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Project Report:

A Sentiment Analysis of Virginia Woolf's Fictional Works Using VADER

By

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I. Introduction

While it can be regarded as a fact that famous English writer Virginia Woolf was experiencing several psychic breakdowns during her lifetime, it is until today debated what exact mental illness Woolf was suffering from. The actual cause for her various phases of hospitalisation and suicide attempts (cf. Kottler 2006: 115, 119) remains unclear due to a yet not fully developed methodology of identifying psychic diseases in the early 20th century. Woolf's husband Leonard, for example, believed her symptoms to be rooted in a depression (Koutsantoni 2012: 11). Suzette Henke, on the other hand, takes Woolf's struggles for a post-traumatic stress disorder based on traumatic events during her childhood and youth (Henke 2010: 7). Psychologist and literary scholar Katerina Koutsantoni, after having analysed not only Woolf's books and biography, but also her family's history of mental and emotional problems, draws a different conclusion. According to Koutsantoni, Woolf was suffering from a manic-depressive illness or rather bipolar II mood disorder (Koutsantoni 2012: 9-12). Bipolar II is characterized by "a history of at least one major depressive episode and a series of less severe but recurring manic episodes or hypomanias" (ibid.: 9). Among other symptoms, people being in a hypomanic phase normally experience a tendency to cheerfulness or even euphoria (ibid.). Furthermore, they have an increased capacity of concentration as well as "enhanced access to vocabulary, memory and other cognitive resources" (ibid.: 12, cf. MacCabe et al. 2012: 114). Looking at Woolf's literary work, Koutsantoni further suggests Woolf was having a hypomanic phase during the writing of her novel *Jacob's Room*, published in 1922 (Koutsantoni 2012: 12). However, as this assumption does not represent the main argument of Koutsantoni's paper on Woolf, it is merely based on a very short qualitative reflection on the experimental plot structure of *Jacob's Room* as well as Woolf's own autobiographic descriptions of that time. No objectifiable evidence is provided. And yet, Koutsantoni's believe *Jacob's Room* could have been created within a hypomanic phase rouse my personal interest. If hypomania comes along with elevation of mood and enhanced vocabulary access, it is conceivable that a book written in a hypomanic phase could have two specific characteristics regarding its literary style. First, in comparison to other works, the book might contain a broader range of vocabulary. Second, the words used in the book might have a more positive connotation on average. These two characteristics, if present, could be identified with computational methods.

Accordingly, this report depicts my attempt to use Python in order to examine all books of Virginia Woolf and to answer two questions:

1. *In comparison to all of Woolf's other fictional works, does* Jacob's Room *contain a higher amount of distinct words?* This question is answered by counting the number of distinct words per 1000 words in total for every fictional book and short story by Woolf.

2. *In comparison to all of Woolf's other fictional works, does* Jacob's Room *have a higher sentiment score?* This question is answered by using VADER to conduct a lexicon-based sentiment analysis of every sentence of every fictional book and short story by Woolf. This way, based on the estimations given by VADER, three values for each work are determined: the percentage of sentences being rated as positive, the average general positivity, and the average compound-value, meaning the "normalized weighted composite score" (Frangidis et al. 2020: 433).

If these two questions were to be affirmed, my results could be regarded as a quantitative verification of Koutsantoni's qualitative analysis stating that Woolf wrote *Jacob's Room* while having a hypomanic phase. However, as I will show below, none of the mentioned quantitative relationships between *Jacob's Room* and Woolf's other fictional works could be identified. Koutsantoni's assumption could thus not be verified. On the following pages, I will outline how I was led to this conclusion:

I will begin by giving a short overview of the outset of my approach to sentiment analysis as well as the corpus I used (II.a). Hereafter, the exact implementation of determining the amount of distinct words within the corpus and of conducting sentiment analysis in Python will be described (II.b). The third chapter will present the results of my course of action and answer both of my research questions (III). Finally, I will come back to the question whether Woolf was having a hypomanic phase while writing *Jacob's Room* (IV).

II. Description of my course of action

a) Overview of my approach to sentiment analysis and the corpus

Although sentiment analysis is a multi-facetted field of study, the term mostly describes the process of analysing and retrieving positive and negative feelings underlying people's opinions expressed in written text (cf. Liu 2015: 1f., cf. Kim, Klinger 2019: 1). There are mainly two distinct approaches to doing sentiment analysis, one using machine learning methods and one

relying on sentiment lexicons (Raj, Jagadeesh 2021). For this project, I decided to use VADER, which is a sentiment analysis tool with a lexicon-based approach as well as several built-in and pre-trained heuristics "taking into consideration punctuation marks […], capitalization, degree modifiers (boosters and dampeners) Shift Polarity (with words like 'but') and Negation Handling using tri-grams" (Frangidis et al. 2020: 433). When giving a string to VADER, it returns a sentiment dictionary consisting out of four values: negative (listed with the key "neg"), neutral ("neu"), positive ("pos"), and compound ("compound"). While the first three values indicate the specific manifestation of the respective parameter within the string, the latter combines these three to a "normalized weighted composite score" (ibid.) and represents, so to speak, the final verdict over the sentiment expressed in the string.

Within my project, I used VADER for a document-level sentiment classification (cf. Liu 2015: 9), meaning I determined the sentiment score of whole documents or, in this case, books. However, this was achieved by iterating over every sentence of each document, thus by applying VADER on a sentence-level and then calculating the arithmetic mean of all sentences for each book.

The corpus I used consists of all published fictional works written by Virginia Woolf.[1] More specifically, it compromises *The Voyage Out* (published in 1915/listed in the Bibliography [IV.a] according to its e-book release in 1994), *Night and Day* (1920/1998), *Monday or Tuesday* (1921/2009), *Jacob's Room* (1922/2004), *Mrs Dalloway* (1925/2002a), *To the Lighthouse* (1927/2001), *Orlando* (1928/2002b), *The Waves* (1931/2002c), *Flush* (1933/2003b), *The Years* (1937/2003c), and *Between the Acts* (1941 [posthumously]/2003a). All works were downloaded manually from the Project Gutenberg and the Project Gutenberg Australia. Before starting with the automated processing of the documents, I manually removed all text not belonging to the actual content of the novel or short story from each file, e.g. respective metadata, tables of contents, and copyright information. All documents – in their original as well as their manually edited version – will be openly accessible via the "data"-folder in my personal GitHub-repository until 31 March 2022 (https://github.com/jakobvogel123/woolf_sentiment_analysis).

[1] Thus, Woolf's other works such as her essays (e.g. *A Room of One's Own*), diaries (*A Writer's Diary*), and non-fictional biographies (e.g. *Roger Fry*) were excluded from the corpus. *Two Stories* was also excluded as it only contains one short story by Woolf, namely *The Mark on the Wall*, which is already present in the corpus within *Monday or Tuesday*.

b) My implementation

In order to answer both questions raised in the Introduction chapter, I created two separate Python-scripts, namely *word_count.ipynb* and *sentiment_analysis.ipynb*, as well as a third script named *visualizations.ipynb* for working through my results (as will be shown in chapter III). All of these can be openly accessed via the "scripts"-folder in my GitHub-repository until the already specified date.

Within the *word_count*-script, I tried to determine if *Jacob's Room*, compared to Woolf's other books, contains a greater vocabulary range. More precisely, I examined each document to count the number of distinct words depending on the total amount of words.

First, for every file, I iterated over every line and appended it to a string, ignoring lines starting with the word "chapter" or containing only numbers in order to pass markers of chapter beginnings without an actual title.[2] Second, I substituted new-line-markers, meaning every "\n"-substring, with normal whitespace. By doing so, I created a dictionary with all book titles as keys and their respective plain text as value.
Hereafter, I tokenized every text using the ntlk-library. From the resulting lists of tokens, I removed punctuation marks and lowercased all tokens, as from my understanding, both punctuation and capitalization – at least in the English language – are irrelevant for determining a person's vocabulary range or literary creativity. Stemming or lemmatization, however, were forgone to acknowledge the creative impact of forming multiple words out of one stem.
In the next step, for each text, I counted the total amount of words and the number of distinct words by creating a set out of all tokens.
Finally, I created a pandas-DataFrame (*df_word_*count) and, out of this, a csv-file containing each book title together with its total amount of words, number of distinct words, and number of distinct words per 1000 words in total. The latter shall represent a sort of literary creativity score by which I will compare all books according to their vocabulary range in chapter III.

For conducting the sentiment analysis with VADER, I created the *sentiment_analysis*-script. Within this script, for each book, I determined the percentage of positively rated sentences as well as the average positive sentiment score and average compound sentiment score of all sentences summed up.

[2] Lines with an actual chapter title, on the other hand, were appended to the string.

First, I created a dictionary containing the book titles and their plain texts the same way I did in the *word_count*-script. I then split all texts into sentences using the sent_tokenize-function of the nltk-library.

It is debatable whether sentiment analysis works more efficiently with or without pre-processing the respective textual data. In their study on movie scripts and reviews, for example, Paschalis Frangidis et al. recommend lemmatization and stop-word-removal when conducting sentiment analysis (Frangidis et al. 2020: 433). Thomas Schmidt and Manuel Burghardt, however, show that, when dealing with literary pieces, such pre-processing can adversely affect the outcome of sentiment analysis (Schmidt, Burghardt 2018: 142-145). Especially when working with a tool like VADER which, due to its heuristics, recognizes the meaning of certain stop words and their influence on a sentence's sentiment score, pre-processing the data might skew the results of sentiment analysis.

It is for this ambiguity that I decided to use two separate dictionaries for my analysis: one containing the sentences of each book without pre-processing (*sentences_all_texts*), and one containing the sentences of each book with stop words being removed and all other tokens being lemmatized (*no_stop_lemma_all_texts*).

For stop-word-removal, I tokenized every sentence in *no_stop_lemma_all_texts*, compared the lowercased tokens to the nltk-corpus of English stop words, and removed all matches. After POS-tagging the tokens with the nltk.pos_tag-function, lemmatization could be done with the WordNetLemmatizer. After this, I remerged the tokens into word sequences, i.e., sentences.

Having finished the pre-processing, I could finally start with the actual sentiment analysis. For every key, meaning for every book, in the non-edited *sentences_all_texts*-dictionary and the pre-processed *no_stop_lemma_all_texts*-dictionary, I iterated over every sentence and used VADER's SentimentIntensityAnalyzer to create a sentiment-dictionary for that sentence. The values of all four keys of the sentiment dictionary – "neg", "neu", "pos", and "compound" – of all sentences were summed up and eventually divided through the total amount of sentences to get their average value for each book. Furthermore, the number of positive, neutral, and negative sentences was counted according to the compound-value of each sentence: every sentence with a value higher than 0.05 was counted as positive, everyone with a value lower than -0.05 as negative, the rest was counted as neutral.[3] Finally, depending on the total amount of sentences, the percentage of positive, negative, and neutral sentences was determined.

[3] Choosing a different range for this selection would be possible, as long as it still enables a differentiated comparison of the books.

As I worked with two dictionaries containing all books, two different DataFrames were created out of the results – one for the unedited versions of the books (*df_unedited*) and one for the pre-processed versions (*df_no_stop_lemma*) – and saved as csv-file.

In order to evaluate the results of my course of action, I loaded all csv-files I had written into the *visualizations*-script and recreated the respective pandas-DataFrames out of them. For every column in all three tables, I first determined the arithmetic mean of its values – excluding *Jacob's Room* – using pandas' mean-function and added these to the DataFrame. I then used the matplotlib-library to generate several bar charts depicting the relation between *Jacob's Room* and all other works by Woolf.

III. Results

The operations undertaken in the *word_count*-script as described above lead to the following results:

	name	count_words_total	count_words_distinct	distinct_words_per_1000_words
0	The Voyage Out	146530.0	10929.0	74.585409
1	Night and Day	177794.0	11734.0	65.997728
2	Monday or Tuesday	19637.0	3796.0	193.308550
3	Jacob's Room	57977.0	7450.0	128.499232
4	Mrs Dalloway	65816.0	7150.0	108.636198
5	To the Lighthouse	71214.0	6813.0	95.669391
6	Orlando	80442.0	9452.0	117.500808
7	The Waves	78626.0	8924.0	113.499351
8	Flush	35311.0	5293.0	149.896633
9	The Years	138161.0	8568.0	62.014606
10	Between the Acts	48288.0	6535.0	135.333830
11	mean	86181.9	7919.4	111.644250

Figure 1: screenshot DataFrame df_word_count – visualizations-script

The order of entries in this and all other DataFrames depicted here complies with the chronology of their publication. As already pointed out, the mean-entry in this as well as all other tables was calculated excluding *Jacob's Room*.

In order to compare the literary creativity of *Jacob's Room* to all other books, I only want to take into account the creativity score I defined, namely the number of distinct words per 1000 words in total (*distinct_words_per_1000_words*). For a better overview of that relation, let's take a look at the following chart:

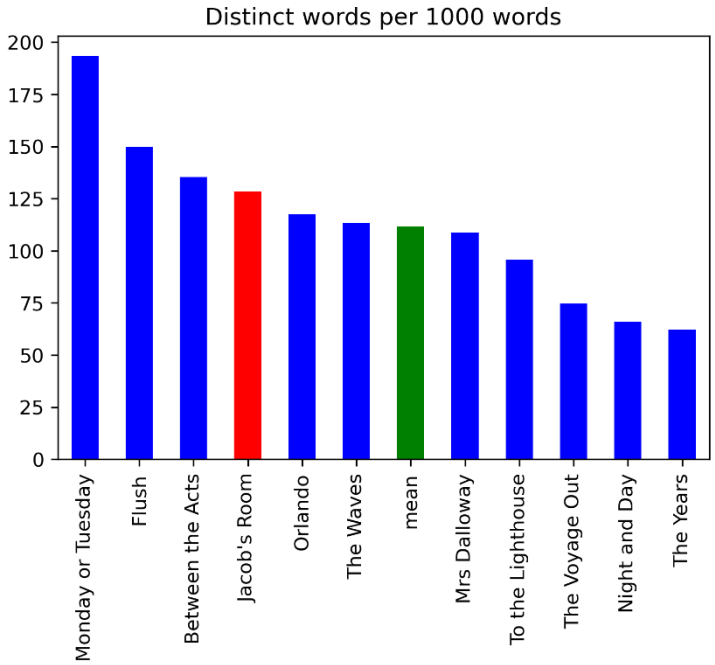

Figure 2: df_word_count, x = name, y = distinct_words_per_1000_words

As we can see, *Jacob's Room* has indeed got a higher creativity score than the mean of all other fictional books written by Woolf. More precisely, *Jacob's Room* uses around 128.45 distinct words per 1000 words, whereas the average of all other books is approximately 111.64. And yet, in comparison to the mean, the creativity score of *Jacob's Room* is only around 15% higher. From the total of ten comparison objects, three have a higher score than *Jacob's Room*. The distance from *Jacob's Room* to the book with the maximum score (*Monday or Tuesday* with a score of 193.21, distance to *Jacob's Room*: 64.76) is almost identical to its distance to the book with the minimum score (*The Years* with a score of 62.01, distance to *Jacob's Room*: 66.44). The standard deviation of all entries excluding *Jacob's Room* and the mean-entry – which can be calculated with pandas' describe-function – is around 40.71. This means that *Jacob's Room*, having a distance to the mean-value of approximately 16.81, is within one deviation. Hence,

statistically, although the creativity score of *Jacob's Room* is slightly above average, its distance to the mean can be neglected. *Jacob's Room* hardly contains more distinct words than the average of all other fictional works by Woolf, and my first research question – as stated in the Introduction chapter – can be answered in the negative.

Looking at the results of the actual sentiment analysis, I first want to shed light on the outcome of the operations undertaken with the unedited data, i.e, the texts without pre-processing. The results are as follows:

	name	neg_sentences_perc	neu_sentences_perc	pos_sentences_perc	avg_neg	avg_neu	avg_pos	avg_comp
0	The Voyage Out	23.964455	40.318188	35.717357	0.056750	0.862865	0.080377	0.077669
1	Night and Day	26.112366	33.550272	40.337362	0.062205	0.850129	0.087663	0.094508
2	Monday or Tuesday	21.792619	47.275923	30.931459	0.069490	0.838007	0.092510	0.053961
3	Jacob's Room	21.629543	50.293083	28.077374	0.058438	0.870877	0.070682	0.043306
4	Mrs Dalloway	22.769064	45.078421	32.152515	0.071012	0.836510	0.092484	0.072555
5	To the Lighthouse	24.189881	42.950540	32.859579	0.062536	0.855915	0.081550	0.062279
6	Orlando	25.871667	38.265456	35.862877	0.063321	0.853260	0.083415	0.071983
7	The Waves	24.701349	48.728324	26.570328	0.068340	0.865676	0.065984	0.016515
8	Flush	29.468822	47.066975	23.464203	0.076055	0.865644	0.058298	-0.008477
9	The Years	15.456293	64.317409	20.226298	0.046482	0.892418	0.061101	0.034301
10	Between the Acts	14.162473	67.864845	17.972682	0.044493	0.903048	0.052457	0.031151
11	mean	22.848899	47.541635	29.609466	0.062068	0.862347	0.075584	0.050645

Figure 3: screenshot DataFrame df_unedited – visualizations-script

As it is my aim to find out if *Jacob's Room* uses a more positively connotated language than all other books, I eventually chose three parameters for this comparison, all indicating how positive the style of each document is: The percentage of positive sentences (*pos_sentences_perc*), the average positive-value (*avg_pos*), and the average compound value (*avg_comp*). For a better overview, let's consider the following charts, each depicting one of the three relevant values:

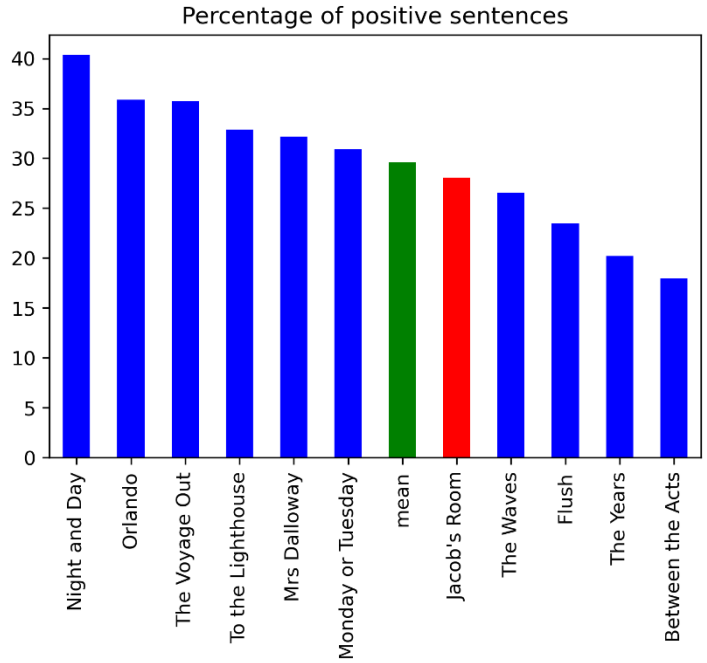

Figure 4: df_unedited, x = name, y = pos_sentences_perc

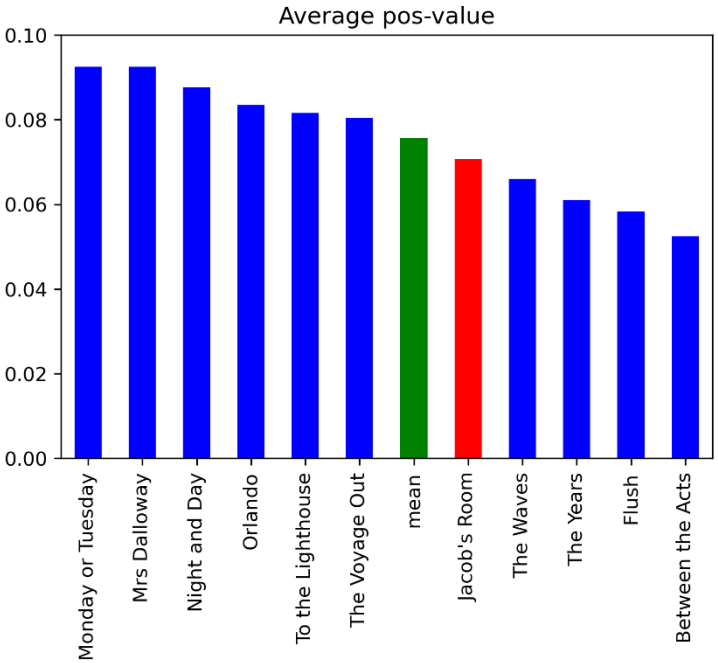

Figure 5: df_unedited, x = name, y = avg_pos

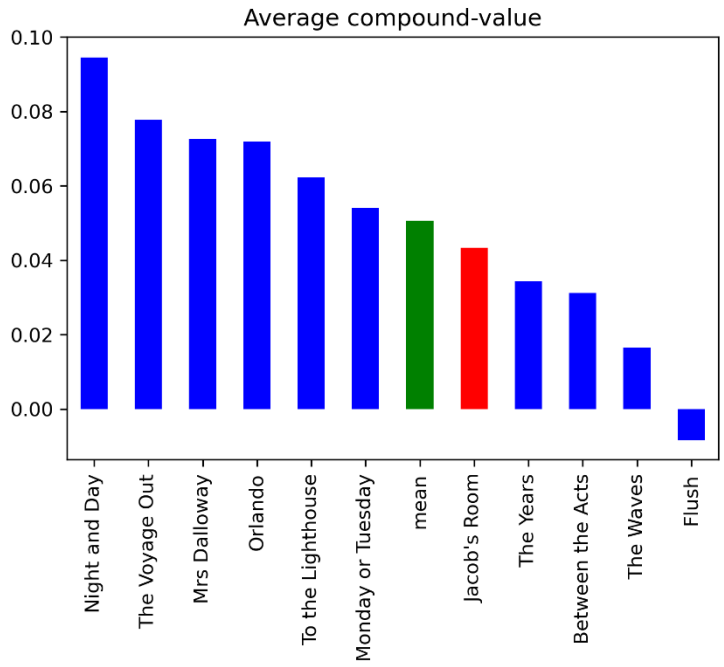

Figure 6: df_unedited, x = name, y = avg_comp

Sorting the DataFrame according to the three values I chose for the comparison, the result is very clear. No matter which value we focus on, the sentiment score of *Jacob's Room* remains slightly below average. It is for this visual clarity that I decide to forgo a further statistical analysis at this point.[4]

When looking at the results of the sentiment analysis undertaken with the pre-processed data, a very similar picture emerges:

[4] Interestingly, *Flush* has got a very low sentiment score within all three parameters. This circumstance points out to a major problem sentiment analysis is still facing until today, namely the problem of recognizing irony (cf. Schmidt, Burghardt 2018: 146). *Flush* is a fictional biography of Elizabeth Barrett Browning's dog. Its writing style is often ambiguously humorous. While human annotators would normally recognize *Flush* as the parody it is – and therefore maybe give it a relatively high sentiment score –, automatized sentiment analysis reaches its limits here.

	name	neg_sentences_perc	neu_sentences_perc	pos_sentences_perc	avg_neg	avg_neu	avg_pos	avg_comp
0	The Voyage Out	22.502508	36.491329	41.006163	0.073472	0.803337	0.123190	0.112337
1	Night and Day	23.748174	31.451720	44.800106	0.078337	0.787602	0.134059	0.132330
2	Monday or Tuesday	20.562390	45.694200	33.743409	0.073873	0.814946	0.111181	0.077130
3	Jacob's Room	20.867526	49.560375	29.572098	0.067657	0.843924	0.088424	0.055916
4	Mrs Dalloway	20.876149	44.835046	34.288805	0.082544	0.797050	0.120402	0.091306
5	To the Lighthouse	21.461057	42.382035	36.156907	0.078344	0.803622	0.118030	0.088968
6	Orlando	23.469089	37.943159	38.587753	0.079297	0.801791	0.118919	0.100176
7	The Waves	22.273603	49.691715	28.034682	0.079472	0.826746	0.093781	0.036466
8	Flush	27.852194	47.713626	24.434180	0.093440	0.824173	0.082384	0.007876
9	The Years	14.701967	63.296850	22.001183	0.053322	0.869668	0.077009	0.044137
10	Between the Acts	13.425593	67.433501	19.140906	0.047874	0.886191	0.065934	0.039222
11	mean	21.087272	46.693318	32.219409	0.073998	0.821513	0.104489	0.072995

Figure 7: screenshot DataFrame df_no_stop_lemma – visualizations-script

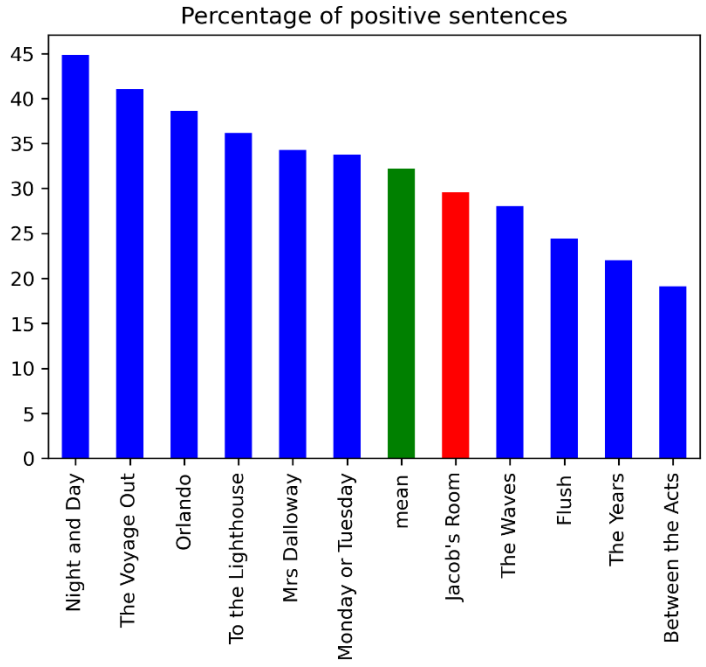

Figure 8: df_no_stop_lemma, x = name, y = pos_sentences_perc

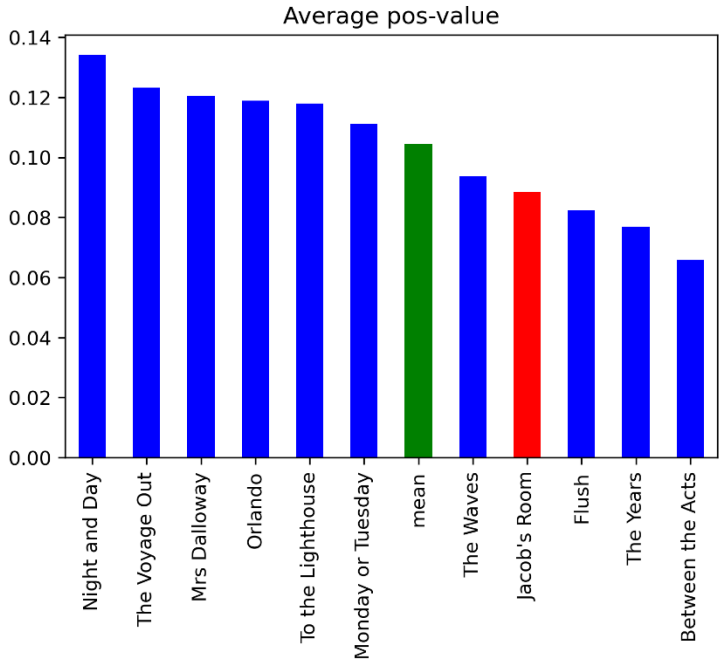

Figure 9: df_no_stop_lemma, x = name, y = avg_pos

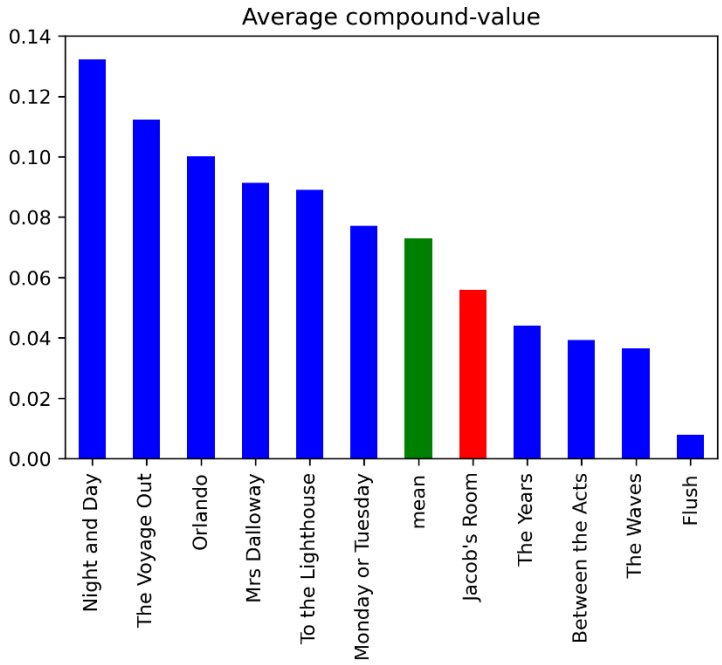

Figure 10: df_no_stop_lemma, x = name, y = avg_comp

Although the absolute values of the comparison parameters change when regarding the pre-processed data, the order of the books, based on their relative proportions to each other, nearly stays the same.[5] As with the non-edited data, looking at the pre-processed texts, *Jacob's Room* is slightly below average within all three comparison parameters. Here again, due to this overwhelming clarity, I forgo a statistical analysis of these results.

The second research question stated in the Introduction chapter was whether *Jacob's Room* has a higher sentiment score in comparison to all other fictional books written by Woolf. As the sentiment score of *Jacob's Room* is quite average or rather slightly below average in all tested cases, this question can be answered in the negative.

IV. Conclusion

As pointed out in the previous chapter, both of my research questions could not be answered in the affirmative. In comparison to all other fictional books by Woolf, *Jacob's Room* does not have a higher range of vocabulary nor a higher sentiment score. Thus, by means of my approach, there is no indication that *Jacob's Room* was written under the influence of an increased literary creativity – or rather enhanced access to vocabulary – and lifted mood. Therefore, Koutsantoni's argument that Woolf was having a hypomanic phase during the writing of *Jacob's Room* could not be verified. This is of course a somehow disappointing finding – and yet, a finding. Naturally, this is not to say that Koutsantoni's argument has been falsified. It is conceivable that either Woolf was not an author who led her current psychic state influence her style of writing, or that with a different approach to sentiment analysis, a quantitative difference between *Jacob's Room* and Woolf's other fictional works could indeed be identified. Both hypotheses are possible conclusions to my project and could be tested in future studies.

[5] One exception being the average pos-value, where *Jacob's Room* has the seventh highest value within the non-edited dataset, but only the eighth highest when data is pre-processed. For my research question, however, this is irrelevant, as in both cases the value of *Jacob's Room* remains below average.

V. Appendix

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b) Declaration of authorship

I hereby certify that this report has been composed by me and is based on my own work, unless stated otherwise. No other person's work has been used without due acknowledgement in this report. All references and verbatim extracts have been quoted, and all sources of information have been specifically acknowledged. All graphs and images were created by me using the indicated tools.

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