In [1]:

```
import pandas as pd
import os
import ast
import seaborn as sns
import numpy as np
import random
from matplotlib import pyplot as plt
from tabulate import tabulate

from load_data import *
from analysis import *
from main import *
```

In [2]:

```
review_df = pd.read_csv('data/review_df.csv')
review_metadata_df = pd.read_csv('data/review_metadata_df.csv')
```

In [3]:

```
review_df.head()
```

Out[3]:

	Unnamed: 0	Unnamed: 0.1	Unnamed: 0.1.1	reviewerID	asin	reviewerName	helpful	reviewTextLength	overall	summaryLength	unixReviewTime	reviewTime	n
0	0	0	0	A1KLRMWW2FWPL4	0000031887	Amazon Customer "cameramom"	NaN	35	5.0	5	1297468800	02 12, 2011	
1	1	1	1	A2G5TCU2WDFZ65	0000031887	Amazon Customer	NaN	61	5.0	2	1358553600	01 19, 2013	
2	2	2	2	A1RLQXYNCMWRWN	0000031887	Carola	NaN	62	5.0	6	1357257600	01 4, 2013	
3	3	3	3	A8U3FAMSJVHS5	0000031887	Caromcg	NaN	76	5.0	2	1398556800	04 27, 2014	
4	4	4	4	A3GEOILWLK86XM	0000031887	CJ	NaN	80	5.0	4	1394841600	03 15, 2014	

In [4]:

```
review_metadata_df.head()
```

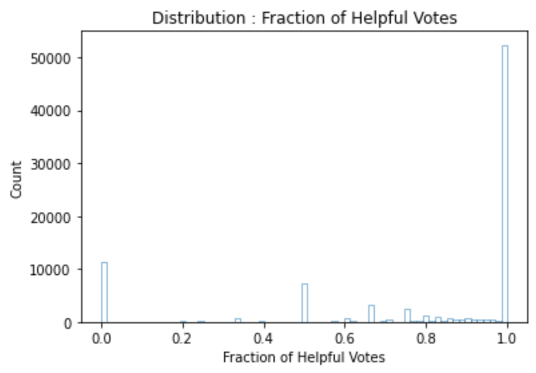
Out[4]:

	Unnamed: 0	asin	salesRank	title	productDescriptionLength	price	bought_togethe
0	0	B00004SR8Z	1631.0	Lewis N. Clark Deluxe Neck Stash	0	12.80	NaN
1	1	B0000ZE74A	4742.0	Vanity Fair Women's Lollipop Plus Size Cuff Le...	0	NaN	['B004PEHJ6U', 'B004A7XXJO', 'B0007YY8H0', 'B0..
2	2	B00012O12A	4.0	Levi's Men's 505 Regular-Fit Jean	0	NaN	NaN
3	3	B0002XSXWC	300.0	Columbia Men's Bonehead Short Sleeve Fishing S...	0	NaN	['B0031RFWMU', 'B0031RFWSE', 'B0050VLSLO', 'B0..
4	4	B00066TWMU	1199.0	ASICS Mesh Backpack	0	12.41	['B00KOWEIAW', 'B00G3K71KS', 'B00CR60HLM', 'B0..

Q1: What is the relation between the reviews and the helpfulness?

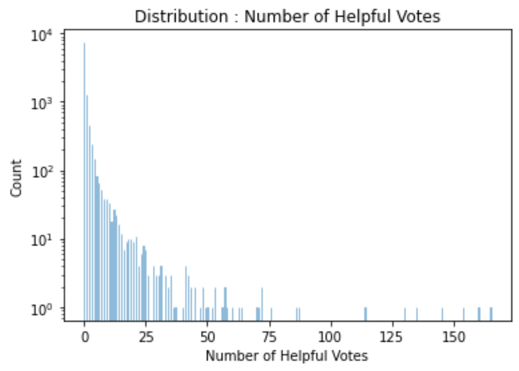
In [5]:

```
plot_histogram(None, review_df, HELPFULNESS)
```



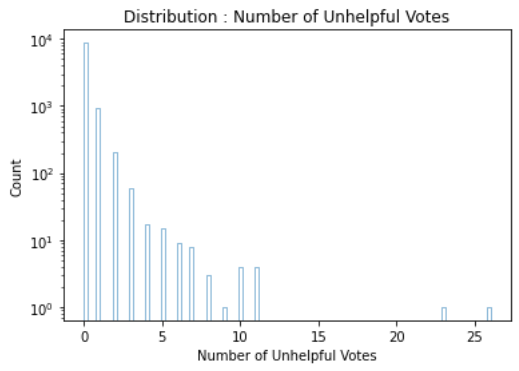
In [6]:

```
plot_histogram(None, review_df, NUM_HELPFUL, log=True, max_samples=10000)
```



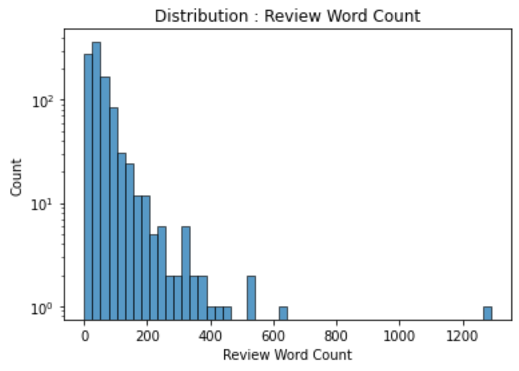
In [7]:

```
plot_histogram(None, review_df, NUM_UNHELPFUL, log=True, max_samples=10000, bins=100)
```



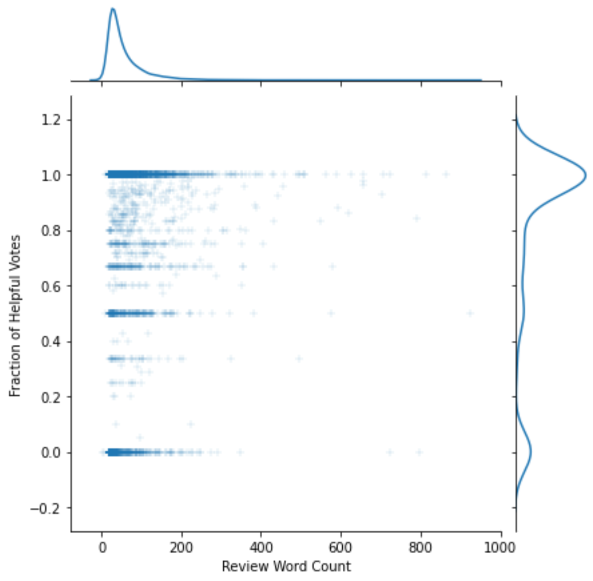
In [8]:

```
plot_histogram(None, review_df, REVIEW_WORD_COUNT, log=True, fill=True, max_samples=1000, bins=50)
```



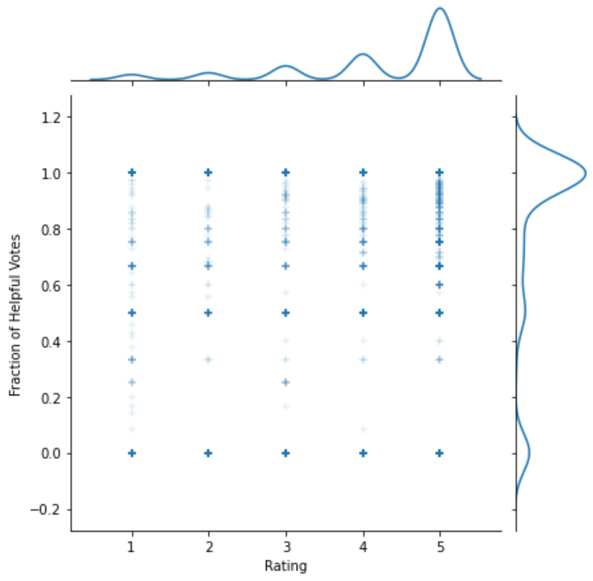
In [9]:

```
joint_plot(None, review_df, REVIEW_WORD_COUNT, HELPFULNESS, alpha=0.25, max_samples=10000)
```



In [10]:

```
joint_plot(None, review_df, RATING, HELPFULNESS, max_samples=10000, alpha=0.25)
```



In [11]:

```
# sns.regplot(RATING, HELPFULNESS, data=review_df)
```

In [12]:

```
print_correlation(review_df, HELPFULNESS, RATING, "helpfulness", "rating")
print_correlation(review_df, HELPFULNESS, REVIEW_WORD_COUNT, "helpfulness", "review word count")
print_correlation(review_df, HELPFULNESS, SUMMARY_LENGTH, "helpfulness", "summary length")
```

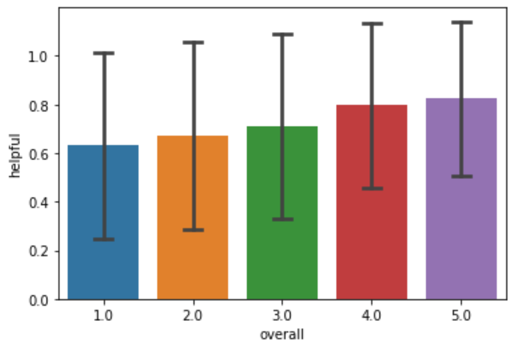
```
Correlation between helpfulness and rating = 18.1%
Correlation between helpfulness and review word count = 5.4%
Correlation between helpfulness and summary length = -0.1%
```

In [13]:

```
sns.barplot(x=RATING, y=HELPFULNESS, data=review_df, ci='sd', capsize=.2)
```

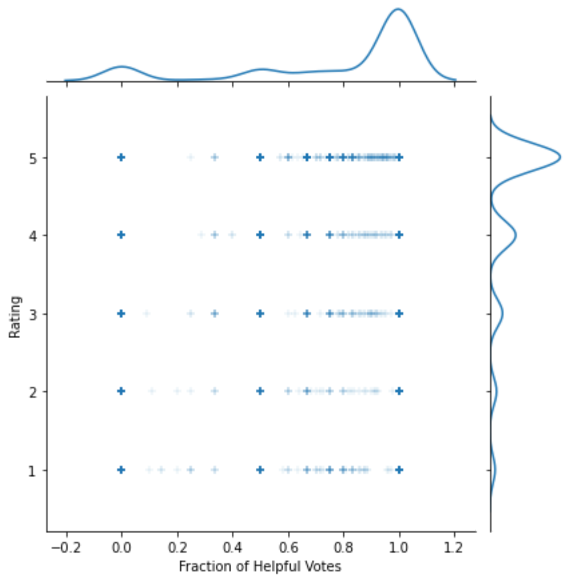
Out[13]:

```
<AxesSubplot:xlabel='overall', ylabel='helpful'>
```



In [14]:

```
joint_plot(None, review_df, HELPFULNESS, RATING, 10000, alpha=0.25)
```



Q2: What is the review behavior among different categories?

In [15]:

```
joined_df = review_df.set_index(PRODUCT_ID).join(review_metadata_df.set_index(PRODUCT_ID),
                                                 lsuffix='', rsuffix='_right').reset_index()
review_df.shape, review_metadata_df.shape, joined_df.shape
```

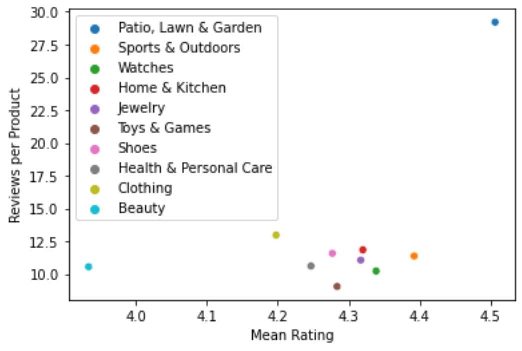
Out[15]:

```
((278677, 16), (23033, 9), (278677, 24))
```

In [40]:

```
metric = RATING

review_by_category_df = review_behavior_by_category(joined_df, metric)
# TODO: scatterplot
sns.scatterplot(f'{metric}_mean',
                'reviews_per_product',
                data=review_by_category_df,
                hue=CATEGORY)
plt.legend(loc='upper left')
plt.xlabel(get_label(f'{metric}_mean'))
plt.ylabel(get_label('Reviews per Product'))
plt.show()
```

```
/home/asharma/anaconda3/envs/develop/lib/python3.7/site-packages/seaborn/_decorators.py:43: FutureWarning: Pass the following
s: x, y. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit
n error or misinterpretation.
  FutureWarning
```



In [41]:

```
review_by_category_df
```

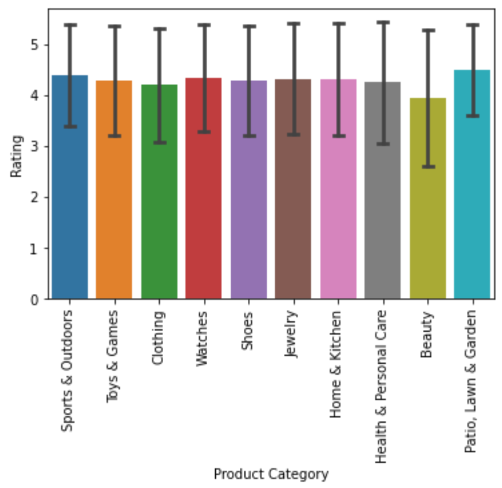
Out[41]:

	category	overall_mean	overall_count	asin_nunique	reviews_per_product
0	Patio, Lawn & Garden	4.506306	555	19	29.210526
1	Sports & Outdoors	4.392251	8311	730	11.384932
2	Watches	4.338580	10166	993	10.237664
3	Home & Kitchen	4.319905	2110	178	11.853933
4	Jewelry	4.316975	29179	2635	11.073624
5	Toys & Games	4.283582	2211	244	9.061475
6	Shoes	4.276943	69238	5975	11.587950
7	Health & Personal Care	4.246779	1009	95	10.621053
8	Clothing	4.197557	139752	10768	12.978455
9	Beauty	3.933333	750	71	10.563380

In [44]:

```
### TODO: add plot
top_categories = review_by_category_df[CATEGORY].tolist()
filtered_df = joined_df[joined_df[CATEGORY].isin(top_categories)]
sns.barplot(CATEGORY, metric, data=filtered_df, ci='sd', capsize=.2)
# sns.boxplot(CATEGORY, metric, data=filtered_df)

plt.xticks(rotation=90)
plt.xlabel(get_label(CATEGORY))
plt.ylabel(get_label(metric))
# plt.ylim(2, 5)
plt.show()
```

```
/home/asharma/anaconda3/envs/develop/lib/python3.7/site-packages/seaborn/_decorators.py:43: FutureWarning: Pass the following
x, y. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit ke
or or misinterpretation.
  FutureWarning
```

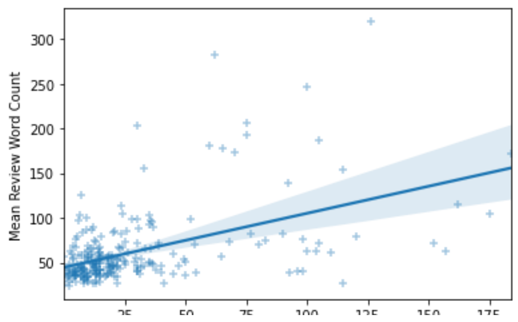


Q3: Is there a relationship between price and reviews?

In [48]:

```
# # correlation per-review
# print_correlation(joined_df[[REVIEW_WORD_COUNT, PRICE]], PRICE, REVIEW_WORD_COUNT, 'Price', 'Review Word Count')
# print_correlation(joined_df[[RATING, PRICE]], PRICE, RATING, 'Price', 'Rating')

# correlation per-product
product_price_wordcount_df = get_average_metric_with_price(review_df, review_metadata_df, REVIEW_WORD_COUNT)
print_correlation(product_price_wordcount_df,
                  PRICE, f'{REVIEW_WORD_COUNT}_mean',
                  'Price', 'Mean Review Word Count')
g = sns.regplot(data=product_price_wordcount_df.sample(250), x=PRICE, y=f'{REVIEW_WORD_COUNT}_mean', marker='+',
            scatter_kws={'alpha': 0.4})
plt.xlabel(get_label(PRICE))
plt.ylabel(get_label(f'{REVIEW_WORD_COUNT}_mean'))
plt.show()
```

```
/home/asharma/Personal/Shabana/takeaway/main.py:38: FutureWarning: Index.ravel returning ndarray is deprecated; in a future ve
view on self.
  product_metric_df.columns = ["_".join(x) for x in product_metric_df.columns.ravel()]

Correlation between Price and Mean Review Word Count = 40.9%
```



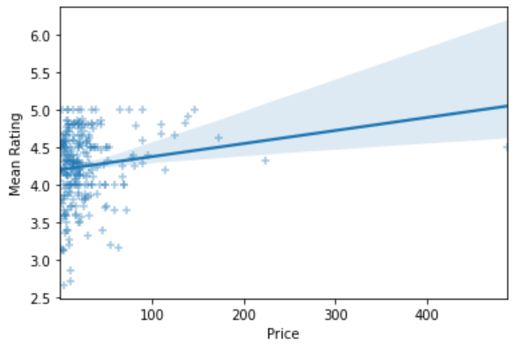
In [20]:

```
# joint_plot(None, product_price_wordcount_df, PRICE, f'{REVIEW_WORD_COUNT}_mean', 250, alpha=0.25)
```

In [47]:

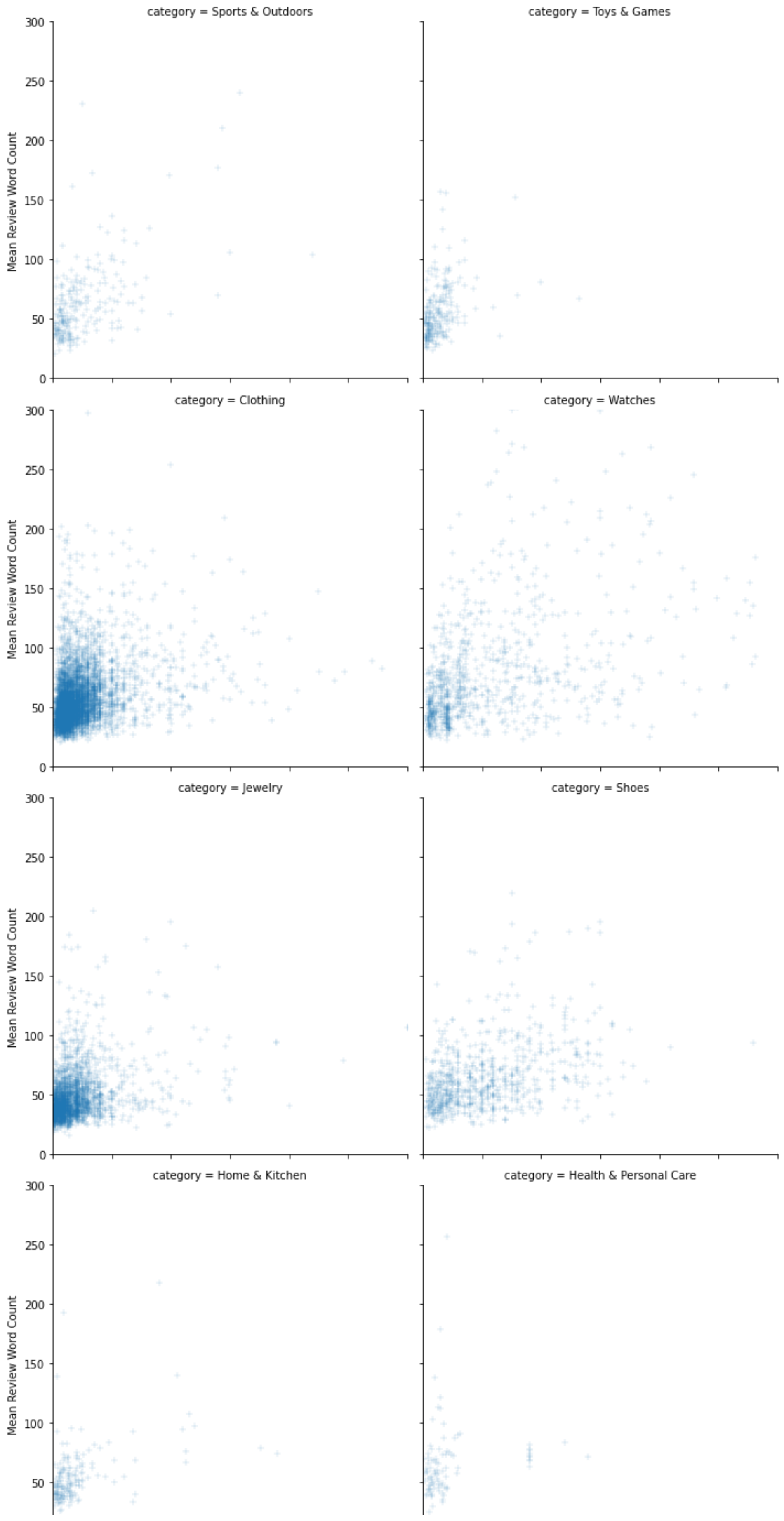
```
product_price_rating_df = get_average_metric_with_price(review_df, review_metadata_df, RATING)
print_correlation(product_price_rating_df,
                  PRICE, f'{RATING}_mean',
                  'Price', 'Mean Rating')
g = sns.regplot(data=product_price_rating_df.sample(250), x=PRICE, y=f'{RATING}_mean', marker='+',
            scatter_kws={'alpha': 0.4})
plt.xlabel(get_label(PRICE))
plt.ylabel(get_label(f'{RATING}_mean'))
plt.show()
```

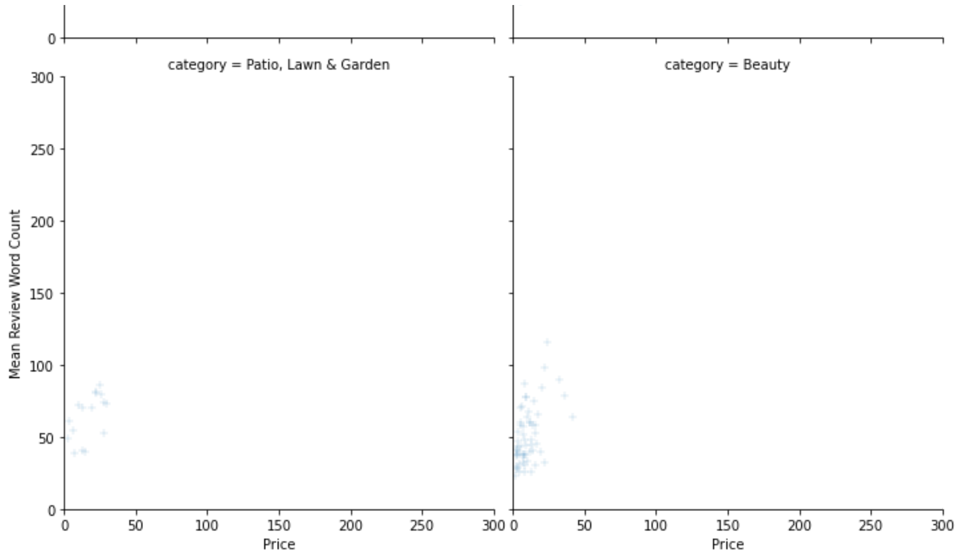
```
Correlation between Price and Mean Rating = 9.9%

/home/asharma/Personal/Shabana/takeaway/main.py:38: FutureWarning: Index.ravel returning ndarray is deprecated; in a future ve
ew on self.
  product_metric_df.columns = ["_".join(x) for x in product_metric_df.columns.ravel()]
```



In [22]:

```
filtered_df = product_price_wordcount_df[product_price_wordcount_df[CATEGORY].isin(top_categories)]

g = sns.FacetGrid(filtered_df, col=CATEGORY, height=5, col_wrap=2)
g.map(sns.scatterplot, PRICE, f'{REVIEW_WORD_COUNT}_mean', marker='+', alpha=0.3)
g.set_axis_labels(get_label(PRICE), get_label(f'{REVIEW_WORD_COUNT}_mean'))
plt.xlim(0,300)
plt.ylim(0,300)
plt.show()
```

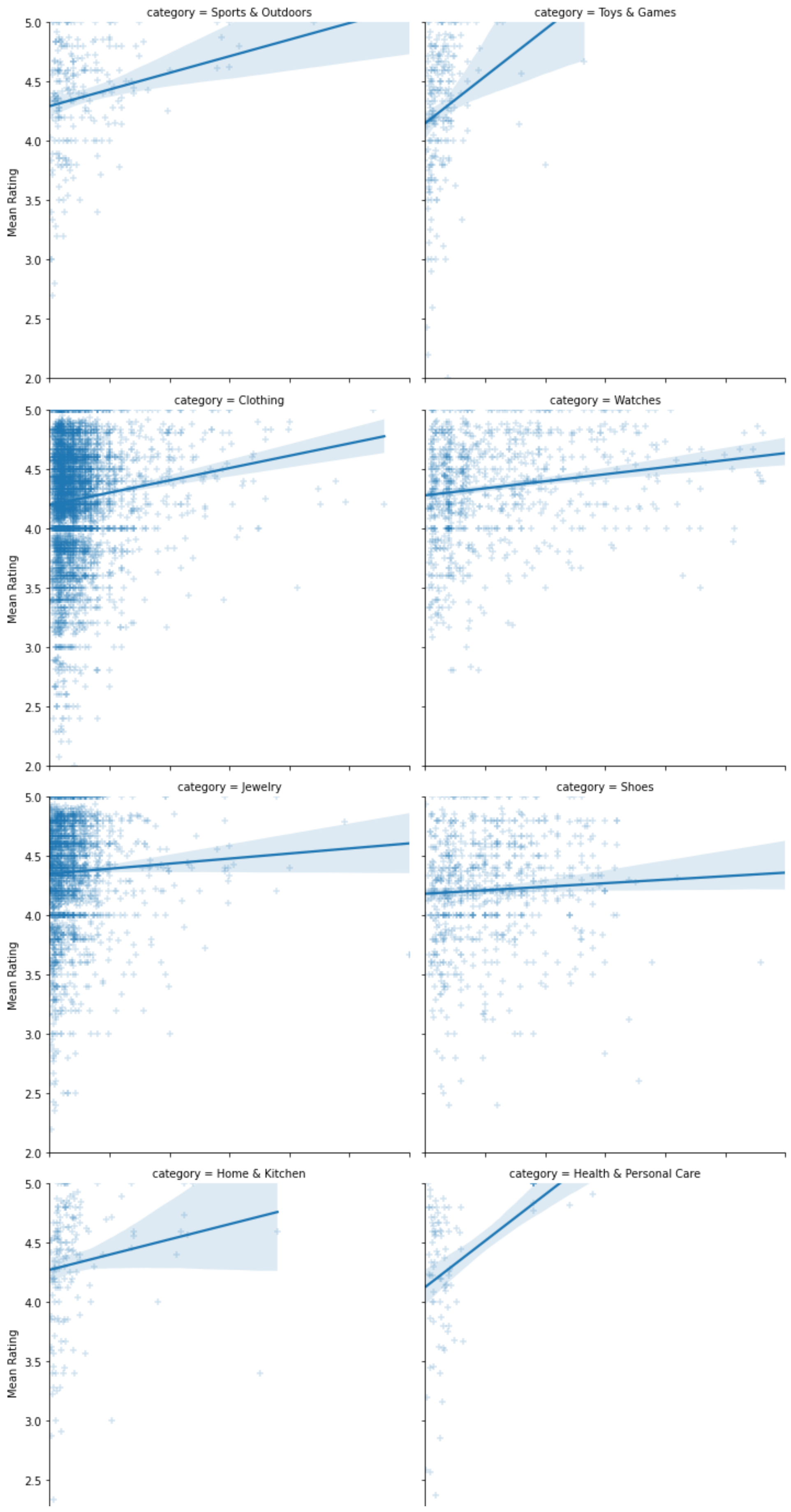


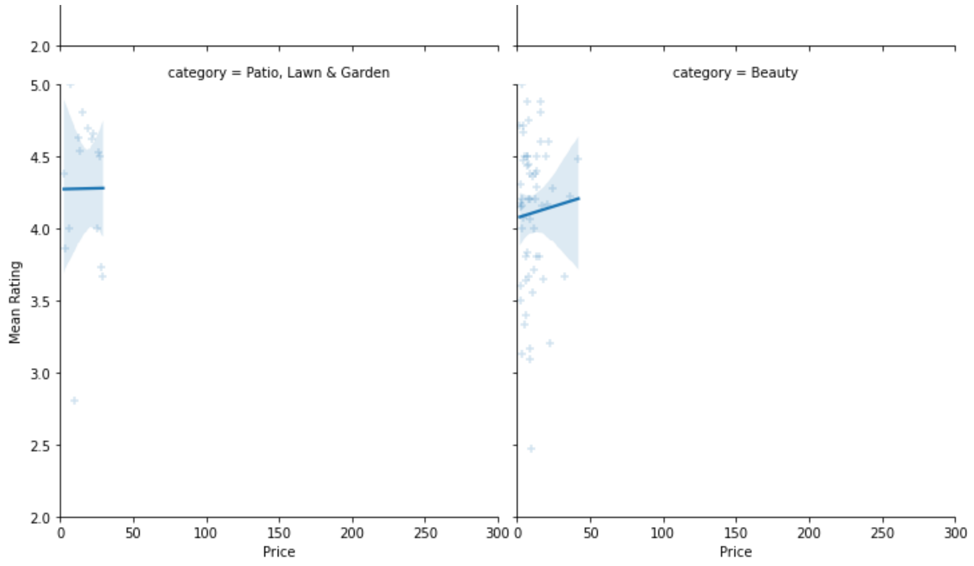


0
category = Patio, Lawn & Garden
category = Beauty
Mean Review Word Count
Price
Price
0
50
100
150
200
250
300

In [23]:

```
filtered_df = product_price_rating_df[product_price_rating_df[CATEGORY].isin(top_categories)]

g = sns.FacetGrid(filtered_df, col=CATEGORY, height=5, col_wrap=2)
g.map(sns.regplot, PRICE, f'{RATING}_mean', marker='+', scatter_kws={'alpha':0.2})
g.set_axis_labels(get_label(PRICE), get_label(f'{RATING}_mean'))
plt.xlim(0,300)
plt.ylim(2,5)
plt.show()
```





Q4: Which group of reviewers is more valuable to the business?

In [24]:

```
# reviewer_summary_df = review_df.groupby([REVIEWER_ID, REVIEWER_NAME]) \
#         .agg({NUM_HELPFUL: ['sum'], NUM_UNHELPFUL: ['sum'], PRODUCT_ID: ['count']})

# reviewer_summary_df.columns = ["_".join(x) for x in reviewer_summary_df.columns.ravel()]
# reviewer_summary_df['net_helpfulness'] = reviewer_summary_df[f'{NUM_HELPFUL}_sum'] - reviewer_summary_df[f'{NUM_UNHELPFUL}_s
```

In [25]:

```
# reviewer_summary_df.sort_values('net_helpfulness', ascending=False).head(10)
```

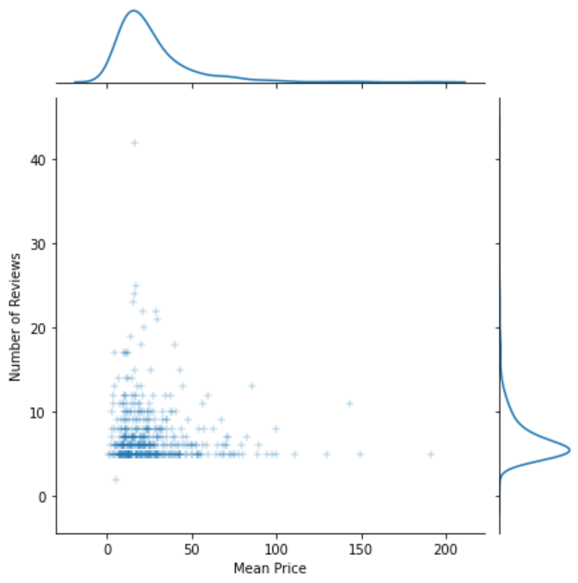
In [26]:

```
reviewer_summary_df = joined_df.groupby([REVIEWER_ID, REVIEWER_NAME]) \
        .agg({PRICE: ['mean'], PRODUCT_ID: ['count']})

reviewer_summary_df.columns = ["_".join(x) for x in reviewer_summary_df.columns.ravel()]
```

```
/home/asharma/anaconda3/envs/develop/lib/python3.7/site-packages/ipykernel_launcher.py:4: FutureWarning: Index.ravel returning
a future version this will return a view on self.
  after removing the cwd from sys.path.
```

In [27]:

```
reviewer_summary_df['Number of Reviews'] = reviewer_summary_df[f'{PRODUCT_ID}_count']
joint_plot(None, reviewer_summary_df, f'{PRICE}_mean', 'Number of Reviews', max_samples=500, alpha=0.6)
```



In [28]:

```
# print_correlation(reviewer_summary_df, f'{PRICE}_mean', f'{PRODUCT_ID}_count',
#                   f'{PRICE}_mean', f'{PRODUCT_ID}_count')
```

Q5: Is there a relation between reviews from products which are bought together?

In [29]:

```
rating_pair_df = sample_products_bought_together(review_df, review_metadata_df, num_samples=1000)
print_correlation(rating_pair_df, 'Rating_1', 'Rating_2', 'Rating_1', 'Rating_2')
```

```
/home/asharma/Personal/Shabana/takeaway/main.py:62: FutureWarning: Index.ravel returning ndarray is deprecated; in a future ve
ew on self.
  product_rating_df.columns = ["_".join(x) for x in product_rating_df.columns.ravel()]

Correlation between Rating_1 and Rating_2 = 28.3%
```

In [30]:

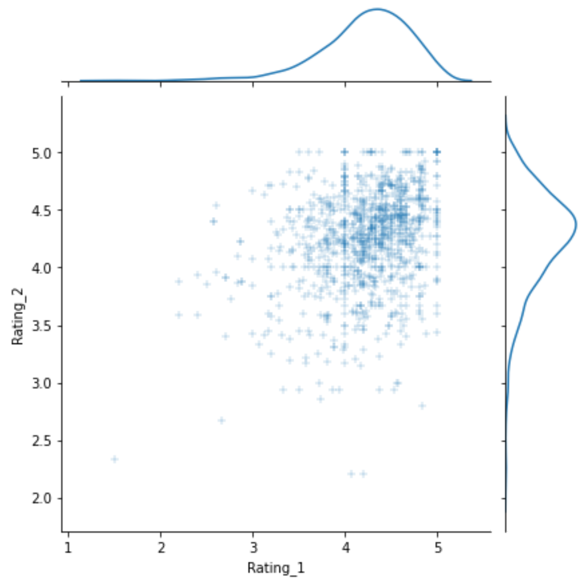
```
rating_pair_df.head(10)
```

Out[30]:

	Product_ID_1	Rating_1	Product_ID_2	Rating_2
0	B00DHKYE52	3.200000	B00DHKL51I	3.571429
1	B008E3CCF6	4.447368	B00A97X6Y6	4.555556
2	B003U7BK90	3.833333	B003U7CXBY	4.454545
3	B001UL8SJS	4.750000	B006P4NDFE	4.428571
4	B002AQSQ76	4.714286	B004UDMETS	3.900000
5	B006TQLRL0	4.357143	B006TQLR42	3.375000
6	B004VMOSWE	4.375000	B0052OPAM2	4.250000
7	B00EQ81GKA	4.833333	B005EOIQRQ	4.538462
8	B007JZ983Y	5.000000	B005H0JHM0	5.000000
9	B0074ZVIX2	4.181818	B00E924N9O	4.200000

In [31]:

```
joint_plot(None, rating_pair_df, 'Rating_1', 'Rating_2', max_samples=1000, alpha=0.5)
```



Q6: Temporal analysis of reviews

In [32]:

```
YEAR = 'year'
time_joined_df = review_df.set_index(PRODUCT_ID).join(review_metadata_df.set_index(PRODUCT_ID),
                                                  lsuffix='', rsuffix='_right').reset_index()
```

In [33]:

```
# filtered_df = time_joined_df[time_joined_df[CATEGORY]=='Clothing']
# rating_df = filtered_df[[YEAR, PRODUCT_ID, RATING]].groupby([YEAR, PRODUCT_ID]).mean(RATING).reset_index()
```

In [34]:

```
# rating_df = rating_df.groupby([YEAR]).mean(RATING).reset_index()
```

In [35]:

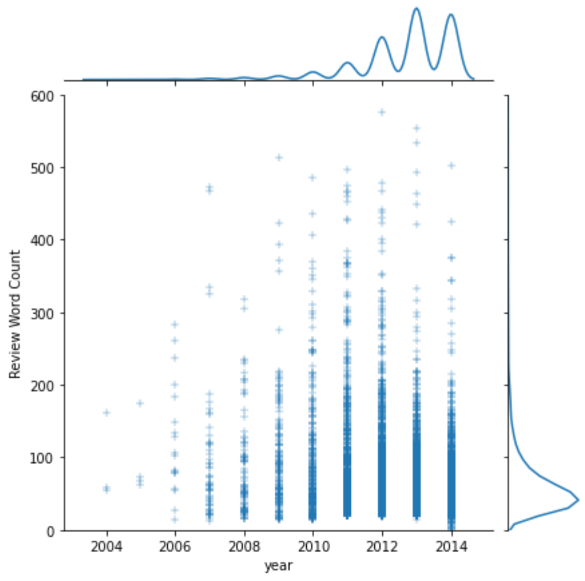
```
# sns.lineplot(data=rating_df, x="year", y="overall")
```

In [36]:

```
# top_3_categories = ['Clothing', 'Shoes', 'Jewelry']
# filtered_df = time_joined_df[time_joined_df[CATEGORY].isin(top_3_categories)]
# rating_df = filtered_df[[YEAR, CATEGORY, PRODUCT_ID, RATING]].groupby([YEAR, CATEGORY, PRODUCT_ID]).mean(RATING).reset_index
# g = sns.FacetGrid(rating_df, col=CATEGORY, height=5, col_wrap=1)
# g.map(sns.lineplot, YEAR, RATING)
```

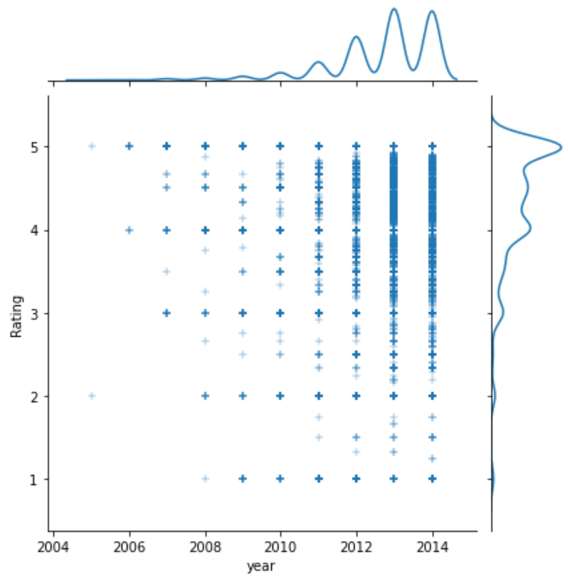
In [37]:

```
metric = REVIEW_WORD_COUNT
rating_df = time_joined_df[[YEAR, PRODUCT_ID, metric]].groupby([YEAR, PRODUCT_ID]).mean(metric).reset_index()
joint_plot(None, rating_df, YEAR, metric, alpha=0.75, max_samples=10000)
plt.ylim(0, 600)
plt.show()
```



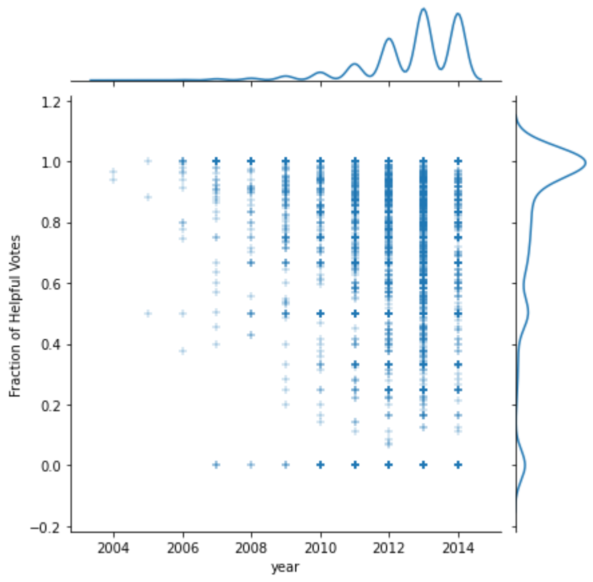
In [38]:

```
metric = RATING
rating_df = time_joined_df[[YEAR, PRODUCT_ID, metric]].groupby([YEAR, PRODUCT_ID]).mean(metric).reset_index()
joint_plot(None, rating_df, YEAR, metric, alpha=0.75, max_samples=10000)
plt.show()
```



In [39]:

```
metric = HELPFULNESS
rating_df = time_joined_df[[YEAR, PRODUCT_ID, metric]].groupby([YEAR, PRODUCT_ID]).mean(metric).reset_index()
joint_plot(None, rating_df, YEAR, metric, alpha=0.75, max_samples=10000)
plt.show()
```


Fraction of Helpful Votes
year