Wordle

January 19, 2022

1 Wordle Analysis

The first thing to do is load the required libraries! I am using `pandas` for my datasets, `seaborn` for my plotting, `string` for its useful alphabet string and `matplotlib` for managing my `seaborn` plots.

[1]:
```
%matplotlib inline
import string
import seaborn as sns
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

We will now load the dataset `words.txt` from this source. I then filter this dataset: - `len(word) == 5` only 5 letter words - `word.isalpha()` only words made of pure text (no hypens) - `word[0].upper() != word[0]` to remove any proper nouns

You may ask why I didn't choose to use the `words-alpha.txt`, the issue with this document is that it is all in lower case, so I have no idea which words are proper nouns!

[2]:
```
with open("words.txt", "r", encoding="utf-8") as f:
    words = [
        word.upper()
        for word in f.read().splitlines()
        if len(word) == 5 and word.isalpha() and word[0].upper() != word[0]
    ]
    num_words = len(words)

# letter = (pd.DataFrame.from_records(letter_count[0]))
```

We will then create an empty DataFrame which will be used to count how often each letter falls in each position of a letter! For example, the word "pilot", has one "P" in the column `count0`, one "I" in the column `count1`, one "L" in the column `count2` etc…

[3]:
```
letter_count = pd.DataFrame(
    0, columns=[f"count{i}" for i in range(5)], index=list(string.
 ↪ascii_uppercase)
)
print(letter_count)
```

```
   count0  count1  count2  count3  count4
A       0       0       0       0       0
B       0       0       0       0       0
C       0       0       0       0       0
D       0       0       0       0       0
E       0       0       0       0       0
F       0       0       0       0       0
G       0       0       0       0       0
H       0       0       0       0       0
I       0       0       0       0       0
J       0       0       0       0       0
K       0       0       0       0       0
L       0       0       0       0       0
M       0       0       0       0       0
N       0       0       0       0       0
O       0       0       0       0       0
P       0       0       0       0       0
Q       0       0       0       0       0
R       0       0       0       0       0
S       0       0       0       0       0
T       0       0       0       0       0
U       0       0       0       0       0
V       0       0       0       0       0
W       0       0       0       0       0
X       0       0       0       0       0
Y       0       0       0       0       0
Z       0       0       0       0       0
```

For every word, do the same as we did for the word "pilot".

[4]:
```
for word in words:
    for idx, letter in enumerate(word):
        letter_count.at[letter, f"count{idx}"] += 1

print(letter_count)
```

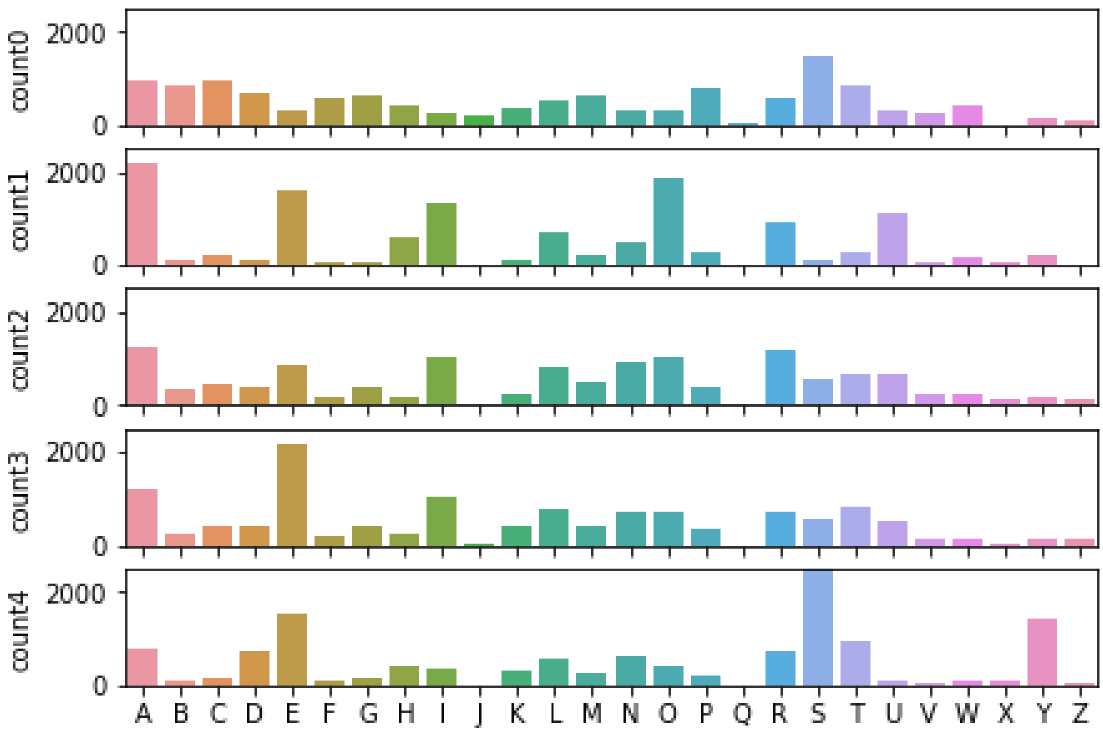
```
   count0  count1  count2  count3  count4
A     928    2183    1221    1217     808
B     868      94     353     236      85
C     946     223     441     406     172
D     669     110     403     404     761
E     335    1600     874    2141    1525
F     599      38     170     195      90
G     616      84     367     402     168
H     438     606     159     242     390
I     250    1336    1030    1038     338
J     193      15      40      26       2
K     366      89     257     425     293
```

```
L     516   710   803   761   589
M     618   194   510   388   245
N     326   499   935   715   619
O     289  1889  1016   742   399
P     790   249   376   374   199
Q      71    18    21     2     4
R     582   899  1196   702   711
S    1509   128   555   586  2813
T     829   271   644   836   953
U     294  1144   661   521   122
V     244    71   233   163    19
W     407   154   241   146    93
X      17    70   114    15    85
Y     134   227   185   127  1406
Z      93    26   122   117    38
```

Create a plot showing the frequency of each letter in the dataset (by position)

[5]:
```python
f, axs = plt.subplots(5, 1, figsize=(7, 5), sharex=True)
for ax in axs:
    ax.set(ylim=(0, 2500))
sns.barplot(x=letter_count.index, y=letter_count.count0, ax=axs[0])
sns.barplot(x=letter_count.index, y=letter_count.count1, ax=axs[1])
sns.barplot(x=letter_count.index, y=letter_count.count2, ax=axs[2])
sns.barplot(x=letter_count.index, y=letter_count.count3, ax=axs[3])
sns.barplot(x=letter_count.index, y=letter_count.count4, ax=axs[4])

plt.show()
```



This here creates a scoring system for every 5 letter word! It's easiest to explaing this with an example! Let's take the word "hello"

Let's refer to our previous table: - the letter "h" in the column `count0` scores: `438` (because it occurs `438` times in the dataset! - "e", `count1`: `1600` - "l", `count2`: `803` - "l", `count3`: `761` - "o", `count4`: `399`

So the total score of "hello" is: `4001`

[6]:
```
word_scoring = pd.DataFrame(columns=["Word", "Score"])
for idx, word in enumerate(words):
    score = sum(
        [letter_count.at[letter, f"count{idx}"] for idx, letter in␣
 ↪enumerate(word)]
    )
    x = pd.DataFrame({"Word": [word], "Score": [score]})
    word_scoring.loc[idx] = [word, score]


print(word_scoring.sort_values(by=["Score"], ascending=False).head())
# word_scoring.to_csv("scoring.csv", index=False)
```

```
        Word Score
9610   SANES  9581
10534  SORES  9548
9584   SALES  9449
```

```
9650   SATES  9290
10508  SONES  9287
```

The issue with this method, is that it gives high scores to words with repeated letters. Clearly, repeated letters do appear, but what if the letter had no "s", "SANES", "SORES", "SALES", "SATES", "SONES" all have these repeated letters (because that is the most common occurance).

So, what if we look at the total occurance of all the letters?

[7]:
```python
letter_count["sum"] = letter_count.sum(axis=1)
print(letter_count["sum"].to_dict())
```

```
{'A': 6357, 'B': 1636, 'C': 2188, 'D': 2347, 'E': 6475, 'F': 1092, 'G': 1637,
'H': 1835, 'I': 3992, 'J': 276, 'K': 1430, 'L': 3379, 'M': 1955, 'N': 3094, 'O':
4335, 'P': 1988, 'Q': 116, 'R': 4090, 'S': 5591, 'T': 3533, 'U': 2742, 'V': 730,
'W': 1041, 'X': 301, 'Y': 2079, 'Z': 396}
```

And then take the top 5 most common letters:

[8]:
```python
highest_frequency = sorted(letter_count["sum"].to_dict().items(), key=lambda␣
 ↪item: item[1])[-5:]
high_freq_l = ([group[0] for group in highest_frequency])
```

And then we can see which words conform to only these unique 5 letters:

[9]:
```python
[word for word in word_scoring["Word"] if sorted(list(word)) ==␣
 ↪sorted(high_freq_l)]
```

[9]:
```
['AROSE', 'SEORA']
```

There are some issues with this: - Not all the words in the dataset are allowed on wordle! For example, "SEORA" is not acceptable! This will cause skewness in our analysis! - It's still not a perfect solution, but what if we were to combine our knowledge from the "per position" scoring and the "per letter" scoring, and anaylse it that way?

[10]:
```python
# word_scoring.rename({"Score": "CountScore", "Word": "Word"})
word_scoring["LetterScore"] = np.nan
word_scoring
```

[10]:

	Word	Score	LetterScore
0	AAHED	6172	NaN
1	AALII	5290	NaN
2	AARGH	5099	NaN
3	ABACA	3457	NaN
4	ABACI	2987	NaN
...	...	...	...
12922	ZORRO	4279	NaN
12923	ZOWIE	4786	NaN
12924	ZUCCO	2483	NaN
12925	ZUDDA	2852	NaN

```
12926  ZUNIS   6023          NaN

[12927 rows x 3 columns]
```

[11]:
```
for idx, word in enumerate(words):
    score = sum(
        [letter_count["sum"].to_dict()[letter] for letter in word]
    )
    word_scoring.at[idx, "LetterScore"] = score
word_scoring
```

[11]:
```
        Word  Score  LetterScore
0      AAHED   6172      23371.0
1      AALII   5290      24077.0
2      AARGH   5099      20276.0
3      ABACA   3457      22895.0
4      ABACI   2987      20530.0
...      ...    ...          ...
12922  ZORRO   4279      17246.0
12923  ZOWIE   4786      16239.0
12924  ZUCCO   2483      11849.0
12925  ZUDDA   2852      14189.0
12926  ZUNIS   6023      15815.0

[12927 rows x 3 columns]
```

[12]:
```
word_scoring["Total Score"] = word_scoring["Score"] + word_scoring["LetterScore"]
word_scoring.sort_values(by=["Total Score"], ascending=False).head(20)
```

[12]:
```
        Word  Score  LetterScore  Total Score
3421   EASES   8027      30489.0      38516.0
9584   SALES   9449      27393.0      36842.0
9650   SATES   9290      27547.0      36837.0
9610   SANES   9581      27108.0      36689.0
9039   RASES   8274      28104.0      36378.0
7808   OASES   7981      28349.0      36330.0
757    ASSES   6565      29605.0      36170.0
9644   SASSE   6358      29605.0      35963.0
9818   SEERS   7498      28222.0      35720.0
3663   ESSES   5972      29723.0      35695.0
10534  SORES   9548      26082.0      35630.0
6432   LASES   8208      27393.0      35601.0
652    AREAS   6731      28870.0      35601.0
10159  SISES   8354      27240.0      35594.0
9794   SEATS   7979      27547.0      35526.0
9035   RARES   8915      26603.0      35518.0
774    ATEES   7027      28431.0      35458.0
```

```
708     ARSES  7336      28104.0      35440.0
9544    SADES  9049      26361.0      35410.0
9790    SEALS  7904      27393.0      35297.0
```

The problem we see here is that "AROSE" doesn't even appear on this list!

This is probably because my statistical analysis is not good enough! The problem is that "S" is disproportionately outwaying the other letters because a lot of these words are 4 letter plurals (so 5 with an "S" at the end)

I hope this information could help someone do their own analysis of this dataset, it would be interesting to see what the best word is! Perhaps making a simulation of the game would give different results?

1.0.1 Scrabbling Scoring

[13]:
```
# https://gist.github.com/jimbob88/15b2e7d7a2dd20698c9720b472fdc505
scrabble_score = {
  "A": 1,
  "B": 3,
  "C": 3,
  "D": 2,
  "E": 1,
  "F": 4,
  "G": 2,
  "H": 4,
  "I": 1,
  "J": 8,
  "K": 5,
  "L": 1,
  "M": 3,
  "N": 1,
  "O": 1,
  "P": 3,
  "Q": 10,
  "R": 1,
  "S": 1,
  "T": 1,
  "U": 1,
  "V": 4,
  "W": 4,
  "X": 8,
  "Y": 4,
  "Z": 10
}
for idx, word in enumerate(words):
    score = sum(
        [scrabble_score[letter] for letter in word]
```

```
    )
    word_scoring.at[idx, "ScrabbleScore"] = score
```

[14]:
```
word_scoring.sort_values(by=["ScrabbleScore"], ascending=True).head(20)
```

[14]:

	Word	Score	LetterScore	Total Score	ScrabbleScore
10781	STERE	4881	26164.0	31045.0	5.0
10778	STENO	3768	23028.0	26796.0	5.0
10773	STELL	4004	22357.0	26361.0	5.0
10772	STELE	4940	25453.0	30393.0	5.0
10771	STELA	4223	25335.0	29558.0	5.0
10768	STEER	5506	26164.0	31670.0	5.0
10763	STEAN	4490	25050.0	29540.0	5.0
10761	STEAL	4460	25335.0	29795.0	5.0
12150	UTERO	2540	21175.0	23715.0	5.0
10755	STAUN	4141	21317.0	25458.0	5.0
10750	START	4656	23104.0	27760.0	5.0
10749	STARN	4322	22665.0	26987.0	5.0
10747	STARE	5228	26046.0	31274.0	5.0
10743	STANE	5241	25050.0	30291.0	5.0
10740	STALL	4351	22239.0	26590.0	5.0
10739	STALE	5287	25335.0	30622.0	5.0
10736	STAIR	4750	23563.0	28313.0	5.0
10753	STATS	6650	24605.0	31255.0	5.0
10782	STERI	3694	23681.0	27375.0	5.0
10784	STERO	3755	24024.0	27779.0	5.0