTION"]
PREPROCESSED_FILENAME_NEGATIVE_EMOTION =␣
  ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NEGATIVE_EMOTION"]
PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION =␣
  ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION"]

ALL_EMOTION_PATH = Path(DATA_DIR) / PREPROCESSED_FILENAME_EMOTION
NEG_EMOTION_PATH = Path(DATA_DIR) / PREPROCESSED_FILENAME_NEGATIVE_EMOTION
NON_NEG_EMOTION_PATH = Path(DATA_DIR) /␣
  ↪PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION

print("ALL_EMOTION_PATH:", ALL_EMOTION_PATH)
print("NEG_EMOTION_PATH:", NEG_EMOTION_PATH)
print("NON_NEG_EMOTION_PATH:", NON_NEG_EMOTION_PATH)
```

```
ALL_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer Reviews_preprocessed_emotion.csv
NEG_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_negative_emotion.csv
NON_NEG_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_non_negative_emotion.csv
```

[166]:
```
# Load preprocessed dataset only (single inference run)

df_all = load_csv(PREPROCESSED_PATH)
print("All reviews:", len(df_all))
display(df_all.head(4))
```

```
All reviews: 11300

   Rating Date Experienced                                    Review Title  \
0       4       2023-12-17  A well equipped gym, lacked cleaning facilities
1       4       2023-12-13                        Overall a good experience
2       5       2023-12-12                                    Excellent gym
3       5       2023-11-12                            I'm going to be so fit

                                                                          ␣
 ↪                                                                        ␣
 ↪                                                                        ␣
 ↪                             Review
0                                                                         ␣
 ↪                                                 well equipped notice one␣
 ↪machine order disappoint lack blue towel sanitizer spray customer use finish␣
 ↪notice ask customer matter respect user
1  overall good experience still cramp compare old redditch number seem reduce␣
 ↪little little readily available change room far small though take look␣
 ↪sunderland comparison one jewel crown mark fisher guy class insane nice␣
 ↪possible way book class early avoid disappointment
2                                                                         ␣
 ↪       excellent friendly environment plenty choice space exercise personal␣
 ↪trainer hand excellent opening hour basically go whenever want   get busy time␣
 ↪always get something class also good
3                                                                         ␣
 ↪                                                                        ␣
 ↪                          havnt member year state art brand new friendly staff␣
 ↪really good competitive monthly price
```

[167]:
```
tokenizer = Initialiser.init_tokenizer(EmotionParams.MODEL_NAME_V2)
model = Initialiser.init_model(EmotionParams.MODEL_NAME_V2)

compiler = EmotionModelDataCompiler(
    df=df_all,
    text_col=TEXT_COL,
    tokenizer=tokenizer,
    model=model,
    device=EmotionParams.DEVICE,
    batch_size=EmotionParams.BATCH_SIZE,
    max_length=EmotionParams.MAX_LENGTH,
    label_col=EmotionParams.LABEL_COL,
    score_col=EmotionParams.SCORE_COL,
    padding=EmotionParams.PADDING,
    truncation=EmotionParams.TRUNCATION,
)
```

[168]:
```
MODEL_TAG = re.sub(r"[^A-Za-z0-9]+", "_", EmotionParams.MODEL_NAME_V2).
 ↪strip("_")

# Print params
print("\nEmotionParams used:")
print("MODEL_NAME:", EmotionParams.MODEL_NAME_V2)
print("DEVICE:", EmotionParams.DEVICE)
print("BATCH_SIZE:", EmotionParams.BATCH_SIZE)
print("MAX_LENGTH:", EmotionParams.MAX_LENGTH)
print("PADDING:", EmotionParams.PADDING)
print("TRUNCATION:", EmotionParams.TRUNCATION)
print("LABEL_COL:", EmotionParams.LABEL_COL)
print("SCORE_COL:", EmotionParams.SCORE_COL)
print("TEXT_COL:", TEXT_COL)
print("Rows:", len(df_all))

print("Tokenizer class:", type(tokenizer).__name__)
print("Is fast tokenizer:", getattr(tokenizer, "is_fast", False))
print("Vocab size:", tokenizer.vocab_size)
print("Model max length:", tokenizer.model_max_length)
print("Pad token:", tokenizer.pad_token, tokenizer.pad_token_id)
print("EOS token:", tokenizer.eos_token, tokenizer.eos_token_id)
```

```
EmotionParams used:
MODEL_NAME: bhadresh-savani/bert-base-uncased-emotion
DEVICE: cpu
BATCH_SIZE: 16
MAX_LENGTH: 192
PADDING: True
TRUNCATION: True
LABEL_COL: Dominant Emotion
SCORE_COL: Confidence Score
TEXT_COL: Review
Rows: 11300
```

```
Tokenizer class: BertTokenizerFast
Is fast tokenizer: True
Vocab size: 30522
Model max length: 512
Pad token: [PAD] 0
EOS token: None None
```

[169]:
```
# Apply: All reviews
df_all_emotion = compiler.apply()
```

[170]:
```
# Split from annotated dataset
df_negative_emotion = df_all_emotion[df_all_emotion["Rating"].
 ↪isin(NEGATIVE_RATINGS)].copy()
df_non_negative_emotion = df_all_emotion[~df_all_emotion["Rating"].
 ↪isin(NEGATIVE_RATINGS)].copy()

print("Negative reviews:", len(df_negative_emotion))
print("Non-negative reviews:", len(df_non_negative_emotion))

display(df_negative_emotion[[TEXT_COL, EmotionParams.LABEL_COL, EmotionParams.
 ↪SCORE_COL]].head(4))
display(df_non_negative_emotion[[TEXT_COL, EmotionParams.LABEL_COL,␣
 ↪EmotionParams.SCORE_COL]].head(4))
```

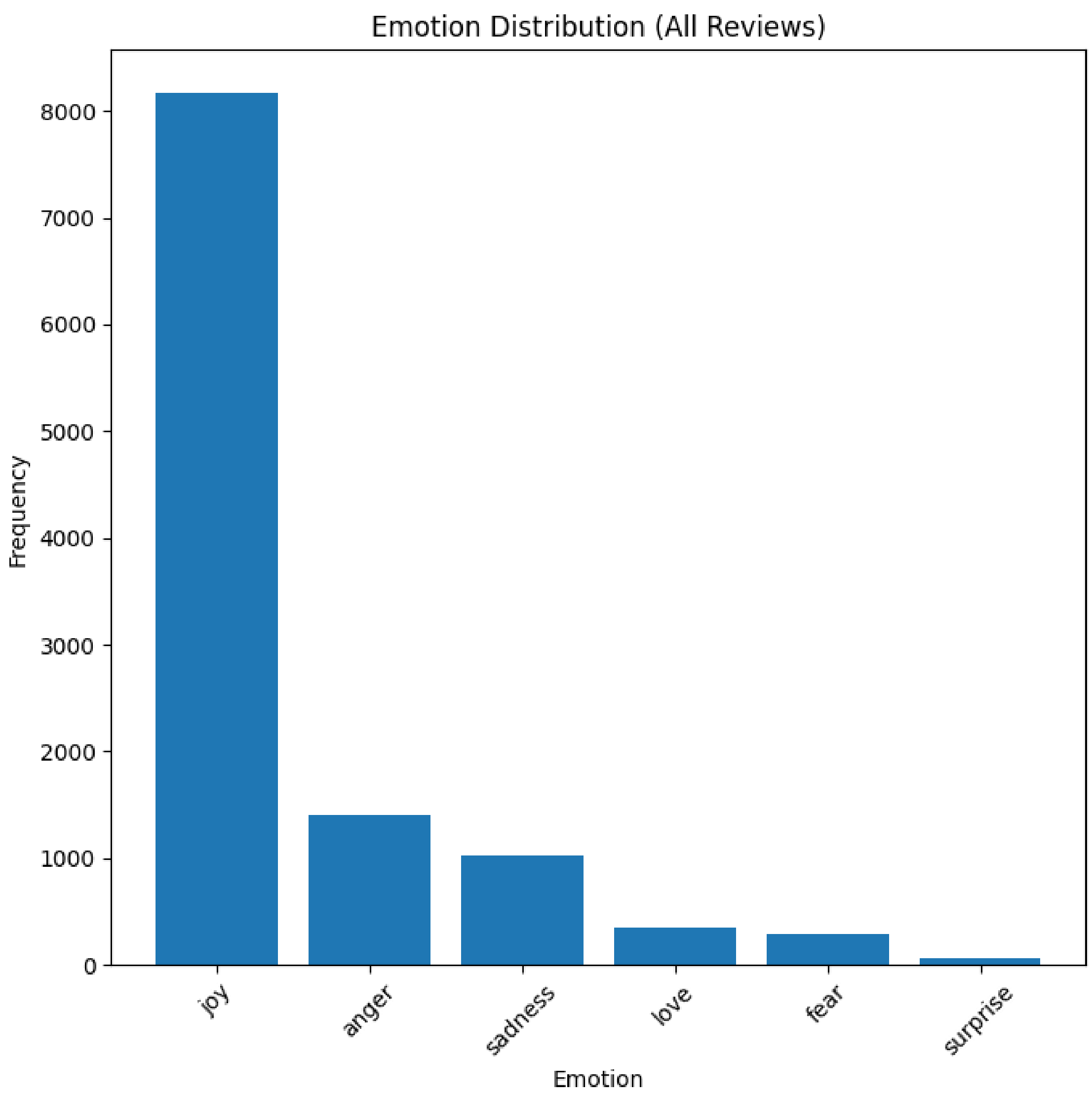
```
Negative reviews: 2368
Non-negative reviews: 8932

                                                                            ␣
 ↪                                                                           ␣
 ↪                                                                           ␣
 ↪                                                              Review   \
10                                                                          ␣
 ↪                 historically upkeep machine facility slow ok last month men␣
 ↪shower lukewarm best know member notice pay membership every month cold shower␣
 ↪good enough let worry carbon footprint cost go increase membership fee
16  joined local zero join fee except local exempt charge £ join fee ready train␣
 ↪festive period local close festive period due staff shortage company thay␣
 ↪adverises day access yet access want close make sence policy place manager␣
 ↪abuse futher conversion manager team stay u conversion transcript share staff
17        almost week shut still receive single email update proceed go like␣
 ↪finsbury park near one hence join local seven sister one keep come check open␣
 ↪every day absolutely commitment keep u loop maintenance carry try solve␣
 ↪problem make think catch £ first month offer want u cancel membership go £␣
 ↪month
21                                                                          ␣
 ↪                                                                           ␣
 ↪                          dirty almost never cleaning staff enforce use towel␣
 ↪bench full sweat hair gel handwash toilet urine excrement toilet time
```

```
   Dominant Emotion  Confidence Score
10            anger          0.965633
16              joy          0.895263
17              joy          0.917807
21            anger          0.741413

                                                                                ␣
 ↪                                                                               ␣
 ↪                                                                               ␣
 ↪                            Review  \
0                                                                               ␣
 ↪                                                  well equipped notice one␣
 ↪machine order disappoint lack blue towel sanitizer spray customer use finish␣
 ↪notice ask customer matter respect user
1  overall good experience still cramp compare old redditch number seem reduce␣
 ↪little little readily available change room far small though take look␣
 ↪sunderland comparison one jewel crown mark fisher guy class insane nice␣
 ↪possible way book class early avoid disappointment
2                                                                               ␣
 ↪       excellent friendly environment plenty choice space exercise personal␣
 ↪trainer hand excellent opening hour basically go whenever want   get busy time␣
 ↪always get something class also good
3                                                                               ␣
 ↪                                                                               ␣
 ↪                     havnt member year state art brand new friendly staff␣
 ↪really good competitive monthly price

  Dominant Emotion  Confidence Score
0              joy          0.970297
1              joy          0.850009
2              joy          0.995373
3              joy          0.998229
```

[171]:
```python
# Tables and Plots: All reviews
counts_all = df_all_emotion[EmotionParams.LABEL_COL].value_counts(dropna=False)
counts_all_df = counts_all.rename_axis("Emotion").reset_index(name="Count")
display(counts_all_df)

out_path = TABLE_DIR / f"emotion_counts_all_reviews_{MODEL_TAG}.csv"
counts_all_df.to_csv(out_path, index=False)
print("Saved table to:", out_path)

bar_plot(
    counts_all,
    title="Emotion Distribution (All Reviews)",
    x_label="Emotion",
    y_label="Frequency",
    figsize=FIGSIZE,
    show=True,
    save=True,
    output_dir=PLOT_DIR,
    filename=f"emotion_distribution_all_reviews_{MODEL_TAG}.png",
    dpi=DPI,
)
```

```
    Emotion  Count
0       joy   8163
1     anger   1402
2   sadness   1027
3      love    356
4      fear    287
5  surprise     65
```

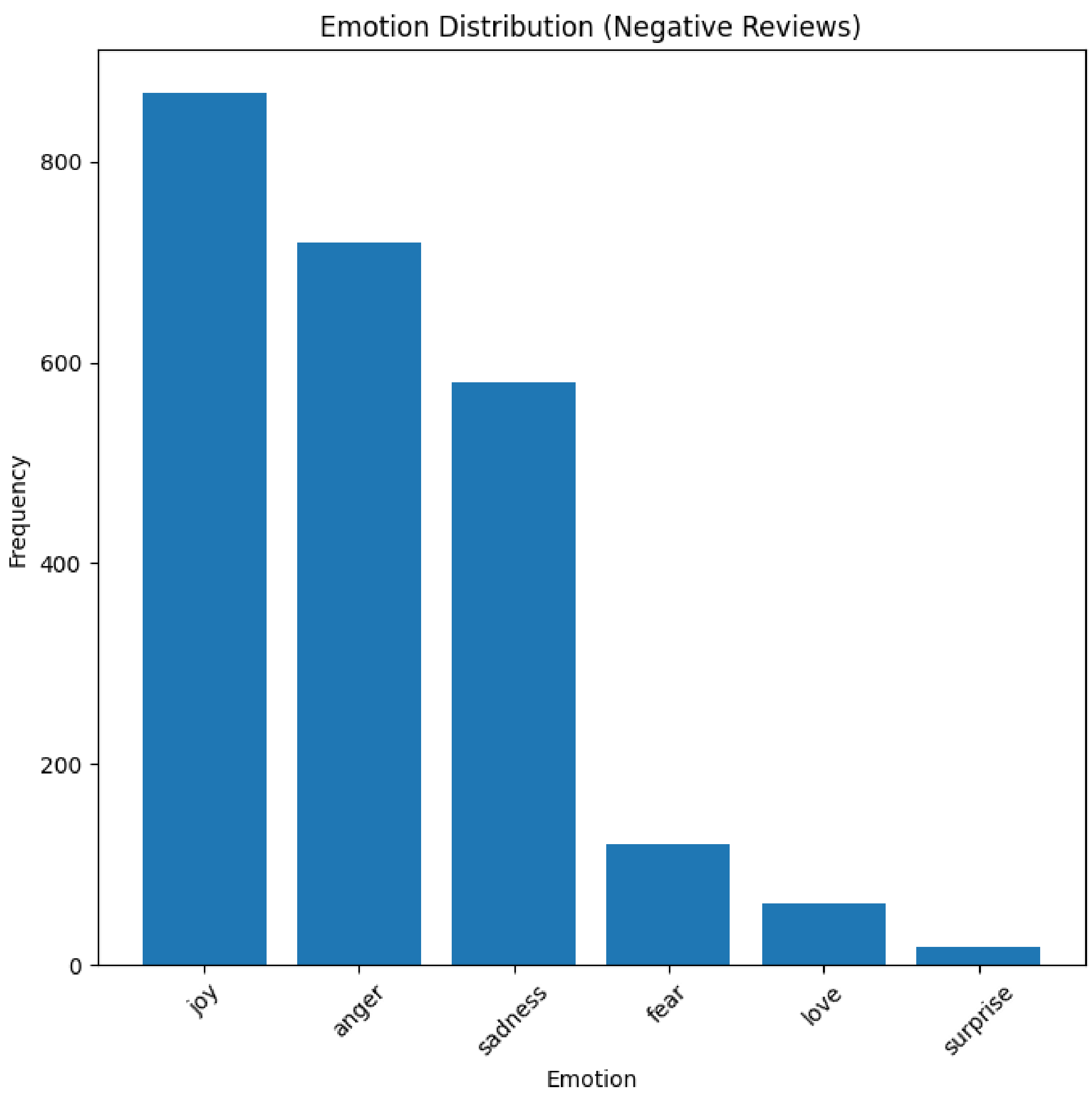
```
Saved table to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/04b_emotion_analysis/emotion_counts_all_r
eviews_bhadresh_savani_bert_base_uncased_emotion.csv
Saved plot to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/04b_emotion_analysis/emotion_distribution_
all_reviews_bhadresh_savani_bert_base_uncased_emotion.png
```



[172]:
```
# Tables and Plots: Negative reviews
counts_neg = df_negative_emotion[EmotionParams.LABEL_COL].
 ↪value_counts(dropna=False)
counts_neg_df = counts_neg.rename_axis("Emotion").reset_index(name="Count")
display(counts_neg_df)

out_path = TABLE_DIR / f"emotion_counts_negative_reviews_{MODEL_TAG}.csv"
counts_neg_df.to_csv(out_path, index=False)
print("Saved table to:", out_path)

bar_plot(
    counts_neg,
    title="Emotion Distribution (Negative Reviews)",
    x_label="Emotion",
    y_label="Frequency",
    figsize=FIGSIZE,
    show=True,
    save=True,
    output_dir=PLOT_DIR,
    filename=f"emotion_distribution_negative_reviews_{MODEL_TAG}.png",
    dpi=DPI,
)
```

```
    Emotion  Count
0       joy    868
1     anger    720
2   sadness    580
3      fear    121
4      love     61
5  surprise     18
```

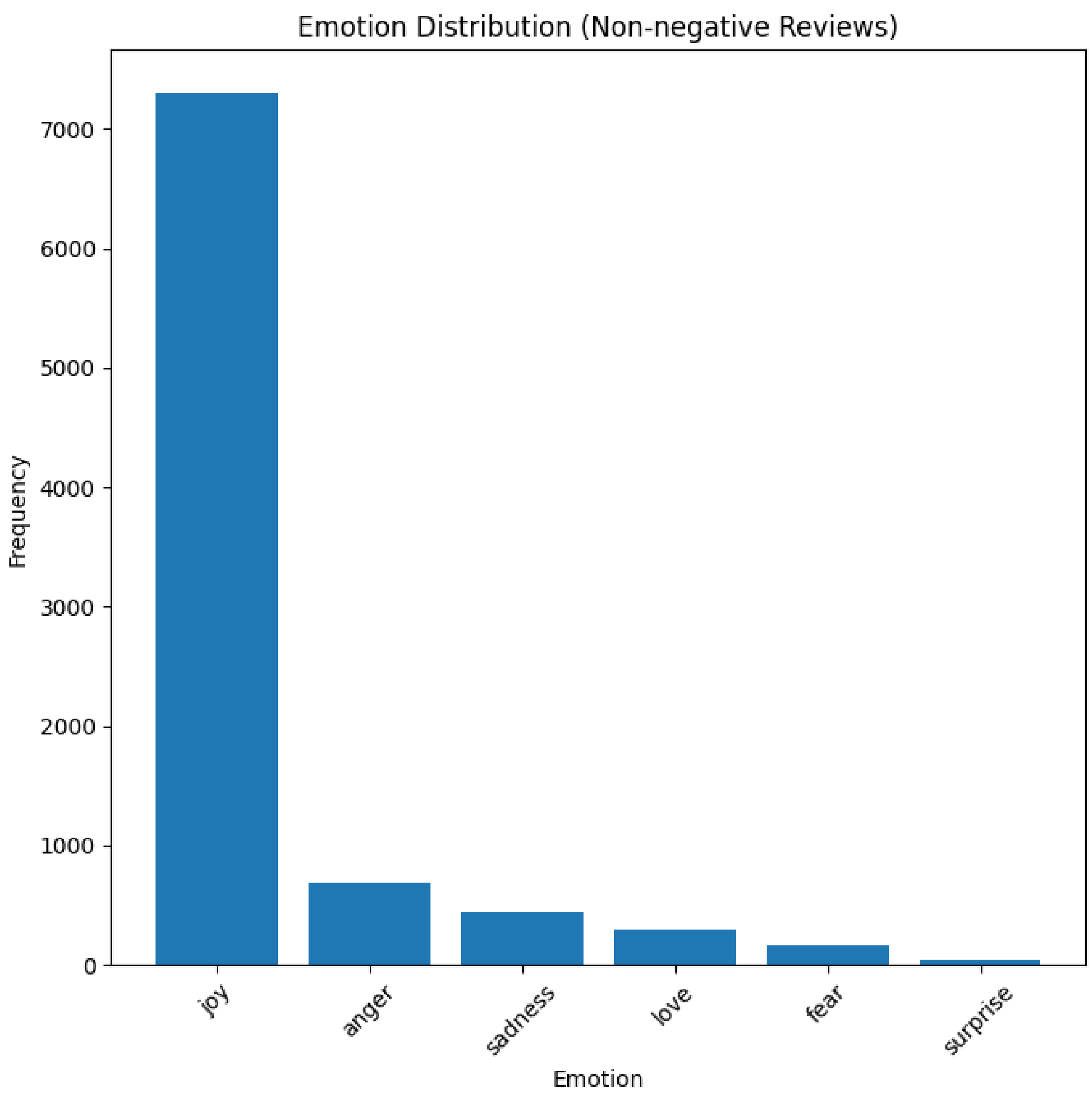
```
Saved table to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/04b_emotion_analysis/emotion_counts_negat
ive_reviews_bhadresh_savani_bert_base_uncased_emotion.csv
Saved plot to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/04b_emotion_analysis/emotion_distribution_
negative_reviews_bhadresh_savani_bert_base_uncased_emotion.png
```



[173]:
```
# Tables and Plots: Non-negative reviews
counts_non_neg = df_non_negative_emotion[EmotionParams.LABEL_COL].
  ↪value_counts(dropna=False)
counts_non_neg_df = counts_non_neg.rename_axis("Emotion").
  ↪reset_index(name="Count")
display(counts_non_neg_df)

out_path = TABLE_DIR / f"emotion_counts_non_negative_reviews_{MODEL_TAG}.csv"
counts_non_neg_df.to_csv(out_path, index=False)
print("Saved table to:", out_path)

bar_plot(
    counts_non_neg,
    title="Emotion Distribution (Non-negative Reviews)",
    x_label="Emotion",
    y_label="Frequency",
    figsize=FIGSIZE,
    show=True,
    save=True,
    output_dir=PLOT_DIR,
    filename=f"emotion_distribution_non_negative_reviews_{MODEL_TAG}.png",
    dpi=DPI,
)
```

```
    Emotion  Count
0       joy   7295
1     anger    682
2   sadness    447
3      love    295
4      fear    166
5  surprise     47
```

```
Saved table to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/tables/04b_emotion_analysis/emotion_counts_non_n
egative_reviews_bhadresh_savani_bert_base_uncased_emotion.csv
Saved plot to: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/04b_emotion_analysis/emotion_distribution_
non_negative_reviews_bhadresh_savani_bert_base_uncased_emotion.png
```



[174]:
```
elapsed_s = time.perf_counter() - NOTEBOOK_T0
elapsed_m = elapsed_s / 60

print(f"\nTotal runtime: {elapsed_s:,.1f} seconds ({elapsed_m:,.2f} minutes)")
```

```
Total runtime: 81.9 seconds (1.37 minutes)
```

7 05_topic_modelling_bertopic_per_emotion_neg_reviews

This section applies BERTopic to emotion-specific subsets of negative reviews (e.g. sadness) to obtain emotion-conditioned topics:

- Loads emotion-annotated datasets.

- Filters to negative reviews and subsets by dominant emotion, enforcing a minimum document threshold.
- Fits BERTopic and saves topic summaries and plots.

Outputs:

- Models: `output/models/05_topic_modelling_bertopic_per_emotion_neg_reviews/`
- Tables: `output/tables/05_topic_modelling_bertopic_per_emotion_neg_reviews/`
- Plots: `output/plots/05_topic_modelling_bertopic_per_emotion_neg_reviews/`

Compute and reproducibility: CPU-only local execution, fixed random seed **901**.

[175]:
```
NOTEBOOK_T0 = time.perf_counter()
print("Section timer started.")
```

```
Section timer started.
```

[176]:
```
# BERTopic Runner
from modelling.bertopic.bertopic_runner import BERTopicRunner

PLOT_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["PLOT_DIR"] /␣
 ↪"05_topic_modelling_bertopic_per_emotion_neg_reviews"
TABLE_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["TABLE_DIR"] /␣
 ↪"05_topic_modelling_bertopic_per_emotion_neg_reviews"
MODEL_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["MODEL_DIR"] /␣
 ↪"05_topic_modelling_bertopic_per_emotion_neg_reviews"

BERTOPIC_NEGATIVE_MODEL = CONFIG["MODELS"]["BERTOPIC_NEGATIVE"]
BERTOPIC_NON_NEGATIVE_MODEL = CONFIG["MODELS"]["BERTOPIC_NON_NEGATIVE"]

EMOTION_COL = CONFIG["FILTERING"]["EMOTION_COL"]

TOP_N_TOPICS = 4
N_WORDS_BARCHART = 5
SHOW_PLOTS = True
SAVE_PNG = True
PNG_SCALE = 2

UMAP_N_NEIGHBOURS = 25
UMAP_N_COMPONENTS = 5
UMAP_MIN_DIST = 0
UMAP_METRIC = "cosine"

MIN_DOCS_PER_EMOTION = 50
```

[177]:
```
PREPROCESSED_FILENAME_EMOTION = CONFIG["DATA"]["PREPROCESSED_FILENAME_EMOTION"]
PREPROCESSED_FILENAME_NEGATIVE_EMOTION =␣
 ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NEGATIVE_EMOTION"]
```

```
PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION =␣
  ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION"]

ALL_EMOTION_PATH = Path(DATA_DIR) / PREPROCESSED_FILENAME_EMOTION
NEG_EMOTION_PATH = Path(DATA_DIR) / PREPROCESSED_FILENAME_NEGATIVE_EMOTION
NON_NEG_EMOTION_PATH = Path(DATA_DIR) /␣
  ↪PREPROCESSED_FILENAME_NON_NEGATIVE_EMOTION

print("ALL_EMOTION_PATH:", ALL_EMOTION_PATH)
print("NEG_EMOTION_PATH:", NEG_EMOTION_PATH)
print("NON_NEG_EMOTION_PATH:", NON_NEG_EMOTION_PATH)
```

```
ALL_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer Reviews_preprocessed_emotion.csv
NEG_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_negative_emotion.csv
NON_NEG_EMOTION_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_non_negative_emotion.csv
```

[178]:
```
#  Load datasets with emotion column
df_all_emotion = load_csv(ALL_EMOTION_PATH)
df_negative_emotion = load_csv(NEG_EMOTION_PATH)
df_non_negative_emotion = load_csv(NON_NEG_EMOTION_PATH)

print("All emotion-annotated rows:", len(df_all_emotion))
print("Negative emotion-annotated rows:", len(df_negative_emotion))
print("Non-negative emotion-annotated rows:", len(df_non_negative_emotion))
```

```
All emotion-annotated rows: 11300
Negative emotion-annotated rows: 2368
Non-negative emotion-annotated rows: 8932
```

[179]:
```
# Initialise BERTopic runner
runner = BERTopicRunner(
    model_dir=MODEL_DIR,
    plot_dir=PLOT_DIR,
    table_dir=TABLE_DIR,
    seed=SEED,

    # Topic-level controls
    top_n_topics=TOP_N_TOPICS,
    n_words_barchart=N_WORDS_BARCHART,
    min_topic_size = 25,

    # Plotting controls
    show_plots=SHOW_PLOTS,
    save_png=SAVE_PNG,
    png_scale=PNG_SCALE,

    # UMAP controls
    umap_n_neighbors=UMAP_N_NEIGHBOURS,
    umap_n_components=UMAP_N_COMPONENTS,
    umap_min_dist=UMAP_MIN_DIST,
    umap_metric=UMAP_METRIC,
)
```

Sadness (negative reviews)

[180]:
```
# Sadness (negative reviews)
emotion = "sadness"
subset = df_negative_emotion[df_negative_emotion[EMOTION_COL] == emotion].copy()

print(f"\nNegative reviews with dominant emotion = '{emotion}': {len(subset)}")

if len(subset) < MIN_DOCS_PER_EMOTION:
    print(f"Skipping '{emotion}' (only {len(subset)} docs, need at least␣
  ↪{MIN_DOCS_PER_EMOTION}).")
else:
    label = f"emotion_negative_{emotion}"
    result_sadness = runner.run(subset, label=label, text_col=TEXT_COL,␣
  ↪verbose=True)

    print(result_sadness.plot_paths)

    topic_info_head = result_sadness.topic_info
    top_topics_table = result_sadness.top_topics_table

    topic_info_head.to_csv(TABLE_DIR / f"{label}_topic_info_head10.csv",␣
  ↪index=False)
    top_topics_table.to_csv(TABLE_DIR / f"{label}_top_topics_table.csv",␣
  ↪index=False)
```

```
2026-01-21 17:32:04,752 - BERTopic - Embedding - Transforming documents to
embeddings.


Negative reviews with dominant emotion = 'sadness': 712

Batches: 100%|      | 23/23 [00:00<00:00, 57.82it/s]
2026-01-21 17:32:07,129 - BERTopic - Embedding - Completed
2026-01-21 17:32:07,129 - BERTopic - Dimensionality - Fitting the dimensionality
reduction algorithm
2026-01-21 17:32:07,958 - BERTopic - Dimensionality - Completed
2026-01-21 17:32:07,959 - BERTopic - Cluster - Start clustering the reduced
embeddings
```

```
2026-01-21 17:32:07,968 - BERTopic - Cluster - Completed
2026-01-21 17:32:07,969 - BERTopic - Representation - Fine-tuning topics using
representation models.
2026-01-21 17:32:07,981 - BERTopic - Representation - Completed
2026-01-21 17:32:07,994 - BERTopic - WARNING: When you use `pickle` to save/load
a BERTopic model,please make sure that the environments in which you saveand
load the model are **exactly** the same. The version of BERTopic,its
dependencies, and python need to remain the same.
```

```
{'intertopic_distance_html': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_berto
pic_per_emotion_neg_reviews/bertopic_emotion_negative_sadness_intertopic_distanc
e.html'), 'intertopic_distance_png':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_bertopic_per_emotion_ne
g_reviews/bertopic_emotion_negative_sadness_intertopic_distance.png'),
'barchart_top_topics_html': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_berto
pic_per_emotion_neg_reviews/bertopic_emotion_negative_sadness_barchart_top4.html
'), 'barchart_top_topics_png': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_berto
pic_per_emotion_neg_reviews/bertopic_emotion_negative_sadness_barchart_top4.png'
), 'heatmap_all_topics_html': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_berto
pic_per_emotion_neg_reviews/bertopic_emotion_negative_sadness_heatmap_all_topics
.html'), 'heatmap_all_topics_png':
PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_bertopic_per_emotion_ne
g_reviews/bertopic_emotion_negative_sadness_heatmap_all_topics.png'),
'heatmap_top_topics_html': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_berto
pic_per_emotion_neg_reviews/bertopic_emotion_negative_sadness_heatmap_top4.html'
), 'heatmap_top_topics_png': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/plots/05_topic_modelling_berto
pic_per_emotion_neg_reviews/bertopic_emotion_negative_sadness_heatmap_top4.png')
, 'topic_info_csv': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8
Unstructured Data Analysis/PureGym-NLP-UDA/output/tables/05_topic_modelling_bert
opic_per_emotion_neg_reviews/bertopic_emotion_negative_sadness_topic_info.csv'),
'top_topics_csv': PosixPath('/Users/Joshua.Dixon/Documents/8_uni/8 Unstructured
Data Analysis/PureGym-NLP-UDA/output/tables/05_topic_modelling_bertopic_per_emot
ion_neg_reviews/bertopic_emotion_negative_sadness_top_topics.csv')}
```

[181]:
```python
elapsed_s = time.perf_counter() - NOTEBOOK_T0
elapsed_m = elapsed_s / 60

print(f"\nTotal runtime: {elapsed_s:,.1f} seconds ({elapsed_m:,.2f} minutes)")
```

```
Total runtime: 8.6 seconds (0.14 minutes)
```

8 06_topic_modelling_lda_gensim

This section runs classical topic modelling with Gensim LDA as a baseline against BERTopic:

- Builds dictionary and bag-of-words corpora from preprocessed tokens.
- Trains (or loads) LDA models for multiple subsets (all reviews, negative reviews, and selected emotion subsets).
- Evaluates with c_v coherence and exports topic tables aligned to pyLDAvis numbering.
- Produces interactive pyLDAvis HTML visualisations.

Outputs:

- Models and artefacts: `output/models/06_topic_modelling_lda_gensim/` (including `gensim_lda_runs/`)
- Tables: `output/tables/06_topic_modelling_lda_gensim/`
- Visualisations: `output/plots/06_topic_modelling_lda_gensim/`

Compute and reproducibility: CPU-only local execution, fixed random seed **901**.

[182]:
```
# Timer start
import time

NOTEBOOK_T0 = time.perf_counter()
print("Notebook timer started.")
```

```
Notebook timer started.
```

[183]:
```
# Gensim imports
from gensim import corpora
from gensim.corpora import MmCorpus
from gensim.models import LdaModel
from gensim.models.coherencemodel import CoherenceModel

import pyLDAvis
import pyLDAvis.gensim_models as gensimvis

from IPython.display import HTML, display

pyLDAvis.enable_notebook()


PREPROCESSED_FILENAME = CONFIG["DATA"]["PREPROCESSED_FILENAME"]
PREPROCESSED_FILENAME_NEGATIVE =␣
  ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NEGATIVE"]
PREPROCESSED_FILENAME_NEGATIVE_EMOTION =␣
  ↪CONFIG["DATA"]["PREPROCESSED_FILENAME_NEGATIVE_EMOTION"]
```

```
PREPROCESSED_PATH = f"{DATA_DIR}/{PREPROCESSED_FILENAME}"
PREPROCESSED_NEG_PATH = f"{DATA_DIR}/{PREPROCESSED_FILENAME_NEGATIVE}"
PREPROCESSED_NEG_EMO_PATH = f"{DATA_DIR}/
  ↪{PREPROCESSED_FILENAME_NEGATIVE_EMOTION}"

EMOTION_COL = CONFIG["FILTERING"]["EMOTION_COL"]

# OUTPUT
PLOT_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["PLOT_DIR"] /␣
  ↪"06_topic_modelling_lda_gensim"
TABLE_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["TABLE_DIR"] /␣
  ↪"06_topic_modelling_lda_gensim"
MODEL_DIR = PROJECT_ROOT / CONFIG["OUTPUT"]["MODEL_DIR"] /␣
  ↪"06_topic_modelling_lda_gensim"

PLOT_DIR.mkdir(parents=True, exist_ok=True)
TABLE_DIR.mkdir(parents=True, exist_ok=True)
MODEL_DIR.mkdir(parents=True, exist_ok=True)


print("PREPROCESSED_PATH:", PREPROCESSED_PATH)
print("PREPROCESSED_NEG_PATH:", PREPROCESSED_NEG_PATH)
print("PREPROCESSED_NEG_EMO_PATH:", PREPROCESSED_NEG_EMO_PATH)
print("TEXT_COL:", TEXT_COL)
print("EMOTION_COL:", EMOTION_COL)
print("SEED:", SEED)
```

```
PREPROCESSED_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer Reviews_preprocessed.csv
PREPROCESSED_NEG_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data
Analysis/PureGym-NLP-UDA/data/PureGym Customer Reviews_preprocessed_negative.csv
PREPROCESSED_NEG_EMO_PATH: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured
Data Analysis/PureGym-NLP-UDA/data/PureGym Customer
Reviews_preprocessed_negative_emotion.csv
TEXT_COL: Review
EMOTION_COL: Dominant Emotion
SEED: 901
```

8.1 LDA Classes

[184]:
```
@dataclass(frozen=True)
class LDAConfig:
    """
    Configuration for a Gensim LDA run.

    Parameters
    ----------
    ...
    alpha
        Document-topic Dirichlet prior. Can be a float, "symmetric",␣
↪"asymmetric", or "auto".
    eta
        Topic-word Dirichlet prior. Can be a float, "symmetric", or "auto".
    """

    seed: int
    train_new_model: bool
    num_topics: int
    passes: int
    chunksize: int
    iterations: int
    eval_every: Any
    no_below: int
    no_above: float
    top_n_words: int
    plot_dir: Path
    table_dir: Path
    model_dir: Path
    alpha: Optional[Any] = None
    eta: Optional[Any] = None



@dataclass(frozen=True)
class LDARunResult:
    """
    Outputs from a single LDA run.

    Parameters
    ----------
    label
        Run label used for filenames.
    model_path
        Path to the saved/loaded LDA model.
    dict_path
        Path to the saved dictionary.
    corpus_path
        Path to the saved corpus (.mm).
    topics_csv
        Path to the saved topics summary CSV.
    vis_path
        Path to the saved pyLDAvis HTML file.
    coherence_cv
        c_v coherence score.
    topics_table
        DataFrame of topic ids and top words.
    vis
        pyLDAvis prepared visualisation object.
    """

    label: str
    model_path: Path
    dict_path: Path
    corpus_path: Path
    topics_csv: Path
    vis_path: Path
    coherence_cv: float
    topics_table: pd.DataFrame
    vis: Any


class LDAArtefactStore:
    """Handle file paths and persistence for dictionary, corpus, and model."""

    def __init__(self, model_dir: Path) -> None:
        """
        Parameters
        ----------
        model_dir
            Root directory for saved models and intermediate artefacts.
        """
        self._run_dir = model_dir / "gensim_lda_runs"
        self._run_dir.mkdir(parents=True, exist_ok=True)

    def paths(self, label: str) -> tuple[Path, Path, Path]:
        """
        Get artefact paths for a run label.

        Parameters
        ----------
        label
            Run label.

        Returns
        -------
        tuple[pathlib.Path, pathlib.Path, pathlib.Path]
            (dict_path, corpus_path, model_path)
        """
        dict_path = self._run_dir / f"{label}_dictionary.dict"
        corpus_path = self._run_dir / f"{label}_corpus.mm"
        model_path = self._run_dir / f"{label}_lda_model.gensim"
        return dict_path, corpus_path, model_path

    def save_dictionary(self, dictionary: corpora.Dictionary, path: Path) ->␣
↪None:
        dictionary.save(str(path))

    def save_corpus(self, corpus: list[list[tuple[int, int]]], path: Path) ->␣
↪None:
        MmCorpus.serialize(str(path), corpus)

    def save_model(self, model: LdaModel, path: Path) -> None:
        model.save(str(path))

    def load_model(self, path: Path) -> LdaModel:
        return LdaModel.load(str(path))


class LDATrainer:
    """Train a Gensim LDA model."""

    def train(
        self,
        *,
        corpus: list[list[tuple[int, int]]],
        dictionary: corpora.Dictionary,
        config: LDAConfig,
    ) -> LdaModel:
        return LdaModel(
            corpus=corpus,
            id2word=dictionary,
            num_topics=config.num_topics,
            passes=config.passes,
            chunksize=config.chunksize,
            iterations=config.iterations,
            random_state=config.seed,
            eval_every=config.eval_every,
            alpha=config.alpha,
            eta=config.eta,
        )



class LDAEvaluator:
    """Compute topic summaries and coherence for an LDA model."""

    @staticmethod
    def _total_tokens(corpus: list[list[tuple[int, int]]]) -> int:
        return int(sum(cnt for doc in corpus for _, cnt in doc))

    @staticmethod
    def _as_vis_dict(vis: Any) -> dict[str, Any]:
        if hasattr(vis, "to_dict"):
            return vis.to_dict()
        if isinstance(vis, dict):
            return vis
        raise TypeError("Expected a pyLDAvis PreparedData object or dict-like␣
↪representation.")

    @staticmethod
    def _top_terms_from_tinfo(
        tinfo: pd.DataFrame,
        *,
        topic_num: int,
        top_n: int,
        lambda_val: float,
    ) -> list[str]:
        """
        Compute LDAvis relevance ranking for a given topic.

        LDAvis relevance (Sievert & Shirley) uses:
        relevance = lambda * logprob + (1 - lambda) * loglift
        """
        df_t = tinfo[tinfo["Category"] == f"Topic{topic_num}"].copy()
        if df_t.empty:
            return []

        df_t["relevance"] = (lambda_val * df_t["logprob"]) + ((1 - lambda_val)␣
↪* df_t["loglift"])
        df_t = df_t.sort_values("relevance", ascending=False)
        return df_t["Term"].head(top_n).astype(str).tolist()

    @staticmethod
    def _dominant_topic_counts(
        model: LdaModel,
        corpus: list[list[tuple[int, int]]],
    ) -> dict[int, int]:
        """
        Count documents (reviews) by dominant topic.

        Returns a mapping keyed by pyLDAvis topic numbering (1..K).
        """
        counts: dict[int, int] = {}
        for bow in corpus:
            topic_probs = model.get_document_topics(bow, minimum_probability=0.
↪0)
            dominant_topic = max(topic_probs, key=lambda x: x[1])[0]  # 0-based
            topic_vis = int(dominant_topic) + 1  # pyLDAvis is 1-based
            counts[topic_vis] = counts.get(topic_vis, 0) + 1
        return counts

    def topic_table(
        self,
        model: LdaModel,
        *,
        top_n_words: int,
        vis: Any,
        corpus: list[list[tuple[int, int]]],
        coherence_cv: float,
        lambda_alt: float = 0.1,
    ) -> pd.DataFrame:
        """
        Build a topic summary table, ranked by document count.

        Notes
        -----
        - TopicId matches pyLDAvis numbering (1..K).
        - Topic is 1..K after sorting by Count (largest first).
        - Count is document-level (dominant topic per review).
        """
        vis_d = self._as_vis_dict(vis)

        mds = pd.DataFrame(vis_d["mdsDat"])
        tinfo = pd.DataFrame(vis_d["tinfo"])

        if "topics" not in mds.columns or "Freq" not in mds.columns:
            raise KeyError("pyLDAvis mdsDat is missing expected columns␣
↪('topics', 'Freq').")

        doc_counts = self._dominant_topic_counts(model, corpus)

        rows: list[dict[str, Any]] = []
        for topic_num in range(1, model.num_topics + 1):
            count_docs = int(doc_counts.get(int(topic_num), 0))

            top_l1 = self._top_terms_from_tinfo(
                tinfo,
                topic_num=topic_num,
                top_n=top_n_words,
                lambda_val=1.0,
            )
            top_lalt = self._top_terms_from_tinfo(
                tinfo,
                topic_num=topic_num,
                top_n=top_n_words,
                lambda_val=float(lambda_alt),
            )

            rows.append(
                {
                    "TopicId": int(topic_num),
                    "Count": count_docs,
                    "TopWords_lambda_1_0": ", ".join(top_l1),
                    "TopWords_lambda_0_1": ", ".join(top_lalt),
                    "Coherence_c_v": float(coherence_cv),
                }
            )

        df = (
            pd.DataFrame(rows)
            .sort_values(["Count", "TopicId"], ascending=[False, True])
            .reset_index(drop=True)
        )

        df.insert(0, "Topic", range(1, len(df) + 1))
        df = df[["Topic", "TopicId", "Count", "TopWords_lambda_1_0",␣
 ↪"TopWords_lambda_0_1", "Coherence_c_v"]]
        return df

    def coherence_cv(
        self,
        *,
        model: LdaModel,
        tokens: list[list[str]],
        dictionary: corpora.Dictionary,
    ) -> float:
        coherence_model = CoherenceModel(model=model, texts=tokens,␣
 ↪dictionary=dictionary, coherence="c_v")
        return float(coherence_model.get_coherence())


class LDAVizWriter:
    """Create and persist pyLDAvis artefacts."""

    def build(self, model: LdaModel, corpus: list[list[tuple[int, int]]],␣
 ↪dictionary: corpora.Dictionary) -> Any:
        return gensimvis.prepare(model, corpus, dictionary)
    def save_html(self, vis: Any, path: Path) -> None:
        pyLDAvis.save_html(vis, str(path))


class LDARunner:
    """
    Orchestrate an end-to-end LDA run (build, train/load, evaluate, export).

    Notes
    -----
    Output naming convention:
    - {label}_dictionary.dict
    - {label}_corpus.mm
    - {label}_lda_model.gensim
    - {label}_gensim_lda_topics.csv
    - {label}_gensim_lda_intertopic_map.html
    """

    def __init__(
        self,
        config: LDAConfig,
        *,
        tokeniser: Any,
        builder: Any,
        store: Optional[LDAArtefactStore] = None,
        trainer: Optional[LDATrainer] = None,
        evaluator: Optional[LDAEvaluator] = None,
        viz: Optional[LDAVizWriter] = None,
    ) -> None:
        self.cfg = config
        np.random.seed(self.cfg.seed)

        self.tokeniser = tokeniser
        self.builder = builder
        self.store = store or LDAArtefactStore(self.cfg.model_dir)
        self.trainer = trainer or LDATrainer()
        self.evaluator = evaluator or LDAEvaluator()
        self.viz = viz or LDAVizWriter()

    def run(self, *, tokens: list[list[str]], label: str, show_vis: bool =␣
 ↪True) -> LDARunResult:
        if len(tokens) == 0:
            raise ValueError(f"{label}: no documents after cleaning/
 ↪tokenisation.")

        dict_path, corpus_path, model_path = self.store.paths(label)
        dictionary = self.builder.build_dictionary(tokens, no_below=self.cfg.
↪no_below, no_above=self.cfg.no_above)
        corpus = self.builder.build_bow(tokens, dictionary)

        if len(dictionary) == 0 or len(corpus) == 0:
            raise ValueError(
                f"{label}: corpus/dictionary empty. Try relaxing no_below/
↪no_above or check preprocessing."
            )

        self.store.save_dictionary(dictionary, dict_path)
        self.store.save_corpus(corpus, corpus_path)

        if self.cfg.train_new_model:
            model = self.trainer.train(corpus=corpus, dictionary=dictionary,␣
↪config=self.cfg)
            self.store.save_model(model, model_path)
        else:
            model = self.store.load_model(model_path)

        coherence_cv = self.evaluator.coherence_cv(model=model, tokens=tokens,␣
↪dictionary=dictionary)

        vis = self.viz.build(model, corpus, dictionary)
        vis_path = self.cfg.plot_dir / f"{label}_gensim_lda_intertopic_map.html"
        self.viz.save_html(vis, vis_path)

        # Topic table aligned to pyLDAvis topic numbering
        # Count is now document-level (dominant topic per review).
        topics_table = self.evaluator.topic_table(
            model,
            top_n_words=self.cfg.top_n_words,
            vis=vis,
            corpus=corpus,
            coherence_cv=coherence_cv,
            lambda_alt=0.1,
        )

        topics_csv = self.cfg.table_dir / f"{label}_gensim_lda_topics.csv"
        topics_table.to_csv(topics_csv, index=False)

        result = LDARunResult(
            label=label,
            model_path=model_path,
            dict_path=dict_path,
            corpus_path=corpus_path,
            topics_csv=topics_csv,
            vis_path=vis_path,
            coherence_cv=coherence_cv,
            topics_table=topics_table,
            vis=vis,
        )

        print("Saved:", result.topics_csv)
        print("Saved:", result.vis_path)
        print("Coherence (c_v):", round(result.coherence_cv, 4))
        display(result.topics_table)

        if show_vis:
            display(HTML(pyLDAvis.prepared_data_to_html(result.vis)))

        return result

    @staticmethod
    def summary_row(result: LDARunResult) -> dict[str, Any]:
        return {
            "Label": result.label,
            "TopicsCSV": str(result.topics_csv),
            "VisHTML": str(result.vis_path),
            "Coherence_c_v": result.coherence_cv,
        }
```

[185]:
```
TokenNormaliser = Callable[[str], list[str]]

class PreprocessedTokeniser:
    """Tokenise preprocessed text into token lists."""

    def __init__(self, *, normaliser: Optional[TokenNormaliser] = None) -> None:
        """
        Parameters
        ----------
        normaliser
            Optional token normaliser applied per whitespace token.
            If None, tokens are returned unchanged (whitespace split only).
        """
        self._normaliser = normaliser
        self._ws_re = re.compile(r"\s+")

    def transform(self, series: pd.Series) -> list[list[str]]:
        """
        Convert a Series of strings into token lists.

        Parameters
        ----------
        series
            Series containing preprocessed text.

        Returns
        -------
        list[list[str]]
            Token lists, one per non-empty document.
        """
        texts = series.fillna("").astype(str).str.strip()
        texts = texts.loc[texts.ne("")]
        texts = texts.str.replace(self._ws_re, " ", regex=True).str.strip()

        docs: list[list[str]] = []
        for text in texts.tolist():
            raw_tokens = text.split()

            if self._normaliser is None:
                doc_tokens = raw_tokens
            else:
                doc_tokens = []
                for tok in raw_tokens:
                    doc_tokens.extend(self._normaliser(tok))

            if doc_tokens:
                docs.append(doc_tokens)

        return docs

    def describe(self, label: str, tokens: list[list[str]]) -> None:
        """
        Print summary statistics for a tokenised corpus.

        Parameters
        ----------
        label
            Short label for printed output.
        tokens
            Tokenised documents.
        """
        doc_count = len(tokens)
        total_tokens = sum(len(t) for t in tokens)
        avg_len = total_tokens / doc_count if doc_count else 0
        print(f"{label}: docs={doc_count:,} total_tokens={total_tokens:,}␣
↪avg_doc_len={avg_len:.1f}")
```

[186]:
```
class GensimCorpusBuilder:
    """Build a Gensim dictionary and BoW corpus from tokenised documents."""
    def build_dictionary(self, tokens: list[list[str]], *, no_below: int,␣
↪no_above: float) -> corpora.Dictionary:
        """
        Create and filter a Gensim dictionary.

        Parameters
        ----------
        tokens
            Tokenised documents.
        no_below
            Minimum document frequency threshold.
        no_above
            Maximum document frequency fraction threshold.

        Returns
        -------
        gensim.corpora.Dictionary
            Filtered dictionary.
        """
        dictionary = corpora.Dictionary(tokens)
        dictionary.filter_extremes(no_below=no_below, no_above=no_above)
        return dictionary

    def build_bow(self, tokens: list[list[str]], dictionary: corpora.
↪Dictionary) -> list[list[tuple[int, int]]]:
        """
        Convert documents into BoW count vectors.

        Parameters
        ----------
        tokens
            Tokenised documents.
        dictionary
            Token-id mapping.

        Returns
        -------
        list[list[tuple[int, int]]]
            BoW corpus in (token_id, count) format.
        """
        return [dictionary.doc2bow(doc) for doc in tokens]
```

8.2 Analysis

[187]:
```
# Loads CSVs
df_preprocessed = load_csv(PREPROCESSED_PATH)
df_preprocessed_negative = load_csv(PREPROCESSED_NEG_PATH)
df_preprocessed_negative_emotion = load_csv(PREPROCESSED_NEG_EMO_PATH)

print("df_preprocessed rows:", len(df_preprocessed))
print("df_preprocessed_negative rows:", len(df_preprocessed_negative))
print("df_preprocessed_negative_emotion rows:",␣
 ↪len(df_preprocessed_negative_emotion))
```

```
df_preprocessed rows: 11300
df_preprocessed_negative rows: 2368
df_preprocessed_negative_emotion rows: 2368
```

[188]:
```
# LDA settings

TRAIN_NEW_MODEL = True  # If True, trains a fresh LDA model and overwrites␣
 ↪saved artefacts

NUM_TOPICS = 5       # Number of latent topics (K) - lower creates broader topics
PASSES = 10          # Number of full epochs over the whole corpus
CHUNKSIZE = 100      # Documents processed per training chunk
ITERATIONS = 1000     # Higher to improve stability/convergence but increase␣
 ↪runtime.
EVAL_EVERY = None    # None disables evaluation (faster).

NO_BELOW = 10        # drop tokens that appear in fewer than this many documents␣
 ↪(removes rare noise terms).
NO_ABOVE = 0.25       #  drop tokens that appear in more than this fraction of␣
 ↪documents (removes very common terms).
TOP_N_WORDS = 5    #  how many top words per topic to export/display (does not␣
 ↪affect model training).

ALPHA = "asymmetric"    # Document-topic prior. Lower/more uneven values␣
 ↪encourage fewer topics per document and can reduce topic mixing.
ETA = "auto"            # Topic-word prior. Lower values encourage sharper,␣
 ↪more distinctive topic vocabularies; "auto" learns this from data.

print("TRAIN_NEW_MODEL:", TRAIN_NEW_MODEL)
print("NUM_TOPICS:", NUM_TOPICS)
print("NO_BELOW / NO_ABOVE:", NO_BELOW, NO_ABOVE)
print("ALPHA:", ALPHA)
print("ETA:", ETA)
```

```
TRAIN_NEW_MODEL: True
NUM_TOPICS: 5
```

```
NO_BELOW / NO_ABOVE: 10 0.25
ALPHA: asymmetric
ETA: auto
```

[189]:
```
tokeniser = PreprocessedTokeniser()
builder = GensimCorpusBuilder()

lda_cfg = LDAConfig(
    seed=SEED,
    train_new_model=TRAIN_NEW_MODEL,
    num_topics=NUM_TOPICS,
    passes=PASSES,
    chunksize=CHUNKSIZE,
    iterations=ITERATIONS,
    eval_every=EVAL_EVERY,
    no_below=NO_BELOW,
    no_above=NO_ABOVE,
    top_n_words=TOP_N_WORDS,
    plot_dir=PLOT_DIR,
    table_dir=TABLE_DIR,
    model_dir=MODEL_DIR,
    alpha=ALPHA,
    eta=ETA,
)

lda_runner = LDARunner(lda_cfg, tokeniser=tokeniser, builder=builder)
```

[190]:
```
tokens_negative = lda_runner.tokeniser.
 ↪transform(df_preprocessed_negative[TEXT_COL])
lda_runner.tokeniser.describe("NEG", tokens_negative)
result_negative = lda_runner.run(tokens=tokens_negative,␣
 ↪label="lda_preprocessed_negative")
```

```
NEG: docs=2,368 total_tokens=79,619 avg_doc_len=33.6
Saved: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/PureGym-
NLP-UDA/output/tables/06_topic_modelling_lda_gensim/lda_preprocessed_negative_ge
nsim_lda_topics.csv
Saved: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/PureGym-
NLP-UDA/output/plots/06_topic_modelling_lda_gensim/lda_preprocessed_negative_gen
sim_lda_intertopic_map.html
Coherence (c_v): 0.4031

   Topic  TopicId  Count                          TopWords_lambda_1_0  \
0      1        1   1150                time, member, room, people, one
1      2        2    558             staff, member, shower, water, like
2      3        5    460                  class, hour, time, spin, early
3      4        3    166  membership, customer, email, service, month
4      5        4     34             machine, weight, area, space, busy
```

```
                      TopWords_lambda_0_1  Coherence_c_v
0     room, changing, toilet, locker, open       0.403075
1              water, air, hot, access, cold       0.403075
2      class, spin, early, min, instructor       0.403075
3  membership, email, cancel, £, cancelled       0.403075
4  weight, space, amount, cleaned, machine       0.403075

<IPython.core.display.HTML object>
```

8.2.1 Run Emotion Subsets on Negative Reviews

[191]:
```
# LDA settings

TRAIN_NEW_MODEL = True

NUM_TOPICS = 3
PASSES = 10
CHUNKSIZE = 100
ITERATIONS = 1000
EVAL_EVERY = None

NO_BELOW = 10
NO_ABOVE = 0.3
TOP_N_WORDS = 5

ALPHA = "asymmetric"
ETA = "auto"

print("TRAIN_NEW_MODEL:", TRAIN_NEW_MODEL)
print("NUM_TOPICS:", NUM_TOPICS)
print("NO_BELOW / NO_ABOVE:", NO_BELOW, NO_ABOVE)
print("ALPHA:", ALPHA)
print("ETA:", ETA)
```

```
TRAIN_NEW_MODEL: True
NUM_TOPICS: 3
NO_BELOW / NO_ABOVE: 10 0.3
ALPHA: asymmetric
ETA: auto
```

[192]:
```
lda_cfg = LDAConfig(
    seed=SEED,
    train_new_model=TRAIN_NEW_MODEL,
    num_topics=NUM_TOPICS,
    passes=PASSES,
    chunksize=CHUNKSIZE,
    iterations=ITERATIONS,
    eval_every=EVAL_EVERY,
    no_below=NO_BELOW,
    no_above=NO_ABOVE,
    top_n_words=TOP_N_WORDS,
    plot_dir=PLOT_DIR,
    table_dir=TABLE_DIR,
    model_dir=MODEL_DIR,
    alpha=ALPHA,
    eta=ETA,
)

lda_runner = LDARunner(lda_cfg, tokeniser=tokeniser, builder=builder)
```

[193]:
```
def run_emotion_subset(emotion: str) -> LDARunResult:
    df_sub =␣
  ↪df_preprocessed_negative_emotion[df_preprocessed_negative_emotion[EMOTION_COL]␣
  ↪== emotion].copy()
    print(f"Negative emotion rows ({emotion}):", len(df_sub))
    tokens = lda_runner.tokeniser.transform(df_sub[TEXT_COL])
    lda_runner.tokeniser.describe(emotion.upper(), tokens)
    return lda_runner.run(tokens=tokens,␣
  ↪label=f"lda_preprocessed_negative_emotion_{emotion}")
```

[194]:
```
result_neg_sadness = run_emotion_subset("sadness")
```

```
Negative emotion rows (sadness): 712
SADNESS: docs=712 total_tokens=25,365 avg_doc_len=35.6
Saved: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/PureGym-
NLP-UDA/output/tables/06_topic_modelling_lda_gensim/lda_preprocessed_negative_em
otion_sadness_gensim_lda_topics.csv
Saved: /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/PureGym-
NLP-UDA/output/plots/06_topic_modelling_lda_gensim/lda_preprocessed_negative_emo
tion_sadness_gensim_lda_intertopic_map.html
Coherence (c_v): 0.3983
```

```
   Topic  TopicId  Count                  TopWords_lambda_1_0  \
0      1        1    429     shower, change, go, time, member
1      2        3    182  machine, open, weight, since, space
2      3        2    101  cancel, class, membership, get, pay

                          TopWords_lambda_0_1  Coherence_c_v
0                shower, order, clean, bad, leave       0.398338
1             weight, space, press, free, workout       0.398338
2  cancel, membership, subscription, freeze, say       0.398338
```

```
<IPython.core.display.HTML object>
```

[195]:
```
summary_rows = [
    lda_runner.summary_row(result_negative),
    lda_runner.summary_row(result_neg_sadness)
]

df_summary = pd.DataFrame(summary_rows)
display(df_summary)
```

```
                                       Label  \
0                  lda_preprocessed_negative
1  lda_preprocessed_negative_emotion_sadness

                                                                                                    ␣
 ↪                                                                                                  ␣
 ↪                        TopicsCSV  \
0                  /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data␣
 ↪Analysis/PureGym-NLP-UDA/output/tables/06_topic_modelling_lda_gensim/
 ↪lda_preprocessed_negative_gensim_lda_topics.csv
1  /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/
 ↪PureGym-NLP-UDA/output/tables/06_topic_modelling_lda_gensim/
 ↪lda_preprocessed_negative_emotion_sadness_gensim_lda_topics.csv

                                                                                                    ␣
 ↪                                                                                                  ␣
 ↪                                    VisHTML  \
0                  /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data␣
 ↪Analysis/PureGym-NLP-UDA/output/plots/06_topic_modelling_lda_gensim/
 ↪lda_preprocessed_negative_gensim_lda_intertopic_map.html
1  /Users/Joshua.Dixon/Documents/8_uni/8 Unstructured Data Analysis/
 ↪PureGym-NLP-UDA/output/plots/06_topic_modelling_lda_gensim/
 ↪lda_preprocessed_negative_emotion_sadness_gensim_lda_intertopic_map.html

   Coherence_c_v
0       0.403075
1       0.398338
```

[196]:
```
elapsed_s = time.perf_counter() - NOTEBOOK_T0
elapsed_m = elapsed_s / 60
print(f"\nTotal runtime: {elapsed_s:,.1f} seconds ({elapsed_m:,.2f} minutes)")
```

```

Total runtime: 6.3 seconds (0.11 minutes)
```

[197]:
```
elapsed_s_global = time.perf_counter() - NOTEBOOK_T0_GLOBAL
elapsed_m_global = elapsed_s_global / 60

print(f"\nFull notebook total runtime: {elapsed_s_global:,.1f} seconds␣
 ↪({elapsed_m_global:,.2f} minutes)")
```

```
Full notebook total runtime: 200.6 seconds (3.34 minutes)
```