

2_0_Lexical_Complexity_Binary_Classification_Prediction_Data_Preparat

April 8, 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
```

491.2/491.2 kB

10.2 MB/s eta 0:00:00

116.3/116.3 kB

10.5 MB/s eta 0:00:00

183.9/183.9 kB

16.6 MB/s eta 0:00:00

143.5/143.5 kB

12.4 MB/s eta 0:00:00

194.8/194.8 kB

17.4 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-cuspars-cu12==12.3.1.170; platform_system == "Linux" and platform_machine == "x86_64", but you have nvidia-cuspars-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==2025.3.2,² but you have fsspec 2024.12.0 which is incompatible.

2.6 MB/s eta 0:00:00
289.9/289.9 kB
7.0 MB/s eta 0:00:00
118.3/118.3 kB
10.7 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]
Hit:2 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:4 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64
InRelease [1,581 B]
Get:5 https://r2u.stat.illinois.edu/ubuntu jammy InRelease [6,555 B]
Get:6 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Get:7 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [127 kB]
Get:8 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64
Packages [1,381 kB]
Hit:9 https://ppa.launchpadcontent.net/deadsnakes/ppa/ubuntu jammy InRelease
Get:10 https://r2u.stat.illinois.edu/ubuntu jammy/main all Packages [8,804 kB]
Hit:11 https://ppa.launchpadcontent.net/graphics-drivers/ppa/ubuntu jammy
InRelease
Get:12 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [3,092
kB]
Hit:13 https://ppa.launchpadcontent.net/ubuntugis/ppa/ubuntu jammy InRelease
Get:14 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages
[4,148 kB]
Get:15 https://r2u.stat.illinois.edu/ubuntu jammy/main amd64 Packages [2,683 kB]
Get:16 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages
[1,540 kB]
Get:17 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages
[1,241 kB]
Get:18 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages
[2,775 kB]
Get:19 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64
Packages [3,978 kB]
Fetched 30.0 MB in 2s (12.7 MB/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 45 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 0s (360 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  
    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

```
[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:  
test_multi_df.csv  test_single_df.csv  
  
/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-train:
```

```
train_multi_df.csv  train_single_df.csv
```

```
/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-trial-val:  
trial_val_multi_df.csv  trial_val_single_df.csv
```

```
/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
```

```
[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} =====")

    # 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): 0.2666666666666667 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%: 0.31666666666666666 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]: print(train_multi_df.head())
```

```

              id corpus \
0  3S37Y8CWI80N8KVM53U4E6JKCDC4WE  bible
1  3WGCNLZJKF877FYC1Q6COKNWDWD11  bible
2  3UOMW19E6D6WQ5TH2HDD74IVKTP5CB  bible
3  36JW4WBRO6KF9AXMUL4N476OMF8FHD  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]: #@title Data Engineering
```

```
[19]: # 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'})

# 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]: 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]: tokenizer = RegexpTokenizer(r'\w+')

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}...")

        q1 = df['complexity'].quantile(0.25)
        q2 = df['complexity'].quantile(0.50)
        q3 = df['complexity'].quantile(0.75)

        def get_quartile(x):
            if x <= q1:
                return 'Q1'
            elif x <= q2:
                return 'Q2'
            elif x <= q3:
                return 'Q3'
            else:
                return 'Q4'

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

        def compute_span_metrics(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(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})
```



```

span_metrics = df['sentence'].apply(compute_span_metrics)
df = pd.concat([df, span_metrics], axis=1)

corpus_col = 'corpus' if 'corpus' in df.columns else 'subcorpus'

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'])

return results_df

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 = analyze_sentence_spans_by_corpus_and_quartile(dfs)

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

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:

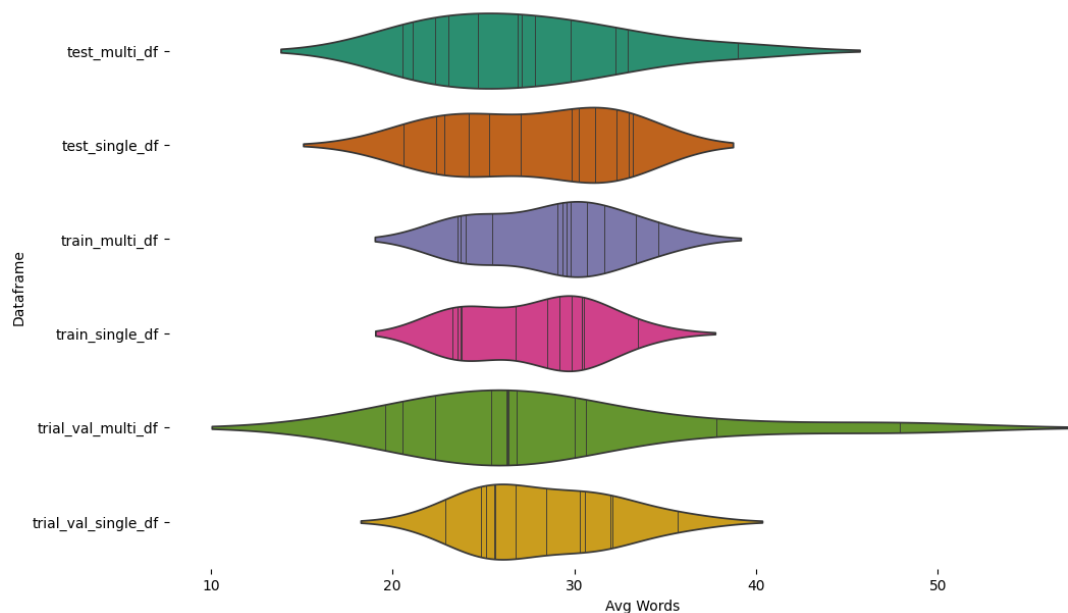
/content/drive/MyDrive/266-final/results/sentence_span_analysis.csv

```
[23]: 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)
```

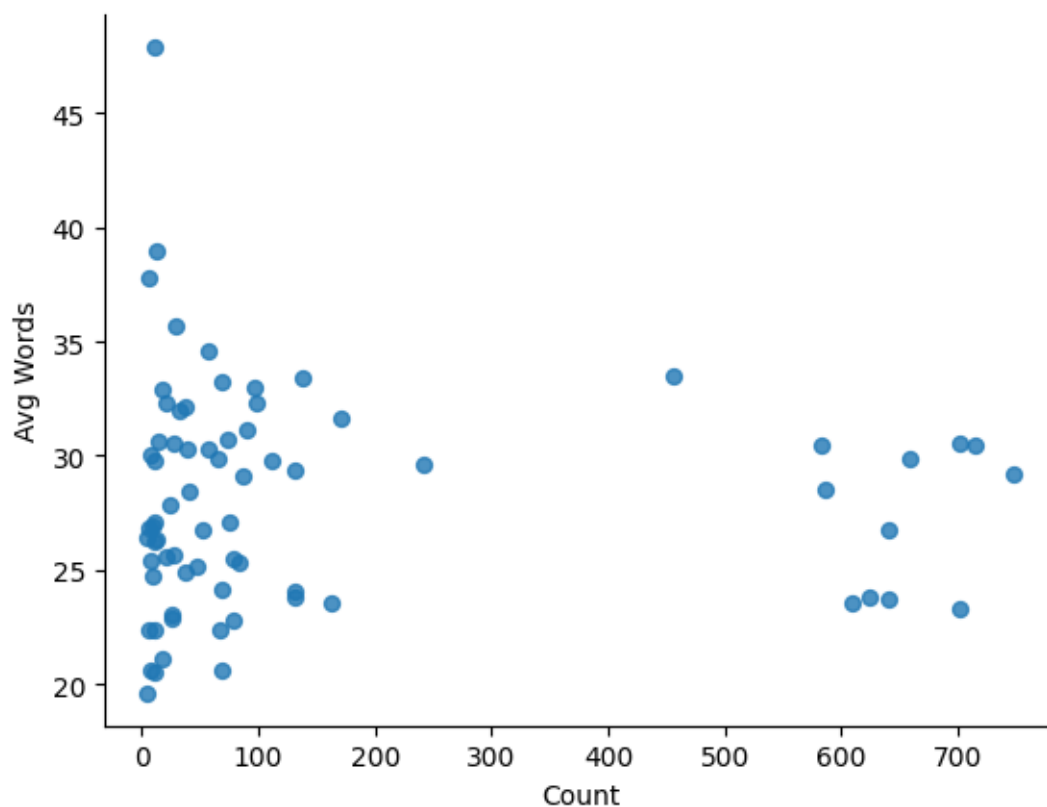
<ipython-input-23-00a8ad5642c1>:5: FutureWarning:

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)
```

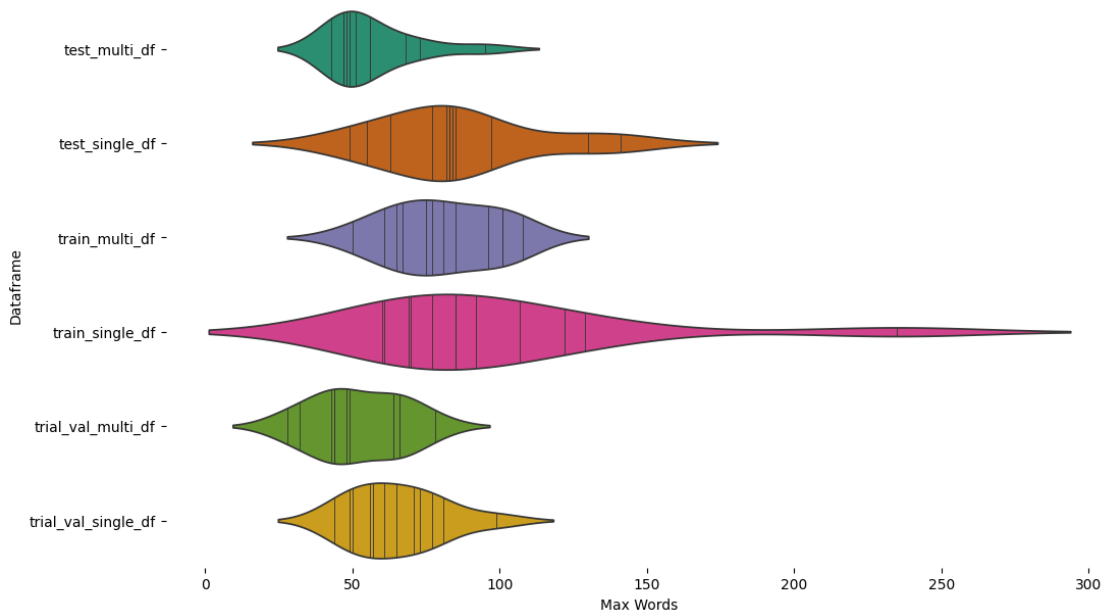


```
[25]: from matplotlib import pyplot as plt
import seaborn as sns
figsize = (12, 1.2 * len(span_analysis['Dataframe'].unique()))
plt.figure(figsize=figsize)
sns.violinplot(span_analysis, x='Max Words', y='Dataframe', inner='stick',
               palette='Dark2')
sns.despine(top=True, right=True, 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]: g = sns.FacetGrid(span_analysis, col="Corpus", col_wrap=3, height=4, aspect=1.5)
g.map(sns.violinplot, "Max Words", "Dataframe", inner='stick', palette='Dark2')
g.despine(top=True, right=True, bottom=True, left=True)
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.

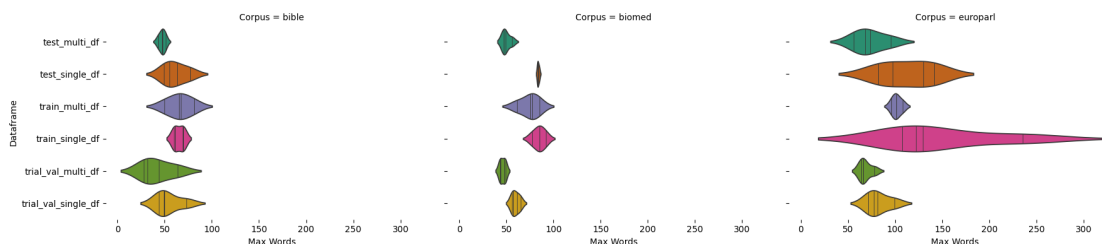
```
func(*plot_args, **plot_kwargs)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:854: FutureWarning:
```

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]: 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()
df['sentence_no_contractions'] = df['sentence'].apply(
    lambda s: contractions.fix(s) if pd.notna(s) else s
)

df['contraction_expanded'] = df.apply(
    lambda row: row['sentence'] != row['sentence_no_contractions'], axis=1
)

results_by_corpus = {}
for corpus_val, group in df.groupby('corpus'):
    changed_rows = group[group['contraction_expanded']]
    first_three = changed_rows.head(3)
    results_by_corpus[corpus_val] = first_three
return df, results_by_corpus

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:
    updated_df, corpus_examples = expand_contractions_in_df(df)
    globals()[df_name] = updated_df

    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]
        if len(subset) == 0:
            continue
        print(f"\n Corpus: {corpus_val}")
        print("    -- BEFORE --")
        for _, row in subset.iterrows():
            print(f"        {row['sentence']}")
        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 --

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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 Itpr1 Δ 18 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 --

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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 Țicău), and

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

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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 --

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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].

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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 --

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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.

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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 --

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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.

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=====
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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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.

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Corpus: europarl

-- BEFORE --

The next item is the oral question to the Commission (B7-0240/2009) by Silvia-Adriana Țicău, Brian Simpson, János Áder, Hannes Swoboda, Eva Lichtenberger, Michael Cramer, Saïd El Khadraoui, Mathieu Grosch, Iuliu Winkler, Victor Boștinăru, Ioan Mircea Pașcu, 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 Crețu, George Sabin Cutaș, 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 --

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=====
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]: # 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]: 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]: # 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]: # 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 34ROBODSP1ZEN3DVMY8J8XSIY551E5C 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 3BFNCI9LYKQN09BHXHH9CLSX5KP738 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 3WGCNLZJKF877FYC1Q6COKNWDWD11 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 3QI9WAYOGQB8GQIR4MDIEFOD2RLS67 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 3T8DUCXYON6WD9X4RTLK8UN1U929TF bible that sends ambassadors by the sea,
even in ves... sea 0.102941 that sends ambassadors by the sea, even in
ves... False

2 3I7KR83SNADXAQ7HXX7S7305BYB9KD bible and they entered into the boat, and
were going... sea 0.109375 and they entered into the boat, and were
going... False

3 3B03NEOQMOHK9ERYPN0GQIWCPC4IAQ 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 3Y3CZJSZ9KTOW7I0KE38WZHHKSW5RH 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 31HLTCK4BLVQ5B01AUR91TX9V9IVGH 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 389A2A3040IXVY7G5B71Q9M43LEOCL bible unleavened bread, unleavened cakes
mixed with ... wheat flour 0.157895 unleavened bread, unleavened cakes
mixed with ... False

2 31N9JPQXIPRX2A3S9NOCCFX06TNHR 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 3JVP4ZJHDPS081TGXL3N1CKZGQY0IN 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 3JAOYN9IHL25ZQAUV5EJZ4GHOKL33L 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 3ULIZOH1VA5C32JMKOTQ8Z4GUS51B 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 3BFFODJK8XCEIOT30ZLBPPSRMZQTSD 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  3UXQ63NLAAMRIP4WG4XPD98A0YOBXLX  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  3FJ2RVH25Z62TA3R8E1077EBUYU92W  bible  All these were cities fortified with
high wall...      high walls    0.100000  All these were cities fortified with
high wall...                False
2  3Y04AH2FPDK1PZHAT8WAEBL7OEQOF  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  3X52SWXE0X5Q3081YIOMX4V84QTCWZ  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]: tokenizer = RegexpTokenizer(r'\w+')

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'...")
        df = df.copy()

        q1 = df['complexity'].quantile(0.25)
        q2 = df['complexity'].quantile(0.50)
        q3 = df['complexity'].quantile(0.75)

        def get_quartile(x):
            if x <= q1:
                return 'Q1'
            elif x <= q2:
                return 'Q2'
            elif x <= q3:
                return 'Q3'

```

```

        else:
            return 'Q4'

df['quartile'] = df['complexity'].apply(get_quartile)

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
    })

span_metrics_nc = df['sentence_no_contractions'].
↪ apply(compute_span_metrics_no_contracts)
df = pd.concat([df, span_metrics_nc], axis=1)

corpus_col = 'corpus'
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'])
return results_df

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)

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

results_path_nc = os.path.join(dir_results,
    ↳'sentence_span_analysis_no_contracts.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_contracts'...
 Processing train_multi_df on 'sentence_no_contracts'...
 Processing trial_val_single_df on 'sentence_no_contracts'...
 Processing trial_val_multi_df on 'sentence_no_contracts'...
 Processing test_single_df on 'sentence_no_contracts'...
 Processing test_multi_df on 'sentence_no_contracts'...

	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 successfully, confirmed with Avg Word deltas between 'sentence' and 'sentence_no_contractions'

0.4 Enrich Dataset 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 2.7 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]: text = "This is a sample sentence for testing spaCy."

doc = nlp(text)

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]: 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():
        pos_tags.append([])
        dep_tags.append([])
        morph_tags.append([])
        morph_complexities.append(0.0)
        continue

    doc = nlp(text)

    pos_seq = [token.pos_ for token in doc]
    dep_seq = [token.dep_ for token in doc]
    morph_seq = [token.morph for token in doc]

    total_features = 0
    for token in doc:
        features_dict = token.morph.to_dict()
        total_features += len(features_dict)

    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)

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')
    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"\n{'='*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, CONJ, 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]: *# 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]: train_single_median = train_single_df['complexity'].median()

def binarize_complexity(value, threshold):
    """
    If value <= threshold, return 0, else return 1.

```

```

"""
    if value <= threshold:
        return 0
    else:
        return 1

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)
)

train_multi_median = train_multi_df['complexity'].median()

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)
)

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	34ROBODSP1ZBN3DVY8J8XSIY551E5C	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	3WGCNLZJKF877FYC1Q6COKNWDWD11	0.050000	0
2	3UOMW19E6D6WQ5TH2HDD74IVKTP5CB	0.050000	0
3	36JW4WBRO6KF9AXMUL4N476OMF8FHD	0.050000	0
4	3HRWUH63QU2FH9Q8R7MRNFC7JX2N5A	0.075000	0

```
[41]: # 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

```

```

[42]: # 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  34ROBODSP1ZBN3DVY8J8XSIY551E5C  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, pobj...  [(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  3WGCNLZJKF877FYC1Q6COKNWDWD11  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 3U0MW19E6D6WQ5TH2HDD74IVKTP5CB 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 36JW4WBRO6KF9AXMUL4N4760MF8FHD 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 3QI9WAYOGQB8GQIR4MDIEFOD2RLS67 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 3T8DUCXYON6WD9X4RTLK8UN1U929TF 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 3I7KR83SNADXAQ7HXXK7S7305BYB9KD 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, CC0... [cc, nsubj, ROOT, prep, det, pobj, punct, cc, ... [(ConjType=Cmp), (Case=Nom, Number=Plur, Perso... 1.437500 0

3 3B03NEOQMOHK9ERYPN0GQIWCPC4IAQ 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 3Y3CZJSZ9KTOW7IOKE38WZHHKSW5RH 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 31HLTCK4BLVQ5B01AUR91TX9V9IVGH	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 389A2A3040IXVY7G5B71Q9M43LEOCL	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, pobj...	[(Degree=Pos), (Number=Sing), (PunctType=Comm)...	1.200000 0
2 31N9JPQXIPIRX2A3S9N0CCFX06TNHR	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...	[(Degree=Pos, PronType=Art), (Degree=Pos...	1.190476 0
3 3JVP4ZJHDP5081TGXL3N1CKZGQY0IN	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 3JAOYN9IHL25ZQAU5EJZ4GHOKL33L	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 3Q2T3FDOON86LCI41NJYV3PNOBW3MV	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 3ULIZOH1VA5C32JMKOTQ8Z4GUS51B	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 3BFFODJK8XCEIOT30ZLBPPSRMZQTSD	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, CONJ, 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 3UXQ63NLAAMRIP4WG4XPD98A0YOBXL 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 3FJ2RVH25Z62TA3R8E1077EBUYU92W 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 3Y04AH2FPDK1PZHZA8WAEBL70EQOF 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 3X52SWXEOX5Q3081YIOMX4V84QTCWZ 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

```

```

[43]: 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,

```

```

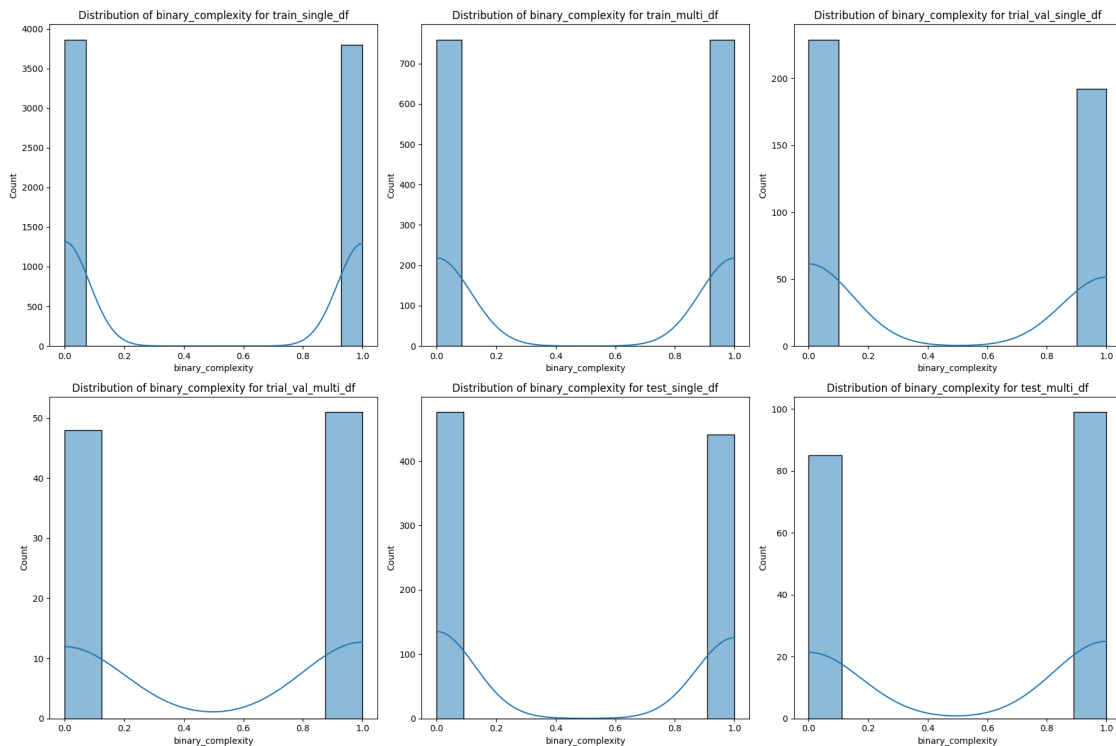
    "test_multi_df": test_multi_df
}

fig, axes = plt.subplots(2, 3, figsize=(18, 12))

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)
    ax.set_title(f'Distribution of binary_complexity for {df_name}')
    ax.set_xlabel('binary_complexity')

plt.tight_layout()
plt.show()

```



```
[44]: !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:
test_multi_df.csv  test_single_df.csv

```

```

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-train:
train_multi_df.csv  train_single_df.csv

/content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-trial-val:
trial_val_multi_df.csv  trial_val_single_df.csv

/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

```

```
[45]: !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

```
[46]: import os
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)
        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

[47]: `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

```
[48]: print(dir_data)
```

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

```
[60]: df_names = [
    "train_single_df",
    "train_multi_df",
    "trial_val_single_df",
    "trial_val_multi_df",
    "test_single_df",
    "test_multi_df"
]

loaded_dataframes = {}

for df_name in df_names:
    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"
    else:
        subdir = None

    if subdir:
        read_path = os.path.join(dir_data, subdir, f"{df_name}.csv")
        loaded_df = pd.read_csv(read_path)
        loaded_dataframes[df_name] = loaded_df
        print(f"Loaded {df_name} from {read_path}")

for df_name, df in loaded_dataframes.items():
    print(f"\n>>> {df_name} shape: {df.shape}")
    if 'binary_complexity' in df.columns:
        print(df['binary_complexity'].value_counts())
```

```

Loaded train_single_df from /content/drive/MyDrive/266-final/data/266-comp-lex-
master/fe-train/train_single_df.csv
Loaded train_multi_df from /content/drive/MyDrive/266-final/data/266-comp-lex-
master/fe-train/train_multi_df.csv
Loaded trial_val_single_df from /content/drive/MyDrive/266-final/data/266-comp-
lex-master/fe-trial-val/trial_val_single_df.csv

```

```
Loaded trial_val_multi_df from /content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-trial-val/trial_val_multi_df.csv
Loaded test_single_df from /content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-test-labels/test_single_df.csv
Loaded test_multi_df from /content/drive/MyDrive/266-final/data/266-comp-lex-master/fe-test-labels/test_multi_df.csv
```

```
>>> train_single_df shape: (7662, 12)
binary_complexity
0    3865
1    3797
Name: count, dtype: int64
```

```
>>> train_multi_df shape: (1517, 12)
binary_complexity
0     759
1     758
Name: count, dtype: int64
```

```
>>> trial_val_single_df shape: (421, 12)
binary_complexity
0     229
1     192
Name: count, dtype: int64
```

```
>>> trial_val_multi_df shape: (99, 12)
binary_complexity
1      51
0      48
Name: count, dtype: int64
```

```
>>> test_single_df shape: (917, 12)
binary_complexity
0     476
1     441
Name: count, dtype: int64
```

```
>>> test_multi_df shape: (184, 12)
binary_complexity
1      99
0      85
Name: count, dtype: int64
```

```
[61]: # 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

[62]: *# 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  34ROBODSP1ZBN3DVY8J8XSIY551E5C  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, CONJ, ...

```

[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, pobj... [(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 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 [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 3WGCNLZJKF877FYC1Q6COKNWDWD11 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 36JW4WBRO6KF9AXMUL4N476OMF8FHD 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	3QI9WAYOQB8GQIR4MDIEFOD2RLS67	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	3T8DUCXYON6WD9X4RTLK8UN1U929TF	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	3I7KR83SNADXAQ7HXX7S7305BYB9KD	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	3B03NEOQMOHK9ERYPN0GQIWCPC4IAQ	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	3Y3CZJSZ9KTOW7IOKE38WZHHKSW5RH	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	31HLTCK4BLVQ5B01AUR91TX9V9IVGH	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	389A2A3040IXVY7G5B71Q9M43LEOCL	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	31N9JPQXIPIRX2A3S9NOCCFX06TNHR	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 3JVP4ZJHDP081TGXL3N1CKZGQY0IN 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 3JAOYN9IHL25ZQAU5EJZ4GHOKL33L 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 3Q2T3FD00N86LCI41NJYV3PNOBW3MV 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 3ULIZOH1VA5C32JJMKOTQ8Z4GUS51B 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 3BFFODJK8XCEIOT30ZLBPPSRMZQTSD 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 3QREJ3J433XSBS8QMHAICCRQBQ1LKR 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 3UXQ63NLAAMRIP4WG4XPD98AOYOBXLX 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 3FJ2RVH25Z62TA3R8E1077EBUYU92W 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 3Y04AH2FPDK1PZHZAT8WAEBL70EQOF 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 3X52SWXEOX5Q3081YIOMX4V84QTCWZ 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

```

```

[63]: 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
}

for df_name, df in dataframes.items():
    print(f"\n=== {df_name} ===")
    print(df['binary_complexity'].value_counts())

```

```

=== train_single_df ===
binary_complexity
0    3865
1    3797
Name: count, dtype: int64

```

```

=== train_multi_df ===
binary_complexity
0    759

```

```

1      758
Name: count, dtype: int64

=== trial_val_single_df ===
binary_complexity
0      229
1      192
Name: count, dtype: int64

=== trial_val_multi_df ===
binary_complexity
1       51
0       48
Name: count, dtype: int64

=== test_single_df ===
binary_complexity
0      476
1      441
Name: count, dtype: int64

=== test_multi_df ===
binary_complexity
1       99
0       85
Name: count, dtype: int64

```

- These counts match my offline calculations exactly. The binarized outcome variables have been split on on the median of the TRAIN_SINGLE and TRAIN_MULTI dataset splits ONLY, thus this median is applied to trial_val and test. The first two quartiles (up to the train median) are equal to 0 in 'binary_complexity' and the next two quartiles are equal to 1.
- Because the dataset has been excellently balanced by the Task's annotators, we're lucky that no further data processing is necessary prior to moving onto the modeling step, and ensuring protection from data leakage by (later) removing necessary columns prior to vectorization.
- Lastly, a note on the balanced nature of the data. It should be noted that (even in the continuous outcome representation of 'complexity') the medians were 0.28 in train_single, and 0.27 in both trial_single and test_single—for multi, it was 0.41 in train_multi, and 0.42 in trial_multi and 0.43 in test_multi.
- We also find that after Data Engineering, our sanity checks have come out successfully. No records have been lost, shapes are consistent with our expectations, and we have enriched the dataset with SpaCy-derived features to give us flexibility in multi-channel inputs or vectorization ablations. This is a very thorough dataset, and we are now ready for modeling.

[]: