2_0_Lexical_Complexity_Binary_Classification_Prediction_Data_Preparat

April 6, 2025

[1]:
```
#@title Install Packages
```

[2]:
```
!pip install -q transformers
!pip install -q torchinfo
!pip install -q datasets
!pip install -q evaluate
!pip install -q nltk
!pip install -q contractions
```

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                              491.2/491.2 kB
24.1 MB/s eta 0:00:00
                              116.3/116.3 kB
12.7 MB/s eta 0:00:00
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17.9 MB/s eta 0:00:00
                              143.5/143.5 kB
14.0 MB/s eta 0:00:00
                              194.8/194.8 kB
17.6 MB/s eta 0:00:00
```

```
ERROR: pip's dependency resolver does not currently take into account
all the packages that are installed. This behaviour is the source of the
following dependency conflicts.
torch 2.6.0+cu124 requires nvidia-cublas-cu12==12.4.5.8; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-cublas-cu12
12.5.3.2 which is incompatible.
torch 2.6.0+cu124 requires nvidia-cuda-cupti-cu12==12.4.127; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-cuda-cupti-cu12
12.5.82 which is incompatible.
torch 2.6.0+cu124 requires nvidia-cuda-nvrtc-cu12==12.4.127; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-cuda-nvrtc-cu12
12.5.82 which is incompatible.
torch 2.6.0+cu124 requires nvidia-cuda-runtime-cu12==12.4.127; platform_system
== "Linux" and platform_machine == "x86_64", but you have nvidia-cuda-runtime-
cu12 12.5.82 which is incompatible.
torch 2.6.0+cu124 requires nvidia-cudnn-cu12==9.1.0.70; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-cudnn-cu12
9.3.0.75 which is incompatible.
torch 2.6.0+cu124 requires nvidia-cufft-cu12==11.2.1.3; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-cufft-cu12
11.2.3.61 which is incompatible.
torch 2.6.0+cu124 requires nvidia-curand-cu12==10.3.5.147; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-curand-cu12
10.3.6.82 which is incompatible.
torch 2.6.0+cu124 requires nvidia-cusolver-cu12==11.6.1.9; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-cusolver-cu12
11.6.3.83 which is incompatible.
torch 2.6.0+cu124 requires nvidia-cusparse-cu12==12.3.1.170; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-cusparse-cu12
12.5.1.3 which is incompatible.
torch 2.6.0+cu124 requires nvidia-nvjitlink-cu12==12.4.127; platform_system ==
"Linux" and platform_machine == "x86_64", but you have nvidia-nvjitlink-cu12
12.5.82 which is incompatible.
gcsfs 2025.3.2 requires fsspec==2025.3.2, but you have fsspec 2024.12.0 which is
incompatible.
                         84.0/84.0 kB
```

```
4.1 MB/s eta 0:00:00
                              289.9/289.9 kB
23.5 MB/s eta 0:00:00
                              118.3/118.3 kB
12.0 MB/s eta 0:00:00
```

[3]:

```
!sudo apt-get update
! sudo apt-get install tree
```

```
Get:1 https://cloud.r-project.org/bin/linux/ubuntu jammy-cran40/ InRelease
[3,632 B]
Get:2 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64
InRelease [1,581 B]
Get:3 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64
Packages [1,381 kB]
Get:4 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Hit:5 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:6 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Hit:7 https://ppa.launchpadcontent.net/deadsnakes/ppa/ubuntu jammy InRelease
Hit:8 https://ppa.launchpadcontent.net/graphics-drivers/ppa/ubuntu jammy
InRelease
Get:9 https://r2u.stat.illinois.edu/ubuntu jammy InRelease [6,555 B]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64
Packages [3,978 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [127 kB]
Hit:12 https://ppa.launchpadcontent.net/ubuntugis/ppa/ubuntu jammy InRelease
Get:13 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages
[4,148 kB]
Get:14 https://r2u.stat.illinois.edu/ubuntu jammy/main all Packages [8,809 kB]
Get:15 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages
[1,241 kB]
Get:16 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages
[2,775 kB]
Get:17 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages
[1,540 kB]
Get:18 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [3,092
kB]
Get:19 https://r2u.stat.illinois.edu/ubuntu jammy/main amd64 Packages [2,688 kB]
Fetched 30.0 MB in 4s (6,824 kB/s)
Reading package lists… Done
W: Skipping acquire of configured file 'main/source/Sources' as repository
'https://r2u.stat.illinois.edu/ubuntu jammy InRelease' does not seem to provide
it (sources.list entry misspelt?)
Reading package lists… Done
Building dependency tree… Done
Reading state information… Done
The following NEW packages will be installed:
```

```
  tree
0 upgraded, 1 newly installed, 0 to remove and 44 not upgraded.
Need to get 47.9 kB of archives.
After this operation, 116 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tree amd64 2.0.2-1
[47.9 kB]
Fetched 47.9 kB in 1s (70.5 kB/s)
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line 78,
<> line 1.)
debconf: falling back to frontend: Readline
debconf: unable to initialize frontend: Readline
debconf: (This frontend requires a controlling tty.)
debconf: falling back to frontend: Teletype
dpkg-preconfigure: unable to re-open stdin:
Selecting previously unselected package tree.
(Reading database … 126213 files and directories currently installed.)
Preparing to unpack …/tree_2.0.2-1_amd64.deb …
Unpacking tree (2.0.2-1) …
Setting up tree (2.0.2-1) …
Processing triggers for man-db (2.10.2-1) …
```

[4]:

```
#@title Imports
import nltk
from nltk.tokenize import RegexpTokenizer

import evaluate
import transformers

import contractions

from torchinfo import summary
from datasets import load_dataset

from transformers import AutoTokenizer, AutoModel,␣
 ↪AutoModelForSequenceClassification
from transformers import TrainingArguments, Trainer

import os
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

import sklearn
```

```
import spacy
```

[5]:
```
# @title Mount Google Drive
```

[6]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[7]:
```
dir_root = '/content/drive/MyDrive/266-final/'
# dir_data = '/content/drive/MyDrive/266-final/data/'
# dir_data = '/content/drive/MyDrive/266-final/data/se21-t1-comp-lex-master/'
dir_data = '/content/drive/MyDrive/266-final/data/266-comp-lex-master'
dir_models = '/content/drive/MyDrive/266-final/models/'
dir_results = '/content/drive/MyDrive/266-final/results/'
```

[8]:
```
!tree /content/drive/MyDrive/266-final/data/266-comp-lex-master/
```

```
/content/drive/MyDrive/266-final/data/266-comp-lex-master/
  fe-test-labels
  fe-train
  fe-trial-val
  test-labels
     lcp_multi_test.tsv
     lcp_single_test.tsv
  train
     lcp_multi_train.tsv
     lcp_single_train.tsv
  trial
      lcp_multi_trial.tsv
      lcp_single_trial.tsv

6 directories, 6 files
```

[9]:
```
!ls -R /content/drive/MyDrive/266-final/data/266-comp-lex-master/
```

```
/content/drive/MyDrive/266-final/data/266-comp-lex-master/:
fe-test-labels  fe-train  fe-trial-val  test-labels  train  trial

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-test-labels:

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-train:

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-trial-val:

/content/drive/MyDrive/266-final/data/266-comp-lex-master/test-labels:
lcp_multi_test.tsv  lcp_single_test.tsv

/content/drive/MyDrive/266-final/data/266-comp-lex-master/train:
```

```
lcp_multi_train.tsv  lcp_single_train.tsv

/content/drive/MyDrive/266-final/data/266-comp-lex-master/trial:
lcp_multi_trial.tsv  lcp_single_trial.tsv
```

[10]:
```
#@title Import Data
```

[11]:
```
# train_single_df = pd.read_csv(os.path.join(dir_data, "train",␣
↪"lcp_single_train.tsv"), sep="\t")
# train_multi_df = pd.read_csv(os.path.join(dir_data, "train", "lcp_multi_train.
↪tsv"), sep="\t")

# trail_val_single_df = pd.read_csv(os.path.join(dir_data, "trial",␣
↪"lcp_single_trial.tsv"), sep="\t")
# trail_val_multi_df = pd.read_csv(os.path.join(dir_data, "trial",␣
↪"lcp_multi_trial.tsv"), sep="\t")

# test_single_df = pd.read_csv(os.path.join(dir_data, "test-labels",␣
↪"lcp_single_test.tsv"), sep="\t")
# test_multi_df = pd.read_csv(os.path.join(dir_data, "test-labels",␣
↪"lcp_multi_test.tsv"), sep="\t")
```

[12]:
```
# # Try to load the files containing unterminated strings
# try:
#     # Approach 1: Try with the C engine but with error handling
#     multi_test_df = pd.read_csv(
#         os.path.join(dir_data, "test", "lcp_multi_test.tsv"),
#         sep="\t",
#         on_bad_lines='skip'  # Skip bad lines
#     )
#     print("Loaded with skipping bad lines")
# except Exception as e:
#     print(f"First approach failed: {e}")
#     try:
#         # Approach 2: Try with the Python engine which might be more forgiving
#         multi_test_df = pd.read_csv(
#             os.path.join(dir_data, "test", "lcp_multi_test.tsv"),
#             sep="\t",
#             engine="python",
#             quoting=3  # QUOTE_NONE
#         )
#         print("Loaded with Python engine")
```

[13]:
```
# Load train data into train_*_df
train_single_df = pd.read_csv(
    os.path.join(dir_data, "train", "lcp_single_train.tsv"),
    sep = "\t",
```

```
    engine = "python",
    quoting = 3
)
train_multi_df = pd.read_csv(
    os.path.join(dir_data, "train", "lcp_multi_train.tsv"),
    sep = "\t",
    engine = "python",
    quoting = 3
)

# Load trial data into trial_val_*_df
trial_val_single_df = pd.read_csv(
    os.path.join(dir_data, "trial", "lcp_single_trial.tsv"),
    sep = "\t",
    engine = "python",
    quoting = 3
)
trial_val_multi_df = pd.read_csv(
    os.path.join(dir_data, "trial", "lcp_multi_trial.tsv"),
    sep = "\t",
    engine = "python",
    quoting = 3
)

# Load test data (with labels) into test_*_df
test_single_df = pd.read_csv(
    os.path.join(dir_data, "test-labels", "lcp_single_test.tsv"),
    sep = "\t",
    engine = "python",
    quoting = 3
)
test_multi_df = pd.read_csv(
    os.path.join(dir_data, "test-labels", "lcp_multi_test.tsv"),
    sep = "\t",
    engine = "python",
    quoting = 3
)

print("Data successfully loaded into train, trial-val, and test variables")
```

```
Data successfully loaded into train, trial-val, and test variables
```

[14]:
```
#@title EDA
```

[15]:
```
def print_dataframe_summary(df_name, df):
    # Print section header
    print(f"========== {df_name} ==========")
```

```python
    # Shape and Columns
    print(f"Shape: {df.shape}")
    print(f"Columns: {list(df.columns)}\n")

    # Data Types
    print("Data Types:")
    print(df.dtypes)
    print()

    # Missing Values
    print("Missing Values (by column):")
    print(df.isna().sum())
    print()

    # 'complexity' column stats
    desc = df['complexity'].describe()  # count, mean, std, min, 25%, 50%, 75%,␣
↪max
    print("'complexity' Column Stats (incl. quartiles and median):")
    print(desc)

    # Calculate frequency counts for each quartile range
    q1 = desc['25%']
    q2 = desc['50%']  # This is the median
    q3 = desc['75%']
    q_max = desc['max']

    # Note: We'll define the ranges as:
    #   <= Q1
    #   > Q1 and <= Q2
    #   > Q2 and <= Q3
    #   > Q3

    freq_q1 = np.sum(df['complexity'] <= q1)
    freq_q2 = np.sum((df['complexity'] > q1) & (df['complexity'] <= q2))
    freq_q3 = np.sum((df['complexity'] > q2) & (df['complexity'] <= q3))
    freq_q4 = np.sum(df['complexity'] > q3)

    print()
    print("Quartile Frequency Counts (tab-separated next to each quartile):")
    print(f"25%: {q1}\tCount (<= Q1): {freq_q1}")
    print(f"50% (Median): {q2}\tCount (Q1 < x <= Q2): {freq_q2}")
    print(f"75%: {q3}\tCount (Q2 < x <= Q3): {freq_q3}")
    print(f"100% (Max): {q_max}\tCount (Q3 < x <= Max): {freq_q4}")

    print("======================================\n")

# Now we call this for each of our dataframes
```

```
print_dataframe_summary("train_single_df", train_single_df)
print_dataframe_summary("train_multi_df", train_multi_df)
print_dataframe_summary("trial_val_single_df", trial_val_single_df)
print_dataframe_summary("trial_val_multi_df", trial_val_multi_df)
print_dataframe_summary("test_single_df", test_single_df)
print_dataframe_summary("test_multi_df", test_multi_df)
```

```
========== train_single_df ==========
Shape: (7662, 5)
Columns: ['id', 'corpus', 'sentence', 'token', 'complexity']

Data Types:
id             object
corpus         object
sentence       object
token          object
complexity    float64
dtype: object

Missing Values (by column):
id            0
corpus        0
sentence      0
token         7
complexity    0
dtype: int64

'complexity' Column Stats (incl. quartiles and median):
count    7662.000000
mean        0.302288
std         0.132977
min         0.000000
25%         0.211538
50%         0.279412
75%         0.375000
max         0.861111
Name: complexity, dtype: float64

Quartile Frequency Counts (tab-separated next to each quartile):
25%: 0.2115384615384615 Count (<= Q1): 1928
50% (Median): 0.2794117647058823        Count (Q1 < x <= Q2): 1937
75%: 0.375      Count (Q2 < x <= Q3): 1984
100% (Max): 0.8611111111111112  Count (Q3 < x <= Max): 1813
======================================

========== train_multi_df ==========
Shape: (1517, 5)
Columns: ['id', 'corpus', 'sentence', 'token', 'complexity']
```

```
Data Types:
id              object
corpus          object
sentence        object
token           object
complexity     float64
dtype: object

Missing Values (by column):
id             0
corpus         0
sentence       0
token          0
complexity     0
dtype: int64

'complexity' Column Stats (incl. quartiles and median):
count    1517.000000
mean        0.418362
std         0.155536
min         0.027778
25%         0.302632
50%         0.409091
75%         0.529412
max         0.975000
Name: complexity, dtype: float64

Quartile Frequency Counts (tab-separated next to each quartile):
25%: 0.3026315789473685 Count (<= Q1): 382
50% (Median): 0.409090909090909 Count (Q1 < x <= Q2): 377
75%: 0.5294117647058824 Count (Q2 < x <= Q3): 380
100% (Max): 0.975       Count (Q3 < x <= Max): 378
======================================

========== trial_val_single_df ==========
Shape: (421, 5)
Columns: ['id', 'subcorpus', 'sentence', 'token', 'complexity']

Data Types:
id              object
subcorpus       object
sentence        object
token           object
complexity     float64
dtype: object

Missing Values (by column):
```

```
id            0
subcorpus     0
sentence      0
token         0
complexity    0
dtype: int64

'complexity' Column Stats (incl. quartiles and median):
count    421.000000
mean       0.298631
std        0.137619
min        0.000000
25%        0.214286
50%        0.266667
75%        0.359375
max        0.875000
Name: complexity, dtype: float64

Quartile Frequency Counts (tab-separated next to each quartile):
25%: 0.2142857142857143 Count (<= Q1): 106
50% (Median): 0.26666666666666667        Count (Q1 < x <= Q2): 107
75%: 0.359375   Count (Q2 < x <= Q3): 103
100% (Max): 0.875       Count (Q3 < x <= Max): 105
======================================

========== trial_val_multi_df ==========
Shape: (99, 5)
Columns: ['id', 'subcorpus', 'sentence', 'token', 'complexity']

Data Types:
id             object
subcorpus      object
sentence       object
token          object
complexity    float64
dtype: object

Missing Values (by column):
id            0
subcorpus     0
sentence      0
token         0
complexity    0
dtype: int64

'complexity' Column Stats (incl. quartiles and median):
count    99.000000
mean      0.417961
```

```
std       0.153752
min       0.000000
25%       0.309028
50%       0.421875
75%       0.513932
max       0.825000
Name: complexity, dtype: float64

Quartile Frequency Counts (tab-separated next to each quartile):
25%: 0.3090277777777778 Count (<= Q1): 25
50% (Median): 0.421875  Count (Q1 < x <= Q2): 25
75%: 0.5139318885448916 Count (Q2 < x <= Q3): 24
100% (Max): 0.825       Count (Q3 < x <= Max): 25
======================================

========== test_single_df ==========
Shape: (917, 5)
Columns: ['id', 'corpus', 'sentence', 'token', 'complexity']

Data Types:
id             object
corpus         object
sentence       object
token          object
complexity    float64
dtype: object

Missing Values (by column):
id            0
corpus        0
sentence      0
token         0
complexity    0
dtype: int64

'complexity' Column Stats (incl. quartiles and median):
count    917.000000
mean       0.296362
std        0.127290
min        0.000000
25%        0.214286
50%        0.276316
75%        0.357143
max        0.777778
Name: complexity, dtype: float64

Quartile Frequency Counts (tab-separated next to each quartile):
25%: 0.2142857142857143 Count (<= Q1): 237
```

```
50% (Median): 0.2763157894736842        Count (Q1 < x <= Q2): 224
75%: 0.3571428571428571 Count (Q2 < x <= Q3): 229
100% (Max): 0.7777777777777777  Count (Q3 < x <= Max): 227
======================================

========== test_multi_df ==========
Shape: (184, 5)
Columns: ['id', 'corpus', 'sentence', 'token', 'complexity']

Data Types:
id              object
corpus          object
sentence        object
token           object
complexity     float64
dtype: object

Missing Values (by column):
id             0
corpus         0
sentence       0
token          0
complexity     0
dtype: int64

'complexity' Column Stats (incl. quartiles and median):
count    184.000000
mean       0.422312
std        0.155785
min        0.000000
25%        0.316667
50%        0.428571
75%        0.527778
max        0.800000
Name: complexity, dtype: float64

Quartile Frequency Counts (tab-separated next to each quartile):
25%: 0.3166666666666666 Count (<= Q1): 47
50% (Median): 0.4285714285714286        Count (Q1 < x <= Q2): 46
75%: 0.5277777777777778 Count (Q2 < x <= Q3): 46
100% (Max): 0.8 Count (Q3 < x <= Max): 45
======================================
```

[16]:
```
print(train_single_df.head())
```

```
                               id corpus  \
0  3ZLW647WALVGE8EBR50EGUBPU4P32A  bible
```

```
1  34R0BODSP1ZBN3DVY8J8XSIY551E5C  bible
2  3S1WOPCJFGTJU2SGNAN2Y213N6WJE3  bible
3  3BFNCI9LYKQN09BHXHH9CLSX5KP738  bible
4  3G5RUKN2EC3YIWSKUXZ8ZVH95R49N2  bible

                                            sentence     token  complexity
0  Behold, there came up out of the river seven c…     river    0.000000
1  I am a fellow bondservant with you and with yo…  brothers    0.000000
2  The man, the lord of the land, said to us, 'By…  brothers    0.050000
3  Shimei had sixteen sons and six daughters; but…  brothers    0.150000
4              "He has put my brothers far from me.  brothers    0.263889
```

[17]:
```python
print(train_multi_df.head())
```

```
                              id corpus  \
0  3S37Y8CWI80N8KVM53U4E6JKCDC4WE  bible
1  3WGCNLZJKF877FYC1Q6COKNWTDWD11  bible
2  3UOMW19E6D6WQ5TH2HDD74IVKTP5CB  bible
3  36JW4WBR06KF9AXMUL4N476OMF8FHD  bible
4  3HRWUH63QU2FH9Q8R7MRNFC7JX2N5A  bible

                                            sentence           token  \
0  but the seventh day is a Sabbath to Yahweh you…     seventh day
1  But let each man test his own work, and then h…        own work
2  To him who by understanding made the heavens; …  loving kindness
3  Remember to me, my God, this also, and spare m…  loving kindness
4  Because your loving kindness is better than li…  loving kindness

   complexity
0    0.027778
1    0.050000
2    0.050000
3    0.050000
4    0.075000
```

[18]:
```python
#@title Data Engineering
```

[19]:
```python
# Assuming you have already loaded the DataFrames:
# train_single_df, train_multi_df, trial_val_single_df, trial_val_multi_df,␣
 ↪test_single_df, test_multi_df

def print_distinct_values(df, column_name):
    """Prints the distinct values of a specified column in a DataFrame."""
    distinct_values = df[column_name].unique()
    print(f"Distinct values in '{column_name}' column:")
    for value in distinct_values:
        print(value)
    print("-" * 30)  # Separator
```

```
# Print distinct values for each DataFrame
print_distinct_values(train_single_df, "corpus")
print_distinct_values(train_multi_df, "corpus")
print_distinct_values(trial_val_single_df, "subcorpus")
print_distinct_values(trial_val_multi_df, "subcorpus")
print_distinct_values(test_single_df, "corpus")
print_distinct_values(test_multi_df, "corpus")
```

```
Distinct values in 'corpus' column:
bible
biomed
europarl
------------------------------
Distinct values in 'corpus' column:
bible
biomed
europarl
------------------------------
Distinct values in 'subcorpus' column:
bible
biomed
europarl
------------------------------
Distinct values in 'subcorpus' column:
bible
biomed
europarl
------------------------------
Distinct values in 'corpus' column:
bible
biomed
europarl
------------------------------
Distinct values in 'corpus' column:
bible
biomed
europarl
------------------------------
```

0.1 standardize column headers: convert trial_val header from 'subcorpus' to 'corpus'

[20]:
```
# Rename the 'subcorpus' column to 'corpus'
trial_val_single_df = trial_val_single_df.rename(columns={'subcorpus':␣
↪'corpus'})
trial_val_multi_df = trial_val_multi_df.rename(columns={'subcorpus': 'corpus'})
```

```python
# Verify the change (optional)
print(trial_val_single_df.columns)
print(trial_val_multi_df.columns)
```

```
Index(['id', 'corpus', 'sentence', 'token', 'complexity'], dtype='object')
Index(['id', 'corpus', 'sentence', 'token', 'complexity'], dtype='object')
```

[21]:
```python
dataframes = [train_single_df, train_multi_df, trial_val_single_df,␣
↪trial_val_multi_df, test_single_df, test_multi_df]

# Get the headers (column names) of the first DataFrame as a reference
reference_headers = list(dataframes[0].columns)

# Loop through the remaining DataFrames and compare headers
all_headers_match = True
for df in dataframes[1:]:
    if list(df.columns) != reference_headers:
        all_headers_match = False
        print(f"Headers do not match for DataFrame: {df.head(0)}")  # Print␣
↪which DataFrame has different headers
        break  # Exit the loop if a mismatch is found

# Print the result
if all_headers_match:
    print("All DataFrames have matching headers.")
else:
    print("Headers do not match for all DataFrames.")
```

```
All DataFrames have matching headers.
```

0.2 Interrogate Span Length by Corpus Value by Data Split

[22]:
```python
# Analyzing sentence spans by complexity quartile and corpus

tokenizer = RegexpTokenizer(r'\w+') # setup tokenizer

def analyze_sentence_spans_by_corpus_and_quartile(dfs_dict):
    """
    Analyze sentence spans (length metrics) grouped by corpus and complexity␣
↪quartile
    for multiple dataframes.
    """
    results = []

    for df_name, df in dfs_dict.items():
        print(f"Processing {df_name}...")
```

```
        # Calculate complexity quartiles for this dataframe
        q1 = df['complexity'].quantile(0.25)
        q2 = df['complexity'].quantile(0.50)
        q3 = df['complexity'].quantile(0.75)

        # Define quartile ranges for labeling
        def get_quartile(x):
            if x <= q1:
                return 'Q1'
            elif x <= q2:
                return 'Q2'
            elif x <= q3:
                return 'Q3'
            else:
                return 'Q4'

        # Add quartile column
        df = df.copy()
        df['quartile'] = df['complexity'].apply(get_quartile)

        # Compute sentence metrics using RegexpTokenizer instead of␣
↪word_tokenize
        def compute_span_metrics(sentence):
            if pd.isna(sentence):
                return pd.Series({'word_count': 0, 'char_count': 0,␣
↪'avg_word_len': 0})

            # Use our tokenizer that doesn't require punkt_tab
            words = tokenizer.tokenize(sentence)
            word_count = len(words)
            char_count = len(sentence)
            avg_word_len = np.mean([len(word) for word in words]) if word_count␣
↪> 0 else 0
            return pd.Series({'word_count': word_count, 'char_count':␣
↪char_count, 'avg_word_len': avg_word_len})

        # Apply the function to each sentence
        span_metrics = df['sentence'].apply(compute_span_metrics)
        df = pd.concat([df, span_metrics], axis=1)

        # Get corpus column name (could be 'corpus' or 'subcorpus')
        corpus_col = 'corpus' if 'corpus' in df.columns else 'subcorpus'

        # Group by corpus and quartile
        for corpus_name, corpus_df in df.groupby(corpus_col):
            for quartile, quartile_df in corpus_df.groupby('quartile'):
                # Calculate statistics
```

```
                complexity_range = f"{quartile_df['complexity'].min():.
↪3f}-{quartile_df['complexity'].max():.3f}"
                stats = {
                    'Dataframe': df_name,
                    'Corpus': corpus_name,
                    'Quartile': quartile,
                    'Complexity Range': complexity_range,
                    'Count': len(quartile_df),
                    'Avg Words': quartile_df['word_count'].mean(),
                    'Median Words': quartile_df['word_count'].median(),
                    'Min Words': quartile_df['word_count'].min(),
                    'Max Words': quartile_df['word_count'].max(),
                    'Std Words': quartile_df['word_count'].std(),
                    'Avg Chars': quartile_df['char_count'].mean(),
                    'Avg Word Len': quartile_df['avg_word_len'].mean()
                }
                results.append(stats)

    # Convert to DataFrame and sort
    results_df = pd.DataFrame(results)
    results_df = results_df.sort_values(['Dataframe', 'Corpus', 'Quartile'])

    return results_df

# Create dictionary of dataframes
dfs = {
    'train_single_df': train_single_df,
    'train_multi_df': train_multi_df,
    'trial_val_single_df': trial_val_single_df,
    'trial_val_multi_df': trial_val_multi_df,
    'test_single_df': test_single_df,
    'test_multi_df': test_multi_df
}

# Run analysis
span_analysis = analyze_sentence_spans_by_corpus_and_quartile(dfs)

# Display results
pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
pd.set_option('display.width', 1000)
display(span_analysis)

# Save the analysis results
results_path = os.path.join(dir_results, 'sentence_span_analysis.csv')
span_analysis.to_csv(results_path, index=False)
print(f"Analysis saved to: {results_path}")
```

```
Processing train_single_df…
Processing train_multi_df…
Processing trial_val_single_df…
Processing trial_val_multi_df…
Processing test_single_df…
Processing test_multi_df…

              Dataframe    Corpus Quartile Complexity Range  Count  Avg Words ␣
↪Median Words  Min Words  Max Words  Std Words   Avg Chars  Avg Word Len
60        test_multi_df     bible       Q1      0.025-0.317     26  23.076923   ␣
↪       22.0         4.0       48.0  11.831900  118.653846      4.128898
61        test_multi_df     bible       Q2      0.325-0.417     11  20.545455   ␣
↪       17.0         7.0       47.0  12.917923  109.545455      4.209752
62        test_multi_df     bible       Q3      0.432-0.528     18  21.111111   ␣
↪       21.5         4.0       43.0  10.889222  112.777778      4.474206
63        test_multi_df     bible       Q4      0.542-0.694     11  22.363636   ␣
↪       20.0         7.0       51.0  11.935432  126.181818      4.605062
64        test_multi_df    biomed       Q1      0.000-0.312     11  29.818182   ␣
↪       29.0        17.0       47.0   8.388304  195.727273      5.491145
65        test_multi_df    biomed       Q2      0.324-0.417     11  27.090909   ␣
↪       24.0         9.0       47.0  11.449494  171.818182      5.436237
66        test_multi_df    biomed       Q3      0.456-0.528     10  26.900000   ␣
↪       26.5        10.0       49.0  10.712921  177.500000      5.497409
67        test_multi_df    biomed       Q4      0.562-0.800     21  32.285714   ␣
↪       34.0        14.0       56.0  13.598319  209.285714      5.460101
68        test_multi_df  europarl       Q1      0.214-0.303     10  24.700000   ␣
↪       24.5         7.0       56.0  14.189589  146.900000      5.049688
69        test_multi_df  europarl       Q2      0.321-0.429     24  27.833333   ␣
↪       27.0         9.0       73.0  15.352855  172.291667      5.269610
70        test_multi_df  europarl       Q3      0.432-0.516     18  32.944444   ␣
↪       32.0         6.0       68.0  19.129504  209.888889      5.512245
71        test_multi_df  europarl       Q4      0.531-0.562     13  39.000000   ␣
↪       36.0         6.0       95.0  29.631065  237.076923      5.100616
48       test_single_df     bible       Q1      0.000-0.214     79  22.835443   ␣
↪       22.0         7.0       49.0  10.602891  116.797468      4.031532
49       test_single_df     bible       Q2      0.217-0.276     68  24.176471   ␣
↪       21.0         2.0       77.0  14.393138  125.955882      4.167352
50       test_single_df     bible       Q3      0.278-0.353     67  22.388060   ␣
↪       20.0         4.0       63.0  11.306950  119.731343      4.254090
51       test_single_df     bible       Q4      0.359-0.732     69  20.579710   ␣
↪       19.0         1.0       55.0  11.264736  110.550725      4.337010
52       test_single_df    biomed       Q1      0.000-0.214     75  27.080000   ␣
↪       25.0        10.0       84.0  12.025603  172.893333      5.271985
53       test_single_df    biomed       Q2      0.217-0.275     58  30.275862   ␣
↪       26.0        10.0       83.0  15.856587  197.775862      5.434573
54       test_single_df    biomed       Q3      0.278-0.357     66  29.833333   ␣
↪       29.0        13.0       85.0  11.754650  191.863636      5.334048
```

```
55      test_single_df    biomed       Q4     0.359-0.778      90  31.144444
      30.0         14.0        83.0  12.089146  203.055556       5.393138
56      test_single_df  europarl       Q1     0.000-0.214      83  25.337349
      21.0          3.0        82.0  16.032191  151.891566       5.044222
57      test_single_df  europarl       Q2     0.217-0.276      98  32.326531
      30.0          1.0        97.0  18.707061  195.653061       5.062296
58      test_single_df  europarl       Q3     0.278-0.357      96  33.000000
      30.0          3.0       141.0  21.404377  201.760417       5.124551
59      test_single_df  europarl       Q4     0.361-0.583      68  33.235294
      29.0          1.0       130.0  20.440023  206.514706       5.164123
12      train_multi_df     bible       Q1     0.028-0.300     163  23.588957
      22.0          3.0        67.0  12.429421  124.834356       4.232989
13      train_multi_df     bible       Q2     0.304-0.409     132  24.053030
      22.0          6.0        65.0  11.738444  129.575758       4.302615
14      train_multi_df     bible       Q3     0.411-0.529     131  23.770992
      23.0          4.0        50.0  11.158691  127.389313       4.324088
15      train_multi_df     bible       Q4     0.533-0.778      79  25.481013
      24.0          3.0        81.0  13.490605  139.240506       4.486716
16      train_multi_df    biomed       Q1     0.028-0.303      87  29.091954
      28.0          9.0        77.0  11.882792  185.954023       5.276290
17      train_multi_df    biomed       Q2     0.304-0.408      74  30.716216
      28.0         11.0        85.0  13.521693  195.864865       5.370313
18      train_multi_df    biomed       Q3     0.411-0.529     111  29.783784
      29.0          8.0        61.0  10.912383  193.855856       5.430133
19      train_multi_df    biomed       Q4     0.531-0.975     242  29.595041
      28.0         10.0        75.0  12.040443  194.995868       5.534629
20      train_multi_df  europarl       Q1     0.118-0.303     132  29.363636
      27.0          3.0       101.0  17.874146  176.553030       5.002618
21      train_multi_df  europarl       Q2     0.304-0.409     171  31.654971
      28.0          3.0       108.0  19.099221  195.152047       5.176834
22      train_multi_df  europarl       Q3     0.411-0.529     138  33.398551
      30.0          7.0       101.0  18.992715  208.304348       5.286607
23      train_multi_df  europarl       Q4     0.533-0.750      57  34.596491
      31.0          6.0        96.0  20.318763  218.350877       5.345891
0      train_single_df     bible       Q1     0.000-0.212     701  23.275321
      22.0          4.0        61.0  11.760701  121.607703       4.126789
1      train_single_df     bible       Q2     0.212-0.279     640  23.753125
      22.0          3.0        60.0  11.577932  124.576562       4.148961
2      train_single_df     bible       Q3     0.281-0.375     624  23.823718
      22.0          3.0        70.0  11.958906  126.230769       4.208102
3      train_single_df     bible       Q4     0.380-0.861     609  23.577997
      21.0          3.0        69.0  12.461688  126.518883       4.295608
4      train_single_df    biomed       Q1     0.000-0.212     586  28.534130
      27.0          2.0        85.0  12.115387  182.011945       5.319754
5      train_single_df    biomed       Q2     0.212-0.279     583  30.435678
      29.0          7.0        92.0  11.872558  193.789022       5.285758
```

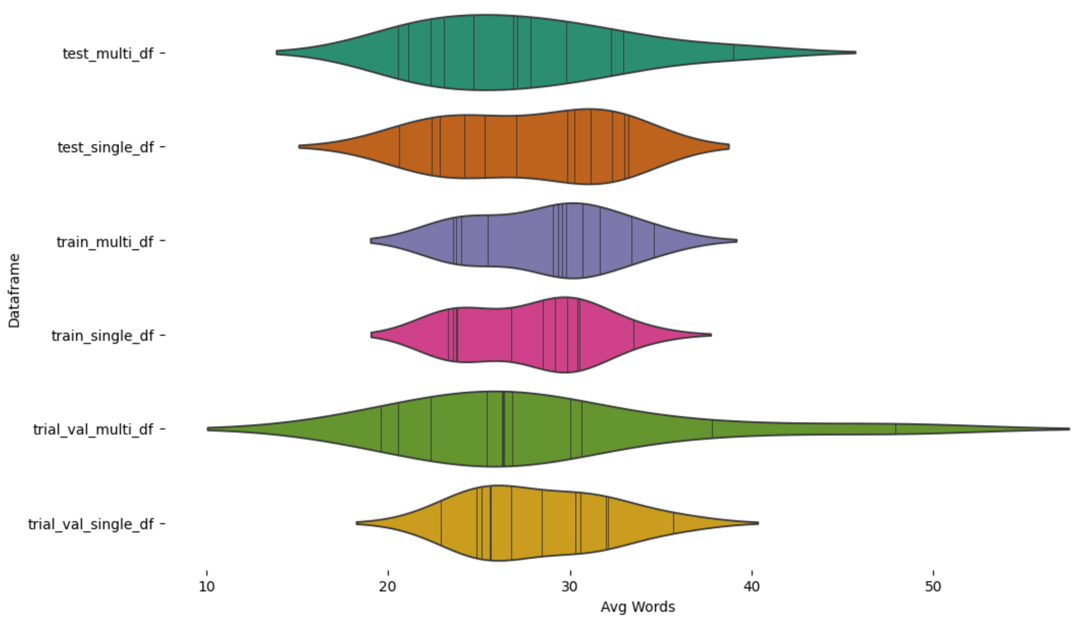
```
6        train_single_df    biomed       Q3     0.281-0.375     659  29.860395
 ↪      28.0          4.0         77.0  11.591263  191.050076      5.328161
7        train_single_df    biomed       Q4     0.381-0.861     748  29.176471
 ↪      28.0          3.0         85.0  12.246613  186.909091      5.298112
8        train_single_df  europarl       Q1     0.025-0.212     641  26.761310
 ↪      24.0          2.0        107.0  15.230853  159.180967      4.942557
9        train_single_df  europarl       Q2     0.212-0.279     714  30.420168
 ↪      27.0          1.0        129.0  18.383783  183.093838      4.995672
10       train_single_df  europarl       Q3     0.281-0.375     701  30.523538
 ↪      28.0          1.0        122.0  18.163026  185.840228      5.114587
11       train_single_df  europarl       Q4     0.381-0.775     456  33.528509
 ↪      31.0          2.0        235.0  21.704693  203.592105      5.054701
36    trial_val_multi_df     bible       Q1     0.000-0.292      11  26.272727
 ↪      21.0         13.0         64.0  13.950562  141.363636      4.282457
37    trial_val_multi_df     bible       Q2     0.333-0.400       7  20.571429
 ↪      23.0          5.0         28.0   7.412987  110.857143      4.279406
38    trial_val_multi_df     bible       Q3     0.425-0.500       5  19.600000
 ↪      19.0          9.0         32.0   8.905055  109.200000      4.431391
39    trial_val_multi_df     bible       Q4     0.525-0.661       6  22.333333
 ↪      20.5          9.0         44.0  12.242004  117.833333      4.178525
40    trial_val_multi_df    biomed       Q1     0.083-0.303       6  26.833333
 ↪      25.0         15.0         49.0  11.771434  159.166667      4.899969
41    trial_val_multi_df    biomed       Q2     0.317-0.422       7  25.428571
 ↪      21.0         15.0         48.0  11.588171  156.000000      5.194383
42    trial_val_multi_df    biomed       Q3     0.438-0.513       6  37.833333
 ↪      39.5         26.0         44.0   6.675827  247.500000      5.438593
43    trial_val_multi_df    biomed       Q4     0.537-0.825      14  30.642857
 ↪      29.5         17.0         43.0   9.849695  211.428571      5.730623
44    trial_val_multi_df  europarl       Q1     0.176-0.306       8  30.000000
 ↪      25.5          4.0         64.0  20.361027  186.750000      5.306837
45    trial_val_multi_df  europarl       Q2     0.312-0.412      11  47.909091
 ↪      46.0         24.0         78.0  18.651834  296.909091      5.058375
46    trial_val_multi_df  europarl       Q3     0.432-0.500      13  26.307692
 ↪      26.0          5.0         66.0  18.167666  166.153846      5.263847
47    trial_val_multi_df  europarl       Q4     0.515-0.714       5  26.400000
 ↪      15.0          6.0         66.0  24.316661  164.600000      4.998182
24   trial_val_single_df     bible       Q1     0.000-0.214      52  26.750000
 ↪      26.0          5.0         73.0  15.530962  137.230769      4.071006
25   trial_val_single_df     bible       Q2     0.217-0.266      38  24.868421
 ↪      23.0          7.0         50.0  10.768249  131.236842      4.195550
26   trial_val_single_df     bible       Q3     0.268-0.355      26  22.884615
 ↪      20.5          5.0         44.0   9.961233  121.269231      4.312026
27   trial_val_single_df     bible       Q4     0.361-0.633      27  25.666667
 ↪      23.0          6.0         49.0  12.554497  137.555556      4.212685
28   trial_val_single_df    biomed       Q1     0.028-0.214      21  25.571429
 ↪      21.0         13.0         65.0  11.543706  163.904762      5.305404
```

```
29  trial_val_single_df    biomed      Q2     0.217-0.267     28  30.571429   ␣
 ↪      27.5        11.0        57.0  12.099674  198.142857      5.315287
30  trial_val_single_df    biomed      Q3     0.268-0.359     38  32.105263   ␣
 ↪      29.0        11.0        61.0  12.710476  206.947368      5.364934
31  trial_val_single_df    biomed      Q4     0.364-0.875     48  25.145833   ␣
 ↪      25.5         6.0        56.0  11.721937  163.979167      5.439709
32  trial_val_single_df  europarl      Q1     0.050-0.214     33  31.969697   ␣
 ↪      28.0         5.0        81.0  20.356947  185.969697      4.799024
33  trial_val_single_df  europarl      Q2     0.217-0.267     41  28.463415   ␣
 ↪      28.0         4.0        71.0  15.386841  172.780488      4.997706
34  trial_val_single_df  europarl      Q3     0.268-0.359     39  30.282051   ␣
 ↪      28.0         3.0        99.0  20.040681  184.358974      5.086945
35  trial_val_single_df  europarl      Q4     0.367-0.605     30  35.700000   ␣
 ↪      30.5         5.0        77.0  20.142852  215.400000      4.910759

Analysis saved to:
/content/drive/MyDrive/266-final/results/sentence_span_analysis.csv
```

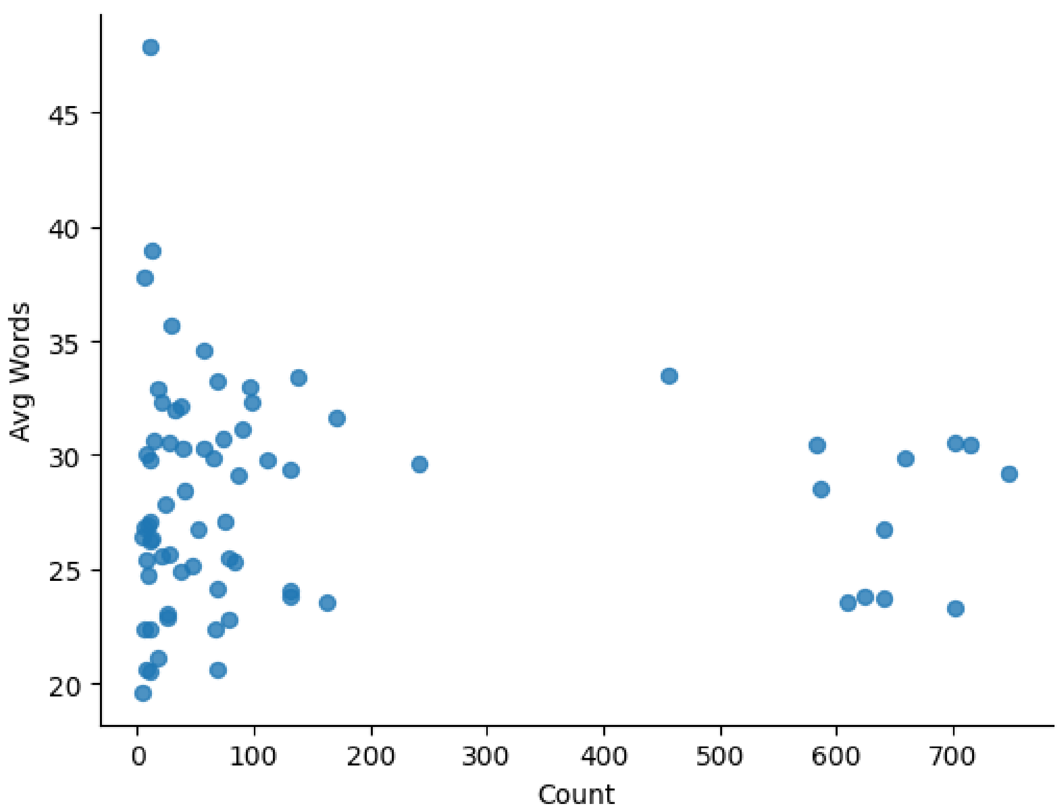
[23]:

```python
from matplotlib import pyplot as plt
import seaborn as sns
figsize = (12, 1.2 * len(span_analysis['Dataframe'].unique()))
plt.figure(figsize=figsize)
sns.violinplot(span_analysis, x='Avg Words', y='Dataframe', inner='stick',␣
 ↪palette='Dark2')
sns.despine(top=True, right=True, bottom=True, left=True)
```

```
<ipython-input-23-00a8ad5642c1>:5: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
v0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same
effect.

  sns.violinplot(span_analysis, x='Avg Words', y='Dataframe', inner='stick',
palette='Dark2')
```

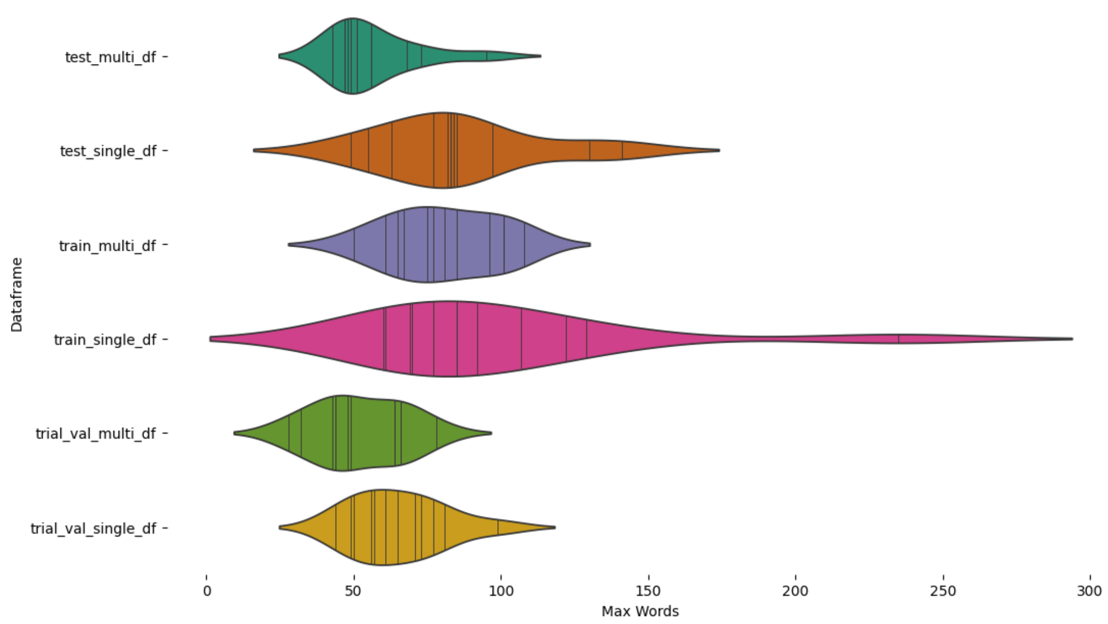


[24]:
```
from matplotlib import pyplot as plt
span_analysis.plot(kind='scatter', x='Count', y='Avg Words', s=32, alpha=.8)
plt.gca().spines[['top', 'right',]].set_visible(False)
```



[25]:
```
from matplotlib import pyplot as plt
import seaborn as sns
figsize = (12, 1.2 * len(span_analysis['Dataframe'].unique()))
plt.figure(figsize=figsize)
sns.violinplot(span_analysis, x='Max Words', y='Dataframe', inner='stick',␣
↪palette='Dark2')
sns.despine(top=True, right=True, bottom=True, left=True)
```

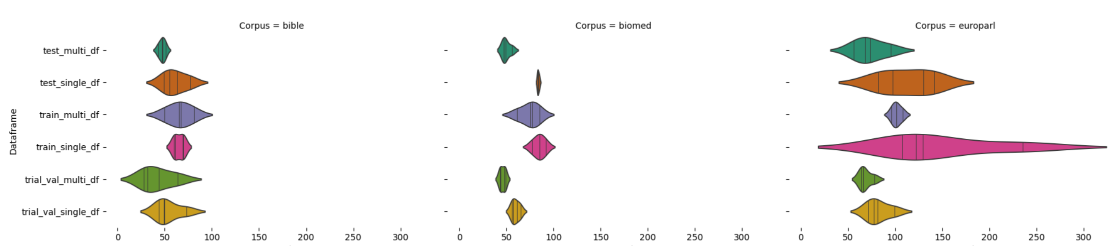
```
<ipython-input-25-01bf0c89d620>:5: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
v0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same
effect.

  sns.violinplot(span_analysis, x='Max Words', y='Dataframe', inner='stick',
palette='Dark2')
```



[26]:
```
# Create a FacetGrid
g = sns.FacetGrid(span_analysis, col="Corpus", col_wrap=3, height=4, aspect=1.
↪5)  # Adjust col_wrap and height as needed

# Map the violinplot to the FacetGrid
g.map(sns.violinplot, "Max Words", "Dataframe", inner='stick', palette='Dark2')
```

```python
# Remove spines for cleaner look
g.despine(top=True, right=True, bottom=True, left=True)

# Adjust layout and display the plot
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:718: UserWarning:
Using the violinplot function without specifying `order` is likely to produce an
incorrect plot.
  warnings.warn(warning)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:854: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
v0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same
effect.

  func(*plot_args, **plot_kwargs)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:854: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
v0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same
effect.

  func(*plot_args, **plot_kwargs)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:854: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
v0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same
effect.

  func(*plot_args, **plot_kwargs)
```



- decision: no modifications to sentence spans will be applied, except for Contraction standardization

0.3 Normalize / Eliminate Contractions

[27]:
```
# --- STEP 1: CREATE A UTILITY FUNCTION ---

def expand_contractions_in_df(df):
    """
    1) Creates a new column 'sentence_no_contractions' by expanding any␣
 ↪contractions.
    2) Identifies rows where a contraction was actually expanded (the text␣
 ↪changed).
    3) Returns the updated DataFrame and a grouped subset of rows for printing␣
 ↪examples.
    """
    df = df.copy()

    # Create the new column with expanded contractions
    df['sentence_no_contractions'] = df['sentence'].apply(
        lambda s: contractions.fix(s) if pd.notna(s) else s
    )

    # Check if anything changed after expansion:
    df['contraction_expanded'] = df.apply(
        lambda row: row['sentence'] != row['sentence_no_contractions'], axis=1
    )

    # Group by corpus
    results_by_corpus = {}
    for corpus_val, group in df.groupby('corpus'):
        # Filter to rows that actually had a contraction
        changed_rows = group[group['contraction_expanded']]
        # Take the first 3
        first_three = changed_rows.head(3)
        results_by_corpus[corpus_val] = first_three

    return df, results_by_corpus


# --- STEP 2: APPLY TO ALL 6 DATAFRAMES ---

dataframes_info = [
    ("train_single_df", train_single_df),
    ("train_multi_df", train_multi_df),
    ("trial_val_single_df", trial_val_single_df),
    ("trial_val_multi_df", trial_val_multi_df),
    ("test_single_df", test_single_df),
    ("test_multi_df", test_multi_df),
]
```

```python
for df_name, df in dataframes_info:
    # Expand contractions and collect examples
    updated_df, corpus_examples = expand_contractions_in_df(df)

    # Overwrite the old DataFrame variable if desired:
    # (So that we retain the new column for future tasks)
    # Otherwise, you can store it in a new variable.
    globals()[df_name] = updated_df

    # Print 3 "before" and 3 "after" examples per corpus
    print(f"\n{'='*60}")
    print(f"DataFrame: {df_name}")
    print(f"{'='*60}")

    for corpus_val in sorted(corpus_examples.keys()):
        subset = corpus_examples[corpus_val]

        # Only proceed if we found any changed rows in this corpus
        if len(subset) == 0:
            continue

        print(f"\n  Corpus: {corpus_val}")

        # Print BEFORE lines
        print("    -- BEFORE --")
        for _, row in subset.iterrows():
            print(f"       {row['sentence']}")

        # Print AFTER lines
        print("    -- AFTER  --")
        for _, row in subset.iterrows():
            print(f"       {row['sentence_no_contractions']}")
```

```
============================================================
DataFrame: train_single_df
============================================================

  Corpus: bible
    -- BEFORE --
       Shimei had sixteen sons and six daughters; but his brothers didn't have
many children, neither did all their family multiply like the children of Judah.
       When his speech is charming, don't believe him; for there are seven
abominations in his heart.
       Jesus said, "Father, forgive them, for they don't know what they are
doing."
    -- AFTER  --
```

Shimei had sixteen sons and six daughters; but his brothers did not have many children, neither did all their family multiply like the children of Judah.

When his speech is charming, do not believe him; for there are seven abominations in his heart.

Jesus said, "Father, forgive them, for they do not know what they are doing."

Corpus: biomed

-- BEFORE --

Although missense mutation of ITPR1 had previously been ruled out [2] and the mode of inheritance was inconsistent with that seen in the Itpr1Δ18 and Itpr1opt mice, the phenotypic presence of ataxia in the mice led us to reexamine this candidate gene as a possible cause of SCA15.

Human germline mutations in APC cause FAP [4,5], which is characterized by hundreds of adenomatous colorectal polyps, with an almost inevitable progression to colorectal cancer in the third and fourth decades of life.

Null mutations in Bmpr1a cause early embryonic lethality, with defects in gastrulation similar to those seen in mice with mutations in Bmp4 (Mishina et al. 1995; Winnier et al. 1995).

-- AFTER --

Although missense mutation of ITPR1 had previously been ruled out [2] and the mode of inheritance was inconsistent with that seen in the Itpr1Δ18 and Itpr1opt mice, the phenotypic presence of ataxia in the mice led us to reexamine this candidate gene as a possible because of SCA15.

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Null mutations in Bmpr1a because early embryonic lethality, with defects in gastrulation similar to those seen in mice with mutations in Bmp4 (Mishina et al. 1995; Winnier et al. 1995).

Corpus: europarl

-- BEFORE --

At the same time, you will also have an important role in winning over the general public of the Member States to the cause of enlargement, of enlargement based on conditionality.

the recommendation for second reading from the Committee on Transport and Tourism on the common position adopted by the Council with a view to the adoption of a Regulation of the European Parliament and of the Council establishing common rules concerning the conditions to be complied with to pursue the occupation of road transport operator and repealing Council Directive 96/26/EC (11783/1/2008 - C6-0015/2009 - (Rapporteur: Silvia-Adriana Ţicău), and

Yet, although credit rating agencies were not the main cause of the recent financial crisis, they did have a harmful influence.

-- AFTER --

At the same time, you will also have an important role in winning over the general public of the Member States to the because of enlargement, of enlargement based on conditionality.

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Yet, although credit rating agencies were not the main because of the recent financial crisis, they did have a harmful influence.

```
============================================================
DataFrame: train_multi_df
============================================================

  Corpus: bible
    -- BEFORE --
       Jahath was the chief, and Zizah the second: but Jeush and Beriah didn't have many sons; therefore they became a fathers' house in one reckoning.
       But Yahweh said to Samuel, "Don't look on his face, or on the height of his stature; because I have rejected him: for I see not as man sees; for man looks at the outward appearance, but Yahweh looks at the heart."
       Because indeed a notable miracle has been done through them, as can be plainly seen by all who dwell in Jerusalem, and we can't deny it.
    -- AFTER  --
       Jahath was the chief, and Zizah the second: but Jeush and Beriah did not have many sons; therefore they became a fathers' house in one reckoning.
       But Yahweh said to Samuel, "Do not look on his face, or on the height of his stature; because I have rejected him: for I see not as man sees; for man looks at the outward appearance, but Yahweh looks at the heart."
       Because indeed a notable miracle has been done through them, as can be plainly seen by all who dwell in Jerusalem, and we cannot deny it.

  Corpus: biomed
    -- BEFORE --
       The aim in the present study was to determine the location of pendrin and the cause of deafness in Slc26a4-/- mice.
       These characteristics should make RMCE-ASAP a robust and general technology for analysis of mammalian genes under conditions that preserve normal control mechanisms in different tissues.
       It was also demonstrated that mutations leading to abolishment of the enzymatic activity of CLN2 were the direct cause of a fatal inherited neurodegenerative disease, classical late-infantile neuronal ceroid lipofuscinosis [2].
    -- AFTER  --
       The aim in the present study was to determine the location of pendrin and the because of deafness in Slc26a4-/- mice.
       These characteristics should make RMCE-AS SOON AS POSSIBLE a robust and general technology for analysis of mammalian genes under conditions that
```

```
preserve normal control mechanisms in different tissues.
       It was also demonstrated that mutations leading to abolishment of the
enzymatic activity of CLN2 were the direct because of a fatal inherited
neurodegenerative disease, classical late-infantile neuronal ceroid
lipofuscinosis [2].

  Corpus: europarl
    -- BEFORE --
       Account must also be taken of the costs to health, the environment and
the climate of the fact that vehicles emit different types of particles and
that, in burning fossil fuels, they cause increased pollution and thus more
global warming.
       However, this unequal trade relationship is not the only cause for
concern; another is the case of unsafe products coming from China.
       (IT) Madam President, ladies and gentlemen, the oral amendment that our
Group is proposing involves replacing the words 'all forms of glorifying' by the
word 'apology'.
    -- AFTER  --
       Account must also be taken of the costs to health, the environment and
the climate of the fact that vehicles emit different types of particles and
that, in burning fossil fuels, they because increased pollution and thus more
global warming.
       However, this unequal trade relationship is not the only because for
concern; another is the case of unsafe products coming from China.
       (IT) Madam President, ladies and gentlemen, the oral amendment that our
Group is proposing involves replacing the words  forms of glorifying' by the
word 'apology'.

============================================================
DataFrame: trial_val_single_df
============================================================

  Corpus: bible
    -- BEFORE --
       Don't curse the king, no, not in your thoughts; and don't curse the rich
in your bedroom: for a bird of the sky may carry your voice, and that which has
wings may tell the matter.
       The young man didn't wait to do this thing, because he had delight in
Jacob's daughter, and he was honored above all the house of his father.
       If the axe is blunt, and one doesn't sharpen the edge, then he must use
more strength; but skill brings success.
    -- AFTER  --
       Do not curse the king, no, not in your thoughts; and do not curse the
rich in your bedroom: for a bird of the sky may carry your voice, and that which
has wings may tell the matter.
       The young man did not wait to do this thing, because he had delight in
Jacob's daughter, and he was honored above all the house of his father.
       If the axe is blunt, and one does not sharpen the edge, then he must use
```

```
more strength; but skill brings success.

  Corpus: biomed
    -- BEFORE --
       For example, the non-BC individual and BC individual groups are not
perfectly matched with respect to age, gender or smoking history (Table 1) and
each of these factors could contribute to the observed difference in correlation
between groups.
       EM and ER conducted transmission electron microscopy.
    -- AFTER  --
       For example, the non-BECAUSE individual and BECAUSE individual groups are
not perfectly matched with respect to age, gender or smoking history (Table 1)
and each of these factors could contribute to the observed difference in
correlation between groups.
       THEM and ER conducted transmission electron microscopy.

  Corpus: europarl
    -- BEFORE --
       With their help, John has sought to shed light on what has been a very
murky area, and to bring clarity where uncertainty prevailed before, based
consistently on the twin principles that the patient must always come first and
that patient choice should be determined by needs and not by means.
    -- AFTER  --
       With their help, John has sought to she would light on what has been a
very murky area, and to bring clarity where uncertainty prevailed before, based
consistently on the twin principles that the patient must always come first and
that patient choice should be determined by needs and not by means.

============================================================
DataFrame: trial_val_multi_df
============================================================

============================================================
DataFrame: test_single_df
============================================================


  Corpus: bible
    -- BEFORE --
       the ten sons of Haman the son of Hammedatha, the Jew's enemy, but they
didn't lay their hand on the plunder.
       Hezekiah listened to them, and showed them all the house of his precious
things, the silver, and the gold, and the spices, and the precious oil, and the
house of his armor, and all that was found in his treasures: there was nothing
in his house, nor in all his dominion, that Hezekiah didn't show them.
       Of Manasseh also there fell away some to David, when he came with the
Philistines against Saul to battle; but they didn't help them; for the lords of
the Philistines sent him away after consultation, saying, "He will fall away to
his master Saul to the jeopardy of our heads."
```

-- AFTER --

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Hezekiah listened to them, and showed them all the house of his precious things, the silver, and the gold, and the spices, and the precious oil, and the house of his armor, and all that was found in his treasures: there was nothing in his house, nor in all his dominion, that Hezekiah did not show them.

Of Manasseh also there fell away some to David, when he came with the Philistines against Saul to battle; but they did not help them; for the lords of the Philistines sent him away after consultation, saying, "He will fall away to his master Saul to the jeopardy of our heads."

Corpus: biomed

-- BEFORE --

In that study, there was a tendency towards correlation in transcript abundance between several pairs of antioxidant or DNA repair genes in non-BC individuals, but not in BC individuals.

This, in turn, leads to increased representation among BC individuals of individuals with lack of correlation between CEBPG and each of the affected antioxidant and/or DNA repair genes.

The 'pregnancy rate' in mice is defined as successful pregnancies per detected vaginal plug, a phenotype associated with early pregnancy failure, which in turn possibly could have an inflammatory cause.

-- AFTER --

In that study, there was a tendency towards correlation in transcript abundance between several pairs of antioxidant or DNA repair genes in non-BECAUSE individuals, but not in BECAUSE individuals.

This, in turn, leads to increased representation among BECAUSE individuals of individuals with lack of correlation between CEBPG and each of the affected antioxidant and/or DNA repair genes.

The 'pregnancy rate' in mice is defined as successful pregnancies per detected vaginal plug, a phenotype associated with early pregnancy failure, which in turn possibly could have an inflammatory because.

Corpus: europarl

-- BEFORE --

The next item is the oral question to the Commission (B7-0240/2009) by Silvia-Adriana Ţicău, Brian Simpson, János Áder, Hannes Swoboda, Eva Lichtenberger, Michael Cramer, Saïd El Khadraoui, Mathieu Grosch, Iuliu Winkler, Victor Boştinaru, Ioan Mircea Paşcu, Marian-Jean Marinescu, Ivailo Kalfin, Norica Nicolai, Dirk Sterckx, Csaba Sándor Tabajdi, Michael Theurer, Ismail Ertug, Inés Ayala Sender, Jiří Havel, Edit Herczog, Stanimir Ilchev, Iliana Malinova Iotova, Jelko Kacin, Evgeni Kirilov, Ádám Kósa, Ioan Enciu, Eduard Kukan, Gesine Meissner, Alajos Mészáros, Nadezhda Neynsky, Katarína Neveďalová, Daciana Octavia Sârbu, Vilja Savisaar, Olga Sehnalová, Catherine Stihler, Peter van Dalen, Louis Grech, Corina Creţu, George Sabin Cutaş, Vasilica Viorica Dăncilă, Cătălin Sorin Ivan, Tanja Fajon, Kinga Göncz, Antonyia Parvanova, Adina-Ioana Vălean and Rovana Plumb, on the European Strategy for the Danube

```
Region.
    -- AFTER  --
       The next item is the oral question to the Commission (B7-0240/2009) by
Silvia-Adriana Ţicăyou, Brian Simpson, János Áder, Hannes Swoboda, Eva
Lichtenberger, Michael Cramer, Saïd El Khadraoui, Mathieu Grosch, Iuliu Winkler,
Victor Boştinaru, Ioan Mircea Paşcu, Marian-Jean Marinescu, Ivailo Kalfin,
Norica Nicolai, Dirk Sterckx, Csaba Sándor Tabajdi, Michael Theurer, Ismail
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Malinova Iotova, Jelko Kacin, Evgeni Kirilov, Ádám Kósa, Ioan Enciu, Eduard
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Adina-Ioana Vălean and Rovana Plumb, on the European Strategy for the Danube
Region.

============================================================
DataFrame: test_multi_df
============================================================

  Corpus: bible
    -- BEFORE --
       Yet he didn't leave himself without witness, in that he did good and gave
you rains from the sky and fruitful seasons, filling our hearts with food and
gladness."
       When he has leveled its surface, doesn't he plant the dill, and scatter
the cumin seed, and put in the wheat in rows, the barley in the appointed place,
and the spelt in its place?
       Don't count your handmaid for a wicked woman; for I have been speaking
out of the abundance of my complaint and my provocation."
    -- AFTER  --
       Yet he did not leave himself without witness, in that he did good and
gave you rains from the sky and fruitful seasons, filling our hearts with food
and gladness."
       When he has leveled its surface, does not he plant the dill, and scatter
the cumin seed, and put in the wheat in rows, the barley in the appointed place,
and the spelt in its place?
       Do not count your handmaid for a wicked woman; for I have been speaking
out of the abundance of my complaint and my provocation."
```

[28]:
```python
# check for null values

dataframes = [train_single_df, train_multi_df, trial_val_single_df,␣
 ↪trial_val_multi_df, test_single_df, test_multi_df]
for df in dataframes:
  print(df['sentence_no_contractions'].isnull().values.any())
```

```
False
```

```
False
False
False
False
False
```

[29]:
```python
dataframes = {
    "train_single_df": train_single_df,
    "train_multi_df": train_multi_df,
    "trial_val_single_df": trial_val_single_df,
    "trial_val_multi_df": trial_val_multi_df,
    "test_single_df": test_single_df,
    "test_multi_df": test_multi_df
}

total_true_counts = 0
for df_name, df in dataframes.items():
    true_count = df['contraction_expanded'].sum()
    print(f"{df_name}: {true_count} True values in 'contraction_expanded'")
    total_true_counts += true_count

print(f"\nTotal True values across all dataframes: {total_true_counts}")
```

```
train_single_df: 254 True values in 'contraction_expanded'
train_multi_df: 54 True values in 'contraction_expanded'
trial_val_single_df: 16 True values in 'contraction_expanded'
trial_val_multi_df: 0 True values in 'contraction_expanded'
test_single_df: 31 True values in 'contraction_expanded'
test_multi_df: 7 True values in 'contraction_expanded'

Total True values across all dataframes: 362
```

[30]:
```python
# verify column headers

dataframes = [train_single_df, train_multi_df, trial_val_single_df,␣
 ↪trial_val_multi_df, test_single_df, test_multi_df]
for df in dataframes:
  print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7662 entries, 0 to 7661
Data columns (total 7 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       7662 non-null   object
 1   corpus                   7662 non-null   object
 2   sentence                 7662 non-null   object
 3   token                    7655 non-null   object
 4   complexity               7662 non-null   float64
```

```
 5   sentence_no_contractions  7662 non-null   object
 6   contraction_expanded      7662 non-null   bool
dtypes: bool(1), float64(1), object(5)
memory usage: 366.8+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1517 entries, 0 to 1516
Data columns (total 7 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   id                        1517 non-null   object
 1   corpus                    1517 non-null   object
 2   sentence                  1517 non-null   object
 3   token                     1517 non-null   object
 4   complexity                1517 non-null   float64
 5   sentence_no_contractions  1517 non-null   object
 6   contraction_expanded      1517 non-null   bool
dtypes: bool(1), float64(1), object(5)
memory usage: 72.7+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 421 entries, 0 to 420
Data columns (total 7 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   id                        421 non-null    object
 1   corpus                    421 non-null    object
 2   sentence                  421 non-null    object
 3   token                     421 non-null    object
 4   complexity                421 non-null    float64
 5   sentence_no_contractions  421 non-null    object
 6   contraction_expanded      421 non-null    bool
dtypes: bool(1), float64(1), object(5)
memory usage: 20.3+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 99 entries, 0 to 98
Data columns (total 7 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   id                        99 non-null     object
 1   corpus                    99 non-null     object
 2   sentence                  99 non-null     object
 3   token                     99 non-null     object
 4   complexity                99 non-null     float64
 5   sentence_no_contractions  99 non-null     object
 6   contraction_expanded      99 non-null     bool
dtypes: bool(1), float64(1), object(5)
```

```
memory usage: 4.9+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 917 entries, 0 to 916
Data columns (total 7 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       917 non-null    object
 1   corpus                   917 non-null    object
 2   sentence                 917 non-null    object
 3   token                    917 non-null    object
 4   complexity               917 non-null    float64
 5   sentence_no_contractions 917 non-null    object
 6   contraction_expanded     917 non-null    bool
dtypes: bool(1), float64(1), object(5)
memory usage: 44.0+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 184 entries, 0 to 183
Data columns (total 7 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       184 non-null    object
 1   corpus                   184 non-null    object
 2   sentence                 184 non-null    object
 3   token                    184 non-null    object
 4   complexity               184 non-null    float64
 5   sentence_no_contractions 184 non-null    object
 6   contraction_expanded     184 non-null    bool
dtypes: bool(1), float64(1), object(5)
memory usage: 8.9+ KB
None
```

[31]:

```python
# inspect each df

dataframes = [train_single_df, train_multi_df, trial_val_single_df,
 ↪trial_val_multi_df, test_single_df, test_multi_df]
for df in dataframes:
  print(df.head())
```

```
                               id corpus
sentence     token  complexity
sentence_no_contractions  contraction_expanded
0  3ZLW647WALVGE8EBR50EGUBPU4P32A  bible  Behold, there came up out of the river
seven c…     river    0.000000  Behold, there came up out of the river seven
c…                 False
1  34R0BODSP1ZBN3DVY8J8XSIY551E5C  bible  I am a fellow bondservant with you and
with yo…  brothers    0.000000  I am a fellow bondservant with you and with
```

```
yo…                False
2  3S1WOPCJFGTJU2SGNAN2Y213N6WJE3  bible  The man, the lord of the land, said to
us, 'By…  brothers    0.050000  The man, the lord of the land, said to us,
'By…                False
3  3BFNCI9LYKQNO9BHXHH9CLSX5KP738  bible  Shimei had sixteen sons and six
daughters; but…  brothers    0.150000  Shimei had sixteen sons and six
daughters; but…                True
4  3G5RUKN2EC3YIWSKUXZ8ZVH95R49N2  bible              "He has put my brothers
far from me.  brothers    0.263889              "He has put my brothers far
from me.                False
                               id corpus
sentence            token  complexity
sentence_no_contractions  contraction_expanded
0  3S37Y8CWI80N8KVM53U4E6JKCDC4WE  bible  but the seventh day is a Sabbath to
Yahweh you…      seventh day    0.027778  but the seventh day is a Sabbath to
Yahweh you…                False
1  3WGCNLZJKF877FYC1Q6COKNWTDWD11  bible  But let each man test his own work,
and then h…         own work    0.050000  But let each man test his own work,
and then h…                False
2  3UOMW19E6D6WQ5TH2HDD74IVKTP5CB  bible  To him who by understanding made the
heavens; …  loving kindness    0.050000  To him who by understanding made the
heavens; …                False
3  36JW4WBR06KF9AXMUL4N476OMF8FHD  bible  Remember to me, my God, this also, and
spare m…  loving kindness    0.050000  Remember to me, my God, this also, and
spare m…                False
4  3HRWUH63QU2FH9Q8R7MRNFC7JX2N5A  bible  Because your loving kindness is better
than li…  loving kindness    0.075000  Because your loving kindness is better
than li…                False
                               id corpus
sentence token  complexity                           sentence_no_contractions
contraction_expanded
0  3QI9WAYOGQB8GQIR4MDIEF0D2RLS67  bible  They will not hurt nor destroy in all
my holy …   sea    0.000000  They will not hurt nor destroy in all my holy …
False
1  3T8DUCXY0N6WD9X4RTLK8UN1U929TF  bible  that sends ambassadors by the sea,
even in ves…   sea    0.102941  that sends ambassadors by the sea, even in
ves…                False
2  3I7KR83SNADXAQ7HXK7S7305BYB9KD  bible  and they entered into the boat, and
were going…   sea    0.109375  and they entered into the boat, and were
going…                False
3  3BO3NEOQM0HK9ERYPN0GQIWCPC4IAQ  bible  Joseph laid up grain as the sand of
the sea, v…   sea    0.160714  Joseph laid up grain as the sand of the sea,
v…                False
4  3Y3CZJSZ9KT0W7I0KE38WZHHKSW5RH  bible  There will be a highway for the
remnant that i…  land    0.000000  There will be a highway for the remnant
that i…                False
                               id corpus
sentence          token  complexity
```

```
sentence_no_contractions  contraction_expanded
0  31HLTCK4BLVQ5BO1AUR91TX9V9IVGH  bible  The name of one son was Gershom, for
Moses sai…   foreign land    0.000000  The name of one son was Gershom, for
Moses sai…                  False
1  389A2A304OIXVY7G5B71Q9M43LE0CL  bible  unleavened bread, unleavened cakes
mixed with …    wheat flour    0.157895  unleavened bread, unleavened cakes
mixed with …                  False
2  31N9JPQXIPIRX2A3S9N0CCFXO6TNHR  bible  However the high places were not taken
away; t…  burnt incense    0.200000  However the high places were not taken
away; t…                  False
3  3JVP4ZJHDPSO81TGXL3N1CKZGQY0IN  bible  and he burnt incense of sweet spices
on it, as…  burnt incense    0.250000  and he burnt incense of sweet spices on
it, as…                  False
4  3JAOYN9IHL25ZQAUV5EJZ4GH0KL33L  bible  The same day the king made the middle
of the c…   bronze altar    0.214286  The same day the king made the middle of
the c…                  False
                               id corpus
sentence     token  complexity
sentence_no_contractions  contraction_expanded
0  3K8CQCU3KE19US5SN890DFPK3SANWR  bible  But he, beckoning to them with his
hand to be …      hand    0.000000  But he, beckoning to them with his hand to
be …                  False
1  3Q2T3FDOON86LCI41NJYV3PN0BW3MV  bible  If I forget you, Jerusalem, let my
right hand …      hand    0.197368  If I forget you, Jerusalem, let my right
hand …                  False
2  3ULIZ0H1VA5C32JJMKOTQ8Z4GUS51B  bible  the ten sons of Haman the son of
Hammedatha, t…      hand    0.200000  the ten sons of Haman the son of
Hammedatha, t…                  True
3  3BFF0DJK8XCEIOT30ZLBPPSRMZQTSD  bible  Let your hand be lifted up above your
adversar…      hand    0.267857  Let your hand be lifted up above your
adversar…                  False
4  3QREJ3J433XSBS8QMHAICCR0BQ1LKR  bible  Abimelech chased him, and he fled
before him, …  entrance    0.000000  Abimelech chased him, and he fled before
him, …                  False
                               id corpus
sentence           token  complexity
sentence_no_contractions  contraction_expanded
0  3UXQ63NLAAMRIP4WG4XPD98AOYOBLX  bible  for he had an only daughter, about
twelve year…   only daughter    0.025000  for he had an only daughter, about
twelve year…                  False
1  3FJ2RVH25Z62TA3R8E1O77EBUYU92W  bible  All these were cities fortified with
high wall…      high walls    0.100000  All these were cities fortified with
high wall…                  False
2  3YO4AH2FPDK1PZHZAT8WAEBL70EQ0F  bible  In the morning, 'It will be foul
weather today…   weather today    0.125000  In the morning, 'It will be foul
weather today…                  False
3  3X52SWXE0X5Q3O81YI0MX4V84QTCWZ  bible  Her young children also were dashed in
pieces …  young children    0.160714  Her young children also were dashed in
```

```
pieces …                 False
4  32K26U12DNONTREA84Q1V8UCIH2VD7  bible  All king Solomon's drinking vessels
were of go…       pure gold    0.178571  All king Solomon's drinking vessels
were of go…                  False
```

[32]:
```
from nltk.tokenize import RegexpTokenizer
import pandas as pd
import numpy as np

tokenizer = RegexpTokenizer(r'\w+')  # same tokenizer as before

def analyze_sentence_spans_by_corpus_and_quartile_no_contracts(dfs_dict):
    """
    Analyze sentence spans (length metrics) grouped by corpus and complexity␣
 ↪quartile
    for multiple dataframes, but this time using the 'sentence_no_contractions'␣
 ↪column
    instead of the original 'sentence'.
    """
    results = []

    for df_name, df in dfs_dict.items():
        print(f"Processing {df_name} on 'sentence_no_contractions'...")

        # Make a copy to avoid altering the original
        df = df.copy()

        # Calculate complexity quartiles (unchanged logic)
        q1 = df['complexity'].quantile(0.25)
        q2 = df['complexity'].quantile(0.50)
        q3 = df['complexity'].quantile(0.75)

        # Function to map complexity to quartiles
        def get_quartile(x):
            if x <= q1:
                return 'Q1'
            elif x <= q2:
                return 'Q2'
            elif x <= q3:
                return 'Q3'
            else:
                return 'Q4'

        # Create a new column storing quartile label
        df['quartile'] = df['complexity'].apply(get_quartile)

        # Define a local function to compute sentence metrics
```

```python
    def compute_span_metrics_no_contracts(sentence):
        if pd.isna(sentence):
            return pd.Series({'word_count': 0, 'char_count': 0,␣
↪'avg_word_len': 0})

        words = tokenizer.tokenize(sentence)
        word_count = len(words)
        char_count = len(sentence)
        avg_word_len = np.mean([len(w) for w in words]) if word_count > 0␣
↪else 0

        return pd.Series({
            'word_count': word_count,
            'char_count': char_count,
            'avg_word_len': avg_word_len
        })

    # Apply our function to 'sentence_no_contractions'
    span_metrics_nc = df['sentence_no_contractions'].
↪apply(compute_span_metrics_no_contracts)
    # Merge the results back into df
    df = pd.concat([df, span_metrics_nc], axis=1)

    # Group by corpus + quartile, same as before
    corpus_col = 'corpus'  # or subcorpus if you have that column
    for corpus_name, corpus_df in df.groupby(corpus_col):
        for quartile, quartile_df in corpus_df.groupby('quartile'):
            complexity_range = f"{quartile_df['complexity'].min():.
↪3f}-{quartile_df['complexity'].max():.3f}"
            stats = {
                'Dataframe': df_name,
                'Corpus': corpus_name,
                'Quartile': quartile,
                'Complexity Range': complexity_range,
                'Count': len(quartile_df),
                'Avg Words': quartile_df['word_count'].mean(),
                'Median Words': quartile_df['word_count'].median(),
                'Min Words': quartile_df['word_count'].min(),
                'Max Words': quartile_df['word_count'].max(),
                'Std Words': quartile_df['word_count'].std(),
                'Avg Chars': quartile_df['char_count'].mean(),
                'Avg Word Len': quartile_df['avg_word_len'].mean()
            }
            results.append(stats)

results_df = pd.DataFrame(results)
results_df = results_df.sort_values(['Dataframe', 'Corpus', 'Quartile'])
```

```python
    return results_df


# Example usage:
dfs = {
    'train_single_df': train_single_df,
    'train_multi_df': train_multi_df,
    'trial_val_single_df': trial_val_single_df,
    'trial_val_multi_df': trial_val_multi_df,
    'test_single_df': test_single_df,
    'test_multi_df': test_multi_df
}

span_analysis_nc =␣
 ↪analyze_sentence_spans_by_corpus_and_quartile_no_contracts(dfs)

# Show results
pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
pd.set_option('display.width', 1000)
display(span_analysis_nc)

# Save results
results_path_nc = os.path.join(dir_results,␣
 ↪'sentence_span_analysis_no_contractions.csv')
span_analysis_nc.to_csv(results_path_nc, index=False)
print(f"Analysis (NO CONTRACTIONS) saved to: {results_path_nc}")
```

```
Processing train_single_df on 'sentence_no_contractions'…
Processing train_multi_df on 'sentence_no_contractions'…
Processing trial_val_single_df on 'sentence_no_contractions'…
Processing trial_val_multi_df on 'sentence_no_contractions'…
Processing test_single_df on 'sentence_no_contractions'…
Processing test_multi_df on 'sentence_no_contractions'…
```

```
              Dataframe    Corpus Quartile Complexity Range  Count  Avg Words ␣
 ↪Median Words  Min Words  Max Words  Std Words   Avg Chars  Avg Word Len
60         test_multi_df     bible       Q1       0.025-0.317     26  23.076923    ␣
 ↪       22.0         4.0       48.0  11.831900  118.730769      4.131249
61         test_multi_df     bible       Q2       0.325-0.417     11  20.545455    ␣
 ↪       17.0         7.0       47.0  12.917923  109.636364      4.213539
62         test_multi_df     bible       Q3       0.432-0.528     18  21.055556    ␣
 ↪       21.5         4.0       43.0  10.843660  113.166667      4.498610
63         test_multi_df     bible       Q4       0.542-0.694     11  22.363636    ␣
 ↪       20.0         7.0       51.0  11.935432  126.181818      4.605062
64         test_multi_df    biomed       Q1       0.000-0.312     11  29.818182    ␣
 ↪       29.0        17.0       47.0   8.388304  195.727273      5.491145
```

```
65     test_multi_df     biomed    Q2    0.324-0.417    11   27.090909   24.0    9.0    47.0   11.449494   171.818182   5.436237
66     test_multi_df     biomed    Q3    0.456-0.528    10   26.900000   26.5   10.0    49.0   10.712921   177.500000   5.497409
67     test_multi_df     biomed    Q4    0.562-0.800    21   32.285714   34.0   14.0    56.0   13.598319   209.285714   5.460101
68     test_multi_df   europarl    Q1    0.214-0.303    10   24.700000   24.5    7.0    56.0   14.189589   146.900000   5.049688
69     test_multi_df   europarl    Q2    0.321-0.429    24   27.833333   27.0    9.0    73.0   15.352855   172.291667   5.269610
70     test_multi_df   europarl    Q3    0.432-0.516    18   32.944444   32.0    6.0    68.0   19.129504   209.888889   5.512245
71     test_multi_df   europarl    Q4    0.531-0.562    13   39.000000   36.0    6.0    95.0   29.631065   237.076923   5.100616
48    test_single_df      bible    Q1    0.000-0.214    79   22.822785   22.0    7.0    49.0   10.585137   116.924051   4.040893
49    test_single_df      bible    Q2    0.217-0.276    68   24.176471   21.0    2.0    77.0   14.393138   126.088235   4.172273
50    test_single_df      bible    Q3    0.278-0.353    67   22.388060   20.0    4.0    63.0   11.306950   119.776119   4.256042
51    test_single_df      bible    Q4    0.359-0.732    69   20.579710   19.0    1.0    55.0   11.264736   110.637681   4.341070
52    test_single_df     biomed    Q1    0.000-0.214    75   27.080000   25.0   10.0    84.0   12.025603   172.986667   5.277318
53    test_single_df     biomed    Q2    0.217-0.275    58   30.275862   26.0   10.0    83.0   15.856587   198.293103   5.446788
54    test_single_df     biomed    Q3    0.278-0.357    66   29.833333   29.0   13.0    85.0   11.754650   191.863636   5.334048
55    test_single_df     biomed    Q4    0.359-0.778    90   31.144444   30.0   14.0    83.0   12.089146   203.077778   5.393791
56    test_single_df   europarl    Q1    0.000-0.214    83   25.337349   21.0    3.0    82.0   16.032191   151.891566   5.044222
57    test_single_df   europarl    Q2    0.217-0.276    98   32.326531   30.0    1.0    97.0   18.707061   195.653061   5.062296
58    test_single_df   europarl    Q3    0.278-0.357    96   33.000000   30.0    3.0   141.0   21.404377   201.760417   5.124551
59    test_single_df   europarl    Q4    0.361-0.583    68   33.235294   29.0    1.0   130.0   20.440023   206.573529   5.164576
12    train_multi_df      bible    Q1    0.028-0.300   163   23.570552   22.0    3.0    67.0   12.429043   124.871166   4.237932
13    train_multi_df      bible    Q2    0.304-0.409   132   24.053030   22.0    6.0    65.0   11.738444   129.659091   4.305703
14    train_multi_df      bible    Q3    0.411-0.529   131   23.778626   23.0    4.0    50.0   11.179163   127.564885   4.331458
15    train_multi_df      bible    Q4    0.533-0.778    79   25.481013   24.0    3.0    81.0   13.490605   139.405063   4.491816
```

```
16        train_multi_df    biomed       Q1      0.028-0.303     87  29.091954  ␣
 ↪      28.0          9.0        77.0  11.882792  185.977011      5.277384
17        train_multi_df    biomed       Q2      0.304-0.408     74  30.756757  ␣
 ↪      28.0         11.0        85.0  13.511853  196.067568      5.367302
18        train_multi_df    biomed       Q3      0.411-0.529    111  29.783784  ␣
 ↪      29.0          8.0        61.0  10.912383  193.873874      5.430754
19        train_multi_df    biomed       Q4      0.531-0.975    242  29.607438  ␣
 ↪      28.0         10.0        75.0  12.029995  195.107438      5.535387
20        train_multi_df  europarl       Q1      0.118-0.303    132  29.363636  ␣
 ↪      27.0          3.0       101.0  17.874146  176.583333      5.003685
21        train_multi_df  europarl       Q2      0.304-0.409    171  31.666667  ␣
 ↪      28.0          3.0       108.0  19.112977  195.198830      5.176456
22        train_multi_df  europarl       Q3      0.411-0.529    138  33.398551  ␣
 ↪      30.0          7.0       101.0  18.992715  208.304348      5.286607
23        train_multi_df  europarl       Q4      0.533-0.750     57  34.596491  ␣
 ↪      31.0          6.0        96.0  20.318763  218.350877      5.345891
0        train_single_df     bible       Q1      0.000-0.212    701  23.269615  ␣
 ↪      22.0          4.0        61.0  11.764113  121.714693      4.135685
1        train_single_df     bible       Q2      0.212-0.279    640  23.750000  ␣
 ↪      22.0          3.0        60.0  11.579622  124.671875      4.153925
2        train_single_df     bible       Q3      0.281-0.375    624  23.825321  ␣
 ↪      22.0          3.0        70.0  11.963291  126.338141      4.213931
3        train_single_df     bible       Q4      0.380-0.861    609  23.586207  ␣
 ↪      21.0          3.0        69.0  12.460182  126.602627      4.298065
4        train_single_df    biomed       Q1      0.000-0.212    586  28.534130  ␣
 ↪      27.0          2.0        85.0  12.115387  182.076792      5.322266
5        train_single_df    biomed       Q2      0.212-0.279    583  30.442539  ␣
 ↪      29.0          7.0        92.0  11.863182  193.921098      5.289166
6        train_single_df    biomed       Q3      0.281-0.375    659  29.860395  ␣
 ↪      28.0          4.0        77.0  11.591263  191.098634      5.329940
7        train_single_df    biomed       Q4      0.381-0.861    748  29.181818  ␣
 ↪      28.0          3.0        85.0  12.249267  186.978610      5.299963
8        train_single_df  europarl       Q1      0.025-0.212    641  26.761310  ␣
 ↪      24.0          2.0       107.0  15.230853  159.190328      4.942926
9        train_single_df  europarl       Q2      0.212-0.279    714  30.420168  ␣
 ↪      27.0          1.0       129.0  18.383783  183.105042      4.995897
10       train_single_df  europarl       Q3      0.281-0.375    701  30.523538  ␣
 ↪      28.0          1.0       122.0  18.163026  185.843081      5.114626
11       train_single_df  europarl       Q4      0.381-0.775    456  33.543860  ␣
 ↪      31.0          2.0       235.0  21.708515  203.664474      5.054387
36    trial_val_multi_df     bible       Q1      0.000-0.292     11  26.272727  ␣
 ↪      21.0         13.0        64.0  13.950562  141.363636      4.282457
37    trial_val_multi_df     bible       Q2      0.333-0.400      7  20.571429  ␣
 ↪      23.0          5.0        28.0   7.412987  110.857143      4.279406
38    trial_val_multi_df     bible       Q3      0.425-0.500      5  19.600000  ␣
 ↪      19.0          9.0        32.0   8.905055  109.200000      4.431391
```

```
39   trial_val_multi_df     bible       Q4      0.525-0.661      6  22.333333  ␣
 ↪      20.5          9.0         44.0  12.242004  117.833333      4.178525
40   trial_val_multi_df    biomed       Q1      0.083-0.303      6  26.833333  ␣
 ↪      25.0         15.0         49.0  11.771434  159.166667      4.899969
41   trial_val_multi_df    biomed       Q2      0.317-0.422      7  25.428571  ␣
 ↪      21.0         15.0         48.0  11.588171  156.000000      5.194383
42   trial_val_multi_df    biomed       Q3      0.438-0.513      6  37.833333  ␣
 ↪      39.5         26.0         44.0   6.675827  247.500000      5.438593
43   trial_val_multi_df    biomed       Q4      0.537-0.825     14  30.642857  ␣
 ↪      29.5         17.0         43.0   9.849695  211.428571      5.730623
44   trial_val_multi_df  europarl       Q1      0.176-0.306      8  30.000000  ␣
 ↪      25.5          4.0         64.0  20.361027  186.750000      5.306837
45   trial_val_multi_df  europarl       Q2      0.312-0.412     11  47.909091  ␣
 ↪      46.0         24.0         78.0  18.651834  296.909091      5.058375
46   trial_val_multi_df  europarl       Q3      0.432-0.500     13  26.307692  ␣
 ↪      26.0          5.0         66.0  18.167666  166.153846      5.263847
47   trial_val_multi_df  europarl       Q4      0.515-0.714      5  26.400000  ␣
 ↪      15.0          6.0         66.0  24.316661  164.600000      4.998182
24  trial_val_single_df     bible       Q1      0.000-0.214     52  26.769231  ␣
 ↪      26.0          5.0         74.0  15.589860  137.423077      4.074456
25  trial_val_single_df     bible       Q2      0.217-0.266     38  24.868421  ␣
 ↪      23.0          7.0         50.0  10.768249  131.342105      4.200230
26  trial_val_single_df     bible       Q3      0.268-0.355     26  22.884615  ␣
 ↪      20.5          5.0         44.0   9.961233  121.423077      4.316593
27  trial_val_single_df     bible       Q4      0.361-0.633     27  25.666667  ␣
 ↪      23.0          6.0         49.0  12.554497  137.592593      4.213842
28  trial_val_single_df    biomed       Q1      0.028-0.214     21  25.571429  ␣
 ↪      21.0         13.0         65.0  11.543706  164.380952      5.317614
29  trial_val_single_df    biomed       Q2      0.217-0.267     28  30.571429  ␣
 ↪      27.5         11.0         57.0  12.099674  198.142857      5.315287
30  trial_val_single_df    biomed       Q3      0.268-0.359     38  32.105263  ␣
 ↪      29.0         11.0         61.0  12.710476  206.947368      5.364934
31  trial_val_single_df    biomed       Q4      0.364-0.875     48  25.145833  ␣
 ↪      25.5          6.0         56.0  11.721937  164.020833      5.445661
32  trial_val_single_df  europarl       Q1      0.050-0.214     33  31.969697  ␣
 ↪      28.0          5.0         81.0  20.356947  185.969697      4.799024
33  trial_val_single_df  europarl       Q2      0.217-0.267     41  28.487805  ␣
 ↪      28.0          4.0         71.0  15.424205  172.902439      4.997384
34  trial_val_single_df  europarl       Q3      0.268-0.359     39  30.282051  ␣
 ↪      28.0          3.0         99.0  20.040681  184.358974      5.086945
35  trial_val_single_df  europarl       Q4      0.367-0.605     30  35.700000  ␣
 ↪      30.5          5.0         77.0  20.142852  215.400000      4.910759

Analysis (NO CONTRACTIONS) saved to: /content/drive/MyDrive/266-
final/results/sentence_span_analysis_no_contractions.csv
```

- contraction processing successfuly, confirmed with Avg Word deltas between ‘sentence’ and 'sentence_no_contractions'

0.4 Enrich Datset with PoS Tags, Dependency Parsing, and Morphological Complexity

[33]:
```
# !pip install -q spacy
# !python -m spacy download en_core_web_trf
!python -m spacy download en_core_web_lg
```

```
Collecting en-core-web-lg==3.8.0
  Downloading https://github.com/explosion/spacy-
models/releases/download/en_core_web_lg-3.8.0/en_core_web_lg-3.8.0-py3-none-
any.whl (400.7 MB)
                                400.7/400.7

MB 2.6 MB/s eta 0:00:00
Installing collected packages: en-core-web-lg
Successfully installed en-core-web-lg-3.8.0
 Download and installation successful
You can now load the package via spacy.load('en_core_web_lg')
 Restart to reload dependencies
If you are in a Jupyter or Colab notebook, you may need to restart Python in
order to load all the package's dependencies. You can do this by selecting the
'Restart kernel' or 'Restart runtime' option.
```

[34]:
```
nlp = spacy.load("en_core_web_lg")
```

[35]:
```
# prompt: run a test with nlp, my spacy instance

# Sample text for testing
text = "This is a sample sentence for testing spaCy."

# Process the text with spaCy
doc = nlp(text)

# Print the tokens and their part-of-speech tags
for token in doc:
    print(f"Token: {token.text}, POS: {token.pos_}, Dependency: {token.dep_}")
```

```
Token: This, POS: PRON, Dependency: nsubj
Token: is, POS: AUX, Dependency: ROOT
Token: a, POS: DET, Dependency: det
Token: sample, POS: NOUN, Dependency: compound
Token: sentence, POS: NOUN, Dependency: attr
Token: for, POS: ADP, Dependency: prep
Token: testing, POS: VERB, Dependency: pcomp
Token: spaCy, POS: PROPN, Dependency: dobj
Token: ., POS: PUNCT, Dependency: punct
```

[36]:
```python
def enrich_with_spacy(df, text_col='sentence_no_contractions'):
    """
    Processes the 'text_col' with spaCy and appends:
      pos_sequence, dep_sequence, morph_sequence,
      and morph_complexity (float) per row.
    """
    df = df.copy()

    pos_tags = []
    dep_tags = []
    morph_tags = []
    morph_complexities = []

    for text in df[text_col]:
        if pd.isna(text) or not text.strip():
            # If text is NaN or empty, store defaults
            pos_tags.append([])
            dep_tags.append([])
            morph_tags.append([])
            morph_complexities.append(0.0)
            continue

        doc = nlp(text)

        # Build sequences
        pos_seq = [token.pos_ for token in doc]            # e.g. ["DET",␣
↪"NOUN", "VERB"]
        dep_seq = [token.dep_ for token in doc]            # e.g. ["det",␣
↪"nsubj", "ROOT"]
        morph_seq = [token.morph for token in doc]         # e.g.␣
↪[Number=Sing|Person=3, ...]

        # Count morphological features
        total_features = 0
        for token in doc:
            # token.morph.to_dict() => a dict of morphological attributes
            features_dict = token.morph.to_dict()
            total_features += len(features_dict)

        # Average morphological features across tokens
        avg_morph = total_features / len(doc)

        pos_tags.append(pos_seq)
        dep_tags.append(dep_seq)
        morph_tags.append(morph_seq)
        morph_complexities.append(avg_morph)
```

```
    # Add these lists as new columns
    df['pos_sequence'] = pos_tags
    df['dep_sequence'] = dep_tags
    df['morph_sequence'] = morph_tags
    df['morph_complexity'] = morph_complexities

    return df
```

[37]:
```
dataframes_info = [
    ("train_single_df", train_single_df),
    ("train_multi_df", train_multi_df),
    ("trial_val_single_df", trial_val_single_df),
    ("trial_val_multi_df", trial_val_multi_df),
    ("test_single_df", test_single_df),
    ("test_multi_df", test_multi_df),
]

for df_name, df in dataframes_info:
    print(f"Enriching {df_name} with spaCy features...")
    enriched_df = enrich_with_spacy(df, text_col='sentence_no_contractions')
    # Overwrite the old DataFrame variable (or store it somewhere new)
    globals()[df_name] = enriched_df
    print(f"Done! Now '{df_name}' has columns: pos_sequence, dep_sequence,␣
 ↪morph_sequence, morph_complexity.\n")
```

```
Enriching train_single_df with spaCy features…
Done! Now 'train_single_df' has columns: pos_sequence, dep_sequence,
morph_sequence, morph_complexity.

Enriching train_multi_df with spaCy features…
Done! Now 'train_multi_df' has columns: pos_sequence, dep_sequence,
morph_sequence, morph_complexity.

Enriching trial_val_single_df with spaCy features…
Done! Now 'trial_val_single_df' has columns: pos_sequence, dep_sequence,
morph_sequence, morph_complexity.

Enriching trial_val_multi_df with spaCy features…
Done! Now 'trial_val_multi_df' has columns: pos_sequence, dep_sequence,
morph_sequence, morph_complexity.

Enriching test_single_df with spaCy features…
Done! Now 'test_single_df' has columns: pos_sequence, dep_sequence,
morph_sequence, morph_complexity.

Enriching test_multi_df with spaCy features…
Done! Now 'test_multi_df' has columns: pos_sequence, dep_sequence,
morph_sequence, morph_complexity.
```

[38]:
```
for df_name, df in dataframes_info:
    print(f"\n{'='*50}")
    print(f"DataFrame: {df_name}")
    print(f"{'='*50}\n")
    sample_df = globals()[df_name].sample(3, random_state=42)
    display(sample_df[['sentence_no_contractions', 'pos_sequence',␣
↪'dep_sequence', 'morph_sequence', 'morph_complexity']])
```

```
==================================================
DataFrame: train_single_df
==================================================


                               sentence_no_contractions                          ␣
↪             pos_sequence                                        dep_sequence  ␣
↪                                  morph_sequence  morph_complexity
5061  The transgenic approach that was used to creat…  [DET, ADJ, NOUN, PRON,␣
↪AUX, VERB, PART, VERB, …  [det, amod, nsubjpass, nsubjpass, auxpass, rel… ␣
↪[(Definite=Def, PronType=Art), (Degree=Pos), (…          1.500000
2471  When the report comes to Egypt, they will be i…  [SCONJ, DET, NOUN, VERB,␣
↪ADP, PROPN, PUNCT, PR…  [advmod, det, nsubj, advcl, prep, pobj, punct,…  [(),␣
↪(Definite=Def, PronType=Art), (Number=Sin…          1.166667
800   Saul asked counsel of God, "Shall I go down af…  [PROPN, VERB, NOUN, ADP,␣
↪PROPN, PUNCT, PUNCT, …  [nsubj, ROOT, dobj, prep, pobj, punct, punct, … ␣
↪[(Number=Sing), (Tense=Past, VerbForm=Fin), (N…          1.200000


==================================================
DataFrame: train_multi_df
==================================================


                               sentence_no_contractions                          ␣
↪             pos_sequence                                        dep_sequence  ␣
↪                                  morph_sequence  morph_complexity
724   BRCA2 may thus promote RAD51 assembly into rec…  [PROPN, AUX, ADV, VERB,␣
↪PROPN, NOUN, ADP, ADJ,…  [nsubj, aux, advmod, ROOT, compound, dobj, pre… ␣
↪[(Number=Sing), (VerbForm=Fin), (), (VerbForm=…          1.222222
812   Therefore, BMPR1A appears to maintain articula…  [ADV, PUNCT, PROPN, VERB,␣
↪PART, VERB, ADJ, NOU…  [advmod, punct, nsubj, ROOT, aux, xcomp, amod,…  [(),␣
↪(PunctType=Comm), (Number=Sing), (Number=…          1.000000
1466  Continued support for the renewal and modernis…  [VERB, NOUN, ADP, DET,␣
↪NOUN, CCONJ, NOUN, ADP,…  [amod, nsubj, prep, det, pobj, cc, conj, prep,… ␣
↪[(Aspect=Perf, Tense=Past, VerbForm=Part), (Nu…          1.205882
```

```
==================================================
DataFrame: trial_val_single_df
==================================================


                              sentence_no_contractions                          ␣
 ↪            pos_sequence                                       dep_sequence    ␣
 ↪                                  morph_sequence  morph_complexity
145  However, this reduction in bone resorption occ…  [ADV, PUNCT, DET, NOUN,␣
 ↪ADP, NOUN, NOUN, VERB,…  [advmod, punct, det, nsubj, prep, compound, po…  [(),␣
 ↪(PunctType=Comm), (Number=Sing, PronType=…           1.0000
335  A word of thanks is also due to many non-gover…  [DET, NOUN, ADP, NOUN,␣
 ↪AUX, ADV, ADJ, ADP, ADJ…  [det, nsubj, prep, pobj, ROOT, advmod, prep, p… ␣
 ↪[(Definite=Ind, PronType=Art), (Number=Sing), …           1.0625
175  To test the hypothesis that a temporal delay i…  [PART, VERB, DET, NOUN,␣
 ↪SCONJ, DET, ADJ, NOUN,…  [aux, advcl, det, dobj, mark, det, amod, nsubj…  [(),␣
 ↪(VerbForm=Inf), (Definite=Def, PronType=A…           1.2000


==================================================
DataFrame: trial_val_multi_df
==================================================


                             sentence_no_contractions                           ␣
 ↪           pos_sequence                                       dep_sequence    ␣
 ↪                                 morph_sequence  morph_complexity
62  by Mr Virrankoski, on behalf of the Committee …  [ADP, PROPN, PROPN, PUNCT,␣
 ↪ADP, NOUN, ADP, DET…  [prep, compound, pobj, punct, prep, pobj, prep…  [(),␣
 ↪(Number=Sing), (Number=Sing), (PunctType=…         0.892857
40  Indeed, we recently showed that neural crest c…  [ADV, PUNCT, PRON, ADV,␣
 ↪VERB, SCONJ, ADJ, PROP…  [advmod, punct, nsubj, advmod, ROOT, mark, com…  [(),␣
 ↪(PunctType=Comm), (Case=Nom, Number=Plur,…         1.108696
95  It is not an easy task, particularly for the c…  [PRON, AUX, PART, DET, ADJ,␣
 ↪NOUN, PUNCT, ADV, …  [nsubj, ROOT, neg, det, amod, attr, punct, adv… ␣
 ↪[(Case=Nom, Gender=Neut, Number=Sing, Person=3…         1.180328


==================================================
DataFrame: test_single_df
==================================================


                              sentence_no_contractions                          ␣
 ↪            pos_sequence                                       dep_sequence    ␣
 ↪                                  morph_sequence  morph_complexity
668  It is therefore not a matter of indifference h…  [PRON, AUX, ADV, PART,␣
 ↪DET, NOUN, ADP, NOUN, S…  [nsubj, ROOT, advmod, neg, det, attr, prep, po… ␣
 ↪[(Case=Nom, Gender=Neut, Number=Sing, Person=3…         1.200000
```

```
30   then shall he offer with the bull a meal offer…  [ADV, AUX, PRON, VERB,␣
↪ADP, DET, NOUN, DET, NO…  [advmod, aux, nsubj, ROOT, prep, det, pobj, de… ␣
↪[(PronType=Dem), (VerbType=Mod), (Case=Nom, Ge…         1.071429
377  While they do have their limitations (e.g. dev…  [SCONJ, PRON, AUX, VERB,␣
↪PRON, NOUN, PUNCT, AD…  [mark, nsubj, aux, advcl, poss, dobj, punct, a…  [(),␣
↪(Case=Nom, Number=Plur, Person=3, PronTyp…         1.157895


==================================================
DataFrame: test_multi_df
==================================================


                              sentence_no_contractions                          ␣
↪            pos_sequence                                       dep_sequence   ␣
↪                                  morph_sequence  morph_complexity
19   God said, "Let the earth yield grass, herbs yi…  [PROPN, VERB, PUNCT,␣
↪PUNCT, VERB, DET, NOUN, V…  [nsubj, ROOT, punct, punct, xcomp, det, nsubj,… ␣
↪[(Number=Sing), (Tense=Past, VerbForm=Fin), (P…         1.564103
42   Moreover I will make a covenant of peace with …  [ADV, PRON, AUX, VERB,␣
↪DET, NOUN, ADP, NOUN, A…  [advmod, nsubj, aux, ccomp, det, dobj, prep, p… ␣
↪[(), (Case=Nom, Number=Sing, Person=1, PronTyp…         1.550000
156  Developing innovation policy is crucial to EU …  [VERB, NOUN, NOUN, AUX,␣
↪ADJ, ADP, PROPN, NOUN,…  [csubj, compound, dobj, ROOT, acomp, prep, com… ␣
↪[(Aspect=Prog, Tense=Pres, VerbForm=Part), (Nu…         1.333333
```

[39]:

```python
# verify column headers

dataframes = [train_single_df, train_multi_df, trial_val_single_df,␣
 ↪trial_val_multi_df, test_single_df, test_multi_df]
for df in dataframes:
  print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7662 entries, 0 to 7661
Data columns (total 11 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   id                        7662 non-null   object
 1   corpus                    7662 non-null   object
 2   sentence                  7662 non-null   object
 3   token                     7655 non-null   object
 4   complexity                7662 non-null   float64
 5   sentence_no_contractions  7662 non-null   object
 6   contraction_expanded      7662 non-null   bool
 7   pos_sequence              7662 non-null   object
 8   dep_sequence              7662 non-null   object
 9   morph_sequence            7662 non-null   object
 10  morph_complexity          7662 non-null   float64
```

```
dtypes: bool(1), float64(2), object(8)
memory usage: 606.2+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1517 entries, 0 to 1516
Data columns (total 11 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       1517 non-null   object
 1   corpus                   1517 non-null   object
 2   sentence                 1517 non-null   object
 3   token                    1517 non-null   object
 4   complexity               1517 non-null   float64
 5   sentence_no_contractions  1517 non-null   object
 6   contraction_expanded     1517 non-null   bool
 7   pos_sequence             1517 non-null   object
 8   dep_sequence             1517 non-null   object
 9   morph_sequence           1517 non-null   object
 10  morph_complexity         1517 non-null   float64
dtypes: bool(1), float64(2), object(8)
memory usage: 120.1+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 421 entries, 0 to 420
Data columns (total 11 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       421 non-null    object
 1   corpus                   421 non-null    object
 2   sentence                 421 non-null    object
 3   token                    421 non-null    object
 4   complexity               421 non-null    float64
 5   sentence_no_contractions  421 non-null    object
 6   contraction_expanded     421 non-null    bool
 7   pos_sequence             421 non-null    object
 8   dep_sequence             421 non-null    object
 9   morph_sequence           421 non-null    object
 10  morph_complexity         421 non-null    float64
dtypes: bool(1), float64(2), object(8)
memory usage: 33.4+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 99 entries, 0 to 98
Data columns (total 11 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       99 non-null     object
 1   corpus                   99 non-null     object
```

```
 2   sentence                 99 non-null     object
 3   token                    99 non-null     object
 4   complexity               99 non-null     float64
 5   sentence_no_contractions  99 non-null     object
 6   contraction_expanded     99 non-null     bool
 7   pos_sequence             99 non-null     object
 8   dep_sequence             99 non-null     object
 9   morph_sequence           99 non-null     object
 10  morph_complexity         99 non-null     float64
dtypes: bool(1), float64(2), object(8)
memory usage: 8.0+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 917 entries, 0 to 916
Data columns (total 11 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   id                        917 non-null    object
 1   corpus                    917 non-null    object
 2   sentence                  917 non-null    object
 3   token                     917 non-null    object
 4   complexity                917 non-null    float64
 5   sentence_no_contractions  917 non-null    object
 6   contraction_expanded      917 non-null    bool
 7   pos_sequence              917 non-null    object
 8   dep_sequence              917 non-null    object
 9   morph_sequence            917 non-null    object
 10  morph_complexity          917 non-null    float64
dtypes: bool(1), float64(2), object(8)
memory usage: 72.7+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 184 entries, 0 to 183
Data columns (total 11 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   id                        184 non-null    object
 1   corpus                    184 non-null    object
 2   sentence                  184 non-null    object
 3   token                     184 non-null    object
 4   complexity                184 non-null    float64
 5   sentence_no_contractions  184 non-null    object
 6   contraction_expanded      184 non-null    bool
 7   pos_sequence              184 non-null    object
 8   dep_sequence              184 non-null    object
 9   morph_sequence            184 non-null    object
 10  morph_complexity          184 non-null    float64
dtypes: bool(1), float64(2), object(8)
```

```
memory usage: 14.7+ KB
None
```

0.5 Create Binarized Outcome Variable, based on train_single_df median and train_multi_df median, applied to trial-val and test

[40]:
```
# Step 1: Compute the median for single-token train set
train_single_median = train_single_df['complexity'].median()

# Step 2: Define a function that applies the threshold
def binarize_complexity(value, threshold):
    """
    If value <= threshold, return 0, else return 1.
    """
    if value <= threshold:
        return 0
    else:
        return 1

# Step 3: Create 'binary_complexity' in the three single-token DataFrames
train_single_df['binary_complexity'] = train_single_df['complexity'].apply(
    lambda x: binarize_complexity(x, train_single_median)
)
trial_val_single_df['binary_complexity'] = trial_val_single_df['complexity'].
 ↪apply(
    lambda x: binarize_complexity(x, train_single_median)
)
test_single_df['binary_complexity'] = test_single_df['complexity'].apply(
    lambda x: binarize_complexity(x, train_single_median)
)

# Step 4: Compute the median for multi-token train set
train_multi_median = train_multi_df['complexity'].median()

# Step 5: Create 'binary_complexity' in the three multi-token DataFrames
train_multi_df['binary_complexity'] = train_multi_df['complexity'].apply(
    lambda x: binarize_complexity(x, train_multi_median)
)
trial_val_multi_df['binary_complexity'] = trial_val_multi_df['complexity'].
 ↪apply(
    lambda x: binarize_complexity(x, train_multi_median)
)
test_multi_df['binary_complexity'] = test_multi_df['complexity'].apply(
    lambda x: binarize_complexity(x, train_multi_median)
)

# Step 6: (Optional) Print out the medians and some basic info
```

```python
print(f"Median complexity (single): {train_single_median}")
print(f"Median complexity (multi): {train_multi_median}")

print("\nSample rows from train_single_df:")
print(train_single_df[['id', 'complexity', 'binary_complexity']].head())

print("\nSample rows from train_multi_df:")
print(train_multi_df[['id', 'complexity', 'binary_complexity']].head())
```

```
Median complexity (single): 0.2794117647058823
Median complexity (multi): 0.409090909090909

Sample rows from train_single_df:
                               id  complexity  binary_complexity
0  3ZLW647WALVGE8EBR50EGUBPU4P32A    0.000000                  0
1  34R0BODSP1ZBN3DVY8J8XSIY551E5C    0.000000                  0
2  3S1WOPCJFGTJU2SGNAN2Y213N6WJE3    0.050000                  0
3  3BFNCI9LYKQN09BHXHH9CLSX5KP738    0.150000                  0
4  3G5RUKN2EC3YIWSKUXZ8ZVH95R49N2    0.263889                  0

Sample rows from train_multi_df:
                               id  complexity  binary_complexity
0  3S37Y8CWI80N8KVM53U4E6JKCDC4WE    0.027778                  0
1  3WGCNLZJKF877FYC1Q6COKNWTDWD11    0.050000                  0
2  3UOMW19E6D6WQ5TH2HDD74IVKTP5CB    0.050000                  0
3  36JW4WBR06KF9AXMUL4N476OMF8FHD    0.050000                  0
4  3HRWUH63QU2FH9Q8R7MRNFC7JX2N5A    0.075000                  0
```

[44]:

```python
# verify column headers

dataframes = [train_single_df, train_multi_df, trial_val_single_df,␣
 ↪trial_val_multi_df, test_single_df, test_multi_df]
for df in dataframes:
  print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7662 entries, 0 to 7661
Data columns (total 12 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   id                        7662 non-null   object
 1   corpus                    7662 non-null   object
 2   sentence                  7662 non-null   object
 3   token                     7655 non-null   object
 4   complexity                7662 non-null   float64
 5   sentence_no_contractions  7662 non-null   object
 6   contraction_expanded      7662 non-null   bool
 7   pos_sequence              7662 non-null   object
```

```
 8   dep_sequence             7662 non-null   object
 9   morph_sequence           7662 non-null   object
 10  morph_complexity         7662 non-null   float64
 11  binary_complexity        7662 non-null   int64
dtypes: bool(1), float64(2), int64(1), object(8)
memory usage: 666.1+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1517 entries, 0 to 1516
Data columns (total 12 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       1517 non-null   object
 1   corpus                   1517 non-null   object
 2   sentence                 1517 non-null   object
 3   token                    1517 non-null   object
 4   complexity               1517 non-null   float64
 5   sentence_no_contractions  1517 non-null   object
 6   contraction_expanded     1517 non-null   bool
 7   pos_sequence             1517 non-null   object
 8   dep_sequence             1517 non-null   object
 9   morph_sequence           1517 non-null   object
 10  morph_complexity         1517 non-null   float64
 11  binary_complexity        1517 non-null   int64
dtypes: bool(1), float64(2), int64(1), object(8)
memory usage: 132.0+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 421 entries, 0 to 420
Data columns (total 12 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   id                       421 non-null    object
 1   corpus                   421 non-null    object
 2   sentence                 421 non-null    object
 3   token                    421 non-null    object
 4   complexity               421 non-null    float64
 5   sentence_no_contractions  421 non-null    object
 6   contraction_expanded     421 non-null    bool
 7   pos_sequence             421 non-null    object
 8   dep_sequence             421 non-null    object
 9   morph_sequence           421 non-null    object
 10  morph_complexity         421 non-null    float64
 11  binary_complexity        421 non-null    int64
dtypes: bool(1), float64(2), int64(1), object(8)
memory usage: 36.7+ KB
None
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 99 entries, 0 to 98
Data columns (total 12 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   id                        99 non-null     object 
 1   corpus                    99 non-null     object 
 2   sentence                  99 non-null     object 
 3   token                     99 non-null     object 
 4   complexity                99 non-null     float64
 5   sentence_no_contractions  99 non-null     object 
 6   contraction_expanded      99 non-null     bool   
 7   pos_sequence              99 non-null     object 
 8   dep_sequence              99 non-null     object 
 9   morph_sequence            99 non-null     object 
 10  morph_complexity          99 non-null     float64
 11  binary_complexity         99 non-null     int64  
dtypes: bool(1), float64(2), int64(1), object(8)
memory usage: 8.7+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 917 entries, 0 to 916
Data columns (total 12 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   id                        917 non-null    object 
 1   corpus                    917 non-null    object 
 2   sentence                  917 non-null    object 
 3   token                     917 non-null    object 
 4   complexity                917 non-null    float64
 5   sentence_no_contractions  917 non-null    object 
 6   contraction_expanded      917 non-null    bool   
 7   pos_sequence              917 non-null    object 
 8   dep_sequence              917 non-null    object 
 9   morph_sequence            917 non-null    object 
 10  morph_complexity          917 non-null    float64
 11  binary_complexity         917 non-null    int64  
dtypes: bool(1), float64(2), int64(1), object(8)
memory usage: 79.8+ KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 184 entries, 0 to 183
Data columns (total 12 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   id                        184 non-null    object 
 1   corpus                    184 non-null    object 
 2   sentence                  184 non-null    object 
 3   token                     184 non-null    object 
```

```
 4   complexity               184 non-null    float64
 5   sentence_no_contractions 184 non-null    object
 6   contraction_expanded     184 non-null    bool
 7   pos_sequence             184 non-null    object
 8   dep_sequence             184 non-null    object
 9   morph_sequence           184 non-null    object
 10  morph_complexity         184 non-null    float64
 11  binary_complexity        184 non-null    int64
dtypes: bool(1), float64(2), int64(1), object(8)
memory usage: 16.1+ KB
None
```

[45]:
```
# inspect each df

dataframes = [train_single_df, train_multi_df, trial_val_single_df,␣
 ↪trial_val_multi_df, test_single_df, test_multi_df]
for df in dataframes:
  print(df.head())
```

```
                               id corpus
sentence     token  complexity
sentence_no_contractions  contraction_expanded
pos_sequence                                          dep_sequence
morph_sequence  morph_complexity  binary_complexity
0  3ZLW647WALVGE8EBR50EGUBPU4P32A  bible  Behold, there came up out of the river
seven c…     river    0.000000  Behold, there came up out of the river seven
c…                 False  [ADV, PUNCT, PRON, VERB, ADP, ADP, ADP, DET, N…
[advmod, punct, expl, ROOT, prt, prep, prep, d…  [(), (PunctType=Comm), (),
(Tense=Past, VerbFo…          1.041667                  0
1  34R0BODSP1ZBN3DVY8J8XSIY551E5C  bible  I am a fellow bondservant with you and
with yo…  brothers    0.000000  I am a fellow bondservant with you and with
yo…                False  [PRON, AUX, DET, ADJ, NOUN, ADP, PRON, CCONJ, …
[nsubj, ROOT, det, amod, attr, prep, pobj, cc,…  [(Case=Nom, Number=Sing,
Person=1, PronType=Pr…          1.461538                  0
2  3S1WOPCJFGTJU2SGNAN2Y213N6WJE3  bible  The man, the lord of the land, said to
us, 'By…  brothers    0.050000  The man, the lord of the land, said to us,
'By…                 False  [DET, NOUN, PUNCT, DET, PROPN, ADP, DET, NOUN,…
[det, nsubj, punct, det, appos, prep, det, pob…  [(Definite=Def,
PronType=Art), (Number=Sing), …          1.354167                  0
3  3BFNCI9LYKQN09BHXHH9CLSX5KP738  bible  Shimei had sixteen sons and six
daughters; but…  brothers    0.150000  Shimei had sixteen sons and six
daughters; but…              True  [PROPN, VERB, NUM, NOUN, CCONJ, NUM,
NOUN, PUN…  [nsubj, ROOT, nummod, dobj, cc, nummod, conj, …  [(Number=Sing),
(Tense=Past, VerbForm=Fin), (N…          1.275862                  0
4  3G5RUKN2EC3YIWSKUXZ8ZVH95R49N2  bible              "He has put my brothers
far from me.  brothers    0.263889              "He has put my brothers far
from me.                 False  [PUNCT, PRON, AUX, VERB, PRON, NOUN, ADV,
ADP,…  [punct, nsubj, aux, ROOT, poss, dobj, advmod, …  [(PunctSide=Ini,
```

```
PunctType=Quot), (Case=Nom, G…          2.500000                  0
                               id corpus
sentence            token  complexity
sentence_no_contractions  contraction_expanded
pos_sequence                                          dep_sequence
morph_sequence  morph_complexity  binary_complexity
0  3S37Y8CWI8ON8KVM53U4E6JKCDC4WE  bible  but the seventh day is a Sabbath to
Yahweh you…      seventh day    0.027778  but the seventh day is a Sabbath to
Yahweh you…                 False  [CCONJ, DET, ADJ, NOUN, AUX, DET, PROPN,
ADP, …  [cc, det, amod, nsubj, ccomp, det, attr, prep,…  [(ConjType=Cmp),
(Definite=Def, PronType=Art),…         1.341772                  0
1  3WGCNLZJKF877FYC1Q6COKNWTDWD11  bible  But let each man test his own work,
and then h…         own work    0.050000  But let each man test his own work,
and then h…                 False  [CCONJ, VERB, DET, NOUN, VERB, PRON, ADJ,
NOUN…  [cc, ROOT, det, nsubj, ccomp, poss, amod, dobj…  [(ConjType=Cmp),
(VerbForm=Inf), (), (Number=S…         1.608696                  0
2  3UOMW19E6D6WQ5TH2HDD74IVKTP5CB  bible  To him who by understanding made the
heavens; …  loving kindness    0.050000  To him who by understanding made the
heavens; …                 False  [ADP, PRON, PRON, ADP, VERB, VERB, DET,
NOUN, …  [prep, pobj, nsubj, prep, pcomp, advcl, det, d…  [(), (Case=Acc,
Gender=Masc, Number=Sing, Pers…         1.562500                  0
3  36JW4WBR06KF9AXMUL4N476OMF8FHD  bible  Remember to me, my God, this also, and
spare m…  loving kindness    0.050000  Remember to me, my God, this also, and
spare m…                 False  [VERB, ADP, PRON, PUNCT, PRON, PROPN, PUNCT,
P…  [ROOT, prep, pobj, punct, poss, npadvmod, punc…  [(VerbForm=Inf), (),
(Case=Acc, Number=Sing, P…         1.590909                  0
4  3HRWUH63QU2FH9Q8R7MRNFC7JX2N5A  bible  Because your loving kindness is better
than li…  loving kindness    0.075000  Because your loving kindness is better
than li…                 False  [SCONJ, PRON, ADJ, NOUN, AUX, ADJ, ADP, NOUN,
…  [mark, poss, amod, nsubj, advcl, acomp, prep, …  [(), (Person=2,
Poss=Yes, PronType=Prs), (Degr…         1.600000                  0
                               id corpus
sentence token  complexity                           sentence_no_contractions
contraction_expanded                                       pos_sequence
dep_sequence                                         morph_sequence
morph_complexity  binary_complexity
0  3QI9WAYOGQB8GQIR4MDIEF0D2RLS67  bible  They will not hurt nor destroy in all
my holy …   sea    0.000000  They will not hurt nor destroy in all my holy …
False  [PRON, AUX, PART, VERB, CCONJ, VERB, ADP, PRON…  [nsubj, aux, neg,
ccomp, cc, conj, prep, prede…  [(Case=Nom, Number=Plur, Person=3,
PronType=Pr…         1.129032                  0
1  3T8DUCXY0N6WD9X4RTLK8UN1U929TF  bible  that sends ambassadors by the sea,
even in ves…   sea    0.102941  that sends ambassadors by the sea, even in
ves…                 False  [PRON, VERB, NOUN, ADP, DET, NOUN, PUNCT, ADV,…
[nsubj, ROOT, dobj, prep, det, pobj, punct, ad…  [(PronType=Rel),
(Number=Sing, Person=3, Tense…         1.263158                  0
2  3I7KR83SNADXAQ7HXK7S7305BYB9KD  bible  and they entered into the boat, and
were going…   sea    0.109375  and they entered into the boat, and were
```

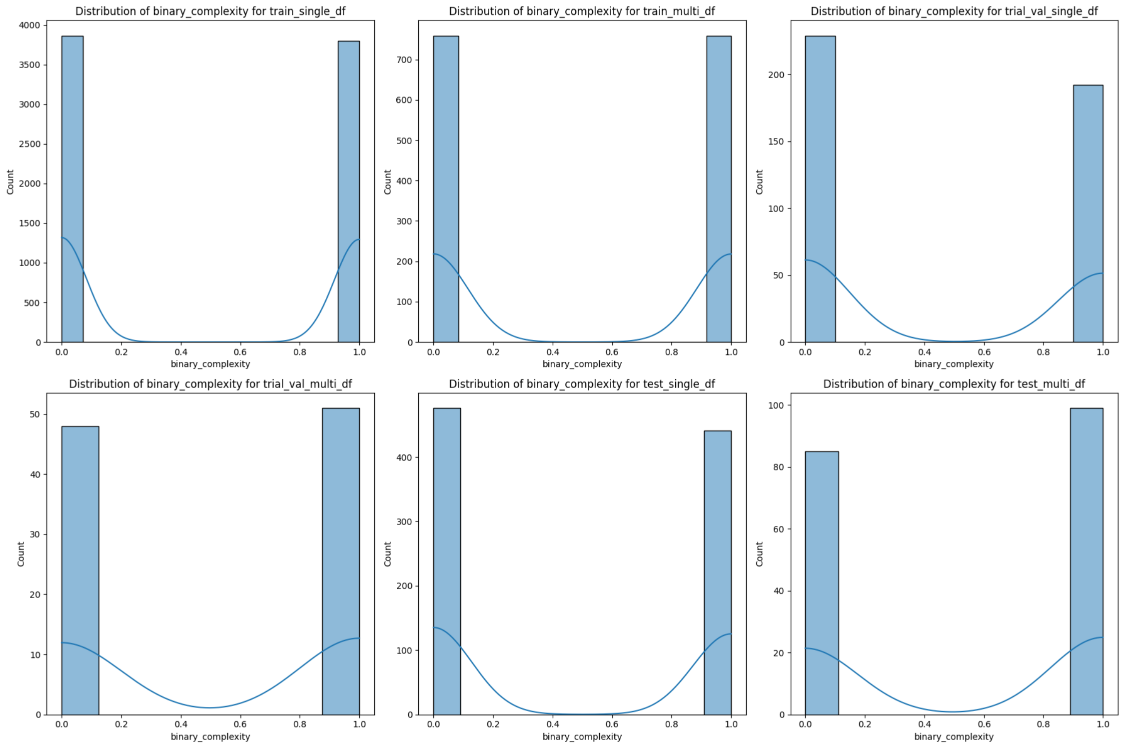
```
going…                  False  [CCONJ, PRON, VERB, ADP, DET, NOUN, PUNCT,
CCO…  [cc, nsubj, ROOT, prep, det, pobj, punct, cc, …  [(ConjType=Cmp),
(Case=Nom, Number=Plur, Perso…         1.437500                 0
3  3BO3NEOQMOHK9ERYPN0GQIWCPC4IAQ  bible  Joseph laid up grain as the sand of
the sea, v…   sea    0.160714  Joseph laid up grain as the sand of the sea,
v…                  False  [PROPN, VERB, ADP, NOUN, ADP, DET, NOUN, ADP, …
[nsubj, ROOT, prt, dobj, prep, det, pobj, prep…  [(Number=Sing), (Tense=Past,
VerbForm=Fin), ()…         1.400000                 0
4  3Y3CZJSZ9KT0W7I0KE38WZHHKSW5RH  bible  There will be a highway for the
remnant that i…  land    0.000000  There will be a highway for the remnant
that i…                  False  [PRON, AUX, AUX, DET, NOUN, ADP, DET, NOUN,
PR…  [expl, aux, ROOT, det, attr, prep, det, pobj, …  [(), (VerbForm=Fin),
(VerbForm=Inf), (Definite…         1.277778                 0
                               id corpus
sentence          token  complexity
sentence_no_contractions  contraction_expanded
pos_sequence                                      dep_sequence
morph_sequence  morph_complexity  binary_complexity
0  31HLTCK4BLVQ5BO1AUR91TX9V9IVGH  bible  The name of one son was Gershom, for
Moses sai…   foreign land    0.000000  The name of one son was Gershom, for
Moses sai…                  False  [DET, NOUN, ADP, NUM, NOUN, AUX, PROPN,
PUNCT,…  [det, nsubj, prep, nummod, pobj, ROOT, attr, p…  [(Definite=Def,
PronType=Art), (Number=Sing), …         1.520000                 0
1  389A2A304OIXVY7G5B71Q9M43LE0CL  bible  unleavened bread, unleavened cakes
mixed with …    wheat flour    0.157895  unleavened bread, unleavened cakes
mixed with …                  False  [ADJ, NOUN, PUNCT, ADJ, NOUN, VERB, ADP,
NOUN,…  [amod, dep, punct, amod, appos, acl, prep, pob…  [(Degree=Pos),
(Number=Sing), (PunctType=Comm)…         1.200000                 0
2  31N9JPQXIPIRX2A3S9N0CCFXO6TNHR  bible  However the high places were not taken
away; t…  burnt incense    0.200000  However the high places were not taken
away; t…                  False  [ADV, DET, ADJ, NOUN, AUX, PART, VERB, ADV,
PU…  [advmod, det, amod, nsubjpass, auxpass, neg, c…  [(), (Definite=Def,
PronType=Art), (Degree=Pos…         1.190476                 0
3  3JVP4ZJHDPSO81TGXL3N1CKZGQY0IN  bible  and he burnt incense of sweet spices
on it, as…  burnt incense    0.250000  and he burnt incense of sweet spices on
it, as…                  False  [CCONJ, PRON, VERB, NOUN, ADP, ADJ, NOUN,
ADP,…  [cc, nsubj, ROOT, dobj, prep, amod, pobj, prep…  [(ConjType=Cmp),
(Case=Nom, Gender=Masc, Numbe…         1.466667                 0
4  3JA0YN9IHL25ZQAUV5EJZ4GH0KL33L  bible  The same day the king made the middle
of the c…  bronze altar    0.214286  The same day the king made the middle of
the c…                  False  [DET, ADJ, NOUN, DET, NOUN, VERB, DET, NOUN,
A…  [det, amod, npadvmod, det, nsubj, ccomp, det, …  [(Definite=Def,
PronType=Art), (Degree=Pos), (…         1.352113                 0
                               id corpus
sentence     token  complexity
sentence_no_contractions  contraction_expanded
pos_sequence                                      dep_sequence
morph_sequence  morph_complexity  binary_complexity
```

```
0  3K8CQCU3KE19US5SN890DFPK3SANWR  bible  But he, beckoning to them with his
hand to be …      hand    0.000000  But he, beckoning to them with his hand to
be …                 False  [CCONJ, PRON, PUNCT, VERB, ADP, PRON, ADP, PRO…
[cc, nsubj, punct, advcl, prep, pobj, prep, po…  [(ConjType=Cmp), (Case=Nom,
Gender=Masc, Numbe…          1.703704                 0
1  3Q2T3FD0ON86LCI41NJYV3PN0BW3MV  bible  If I forget you, Jerusalem, let my
right hand …      hand    0.197368  If I forget you, Jerusalem, let my right
hand …                 False  [SCONJ, PRON, VERB, PRON, PUNCT, PROPN,
PUNCT,…  [mark, nsubj, advcl, dobj, punct, npadvmod, pu…  [(), (Case=Nom,
Number=Sing, Person=1, PronTyp…          1.800000                 0
2  3ULIZ0H1VA5C32JJMK0TQ8Z4GUS51B  bible  the ten sons of Haman the son of
Hammedatha, t…      hand    0.200000  the ten sons of Haman the son of
Hammedatha, t…                  True  [DET, NUM, NOUN, ADP, PROPN, DET, NOUN,
ADP, P…  [det, nummod, ROOT, prep, pobj, det, appos, pr…  [(Definite=Def,
PronType=Art), (NumType=Card),…          1.269231                 0
3  3BFF0DJK8XCEIOT30ZLBPPSRMZQTSD  bible  Let your hand be lifted up above your
adversar…      hand    0.267857  Let your hand be lifted up above your
adversar…                 False  [VERB, PRON, NOUN, AUX, VERB, ADP, ADP, PRON,
…  [ROOT, poss, nsubjpass, auxpass, ccomp, prt, p…  [(VerbForm=Inf),
(Person=2, Poss=Yes, PronType…          1.250000                 0
4  3QREJ3J433XSBS8QMHAICCR0BQ1LKR  bible  Abimelech chased him, and he fled
before him, …  entrance    0.000000  Abimelech chased him, and he fled before
him, …                 False  [PROPN, VERB, PRON, PUNCT, CCONJ, PRON, VERB,
…  [nsubj, ROOT, dobj, punct, cc, nsubj, conj, pr…  [(Number=Sing),
(Tense=Past, VerbForm=Fin), (C…          1.652174                 0
                               id corpus
sentence           token  complexity
sentence_no_contractions  contraction_expanded
pos_sequence                                      dep_sequence
morph_sequence  morph_complexity  binary_complexity
0  3UXQ63NLAAMRIP4WG4XPD98A0Y0BLX  bible  for he had an only daughter, about
twelve year…  only daughter    0.025000  for he had an only daughter, about
twelve year…                 False  [SCONJ, PRON, VERB, DET, ADJ, NOUN, PUNCT,
ADV…  [mark, nsubj, ROOT, det, amod, dobj, punct, ad…  [(), (Case=Nom,
Gender=Masc, Number=Sing, Pers…          1.722222                 0
1  3FJ2RVH25Z62TA3R8E1O77EBUYU92W  bible  All these were cities fortified with
high wall…      high walls    0.100000  All these were cities fortified with
high wall…                 False  [DET, PRON, AUX, NOUN, VERB, ADP, ADJ, NOUN,
P…  [predet, nsubj, ROOT, attr, acl, prep, amod, p…  [(), (Number=Plur,
PronType=Dem), (Mood=Ind, T…          1.136364                 0
2  3YO4AH2FPDK1PZHZAT8WAEBL70EQ0F  bible  In the morning, 'It will be foul
weather today…   weather today    0.125000  In the morning, 'It will be foul
weather today…                 False  [ADP, DET, NOUN, PUNCT, PUNCT, PRON,
AUX, AUX,…  [prep, det, pobj, punct, punct, nsubj, aux, RO…  [(),
(Definite=Def, PronType=Art), (Number=Sin…          1.476190
0
3  3X52SWXE0X5Q3O81YI0MX4V84QTCWZ  bible  Her young children also were dashed in
pieces …  young children    0.160714  Her young children also were dashed in
```

```
pieces …                 False  [PRON, ADJ, NOUN, ADV, AUX, VERB, ADP, NOUN,
A…  [poss, amod, nsubjpass, advmod, auxpass, ROOT,…  [(Gender=Fem,
Number=Sing, Person=3, Poss=Yes,…          1.514286                  0
4  32K26U12DNONTREA84Q1V8UCIH2VD7  bible  All king Solomon's drinking vessels
were of go…       pure gold    0.178571  All king Solomon's drinking vessels
were of go…                 False  [DET, NOUN, PROPN, PART, NOUN, NOUN, AUX,
ADP,…  [det, compound, poss, case, compound, nsubj, c…  [(), (Number=Sing),
(Number=Sing), (), (Number…          1.162791                  0
```

[46]:

```python
# prompt: show me the distributions of binary_complexity for all 6 dataframes

import matplotlib.pyplot as plt
import seaborn as sns

# Assuming your dataframes are named as in the provided code:
dataframes = {
    "train_single_df": train_single_df,
    "train_multi_df": train_multi_df,
    "trial_val_single_df": trial_val_single_df,
    "trial_val_multi_df": trial_val_multi_df,
    "test_single_df": test_single_df,
    "test_multi_df": test_multi_df
}

# Create a figure and axes for the subplots
fig, axes = plt.subplots(2, 3, figsize=(18, 12))  # Adjust figsize as needed

# Iterate through dataframes and create distributions
for i, (df_name, df) in enumerate(dataframes.items()):
  row = i // 3
  col = i % 3
  ax = axes[row, col]
  sns.histplot(df['binary_complexity'], kde=True, ax=ax) #kde=True adds a␣
 ↪kernel density estimate
  ax.set_title(f'Distribution of binary_complexity for {df_name}')
  ax.set_xlabel('binary_complexity')

plt.tight_layout() # Adjust subplot params for a tight layout
plt.show()
```



[49]:
```
!ls -R /content/drive/MyDrive/266-final/data/266-comp-lex-master/
```

```
/content/drive/MyDrive/266-final/data/266-comp-lex-master/:
fe-test-labels  fe-train  fe-trial-val  test-labels  train  trial

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-test-labels:

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-train:

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-trial-val:

/content/drive/MyDrive/266-final/data/266-comp-lex-master/test-labels:
lcp_multi_test.tsv  lcp_single_test.tsv

/content/drive/MyDrive/266-final/data/266-comp-lex-master/train:
lcp_multi_train.tsv  lcp_single_train.tsv

/content/drive/MyDrive/266-final/data/266-comp-lex-master/trial:
lcp_multi_trial.tsv  lcp_single_trial.tsv
```

[50]:
```
!tree /content/drive/MyDrive/266-final/data/266-comp-lex-master/
```

```
/content/drive/MyDrive/266-final/data/266-comp-lex-master/
  fe-test-labels
```

```
  fe-train
  fe-trial-val
  test-labels
      lcp_multi_test.tsv
      lcp_single_test.tsv
  train
      lcp_multi_train.tsv
      lcp_single_train.tsv
  trial
      lcp_multi_trial.tsv
      lcp_single_trial.tsv

6 directories, 6 files
```

[51]:

```
# prompt: save all 6 dataframes to fe-test-labels, fe-train, fe-trial-val which␣
↪are subdirectories located in /content/drive/MyDrive/266-final/data/
↪266-comp-lex-master/

import os
# Assuming your dataframes are named as in the provided code:
dataframes = {
    "train_single_df": train_single_df,
    "train_multi_df": train_multi_df,
    "trial_val_single_df": trial_val_single_df,
    "trial_val_multi_df": trial_val_multi_df,
    "test_single_df": test_single_df,
    "test_multi_df": test_multi_df
}

base_dir = "/content/drive/MyDrive/266-final/data/266-comp-lex-master/"

for df_name, df in dataframes.items():
    subdir = None
    if "train" in df_name:
      subdir = "fe-train"
    elif "trial_val" in df_name:
      subdir = "fe-trial-val"
    elif "test" in df_name:
      subdir = "fe-test-labels"

    if subdir:
      save_path = os.path.join(base_dir, subdir, f"{df_name}.csv")
      os.makedirs(os.path.dirname(save_path), exist_ok=True) # create directory␣
↪if it doesn't exist
      df.to_csv(save_path, index=False)
      print(f"Saved {df_name} to {save_path}")
```

```
Saved train_single_df to /content/drive/MyDrive/266-final/data/266-comp-lex-
```

```
master/fe-train/train_single_df.csv
Saved train_multi_df to /content/drive/MyDrive/266-final/data/266-comp-lex-
master/fe-train/train_multi_df.csv
Saved trial_val_single_df to /content/drive/MyDrive/266-final/data/266-comp-lex-
master/fe-trial-val/trial_val_single_df.csv
Saved trial_val_multi_df to /content/drive/MyDrive/266-final/data/266-comp-lex-
master/fe-trial-val/trial_val_multi_df.csv
Saved test_single_df to /content/drive/MyDrive/266-final/data/266-comp-lex-
master/fe-test-labels/test_single_df.csv
Saved test_multi_df to /content/drive/MyDrive/266-final/data/266-comp-lex-
master/fe-test-labels/test_multi_df.csv
```

[52]:
```
!tree /content/drive/MyDrive/266-final/data/266-comp-lex-master/
```

```
/content/drive/MyDrive/266-final/data/266-comp-lex-master/
  fe-test-labels
     test_multi_df.csv
     test_single_df.csv
  fe-train
     train_multi_df.csv
     train_single_df.csv
  fe-trial-val
     trial_val_multi_df.csv
     trial_val_single_df.csv
  test-labels
     lcp_multi_test.tsv
     lcp_single_test.tsv
  train
     lcp_multi_train.tsv
     lcp_single_train.tsv
  trial
     lcp_multi_trial.tsv
     lcp_single_trial.tsv

6 directories, 12 files
```

[ ]: