Cookie Cats is a hugely popular mobile puzzle game developed by Tactile Entertainment. It's a classic "connect three" style puzzle game where the player must connect tiles of the same color in order to clear the board and win the level. It also features singing cats. We're not kidding!

As players progress through the game they will encounter gates that force them to wait some time before they can progress or make an in-app purchase. In this project, we will analyze the result of an A/B test where the first gate in Cookie Cats was moved from level 30 to level 40. In particular, we will analyze the impact on player retention and game rounds.

To complete this project, you should be comfortable working with pandas DataFrames and with using the pandas plot method. You should also have some understanding of hypothesis testing and bootstrap analysis.

The data is from 90,189 players that installed the game while the AB-test was running. The variables are:

userid - a unique number that identifies each player.

version - whether the player was put in the control group (gate_30 - a gate at level 30) or the test group (gate_40 - a gate at level 40).

sum_gamerounds - the number of game rounds played by the player during the first week after installation

retention_1 - did the player come back and play 1 day after installing?

retention_7 - did the player come back and play 7 days after installing?

When a player installed the game, he or she was randomly assigned to either gate_30 or gate_40.

AB Testing Process¶

- Understanding business problem & data
- Detect and resolve problems in the data (Missing Value, Outliers, Unexpected Value)
- Look summary stats and plots
- Apply hypothesis testing and check assumptions
- Check Normality & Homogeneity
- Apply tests (Shapiro, Levene Test, T-Test, Welch Test, Mann Whitney U Test)
- Evaluate the results
- Make inferences
- Recommend business decision to your customer/director/ceo etc.

```
#import req libraries
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import os

from scipy.stats import shapiro
import·scipy.stats·as·stats

import warnings
warnings.filterwarnings("ignore")
warnings.simplefilter(action='ignore', category=FutureWarning)

pd.set_option('display.max_columns', None)
pd.options.display.float_format = '{:.4f}'.format



path = "/content/cookie_cats.csv"

def load(path, info = True):

    import pandas as pd
    import io

    if len(path.split(".csv")) > 1:
        read = pd.read_csv(path)
    elif len(path.split(".xlsx")) > 1:
        read = pd.read_excel(path)
    if info:
        if len(read) > 0:
            print("# Data imported!")
            print("# -----------------------------------", "\n")
```

```
            print("# DIMENSIONS -------------------------")
            print("Observation:", read.shape[0], "Column:", read.shape[1], "\n")

            print("# DTYPES ----------------------------")
            if len(read.select_dtypes("object").columns) > 0:
                print("Object Variables:", "\n", "# of Variables:",
                      len(read.select_dtypes("object").columns), "\n",
                      read.select_dtypes("object").columns.tolist(), "\n")

            if len(read.select_dtypes("integer").columns) > 0:
                print("Integer Variables:", "\n", "# of Variables:",
                      len(read.select_dtypes("integer").columns), "\n",
                      read.select_dtypes("integer").columns.tolist(), "\n")

            if len(read.select_dtypes("float").columns) > 0:
                print("Float Variables:", "\n", "# of Variables:",
                      len(read.select_dtypes("float").columns), "\n",
                      read.select_dtypes("float").columns.tolist(), "\n")

            if len(read.select_dtypes("bool").columns) > 0:
                print("Bool Variables:", "\n", "# of Variables:",
                      len(read.select_dtypes("bool").columns), "\n",
                      read.select_dtypes("bool").columns.tolist(), "\n")

            print("# MISSING VALUE ----------------------")
            print("Are there any missing values? \n ", np.where(read.isnull().values.any() == False,
                                                                "No missing value!", "Data includes missing value!"), "\n")

            buf = io.StringIO()
            read.info(buf=buf)
            info = buf.getvalue().split('\n')[-2].split(":")[1].strip()
            print("# MEMORY USAGE ---------------------- \n", info)

        else:
            print("# Data did not import!")

    return read

ab = load(path, info = True)
ab.head()
```

```
 # Data imported!
 # -----------------------------------

 # DIMENSIONS -------------------------
 Observation: 90189 Column: 5

 # DTYPES -----------------------------
 Object Variables:
  # of Variables: 1
  ['version']

 Integer Variables:
  # of Variables: 2
  ['userid', 'sum_gamerounds']

 Bool Variables:
  # of Variables: 2
  ['retention_1', 'retention_7']

 # MISSING VALUE ----------------------
 Are there any missing values?
   No missing value!

 # MEMORY USAGE ----------------------
  2.2+ MB
```

	userid	version	sum_gamerounds	retention_1	retention_7
0	116	gate_30	3	False	False
1	337	gate_30	38	True	False
2	377	gate_40	165	True	False
3	483	gate_40	1	False	False
4	488	gate_40	179	True	True

```
#Number of Unique Users
print(ab.userid.nunique() == ab.shape[0])

#summary stats: sum_gamer_rounds
ab.describe([0.01, 0.05, 0.10, 0.20, 0.80, 0.90, 0.95, 0.99])[["sum_gamerounds"]].T
```

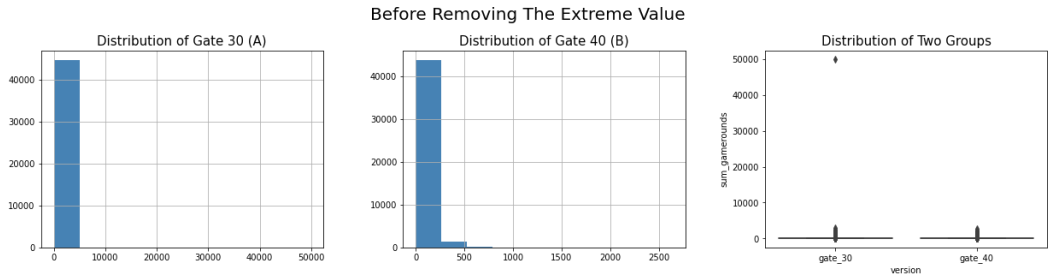
```
True
```

	count	mean	std	min	1%	5%	10%	20%	50%	80%	
sum_gamerounds	90189.0000	51.8725	195.0509	0.0000	0.0000	1.0000	1.0000	3.0000	16.0000	67.0000	1

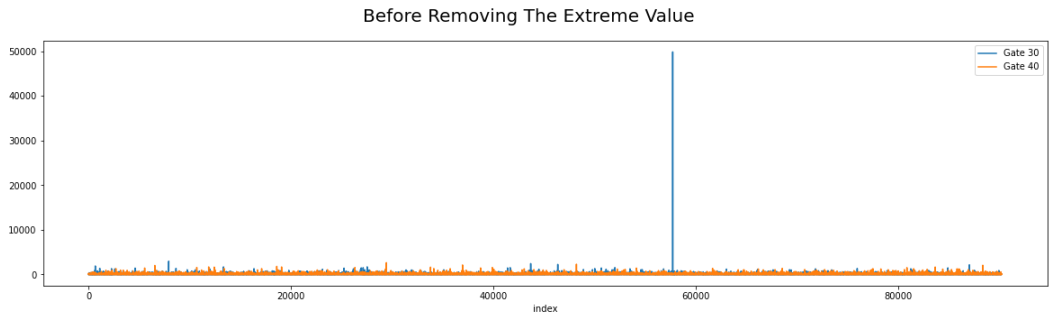
```
# A/B Groups & Target Summary Stats
ab.groupby("version").sum_gamerounds.agg(["count", "median", "mean", "std", "max"])
```

version	count	median	mean	std	max
gate_30	44700	17.0000	52.4563	256.7164	49854
gate_40	45489	16.0000	51.2988	103.2944	2640

```
fig, axes = plt.subplots(1, 3, figsize = (18,5))
ab[(ab.version == "gate_30")].hist("sum_gamerounds", ax = axes[0], color = "steelblue")
ab[(ab.version == "gate_40")].hist("sum_gamerounds", ax = axes[1], color = "steelblue")
sns.boxplot(x = ab.version, y = ab.sum_gamerounds, ax = axes[2])

plt.suptitle("Before Removing The Extreme Value", fontsize = 20)
axes[0].set_title("Distribution of Gate 30 (A)", fontsize = 15)
axes[1].set_title("Distribution of Gate 40 (B)", fontsize = 15)
axes[2].set_title("Distribution of Two Groups", fontsize = 15)

plt.tight_layout(pad = 4);
```



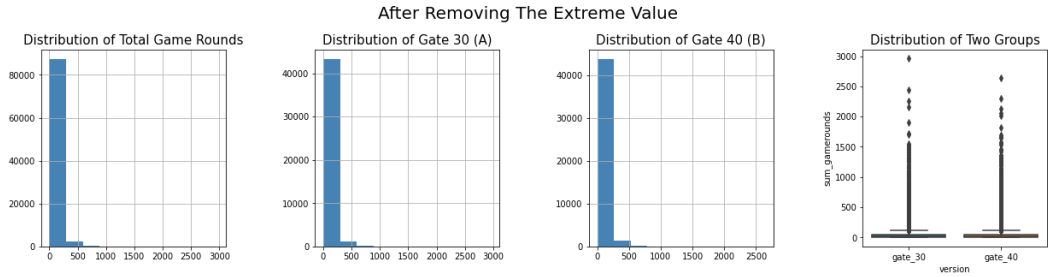

```
ab[ab.version == "gate_30"].reset_index().set_index("index").sum_gamerounds.plot(legend = True, label = "Gate 30", figsize = (20,5))
ab[ab.version == "gate_40"].reset_index().set_index("index").sum_gamerounds.plot(legend = True, label = "Gate 40")
plt.suptitle("Before Removing The Extreme Value", fontsize = 20);
```



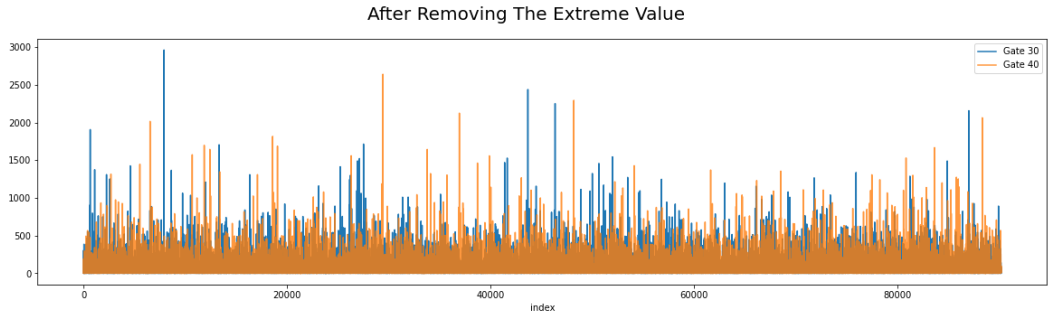
```
#outliers
ab = ab[ab.sum_gamerounds < ab.sum_gamerounds.max()]

# Summary Stats: sum_gamerounds
ab.describe([0.01, 0.05, 0.10, 0.20, 0.80, 0.90, 0.95, 0.99])[["sum_gamerounds"]].T
```

	count	mean	std	min	1%	5%	10%	20%	50%	80%	
sum_gamerounds	90188.0000	51.3203	102.6827	0.0000	0.0000	1.0000	1.0000	3.0000	16.0000	67.0000	1

```
fig, axes = plt.subplots(1, 4, figsize = (18,5))
ab.sum_gamerounds.hist(ax = axes[0], color = "steelblue")
ab[(ab.version == "gate_30")].hist("sum_gamerounds", ax = axes[1], color = "steelblue")
ab[(ab.version == "gate_40")].hist("sum_gamerounds", ax = axes[2], color = "steelblue")
sns.boxplot(x = ab.version, y = ab.sum_gamerounds, ax = axes[3])

plt.suptitle("After Removing The Extreme Value", fontsize = 20)
axes[0].set_title("Distribution of Total Game Rounds", fontsize = 15)
axes[1].set_title("Distribution of Gate 30 (A)", fontsize = 15)
axes[2].set_title("Distribution of Gate 40 (B)", fontsize = 15)
axes[3].set_title("Distribution of Two Groups", fontsize = 15)

plt.tight_layout(pad = 4);
```




```
ab[(ab.version == "gate_30")].reset_index().set_index("index").sum_gamerounds.plot(legend = True, label = "Gate 30", figsize = (20,5))
ab[ab.version == "gate_40"].reset_index().set_index("index").sum_gamerounds.plot(legend = True, label = "Gate 40", alpha = 0.8)
plt.suptitle("After Removing The Extreme Value", fontsize = 20);
```



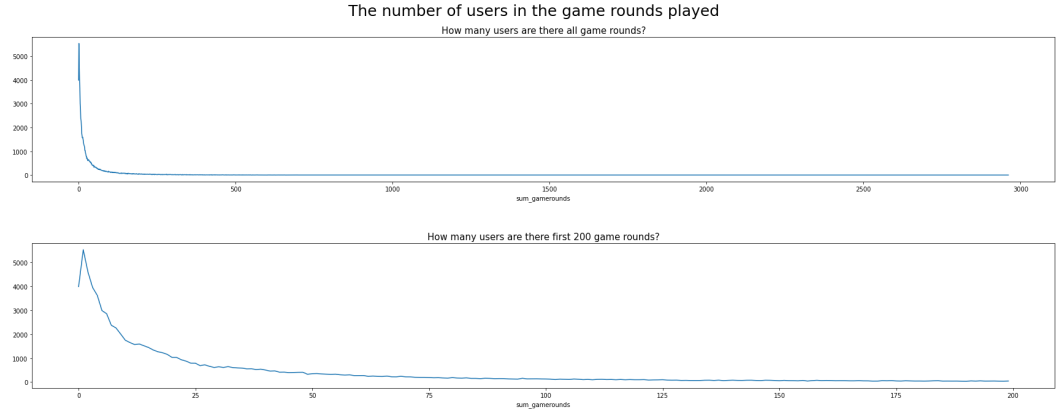
The users installed the game but 3994 users never played the game! Some reasons might explain this situation.

- They have no free time to play game
- Users might prefer to play other games or they play other games already
- Some users don't like the app etc.
- You can comment below for this users also
- The number of users decreases as the levels progress

Most of users played the game at early stage and they didn't progress.

- Tactile Entertainment should learn why users churn playing the game.
- Doing research and collecting data about the game and users would help to understand user churn
- The difficulty of the game can be measured
- Gifts might help player retention

```
fig, axes = plt.subplots(2, 1, figsize = (25,10))
ab.groupby("sum_gamerounds").userid.count().plot(ax = axes[0])
ab.groupby("sum_gamerounds").userid.count()[:200].plot(ax = axes[1])
plt.suptitle("The number of users in the game rounds played", fontsize = 25)
axes[0].set_title("How many users are there all game rounds?", fontsize = 15)
axes[1].set_title("How many users are there first 200 game rounds?", fontsize = 15)
plt.tight_layout(pad=5);
```




```
ab.groupby("sum_gamerounds").userid.count().reset_index().head(20)
```

	sum_gamerounds	userid
0	0	3994
1	1	5538
2	2	4606
3	3	3958

```
# How many users reached gate 30 & gate 40 levels?
ab.groupby("sum_gamerounds").userid.count().loc[[30,40]]
```

```
sum_gamerounds
30    642
40    505
Name: userid, dtype: int64
```

8	8	2267

```
# A/B Groups & Target Summary Stats
ab.groupby("version").sum_gamerounds.agg(["count", "median", "mean", "std", "max"])
```

	count	median	mean	std	max
version					
gate_30	44699	17.0000	51.3421	102.0576	2961
gate_40	45489	16.0000	51.2988	103.2944	2640
15	15	1446			

Retention variables gives us player retention details.

- retention_1 - did the player come back and play 1 day after installing?
- retention_7 - did the player come back and play 7 days after installing?

Also players tend not to play the game! There are many players who quit the game.

- 55 percent of the players didn't play the game 1 day after insalling
- 81 percent of the players didn't play the game 7 day after insalling

```
# Retention Problem
pd.DataFrame({"RET1_COUNT": ab["retention_1"].value_counts(),
              "RET7_COUNT": ab["retention_7"].value_counts(),
              "RET1_RATIO": ab["retention_1"].value_counts() / len(ab),
              "RET7_RATIO": ab["retention_7"].value_counts() / len(ab)})
```

	RET1_COUNT	RET7_COUNT	RET1_RATIO	RET7_RATIO
False	50035	73408	0.5548	0.8139
True	40153	16780	0.4452	0.1861

```
ab.groupby(["version", "retention_1"]).sum_gamerounds.agg(["count", "median", "mean", "std", "max"])
```

		count	median	mean	std	max
version	**retention_1**					
gate_30	**False**	24665	6.0000	16.3591	36.5284	1072
	True	20034	48.0000	94.4117	135.0377	2961
gate_40	**False**	25370	6.0000	16.3404	35.9258	1241
	True	20119	49.0000	95.3812	137.8873	2640

```
ab.groupby(["version", "retention_7"]).sum_gamerounds.agg(["count", "median", "mean", "std", "max"])
```

```
ab["Retention"] = np.where((ab.retention_1 == True) & (ab.retention_7 == True), 1,0)
ab.groupby(["version", "Retention"])["sum_gamerounds"].agg(["count", "median", "mean", "std", "max"])
```

version	Retention	count	median	mean	std	max
gate_30	**0**	38023	12.0000	28.0703	48.0175	1072
	1	6676	127.0000	183.8863	189.6264	2961
gate_40	**0**	38983	12.0000	28.1034	48.9278	2640
	1	6506	133.0000	190.2824	194.2201	2294

A/B Testing

Assumptions:

1. Check normality
2. If Normal Distribution, check homogeneity

Steps:

- Split & Define Control Group & Test Group
- Apply Shapiro Test for normality
- If parametric apply Levene Test for homogeneity of variances
- If Parametric + homogeneity of variances apply T-Test
- If Parametric - homogeneity of variances apply Welch Test
- If Non-parametric apply Mann Whitney U Test directly

```
# Define A/B groups
ab["version"] = np.where(ab.version == "gate_30", "A", "B")
ab.head()
```

	userid	version	sum_gamerounds	retention_1	retention_7	Retention
0	116	A	3	False	False	0
1	337	A	38	True	False	0
2	377	B	165	True	False	0
3	483	B	1	False	False	0
4	488	B	179	True	True	1

```
# A/B Testing Function - Quick Solution
def AB_Test(dataframe, group, target):

    # Packages
    from scipy.stats import shapiro
    import scipy.stats as stats

    # Split A/B
    groupA = dataframe[dataframe[group] == "A"][target]
    groupB = dataframe[dataframe[group] == "B"][target]

    # Assumption: Normality
    ntA = shapiro(groupA)[1] < 0.05
    ntB = shapiro(groupB)[1] < 0.05
    # H0: Distribution is Normal! - False
    # H1: Distribution is not Normal! - True

    if (ntA == False) & (ntB == False): # "H0: Normal Distribution"
        # Parametric Test
        # Assumption: Homogeneity of variances
        leveneTest = stats.levene(groupA, groupB)[1] < 0.05
        # H0: Homogeneity: False
        # H1: Heterogeneous: True

        if leveneTest == False:
            # Homogeneity
```

```
            ttest = stats.ttest_ind(groupA, groupB, equal_var=True)[1]
            # H0: M1 == M2 - False
            # H1: M1 != M2 - True
        else:
            # Heterogeneous
            ttest = stats.ttest_ind(groupA, groupB, equal_var=False)[1]
            # H0: M1 == M2 - False
            # H1: M1 != M2 - True
    else:
        # Non-Parametric Test
        ttest = stats.mannwhitneyu(groupA, groupB)[1]
        # H0: M1 == M2 - False
        # H1: M1 != M2 - True

    # Result
    temp = pd.DataFrame({
        "AB Hypothesis":[ttest < 0.05],
        "p-value":[ttest]
    })
    temp["Test Type"] = np.where((ntA == False) & (ntB == False), "Parametric", "Non-Parametric")
    temp["AB Hypothesis"] = np.where(temp["AB Hypothesis"] == False, "Fail to Reject H0", "Reject H0")
    temp["Comment"] = np.where(temp["AB Hypothesis"] == "Fail to Reject H0", "A/B groups are similar!", "A/B groups are not similar!")

    # Columns
    if (ntA == False) & (ntB == False):
        temp["Homogeneity"] = np.where(leveneTest == False, "Yes", "No")
        temp = temp[["Test Type", "Homogeneity","AB Hypothesis", "p-value", "Comment"]]
    else:
        temp = temp[["Test Type","AB Hypothesis", "p-value", "Comment"]]

    # Print Hypothesis
    print("# A/B Testing Hypothesis")
    print("H0: A == B")
    print("H1: A != B", "\n")

    return temp


 # A/B Testing Hypothesis
 H0: A == B
 H1: A != B
```

	Test Type	AB Hypothesis	p-value	Comment
0	Non-Parametric	Fail to Reject H0	0.0509	A/B groups are similar!