project 1 code

September 21, 2022

[1]:
```
#libraries and necessary packages

#basic
import numpy as np
import pandas as pd

#visualization
import seaborn as sns
import matplotlib.pyplot as plt

#document processing
from csv import DictReader, reader
import nltk
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
from nltk.stem import PorterStemmer
from nltk.tokenize import word_tokenize
from nltk import pos_tag
from wordcloud import WordCloud, STOPWORDS
from sklearn.feature_extraction.text import CountVectorizer

#folder navigation
import os

#sentiment analysis
import text2emotion as te

#Topic modeling
from sklearn.decomposition import LatentDirichletAllocation
import warnings
warnings.filterwarnings('ignore')
```

```
[nltk_data] Downloading package stopwords to /Users/lsx/nltk_data…
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package punkt to /Users/lsx/nltk_data…
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package wordnet to /Users/lsx/nltk_data…
[nltk_data]   Package wordnet is already up-to-date!
```

[2]:
```
import os
import numpy as np
import pandas as pd
import nltk
from nltk.tokenize import word_tokenize
from nltk.corpus import cmudict
!pip install syllables
import syllables
import matplotlib.pyplot as plt
from sklearn.metrics import mean_squared_error, r2_score
from sklearn.linear_model import LinearRegression
from collections import Counter
```

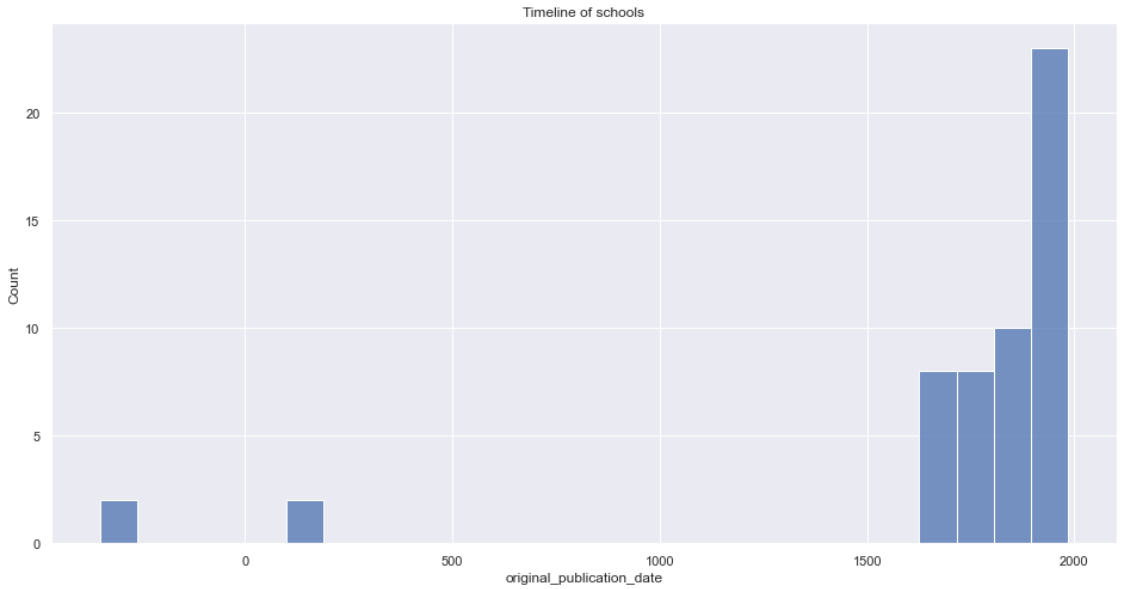
```
Requirement already satisfied: syllables in
/Users/lsx/anaconda3/lib/python3.9/site-packages (1.0.3)
```

[3]:
```
dataset = pd.read_csv('/Users/lsx/Desktop/5243 applied ds /assignments/
 ↪philosophy_data.csv')
```

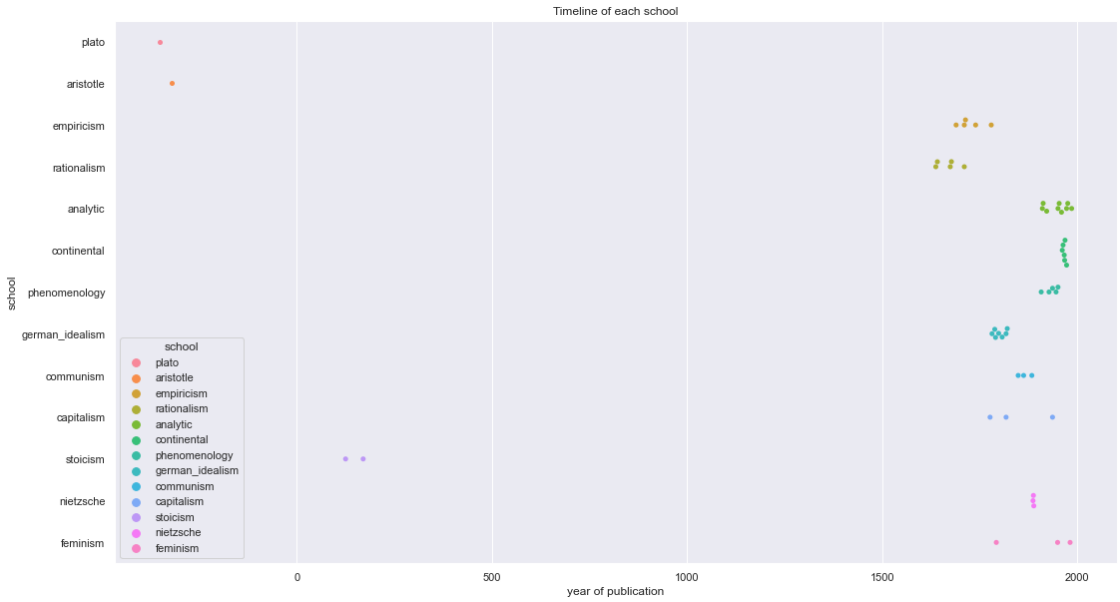
0.1 Data exploration

[4]:
```
#exploring timeline of publications

dataset_sorted =dataset.sort_values(by=['original_publication_date'])
timeline_school = dataset.loc[:, ['school', 'original_publication_date']].
 ↪drop_duplicates()
```

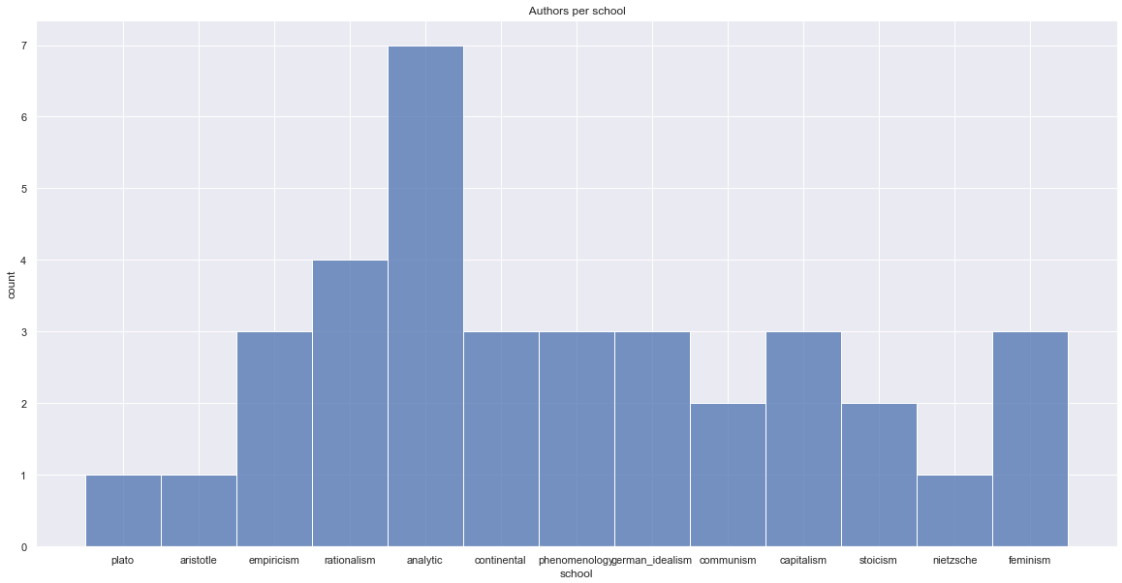
[5]:
```
sns.set(style="darkgrid")
sns.set(rc = {'figure.figsize':(16,8)})
sns.histplot(data=timeline_school, x="original_publication_date" )
plt.title('Timeline of schools')

path = "/Users/lsx/Desktop/Timeline of schools.png"
plt.savefig(path, bbox_inches="tight")

plt.show()
```



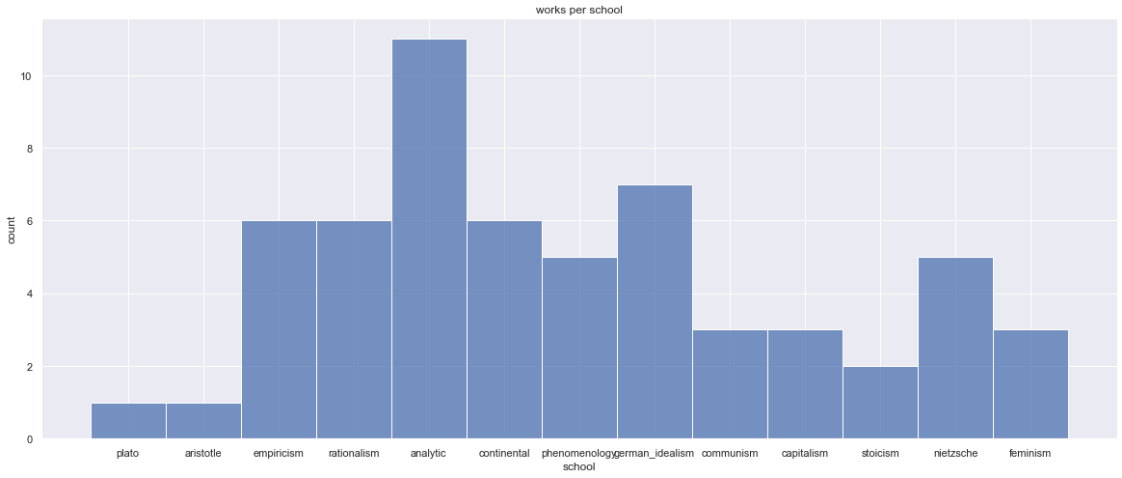
[6]:
```
sns.set_theme(style="whitegrid", palette="dark")
sns.set(rc={'figure.figsize':(18,10)})
sns.swarmplot(data=timeline_school,
              x="original_publication_date",
              y="school", hue="school").set(title='Timeline of each school',␣
 ↪xlabel='year of publication')

path = "/Users/lsx/Desktop/Timeline of schools2.png"
plt.savefig(path, bbox_inches="tight")

plt.show()
```



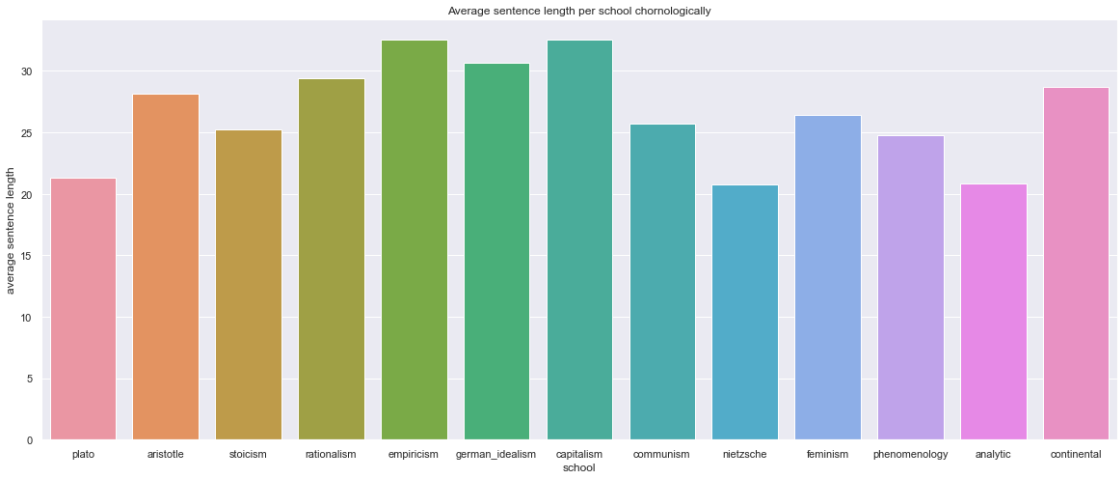
[7]:
```
#Number of authors represinting each school
authors_per_school = dataset.loc[:, ['school', 'author']].drop_duplicates()
authors_per_school_count = authors_per_school['school'].value_counts()
authors_per_school_count

sns.set(rc={'figure.figsize':(20,10)})
sns.histplot(data=authors_per_school,
             x="school").set(ylabel='count',title=' Authors per school');

path = "/Users/lsx/Desktop/Authors per school.png"
plt.savefig(path, bbox_inches="tight")

plt.show()
```



[8]:
```
##Timeline of works for each school
texts_per_school =dataset.loc[:, ['school', 'title']].drop_duplicates()
texts_per_school_count=texts_per_school['school'].value_counts()


sns.set(rc={'figure.figsize':(20,8)})
sns.histplot(data=texts_per_school,
             x="school").set(ylabel='count',title='works per school')

path = "/Users/lsx/Desktop/works per school.png"
plt.savefig(path, bbox_inches="tight")

plt.show()
```



[9]:
```
#sentence length visualization

dataset['new_sentence_length'] =dataset.apply(lambda row: len(row.sentence_str.
 ↪split()), axis=1)
dataset_sorted = dataset.sort_values(by=['original_publication_date'])
#fing avg sentence length per school
mean_df = dataset_sorted.groupby("school")['new_sentence_length' ,␣
 ↪'original_publication_date' ].mean()
mean_df = mean_df.reset_index()
#sort chronologically
mean_df = mean_df.sort_values(by=['original_publication_date'])

sns.set(rc={'figure.figsize':(20,8)})
sns.barplot(data=mean_df, x="school",
            y="new_sentence_length").set(ylabel='average sentence length',␣
 ↪title='Average sentence length per school chornologically');

path = "/Users/lsx/Desktop/Average sentence length per school.png"
plt.savefig(path, bbox_inches="tight")
plt.show()
chronological_order = mean_df['school'].values.tolist()
```



0.2 Data processing

[11]:
```
dataset2=dataset

dataset2['new_lowered_sentence'] =dataset.apply (lambda row: row.sentence_str.
 ↪lower(), axis=1)
```

```
def remove_punctuation(text):
     punctuations = '''!()[]{};«»:'"\,`<>./?@=#$-(%^)+&[*_]~'''
     no_punct = ""
     for char in text:
        if char not in punctuations:
            no_punct = no_punct + char
     return no_punct

dataset2['new_lowered_sentence'] = dataset.apply(lambda row:␣
 ↪remove_punctuation(row.new_lowered_sentence), axis=1)

#remove punctuations when tokenizing
tokenizer = nltk.RegexpTokenizer(r"\w+")
dataset2['new_tokenized_sentence'] = dataset.apply (lambda row: tokenizer.
 ↪tokenize(row.new_lowered_sentence), axis=1)


def remove_stopwords(word_tokens):
    stop_words = set(stopwords.words('english'))
    return [w for w in word_tokens if w.lower() not in stop_words]

dataset2['tokens_without_stop_words'] = dataset2.apply(lambda row:␣
 ↪remove_stopwords(row.new_tokenized_sentence), axis=1)

#lemmatizing words
def lem_sentence(word_tokens):
    pos_map = {'J': 'a', 'N': 'n', 'R': 'r', 'V': 'v'}
    pos_tags_list = pos_tag(word_tokens)
    lemmatizer = WordNetLemmatizer()
    return [lemmatizer.lemmatize(w, pos=pos_map.get(p[0], 'v')) for w, p in␣
 ↪pos_tags_list]

dataset2['lemmatized_tokens'] = dataset2.apply(lambda row: lem_sentence(row.
 ↪tokens_without_stop_words), axis=1)

#additional stop words that we removed
additional_stop_words = ['go', 'sure', 'new', 'list', 'back', 'say', 'one',␣
 ↪'two', 'without', 'much',
                         'whose', 'therefor', 'first', 'within', 'yet', 'would',␣
 ↪'also', 'second', 'whats',
                         'us', 'secondly', 'may', 'upon', 'more', 'thus',␣
 ↪'mine', 'thou', 'thy', 'thee', 'dont']

def remove_additional_stopwords(word_tokens):
    stop_words = set(additional_stop_words)
```

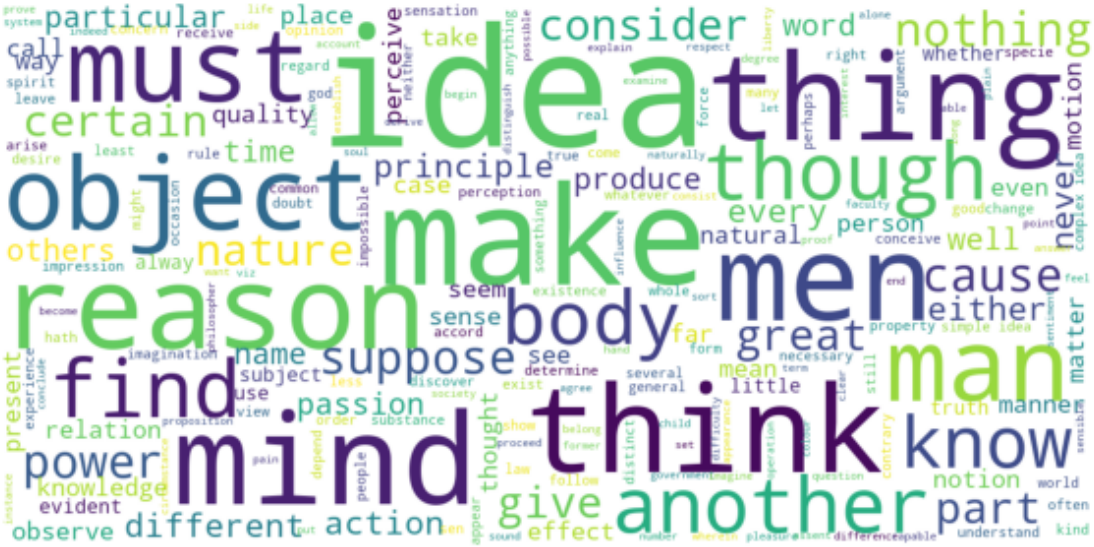
```
    return [w for w in word_tokens if w.lower() not in stop_words]

dataset2['lem_tokens_without_additional_stop_words'] = dataset2.apply(
    lambda row: remove_additional_stopwords(row.lemmatized_tokens), axis=1
)
dataset2['lem_sentence_without_additional_stop_words'] = dataset2.apply(
    lambda row: " ".join(row.lem_tokens_without_additional_stop_words), axis=1
)


# create data frame with the important columns

important_columns = ["title", "author", "school",
                "original_publication_date", "corpus_edition_date",
                "new_lowered_sentence",␣
 ↪"lem_sentence_without_additional_stop_words"]

df = dataset2.loc[:, important_columns].copy(deep=True)
```

0.3 Workclouds

[12]:
```
def display_wordcloud(data, title, color='white', save_fig_path=None):
    wordcloud = WordCloud(background_color=color,
                      stopwords = set(STOPWORDS),
                      max_words=400,
                      max_font_size=60,
                      scale=3,
                      random_state=42
                      ).generate(data)
    fig = plt.figure(1, figsize=(10, 10))
    plt.imshow(wordcloud)
    plt.axis("off")
    fig.suptitle(title, fontsize=20)
    fig.subplots_adjust(top=2.3)




    plt.show()
```

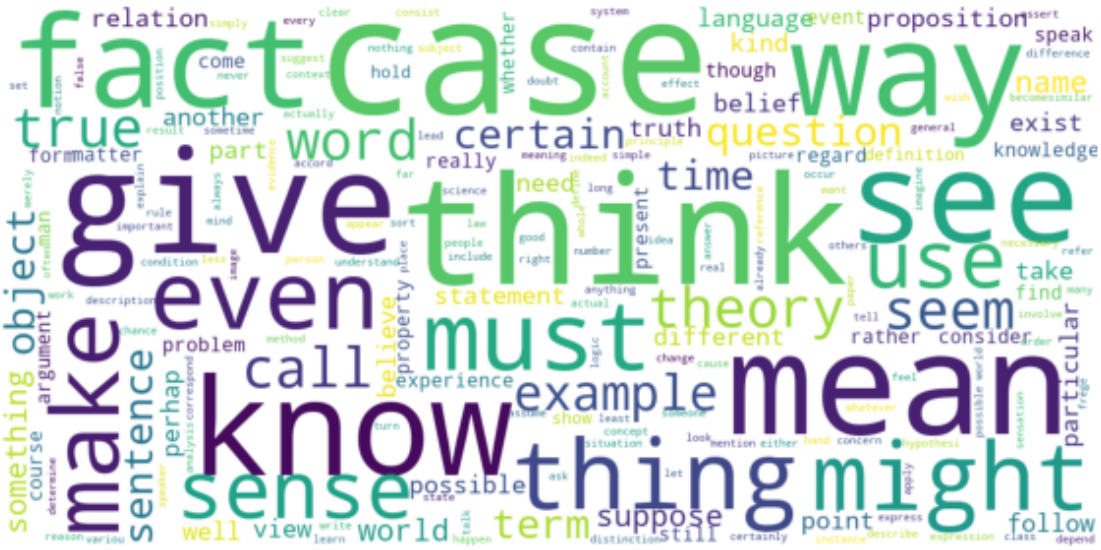
[13]:
```
# worldclouds for each school
schools = df["school"].unique()
for school in schools:
```

```
    school_title = school.replace("_", " ").upper()
    df_temp = df[df.school==school]
    text = " ".join(txt for txt in df_temp.
↪lem_sentence_without_additional_stop_words)
    display_wordcloud(text, school_title)
```

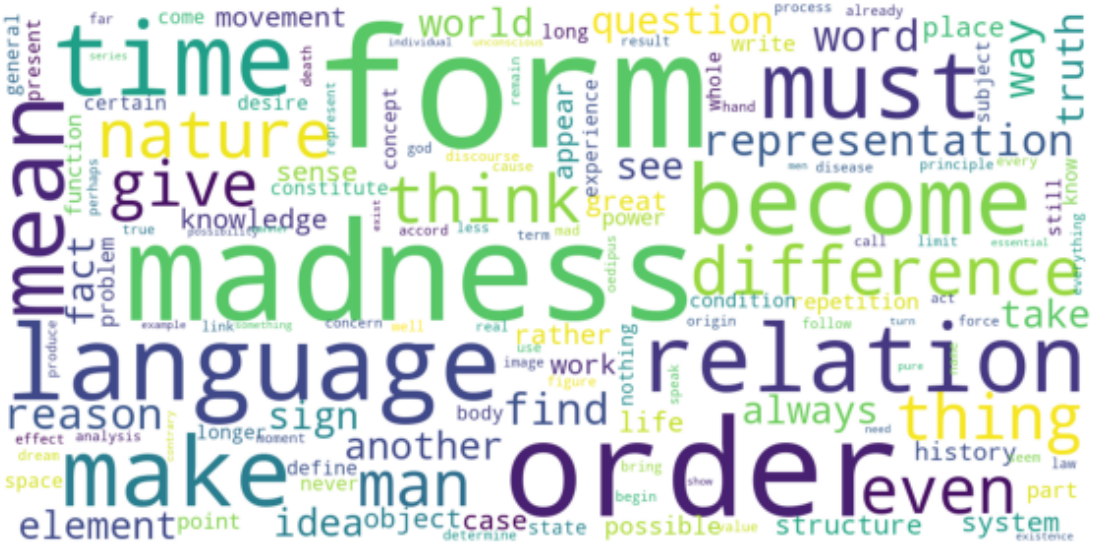


EMPIRICISM

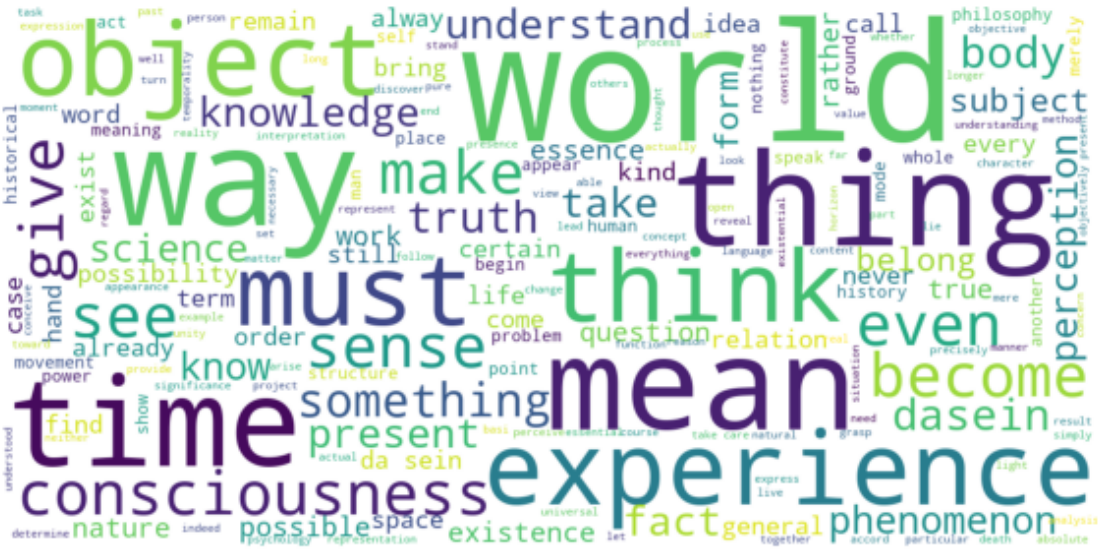
RATIONALISM



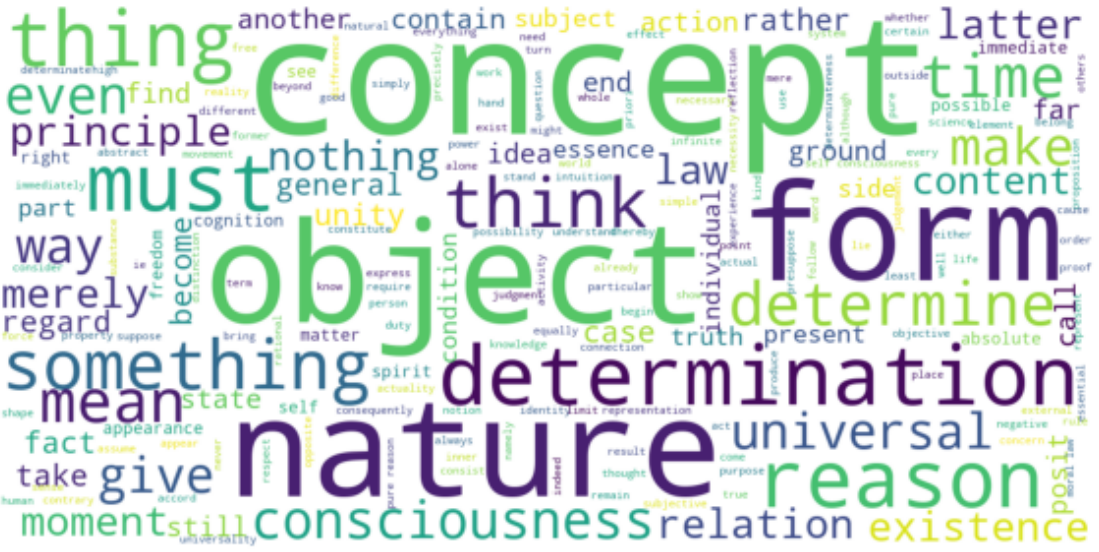
ANALYTIC



CONTINENTAL



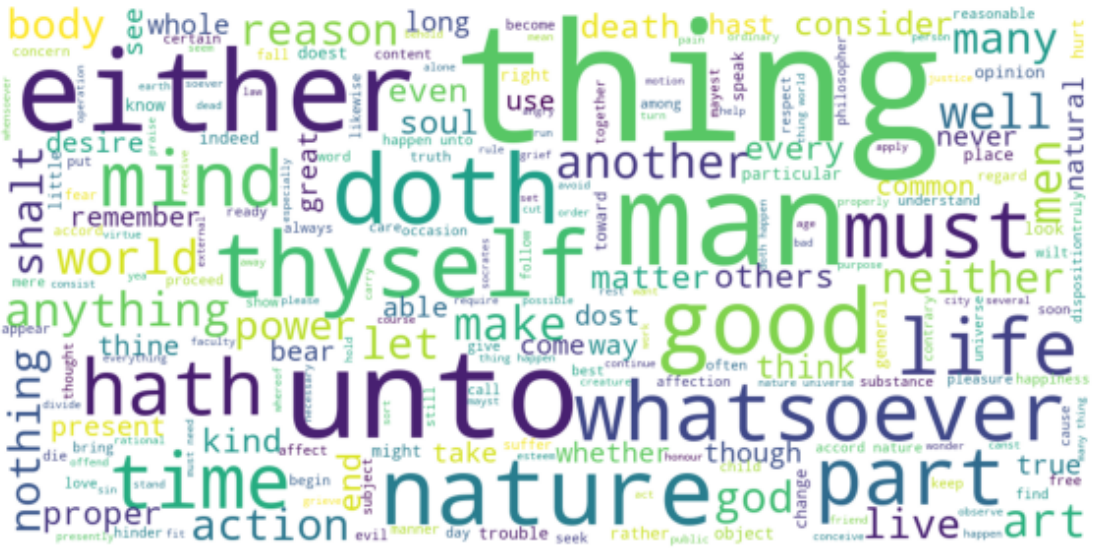
PHENOMENOLOGY



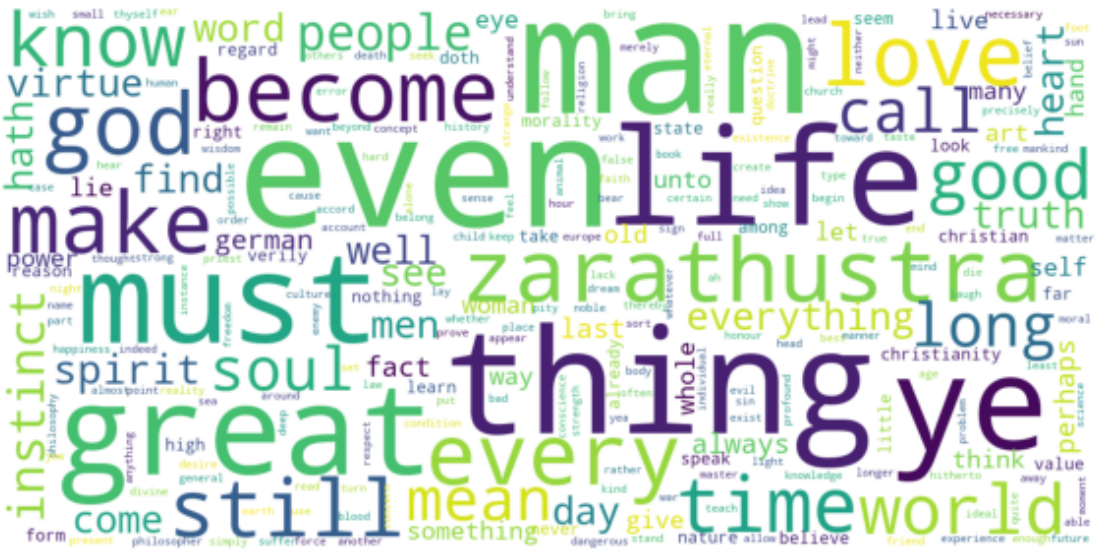
GERMAN IDEALISM

COMMUNISM

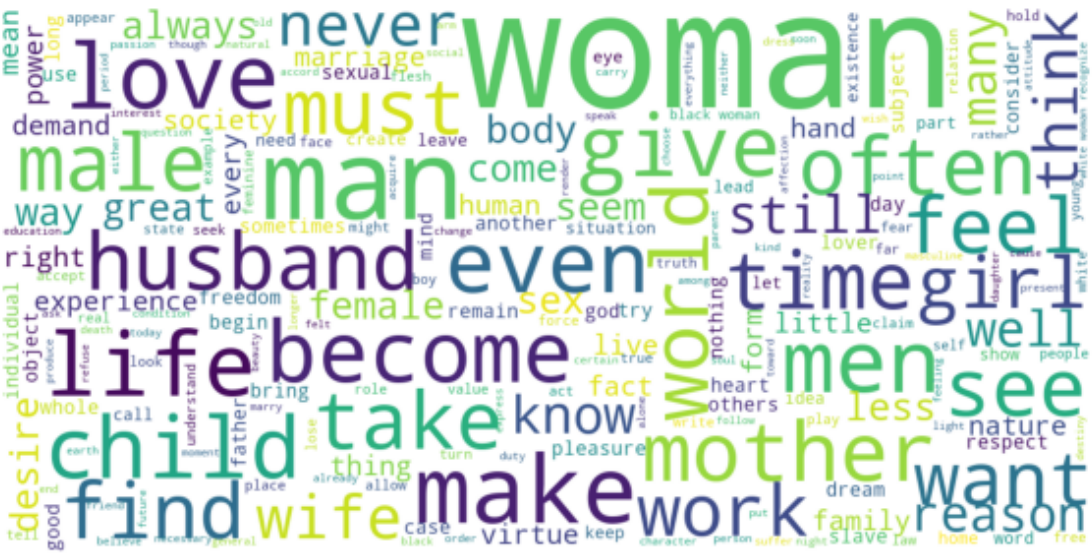
CAPITALISM



STOICISM



NIETZSCHE



FEMINISM

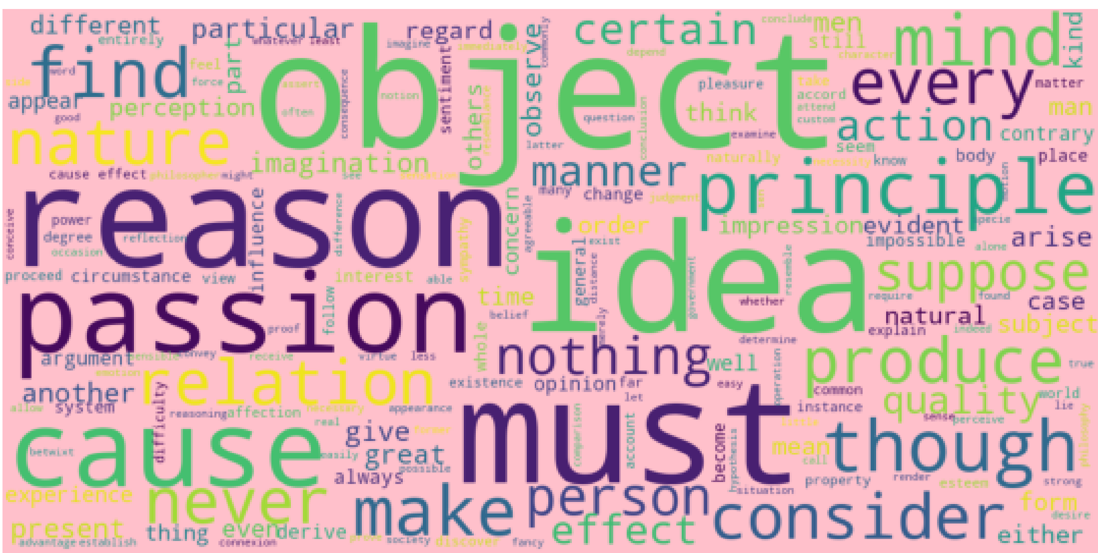
[14]:
```
# worldclouds by author
authors = df["author"].unique()
for author in authors:
    #author_title = school.replace("_", " ").upper()
    df_temp = df[df.author==author]
    text = " ".join(txt for txt in df_temp.
 ↪lem_sentence_without_additional_stop_words)
    display_wordcloud(text, author, 'pink')
```

Plato

Aristotle


idea
make
body
mind
know
man
men
thing
think
another
power
knowledge
reason
though
find
great
part
name
word
others
suppose
take
give
thought
nothing
simple idea
complex idea
right
use
way
understand
truth
little
people
substance
different
determine
matter
time

Locke


object
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reason
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principle
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nature
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person
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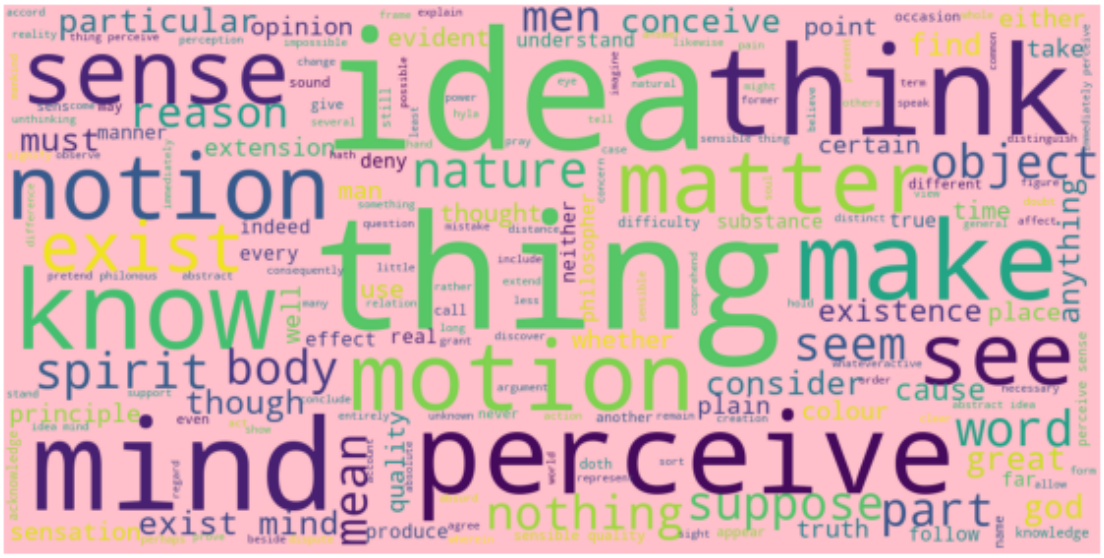
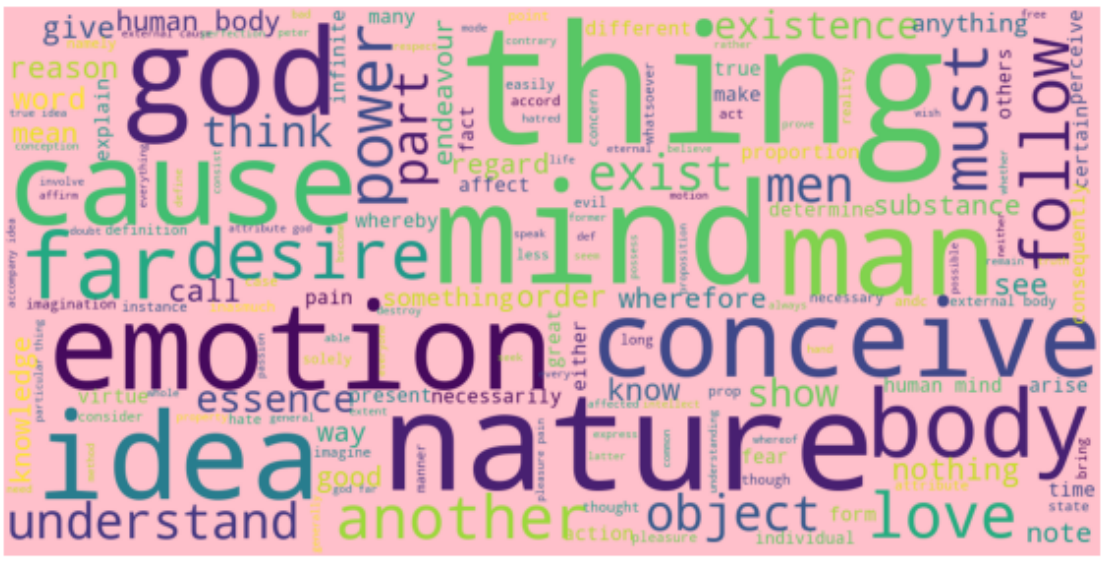
nothing
suppose
action
certain
manner
quality
effect
impression
imagination
perception
particular
different
regard
observe
natural
subject
argument
another
experience
present
give
great

Hume



Berkeley



Spinoza

Leibniz

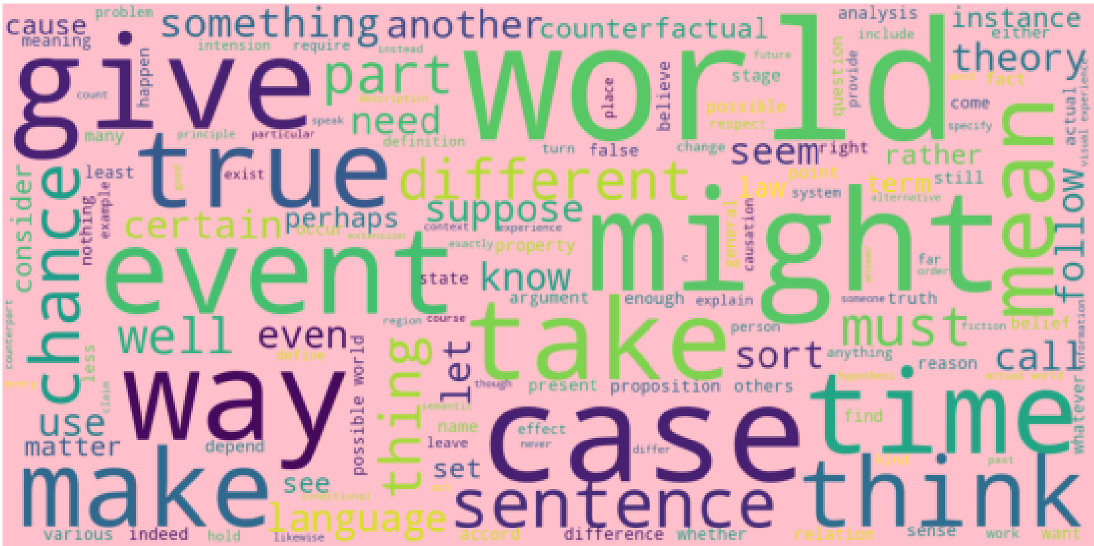
Descartes

Malebranche

Russell

Moore

Wittgenstein


world
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suppose
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well
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let
sort
call
use
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see
set
follow
theory
instance
rather
seem
consider
cause
analysis
law
term
proposition
others
present
argument
state
enough
explain
truth
reason
whatever
possible world
difference
whether
various
indeed
accord
relation
sense
work
want
actual
false
believe
place
question
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possible
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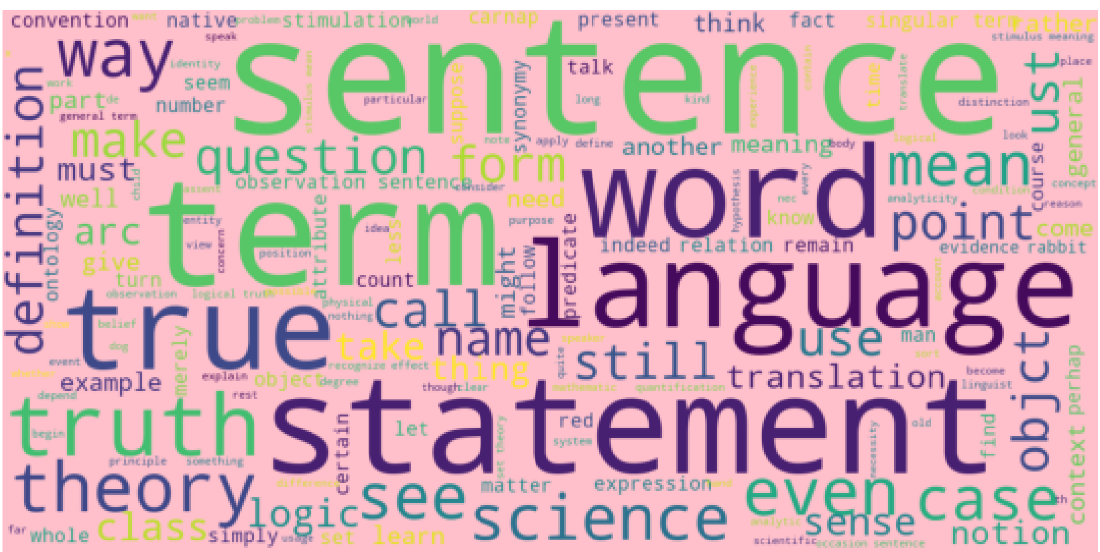
nothing
less
depend
name
effect
leave
find
come
fact
still
belief

Lewis


sentence
term
word
language
statement
true
truth
theory
way
definition
question
form
make
mean
point
use
still
translation
call
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see
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case
logic
class
object
sense
notion
context
perhap
general
must
well
arc
give
turn
part
seem
number
ontology
example
merely
take
thing
might
follow
predicate
synonymy
suppose
attribute
certain
count
another
meaning
indeed relation remain
evidence rabbit
observation sentence
convention
native
stimulation
carnap
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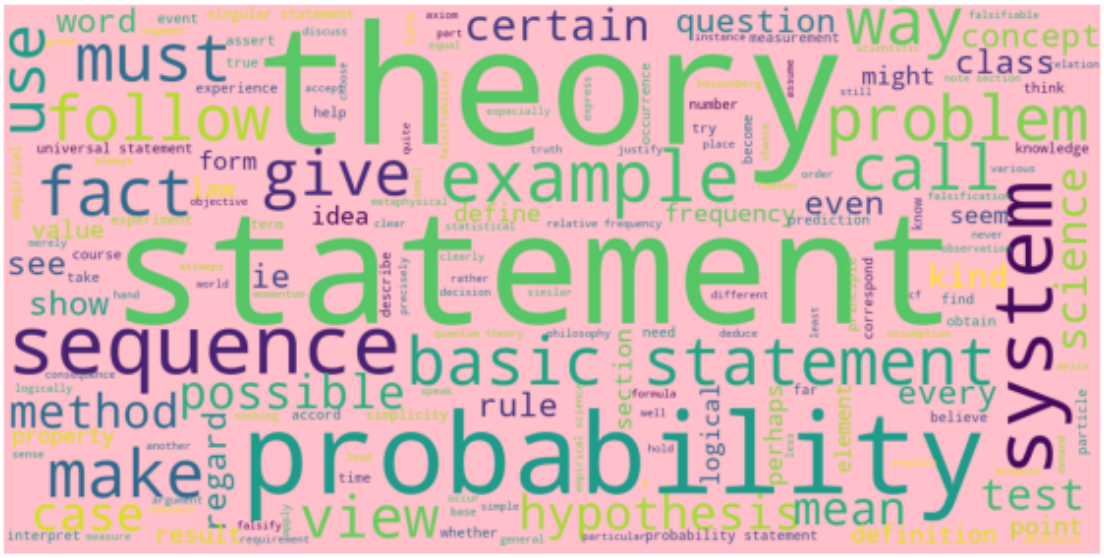
Quine

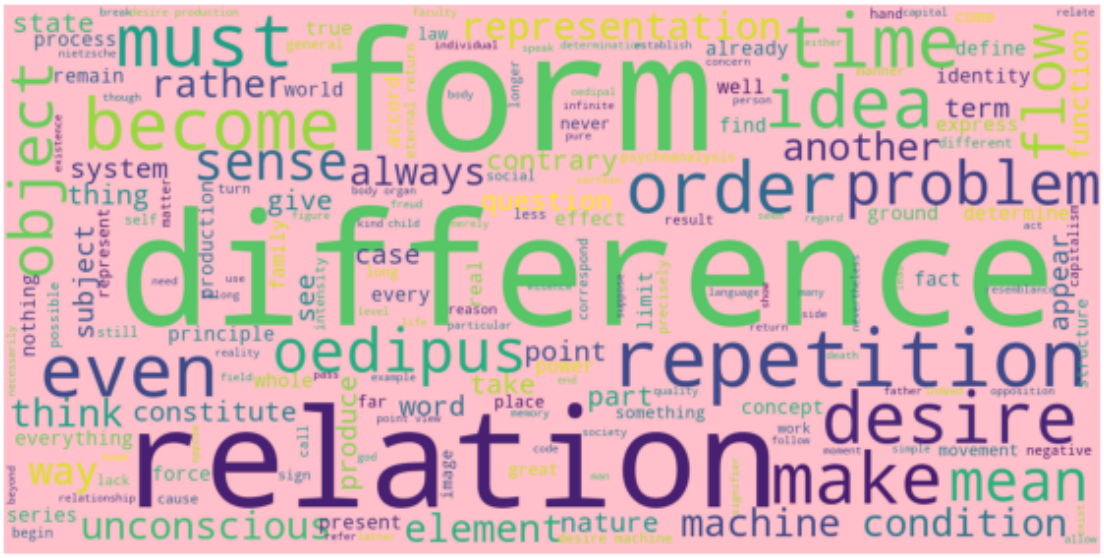


Popper

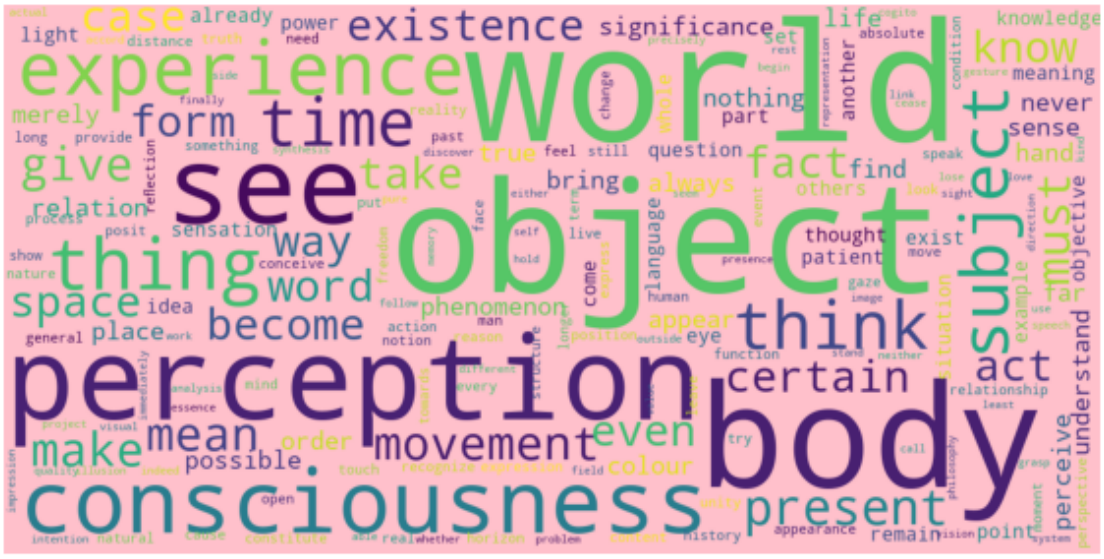
Kripke

Foucault

Derrida



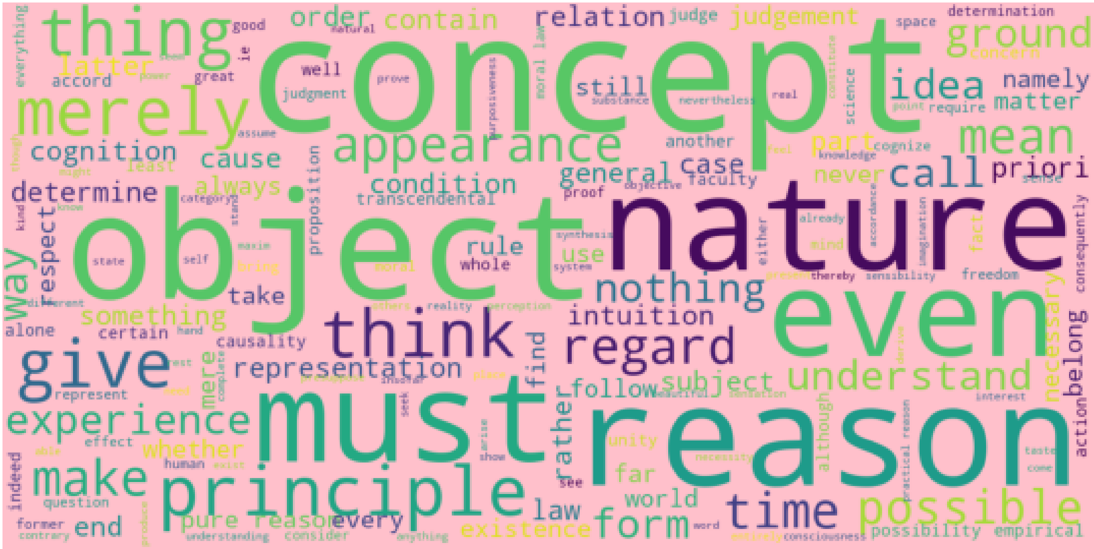
Deleuze



Merleau-Ponty

Husserl

Heidegger


concept
object
nature
reason
must
even
principle
think
give
merely
thing
appearance
regard
possible
experience
time
idea
mean
ground
nothing
understand
make
form
cognition
determine
call
representation
intuition
condition
relation
judgement
contain
order
cause
always
something
whether
rule
subject
general
case
priori
namely
matter
still
law
follow
transcendental
pure reason
existence
empirical

Kant


think
something
mean
duty
must
drive
freedom
concept
case
suppose
reason
act
human
consciousness
nature
follow
determine
object
latter
person
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thing
point
action
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order
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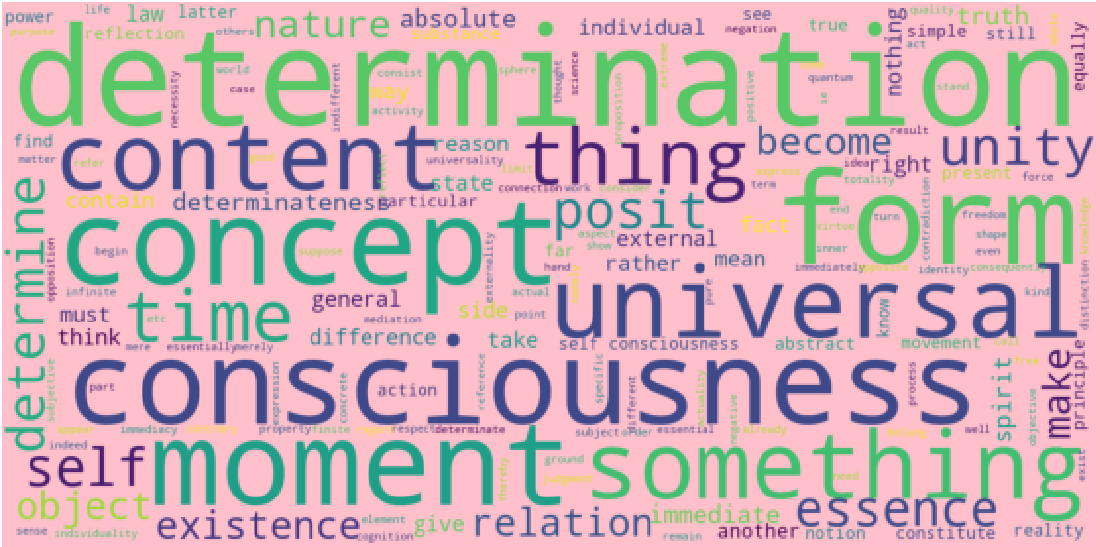
Fichte


determination
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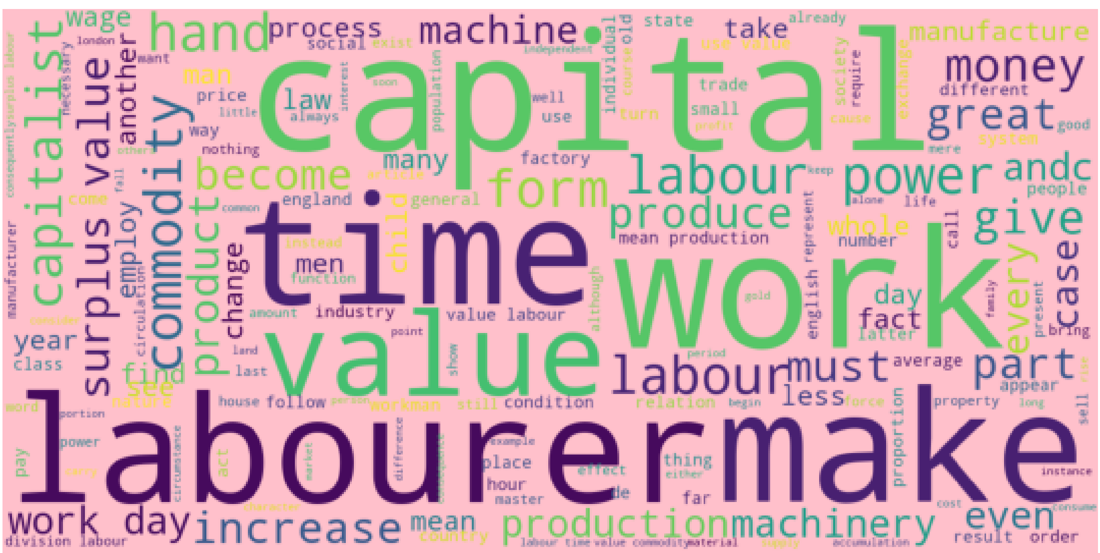
nature
absolute
individual
truth
determinateness
difference
general
reason
state
external
rather
mean
take
self consciousness
abstract
movement
make
spirit
principle
immediate
another
notion
constitute
reality
give
action
must
think
contain
law
latter
power
reflection
simple
still
nothing
right
present
fact
side
particular
true
see
find
equally
know

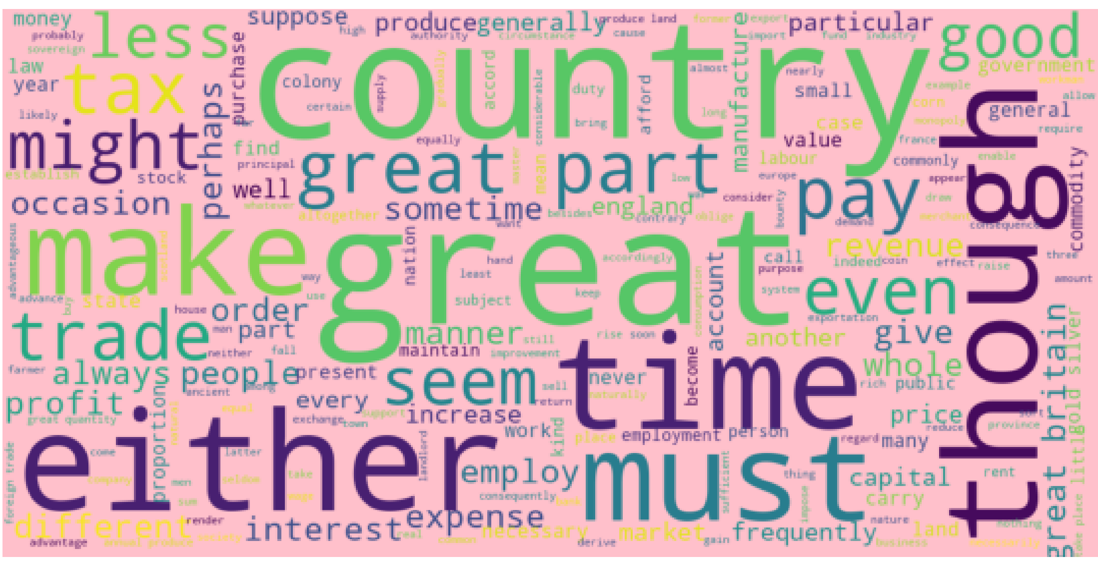
Hegel


capital
time
work
value
labourer
make
labour
money
great
power
andc
give
produce
form
become
commodity
capitalist
surplus value
product
machine
process
hand
wage
many
men
employ
change
another
must
part
case
every
day
fact
year
class
find
see
increase
production
machinery
mean
even
work day
less
manufacture
take
state
law
price
factory
england
industry
value labour
mean production
condition
follow
place
hour
thing
trade
small
different
average
appear
property
result
order
division labour
whole
child

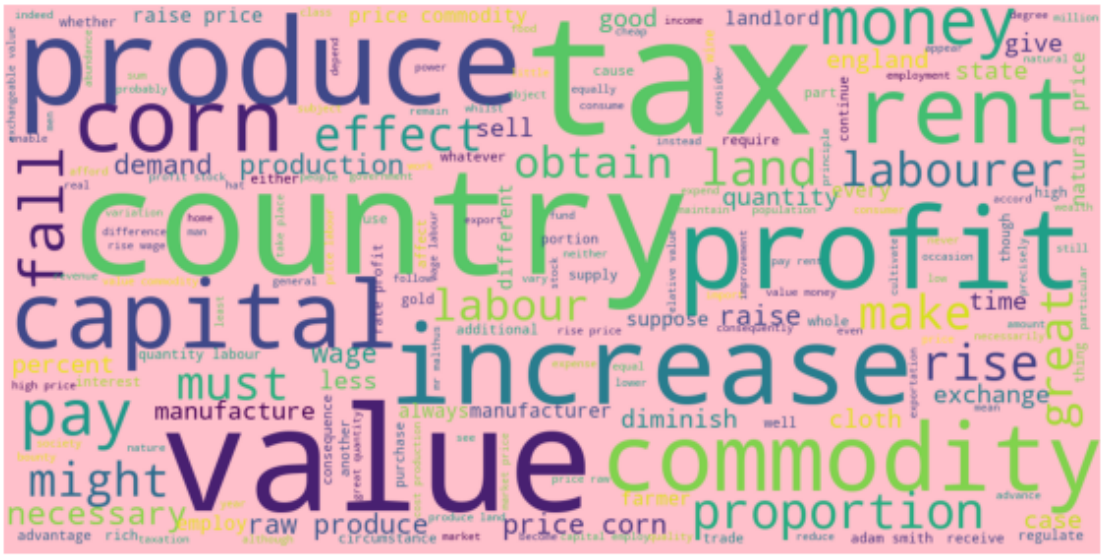
Marx


work
state
worker
capitalism
organization
form
country
must
become
movement
time
imperialism
revolutionary
question
even
marx
fact
political
class
make
industry
kautsky
development
russia
marxism
monopoly
people
democracy
struggle
order
take
bank
german
capitalist
party
give
social democrat
russian
capital
proletariat
condition

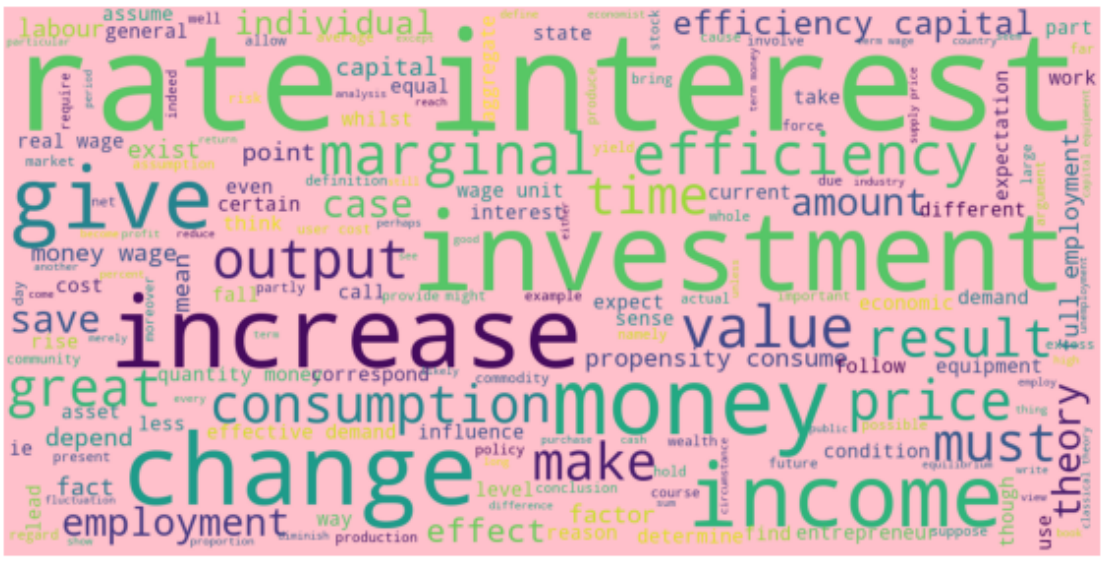
Lenin


country
great
make
either
must
time
though
great part
pay
might
less
tax
trade
seem
even
good
occasion
sometime
england
revenue
order
manner
people
always
profit
whole
give
employ
expense
interest
particular
generally
produce
suppose
perhaps
purchase
manufacture
account
great britain
price
capital
frequently
market
different

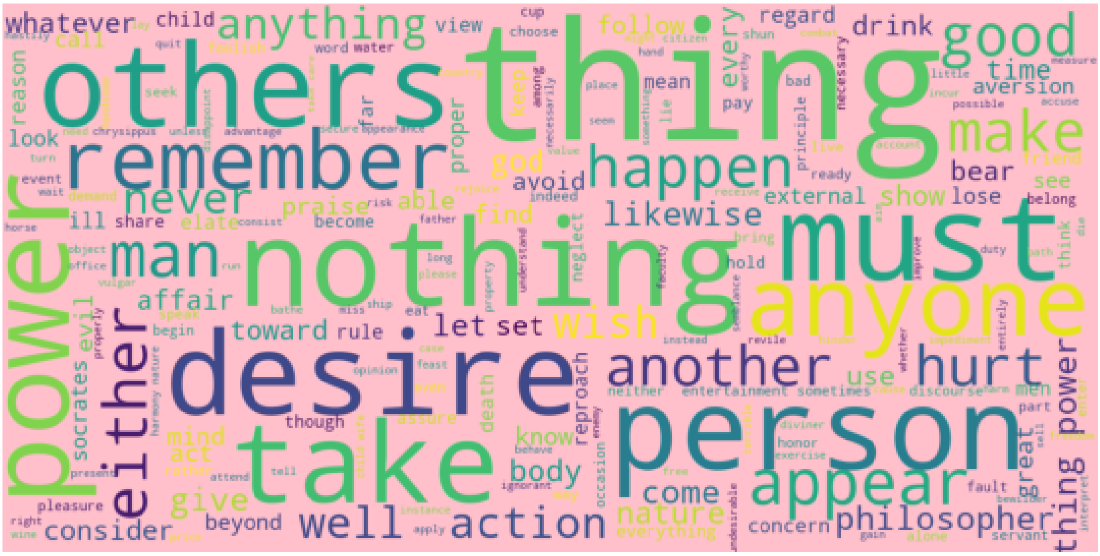
Smith



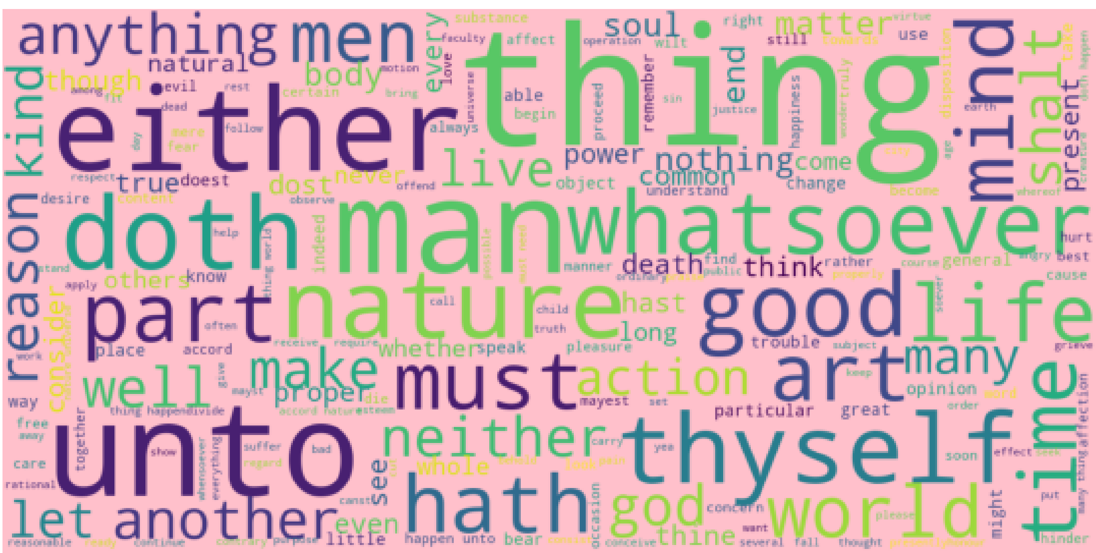
Ricardo



Keynes



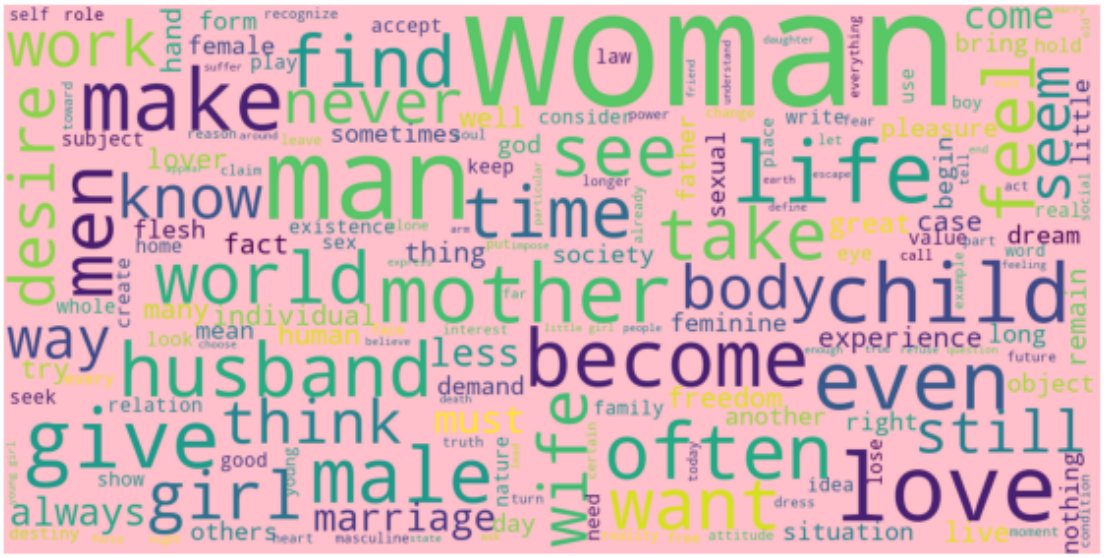
Epictetus



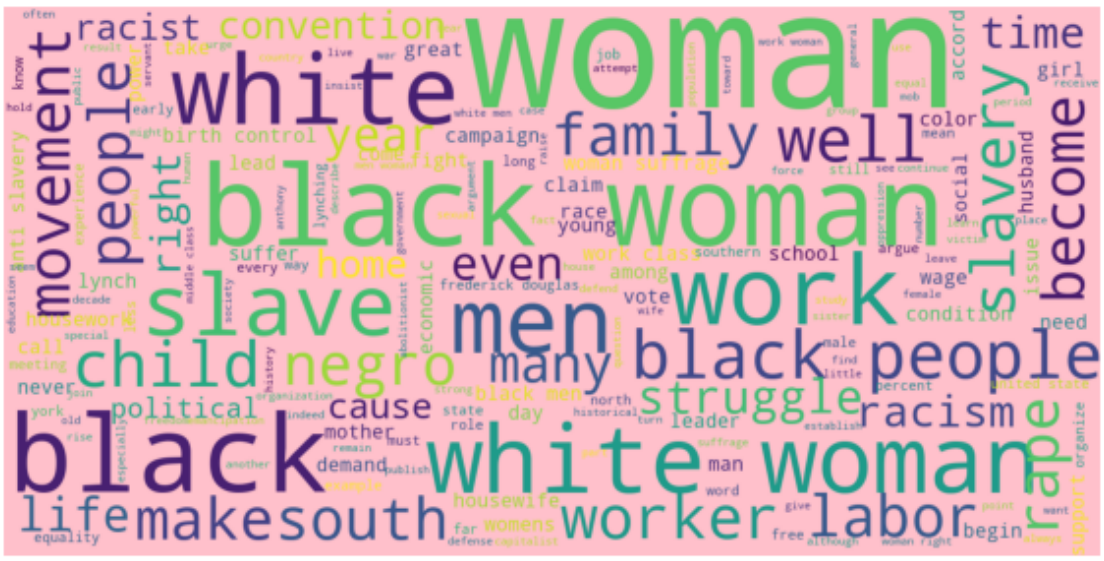
Marcus Aurelius

Nietzsche

Wollstonecraft



Beauvoir



Davis

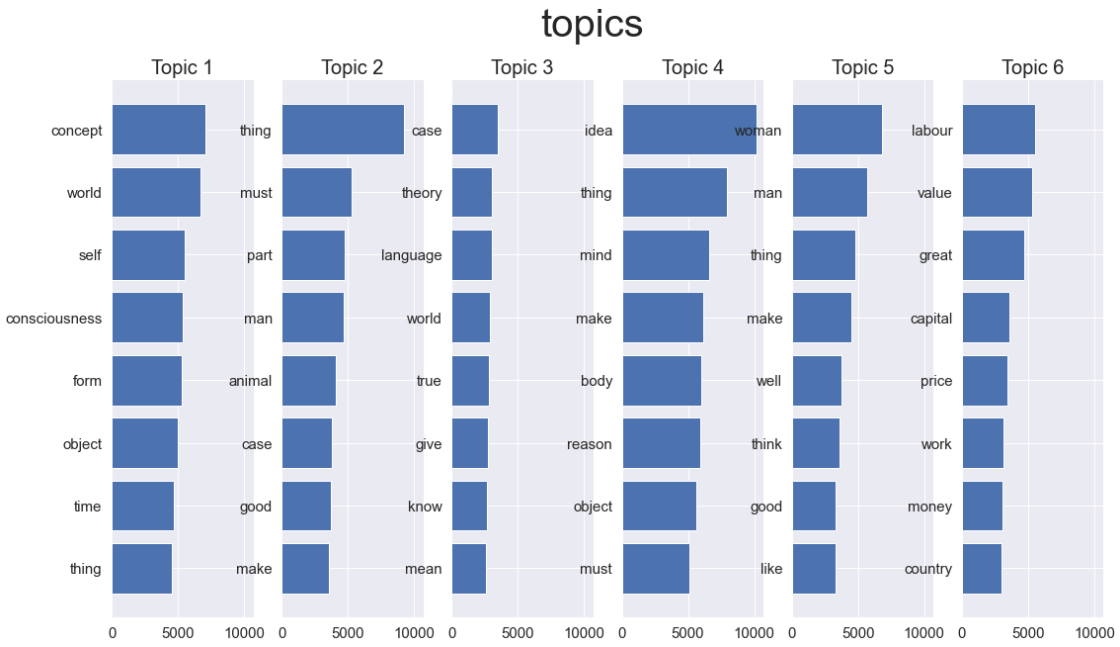
0.4 Topic Modeling using LDA

[15]:
```
titles = df['title'].unique()
titles_text = {}

for title in titles:
    df_title = df[(df.title==title)]
    text = ' '.join(df_title['lem_sentence_without_additional_stop_words'])
    titles_text[title] = [text]

texts_df = pd.DataFrame(data=titles_text)
texts_df = texts_df.T

dataLDA = texts_df[0].values.tolist()


additional_stop_words = ['go', 'sure', 'new', 'list', 'back', 'say', 'one',␣
 ↪'two', 'without', 'much',
                         'whose', 'therefor', 'first', 'within', 'yet', 'would',␣
 ↪'also', 'second', 'whats',
                         'us', 'secondly', 'may', 'upon', 'more', 'thus',␣
 ↪'mine', 'thou', 'thy', 'thee', 'dont', 'eg', 'isnt', 'doesnt',
                         'thats']
```

[16]:
```
st = stopwords.words('english')
st.extend(additional_stop_words)

tf_vectorizer = CountVectorizer(strip_accents = 'unicode', analyzer = 'word',␣
 ↪stop_words = st, lowercase = True)

dtm_tf = tf_vectorizer.fit_transform(dataLDA)

num_components=6
# create LDA object
model=LatentDirichletAllocation(n_components=num_components, random_state=1)
lda_matrix = model.fit(dtm_tf)
# model components
lda_components=model.components_
```

[17]:
```
def top_words_per_topic(model, feature_names, n_top_words, title):
    fig, axes = plt.subplots(1, 6, figsize=(18, 10), sharex=True)
    axes = axes.flatten()
    for index, topic in enumerate(model.components_):
        top_features_ind = topic.argsort()[: -n_top_words - 1 : -1]
        top_features = [feature_names[i] for i in top_features_ind]
        counts = topic[top_features_ind]
        ax = axes[index]
```

```
        ax.barh(top_features, counts, height=0.8)
        ax.set_title(f"Topic {index+1}", fontdict={"fontsize": 20})
        ax.invert_yaxis()
        ax.tick_params(labelsize=15)
        for i in "top right left".split():
            ax.spines[i].set_visible(False)
        fig.suptitle(title, fontsize=40)
        path = "/Users/lsx/Desktop/LDA topics.png"
    plt.savefig(path, bbox_inches="tight")
    plt.show()

    plt.show()
feature_names = tf_vectorizer.get_feature_names()
top_words_per_topic(model, feature_names, 8, "topics")
```

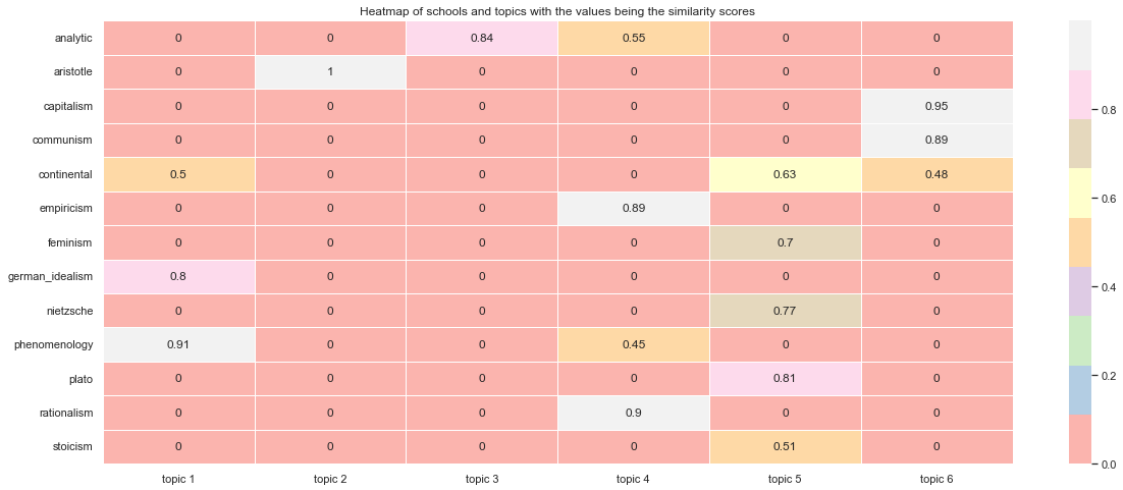


[18]:
```
doc_topic = model.transform(dtm_tf)
prob = {}
documents_topics_dict = {}
for n in range(doc_topic.shape[0]):
    topic_most_pr = doc_topic[n].argmax()
    documents_topics_dict[titles[n]] = topic_most_pr
    prob[titles[n]] = doc_topic[n].max()
```

[19]:
```
mean2_df = df
schools_topics = mean2_df.loc[:, ['school', 'title']].drop_duplicates()
```

```
schools_topics['topic'] = schools_topics.apply (lambda row:␣
 ↪documents_topics_dict[row.title]+1, axis=1)
schools_topics['similarity'] = schools_topics.apply (lambda row: prob[row.
 ↪title], axis=1)
schools_topics_new = schools_topics.groupby(["school", "topic"])['similarity'].
 ↪mean()
schools_topics_sim = schools_topics_new.to_frame().rename(columns={'mean':
 ↪'new_name'}).reset_index()
```

[20]:
```
all_topics = []
for i in range(num_components):
    all_topics.append("topic " + str(i+1))

Cols = schools_topics_sim['school'].unique()
Index = all_topics

column_lists = {}
for col in Cols:
    column_lists[col] = [0] * num_components

for i in range(len(schools_topics_sim['school'])):
   ␣
 ↪column_lists[schools_topics_sim['school'][i]][schools_topics_sim['topic'][i]-1]␣
 ↪= schools_topics_sim['similarity'][i]

column_lists

test = pd.DataFrame(column_lists, index=Index, columns=Cols)
test = test.transpose()
ax = sns.heatmap(test, cmap='Pastel1', linewidths=0.5, annot=True)
ax.set(title = "Heatmap of schools and topics with the values being the␣
 ↪similarity scores")

path = "/Users/lsx/Desktop/heatmap.png"
ax.figure.savefig(path, bbox_inches="tight")
```



- Topic1: Consciousness and existational questions
- Topic2: human and nature
- Topic3: theory and language
- Topic4: thinking and human mind
- Topic5: woman and man (human)
- Topic6: Labour and capital

analytic : theory and language

continental: woman

nietzsche: woman plato: woman stoicism: woman

[21]:
```
df = dataset.drop(columns = ["sentence_str", "sentence_length",␣
↪"sentence_lowered", "lemmatized_str", "tokenized_txt"])
```

[22]:
```
!pip install watermark
# print versions of Python modules and packages with watermark. (https://github.
↪com/rasbt/watermark)
%load_ext watermark
%watermark -v -p numpy,pandas,nltk,syllables,matplotlib,sklearn,wordcloud
```

```
Requirement already satisfied: watermark in
/Users/lsx/anaconda3/lib/python3.9/site-packages (2.3.1)
Requirement already satisfied: ipython in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from watermark) (8.2.0)
Requirement already satisfied: setuptools>=18.5 in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(61.2.0)
Requirement already satisfied: pexpect>4.3 in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(4.8.0)
Requirement already satisfied: pygments>=2.4.0 in
```

```
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(2.11.2)
Requirement already satisfied: jedi>=0.16 in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(0.18.1)
Requirement already satisfied: matplotlib-inline in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(0.1.2)
Requirement already satisfied: pickleshare in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(0.7.5)
Requirement already satisfied: traitlets>=5 in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(5.1.1)
Requirement already satisfied: stack-data in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(0.2.0)
Requirement already satisfied: appnope in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(0.1.2)
Requirement already satisfied: backcall in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(0.2.0)
Requirement already satisfied: decorator in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(5.1.1)
Requirement already satisfied: prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0 in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from ipython->watermark)
(3.0.20)
Requirement already satisfied: parso<0.9.0,>=0.8.0 in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from
jedi>=0.16->ipython->watermark) (0.8.3)
Requirement already satisfied: ptyprocess>=0.5 in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from
pexpect>4.3->ipython->watermark) (0.7.0)
Requirement already satisfied: wcwidth in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from prompt-
toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0->ipython->watermark) (0.2.5)
Requirement already satisfied: pure-eval in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from stack-
data->ipython->watermark) (0.2.2)
Requirement already satisfied: executing in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from stack-
data->ipython->watermark) (0.8.3)
Requirement already satisfied: asttokens in
/Users/lsx/anaconda3/lib/python3.9/site-packages (from stack-
data->ipython->watermark) (2.0.5)
Requirement already satisfied: six in /Users/lsx/anaconda3/lib/python3.9/site-
```

```
packages (from asttokens->stack-data->ipython->watermark) (1.16.0)
Python implementation: CPython
Python version       : 3.9.12
IPython version      : 8.2.0

numpy      : 1.21.5
pandas     : 1.4.2
nltk       : 3.7
syllables  : 1.0.3
matplotlib: 3.5.1
sklearn    : 0.0
wordcloud  : 1.8.2.2
```

[23]:
```
print(dataset.shape)
dataset.head()
```

```
(360808, 18)
```

[23]:

	title	author	school	sentence_spacy	sentence_str	original_publication_date	corpus_edition_date	sentence_length	sentence_lowered
0	Plato - Complete Works	Plato	plato	What's new, Socrates, to make you leave your …	What's new, Socrates, to make you leave your …	-350	1997	125	
1	Plato - Complete Works	Plato	plato	Surely you are not prosecuting anyone before t…	Surely you are not prosecuting anyone before t…	-350	1997	69	
2	Plato - Complete Works	Plato	plato	The Athenians do not call this a prosecution b…	The Athenians do not call this a prosecution b…	-350	1997	74	
3	Plato - Complete Works	Plato	plato	What is this you say?	What is this you say?	-350	1997	21	
4	Plato - Complete Works	Plato	plato	Someone must have indicted you, for you are no…	Someone must have indicted you, for you are no…	-350	1997	101	

```
0   what's new, socrates, to make you leave your …
1  surely you are not prosecuting anyone before t…
2  the athenians do not call this a prosecution b…
3                              what is this you say?
4  someone must have indicted you, for you are no…

                                       tokenized_txt  \
0  ['what', 'new', 'socrates', 'to', 'make', 'you…
1  ['surely', 'you', 'are', 'not', 'prosecuting',…
2  ['the', 'athenians', 'do', 'not', 'call', 'thi…
3              ['what', 'is', 'this', 'you', 'say']
4  ['someone', 'must', 'have', 'indicted', 'you',…

                                      lemmatized_str  new_sentence_length  \
0     what be new , Socrates , to make -PRON- lea…                   23
1   surely -PRON- be not prosecute anyone before …                   13
2   the Athenians do not call this a prosecution …                   12
3                           what be this -PRON- say ?                    5
4   someone must have indict -PRON- , for -PRON- …                   19

                                 new_lowered_sentence  \
0   whats new socrates to make you leave your usu…
1  surely you are not prosecuting anyone before t…
2  the athenians do not call this a prosecution b…
3                                what is this you say
4  someone must have indicted you for you are not…

                               new_tokenized_sentence  \
0  [whats, new, socrates, to, make, you, leave, y…
1  [surely, you, are, not, prosecuting, anyone, b…
2  [the, athenians, do, not, call, this, a, prose…
3                          [what, is, this, you, say]
4  [someone, must, have, indicted, you, for, you,…

                            tokens_without_stop_words  \
0  [whats, new, socrates, make, leave, usual, hau…
1        [surely, prosecuting, anyone, king, archon]
2  [athenians, call, prosecution, indictment, eut…
3                                             [say]
4  [someone, must, indicted, going, tell, indicte…

                                    lemmatized_tokens  \
0  [whats, new, socrates, make, leave, usual, hau…
1          [surely, prosecute, anyone, king, archon]
2  [athenian, call, prosecution, indictment, euth…
3                                             [say]
4  [someone, must, indict, go, tell, indict, some…
```

```
            lem_tokens_without_additional_stop_words  \
0  [socrates, make, leave, usual, haunt, lyceum, …
1          [surely, prosecute, anyone, king, archon]
2  [athenian, call, prosecution, indictment, euth…
3                                                 []
4  [someone, must, indict, tell, indict, someone,…

          lem_sentence_without_additional_stop_words
0  socrates make leave usual haunt lyceum spend t…
1                surely prosecute anyone king archon
2    athenian call prosecution indictment euthyphro
3
4      someone must indict tell indict someone else
```

[24]:
```
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 360808 entries, 0 to 360807
Data columns (total 18 columns):
 #   Column                                    Non-Null Count   Dtype
---  ------                                    --------------   -----
 0   title                                     360808 non-null  object
 1   author                                    360808 non-null  object
 2   school                                    360808 non-null  object
 3   sentence_spacy                            360808 non-null  object
 4   sentence_str                              360808 non-null  object
 5   original_publication_date                 360808 non-null  int64
 6   corpus_edition_date                       360808 non-null  int64
 7   sentence_length                           360808 non-null  int64
 8   sentence_lowered                          360808 non-null  object
 9   tokenized_txt                             360808 non-null  object
 10  lemmatized_str                            360808 non-null  object
 11  new_sentence_length                       360808 non-null  int64
 12  new_lowered_sentence                      360808 non-null  object
 13  new_tokenized_sentence                    360808 non-null  object
 14  tokens_without_stop_words                 360808 non-null  object
 15  lemmatized_tokens                         360808 non-null  object
 16  lem_tokens_without_additional_stop_words  360808 non-null  object
 17  lem_sentence_without_additional_stop_words  360808 non-null  object
dtypes: int64(4), object(14)
memory usage: 49.5+ MB
```

[25]:
```
df = dataset.drop(columns = ["sentence_str", "sentence_length",␣
 ↪"sentence_lowered", "lemmatized_str", "tokenized_txt"])
print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 360808 entries, 0 to 360807
Data columns (total 13 columns):
 #   Column                                    Non-Null Count   Dtype
---  ------                                    --------------   -----
 0   title                                     360808 non-null  object
 1   author                                    360808 non-null  object
 2   school                                    360808 non-null  object
 3   sentence_spacy                            360808 non-null  object
 4   original_publication_date                 360808 non-null  int64
 5   corpus_edition_date                       360808 non-null  int64
 6   new_sentence_length                       360808 non-null  int64
 7   new_lowered_sentence                      360808 non-null  object
 8   new_tokenized_sentence                    360808 non-null  object
 9   tokens_without_stop_words                 360808 non-null  object
 10  lemmatized_tokens                         360808 non-null  object
 11  lem_tokens_without_additional_stop_words  360808 non-null  object
 12  lem_sentence_without_additional_stop_words 360808 non-null  object
dtypes: int64(3), object(10)
memory usage: 35.8+ MB
None
```

[26]:
```
tot_sentences = len(df["sentence_spacy"])
tot_sentences


#The dataset contains 360808 sentences (rows) with 0 duplicated rows
```

[26]:
```
360808
```

[27]:
```
tot_titles = len(df["title"].unique())
tot_authors = len(df["author"].unique())
tot_schools = len(df["school"].unique())
(tot_titles,tot_authors,tot_schools)
#he dataset includes 59 books by 36 authors from 13 schools.
```

[27]:
```
(59, 36, 13)
```

[28]:
```
import nltk
nltk.download('cmudict')


d = cmudict.dict()
```

```
[nltk_data] Downloading package cmudict to /Users/lsx/nltk_data…
[nltk_data]   Package cmudict is already up-to-date!
```

[29]:
```
def count_syllables(words):
    n = 0
```

```
    for word in words:
        try:
            n += [len(list(y for y in x if y[-1].isdigit())) for x in d[word.
 ↪lower()]][0]
        except KeyError:
            n += syllables.estimate(word)
    return n

# use NLTK to tokenize the texts, because stopwords such as pronounce also␣
 ↪impact the results of the readability score,
# I will not drop the stopwords at this stage
tokens_list = []
num_words_list = []
num_syllables_list = []
for idx in df.index:
    tokens = word_tokenize(df.sentence_spacy[idx])
    tokens = [w.lower() for w in tokens]
    tokens = [w for w in tokens if w.isalpha()]
    tokens_list.append(tokens)
    num_words_list.append(len(tokens))
    num_syllables_list.append(count_syllables(tokens))
df["tokenized_words"] = tokens_list
df["num_words"] = num_words_list
df["num_syllables"] = num_syllables_list
```

[30]:
```
print(df["num_words"].describe())
print("-----------------------------------")
print(df["num_syllables"].describe())
```

```
count    360808.000000
mean         26.293303
std          18.147527
min           0.000000
25%          13.000000
50%          22.000000
75%          35.000000
max         415.000000
Name: num_words, dtype: float64
-----------------------------------
count    360808.000000
mean         40.847598
std          28.796219
min           0.000000
25%          20.000000
50%          34.000000
75%          54.000000
max         770.000000
Name: num_syllables, dtype: float64
```

[31]:
```
# Sum up total number of words, syllables, and sentences for each text
df_title = df.groupby(["title","author","school",␣
 ↪"original_publication_date","corpus_edition_date"]).sum().reset_index().
 ↪set_index("title")
df_title = df_title.join(df.groupby(["title"])["sentence_spacy"].count())
df_title = df_title.rename(columns = {"num_words": "tot_words", "num_syllables":
 ↪ "tot_syllables", "sentence_spacy": "tot_sens"})
df_title.head()
```

[31]:

title	author	school	original_publication_date	corpus_edition_date	new_sentence_length	tot_words	tot_syllables
A General Theory Of Employment, Interest, And M…	Keynes	capitalism	1936	2003	114057	113565	184909
A Treatise Concerning The Principles Of Human K…	Berkeley	empiricism	1710	2009	34290	34295	51858
A Treatise Of Human Nature	Hume	empiricism	1739	2003	222516	222614	359224
Anti-Oedipus	Deleuze	continental	1972	1997	183144	182726	310571
Aristotle - Complete Works	Aristotle	aristotle	-320	1991	1374162		

```
Aristotle - Complete Works                                1368824        1970568

                                                        tot_sens
title
A General Theory Of Employment, Interest, And M…        3411
A Treatise Concerning The Principles Of Human K…        1040
A Treatise Of Human Nature                               7047
Anti-Oedipus                                             6679
Aristotle - Complete Works                              48779
```

[32]:
```
print(df_title["tot_words"].describe())
print("-----------------------------------")
print(df_title["tot_syllables"].describe())
print("-----------------------------------")
print(df_title["tot_sens"].describe())
```

```
count    5.900000e+01
mean     1.607938e+05
std      2.067161e+05
min      7.057000e+03
25%      5.537700e+04
50%      1.135650e+05
75%      1.888575e+05
max      1.368824e+06
Name: tot_words, dtype: float64
-----------------------------------
count    5.900000e+01
mean     2.497990e+05
std      3.004124e+05
min      1.005800e+04
25%      8.106300e+04
50%      1.792240e+05
75%      3.101100e+05
max      1.970568e+06
Name: tot_syllables, dtype: float64
-----------------------------------
count       59.000000
mean      6115.389831
std       7964.661865
min        323.000000
25%       1945.000000
50%       4469.000000
75%       7236.000000
max      48779.000000
Name: tot_sens, dtype: float64
```

[33]:
```
# Flesch reading ease score
def FleschTest(totWords, totSyllables, totSentences):
    return 206.835 - 1.015*(totWords/totSentences) - 84.6*(totSyllables/
 ↪totWords)
# Flesch-Kincaid grade level
def gradeTest(totWords, totSyllables, totSentences):
    return 0.39*(totWords/totSentences) + 11.8*(totSyllables/totWords) - 15.59
```

[34]:
```
df_title["Flesch_score"] = np.round(FleschTest(df_title["tot_words"],␣
 ↪df_title["tot_syllables"], df_title["tot_sens"]), 1)
df_title["grade_level"] = np.round(gradeTest(df_title["tot_words"],␣
 ↪df_title["tot_syllables"], df_title["tot_sens"]))
df_title = df_title.sort_values("Flesch_score")
df_title.head()
```

[34]:

title	author	school	original_publication_date	corpus_edition_date	Flesch_score	grade_level
Discourse On Method	Descartes	rationalism	1637	2008	54.7	12
The Crisis Of The European Sciences And Phenome…	Husserl	phenomenology	1936	1970	63.8	10
The Order Of Things	Foucault	continental	1966	2002	64.3	10
Critique Of Judgement	Kant	german_idealism	1790	2007	64.4	10
The Birth Of The Clinic	Foucault	continental	1963	2003	64.5	10

```
                                                    new_sentence_length  \
title
Discourse On Method                                                23018
The Crisis Of The European Sciences And Phenome…                  150355
The Order Of Things                                                172049
Critique Of Judgement                                              153103
The Birth Of The Clinic                                             76353

                                                    tot_words  tot_syllables  \
title
Discourse On Method                                     23019          34047
The Crisis Of The European Sciences And Phenome…       150089         263842
The Order Of Things                                    171240         281554
Critique Of Judgement                                  153146         250363
The Birth Of The Clinic                                 75578         128908

                                                    tot_sens  Flesch_score  \
title
Discourse On Method                                      340          13.0
The Crisis Of The European Sciences And Phenome…        4832          26.6
The Order Of Things                                     4689          30.7
Critique Of Judgement                                   4204          31.6
The Birth Of The Clinic                                 2518          32.1

                                                    grade_level
title
Discourse On Method                                        28.0
The Crisis Of The European Sciences And Phenome…           17.0
The Order Of Things                                        18.0
Critique Of Judgement                                      18.0
The Birth Of The Clinic                                    16.0
```

[35]:
```
print(df_title["Flesch_score"].describe())
print("-----------------------------------")
print(df_title["grade_level"].describe())
```

```
count    59.000000
mean     46.035593
std      11.866437
min      13.000000
25%      38.950000
50%      45.400000
75%      52.700000
max      75.400000
Name: Flesch_score, dtype: float64
-----------------------------------
count    59.000000
mean     13.728814
```

```
std       3.402993
min       6.000000
25%      12.000000
50%      14.000000
75%      15.000000
max      28.000000
Name: grade_level, dtype: float64
```

[36]:
```
print('The book that is most difficult to read is "{t}" by {a} originally␣
 ↪published in {y} with a Flesch reading-ease score of {s}'
     .format(t=df_title.index[0], a=df_title.iloc[0,0], y=df_title.iloc[0,1],␣
 ↪s=df_title.iloc[0,-2]))


print('The book that is easiest to read is "{t}" by {a} originally published in␣
 ↪{y} with a Flesch reading-ease score of {s}'
     .format(t=df_title.index[-1], a=df_title.iloc[-1,0], y=df_title.
 ↪iloc[-1,1], s=df_title.iloc[-1,-2]))
```

```
The book that is most difficult to read is "Discourse On Method" by Descartes
originally published in rationalism with a Flesch reading-ease score of 13.0
The book that is easiest to read is "Thus Spake Zarathustra" by Nietzsche
originally published in nietzsche with a Flesch reading-ease score of 75.4
```

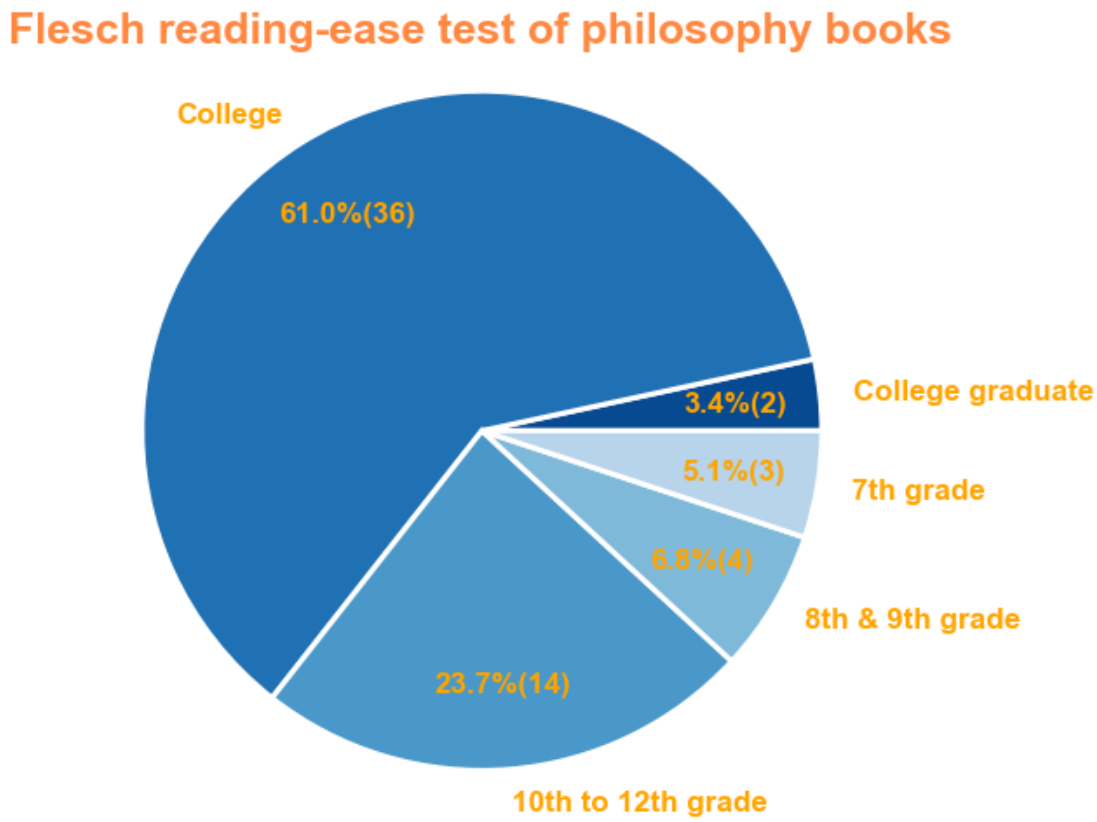
[37]:
```
# Converting the score into the corresponding school level
def scoreToLevel(x):
    if x > 90:
        return "5th grade"
    elif x > 90:
        return "6th grade"
    elif x > 70:
        return "7th grade"
    elif x > 60:
        return "8th & 9th grade"
    elif x > 50:
        return "10th to 12th grade"
    elif x > 30:
        return "College"
    elif x > 10:
        return "College graduate"
    else:
        return "Professional"
```

[38]:
```
school_level_list = []
for idx in range(len(df_title.index)):
    school_level_list.append(scoreToLevel(df_title["Flesch_score"][idx]))
df_title["school_level"] = school_level_list
```

```
counts = df_title.groupby(["school_level"])["school_level"].count()
counts = counts.reindex(["College graduate", "College", "10th to 12th grade",␣
 ↪"8th & 9th grade", "7th grade"])
counts
```

[38]:
```
school_level
College graduate       2
College               36
10th to 12th grade    14
8th & 9th grade        4
7th grade              3
Name: school_level, dtype: int64
```

[39]:
```
# Use a pie char to visualize the finding
plt.figure(figsize=[10,8])
colors = plt.get_cmap("Blues")(np.linspace(0.9, 0.3, len(counts)))
counts.plot(kind="pie",  colors=colors,
            wedgeprops={"linewidth": 3, "edgecolor": "white"},
            autopct=lambda p: "{:.1f}%({:.0f})".format(p,(p/100)*counts.sum()),
            pctdistance=0.75,
            textprops={"fontsize":17, "color":"#FFA500", "fontweight":"bold"})
plt.axis("equal")
plt.ylabel("")
plt.title("Flesch reading-ease test of philosophy books", fontsize=25,␣
 ↪color="#FF8840", fontweight="bold",
          horizontalalignment="center")

plt.savefig("/Users/lsx/Desktop/pie_chart.png")
plt.show()
```



[40]:
```
df_title.drop(columns = {"tot_words", "tot_syllables", "tot_sens"}).head()
```

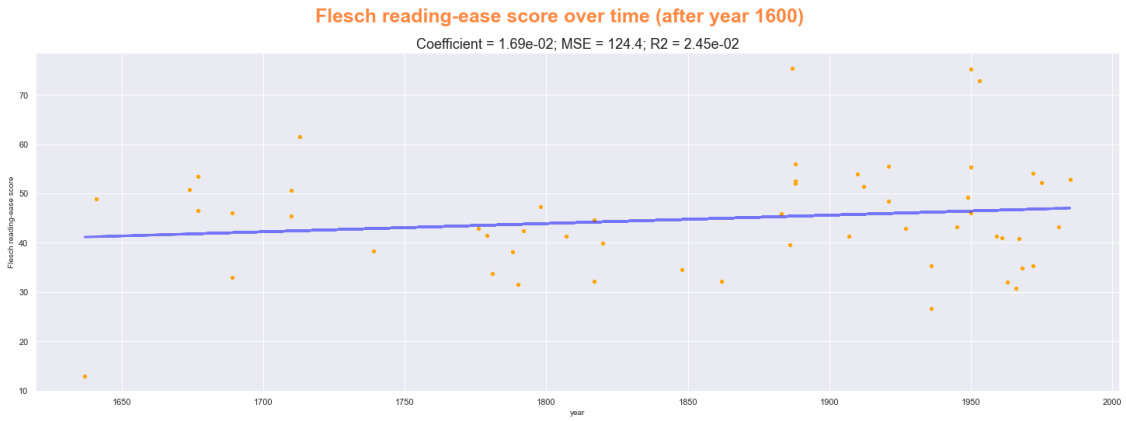
[40]:

title	author	school	original_publication_date
Discourse On Method	Descartes	rationalism	1637
The Crisis Of The European Sciences And Phenome…	Husserl	phenomenology	
The Order Of Things	Foucault	continental	
Critique Of Judgement	Kant	german_idealism	
The Birth Of The Clinic	Foucault	continental	

```
The Crisis Of The European Sciences And Phenome…                        1936
The Order Of Things                                                       1966
Critique Of Judgement                                                     1790
The Birth Of The Clinic                                                   1963

                                                    corpus_edition_date  \
title
Discourse On Method                                                 2008
The Crisis Of The European Sciences And Phenome…                  1970
The Order Of Things                                                 2002
Critique Of Judgement                                               2007
The Birth Of The Clinic                                             2003

                                                    new_sentence_length  \
title
Discourse On Method                                               23018
The Crisis Of The European Sciences And Phenome…                150355
The Order Of Things                                               172049
Critique Of Judgement                                             153103
The Birth Of The Clinic                                            76353

                                                    Flesch_score  grade_level  \
title
Discourse On Method                                         13.0         28.0
The Crisis Of The European Sciences And Phenome…           26.6         17.0
The Order Of Things                                         30.7         18.0
Critique Of Judgement                                       31.6         18.0
The Birth Of The Clinic                                     32.1         16.0

                                                        school_level
title
Discourse On Method                                  College graduate
The Crisis Of The European Sciences And Phenome…  College graduate
The Order Of Things                                          College
Critique Of Judgement                                        College
The Birth Of The Clinic                                      College
```

[41]:
```
# plot all reading-ease score against the original publication date
plt.figure(figsize=[25,8])
plt.scatter(df_title["original_publication_date"],  df_title["Flesch_score"],␣
 ↪s=50, c="blue")
plt.title("Flesch reading-ease score over time", fontsize=25, color="#FF8840",␣
 ↪fontweight="bold",
          horizontalalignment="center")
plt.show()
```

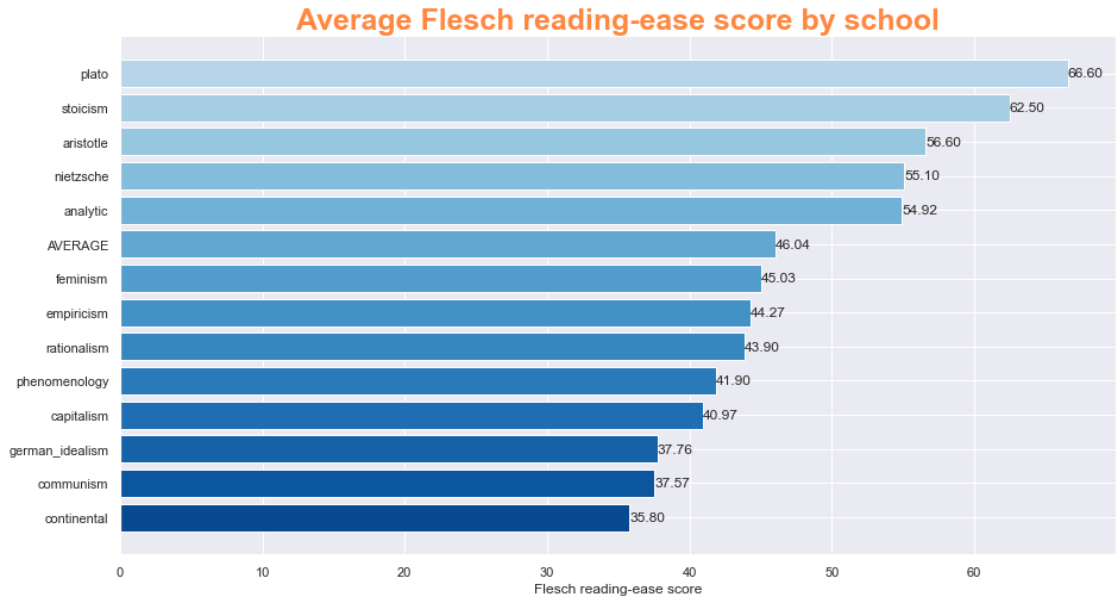
[42]:
```
# after 1600
df_after_1600 = df_title[df_title["original_publication_date"]>1600]

x = df_after_1600["original_publication_date"].to_numpy().reshape(-1, 1)
y = df_after_1600["Flesch_score"]
reg = LinearRegression().fit(x,y)
y_pred = reg.predict(x)

fig, ax = plt.subplots(figsize=[25,8])
ax.plot(x, y_pred, color="blue", linewidth=3, alpha=0.5)
ax.scatter(x, y, linewidth=3, c="orange", s=5)
ax.set_xlabel("year", fontsize=10)
ax.set_ylabel("Flesch reading-ease score", fontsize=10)
plt.suptitle("Flesch reading-ease score over time (after year 1600)",␣
 ↪fontsize=25, color="#FF8840", fontweight="bold")
plt.title("Coefficient = {:.2e}; MSE = {:.1f}; R2 = {:.2e}".format(reg.
 ↪coef_[0], mean_squared_error(y, y_pred), r2_score(y, y_pred)), fontsize=18)


plt.savefig("/Users/lsx/Desktop/score_over_time.png")
plt.show()
```



[43]:
```
schools = df_title.groupby(["school"])["Flesch_score"].mean()
s = pd.Series([df_title["Flesch_score"].mean()], index=["AVERAGE"])
schools = schools.append(s)
schools = schools.sort_values()
schools.describe()
```

[43]:
```
count    14.000000
mean     47.781732
std       9.689290
min      35.800000
25%      41.200000
50%      44.650000
75%      55.054545
max      66.600000
dtype: float64
```

[44]:
```
fig, ax = plt.subplots(figsize=[15,8])
colors = plt.get_cmap("Blues")(np.linspace(0.9, 0.3, len(schools)))
hbars = ax.barh(schools.index, schools.values, color=colors)
ax.set_xlabel("Flesch reading-ease score")
ax.bar_label(hbars, fmt='%.2f')
plt.title("Average Flesch reading-ease score by school", fontsize=25,␣
↪color="#FF8840", fontweight="bold")
plt.savefig("/Users/lsx/Desktop/score_by_school.png")
plt.show()
```



[45]:
```
authors = df_title.groupby(["author"])["Flesch_score"].mean()
authors = authors.append(s)
authors = authors.sort_values()
authors.describe()
```

[45]:
```
count    37.000000
mean     46.398259
std       9.548558
min      30.950000
25%      39.900000
50%      46.035593
75%      52.900000
max      67.866667
dtype: float64
```

[46]:
```
fig, ax = plt.subplots(figsize=[15,10])
colors = plt.get_cmap("Blues")(np.linspace(0.9, 0.3, len(authors)))
hbars = ax.barh(authors.index, authors.values, color=colors)
ax.set_xlabel("Flesch reading-ease score")
ax.bar_label(hbars, fmt='%.2f')
plt.title("Average Flesch reading-ease score by author", fontsize=25,␣
 ↪color="#FF8840", fontweight="bold")
plt.savefig("/Users/lsx/Desktop/score_by_author.png")
plt.show()
```