Marketing Campaign Performance Analysis

Objective: This notebook analyzes a marketing dataset to evaluate campaign effectiveness, uncover actionable insights, and quantify the impact of specific events like technical bugs and A/B tests.

1. Setup and Data Loading

First, we import the necessary libraries for data manipulation, analysis, and visualization. We then load the dataset, ensuring that date columns are correctly parsed upon import.

```
# Import necessary libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from scipy import stats

# Set plotting style for better visualization,
plt.style.use(’seaborn-v0_8-whitegrid’)

# Load the dataset with correct date parsing,
marketing = pd.read_csv(’marketing.csv’,parse_dates=[’date_served’, ’date_subscribed’, ’date_canceled’])
# Display the first few rows to inspect the data,
print(”Dataset Head:”)
display(marketing.head())
```

```
Dataset Head:
/tmp/ipython-input-4267800050.py:11: UserWarning: Could not infer format, so each element will be parsed individually, falling back to `dateutil`. To
  marketing = pd.read_csv(’marketing.csv’,parse_dates=[’date_served’, ’date_subscribed’, ’date_canceled’])
/tmp/ipython-input-4267800050.py:11: UserWarning: Could not infer format, so each element will be parsed individually, falling back to `dateutil`. To
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```

	user_id	date_served	marketing_channel	variant	converted	language_displayed	language_preferred	age_group	date_subs
0	a100000029	2018-01-01	House Ads	personalization	True	English	English	0-18 years	20
1	a100000030	2018-01-01	House Ads	personalization	True	English	English	19-24 years	20
2	a100000031	2018-01-01	House Ads	personalization	True	English	English	24-30 years	20
3	a100000032	2018-01-01	House Ads	personalization	True	English	English	30-36	20

2. Data Cleaning and Feature Engineering

We perform initial data checks and create new features that will be useful for our analysis, such as extracting the day of the week from timestamps.

```
# Check data types to ensure they are correct
print(”Data Information:”)
marketing.info()

# Feature Engineering: Add a ’day of week’ column for ads served
# This helps in analyzing weekly trends. Monday=0, Sunday=6.
marketing[’DoW_served’] = marketing[’date_served’].dt.dayofweek
```

```
Data Information:
<class ’pandas.core.frame.DataFrame’>
RangeIndex: 10037 entries, 0 to 10036
Data columns (total 12 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   user_id             10037 non-null  object
 1   date_served         10021 non-null  datetime64[ns]
 2   marketing_channel   10022 non-null  object
 3   variant             10037 non-null  object
 4   converted           10022 non-null  object
 5   language_displayed  10037 non-null  object
 6   language_preferred  10037 non-null  object
 7   age_group           10037 non-null  object
 8   date_subscribed      1856 non-null   datetime64[ns]
 9   date_canceled        577 non-null    datetime64[ns]
 10  subscribing_channel  1856 non-null   object
 11  is_retained          1856 non-null   object
dtypes: datetime64[ns](3), object(9)
memory usage: 941.1+ KB
```

3. Exploratory Data Analysis (EDA)

In this section, we explore the data to understand overall campaign performance and identify trends across different segments.

3.1 Overall Campaign Performance Metrics

```
# --- Calculate Overall Conversion Rate ---
total_users = marketing['user_id'].nunique()
subscribers = marketing[marketing['converted'] == True]['user_id'].nunique()
conversion_rate = subscribers / total_users
print(f"Overall Conversion Rate: {conversion_rate:.2%}")

# --- Calculate Overall Retention Rate ---
# Retention rate is the percentage of subscribers who remain subscribed
total_subscribers = marketing[marketing['converted'] == True]['user_id'].nunique()
retained_users = marketing[marketing['is_retained'] == True]['user_id'].nunique()
retention_rate = retained_users / total_subscribers
print(f"Overall Retention Rate: {retention_rate:.2%}")
```

```
Overall Conversion Rate: 13.89%
Overall Retention Rate: 66.80%
```

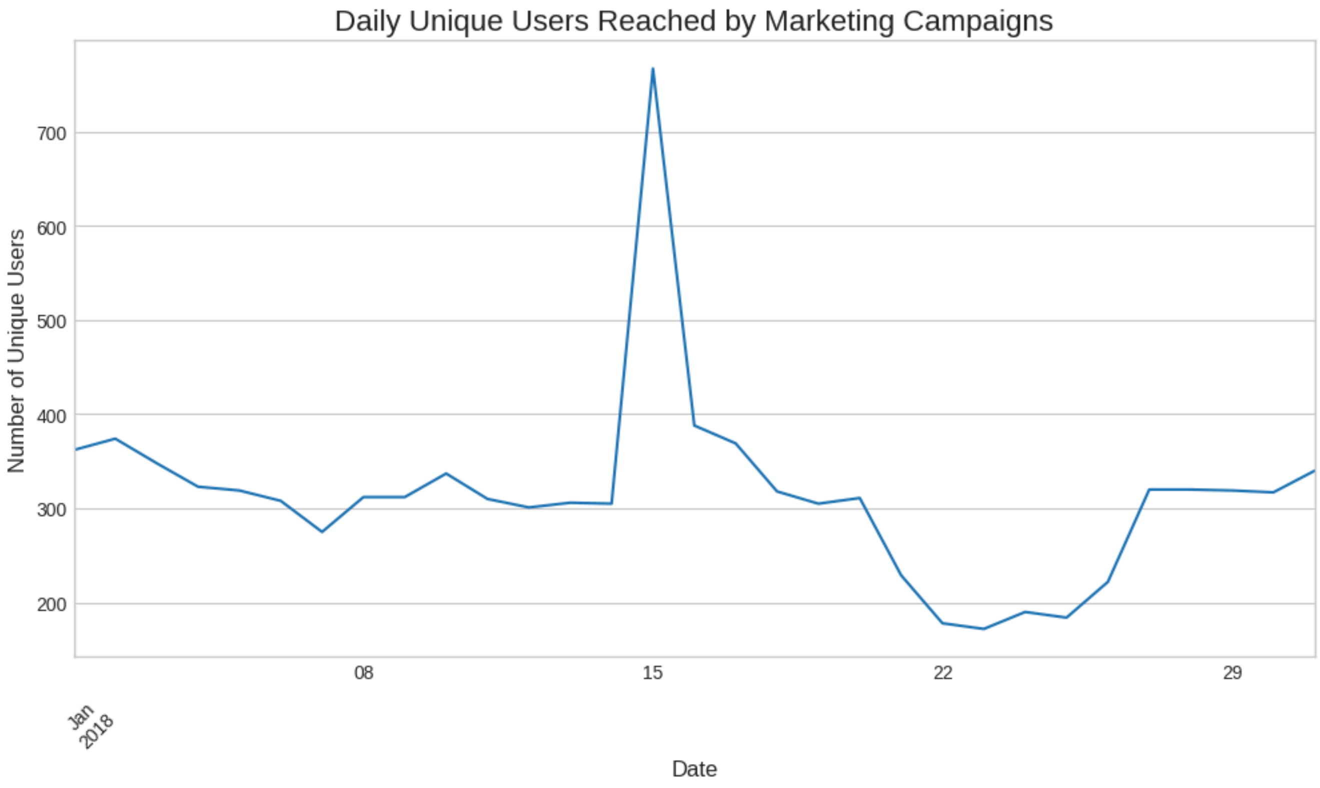
3.2 Daily User Engagement

```
# Group by date served to count unique users per day
daily_users = marketing.groupby(['date_served'])['user_id'].nunique()
print("Daily User Engagement:")
display(daily_users.head())

# Plotting daily users
daily_users.plot(figsize=(12, 6))
plt.title('Daily Unique Users Reached by Marketing Campaigns', fontsize=16)
plt.ylabel('Number of Unique Users', fontsize=12)
plt.xlabel('Date', fontsize=12)
plt.xticks(rotation=45)
plt.show()
```

```
Daily User Engagement:
```

	user_id
date_served	
2018-01-01	362
2018-01-02	374
2018-01-03	348
2018-01-04	323
2018-01-05	319

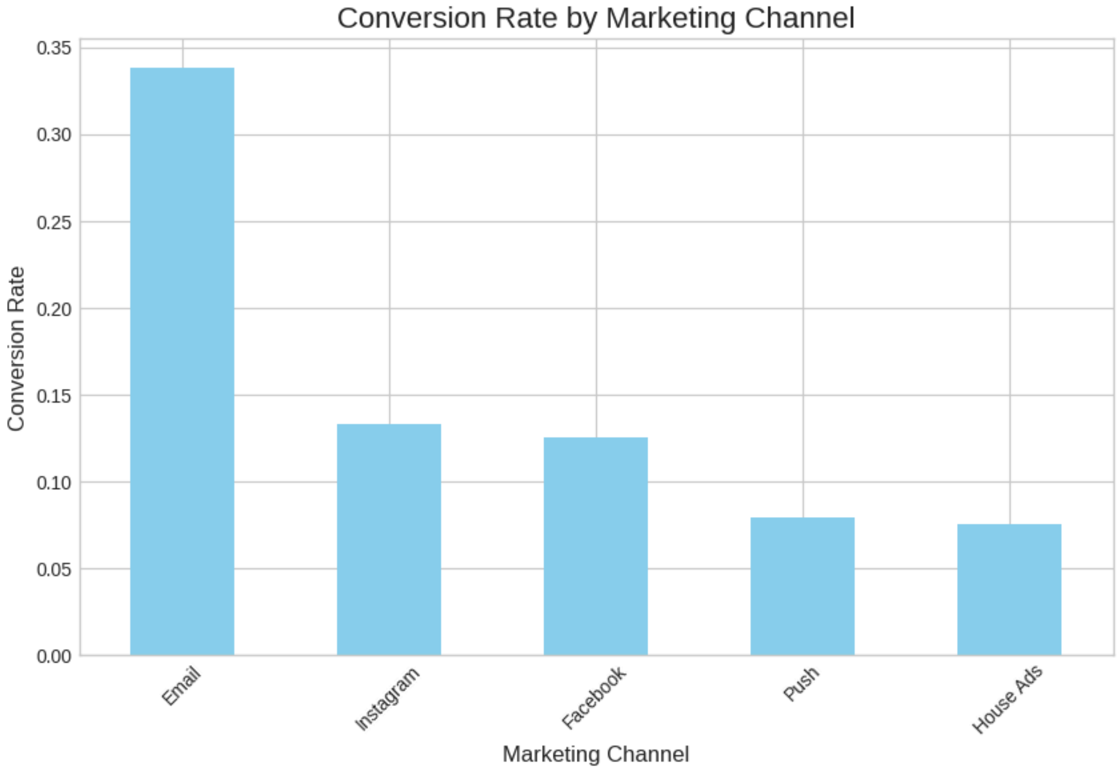
dtype: int64



3.3 Conversion Rate by Marketing Channel

```
# Calculate total users and converted users per channel
total_by_channel = marketing.groupby('marketing_channel')['user_id'].nunique()
converted_by_channel = marketing[marketing['converted'] == True].groupby('marketing_channel')['user_id'].nunique()
# Calculate conversion rate per channel
channel_conversion_rate = (converted_by_channel / total_by_channel).sort_values(ascending=False)

print("Conversion Rate by Marketing Channel:")
print(channel_conversion_rate.apply(lambda x: f"{x:.2%}"))

# Plotting conversion rate by channel
channel_conversion_rate.plot(kind='bar', figsize=(10, 6), color='skyblue')
plt.title('Conversion Rate by Marketing Channel', fontsize=16)
plt.ylabel('Conversion Rate', fontsize=12)
plt.xlabel('Marketing Channel', fontsize=12)
plt.xticks(rotation=45)
plt.show()
```

```
Conversion Rate by Marketing Channel:
marketing_channel
Email        33.82%
Instagram    13.33%
Facebook     12.57%
Push          7.92%
House Ads     7.51%
Name: user_id, dtype: object
```



4. Helper Functions for Deeper Analysis

To avoid repetitive code, we define functions for common analysis tasks like calculating conversion rates across different segments and evaluating A/B test lift.

```
def calculate_conversion_rate(df, group_by_cols):
    '''
    Calculates the conversion rate for a given DataFrame, grouped by specified columns.

    Args:
    df (pd.DataFrame): The input DataFrame.
    group_by_cols (list): A list of column names to group by.

    Returns:
    pd.Series: A Series with the conversion rate for each group.
    '''

    # Total users in each segment
    total_users = df.groupby(group_by_cols)['user_id'].nunique()

    # Converted users in each segment
    converted_users = df[df['converted'] == True].groupby(group_by_cols)['user_id'].nunique()

    # Conversion rate
    conversion_rate = converted_users / total_users

    return conversion_rate.fillna(0)

def calculate_lift(a, b):
    '''
    Calculates the percentage lift of B over A.

    Args:
    a (pd.Series): The baseline (control) conversion data.
    b (pd.Series): The variant (treatment) conversion data.

    Returns:
    str: A string representing the percentage lift.
    '''

    a_mean = np.mean(a)
    b_mean = np.mean(b)
    lift = (b_mean - a_mean) / a_mean
    return f"{lift:.2%}"
```

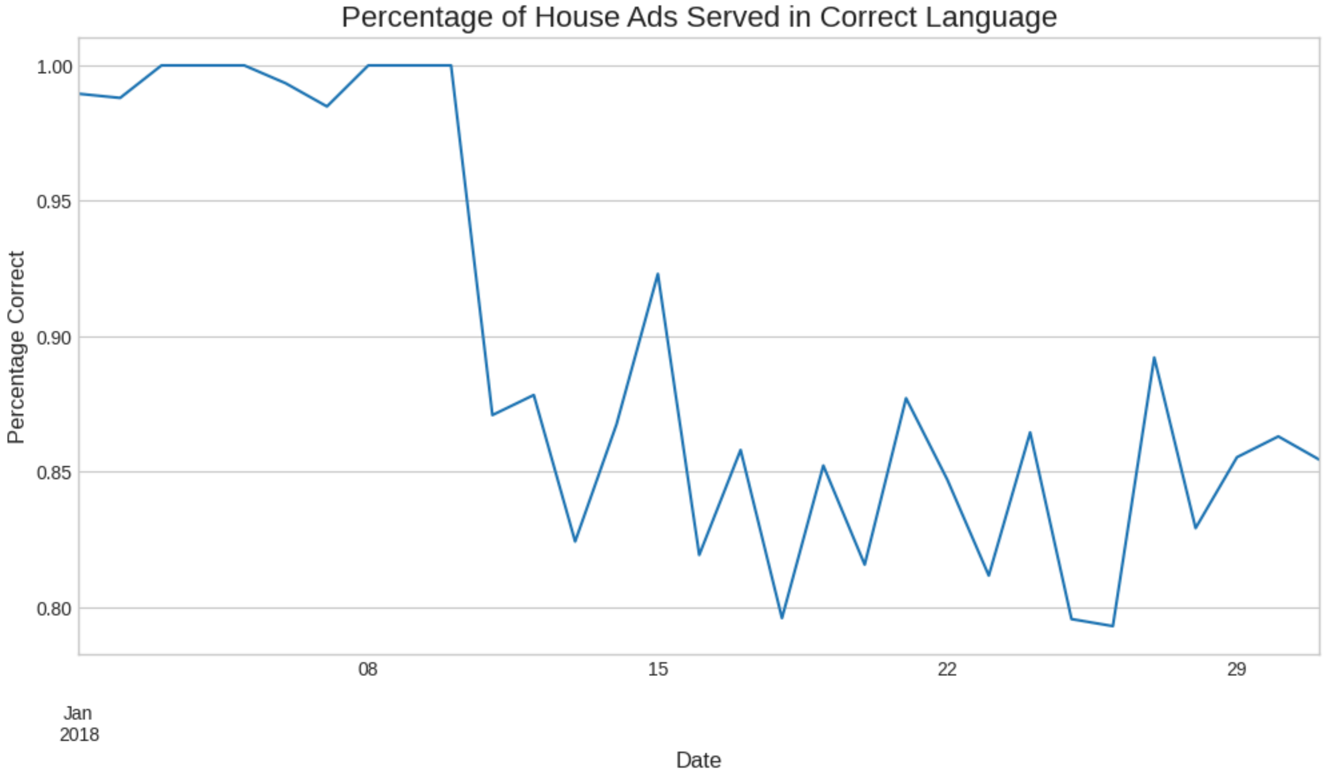
5. Deep Dive 1: Analyzing the Impact of a Marketing Bug

Scenario: An investigation into the `House Ads` channel revealed a period where ads were served in the wrong language. We will identify this period and quantify the number of lost subscribers due to this bug.

5.1 Identifying the Bug Period

```
# Isolate House Ads data
house_ads = marketing[marketing['marketing_channel'] == 'House Ads']

# Check if the displayed language matches the user's preferred language
house_ads['is_correct_lang'] = np.where(
        house_ads['language_displayed'] == house_ads['language_preferred'], 'Yes', 'No'
)

# Group by date and language correctness
language_check = house_ads.groupby(['date_served', 'is_correct_lang'])['user_id'].count()
language_check_df = pd.DataFrame(language_check.unstack(level=1)).fillna(0)

# Calculate the percentage of ads served in the correct language
language_check_df['pct_correct'] = language_check_df['Yes'] / language_check_df.sum(axis=1)

# Plot the percentage of correctly served ads
language_check_df['pct_correct'].plot(figsize=(12, 6))
plt.title('Percentage of House Ads Served in Correct Language', fontsize=16)
plt.ylabel('Percentage Correct', fontsize=12)
plt.xlabel('Date', fontsize=12)
plt.show()

print("The plot clearly shows a drop in correctly served ads between 2018-01-11 and 2018-01-31. This is our bug period.")
```

```
/tmp/ipython-input-1391487525.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  house_ads['is_correct_lang'] = np.where(
```



The plot clearly shows a drop in correctly served ads between 2018-01-11 and 2018-01-31. This is our bug period.

5.2 Quantifying Lost Subscribers

```
# --- Step 1: Establish a pre-bug baseline conversion rate index ---
# We compare other languages' conversion rates to English before the bug.
house_ads_pre_bug = house_ads[house_ads['date_served'] < '2018-01-11']
lang_conv_pre_bug = calculate_conversion_rate(house_ads_pre_bug, ['language_displayed'])

spanish_index = lang_conv_pre_bug['Spanish'] / lang_conv_pre_bug['English']
arabic_index = lang_conv_pre_bug['Arabic'] / lang_conv_pre_bug['English']
german_index = lang_conv_pre_bug['German'] / lang_conv_pre_bug['English']

# --- Step 2: Calculate expected conversions during the bug period ---
bug_period_df = house_ads[(house_ads['date_served'] >= '2018-01-11') & (house_ads['date_served'] <= '2018-01-31')]

# Calculate the daily English conversion rate during the bug period
english_conv_bug_period = calculate_conversion_rate(bug_period_df[bug_period_df['language_preferred'] == 'English'], ['date_served'])

# Estimate what the conversion rate should have been for other languages
expected_conv_rates = pd.DataFrame(english_conv_bug_period, columns=['english_rate'])
expected_conv_rates['expected_spanish'] = expected_conv_rates['english_rate'] * spanish_index
expected_conv_rates['expected_arabic'] = expected_conv_rates['english_rate'] * arabic_index
expected_conv_rates['expected_german'] = expected_conv_rates['english_rate'] * german_index

# Get the number of users served ads in each language during the bug period
users_by_lang = bug_period_df.groupby(['date_served', 'language_preferred'])['user_id'].nunique().unstack()

# --- Step 3: Calculate the number of lost subscribers ---
expected_spanish_subs = (users_by_lang['Spanish'] * expected_conv_rates['expected_spanish']).sum()
expected_arabic_subs = (users_by_lang['Arabic'] * expected_conv_rates['expected_arabic']).sum()
expected_german_subs = (users_by_lang['German'] * expected_conv_rates['expected_german']).sum()

total_expected_subs = expected_spanish_subs + expected_arabic_subs + expected_german_subs

# Get actual subscribers for these languages during the bug period
actual_subs = bug_period_df[bug_period_df['language_preferred'].isin(['Spanish', 'Arabic', 'German'])]['converted'].sum()
```

```
lost_subs = total_expected_subs - actual_subs
print(f"Estimated number of lost subscribers due to the language bug: {int(lost_subs)}")
```

```
Estimated number of lost subscribers due to the language bug: -26
```

6. Deep Dive 2: A/B Test Analysis

Scenario: The email marketing team ran an A/B test to see if a personalized email variant would perform better than the generic control email. We will analyze the results to determine the winner and check for statistical significance.

```
# Isolate email channel data
email_df = marketing[marketing['marketing_channel'] == 'Email']

# Check test allocation
alloc = email_df.groupby('variant')['user_id'].nunique()
alloc.plot(kind='bar')
plt.title('A/B Test Allocation')
plt.ylabel('# of Participants')
plt.xticks(rotation=45)
plt.show()

# Prepare data for analysis: one row per user with their conversion status
subscribers = email_df.groupby(['user_id', 'variant'])['converted'].max().unstack(level=1)

# Convert the 'converted' column to boolean before performing t-test
subscribers['control'] = subscribers['control'].astype(bool)
subscribers['personalization'] = subscribers['personalization'].astype(bool)

control = subscribers['control'].dropna()
personalization = subscribers['personalization'].dropna()

control_conv_rate = np.mean(control)
```