

Product Analytics

NOTE: If you are watching this on Zoom, this session will NOT be recorded. The Zoom chat will also not be monitored.

Presented by
NUS Product Club
NUS Statistics and Data Science Society

12 February 2026 (Thurs)
Topic: A/B Testing
Conducted in Python

Our past collaborations



AY23/24 Sem 2

This workshop goes through the concepts of product analytics and its techniques, as well as advanced Tableau dashboards such as **cohort analysis** and geographical distribution using an open-source e-commerce dataset.

AY24/25 Sem 2

Returning for its second iteration, this collaboration provides an overview of the three main concepts of product analytics: cohort analysis, A/B testing and **predictive analytics** - with the latter being the main focus for this workshop using Tableau.

Presenters



Harry
DSA Grad (2024)



Bernard
Y3 DSA



Keith
Y2 Business



Charles
Y2 DSA



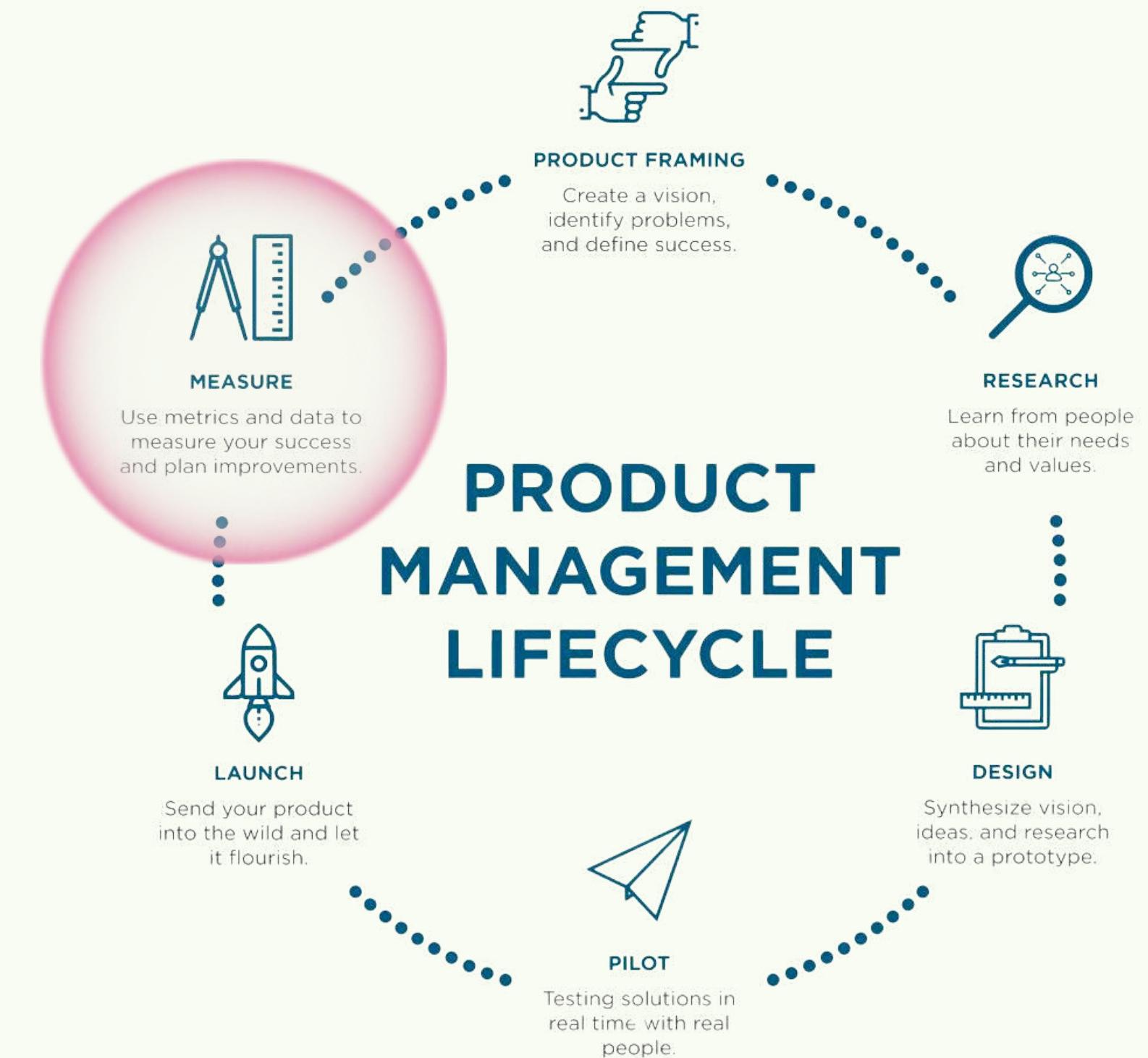
Daeren
Y2 DSA

Outline

- Introduction to product analytics
 - What is product analytics?
 - Why is it important?
 - Techniques and concepts used
- A/B testing: conceptual deep dive
- Code-along segment with Python
- A/B tests on VWO

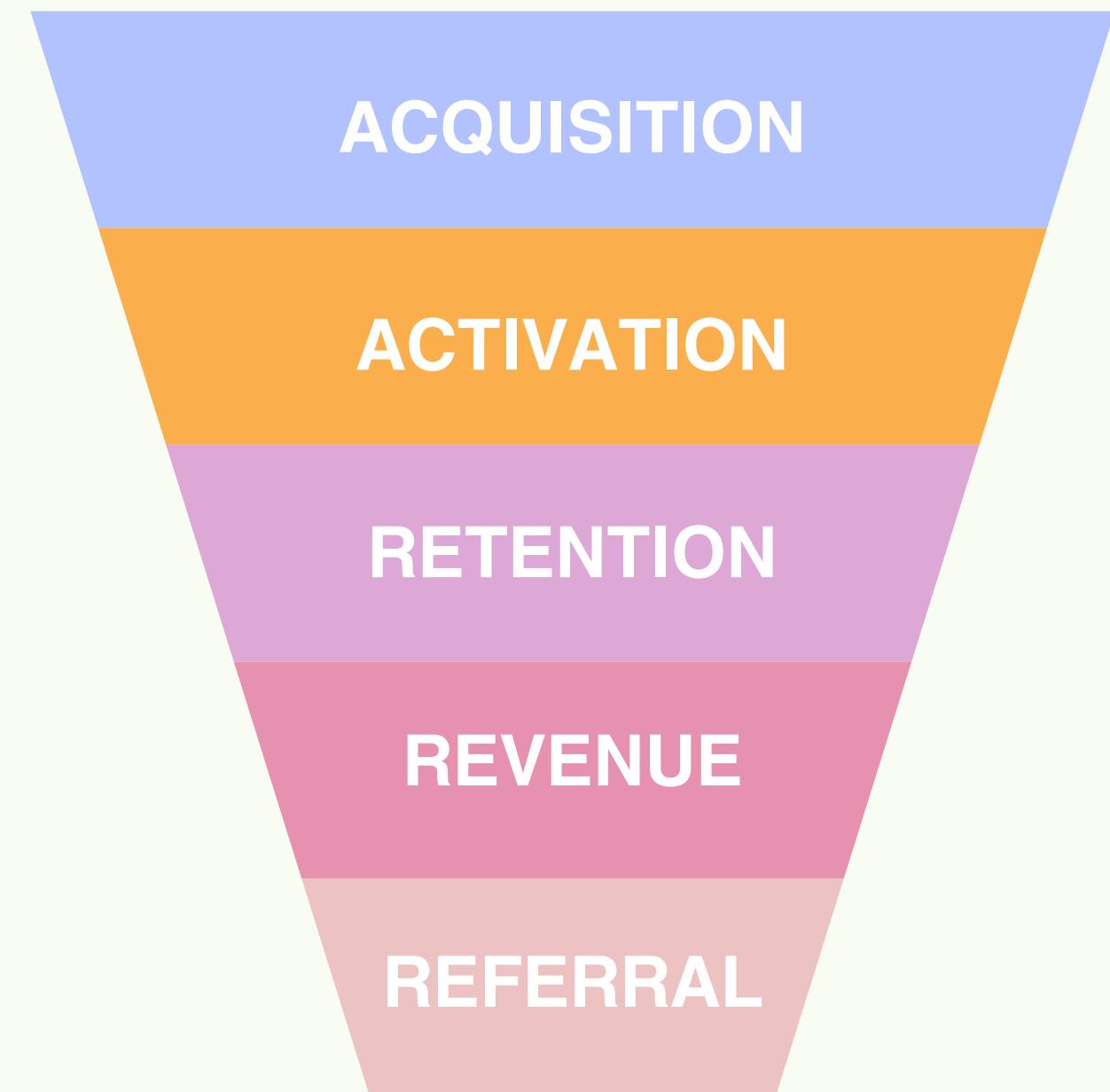
What is product analytics?

A process that dissects how customers engage with digital products. The insights we derive from the process tells us how users actually use the product.



AARRR: Pirate Metrics

A popular framework in product analytics, let us explore how this funnel works!



Exploring the Funnel: One-liners

Acquisition	Getting users to discover and sign up for your product
Activation	Getting users to their first meaningful “aha” moment
Retention	Getting users to come back and use the product again
Revenue	Turning usage into sustainable revenue
Referral	Turning happy users into advocates who bring others



Quick Tip #1 Your first note

To start, click or tap the 'New Note' or '+' button when you open Evernote on your computer or mobile device. Type anything you want to remember later or save text, attachments, audio and more.

Start by adding:

- Checkboxes for shopping and to-do lists
- Photos of whiteboard notes, receipts, and business cards
- Audio recordings of meetings and lectures
- Web clips of online articles, recipes, and gift ideas

Put it all together: save text, attachments, audio and more, all in a single note.

[Learn More](#)



Check out the Evernote Web Clipper

Save anything you see on your computer into your Evernote account with a single click. [Install the Evernote Web Clipper →](#)

Activation: an example

Let us take a look at Evernote's UI. How does it create an “aha moment” for the user?



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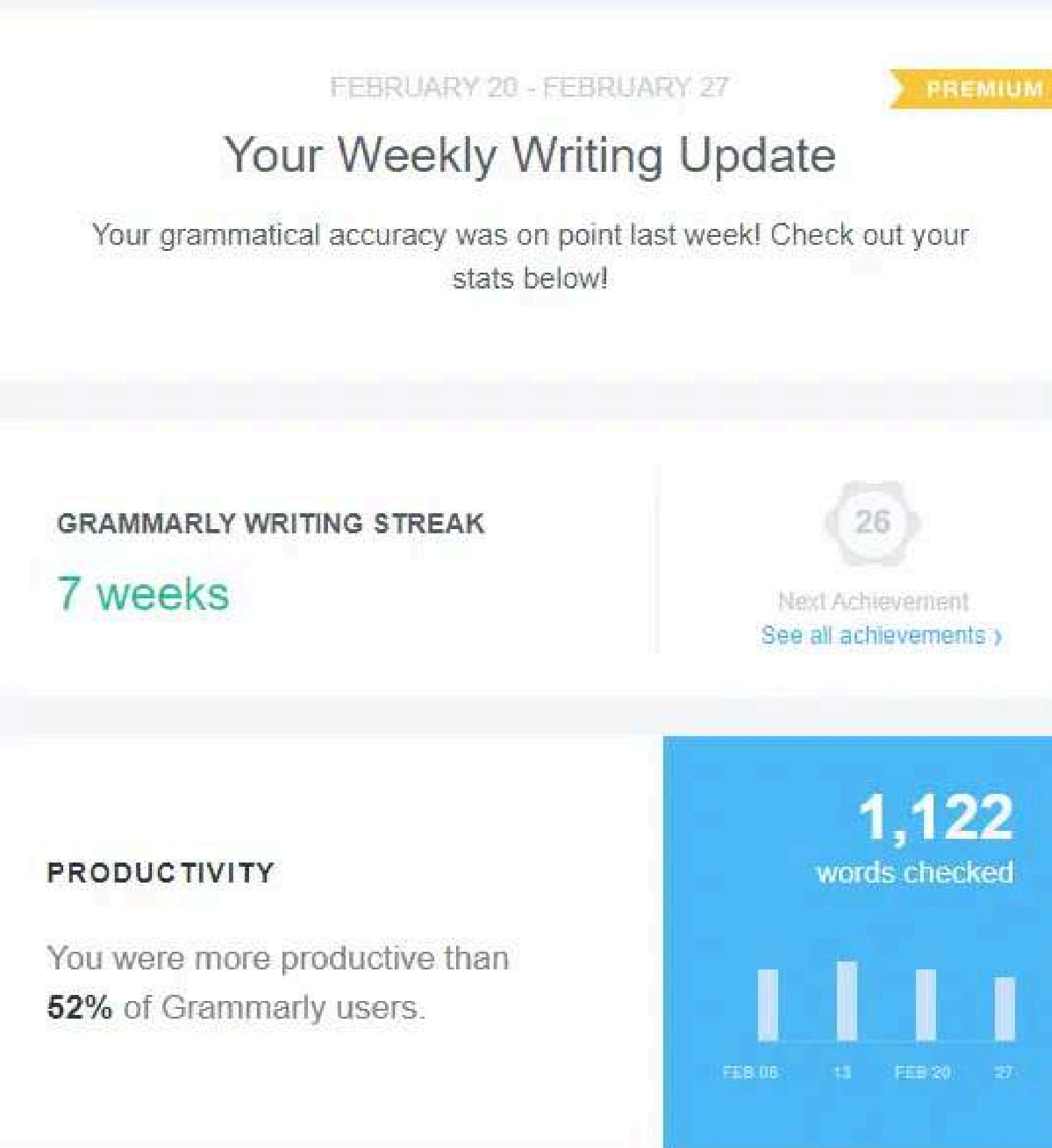


Check out the Evernote Web Clipper

Save anything you see on your computer into your Evernote account with a single click. [Install the Evernote Web Clipper →](#)

Activation: an example

Providing a smooth onboarding experience for new users to start using the product



Retention: an example

In this case, how does Grammarly try to retain its customers/newer users?

FEBRUARY 20 - FEBRUARY 27 

Your Weekly Writing Update

Your grammatical accuracy was on point last week! Check out your stats below!

GRAMMARLY WRITING STREAK

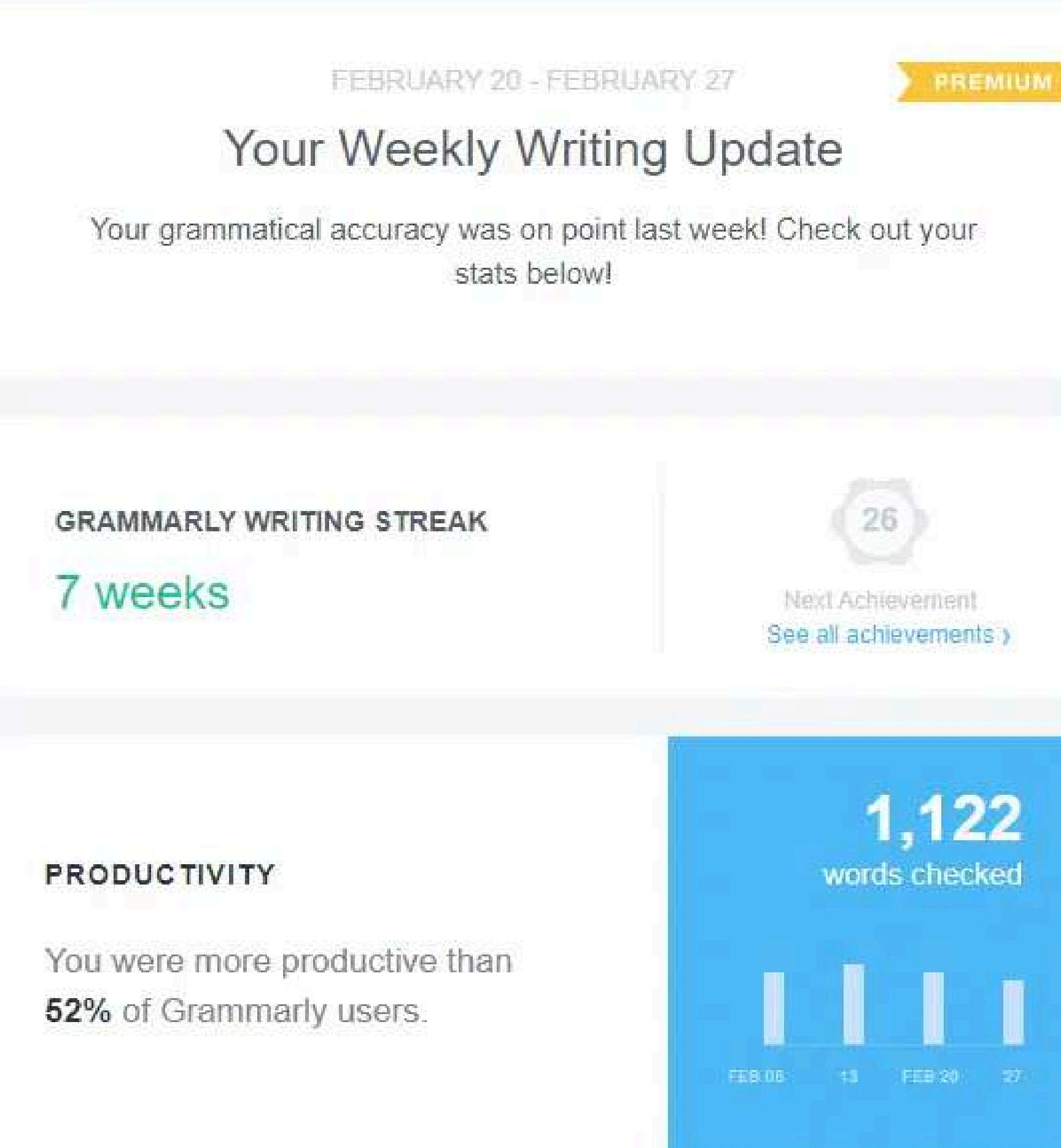
7 weeks 

Next Achievement
[See all achievements >](#)

1,122 words checked

PRODUCTIVITY

You were more productive than 52% of Grammarly users.



Date	Words Checked
FEB 06	280
FEB 13	300
FEB 20	300
FEB 27	200

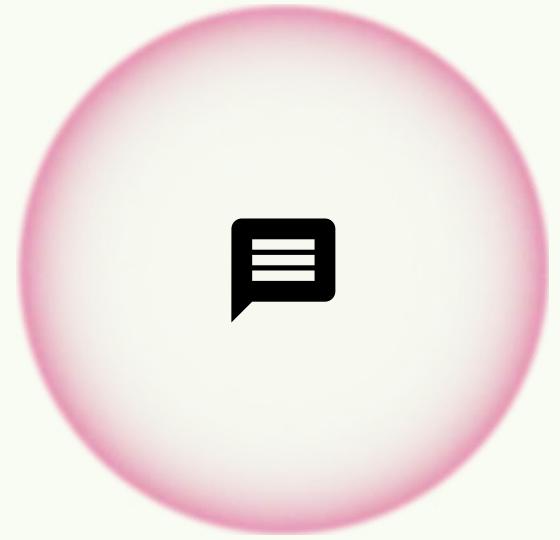
Retention: an example

Grammarly creates badges to directly engage with users, encouraging them to use the product more

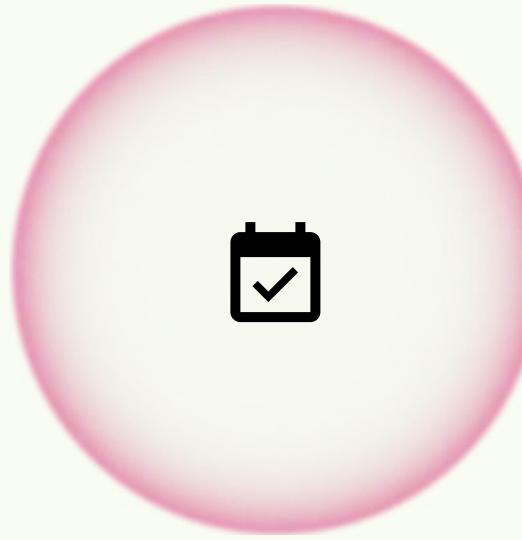
Exploring the Funnel: Key Qns

Acquisition	How do users find us? Why do they click/sign up?
Activation	Do new users experience value quickly & clearly?
Retention	Why do users return (or churn)?
Revenue	How do we monetize without killing experience?
Referral	Why would users invite friends? When to ask?

So, why is product analytics important?



Ensures a user-centric approach when building a product



Early warning system to make necessary data-driven decisions



Helps to identify weaknesses and opportunities within funnel

Some techniques

Commonly used in product analytics

Cohort analysis

Primarily tackles the retention aspect of the AARRR funnel by analysing churn and retention rates among different cohorts of users.

Predictive analytics

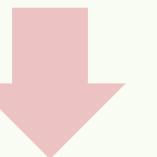
Uses historical data to prioritise high-priority users and predict which segments of users will be activated and/or retained.

A/B testing

Compares the performances of multiple variants of a feature/product, before ultimately deciding which is best for business.

Forming a Product Hypothesis

"If we [change] for [user segment], then [outcome] will [direction] because [reason]."

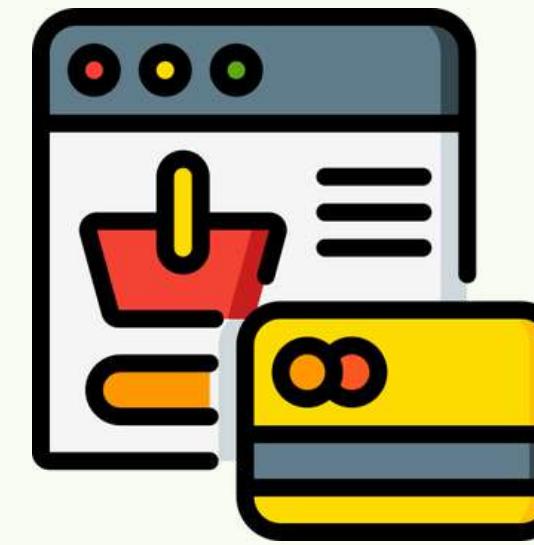
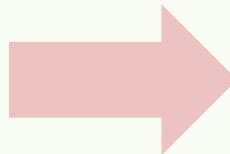


"If we add a progress bar to the checkout flow for users below 25, then checkouts will increase because users can see how many steps remain."

Primary Metric

The metric that defines success for your experiment
(Also generally the metric tested in statistical tests)

"...checkouts will increase..."



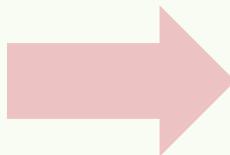
Checkout Conversion Rate

The desired outcome of the experiment determines your primary metric

Secondary Metrics

Secondary metrics provide context and explain changes in the primary metric

"If we add a progress bar to the checkout flow..."



What could change?

Do fewer users leave mid-checkout?

Do users get further in the flow?

Will the experience be faster?

Secondary Metric

Cart abandonment rate

Avg checkout steps completed

Time to complete checkout

Your primary metric and the change you are making determines your secondary metrics

Guardrail Metrics

Primary Metric

>10% uplift in checkout conversion rate

BUT.....

Guardrail Metrics

Retention 7 days later must not drop by more than >5%

Complaint rate and refund rate must stay <10%

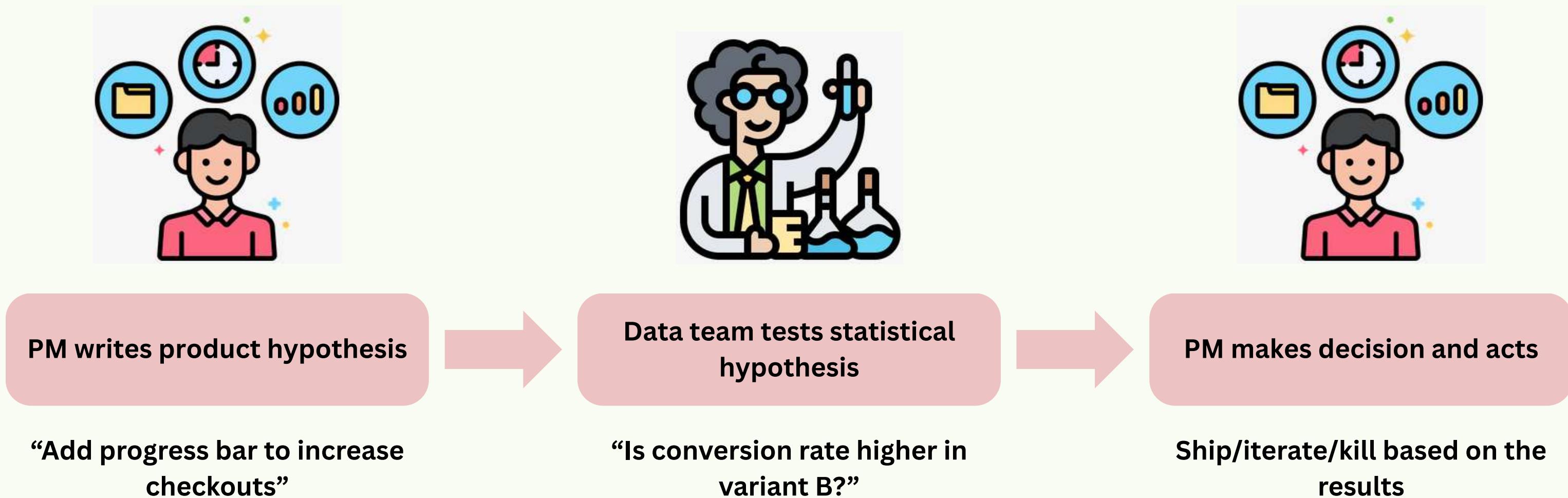
App crash rate must stay <1%; page load time must stay <3 seconds

To determine your guardrail metrics, ask yourself what happens if you're wrong, and what could go wrong even if you're right

Product vs Statistical Hypothesis

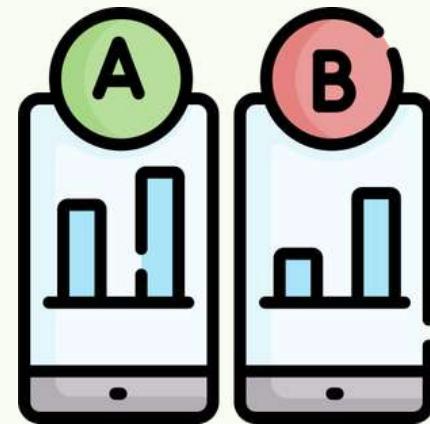
	Product Hypothesis	Statistical Hypothesis
Who uses it	PM / product team	Data scientist / data team
What it looks like	<p><i>“If we add a progress bar to the checkout flow for users below 25, then checkouts will increase because users can see how many steps remain.”</i></p>	<p>H_0 (Null): No difference in conversion rate between control and treatment</p> <p>H_1 (Alternative): Treatment has higher conversion rate than control”</p>
Purpose	Guides product decisions: what to build, what to measure, and why it should work	Guides analysis decisions: what statistical test to run and whether the result is real or random
When it's written	When deciding what to test	When analyzing the results

Product vs Statistical Hypothesis



The PM Research Toolkit

Quantitative



A/B Testing



Cohort Analysis



Surveys



Usability Testing



User Interviews

Qualitative

Product analytics alone isn't always enough.

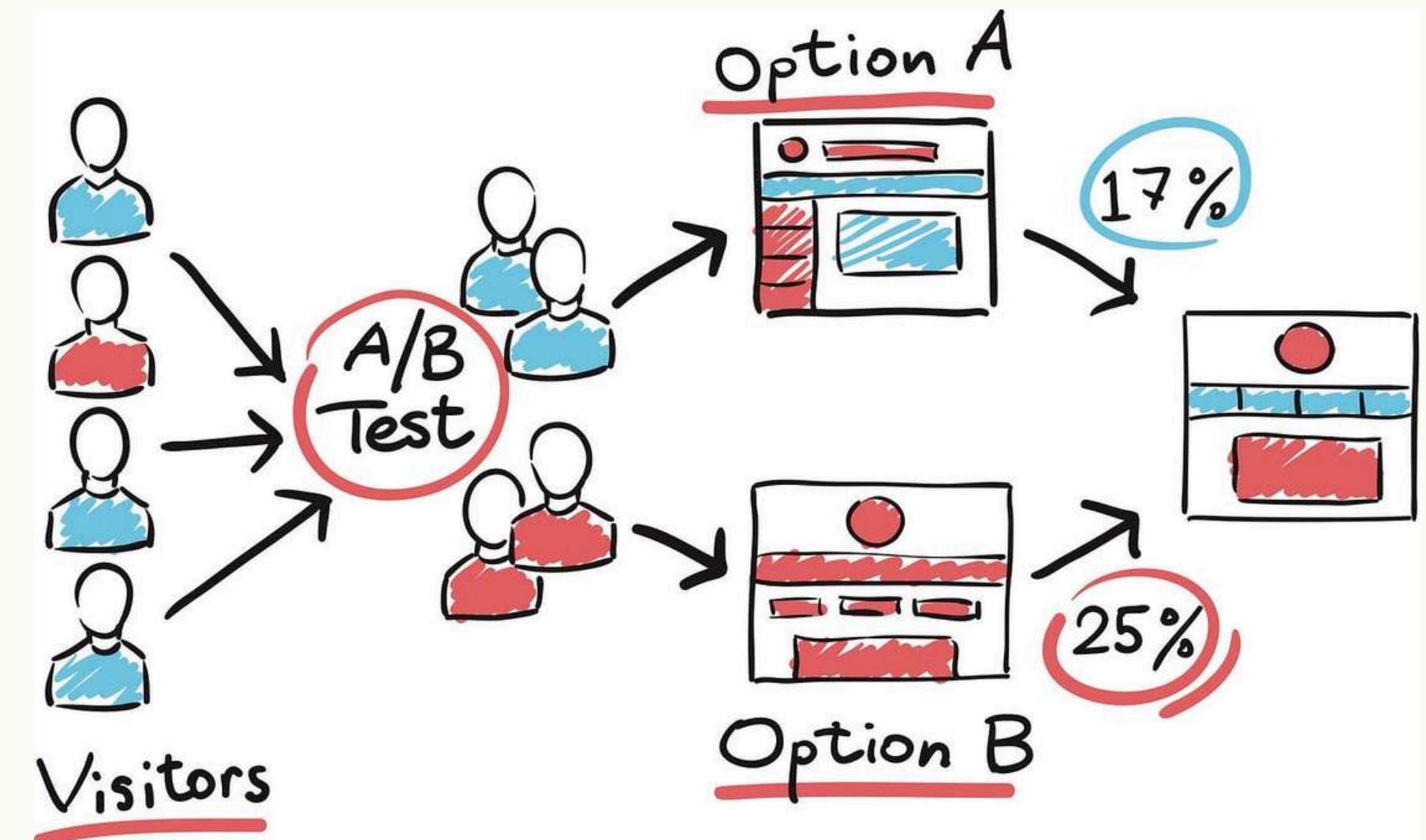
Combine quantitative + qualitative research methods for the full picture.

The PM Research Toolkit

Method	Question it answers	When to use
A/B Testing	"Which version performs better?"	You're choosing between two approaches and want to let the data decide
Cohort Analysis	"Is retention improving over time?"	You want to track how user behavior differs across groups or time periods
Surveys	"What do users think?"	You want to gather broad feedback quickly
Usability Testing	"Can users complete the task?"	You're testing a new flow or design
User Interviews	"Why do users behave this way?"	You need to understand motivations, pain points, and context

What is A/B Testing?

- A controlled experiment where you show two or more versions of something to different user groups at the same time. For example:
- Show version A to group 1, version B to group 2, etc.
- Measure which version achieves a better outcome

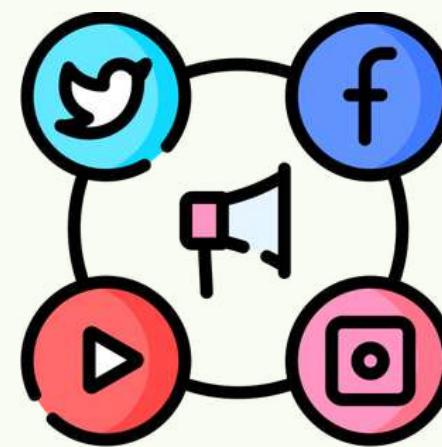


A/B Testing in the Product Lifecycle

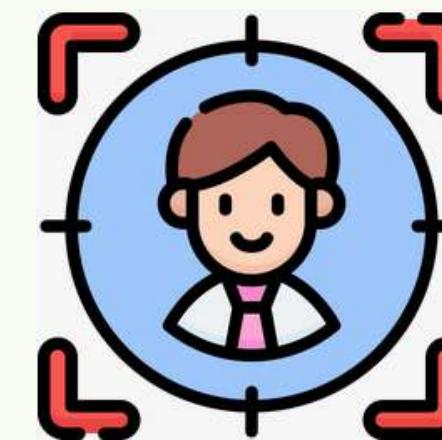
Product managers apply A/B testing to various aspects of a product's lifecycle, such as:



Idea generation
and validation



Product launch



Product
development



Ongoing
optimization

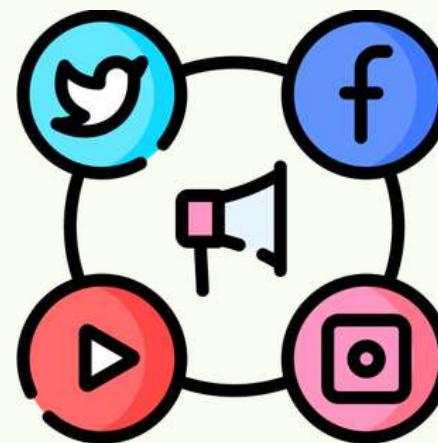
A/B Testing in the Product Lifecycle

In practice, that may look something like this:



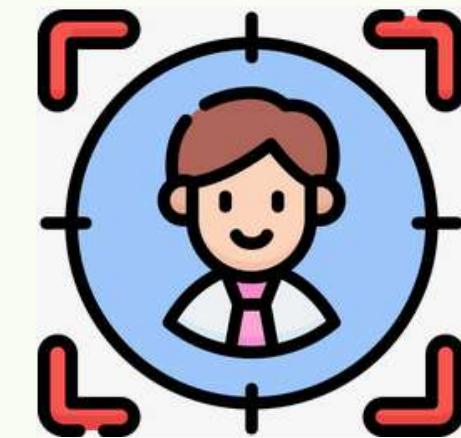
Website/App Features

Test button placements,
calls-to-action, or layouts



Marketing Campaigns

Test email subject lines or
landing page elements



Personalization

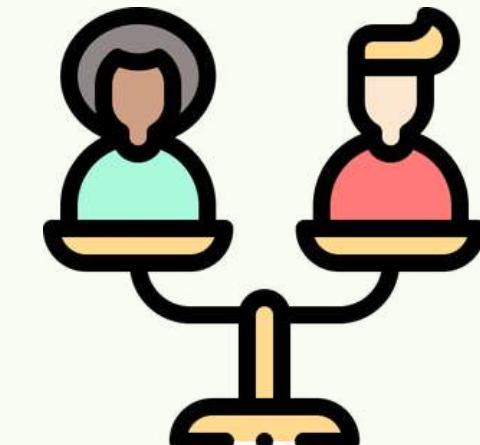
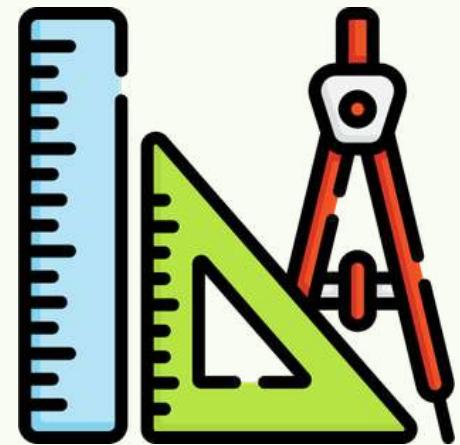
Tailor content or offers
based on behavior or
demographics



Pricing Strategies

Test pricing models
or discounts

When to use A/B Testing



You have enough users/traffic

- Small sample size = unreliable results

The change is measurable

- You need a clear metric (clicks, sign-ups, purchases)

You can split users fairly

- Random assignment must be possible

The decision has real impact

- Don't waste resources testing trivial changes

You can afford to wait

- Tests need data; ending too early = false positives

When NOT to use A/B Testing



Ethical concerns

- Testing different prices/features on different users can be unfair or illegal

You need to understand "why"

- A/B testing tells you what works, but not why

It's an obvious improvement

- Don't test what you already know - fixing a typo doesn't need an experiment

Urgent/emergency fixes

- Security patches, addressing critical bugs

A/B Testing

Which one would get more people to add to basket?

A

Was £0.052		
£0.024		
Price Each (In a Pack of 100)		
100 - 400 units	500 - 2400 units	2500 - 4900 units
£0.024	£0.02	£0.017
£2.40 / pack*	£2.00 / pack*	£1.70 / pack*
5000 - 9900 units	10000 + units	
£0.014	£0.012	
£1.40 / pack*	£1.20 / pack*	
 126100 in stock for FREE next working day delivery		

Quantity 100

▲ units

Add to basket

B

Was £0.052		
£0.024		
Price Each (In a Pack of 100)		
Units	per unit	per pack
100 - 400	£0.024	£2.40*
500 - 2400	£0.02	£2.00*
2500 - 4900	£0.017	£1.70*
5000 - 9900	£0.014	£1.40*
10000 +	£0.012	£1.20*
 126100 in stock for FREE next working day delivery		

Quantity 100

▲ units

Add to basket

A/B Testing

Which one do you think gets more clicks?

A

Was £0.052 £0.024 Price Each (In a Pack of 100)		
100 - 400 units	500 - 2400 units	2500 - 4900 units
£0.024	£0.02	£0.017
£2.40 / pack*	£2.00 / pack*	£1.70 / pack*
5000 - 9900 units	10000 + units	
£0.014	£0.012	
£1.40 / pack*	£1.20 / pack*	
 126100 in stock for FREE next working day delivery		
Quantity	100	units
Add to basket		

B

Was £0.052 £0.024 Price Each (In a Pack of 100)		
Units	per unit	per pack
100 - 400	£0.024	£2.40*
500 - 2400	£0.02	£2.00*
2500 - 4900	£0.017	£1.70*
5000 - 9900	£0.014	£1.40*
10000 +	£0.012	£1.20*
 126100 in stock for FREE next working day delivery		
Quantity	100	units
Add to basket		

Led to 9.16%
increase in clicks

A/B Testing

Which one converts better?

Download 

Download 

A/B Testing

Which one converts better?

Download 

Download 

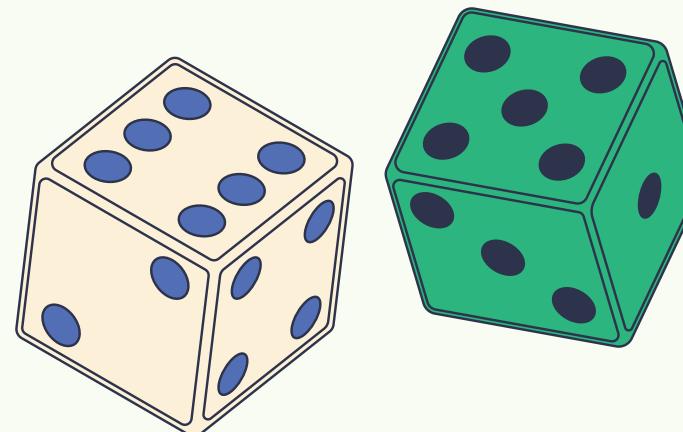
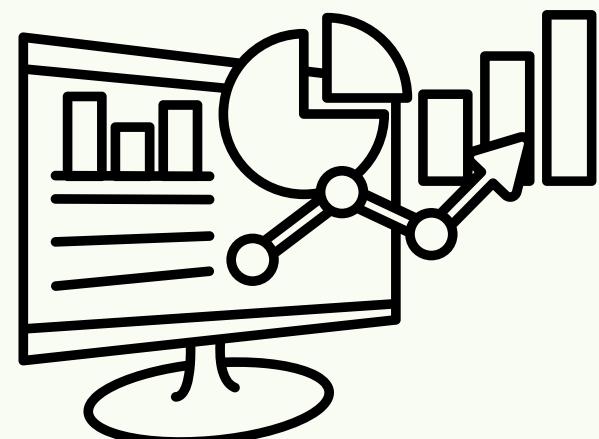
It depends on context, audience, and placement.
There is no universally ‘best’ design

A/B Testing

Why Statistics Are Needed

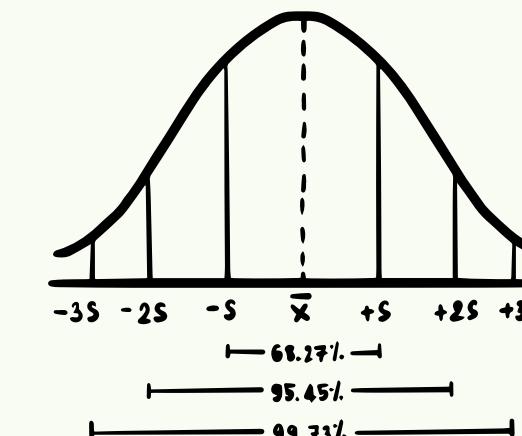
Without statistics:

- Random chance looks like success
- We make false conclusions



With statistics:

- We know if a result is real
- We avoid misleading decisions



A/B Testing

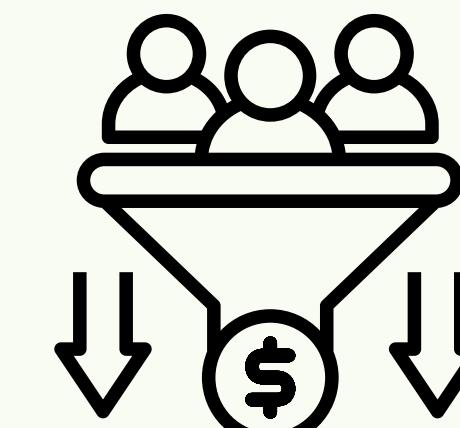
Simple A/B Testing Logic

Version A:
1,000 users →
100 conversions
(10%)

Version B: 1,000
users → 115
conversions
(11.5%)



Is Version B truly better?



A/B Testing

Real-Life Case 1: Airbnb



Instant Book

Instant Book



\$150 per night ★★★★★ 253

Apr 20, 2024 – Apr 22, 2024
2 nights

Check-in 4/20/2024 Check-out 4/22/2024

Instant Book

\$345 total before taxes

It's Instant Book
You can book **instantly** without any approval

Free cancellation before April 19

This is a rare find. Colleen's place on Airbnb is usually fully booked.

Request to Book

Request to Book



\$150 per night ★★★★★ 253

Apr 20, 2024 – Apr 22, 2024
2 nights

Check-in 4/20/2024 Check-out 4/22/2024

Request to Book

\$345 total before taxes

You'll need to request to book
Colleen will have 24 hours to accept your request

Free cancellation before April 19

This is a rare find. Colleen's place on Airbnb is usually fully booked.

Airbnb tested:

- “Request to Book” vs “Instant Book”

Result:

- Instant Book increased conversions significantly

Lesson:

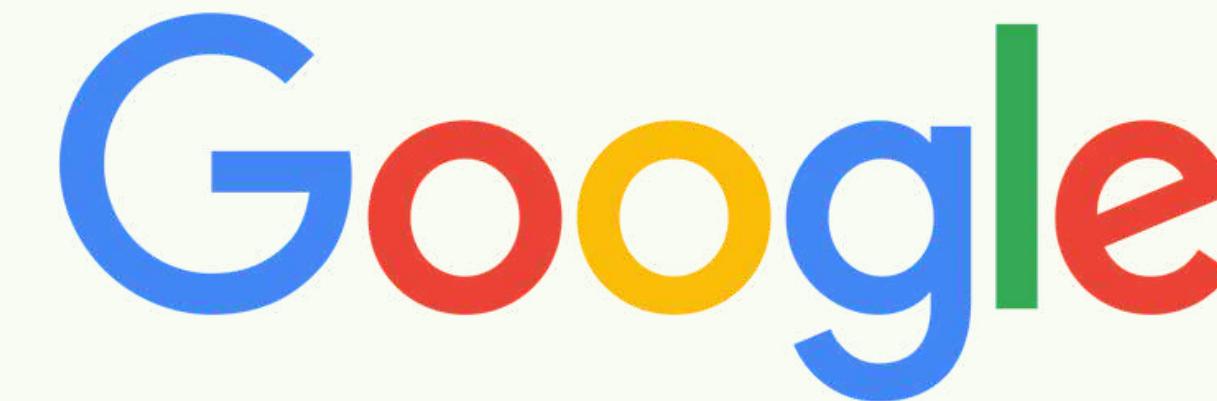
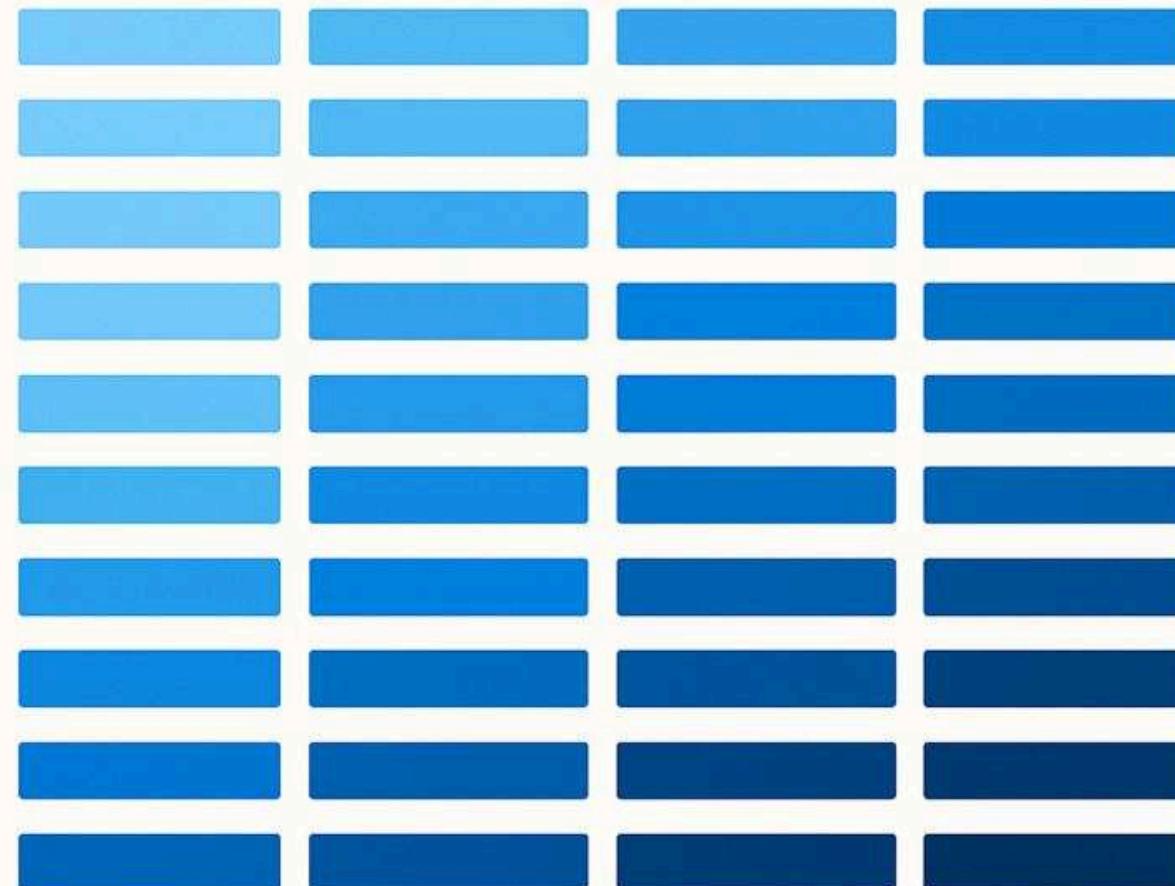
Reducing friction increases trust

A/B Testing

Real-Life Case 2: Google

Google once A/B tested 41 shades of blue for links in Gmail and Google Ads.

Here's what happened (continued in the post):



Google tested:

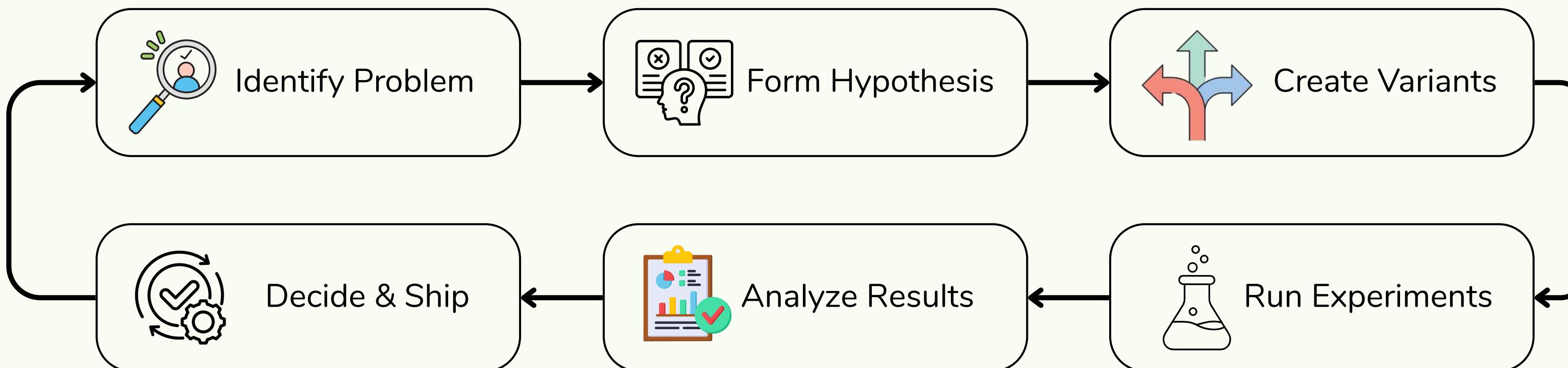
- 41 shades of blue

Lesson:

Small changes matter at scale

A/B Testing

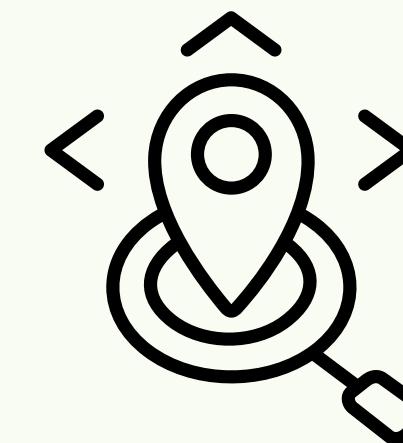
The A/B Testing Flow (PM View)



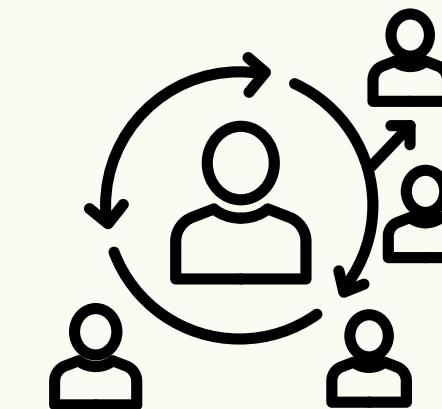
Factors That Affect A/B Testing Results



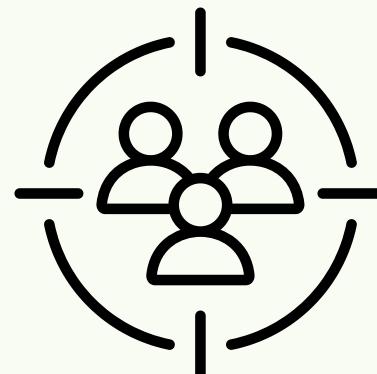
Audience size



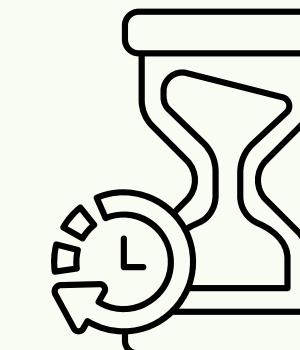
Context & timing



External noise



Audience type

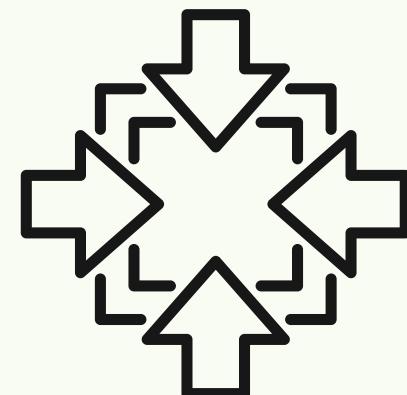


Traffic split &
duration

Why A/B Testing Doesn't Always Give a “Definite Answer”



Results may be
inconclusive

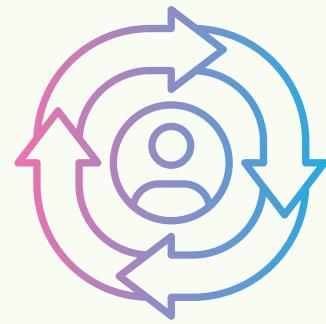


Effect size may
be too small



Trade-offs
across metrics

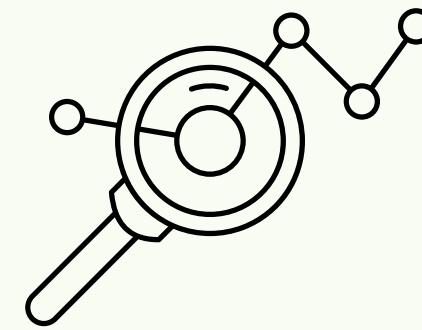
Common Mistakes in A/B Testing



Testing Too Many Changes at Once

✗ Copy, layout, button colour, and flow all change

You don't know what caused the result



Using the Wrong Metric

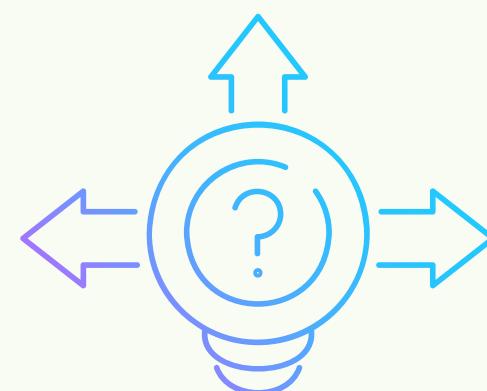
For verification, do not use “Number of Clicks” as metrics of success but “Completion Rate” or “Drop-Off Rate”



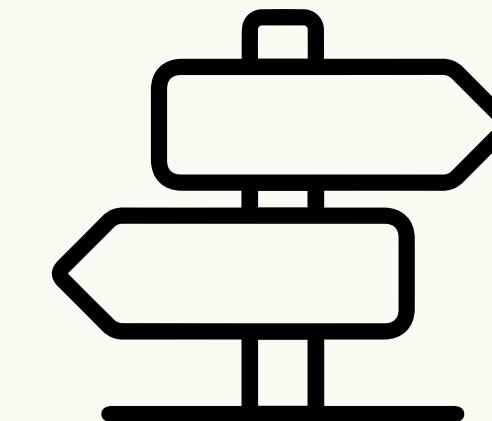
No Clear Hypothesis

- ✗ “Let’s just test and see”
- ✓ “If we change ___, then ___ will improve because ___.”

PM Mindset When Interpreting A/B Test Results



Be comfortable with
uncertainty



Look for direction,
not perfection



Consider risk
before rollout

Interpreting A/B Test Results For Decision Making



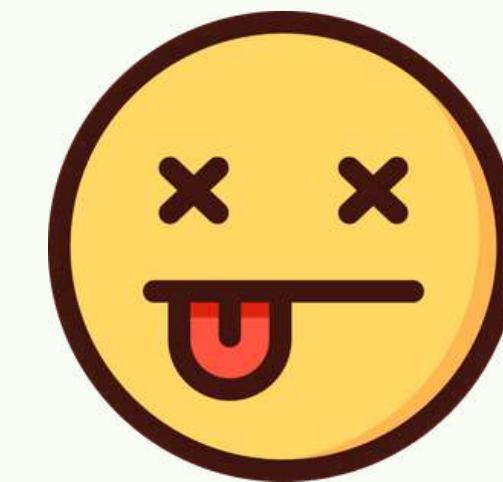
Ship

- Primary metric improves, guardrails are safe, effect is meaningful.
- Phased roll out of features, document learning.



Iterate

- Results are inconclusive or only slightly positive, but direction looks promising.
- Tweak metrics, redesign features



Kill

- Clear negative effect on primary metric and guardrails.
- Revert changes, document learnings, and move on.

Prioritizing what to test

You have limited traffic, engineering time, and attention.

REACH	IMPACT	CONFIDENCE	EFFORT
<p>How many people will this feature affect within a given time period?</p> <p>Example: customers per quarter, transactions per month</p>	<p>How much will this impact individual users? Use a multiple choice scale:</p> <p>3 = massive impact 2 = high impact 1 = medium impact 0.5 = low impact 0.25 = minimal impact</p> <p>Example: How much will this feature affect conversion rates?</p>	<p>How confident are we about the impact and reach scores? How much data do we have to back up those estimates?</p> <p>Use a % score where: 100% = high confidence 80% = medium confidence 50% = low confidence</p>	<p>How much of a time investment will this initiative require from product, design and development?</p> <p>Measure as persons per month (how much work one team member can do in a month).</p>

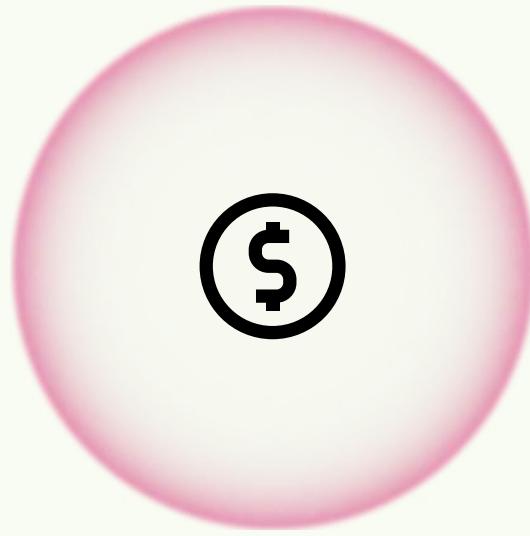
Not every idea deserves a full A/B test; some can be decided qualitatively, or shipped directly and monitored

A/B Testing Across Different Industries

Common Metrics



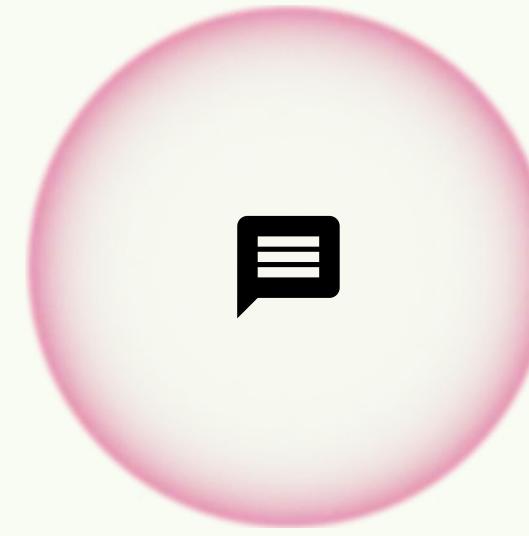
E-commerce & Retail



Fintech & Banking



Online Games/Apps



Travel & Hospitality

E-commerce & Retail

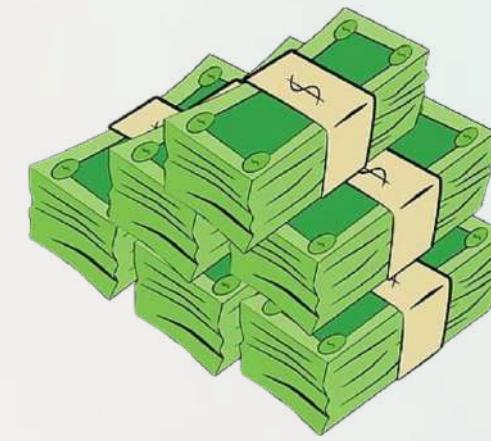


E-commerce & Retail

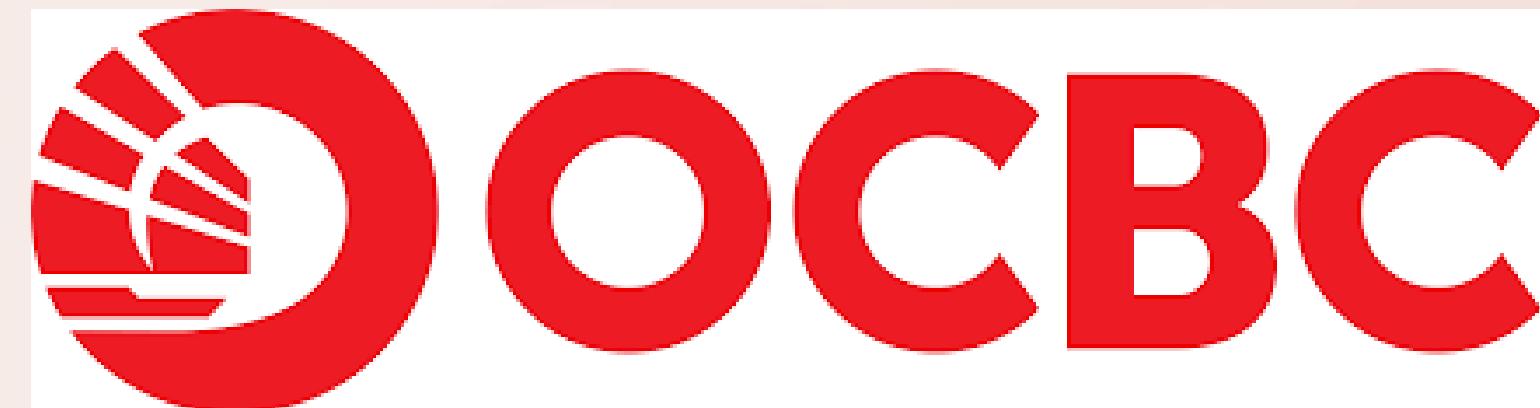


Common A/B Test Areas	Key Metrics
Recommendation System	<ul style="list-style-type: none">• Conversion Rate• Average Order Value (AOV)
Helpbot's Effectiveness	<ul style="list-style-type: none">• Escalation Rate (live agent)• Customer Satisfaction

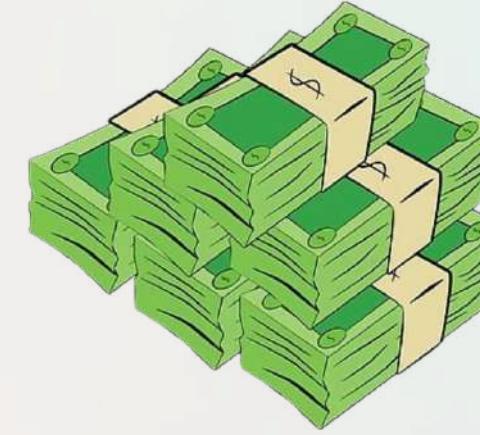
Fintech & Banking



bolttech



Fintech & Banking



Common A/B Test Areas	Key Metrics
Sign-up length/form length	<ul style="list-style-type: none">• Customer completion rate• Abandonment rate
Value proposition messages (save money vs earn rewards)	<ul style="list-style-type: none">• Click through rate (CTR)

Online Games/Apps

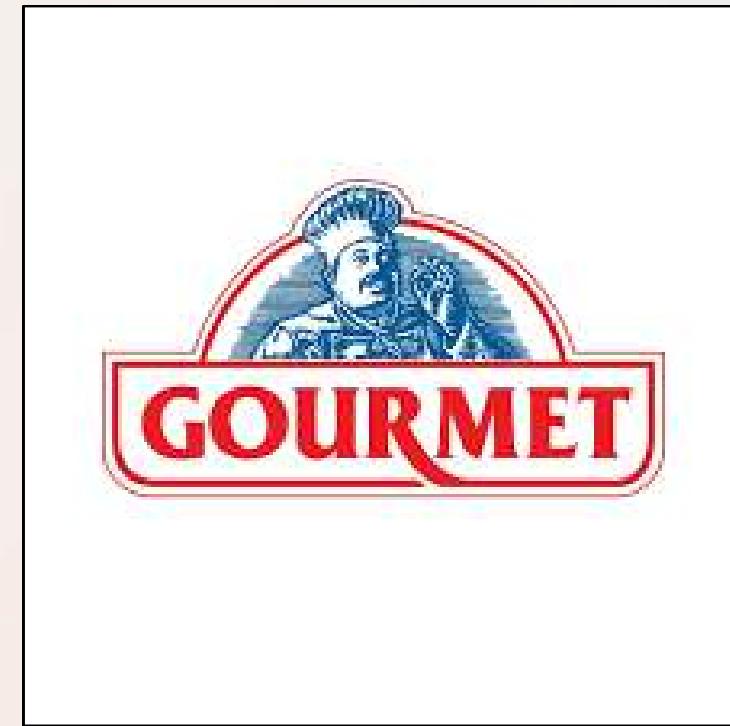


Online Games/Apps



Common A/B Test Areas	Key Metrics
Difficulty tuning (early wins vs challenge)	<ul style="list-style-type: none">• Churn rate• Average retention duration
Reward frequency	<ul style="list-style-type: none">• Sessions per user per day• Session length

Travel & Hospitality



Travel & Hospitality



Common A/B Test Areas	Key Metrics
Price display ("\$200/night" vs "\$180 + taxes")	<ul style="list-style-type: none">• Search to Booking conversion rate• Average booking value
Cancellation policy	<ul style="list-style-type: none">• Cancellation rate

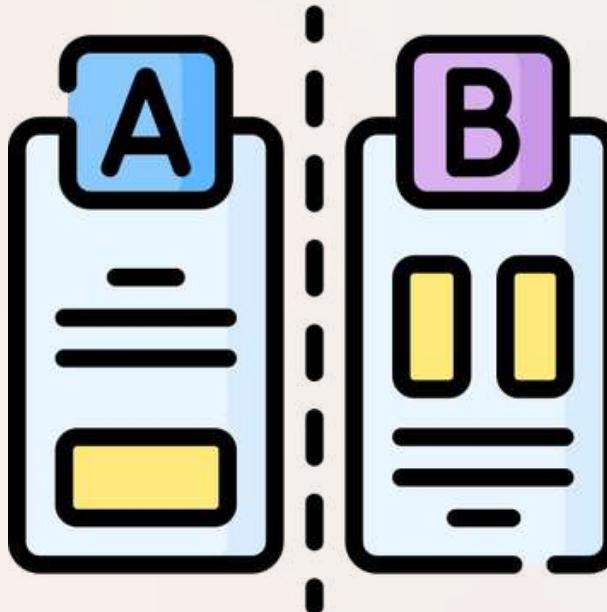
Python Code-Along

Google Colab

Content

1. Introduction
2. Data Cleaning & Merging
3. EDA + Visualisation
4. Hypothesis Testing
5. Conclusion

Introduction



A/B Testing Analysis: Average vs Maximum Bidding Models

Project Overview

Analyzing the performance of two impression bidding strategies for an ad-tech company's retargeting campaign to determine which model drives better conversions.

Key Metrics

Metric	Formula	Purpose
CTR (Click-Through Rate)	# Website Clicks / # Impressions	Measures ad effectiveness in attracting clicks
CR (Conversion Rate)	# Purchases / # Website Clicks	Shows percentage of clicks that result in purchases
CPC (Cost Per Click)	Spend / # Website Clicks	Evaluates efficiency of ad spend per click
CPA (Cost Per Acquisition)	Spend / # Purchases	Average cost to acquire a customer

Hypothesis Testing

Null Hypothesis (H_0): No significant difference in performance between Average Bidding and Maximum Bidding

Alternative Hypothesis (H_1): Significant difference exists between the two bidding models

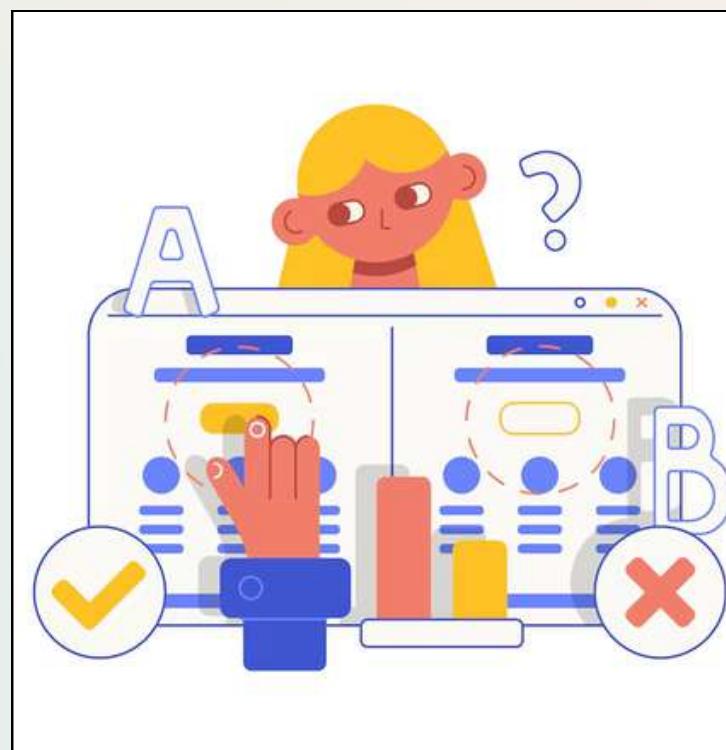
Significance Level (α): 0.05

Dataset Variables

- Campaign Name
- Date
- Spend [USD]
- # of Impressions
- Reach
- # of Website Clicks
- # of Searches
- # of View Content
- # of Add to Cart
- # of Purchase

What is Hypothesis Testing?

a statistical "detective" method used to decide if an assumption about a population is likely **true** or just a **coincidence**, based on sample data



Load Datasets

Imports dataset

- *May need to wait for a couple minutes for colab to import it from Kaggle*
- *If error still persists, can run the import code block again*

```
# Import dataset
import kagglehub

path = kagglehub.dataset_download('ilkeryildiz/example-dataset-for-ab-test')

print("Path to dataset files:", path)
```

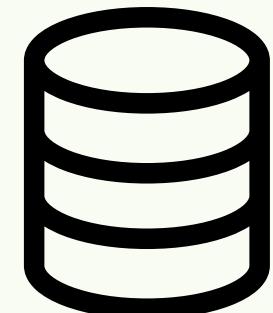
Using Colab cache for faster access to the 'example-dataset-for-ab-test' dataset.
Path to dataset files: /kaggle/input/example-dataset-for-ab-test

```
# Convert each csv to dataframe
test = pd.read_csv('/kaggle/input/example-dataset-for-ab-test/test_group.csv', delimiter = ';')
control = pd.read_csv('/kaggle/input/example-dataset-for-ab-test/control_group.csv', delimiter = ';')
```

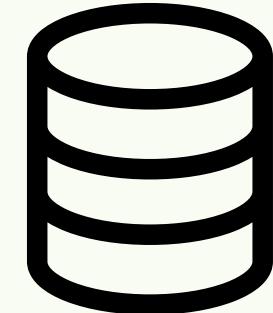
Data Cleaning & Merging

1. Merge

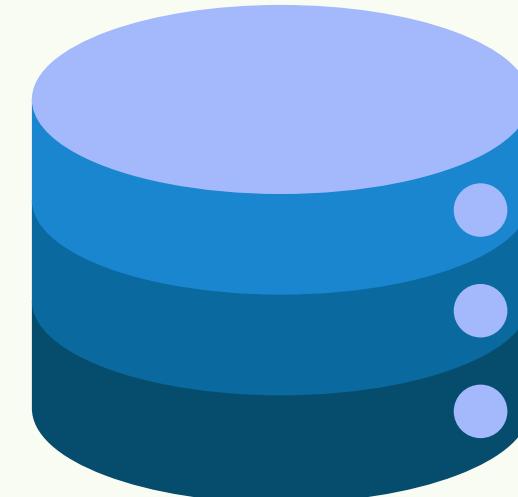
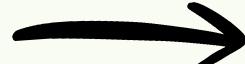
```
# Concatenate dataframes  
df = pd.concat([test, control], axis = 0)  
df = df.reset_index(drop = True)
```



Test



Control



Data Cleaning & Merging

2. Drop Unnecessary Columns (since not used in formula)

```
df.drop(['Reach', '# of Searches', '# of View Content', '# of Add to Cart'], axis=1, inplace=True)
```

Key Metrics

Metric	Formula	Purpose
CTR (Click-Through Rate)	# Website Clicks / # Impressions	Measures ad effectiveness in attracting clicks
CR (Conversion Rate)	# Purchases / # Website Clicks	Shows percentage of clicks that result in purchases
CPC (Cost Per Click)	Spend / # Website Clicks	Evaluates efficiency of ad spend per click
CPA (Cost Per Acquisition)	Spend / # Purchases	Average cost to acquire a customer

Data Cleaning & Merging

3. Fill null values using mean imputation

Common Alternatives:

- Median Imputation to combat outlier
- Mode Imputation for categorical data

What is imputation?

To fill in missing data with estimated values

```
# Impute the mean by subgroups
var_dict = df.groupby('Campaign Name')[['# of Impressions', '# of Website Clicks', '# of Purchase']].mean().round(0).to_dict()

for dict_id, dict_info in var_dict.items():
    df[str(dict_id)] = df[str(dict_id)].fillna(df['Campaign Name'].map(dict_info))
```

EDA

```
# Change 'Date' data type to date
df['Date'] = pd.to_datetime(df["Date"], dayfirst = True).dt.date

# Change 'Spend [USD]' from integer to float
df['Spend [USD]'] = df['Spend [USD]'].astype(float)
```

```
# Obtain summary statistics of the data
df.describe()
```

	Spend [USD]	# of Impressions	# of Website Clicks	# of Purchase
count	60.000000	60.000000	60.000000	60.000000
mean	2425.750000	92072.283333	5676.566667	522.016667
std	381.130461	32270.543500	1740.469149	195.297556
min	1757.000000	22521.000000	2277.000000	222.000000
25%	2073.750000	69558.250000	4230.750000	340.000000
50%	2420.500000	98281.000000	5581.000000	506.000000
75%	2727.500000	117160.500000	7201.250000	685.000000
max	3112.000000	145248.000000	8264.000000	890.000000

Visualisation



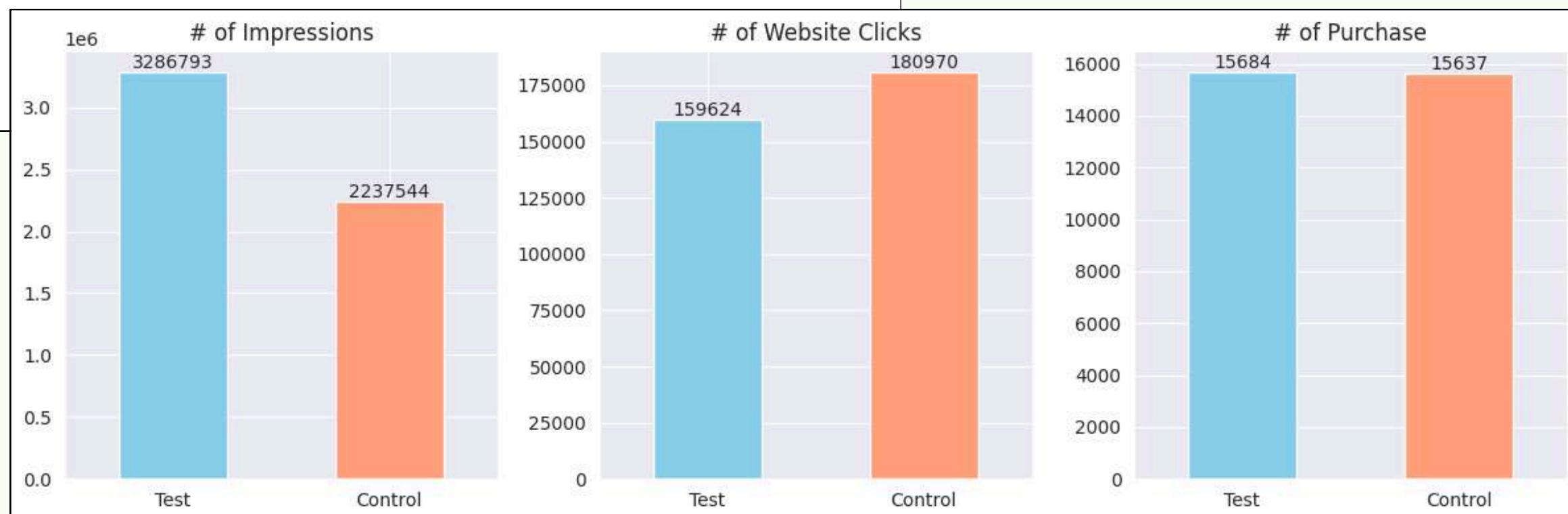
Creates a 1 row by 3 cols grid/space

```
fig, axes = plt.subplots(1, 3, figsize=(12, 4))
num_vars = ['# of Impressions', '# of Website Clicks', '# of Purchase']

for i, var in enumerate(num_vars):
    totals = df.groupby('Campaign Name')[var].sum()
    totals.plot(kind='bar', ax=axes[i], color=['#87CEEB', '#FFA07A'], rot=0)
    axes[i].set_title(var)
    axes[i].set_xlabel('')
    axes[i].set_xticklabels(['Test', 'Control'])

for container in axes[i].containers:
    axes[i].bar_label(container, fmt='%.0f')

plt.tight_layout()
plt.show()
```



EDA + Visualisation

```
# Set an style for the plots
sns.set_style('darkgrid')

# Create a fig and axis for a 2x2 grid
fig, axes = plt.subplots(2, 2, figsize=(10, 8))

# Create a kde plot for each numerical variable
sns.kdeplot(data=df, x = 'Spend [USD]', ax=axes[0, 0], hue = 'Campaign Name', fill = True)
sns.kdeplot(data=df, x = '# of Impressions', ax=axes[0, 1], hue = 'Campaign Name', fill = True)
sns.kdeplot(data=df, x = '# of Website Clicks', ax=axes[1, 0], hue = 'Campaign Name', fill = True)
sns.kdeplot(data=df, x = '# of Purchase', ax=axes[1, 1], hue = 'Campaign Name', fill = True)

# Add labels and titles to each plot
axes[0, 0].set_xlabel("Spend (USD)")
axes[0, 0].set_ylabel("Density")
axes[0, 0].set_title("KDE – Spend (USD)")

axes[0, 1].set_xlabel("Impressions")
axes[0, 1].set_ylabel("Density")
axes[0, 1].set_title("KDE – Number of Impressions")

axes[1, 0].set_xlabel("Website Clicks")
axes[1, 0].set_ylabel("Density")
axes[1, 0].set_title("KDE – Number of Website Clicks")

axes[1, 1].set_xlabel("Purchase")
axes[1, 1].set_ylabel("Density")
axes[1, 1].set_title("KDE – Number of Purchase")

plt.tight_layout()
```

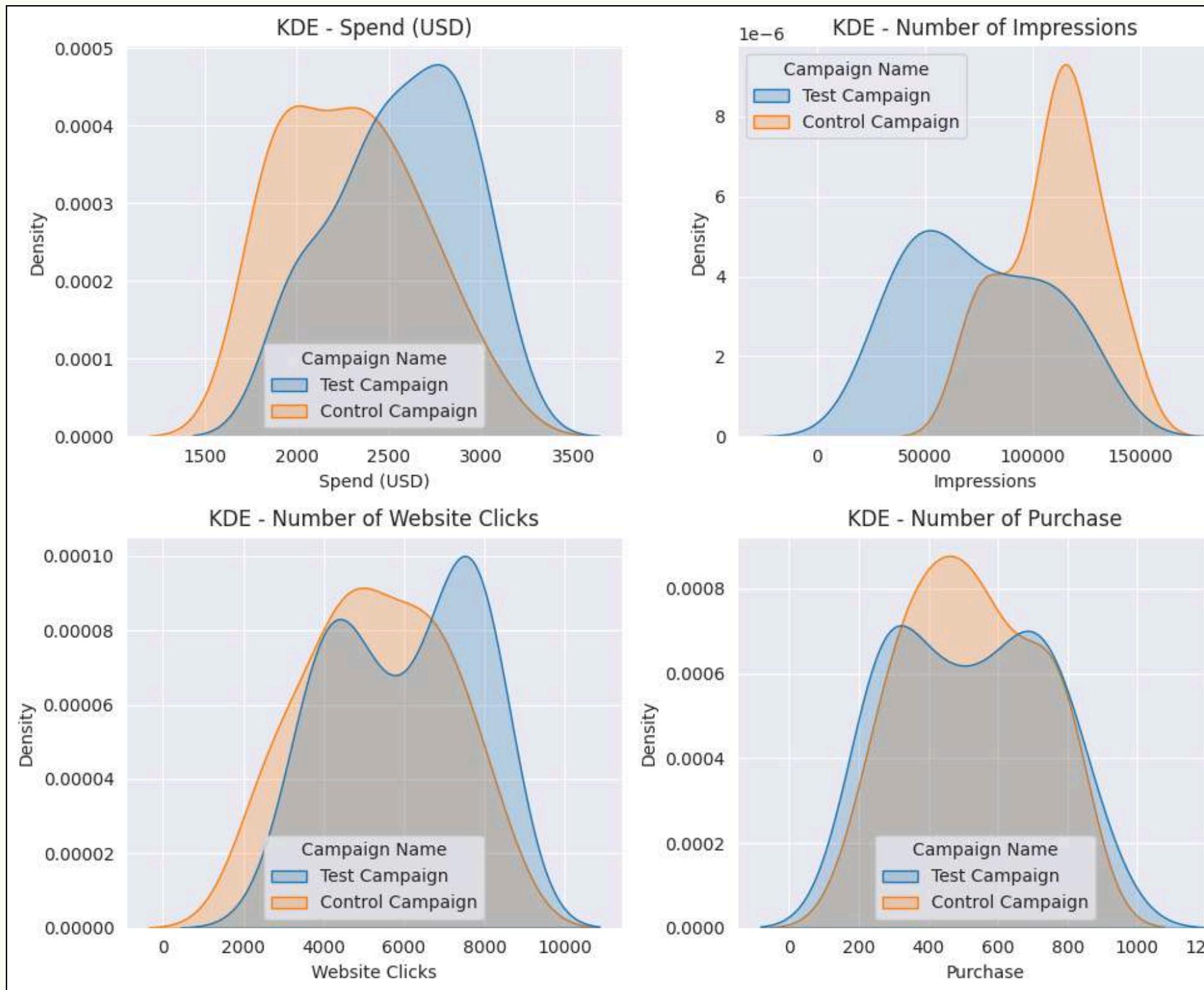
Creates a 2x2 grid/space



*Think of it as which coordinates
[row, col]
you want the plot on the grid*



EDA + Visualisation



Why KDE not just histogram?

Histogram

- Highly dependent on bin size/placement
- Different bin choices can lead to different interpretations of the same data



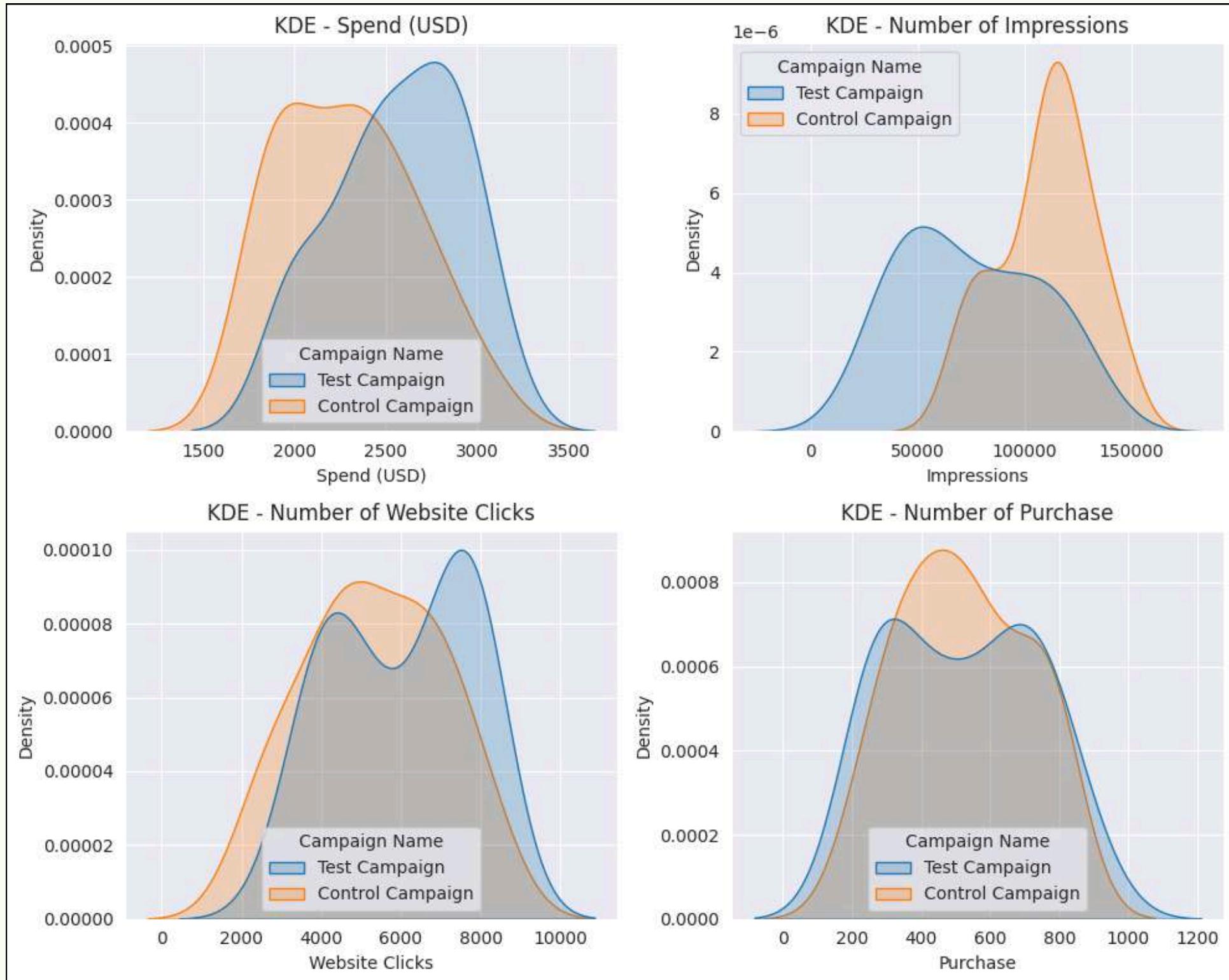
Skewed?



2 peaks



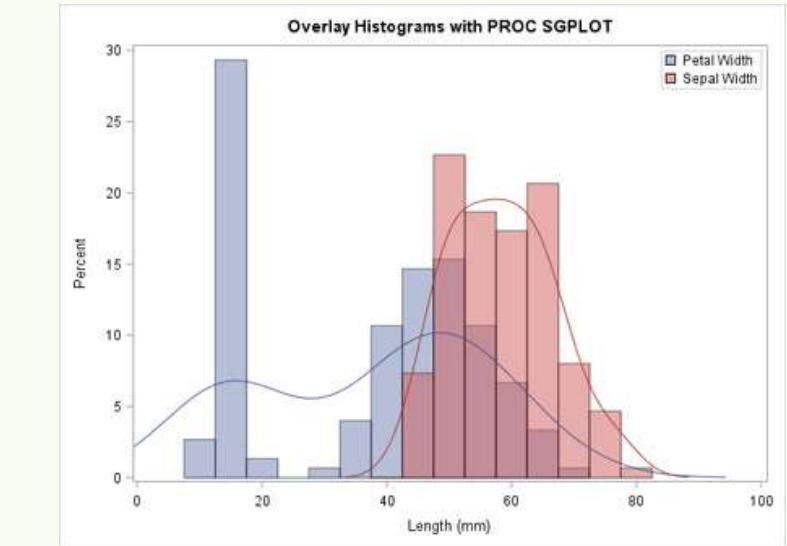
EDA + Visualisation



Why KDE not just histogram?

Kernel Density Estimation (KDE)

- Smoother representation of the underlying distribution
- Easier to identify peaks/multimodal patterns
- Clearer visualization of overlapping distributions with less visual clutter



Note that y-axis is the probability density (how likely an outcome will be), and not the actual frequency

EDA + Visualisation

```
# Set an style for the plots
sns.set_style('darkgrid')

# Create a fig and axis for a 2x2 grid
fig, axes = plt.subplots(2, 2, figsize=(10, 8))

# Create a split violin plot for each numerical variable
sns.violinplot(data=df, x='Campaign Name', y='Spend [USD]', ax=axes[0, 0], hue='Campaign Name', legend=False, split=True, inner='quartile')
sns.violinplot(data=df, x='Campaign Name', y='# of Impressions', ax=axes[0, 1], hue='Campaign Name', legend=False, split=True, inner='quartile')
sns.violinplot(data=df, x='Campaign Name', y='# of Website Clicks', ax=axes[1, 0], hue='Campaign Name', legend=False, split=True, inner='quartile')
sns.violinplot(data=df, x='Campaign Name', y='# of Purchase', ax=axes[1, 1], hue='Campaign Name', legend=False, split=True, inner='quartile')

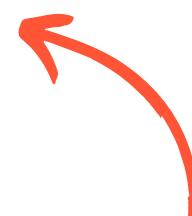
# Add labels and titles to each plot
axes[0, 0].set_xlabel("Campaign")
axes[0, 0].set_ylabel("Spend (USD)")
axes[0, 0].set_title("Violin Plot – Spend (USD)")

axes[0, 1].set_xlabel("Campaign")
axes[0, 1].set_ylabel("Impressions")
axes[0, 1].set_title("Violin Plot – Number of Impressions")

axes[1, 0].set_xlabel("Campaign")
axes[1, 0].set_ylabel("Website Clicks")
axes[1, 0].set_title("Violin Plot – Number of Website Clicks")

axes[1, 1].set_xlabel("Campaign")
axes[1, 1].set_ylabel("Purchase")
axes[1, 1].set_title("Violin Plot – Number of Purchase")

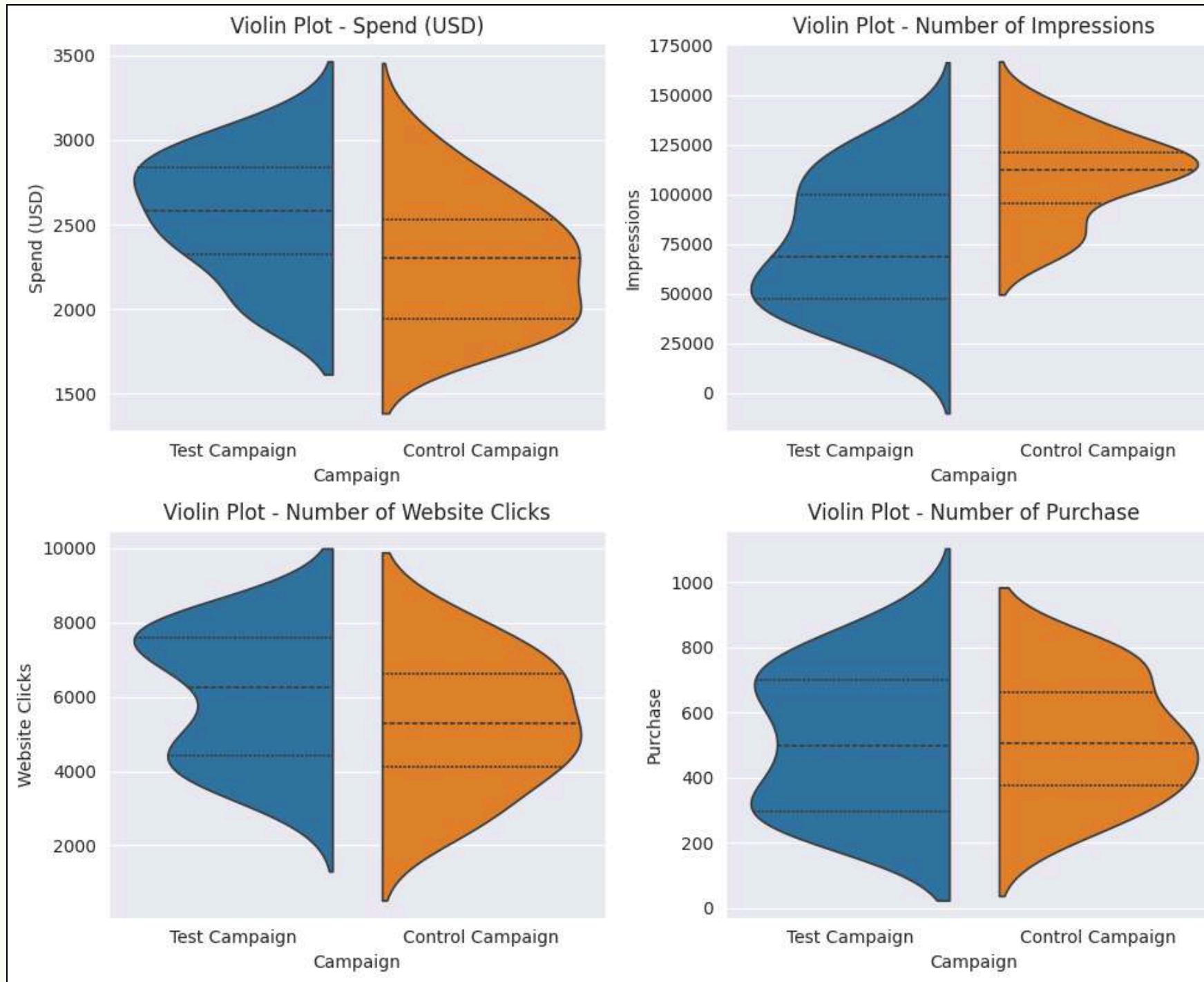
plt.tight_layout()
plt.show()
```



Plot violinplot

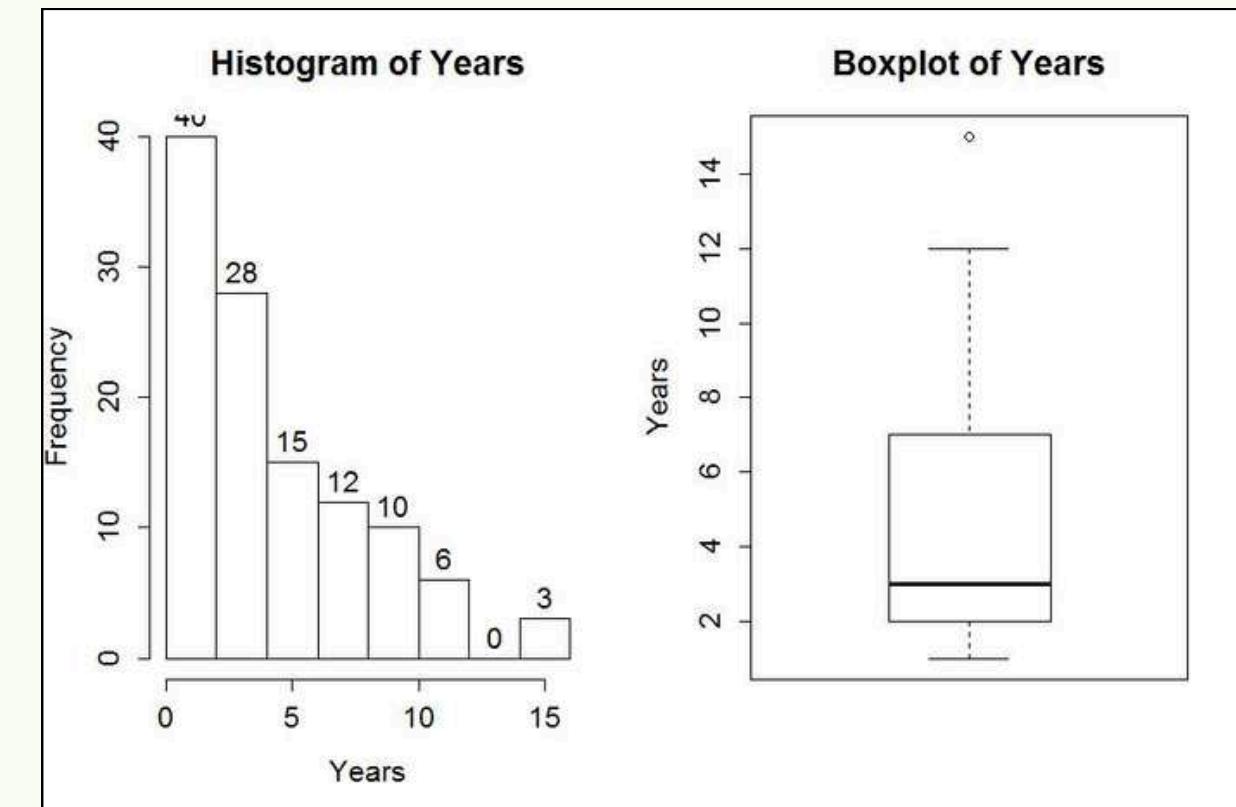
But... what is a violinplot???

EDA + Visualisation

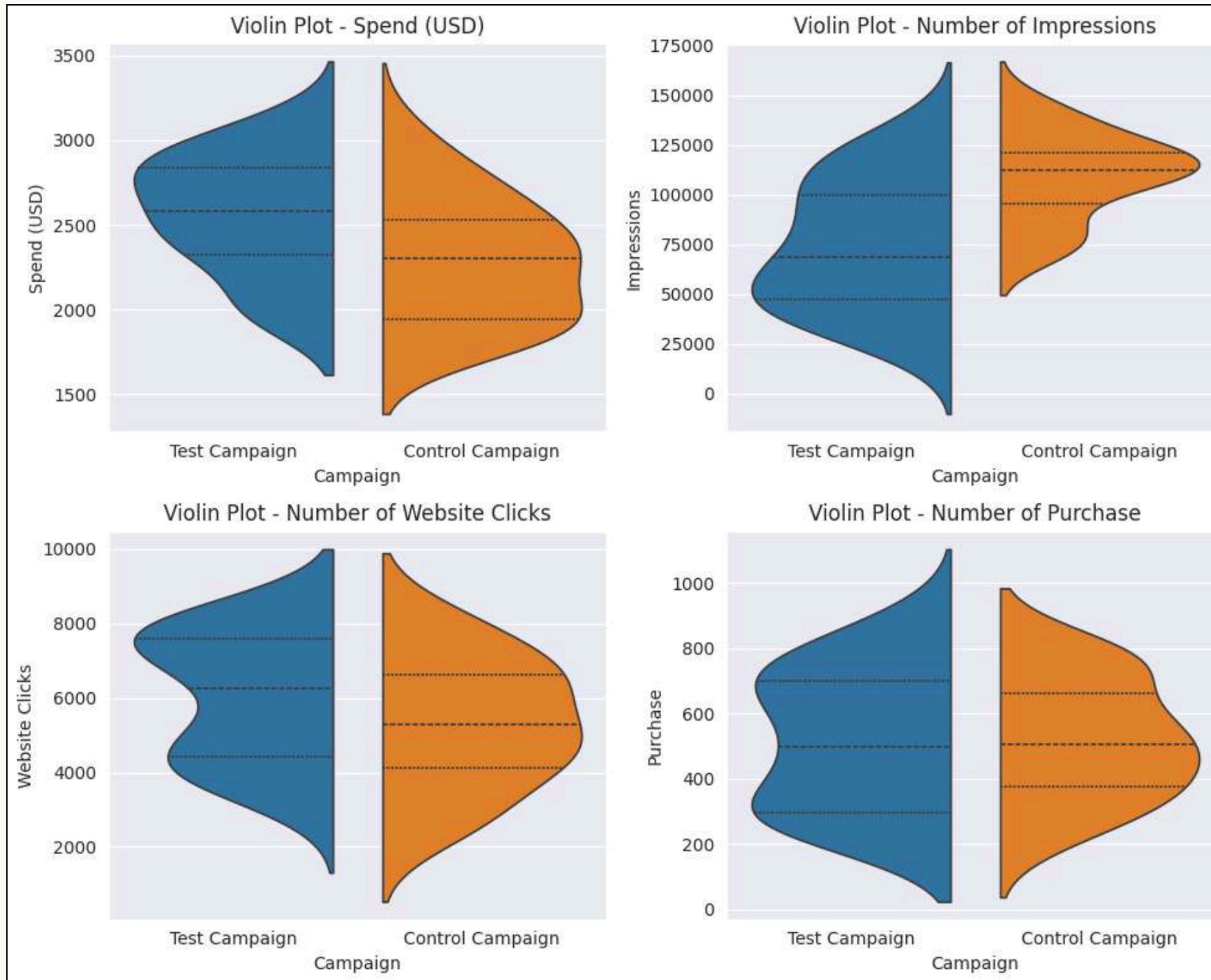


What's a Violin Plot?

Combination of:
Boxplot + Histogram



EDA + Visualisation



Why Violin Plot?

Best of both worlds:

Distribution comparison
(UQ/median/LQ)
[like boxplot]

Can identify peaks easily
[like histogram]

```

# Create a new column and perform calculations for each metric

# Click-Through Rate (CTR) - Helps measure the effectiveness of ads in attracting clicks
df['CTR'] = df['# of Website Clicks'] / df['# of Impressions']

# Conversion Rate (CR) - Shows what percentage of visitors who clicked on the ad actually made a purchase
df['CR'] = df['# of Purchase'] / df['# of Website Clicks']

# Cost Per Click (CPC) - It allows you to evaluate the efficiency of advertising expenses to generate clicks
df['CPC'] = df['Spend [USD]'] / df['# of Website Clicks']

# Cost Per Acquisition (CPA) - Refers to the average cost a company pays to acquire a new customer
df['CPA'] = df['Spend [USD]'] / df['# of Purchase']

# Show results
df.head()

```

	Campaign Name	Date	Spend [USD]	# of Impressions	# of Website Clicks	# of Purchase	CTR	CR	CPC	CPA
0	Test Campaign	2019-08-01	3008.0	39550.0	3038.0	255.0	0.076814	0.083937	0.990125	11.796078
1	Test Campaign	2019-08-02	2542.0	100719.0	4657.0	677.0	0.046238	0.145373	0.545845	3.754801
2	Test Campaign	2019-08-03	2365.0	70263.0	7885.0	578.0	0.112221	0.073304	0.299937	4.091696
3	Test Campaign	2019-08-04	2710.0	78451.0	4216.0	340.0	0.053741	0.080645	0.642789	7.970588
4	Test Campaign	2019-08-05	2297.0	114295.0	5863.0	768.0	0.051297	0.130991	0.391779	2.990885

```

# Create a bar chart for each metric
# Create a list of the columns containing the metrics
metrics = ['CTR', 'CR', 'CPC', 'CPA']

n = 1
plt.figure(figsize= (16, 5))

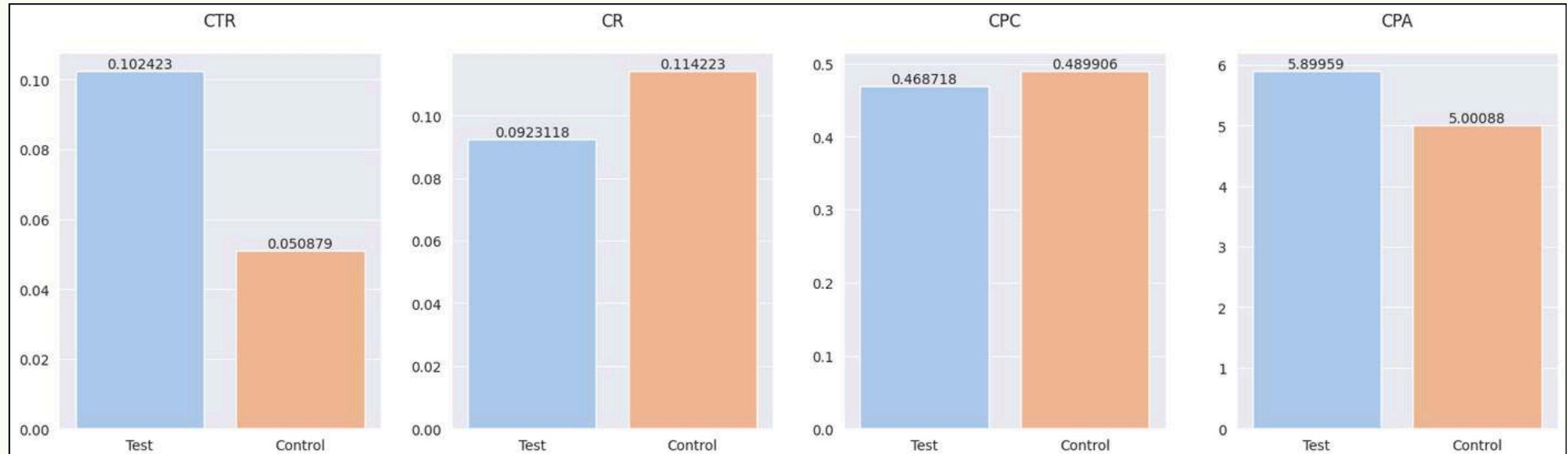
for m in metrics:
    plt.subplot(1, 4, n)

    # Create the plot
    g = sns.barplot(data=df, y=m, x= 'Campaign Name', palette = 'pastel', estimator = 'mean', errorbar=('ci', False))

    g.set_xlabel(None)
    g.set_ylabel(None)
    g.set_title(f'{m}', y =1.05)
    plt.xticks(ticks=range(2), labels=['Test', 'Control'])
    for i in g.containers:
        g.bar_label(i)

    n = n + 1
plt.tight_layout(pad = 2.2)

```



Are these differences significant??

Hypothesis Testing

CTR - Click-Through Rate

- Null Hypothesis (H_0): There is no difference in CTR between Average Bidding and Maximum Bidding.
- Alternative Hypothesis (H_1): There is a significant difference in CTR between Average Bidding and Maximum Bidding.

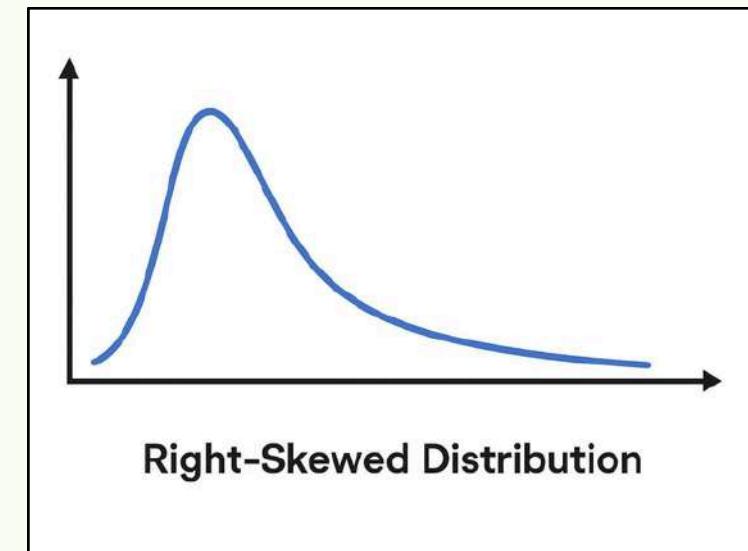
Significance level is 0.05.

```
# Performn MWU test for CTR metric  
mann_whitney_u(metric = 'CTR', alpha = 0.05)
```

Mann Whitney U test for CTR:

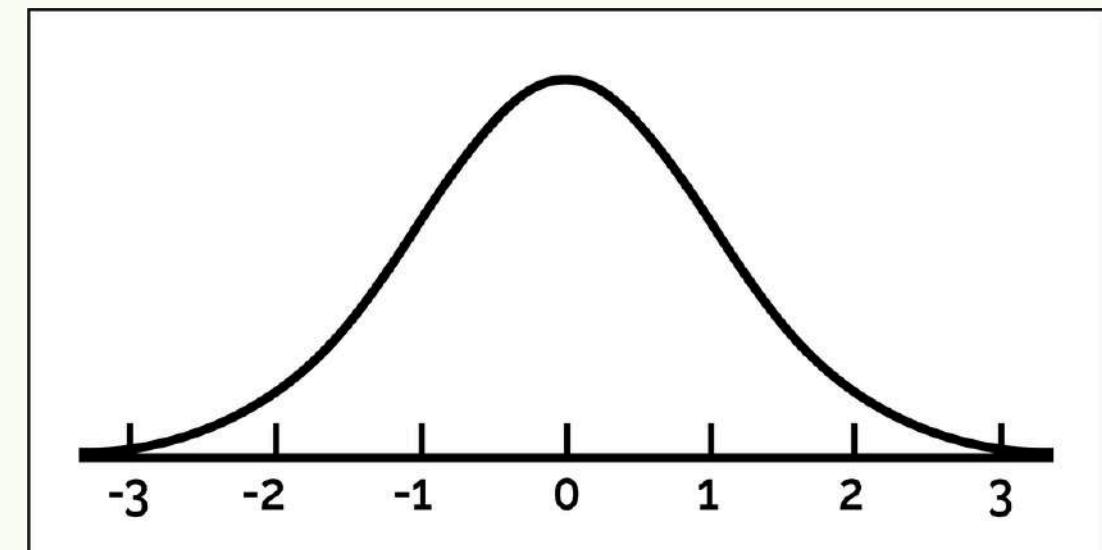
– p value is 0.00021

- Too many very low values
- Too few very high values
- Strange extreme numbers (outliers)



Assumption of Normality:

Mann–Whitney U test (a form of hypothesis test that does not assume the data is normal), unlike other tests like t-test



Hypothesis Testing

E.g. CTR - Click-Through Rate

Null Hypothesis (H0):

There is **no difference** in CTR between Average Bidding and Maximum Bidding.

Alternative Hypothesis (H1):

There is a **significant difference** in CTR between Average Bidding and Maximum Bidding.

Hypothesis Testing

Significance level is 0.05

After probability computed,

if it's:

< 0.05, reject H₀

≥ 0.05 , do not reject H₀

**Think of it as the chance that this happened by luck is very small (if p is less than 5%), so it's probably a real difference.*



Conclusion

**Not statistically
significant**

- Conversion Rate (CR)
- Cost Per Click (CPC)
- Cost Per Acquisition (CPA)

**Is statistically
significant**

- Click-Through Rate (CTR)
- Indicates that the experimental group's ads are more effective at attracting clicks than the control group

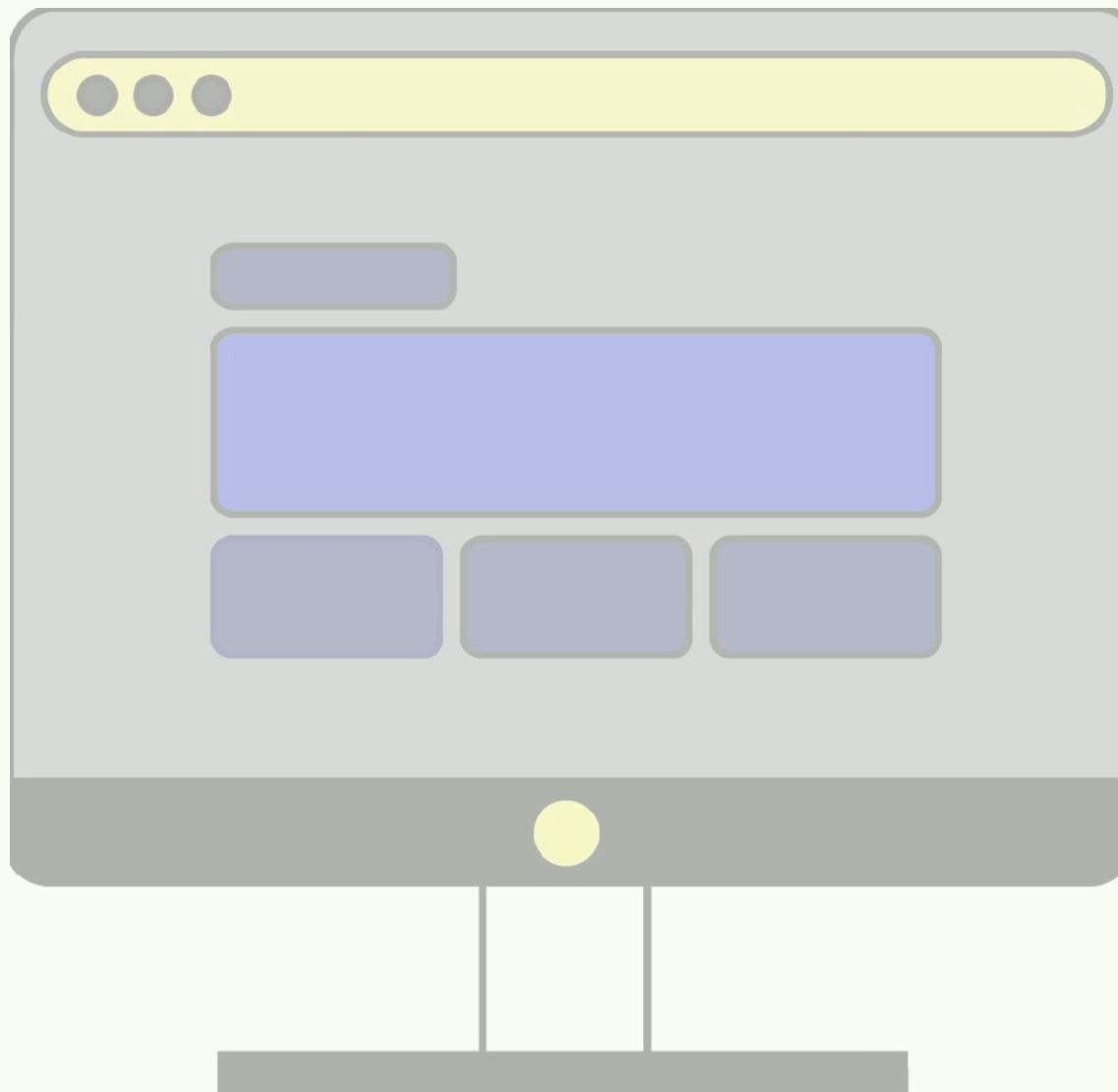
A/B Testing

Visual Website Optimiser (VWO)

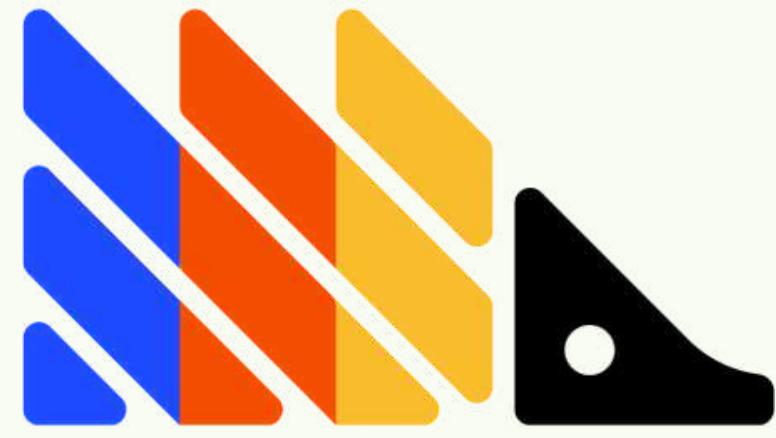
Digital Experience Platforms

Software platform that manages digital experience across a broad range of digital touchpoints (Central, integrated hub of services)

- Content Management
- Digital Asset Management
- Digital Experimentation



Digital Optimisation Tools



PostHog





Engineer-Focused

- Target Audience: High Growth Startups
- Ease of Use: Low. Relatively code-heavy
- Pricing: Generous free plan (plus easier to sign up than Optimizely)



Gold Standard for Enterprise-level Testing

- Target Audience: Enterprise-level companies
- Ease of Use: Low. For developers to run server-side tests, manage feature flags, etc.
- Pricing: Prohibitively high (5 figures)



Customer Experience Optimisation

- Target Audience: Enterprise-level companies
- Ease of Use: Medium-high
- Pricing: Prohibitively high (5 figures)



User-Friendly, Visual-First Testing

- Target Audience: Marketers & Non-technical teams
- Ease of Use: Medium-high
- Pricing: Free up to 50k users/month. Has 30-day free trial with all features enabled

Technical

Non-technical

Why VWO?

[Platform](#)[Grow with us](#)[Pricing](#)[Resources](#)[Company](#)[EN](#)[Login](#)[Get a demo](#)

[Home](#) > VWO and AB Tasty Join Forces to Redefine the Future of Digital Experience Optimization

[News](#)

• Jan 20, 2026 • 5min read

VWO and AB Tasty Join Forces to Redefine the Future of Digital Experience Optimization



ABTasty

Do you have clients in my industry? →

What kind of tests can I run? →

Ask anything about AB Tasty

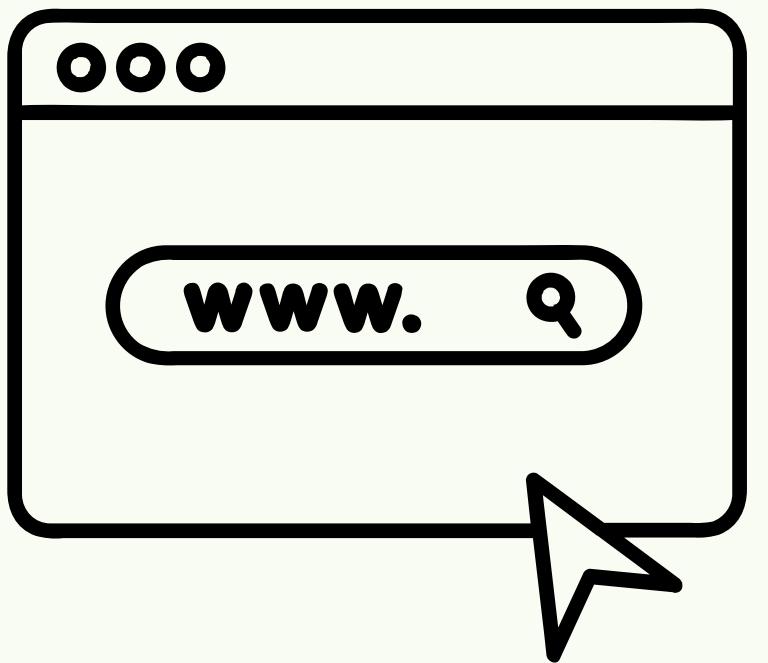
Answers may have limitations or biases · Please connect to your client area for support • AI powered by ROSE

Source: <https://www.abtasty.com/news/vwo-ab-tasty-join-forces/>

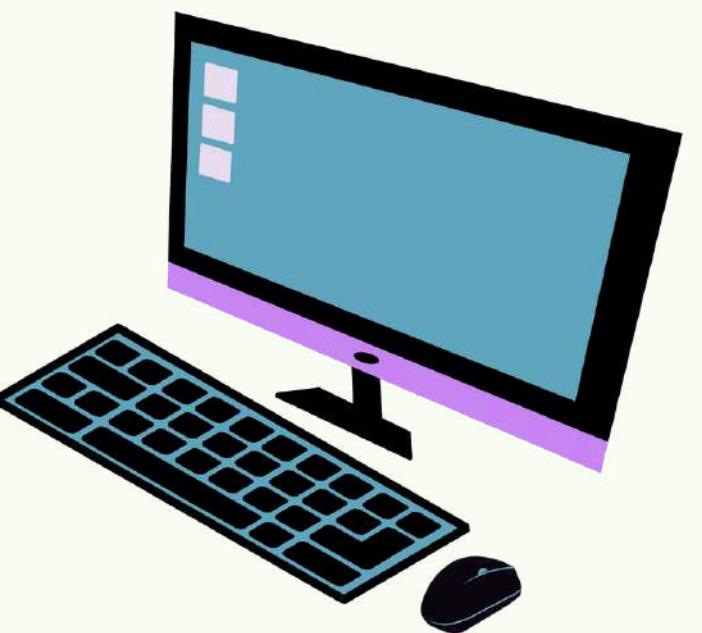
Basic Tutorial

Visual Website Optimiser (VWO)

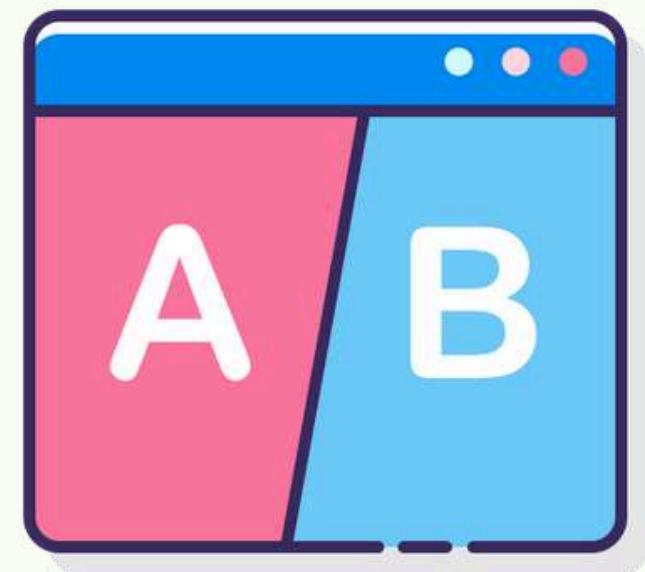
Components



Create Website



Set Up VWO Account

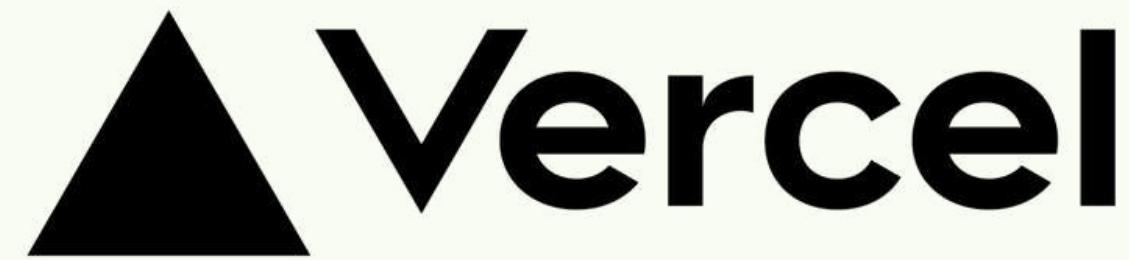


A/B Test

Create Website

For Demonstration

Website Hosting





Web-based platform that hosts software development projects

- Use Git (version control system) to allow collaborators to track changes and manage projects
- I will be using GitHub Pages (free static site hosting service) to publish the website

What is a version control system?



It's Google Doc's version history but **better**

What is a version control system?



Google Docs

Automatically saves the document itself



GitHub



For whole projects; Saving is intentional



Roll back changes to return to the last working “Commit”



“Branch” your work into a parallel universe, write crazy ideas, “Merge” the good parts back

See each other’s cursors / Edit in real-time

Static Website

- Contains fixed content that never changes, no matter who visits or when
- Examples: Resumes, Marketing landing pages

Dynamic Website

- More interactive as content can change based on user input or real-time data
- Examples: E-commerce stores, news pages, social media platforms

The screenshot shows a GitHub repository page for 'A-B-Test'. The repository is public. At the top, there are buttons for 'Pin' and 'Watch' with a count of 0. Below the repository name, it shows 1 branch and 0 tags. There is a search bar for 'Go to file' and a 'Code' button. The commit history lists three commits from 'charlesslim':

File	Commit Message	Time Ago
index.html	Update index.html	4 hours ago
README.md	Update README.md	5 hours ago
index.html	Update index.html	4 hours ago

Steps

1. Create a repository in GitHub
2. Make sure the repository is public, not private
3. Add your website file (index.html)

charlesslim / A-B-Test

Type / to search

Code Issues Pull requests Actions Projects Wiki Security Insights Settings

A-B-Test Public Pin Watch 0 Fork 0 Star 0

General

Access
Collaborators
Moderation options

Code and automation
Branches
Tags
Rules
Actions
Models
Webhooks
Copilot
Environments
Codespaces
Pages

Branch
Your GitHub Pages site is currently being built from the `main` branch. [Learn more about configuring the publishing source for your site.](#)

None Save

Branch
Your GitHub Pages site is currently being built from the `main` branch. [Learn more about configuring the publishing source for your site.](#)

`main` / (root) Save

GitHub Pages

URL

[GitHub Pages](#) is designed to host your personal, organization, or project pages from a GitHub repository.

Your site is live at <https://charlesslim.github.io/A-B-Test/>

Last deployed by  charlesslim 3 minutes ago

[Visit site](#)

[Unpublish site](#)

Build and deployment

Source

[Deploy from a branch ▾](#)

Branch

Your GitHub Pages site is currently being built from the `main` branch. [Learn more about configuring the publishing source for your site.](#)

 `main` ▾

 / (root) ▾

[Save](#)

Set Up of VWO Account

And Linking Website To VWO

We have exciting news to share! VWO and AB Tasty are joining forces.

READ MORE



VWO



See Pricing

Request Demo

NUS Email Sign up for a full-featured trial

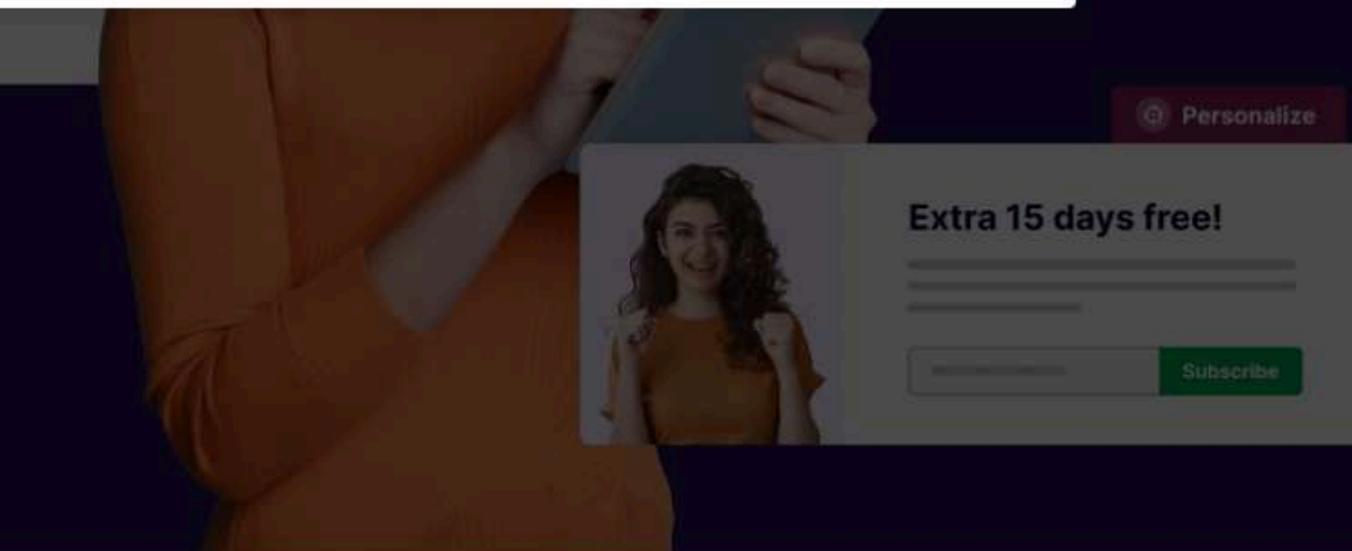
Free for 30 days. No credit card required

Business Email

hame@yourcompany.com

I agree to VWO's [Privacy Policy & Terms](#)

Start Now



Dashboard Get Started Campaigns Overview

Set Up Your Account

These tasks will help you get the most out of VWO. Let's get started!

Basic Setup Takes about 17 min

Review Data Center ✓

Review Products

- VWO Testing - Web Free Trial ?
Web Experimentation View Subscription
- VWO Insights - Web ?
Web Behavior Analytics + Start free trial
- VWO Personalize - Web ?
Web Personalization + Start free trial
- VWO Rollouts - Web Free Trial ?
Web Experience Rollouts View Subscription

⚡ Basic Setup

Manage Data

Product Setup

Privacy & Security

Integrations

Review Data Center, Review Products by VWO, Verify Account, Connect Website

Review Products



VWO Testing - Web Free Trial ?

Web Experimentation



A/B, Multivariate, Split URL Testing

[View Subscription](#)



VWO Insights - Web ?

Web Behavior Analytics

[+ Start free trial](#)



VWO Personalize - Web ?

Web Personalization

[+ Start free trial](#)



VWO Rollouts - Web Free Trial ?

Web Experience Rollouts

[View Subscription](#)



VWO Pulse ?

Voice of Customer

[+ Start free trial](#)



VWO Feature Experimentation ?

Feature experimentation, rollouts and personalization

[+ Start free trial](#)



VWO Insights - Mobile App ?

Mobile App Behavioral Analytics

[+ Start free trial](#)

Multivariate Testing

Test hundreds of distinct combinations of elements on a page and find the optimal combination of specific elements → longer test durations as a higher traffic is required to complete the test

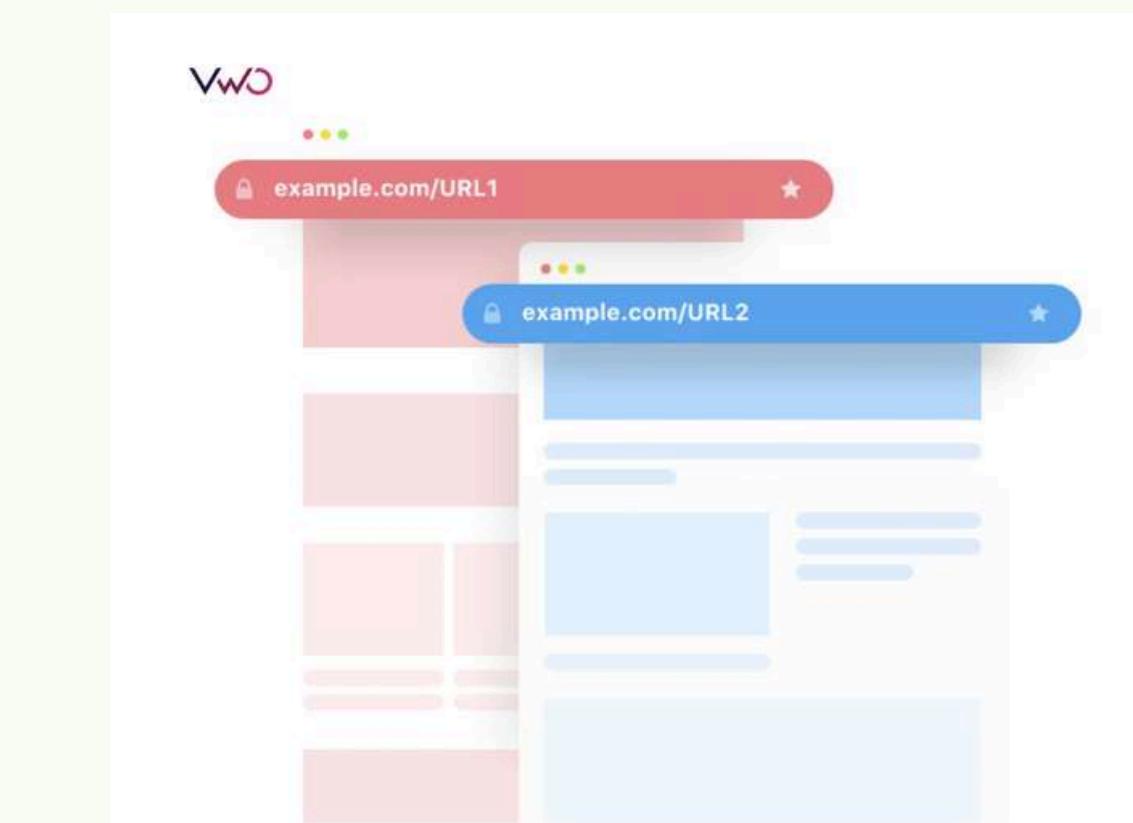
NOT THE SAME as A/B/n Testing!

- Tests multiple complete designs of a page by varying one variable at a time

Split URL Testing

Distribute traffic to multiple URLs and identify which one converts more

- Run tests on different URLs
- Validate huge website overhauls by testing completely different versions



Review Products



	VWO Testing - Web <small>Free Trial</small> <small>?</small>	<small>Web Experimentation</small>	View Subscription
	VWO Insights - Web <small>?</small>	<small>Web Behavior Analytics</small>	+ Start free trial
	VWO Personalize - Web <small>?</small>	<small>Web Personalization</small>	+ Start free trial
	VWO Rollouts - Web <small>Free Trial</small> <small>?</small>	<small>Web Experience Rollouts</small>	View Subscription
	VWO Pulse <small>?</small>	<small>Voice of Customer</small>	+ Start free trial
	VWO Feature Experimentation <small>?</small>	<small>Feature experimentation, rollouts and personalization</small>	+ Start free trial
	VWO Insights - Mobile App <small>?</small>	<small>Mobile App Behavioral Analytics</small>	+ Start free trial



Understand user interactions with heatmaps & session recordings

Heatmaps

Generate a visual report of click behavior on a webpage for any group of visitors and time period

- Visualise click counts, click area of web elements
- **Scrollmap** shows where viewers stop scrolling past
- Use **Frictionmap** where users faced struggle (Plots rage clicks and dead clicks)
 - Rage clicks: rapid, repeated clicks or taps on an unresponsive website element, signaling extreme user frustration
 - Dead clicks: user clicks or taps on a webpage element (like text, an image, or a button) that produces no action, navigation, or visual feedback

Session Recordings

Record and playback individual visitor sessions on your website

- See rage clicks, mouse trails to understand user experience

Authentic Apparel

Light pink tropic print shirt



\$38.3

Men's light pink linen
tropical shirt with soft
finish. Available in
different colors.

M

XL

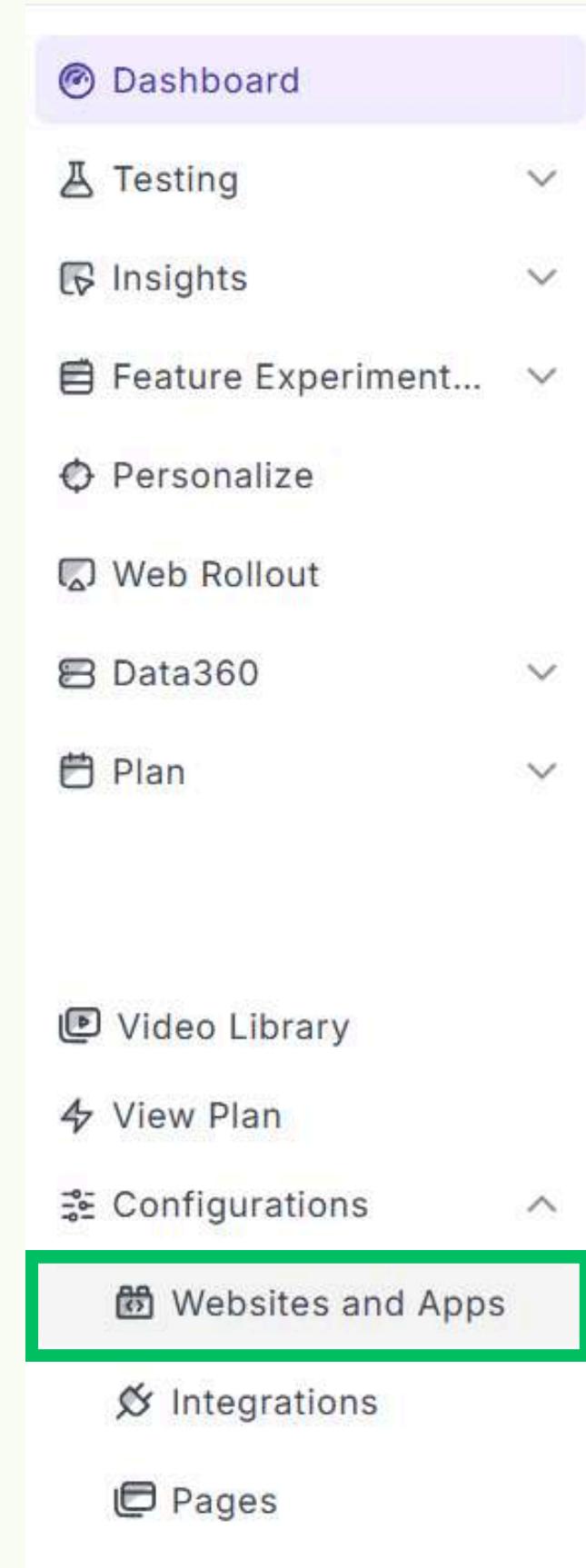
HEATMAP

CLICK MAP

CLICK AREA

SCROLLMAP

ELEMENT LIST



The sidebar menu includes:

- Dashboard
- Testing
- Insights
- Feature Experiment...
- Personalize
- Web Rollout
- Data360
- Plan
- Video Library
- View Plan
- Configurations
- Websites and Apps (highlighted with a green box)
- Integrations
- Pages



Websites and Apps

View details of and manage all websites, mobile apps and server-side projects you have added to VWO.

Search Websites and Apps

Add new

Name	Domain	Type	Status	Last activity
No properties found				



Choose one to connect

Website 0/1 consumed
Use domain name to generate and install SmartCode for your websites deployed on the internet

Connect

Mobile App Insights
Use API key and install SDK for your iOS/Android apps

Connect

Feature Experimentation
Install an SDK and create feature flags to get started

Connect

Add domain name

Enter domain

example.com **paste domain/URL**

Automatically register and track all sub-domains

ⓘ Why is this needed?

Your domain name is used to generate the SmartCode and helps us auto-verify the installation.



Back

Cancel

Add domain

Steps to install HTML SmartCode

1. Copy the generated SmartCode below  [Copy SmartCode](#)
2. Paste the generated code in the head section of your website. [Learn More](#) 
3. Verify the installed SmartCode

SmartCode 2.2
Code size: 5.4KB

```
1  <!-- Start VWO Async SmartCode -->
2  <link rel="preconnect" href="https://dev.visualwebsiteoptimizer.com" />
3  <script type='text/javascript' id='vwoCode'>
4  window._vwo_code ||
5  (function () {
6    var w=window,
7      d=document;
```

 Expand  Share  Copy 

Discover best practices for using VWO SmartCode Effectively [VWO SmartCode Effectively](#).

1. Copy SmartCode
2. Paste SmartCode into head section
of website



<head>
.....
</head>

Check if SmartCode is installed properly on your URL

The URL will open in a new tab in your browser. It will close automatically in 30 seconds once the check is complete.

Check

Last checked on <https://charlesslim.github.io/A-B-Test/> on January 31st, 2026 5:32:07 PM

Check if SmartCode is installed properly by pasting the URL into the box.
A message below will confirm if SmartCode is installed properly.

A/B Testing

Visual Website Optimiser (VWO)

Dashboard

Testing

A/B

Multivariate

Split URL

Insights

Feature Experiment...

Personalize

Web Rollout

Data360

Plan

A/B Test multiple variations of your landing page and find which one converts the best

Need optimization ideas? Use AI to generate new ideas for A/B Test Try now

Create with Copilot

Create

Back to campaigns list

Campaign 3

Start test

Configuration Copilot Early Access

URL matches Save to Data360 for future use

+ Include pages - Exclude pages

URL Validator

[← Back to campaigns list](#)

Campaign 3

[Start test](#)



Configuration  Review Reports

Pages 

Variations 

Metrics 

Audience and Traffic
Segmentation

More configurations >

Variations

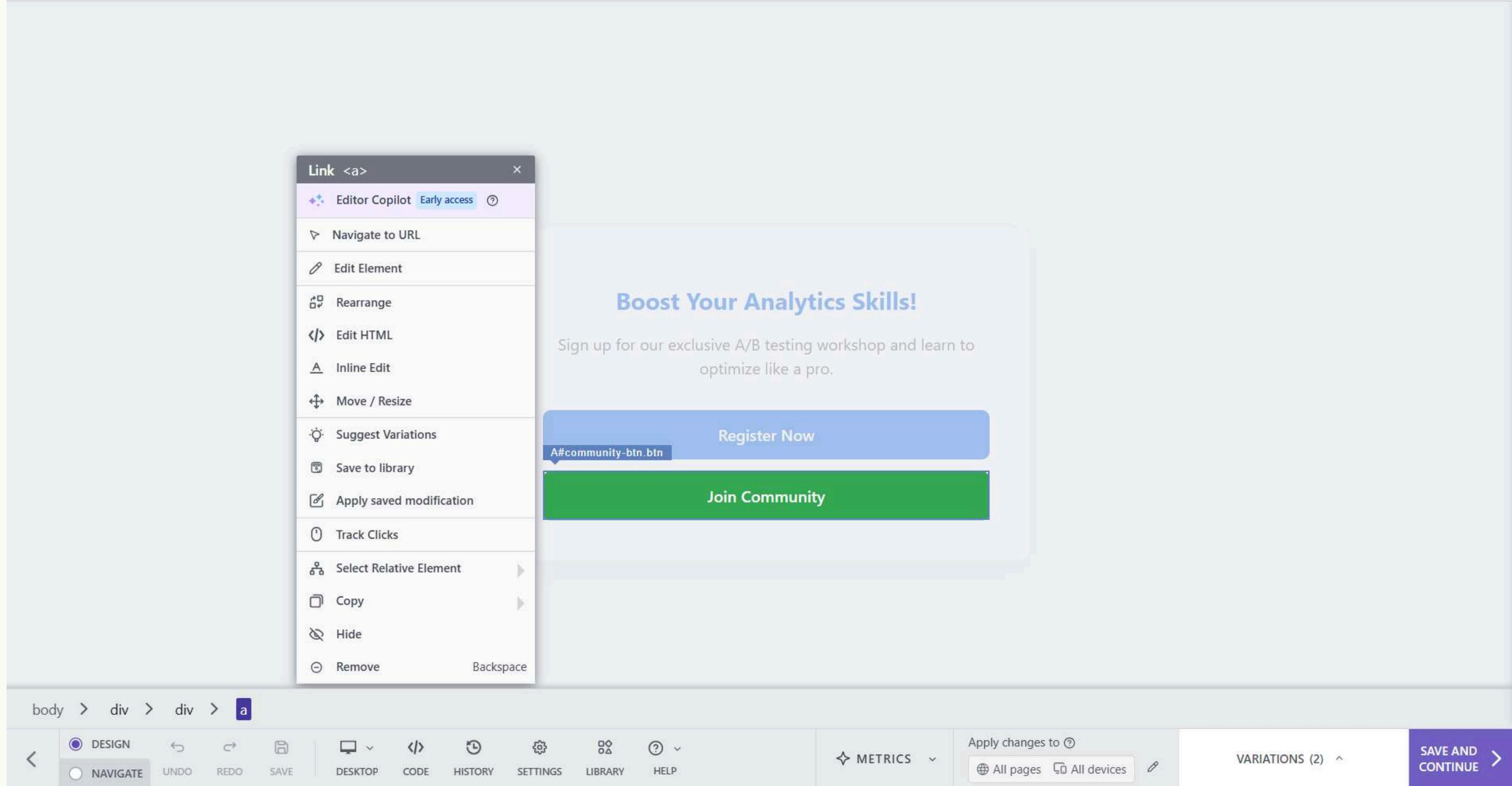
Create variations using Visual Editor or Code Editor

Editor URL:

View mode  Desktop 

Variation Name	Modifications	Traffic split: Equal	Edit with: Visual editor	
 Control	-	50.00% 	View	
 Variation 1	0	50.00% 	Launch Editor	
+ Add variation				

Add variation and launch the visual editor to make changes



Click on webpage elements (e.g. buttons) to trigger this interface. Make edits before clicking on “Track Clicks” to apply the primary metric

The screenshot shows the VWO (Visual Website Optimizer) software interface. On the left, a modal window titled "Boost Your Analytics Skills!" is displayed. It contains a headline, a description, and two buttons: "Register Now" (red) and "Join Community" (green). The modal has a blue header bar labeled "DIV.container". At the bottom of the screen, the VWO toolbar includes buttons for DESIGN (selected), NAVIGATE, UNDO, REDO, SAVE, DESKTOP, CODE, HISTORY, SETTINGS, LIBRARY (highlighted with a green box), and HELP. To the right of the toolbar is the "METRICS" section, which shows one metric across all pages and devices. Below the metrics are sections for "VARIATIONS" (2) and "SAVE AND CONTINUE".

On the right side of the interface is the "Library" panel. The title bar says "Library" with a search bar below it. Below the search bar are tabs for "VWO Gallery" (selected) and "My Library". Under "VWO Gallery", there are two tabs: "Widgets" (selected) and "Basic elements". The "Widgets" tab displays a list of ready-made functionality options:

- Banners:** Promotion banner (represented by a purple and white banner icon).
- Modals:**
 - Image pop-up (represented by a purple and white image icon).
 - Form pop-up (represented by a purple and white form icon).
- Subscription pop-up -** (represented by a purple and white subscription icon).
- Subscription pop-up -** (represented by another purple and white subscription icon).

Below the list of widgets is a note: "Add new functionality on the page using ready-made Widgets".

Click on library to add features to your website without coding at all

Boost Your Analytics Skills!

P#description

Sign up for our exclusive A/B testing workshop and learn to optimize like a pro.

[Register Now](#)

[Join Community](#)

Control Variant

Boost Your Analytics Skills!

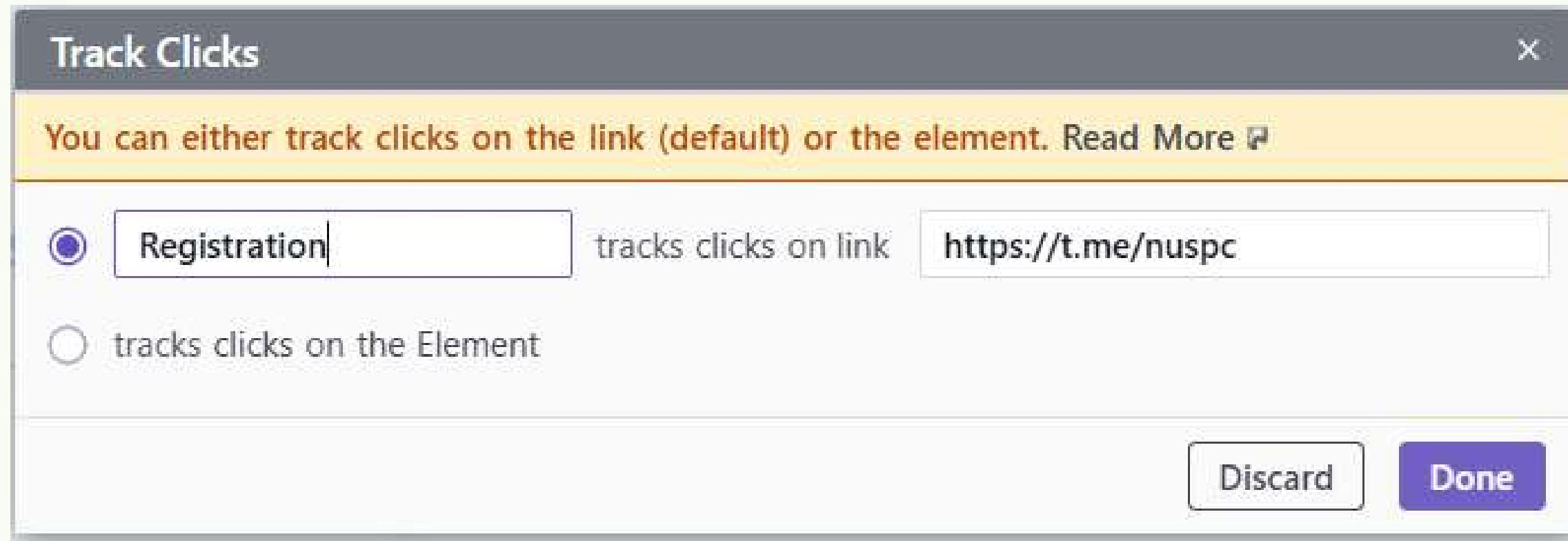
P#description

Sign up for our exclusive A/B testing workshop and learn to optimize like a pro.

[Register Now](#)

[Join Community](#)

Test Variant



We can choose to either track clicks on the link or the button

[← Back to campaigns list](#)

A/B Test

 Start test



Configuration Review Reports

Pages 

Variations 

Metrics 

Audience and Traffic

Segmentation

More configurations >

Primary metric (required)

Primary metric is the key performance indicator that directly influences test outcomes and determines decisions and winners

▼  M1 Registration Created in Editor Add as guardrail 

Definition
Tracks clicks on link
where URL matches <https://t.me/nuspc>

Metric measures Unique visitors
Direction of Better : Increase

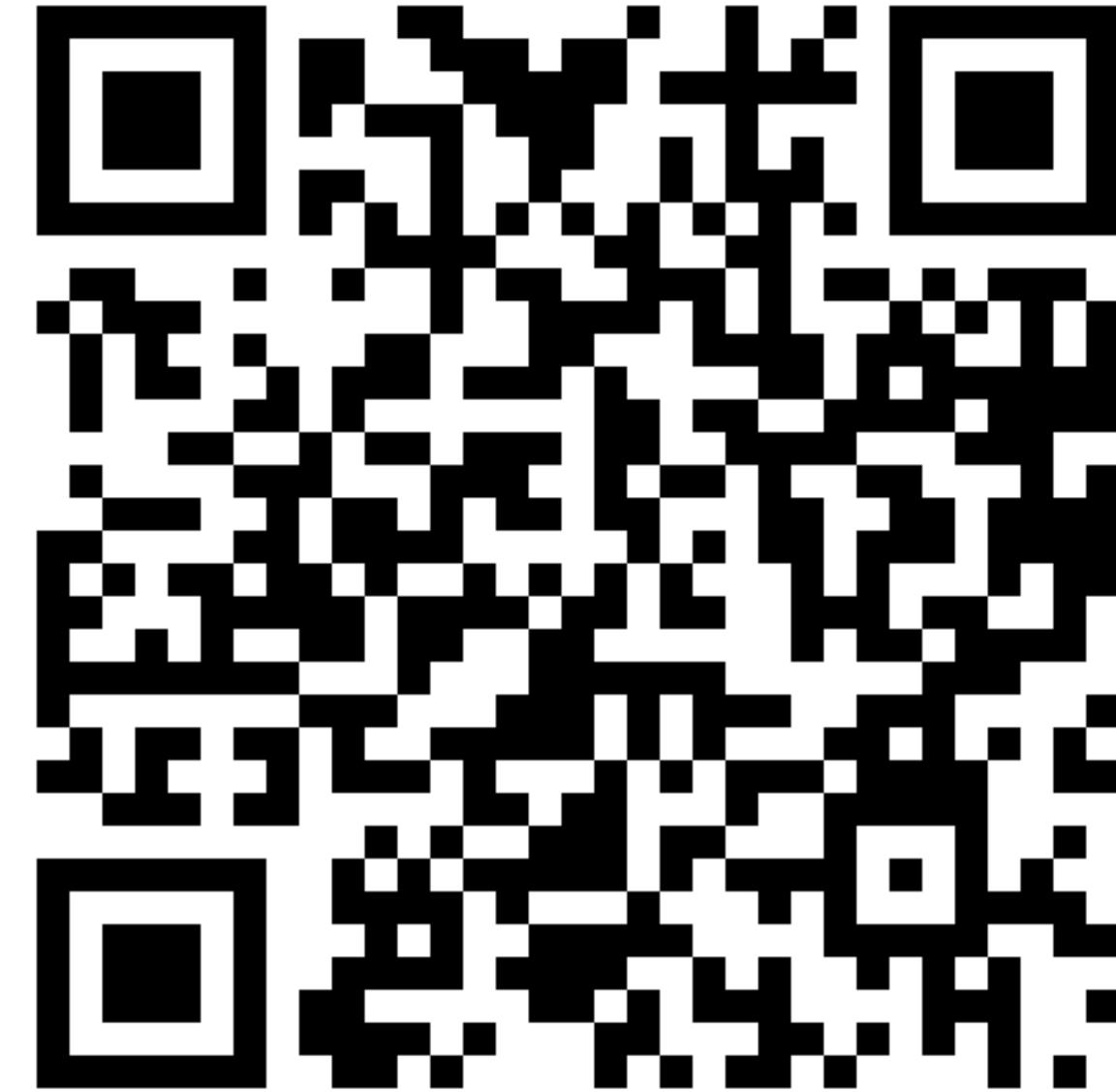
Statistical Parameters

Testing Objective	: Better
Minimum Detectable Effect	: ±20% of baseline average
Region of Practical Equivalence	: ±1%
Statistical Power ($1 - \beta$)	: 80%
False Positive Rate (α)	: 10%

Simulation

People on the left:

- Click green for Control
- Click red for Test



People on the right:

- Exit page for Control
- Click either button for Test

Scan the QR code to visit the page!

<https://charlesslim.github.io/A-B-Test/>

Open the weblink in incognito mode and fully close the window before reopening the weblink

Sample Results by VWO

← Back to campaigns list

Report ⓘ

AB Sample Report

Campaign paused

Start Campaign

Configuration Review Reports

Metrics Compare

M1 Add_to_Cart Primary

M2 Bounce rate

Behavior Analysis

Heatmaps

Session Recordings

Experiment Vitals

Date Filter: Dec 19, 2024 - Jan 05, 2025

Visitor Segments: All Visitors

Visitor Dimensions

M1 Add_to_Cart

Variation 1 is equivalent to or better than baseline

An improvement of **↑78.67%** ($\pm 2\%$) can be expected with a 92% probability of being better.

Rollout Variation: ↑V1

Conclusion arrived **355 days earlier** than expected.

In-depth data review

Configuration Review Reports

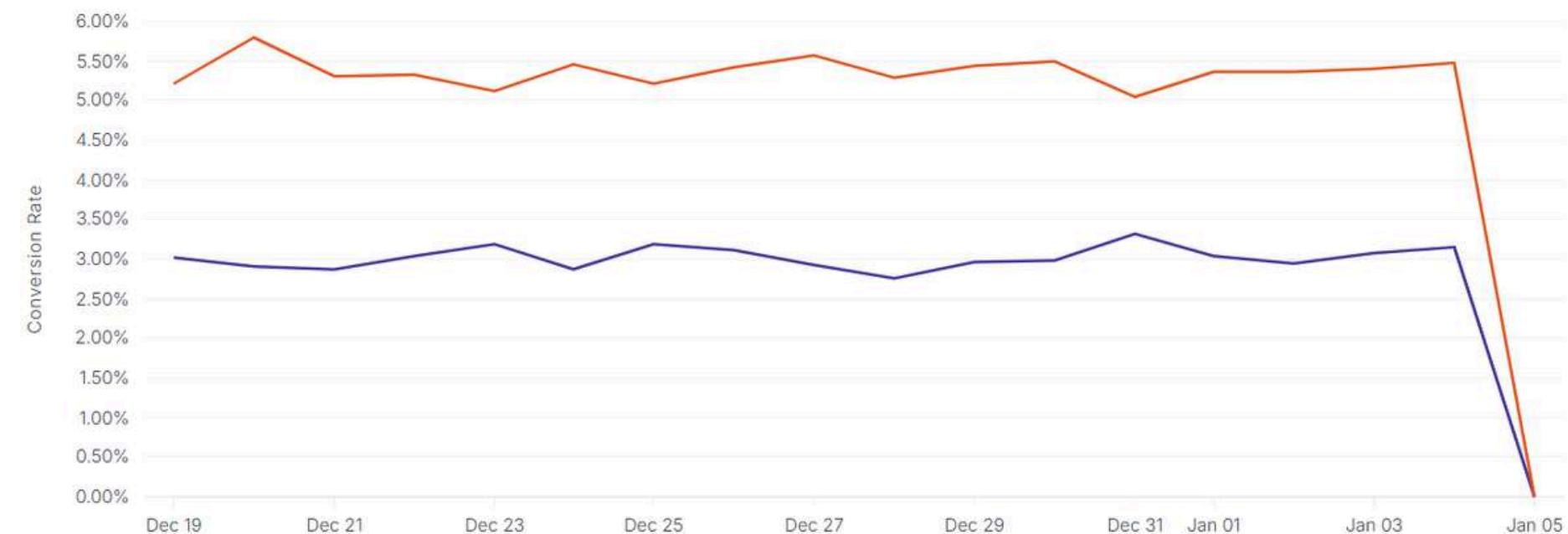
Metrics Compare

Variations

	Variations	Unique Conversions/Visitors	Expected Conversion Rate	Expected Improvement	Decision Probabilities
-101%	Control Baseline	307 / 10,186	3.00%	-	MDE: ±17% ROPE: ±1% Power: 80% FPR: 16%
-51%	Variation 1	545 / 10,144	5.36%	78.67%	Better or Equivalent to Baseline 99.98%
0%	Total	852 / 20,330	-	-	-
51%					
101%					

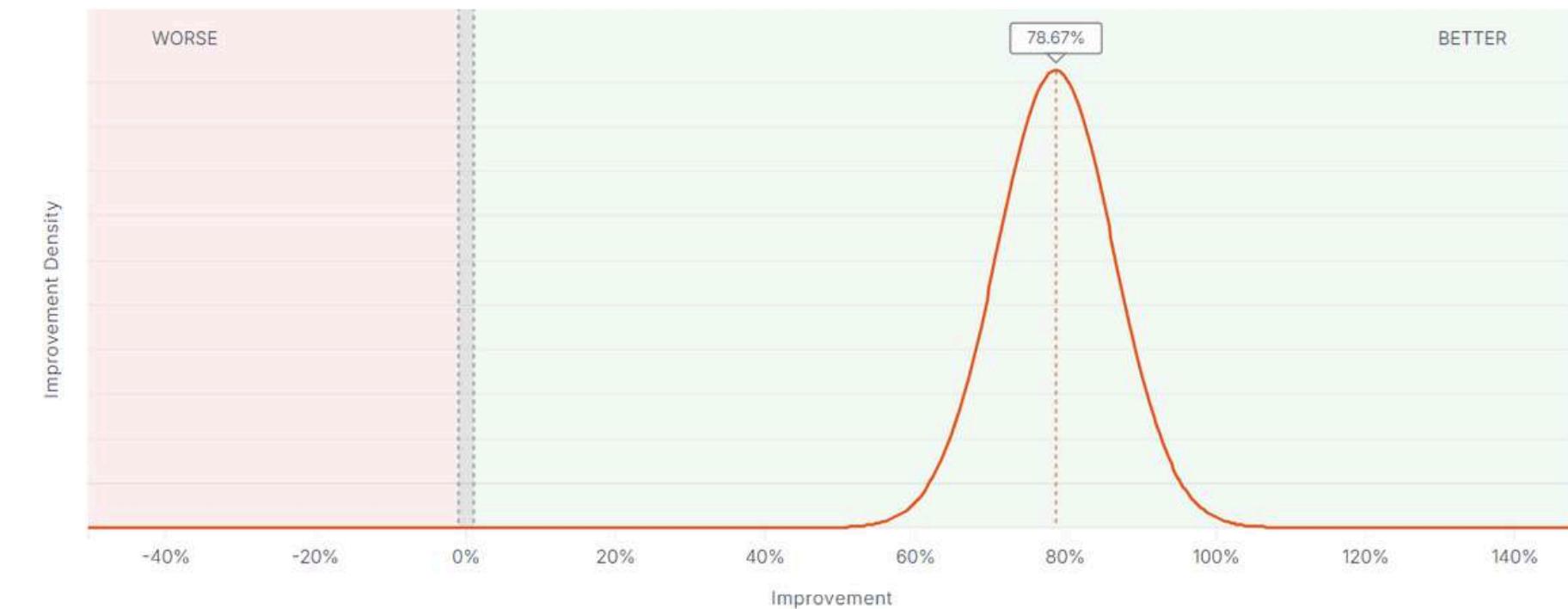
Conversion Rate ▾ Daily ▾

Show ranges ⓘ



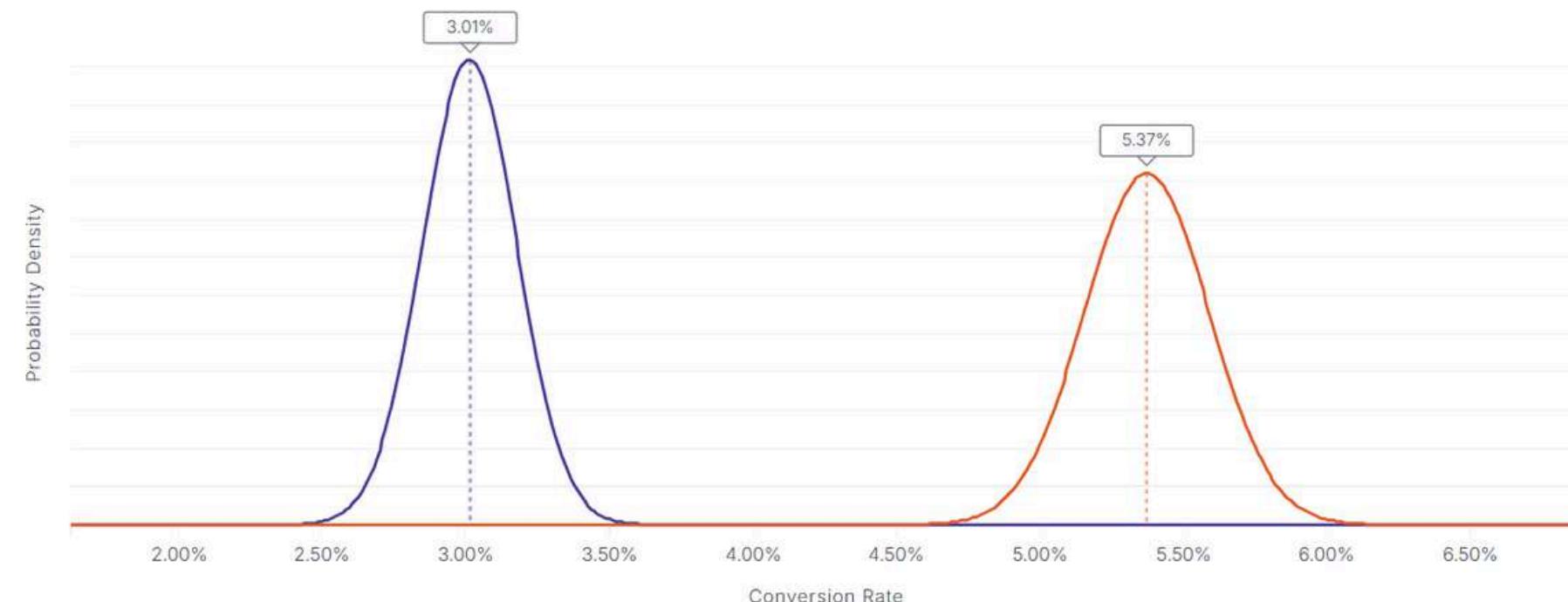
C Control V1 Variation 1

ⓘ Understand the graph



V1 Variation 1

ⓘ Understand the graph



C Control V1 Variation 1

ⓘ Uncertainty Overlap ⓘ

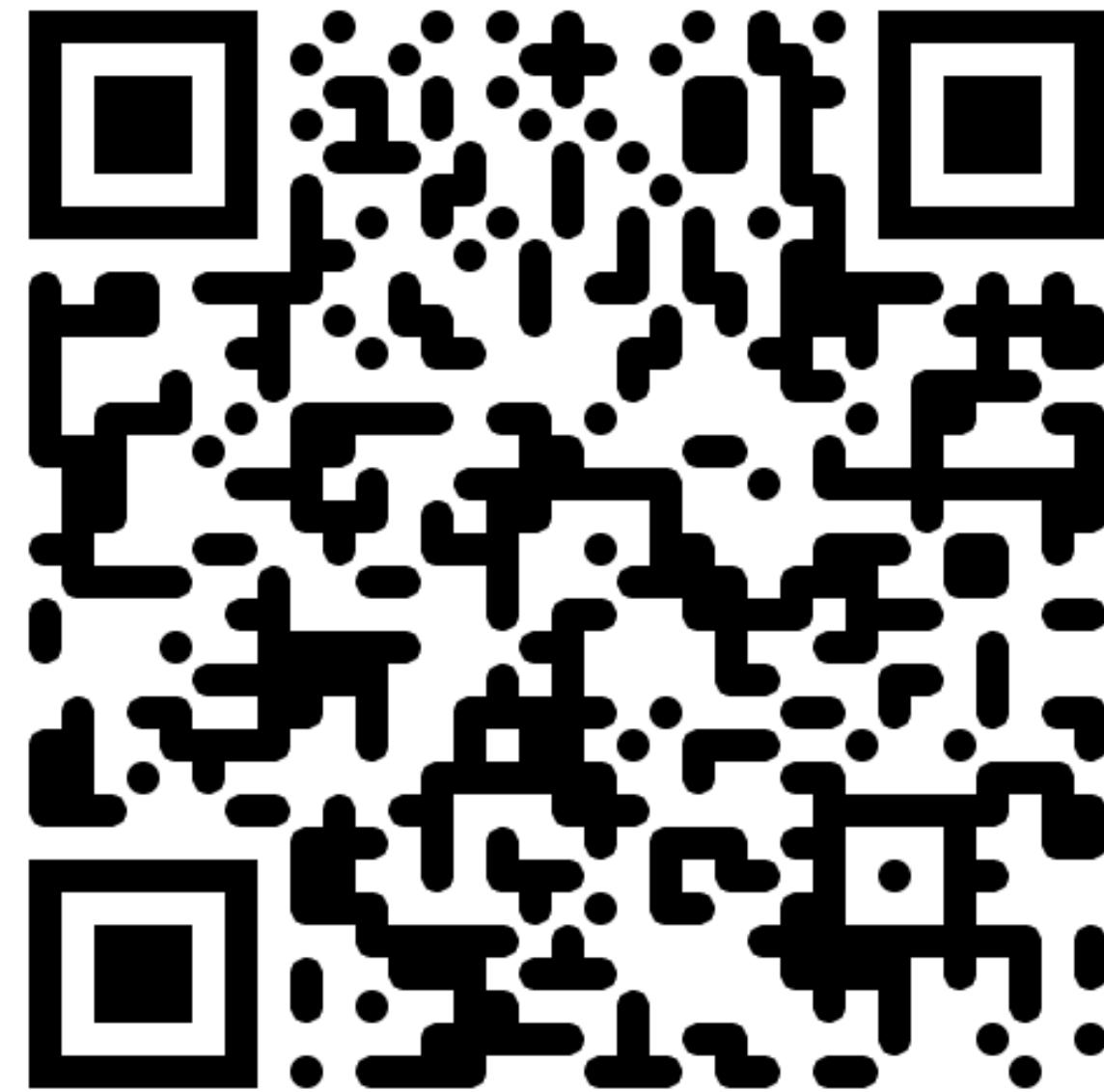
Graphs



Thank you!

Do you have any questions?

FEEDBACK FORM



Please help fill in so we can improve future workshops for you!

SLIDES WILL ALSO BE ON

Github

<https://github.com/NUS-SDS-Workshops/AY-25-26-Public>



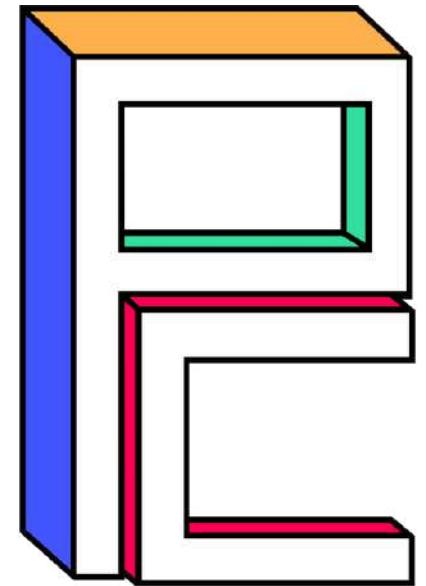
All SDS workshops code and slides will be on there. Do consider ★ starring ★ to stay updated!

MORE WORKSHOPS COMING THIS SEMESTER



- Week 6 Thursday: Azure Cloud Platform for Data Science**
- Week 9: Collab with AI Society - RL/NLP Workshop**
- Week 10: MEGA WORKSHOP (will reveal soon)**

So follow our telegram @nussds or instagram @nus.sds to stay updated!



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