In [1]:

```
import pandas as pd
import matplotlib.pyplot as plt
import plotly.express as px
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn import metrics
from scipy.cluster.hierarchy import linkage, dendrogram, fcluster
from sklearn.cluster import KMeans, DBSCAN
import numpy as np
from sklearn import linear_model
```

In [2]:

```
data = pd.read_csv('data/googleplaystore.csv')
data.head(10)
```

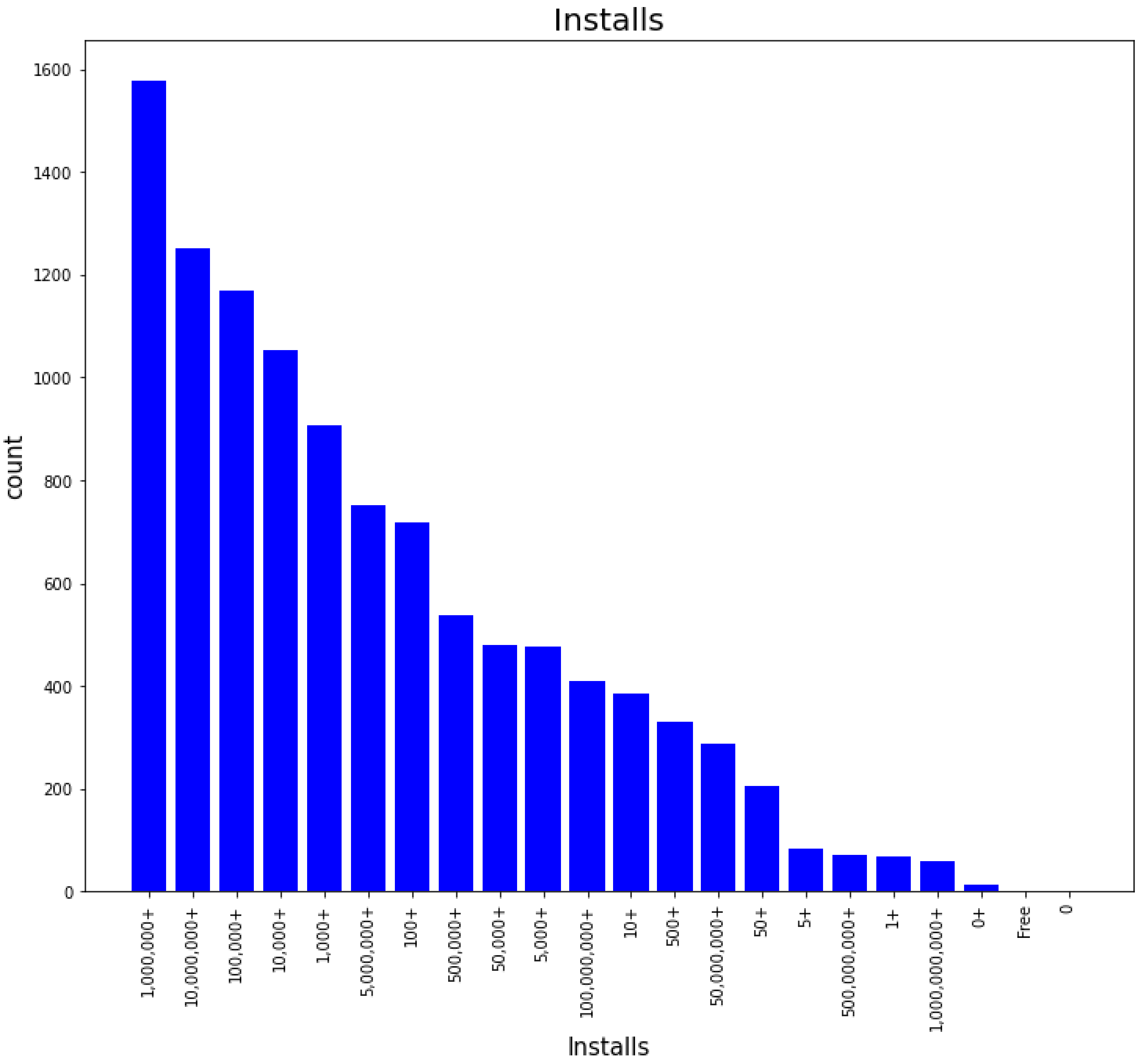
Out[2]:

	App	Category	Rating	Reviews	Size	Installs	Type	Price	Content Rating	Genres	Last Updated	Current Ver	Android Ver
0	Photo Editor & Candy Camera & Grid & ScrapBook	ART_AND_DESIGN	4.1	159	19M	10,000+	Free	0	Everyone	Art & Design	January 7, 2018	1.0.0	4.0.3 and up
1	Coloring book moana	ART_AND_DESIGN	3.9	967	14M	500,000+	Free	0	Everyone	Art & Design;Pretend Play	January 15, 2018	2.0.0	4.0.3 and up
2	U Launcher Lite – FREE Live Cool Themes, Hide ...	ART_AND_DESIGN	4.7	87510	8.7M	5,000,000+	Free	0	Everyone	Art & Design	August 1, 2018	1.2.4	4.0.3 and up
3	Sketch - Draw & Paint	ART_AND_DESIGN	4.5	215644	25M	50,000,000+	Free	0	Teen	Art & Design	June 8, 2018	Varies with device	4.2 and up
4	Pixel Draw - Number Art Coloring Book	ART_AND_DESIGN	4.3	967	2.8M	100,000+	Free	0	Everyone	Art & Design;Creativity	June 20, 2018	1.1	4.4 and up

	App	Category	Rating	Reviews	Size	Installs	Type	Price	Content Rating	Genres	Last Updated	Current Ver	Android Ver
5	Paper flowers instructions	ART_AND_DESIGN	4.4	167	5.6M	50,000+	Free	0	Everyone	Art & Design	March 26, 2017	1.0	2.3 and up
6	Smoke Effect Photo Maker - Smoke Editor	ART_AND_DESIGN	3.8	178	19M	50,000+	Free	0	Everyone	Art & Design	April 26, 2018	1.1	4.0.3 and up
7	Infinite Painter	ART_AND_DESIGN	4.1	36815	29M	1,000,000+	Free	0	Everyone	Art & Design	June 14, 2018	6.1.61.1	4.2 and up
8	Garden Coloring Book	ART_AND_DESIGN	4.4	13791	33M	1,000,000+	Free	0	Everyone	Art & Design	September 20, 2017	2.9.2	3.0 and up
9	Kids Paint Free - Drawing Fun	ART_AND_DESIGN	4.7	121	3.1M	10,000+	Free	0	Everyone	Art & Design;Creativity	July 3, 2018	2.8	4.0.3 and up

In [3]:

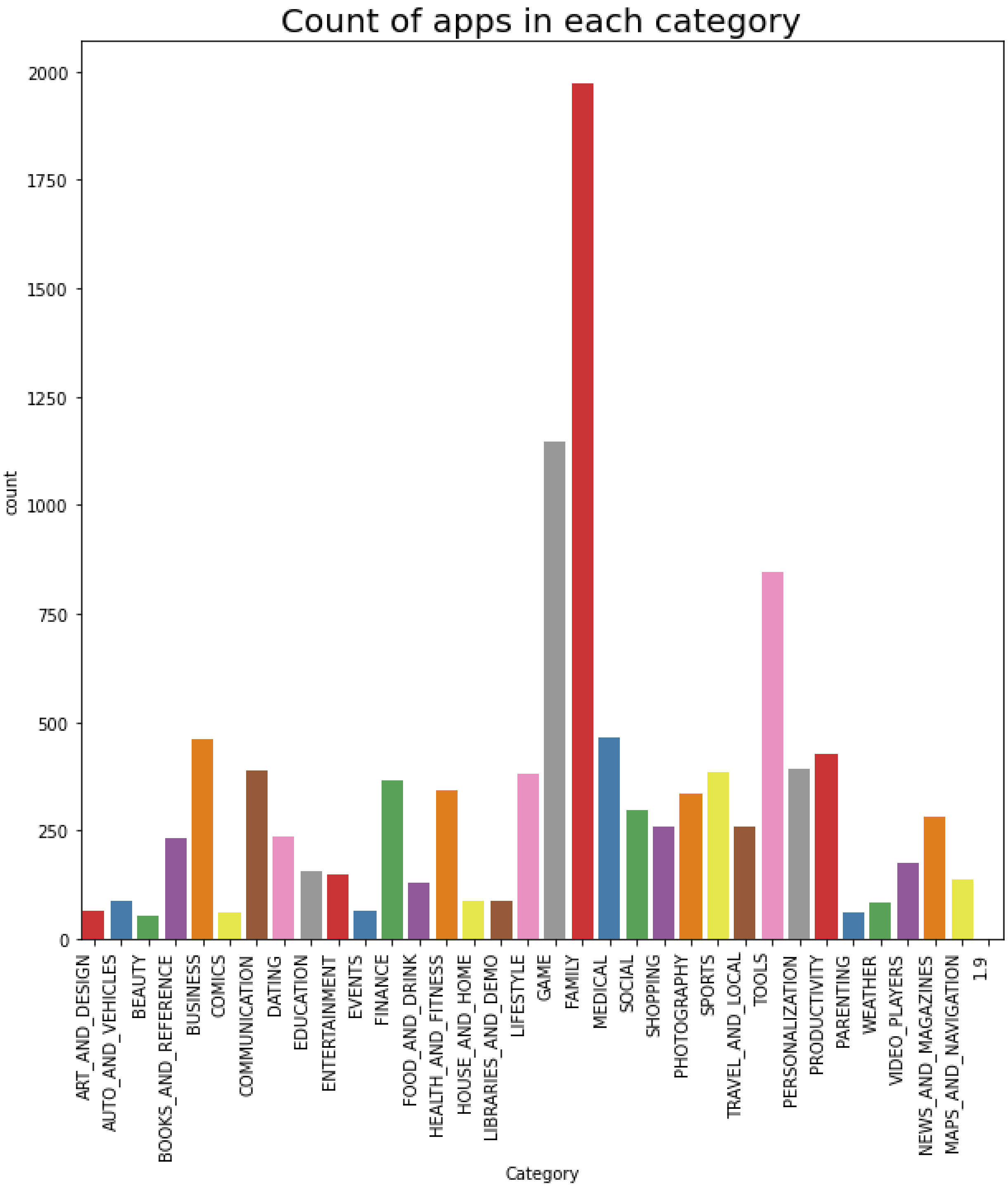
```
# EDA : Plots for exploration

#Plotting installs against how many such apps:

plt.figure(figsize = (12,10))
plt.bar(data['Installs'].value_counts().index.tolist(),data['Installs'].value_counts(), color = "blue")
plt.xticks(rotation=90)
plt.xlabel("Installs",size = 15, color = "black")
plt.ylabel("count",size = 15, color = "black")
plt.title("Installs",size = 20, color = "black")
plt.show()
```



```
In [4]: #Count of apps in each category
```

```
plt.figure(figsize = (10,10))
g = sns.countplot(x="Category",data=data, palette = "Set1")
g.set_xticklabels(g.get_xticklabels(), rotation=90, ha="right")
g
plt.title('Count of apps in each category',size = 20)
```

```
Out[4]: Text(0.5, 1.0, 'Count of apps in each category')
```


Count of apps in each category
count
2000
1750
1500
1250
1000
750
500
250
0
ART_AND_DESIGN
AUTO_AND_VEHICLES
BEAUTY
BOOKS_AND_REFERENCE
BUSINESS
COMICS
COMMUNICATION
DATING
EDUCATION
ENTERTAINMENT
EVENTS
FINANCE
FOOD_AND_DRINK
HEALTH_AND_FITNESS
HOUSE_AND_HOME
LIBRARIES_AND_DEMO
LIFESTYLE
GAME
FAMILY
MEDICAL
SOCIAL
SHOPPING
PHOTOGRAPHY
SPORTS
TRAVEL_AND_LOCAL
TOOLS
PERSONALIZATION
PRODUCTIVITY
PARENTING
WEATHER
VIDEO_PLAYERS
NEWS_AND_MAGAZINES
MAPS_AND_NAVIGATION
1.9
Category

Rating seems to be concentrated around 4.5

In [5]:

```
#Dropping 3 attributes (Android Ver, Last Updated, Current Ver)
data = data.drop(['Android Ver','Last Updated','Current Ver'], axis=1)
```

In [6]:

```
#Drop the duplicate rows having same app names
data.drop_duplicates(subset='App', keep='first', inplace=True)
```

In [7]:

```
#remove data with 0 reviews, 0 installs or null ratings
data.dropna(subset=['Reviews', 'Rating', 'Installs','Content Rating'], inplace=True)
```

In [8]:

```
#Displaying Unique Categories of Apps
print( len(data['Category'].unique()) , "categories")

print("\n".join(data['Category'].unique()))
```

```
33 categories
ART_AND_DESIGN
AUTO_AND_VEHICLES
BEAUTY
BOOKS_AND_REFERENCE
BUSINESS
COMICS
COMMUNICATION
DATING
EDUCATION
ENTERTAINMENT
EVENTS
FINANCE
FOOD_AND_DRINK
HEALTH_AND_FITNESS
HOUSE_AND_HOME
LIBRARIES_AND_DEMO
LIFESTYLE
GAME
FAMILY
MEDICAL
SOCIAL
SHOPPING
PHOTOGRAPHY
SPORTS
TRAVEL_AND_LOCAL
TOOLS
PERSONALIZATION
PRODUCTIVITY
PARENTING
```

```
WEATHER
VIDEO_PLAYERS
NEWS_AND_MAGAZINES
MAPS_AND_NAVIGATION
```

In [9]:

```
#Displaying Unique Genres of Apps
print( len(data['Genres'].unique()) , "allGenres")

print("\n".join(data['Genres'].unique()))
```

```
114 allGenres
Art & Design
Art & Design;Pretend Play
Art & Design;Creativity
Auto & Vehicles
Beauty
Books & Reference
Business
Comics
Comics;Creativity
Communication
Dating
Education;Education
Education
Education;Creativity
Education;Music & Video
Education;Action & Adventure
Education;Pretend Play
Education;Brain Games
Entertainment
Entertainment;Music & Video
Entertainment;Brain Games
Entertainment;Creativity
Events
Finance
Food & Drink
Health & Fitness
House & Home
Libraries & Demo
Lifestyle
Lifestyle;Pretend Play
Adventure;Action & Adventure
Arcade
Casual
Card
Casual;Pretend Play
Action
Strategy
Puzzle
```

```
Sports
Music
Word
Racing
Casual;Creativity
Casual;Action & Adventure
Simulation
Adventure
Board
Trivia
Role Playing
Simulation;Education
Action;Action & Adventure
Casual;Brain Games
Simulation;Action & Adventure
Educational;Creativity
Puzzle;Brain Games
Educational;Education
Educational;Brain Games
Educational;Pretend Play
Entertainment;Education
Casual;Education
Music;Music & Video
Racing;Action & Adventure
Arcade;Pretend Play
Role Playing;Action & Adventure
Simulation;Pretend Play
Puzzle;Creativity
Sports;Action & Adventure
Educational;Action & Adventure
Arcade;Action & Adventure
Entertainment;Action & Adventure
Puzzle;Action & Adventure
Strategy;Action & Adventure
Music & Audio;Music & Video
Health & Fitness;Education
Adventure;Education
Board;Brain Games
Board;Action & Adventure
Board;Pretend Play
Casual;Music & Video
Role Playing;Pretend Play
Entertainment;Pretend Play
Video Players & Editors;Creativity
Card;Action & Adventure
Medical
Social
Shopping
Photography
```

```
Travel & Local
Travel & Local;Action & Adventure
Tools
Tools;Education
Personalization
Productivity
Parenting
Parenting;Music & Video
Parenting;Brain Games
Parenting;Education
Weather
Video Players & Editors
Video Players & Editors;Music & Video
News & Magazines
Maps & Navigation
Health & Fitness;Action & Adventure
Educational
Casino
Adventure;Brain Games
Lifestyle;Education
Books & Reference;Education
Puzzle;Education
Role Playing;Brain Games
Strategy;Education
Racing;Pretend Play
Communication;Creativity
Strategy;Creativity
```

In [10]:

```python
#Only having one of the genres. Hence removing the genres that are followed after ;
data['Genres'] = [i.split(';')[0] for i in data['Genres']]
```

In [11]:

```python
# Remove the + from Installs and make it purely a number
data['Installs'] = [i[:-1].replace(',','') for i in data['Installs']]
data = data[data['Installs'] != '']
data['Installs'] = [int(i) for i in data['Installs']]
```

In [12]:

```python
#Convert Kb to Mb and remove the text and convert the column to float
for i,row in data.iterrows():
    if 'M' in row['Size']:
        x = row['Size'][:-1]
        y = float(x)*1000
    elif 'k' in row['Size']:
        x = row['Size'][:-1]
        y = float(x)
    else:
        y = 0
    data.at[i, 'Size'] = y
data['Size'] = data['Size'].astype(float)
```

In [13]:

```
#verify whether the above snippet of code worked
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 8196 entries, 0 to 10840
Data columns (total 10 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   App             8196 non-null   object 
 1   Category        8196 non-null   object 
 2   Rating          8196 non-null   float64
 3   Reviews         8196 non-null   object 
 4   Size            8196 non-null   float64
 5   Installs        8196 non-null   int64  
 6   Type            8196 non-null   object 
 7   Price           8196 non-null   object 
 8   Content Rating  8196 non-null   object 
 9   Genres          8196 non-null   object 
dtypes: float64(2), int64(1), object(7)
memory usage: 1.0+ MB
```

In [14]:

```
#Drop Null Values from Size
data.dropna(subset=['Size'], inplace=True)
```

Integer encoding for category variable

In [15]:

```
# Converting Category categorical values into numerical values
categoryValues = data["Category"].unique()
category_dict = {}
for i in range(len(categoryValues)):
    category_dict[categoryValues[i]] = i
data["Category_n"] = data["Category"].map(category_dict).astype(int)
```

In [16]:

```
#Resetting Index after dropping Null Values
data = data.reset_index()
```

Integer encoding for content rating

In [17]:

```
# Converting Content Rating categorical values into numerical values
categoryValues = data["Content Rating"].unique()
category_dict = {}
```

```
for i in range(len(categoryValues)):
    category_dict[categoryValues[i]] = i
data["Content Rating_n"] = data["Content Rating"].map(category_dict).astype(int)
```

In [18]:

```
# Visualizing the head of the dataset after performing a few cleaning steps
data.head(10)
```

Out[18]:

	index	App	Category	Rating	Reviews	Size	Installs	Type	Price	Content Rating	Genres	Category_n	Content Rating_n
0	0	Photo Editor & Candy Camera & Grid & ScrapBook	ART_AND_DESIGN	4.1	159	19000.0	10000	Free	0	Everyone	Art & Design	0	0
1	1	Coloring book moana	ART_AND_DESIGN	3.9	967	14000.0	500000	Free	0	Everyone	Art & Design	0	0
2	2	U Launcher Lite – FREE Live Cool Themes, Hide ...	ART_AND_DESIGN	4.7	87510	8700.0	5000000	Free	0	Everyone	Art & Design	0	0
3	3	Sketch - Draw & Paint	ART_AND_DESIGN	4.5	215644	25000.0	50000000	Free	0	Teen	Art & Design	0	1
4	4	Pixel Draw - Number Art Coloring Book	ART_AND_DESIGN	4.3	967	2800.0	100000	Free	0	Everyone	Art & Design	0	0
5	5	Paper flowers instructions	ART_AND_DESIGN	4.4	167	5600.0	50000	Free	0	Everyone	Art & Design	0	0
6	6	Smoke Effect Photo Maker - Smoke Editor	ART_AND_DESIGN	3.8	178	19000.0	50000	Free	0	Everyone	Art & Design	0	0
7	7	Infinite Painter	ART_AND_DESIGN	4.1	36815	29000.0	1000000	Free	0	Everyone	Art & Design	0	0
8	8	Garden Coloring Book	ART_AND_DESIGN	4.4	13791	33000.0	1000000	Free	0	Everyone	Art & Design	0	0
9	9	Kids Paint Free - Drawing Fun	ART_AND_DESIGN	4.7	121	3100.0	10000	Free	0	Everyone	Art & Design	0	0

In [19]:

```
#Remove the dollar sign from the Price and convert the column to float
for i,row in data.iterrows():
    if row['Price'] == '0':
        data.at[i,'Price'] = 0
    else:
        data.at[i,'Price'] = row['Price'][1:]
data['Price'] = data['Price'].astype(float)
```

In [20]:

```
data['Reviews'] = data['Reviews'].astype(int)
```

In [21]:

```
#Convert Type which is either Free or Paid to 0 or 1 for Linear Regression.
for i,row in data.iterrows():
    if row['Type'] == 'Free':
        data.at[i,'Type'] = 0
    else:
        data.at[i,'Type'] = 1
data['Type'] = data['Type'].astype(int)
```

In [22]:

```
#Verify whether the above snippet of code worked as expected
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8196 entries, 0 to 8195
Data columns (total 13 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   index             8196 non-null   int64  
 1   App               8196 non-null   object 
 2   Category          8196 non-null   object 
 3   Rating            8196 non-null   float64
 4   Reviews           8196 non-null   int64  
 5   Size              8196 non-null   float64
 6   Installs          8196 non-null   int64  
 7   Type              8196 non-null   int64  
 8   Price             8196 non-null   float64
 9   Content Rating    8196 non-null   object 
 10  Genres            8196 non-null   object 
 11  Category_n        8196 non-null   int64  
 12  Content Rating_n  8196 non-null   int64  
dtypes: float64(3), int64(6), object(4)
memory usage: 832.5+ KB
```

In [23]:

```
# Dropping Content Rating column from the dataframe
data = data.drop(['Content Rating'], axis=1)
```

Creating dummy variables for category

In [24]:

```
new_data = pd.get_dummies(data, columns=['Category'], drop_first="True")
```

In [25]:
```
new_data.head()
```

Out[25]:

	index	App	Rating	Reviews	Size	Installs	Type	Price	Genres	Category_n	...	Category_PERSONALIZATION	Category_PHOTOG
0	0	Photo Editor & Candy Camera & Grid & ScrapBook	4.1	159	19000.0	10000	0	0.0	Art & Design	0	...	0	
1	1	Coloring book moana	3.9	967	14000.0	500000	0	0.0	Art & Design	0	...	0	
2	2	U Launcher Lite – FREE Live Cool Themes, Hide ...	4.7	87510	8700.0	5000000	0	0.0	Art & Design	0	...	0	
3	3	Sketch - Draw & Paint	4.5	215644	25000.0	50000000	0	0.0	Art & Design	0	...	0	
4	4	Pixel Draw - Number Art Coloring Book	4.3	967	2800.0	100000	0	0.0	Art & Design	0	...	0	

5 rows × 43 columns

In [26]:
```
data.head(5)
```

Out[26]:

	index	App	Category	Rating	Reviews	Size	Installs	Type	Price	Genres	Category_n	Content Rating_n
0	0	Photo Editor & Candy Camera & Grid & ScrapBook	ART_AND_DESIGN	4.1	159	19000.0	10000	0	0.0	Art & Design	0	0
1	1	Coloring book moana	ART_AND_DESIGN	3.9	967	14000.0	500000	0	0.0	Art & Design	0	0

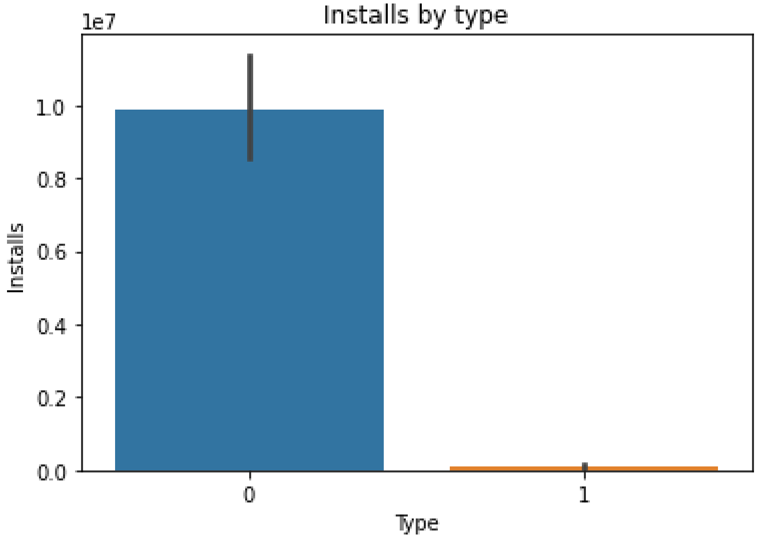
	index	App	Category	Rating	Reviews	Size	Installs	Type	Price	Genres	Category_n	Content Rating_n
2	2	U Launcher Lite – FREE Live Cool Themes, Hide ...	ART_AND_DESIGN	4.7	87510	8700.0	5000000	0	0.0	Art & Design	0	0
3	3	Sketch - Draw & Paint	ART_AND_DESIGN	4.5	215644	25000.0	50000000	0	0.0	Art & Design	0	1
4	4	Pixel Draw - Number Art Coloring Book	ART_AND_DESIGN	4.3	967	2800.0	100000	0	0.0	Art & Design	0	0

In [27]:

```
ax = sns.barplot(x = "Type", y= "Installs", data = data)
ax.set(title = 'Installs by type', xlabel = 'Type', ylabel = 'Installs')
```

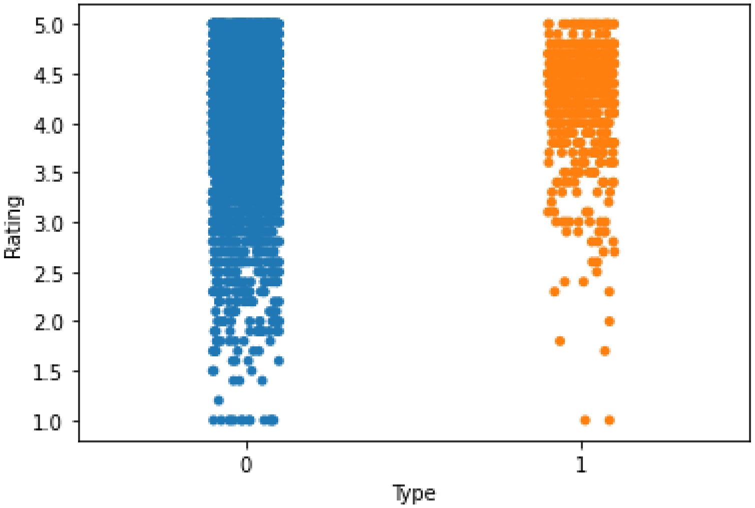
Out[27]:

```
[Text(0.5, 1.0, 'Installs by type'),
 Text(0.5, 0, 'Type'),
 Text(0, 0.5, 'Installs')]
```



In [28]:

```
#Distribution of rating in free and paid apps :

ax = sns.stripplot(x = 'Type', y = 'Rating', data = data)
```



In [29]:
```
# Running linear regression on dummy variables
X = new_data.drop(labels = ['App','Category_n','Rating','Genres'],axis = 1)
y = new_data.Rating
X_train, X_test, y_train, y_test = train_test_split(X, y, train_size=0.75, test_size=0.25, random_state=0)
```

In [30]:
```
scaler = StandardScaler()
scaler.fit(X_train)
x_train_scaled = scaler.transform(X_train)
x_test_scaled = scaler.transform(X_test)
```

In [31]:
```
model = linear_model.LinearRegression().fit(X = x_train_scaled, y = y_train)

score_train = model.score(X = x_train_scaled, y = y_train) # R squared (training)
score_val = model.score(X = x_test_scaled, y = y_test) # R squared (validation)
Results = model.predict(x_test_scaled)
print([score_train, score_val])
```

```
[0.046707756750060336, 0.041394922105016O5]
```

In [32]:
```
print ('Mean Squared Error: '+ str(metrics.mean_squared_error(y_test,Results)))
print ('Mean absolute Error: '+ str(metrics.mean_absolute_error(y_test,Results)))
print ('Mean squared Log Error: '+ str(metrics.mean_squared_log_error(y_test,Results)))
```

```
Mean Squared Error: 0.2556233537838276
Mean absolute Error: 0.36466449289345704
Mean squared Log Error: 0.012473511803013053
```

In [33]:
```
X.head(5)
```

Out[33]:

	index	Reviews	Size	Installs	Type	Price	Content Rating_n	Category_AUTO_AND_VEHICLES	Category_BEAUTY	Category_BOOKS_AND_REFEREN
0	0	159	19000.0	10000	0	0.0	0	0	0	
1	1	967	14000.0	500000	0	0.0	0	0	0	
2	2	87510	8700.0	5000000	0	0.0	0	0	0	
3	3	215644	25000.0	50000000	0	0.0	1	0	0	
4	4	967	2800.0	100000	0	0.0	0	0	0	

5 rows × 39 columns

In [34]:

```
model = linear_model.LinearRegression().fit(X = x_train_scaled[:,[0,1,2]], y = y_train)

score_train = model.score(X = x_train_scaled[:,[0,1,2]], y = y_train) # R squared (training)
score_val = model.score(X = x_test_scaled[:,[0,1,2]], y = y_test) # R squared (validation)
Results = model.predict(x_test_scaled[:,[0,1,2]])
print([score_train, score_val])
```

```
[0.01817821583734991, 0.016597540776479014]
```

In [35]:

```
data.head()
```

Out[35]:

	index	App	Category	Rating	Reviews	Size	Installs	Type	Price	Genres	Category_n	Content Rating_n
0	0	Photo Editor & Candy Camera & Grid & ScrapBook	ART_AND_DESIGN	4.1	159	19000.0	10000	0	0.0	Art & Design	0	0
1	1	Coloring book moana	ART_AND_DESIGN	3.9	967	14000.0	500000	0	0.0	Art & Design	0	0
2	2	U Launcher Lite – FREE Live Cool Themes, Hide ...	ART_AND_DESIGN	4.7	87510	8700.0	5000000	0	0.0	Art & Design	0	0
3	3	Sketch - Draw & Paint	ART_AND_DESIGN	4.5	215644	25000.0	50000000	0	0.0	Art & Design	0	1
4	4	Pixel Draw - Number Art Coloring Book	ART_AND_DESIGN	4.3	967	2800.0	100000	0	0.0	Art & Design	0	0

In [36]:

```
for i,row in data.iterrows():
    data.at[i,'Rating'] = round(row['Rating']*2)/2
```

In [37]:

```
new_data = pd.get_dummies(data, columns=['Category'], drop_first="True")
```

In [38]:

```
# Running linear regression on dummy variables
X = new_data.drop(labels = ['App','Category_n','Rating','Size','Genres','Installs'],axis = 1)
y = new_data.Rating
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)
```

In [39]:

```
scaler = StandardScaler()
scaler.fit(X_train)
x_train_scaled = scaler.transform(X_train)
x_test_scaled = scaler.transform(X_test)
```

In [40]:

```
model = linear_model.LinearRegression()
model.fit(x_train_scaled,y_train)
model.score(X = x_train_scaled, y = y_train)
```

Out[40]:

```
0.04149153996297861
```

In [41]:

```
Results = model.predict(x_test_scaled)
Results
```

Out[41]:

```
array([4.08805477, 4.2126983 , 4.07846449, ..., 4.3344684 , 4.33523789,
       4.32174022])
```

In [42]:

```
corr_coef = np.corrcoef(Results, y_test)[1,0]
R_squared = (corr_coef)**2
print(R_squared)
```

```
0.03941507751250757
```

In [43]:

```
print ('Mean Squared Error: '+ str(metrics.mean_squared_error(y_test,Results)))
print ('Mean absolute Error: '+ str(metrics.mean_absolute_error(y_test,Results)))
print ('Mean squared Log Error: '+ str(metrics.mean_squared_log_error(y_test,Results)))
```

```
Mean Squared Error: 0.2968641720265117
Mean absolute Error: 0.4076689580788986
Mean squared Log Error: 0.014193258688859362
```

In [44]:

```
reviews_data = pd.read_csv('data/googleplaystore_user_reviews.csv')
reviews_data
```

Out[44]:

	App	Translated_Review	Sentiment	Sentiment_Polarity	Sentiment_Subjectivity
0	10 Best Foods for You	I like eat delicious food. That's I'm cooking ...	Positive	1.00	0.533333
1	10 Best Foods for You	This help eating healthy exercise regular basis	Positive	0.25	0.288462
2	10 Best Foods for You	NaN	NaN	NaN	NaN
3	10 Best Foods for You	Works great especially going grocery store	Positive	0.40	0.875000
4	10 Best Foods for You	Best idea us	Positive	1.00	0.300000
...	...	...	...	...	...
64290	Houzz Interior Design Ideas	NaN	NaN	NaN	NaN
64291	Houzz Interior Design Ideas	NaN	NaN	NaN	NaN
64292	Houzz Interior Design Ideas	NaN	NaN	NaN	NaN
64293	Houzz Interior Design Ideas	NaN	NaN	NaN	NaN
64294	Houzz Interior Design Ideas	NaN	NaN	NaN	NaN

64295 rows × 5 columns

In [45]:

```
import seaborn as sns
import matplotlib.pyplot as plt
import nltk
import string
import re
import warnings
nltk.download('stopwords')
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from wordcloud import WordCloud
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer

warnings.filterwarnings('ignore')
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     /Users/sharatnaik/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

In [46]:

```
reviews_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 64295 entries, 0 to 64294
Data columns (total 5 columns):
 #   Column                  Non-Null Count  Dtype  
---  ------                  --------------  -----  
 0   App                     64295 non-null  object 
 1   Translated_Review       37427 non-null  object 
 2   Sentiment               37432 non-null  object 
 3   Sentiment_Polarity      37432 non-null  float64
 4   Sentiment_Subjectivity  37432 non-null  float64
dtypes: float64(2), object(3)
memory usage: 2.5+ MB
```

In [47]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8196 entries, 0 to 8195
Data columns (total 12 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   index             8196 non-null   int64  
 1   App               8196 non-null   object 
 2   Category          8196 non-null   object 
 3   Rating            8196 non-null   float64
 4   Reviews           8196 non-null   int64  
 5   Size              8196 non-null   float64
 6   Installs          8196 non-null   int64  
 7   Type              8196 non-null   int64  
 8   Price             8196 non-null   float64
 9   Genres            8196 non-null   object 
 10  Category_n        8196 non-null   int64  
 11  Content Rating_n  8196 non-null   int64  
dtypes: float64(3), int64(6), object(3)
memory usage: 768.5+ KB
```

In [48]:

```
merged_data = pd.merge(data, reviews_data, how='right')
merged_data
```

Out[48]:

	index	App	Category	Rating	Reviews	Size	Installs	Type	Price	Genres	Category_n	Content Rating_n	Translated_Revie
0	1393.0	10 Best Foods for You	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	Health & Fitness	13.0	2.0	I like eat delicio food. That's I' cooking
1	1393.0	10 Best Foods for You	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	Health & Fitness	13.0	2.0	This help eatii healthy exerci regular ba:

	index	App	Category	Rating	Reviews	Size	Installs	Type	Price	Genres	Category_n	Content Rating_n	Translated_Revie
2	1393.0	10 Best Foods for You	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	Health & Fitness	13.0	2.0	Na
3	1393.0	10 Best Foods for You	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	Health & Fitness	13.0	2.0	Works gre especially goi grocery sto
4	1393.0	10 Best Foods for You	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	Health & Fitness	13.0	2.0	Best idea
...	...	...	...	...	...	...	...	...	...	...	...	...	
64290	1456.0	Houzz Interior Design Ideas	HOUSE_AND_HOME	4.5	353799.0	0.0	10000000.0	0.0	0.0	House & Home	14.0	0.0	Na
64291	1456.0	Houzz Interior Design Ideas	HOUSE_AND_HOME	4.5	353799.0	0.0	10000000.0	0.0	0.0	House & Home	14.0	0.0	Na
64292	1456.0	Houzz Interior Design Ideas	HOUSE_AND_HOME	4.5	353799.0	0.0	10000000.0	0.0	0.0	House & Home	14.0	0.0	Na
64293	1456.0	Houzz Interior Design Ideas	HOUSE_AND_HOME	4.5	353799.0	0.0	10000000.0	0.0	0.0	House & Home	14.0	0.0	Na
64294	1456.0	Houzz Interior Design Ideas	HOUSE_AND_HOME	4.5	353799.0	0.0	10000000.0	0.0	0.0	House & Home	14.0	0.0	Na

64295 rows × 16 columns

Now we will perform sentiment analysis on the merged data

In [49]:

```
merged_data = merged_data.dropna()
merged_data.drop(['App','Sentiment_Polarity','Sentiment_Subjectivity','Genres'],axis=1,inplace=True)
merged_data
```

Out[49]:

	index	Category	Rating	Reviews	Size	Installs	Type	Price	Category_n	Content Rating_n	Translated_Review	Sentiment
0	1393.0	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	13.0	2.0	I like eat delicious food. That's I'm cooking ...	Positive
1	1393.0	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	13.0	2.0	This help eating healthy exercise regular basis	Positive
3	1393.0	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	13.0	2.0	Works great especially going grocery store	Positive
4	1393.0	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	13.0	2.0	Best idea us	Positive
5	1393.0	HEALTH_AND_FITNESS	4.0	2490.0	3800.0	500000.0	0.0	0.0	13.0	2.0	Best way	Positive
...	...	...	...	...	...	...	...	...	...	...	...	...
64222	1638.0	LIFESTYLE	4.0	28301.0	0.0	1000000.0	0.0	0.0	16.0	0.0	Most ads older many agents ..not much owner po...	Positive
64223	1638.0	LIFESTYLE	4.0	28301.0	0.0	1000000.0	0.0	0.0	16.0	0.0	If photos posted portal load, fit purpose. I'm...	Positive
64226	1638.0	LIFESTYLE	4.0	28301.0	0.0	1000000.0	0.0	0.0	16.0	0.0	Dumb app, I wanted post property rent give opt...	Negative
64227	1638.0	LIFESTYLE	4.0	28301.0	0.0	1000000.0	0.0	0.0	16.0	0.0	I property business got link SMS happy perform...	Positive
64230	1638.0	LIFESTYLE	4.0	28301.0	0.0	1000000.0	0.0	0.0	16.0	0.0	Useless app, I searched flats kondapur, Hydera...	Negative

35929 rows × 12 columns

In [50]:

```
sentiment_data = merged_data[['Translated_Review','Sentiment']]
sentiment_data
```

Out[50]:

	Translated_Review	Sentiment
0	I like eat delicious food. That's I'm cooking ...	Positive
1	This help eating healthy exercise regular basis	Positive
3	Works great especially going grocery store	Positive
4	Best idea us	Positive
5	Best way	Positive
...	...	...
64222	Most ads older many agents ..not much owner po...	Positive
64223	If photos posted portal load, fit purpose. I'm...	Positive
64226	Dumb app, I wanted post property rent give opt...	Negative
64227	I property business got link SMS happy perform...	Positive
64230	Useless app, I searched flats kondapur, Hydera...	Negative

35929 rows × 2 columns

Converting the case of reviews to lower

In [51]:

```
sentiment_data['Translated_Review'] = sentiment_data['Translated_Review'].str.lower()
sentiment_data
```

Out[51]:

	Translated_Review	Sentiment
0	i like eat delicious food. that's i'm cooking ...	Positive
1	this help eating healthy exercise regular basis	Positive
3	works great especially going grocery store	Positive
4	best idea us	Positive

	Translated_Review	Sentiment
5	best way	Positive
...	...	...
64222	most ads older many agents ..not much owner po...	Positive
64223	if photos posted portal load, fit purpose. i'm...	Positive
64226	dumb app, i wanted post property rent give opt...	Negative
64227	i property business got link sms happy perform...	Positive
64230	useless app, i searched flats kondapur, hydera...	Negative

35929 rows × 2 columns

Removing punctuation and special characters

In [52]:

```
import re
sentiment_data['Translated_Review'] = [re.sub(r'[^A-Za-z0-9 ]+', '', i) for i in sentiment_data['Translated_Review']]
sentiment_data.head(10)
```

Out[52]:

	Translated_Review	Sentiment
0	i like eat delicious food thats im cooking foo...	Positive
1	this help eating healthy exercise regular basis	Positive
3	works great especially going grocery store	Positive
4	best idea us	Positive
5	best way	Positive
6	amazing	Positive
8	looking forward app	Neutral
9	it helpful site it help foods get	Neutral
10	good you	Positive
11	useful information the amount spelling errors ...	Positive

Remove stop words from the reviews data

In [53]:
```
sentiment_data['Translated_Review'] = sentiment_data['Translated_Review'].apply(lambda x : ' '.join(x for x in x.split()
```

In [54]:
```
sentiment_data
```

Out[54]:

	Translated_Review	Sentiment
0	like eat delicious food thats im cooking food ...	Positive
1	help eating healthy exercise regular basis	Positive
3	works great especially going grocery store	Positive
4	best idea us	Positive
5	best way	Positive
...	...	...
64222	ads older many agents much owner posted detail...	Positive
64223	photos posted portal load fit purpose im sure ...	Positive
64226	dumb app wanted post property rent give option...	Negative
64227	property business got link sms happy performan...	Positive
64230	useless app searched flats kondapur hyderabad ...	Negative

35929 rows × 2 columns

Remove numbers from the data

In [55]:
```
sentiment_data['Translated_Review'] = sentiment_data['Translated_Review'].apply(lambda x : ' '.join(x for x in x.split()
sentiment_data
```

Out[55]:

	Translated_Review	Sentiment
0	like eat delicious food thats im cooking food ...	Positive
1	help eating healthy exercise regular basis	Positive
3	works great especially going grocery store	Positive
4	best idea us	Positive

	Translated_Review	Sentiment
5	best way	Positive
...	...	...
64222	ads older many agents much owner posted detail...	Positive
64223	photos posted portal load fit purpose im sure ...	Positive
64226	dumb app wanted post property rent give option...	Negative
64227	property business got link sms happy performan...	Positive
64230	useless app searched flats kondapur hyderabad ...	Negative

35929 rows × 2 columns

Stemming every word in review text

In [56]:

```
st = PorterStemmer()
sentiment_data['Translated_Review'] = sentiment_data['Translated_Review'].apply(lambda x: " ".join(st.stem(word) for worc
sentiment_data.head()
```

Out[56]:

	Translated_Review	Sentiment
0	like eat delici food that im cook food case be...	Positive
1	help eat healthi exercis regular basi	Positive
3	work great especi go groceri store	Positive
4	best idea us	Positive
5	best way	Positive

In [57]:

```
vectorizer = TfidfVectorizer(max_features=2500, min_df=7, max_df=0.8)
processed_features = vectorizer.fit_transform(sentiment_data['Translated_Review']).toarray()
```

Splitting the data into training and test data

In [58]:

```
x_train,x_test,y_train,y_test = train_test_split(processed_features,sentiment_data['Sentiment'],test_size = 0.25)
```

Running logistic regression model to predict the sentiment of the reviews

In [59]:
```
lr = linear_model.LogisticRegression()
model = lr.fit(x_train,y_train)
```

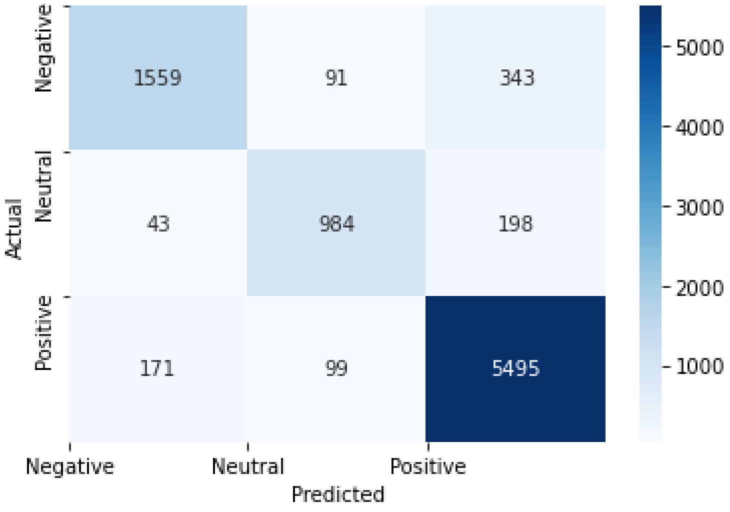
In [60]:
```
Results = model.predict(x_test)
```

In [61]:
```
model.score(x_train,y_train)
```

Out[61]:
```
0.9308246121873376
```

In [62]:
```
from sklearn.metrics import classification_report,confusion_matrix
sns.heatmap(confusion_matrix(y_test,Results),annot=True,fmt = '.5g', cmap = plt.cm.Blues)
plt.xlabel('Predicted')
plt.ylabel('Actual')
plt.xticks(ticks = [0,1,2],labels = ['Negative','Neutral','Positive'])
plt.yticks(ticks = [0,1,2],labels = ['Negative','Neutral','Positive'])
```

Out[62]:
```
([<matplotlib.axis.YTick at 0x7feb4eb08ee0>,
  <matplotlib.axis.YTick at 0x7feb4eb08ac0>,
  <matplotlib.axis.YTick at 0x7feb4d7abd00>],
 [Text(0, 0, 'Negative'), Text(0, 1, 'Neutral'), Text(0, 2, 'Positive')])
```



In [63]:
```
sentiment_data['tokens'] = sentiment_data['Translated_Review'].apply(lambda x: x.split())
sentiment_data
```

Out[63]:

	Translated_Review	Sentiment	tokens

	Translated_Review	Sentiment	tokens
0	like eat delici food that im cook food case be...	Positive	[like, eat, delici, food, that, im, cook, food...
1	help eat healthi exercis regular basi	Positive	[help, eat, healthi, exercis, regular, basi]
3	work great especi go groceri store	Positive	[work, great, especi, go, groceri, store]
4	best idea us	Positive	[best, idea, us]
5	best way	Positive	[best, way]
...	...	...	...
64222	ad older mani agent much owner post detail rep...	Positive	[ad, older, mani, agent, much, owner, post, de...
64223	photo post portal load fit purpos im sure stor...	Positive	[photo, post, portal, load, fit, purpos, im, s...
64226	dumb app want post properti rent give option w...	Negative	[dumb, app, want, post, properti, rent, give, ...
64227	properti busi got link sm happi perform still ...	Positive	[properti, busi, got, link, sm, happi, perform...
64230	useless app search flat kondapur hyderabad non...	Negative	[useless, app, search, flat, kondapur, hyderab...

35929 rows × 3 columns

In [64]:

```
for i,row in sentiment_data.iterrows():
    if(row['Sentiment'] == 'Positive'):
        sentiment_data.at[i, 'Sentiment'] = 1
    else:
        sentiment_data.at[i, 'Sentiment'] = 0
sentiment_data
```

Out[64]:

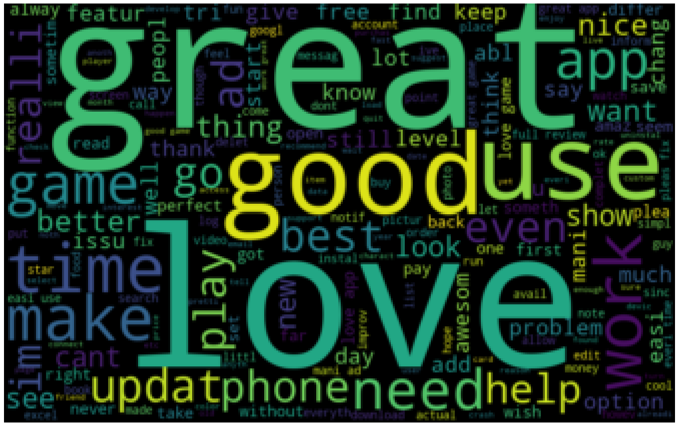
	Translated_Review	Sentiment	tokens
0	like eat delici food that im cook food case be...	1	[like, eat, delici, food, that, im, cook, food...
1	help eat healthi exercis regular basi	1	[help, eat, healthi, exercis, regular, basi]
3	work great especi go groceri store	1	[work, great, especi, go, groceri, store]
4	best idea us	1	[best, idea, us]
5	best way	1	[best, way]
...	...	...	...
64222	ad older mani agent much owner post detail rep...	1	[ad, older, mani, agent, much, owner, post, de...

	Translated_Review	Sentiment	tokens
64223	photo post portal load fit purpos im sure stor...	1	[photo, post, portal, load, fit, purpos, im, s...
64226	dumb app want post properti rent give option w...	0	[dumb, app, want, post, properti, rent, give, ...
64227	properti busi got link sm happi perform still ...	1	[properti, busi, got, link, sm, happi, perform...
64230	useless app search flat kondapur hyderabad non...	0	[useless, app, search, flat, kondapur, hyderab...

35929 rows × 3 columns

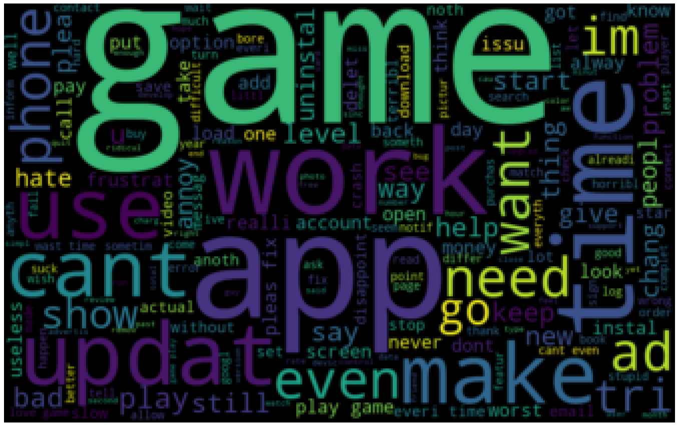
Building a wordcloud to show of positive words in the reviews

```
In [65]:
from wordcloud import WordCloud
list_words_positive = []
for index, row in sentiment_data.iterrows():
    if row['Sentiment'] == 1:
        list_words_positive.extend(row['tokens'])
all_words = ' '.join(list_words_positive)
wordcloud = WordCloud(width = 800, height = 500).generate(all_words)
plt.imshow(wordcloud, interpolation="bilinear")
plt.axis('off')
plt.show()
```



Building a wordcloud to show of negative words in the reviews

```
In [66]:
list_words_negative = []
for index, row in sentiment_data.iterrows():
    if row['Sentiment'] == 0:
        list_words_negative.extend(row['tokens'])
all_words = ' '.join(list_words_negative)
wordcloud = WordCloud(width = 800, height = 500).generate(all_words)
plt.imshow(wordcloud, interpolation="bilinear")
plt.axis('off')
plt.show()
```


game
work
app
time
make
use
cant
updat
need
even
want
phone
im
tri
ad
go
show
level
uninstal
problem
hate
play
bad
still
help
start
issu
give
way
peopl
thing
say
download
account
frustrat
annoy
useless
screen
instal
new
look
keep
chang
pleas fix
disappoint
delet
think
day
back
load
one
put
option
add
pay
plea
take
call
crash
see
realli
open
money
stop
never
dont
actual
without
anoth
play game
worst
everi time
lot
alway
got
know
noth
set
video
message
error
horribl
alreadi
star
log
order
wrong
stupid
point
page
contact
much
bore
turn
save
difficult
pictur
search
buy
year
fail
suck
wish
well
inform
better
tell
allow
love game
read
ask
good
thank
book
cant even
email
featur
purchas
everyth
sign
least
player