Financial Analytics

Lesson 04 | Randomized Controlled Trials (RCTs) and Matching for Causal Inference

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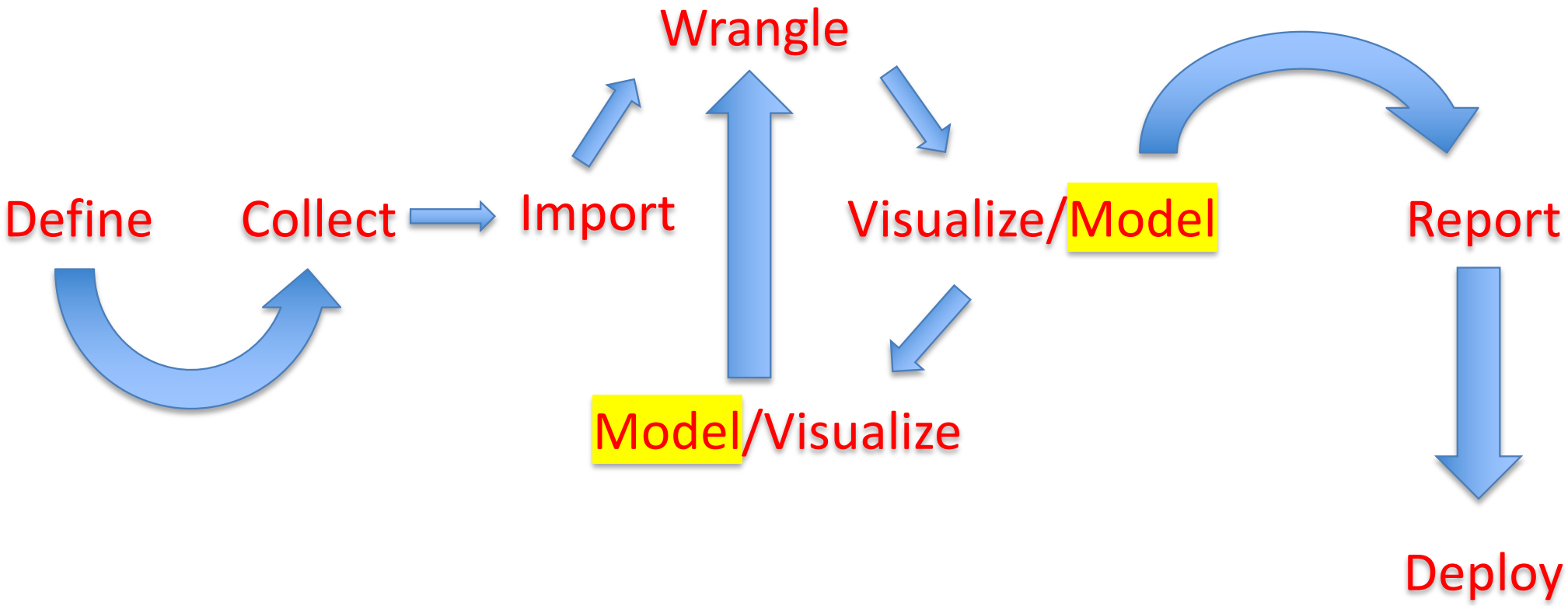
AY 2024-2025 April-Term | **QF627 Extras** | 2025-05-06

SMU Singapore Management University
Lee Kong Chian School of Business

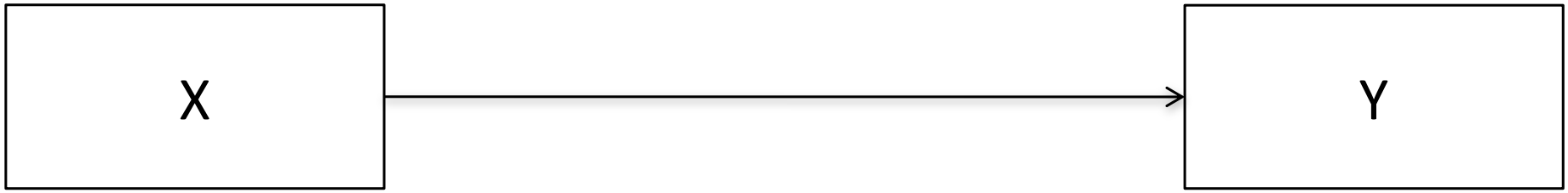
Workflow of Data-Driven Decision Making



How to make a confident claim of X leads to Y (Understanding randomized experiment, a.k.a., A/B RCTs)

Elements of Causal Effects

$$y = f\ (x)$$



Three Necessary (NOT sufficient) Conditions of Causality

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1. Correlation

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1. Correlation

2. Time Lag (Temporal Precedence)

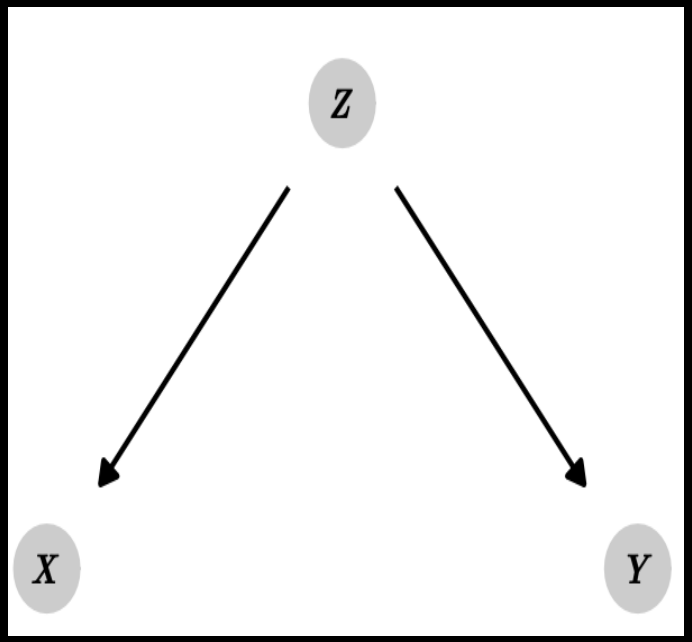
Three Necessary (NOT sufficient) Conditions of Causality

1. Correlation

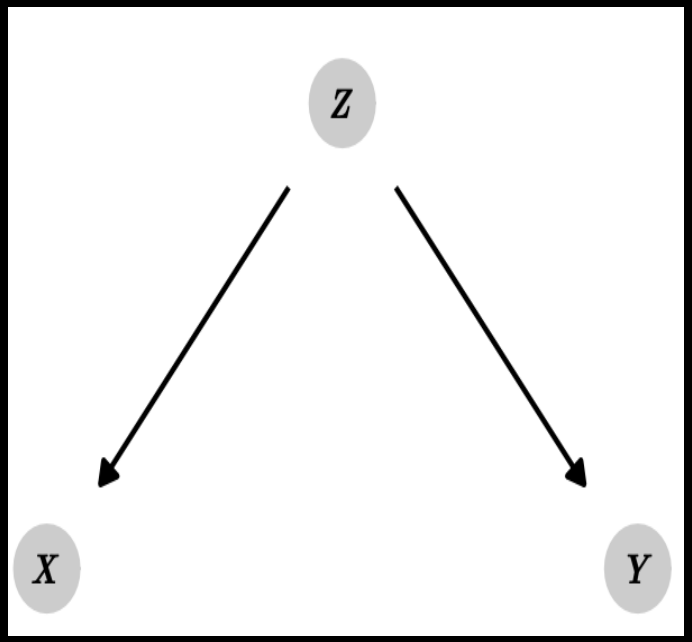
2. Time Lag (Temporal Precedence)

3. Non-Spuriousness
   (Addressing Confounders)

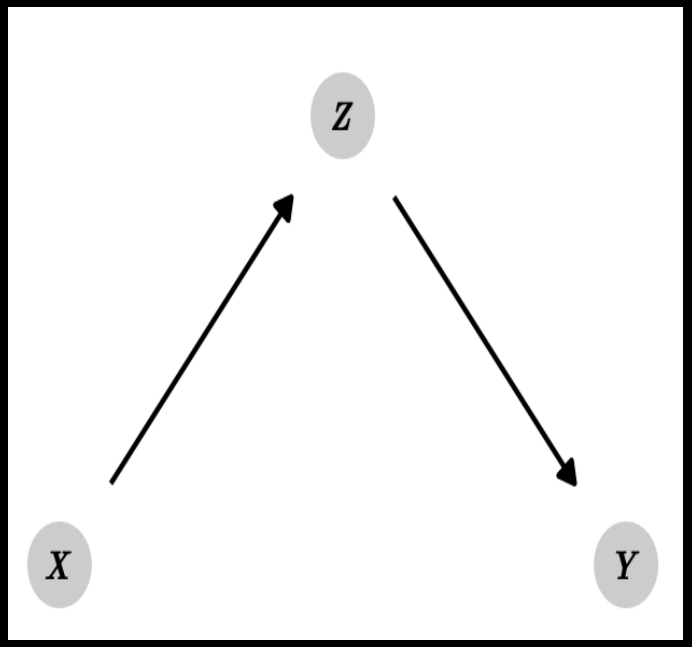
Confounder



Confounder



Mediator



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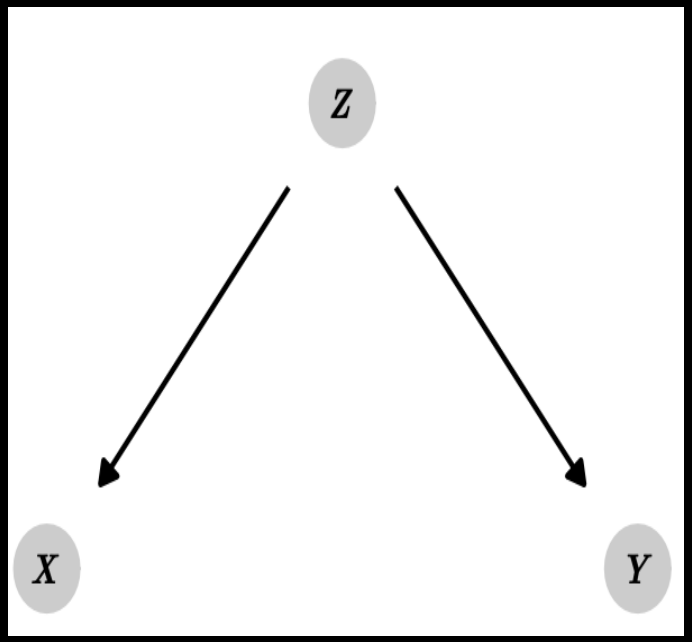

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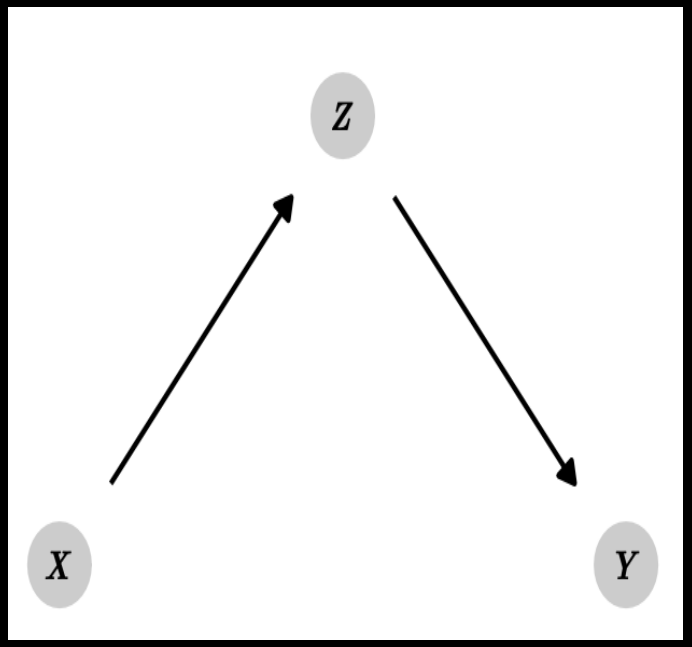
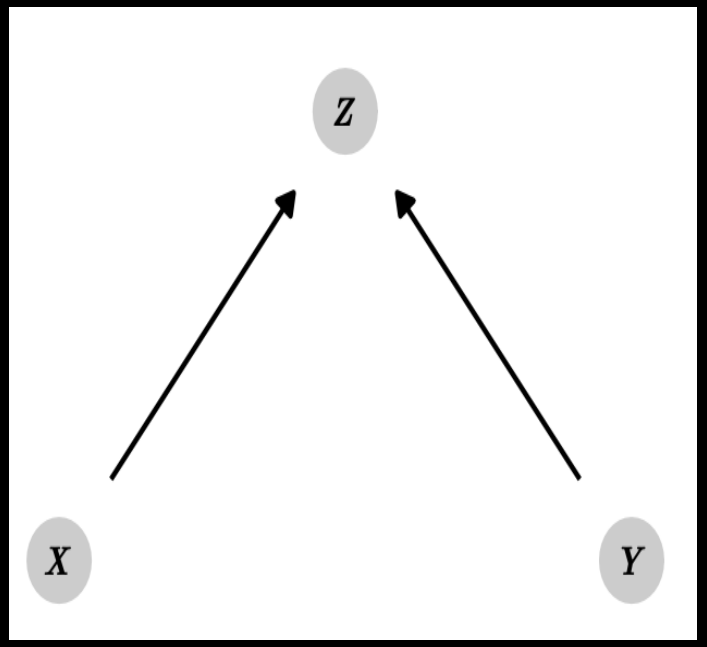


Collider



Data Collection Methods (Study Design)

Observational Studies

Collect data in a way that does not directly interfere with how the data arise ("observe")

Only establish an association

Experimental Studies

Randomly assign subjects to treatments

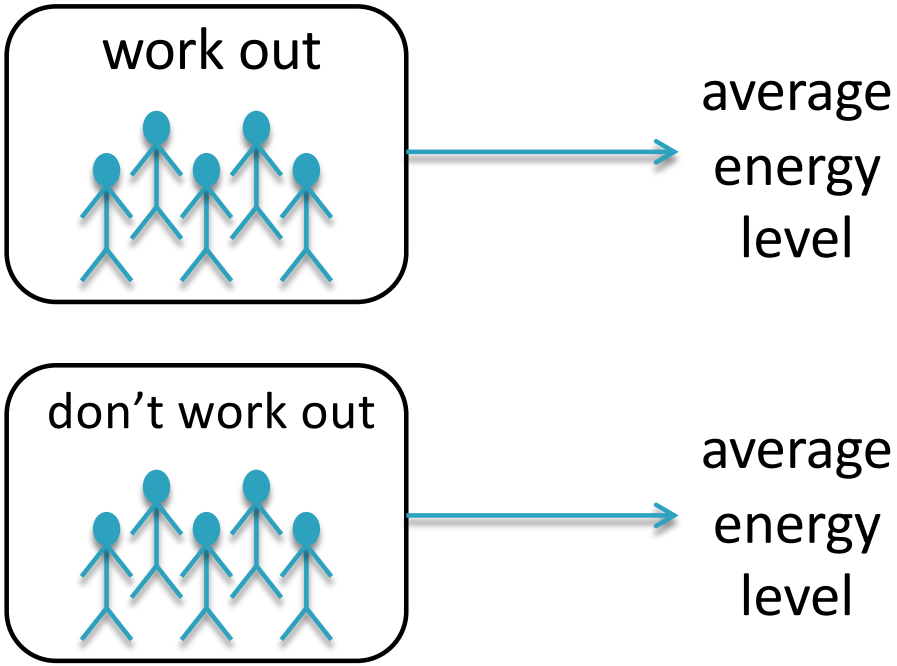
Establish causal connections

Q: Evaluate the relationship between regularly working out and energy level

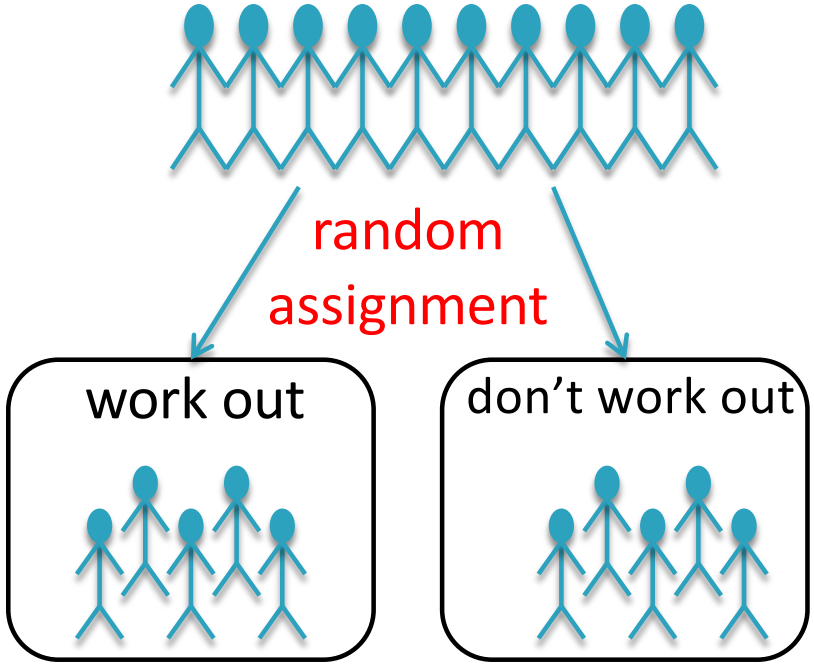
Random Assignment

Q: Evaluate the relationship between regularly working out and energy level

Observational Studies



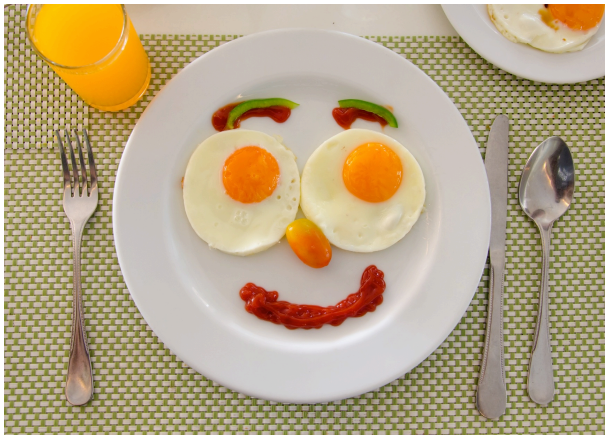
Experimental Studies

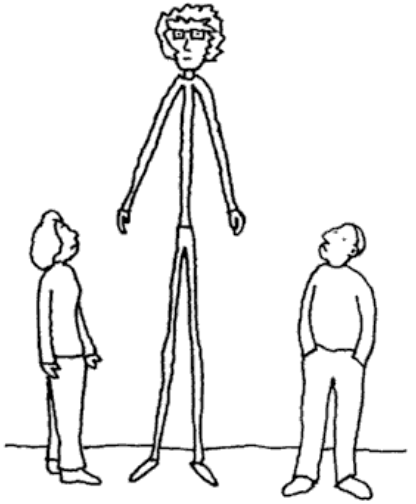


Let’s do some exercise.

3 Plausible Explanations

Eating breakfast causes girls to be slimmer



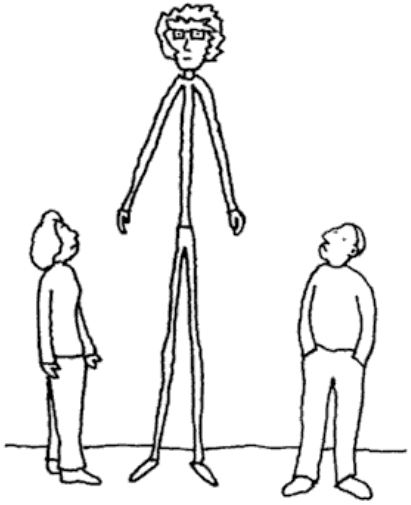


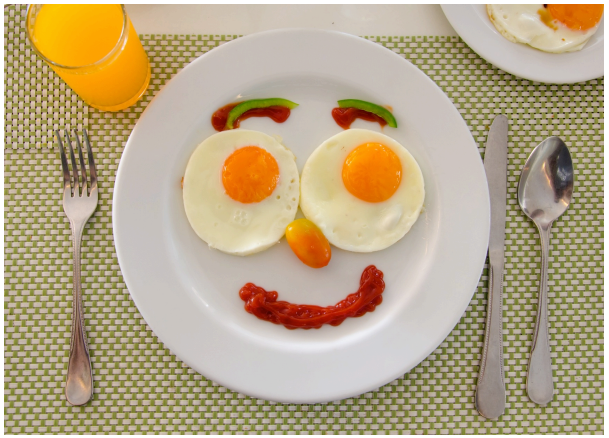
http://pas-wordpress-media.s3.amazonaws.com/wp-content/uploads/2014/03/Culture-Eats-Strategy-For-Breakfast.jpg

http://2.bp.blogspot.com/-b_7DdJVRo_A/UsUGJfKRfBI/AAAAAAAACWg/vzKksyjLvTI/s1600/me-tall.gif

3 Plausible Explanations

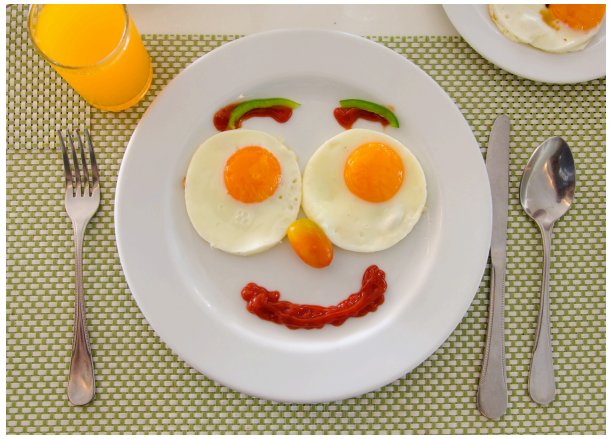
Being slim causes girls to eat breakfast

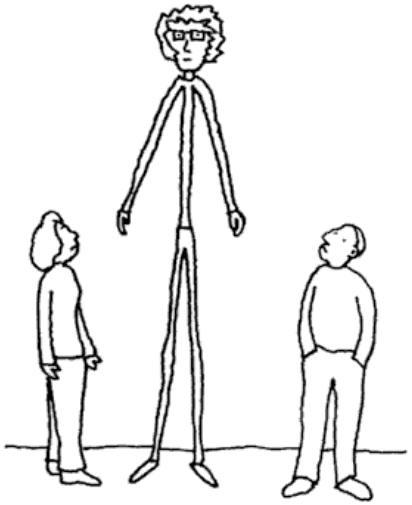




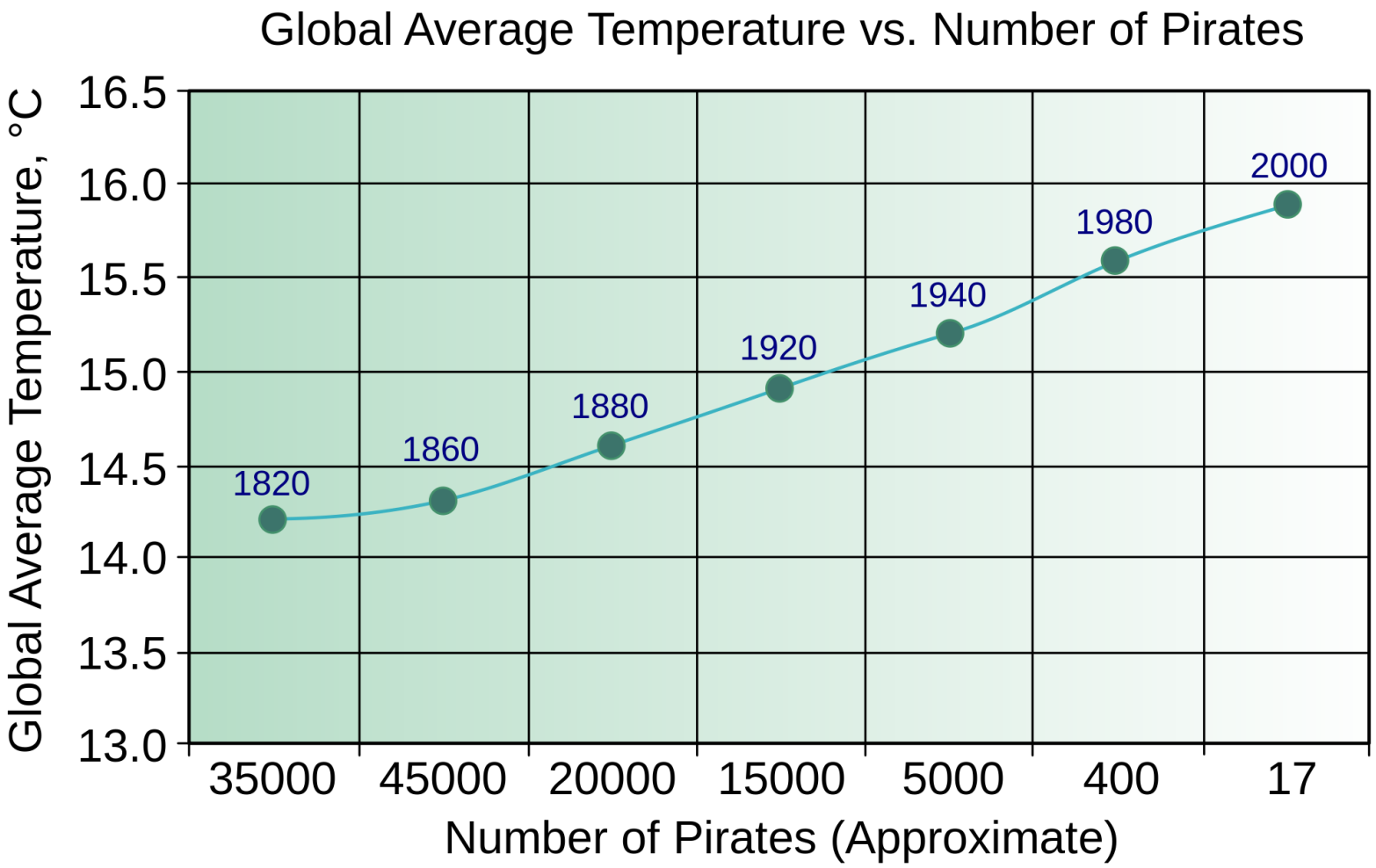
Extraneous variables that affect both the independent and the dependent variable, and that make it seem like there is a relationship between them

Confounding Variables





Correlation Does NOT Imply Causation



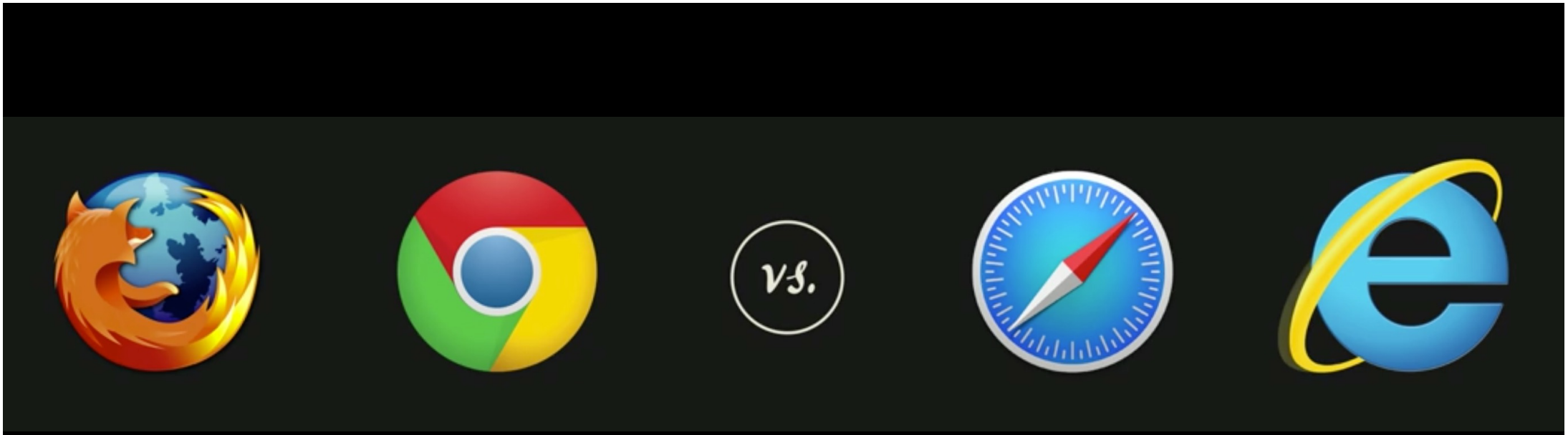
https://upload.wikimedia.org/wikipedia/commons/thumb/d/de/PiratesVsTemp(en).svg/2000px-PiratesVsTemp(en).svg.png

Some executives still mistakenly believe that all they need to do is establish correlation, and causality can be inferred.

Oh Dear… That's Wrong T.T

Let’s do some further exercise.

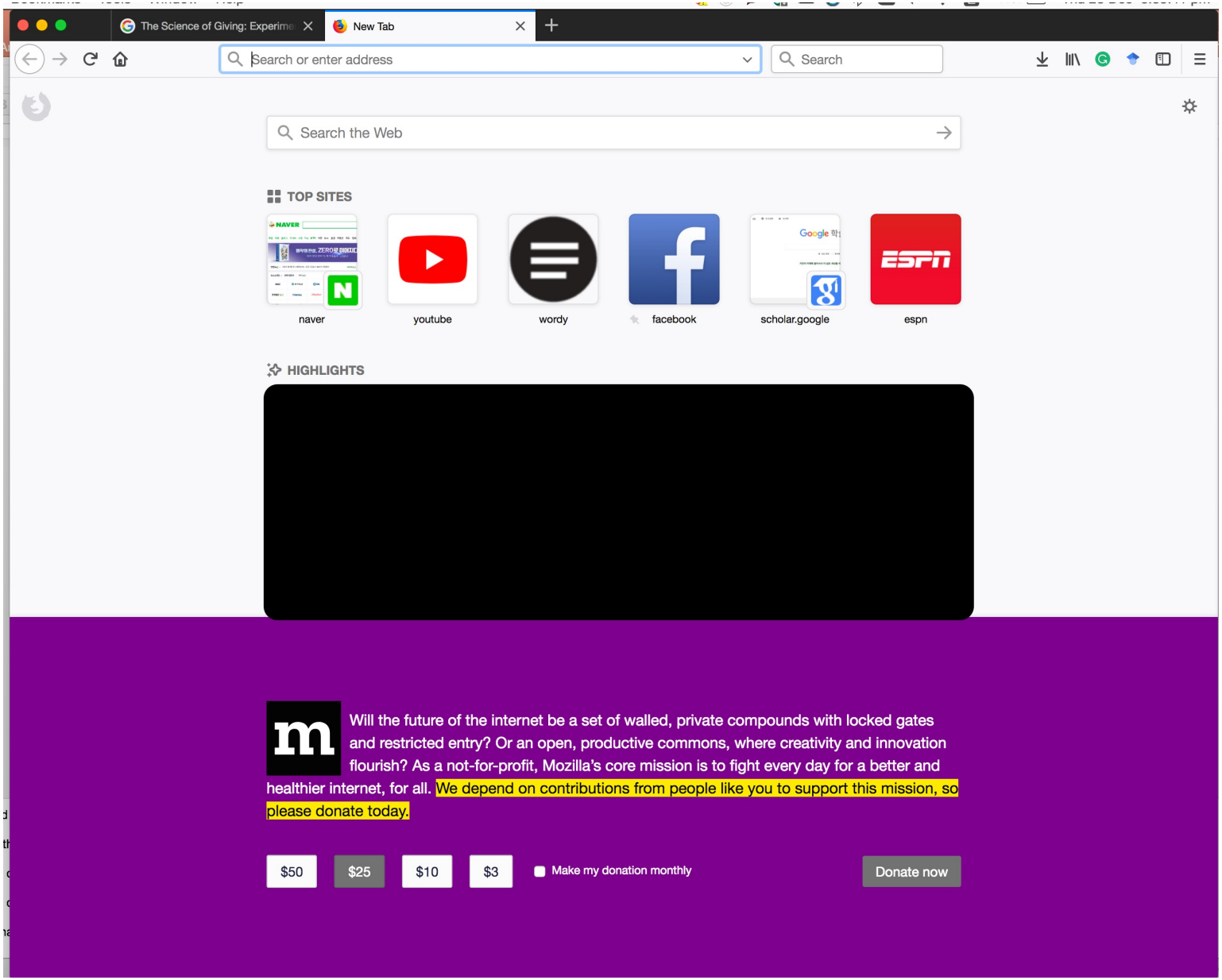
Web Bowser & Job Performance



There is good evidence that
Firefox and Chrome users significantly
outperform Internet Explorer and Safari users.

They also stay in their jobs 15 percent longer.

Why? It's about how you got the browser.


The Science of Giving: Experime
New Tab
Search or enter address
Search
Search the Web
TOP SITES
naver
youtube
wordy
facebook
scholar.google
espn
HIGHLIGHTS
Will the future of the internet be a set of walled, private compounds with locked gates and restricted entry? Or an open, productive commons, where creativity and innovation flourish? As a not-for-profit, Mozilla's core mission is to fight every day for a better and healthier internet, for all. We depend on contributions from people like you to support this mission, so please donate today.
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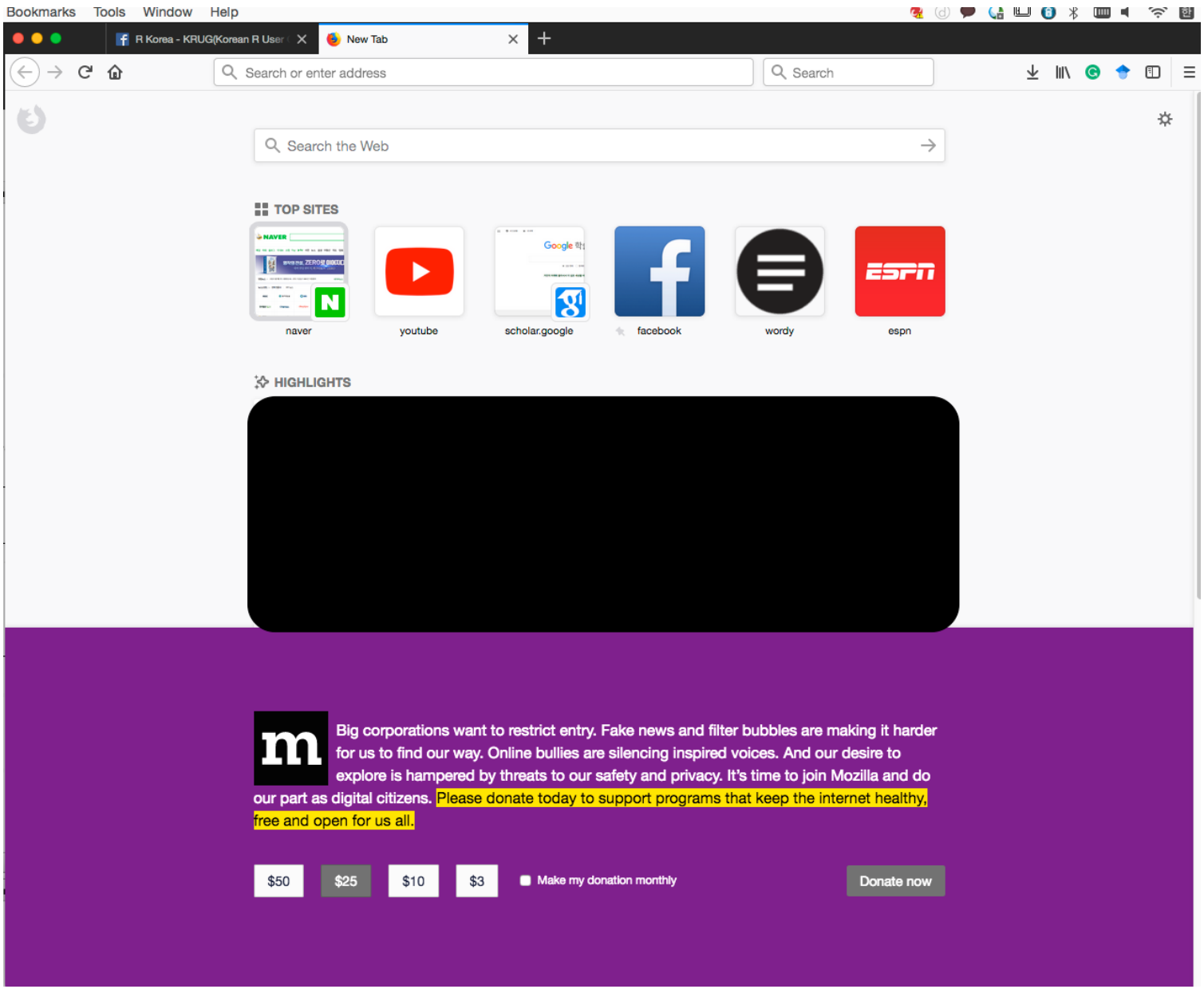
Bookmarks Tools Window Help
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TOP SITES
naver
youtube
scholar.google
facebook
wordy
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HIGHLIGHTS
Big corporations want to restrict entry. Fake news and filter bubbles are making it harder for us to find our way. Online bullies are silencing inspired voices. And our desire to explore is hampered by threats to our safety and privacy. It's time to join Mozilla and do our part as digital citizens. Please donate today to support programs that keep the internet healthy, free and open for us all.
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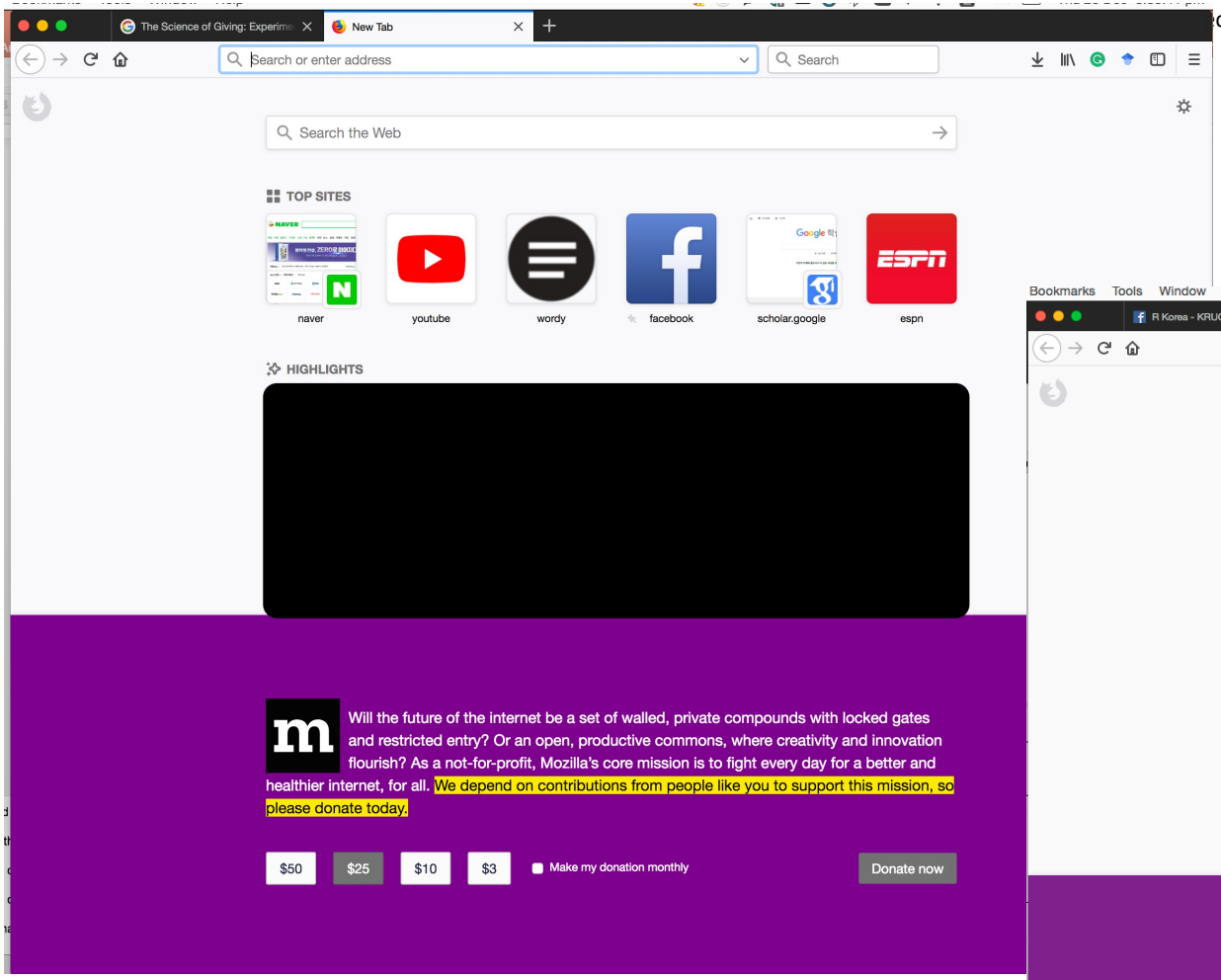
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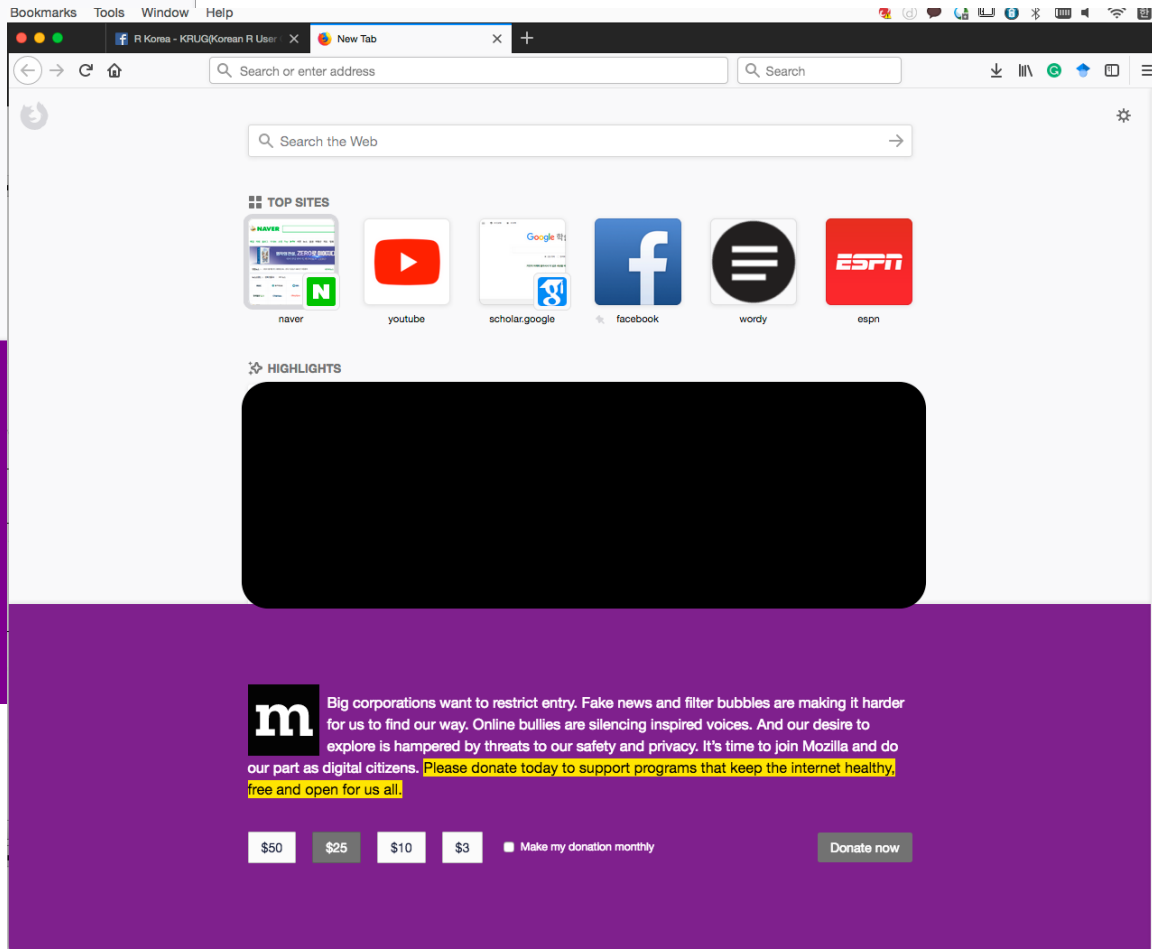
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Tools
Window
Help
R Korea - KRUG(Korean R User
New Tab
Search or enter address
Search
Search the Web
TOP SITES
naver
youtube
scholar.google
facebook
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“Experiment with Everything” Approach

Today, Microsoft and several other leading companies (including Amazon, Booking.com, Facebook, and Google) each conduct more than 10,000 online controlled experiments annually, with many tests engaging millions of users.

“Experiment with Everything” Approach

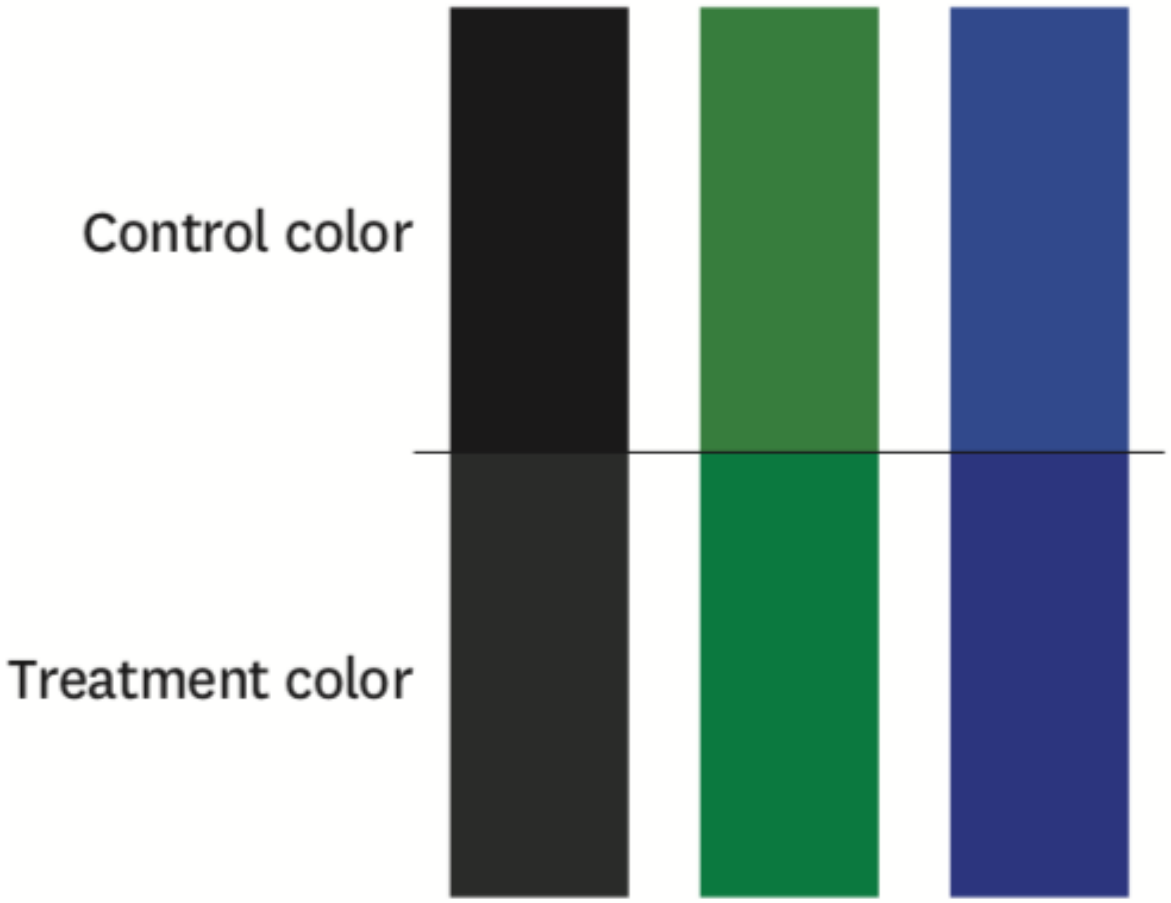
Start-ups and companies without digital roots, such as Walmart, Hertz, and *Singapore Airlines*, also run them regularly, though on a smaller scale.

“Experiment with Everything” Approach

These organizations have discovered that an “experiment with everything” approach has surprisingly large payoffs.

Case Study:
Bing’s small changes with a HUGE impact

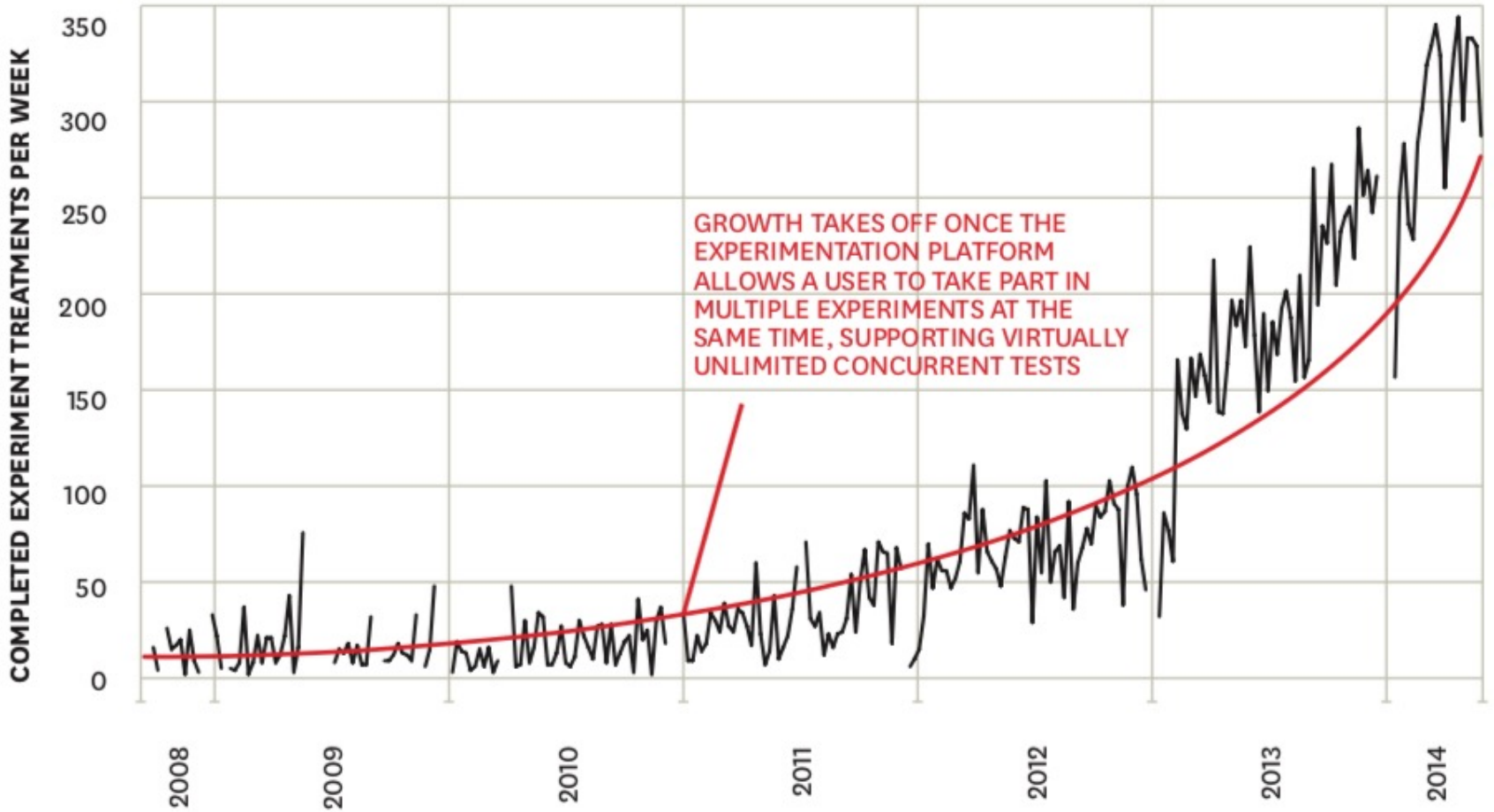
A



B

- Bing's experiments showed that slightly darker blues and greens in titles and a slightly lighter black in captions improved the users' experience.
- When rolled out to all users, the color changes boosted revenue by more than $10 million annually.

The Growth of Experimentation (A/B Testing) at Bing



A Case from *booking.com*

(Thomke, 2020)

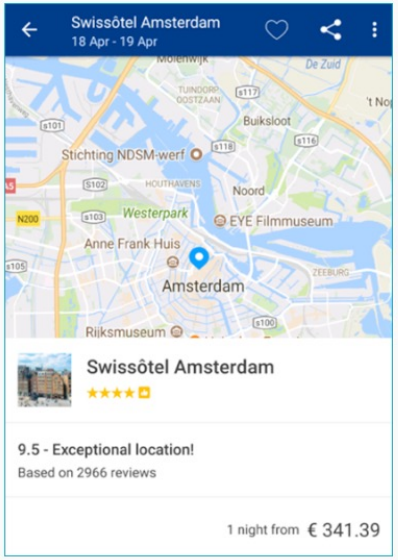
Scenario #1

Hypothesis

Highlighting a neighborhood's walkability helps users make better decisions about property location.

A: The Control

Shows the site's current practice



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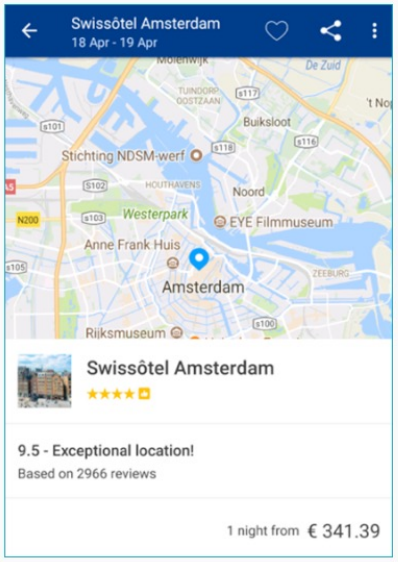
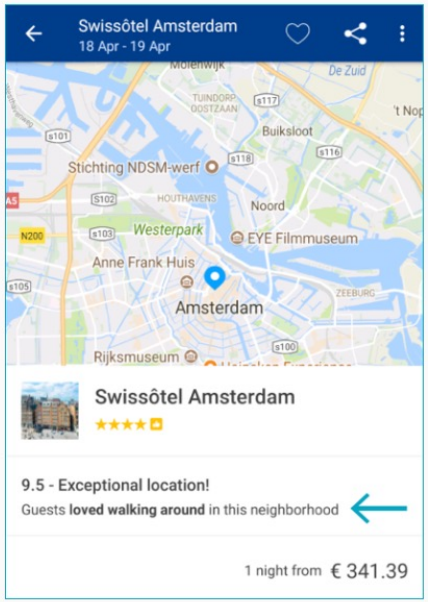


B: The Treatment

Adds walkability information



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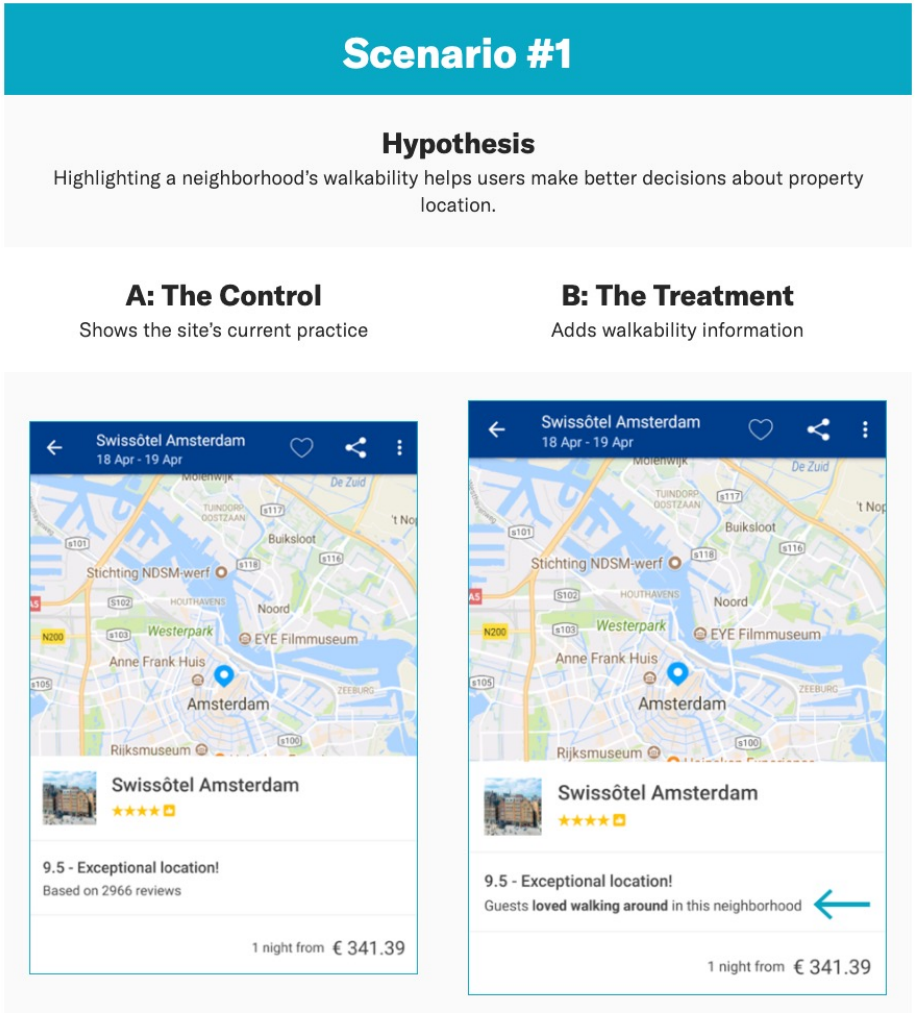


The Result

- The treatment had no significant impact on the key metric.
- The current practice is kept in place.

A Case from *booking.com*

(Thomke, 2020)

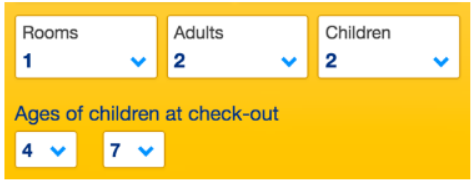
Scenario #2

Hypothesis

Displaying the checkout date when users select the age of children in their party improves their experience.

A: The Control

Shows the site's current practice



A Case from *booking.com*

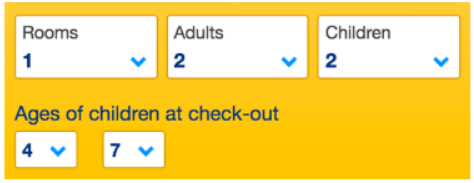
(Thomke, 2020)

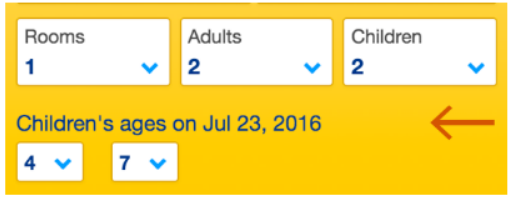
Scenario #2

Hypothesis

Displaying the checkout date when users select the age of children in their party improves their experience.

A: The Control	B: The Treatment
Shows the site's current practice	Adds the checkout date above children's ages



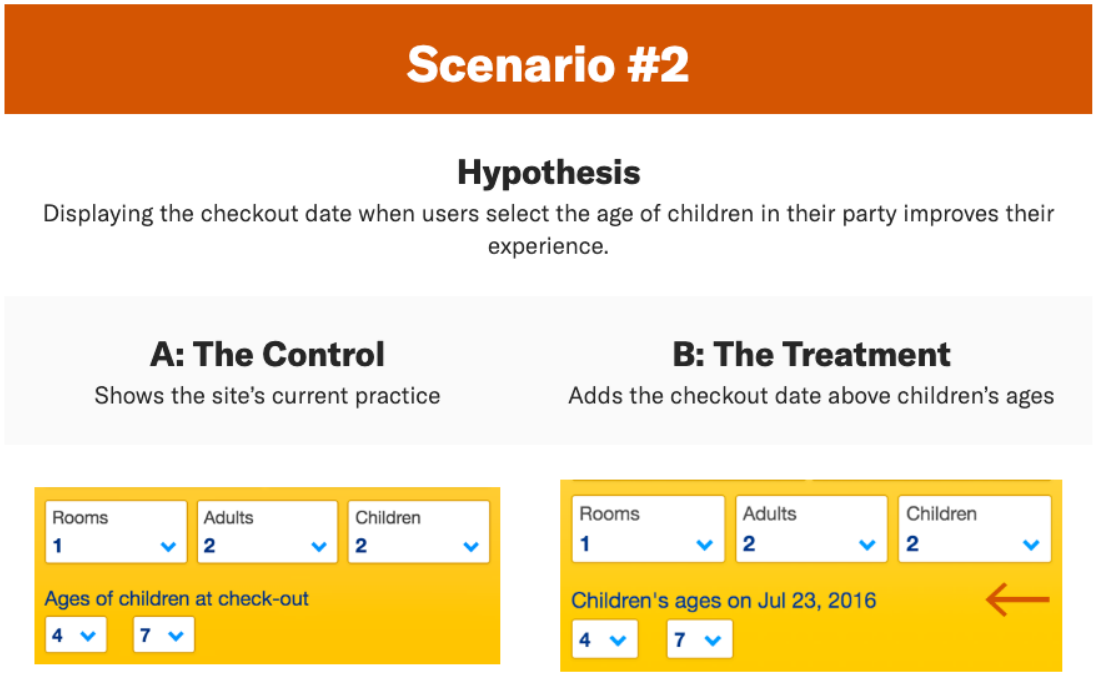


A Case from *booking.com*

(Thomke, 2020)

The Result

- The treatment had a significant positive impact on the key metric, and the change is implemented.



Interventions, A/B Testing, and Causal Inference

- When creating corporate strategies, many companies make decisions—on everything from new product features, to look and feel, to marketing campaigns— using subjective opinions rather than hard data.

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- Companies should conduct controlled experiments (A/B tests) to evaluate their ideas.

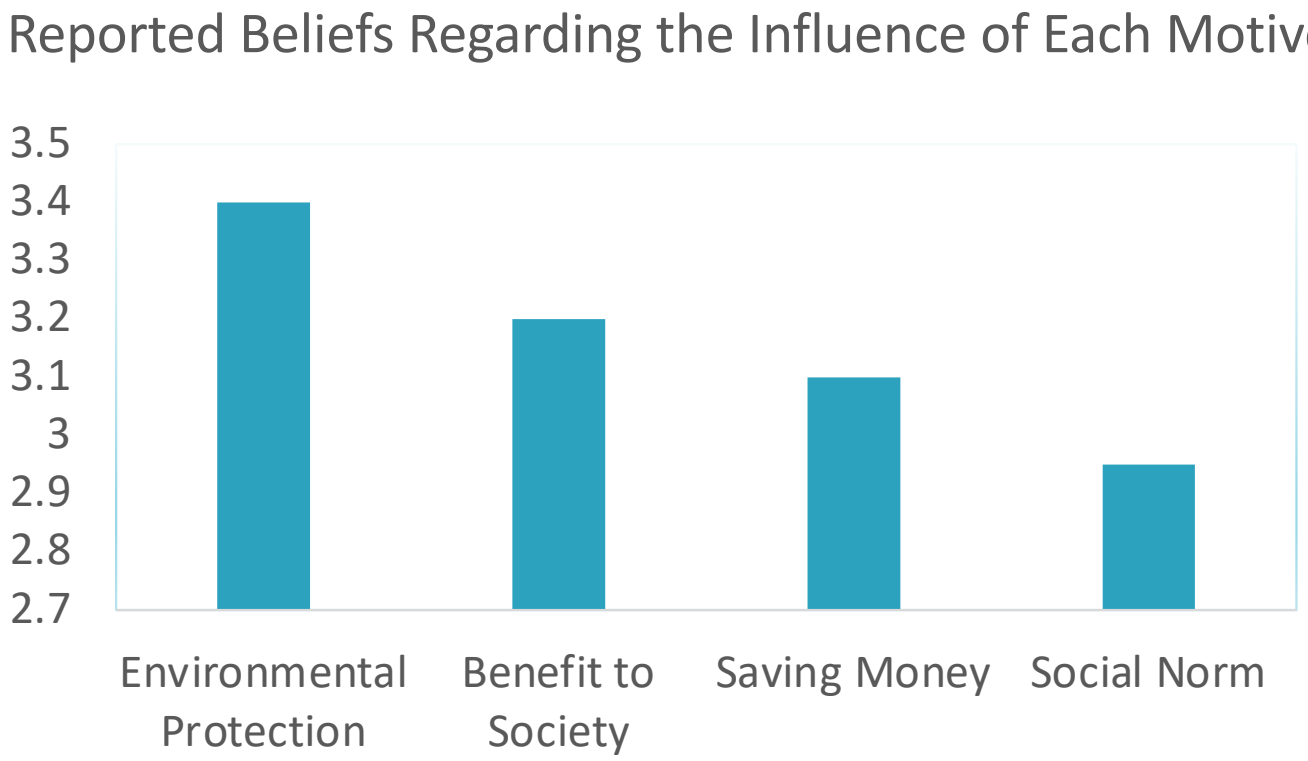
Interventions, A/B Testing, and Causal Inference

- When creating corporate strategies, many companies make decisions—on everything from new product features, to look and feel, to marketing campaigns— using subjective opinions rather than hard data.
- Companies should conduct controlled experiments (A/B tests) to evaluate their ideas.
- Potential improvements should be rigorously tested, because large investments can fail to deliver, and some tiny changes can be surprisingly detrimental while others have big payoffs.

Interventions, A/B Testing, and Causal Inference

Executives should understand how to properly design and execute A/B tests and other controlled experiments, ensure their integrity, interpret their results, and avoid pitfalls.

California Energy Savings Survey (Goldstein et al., 2010)



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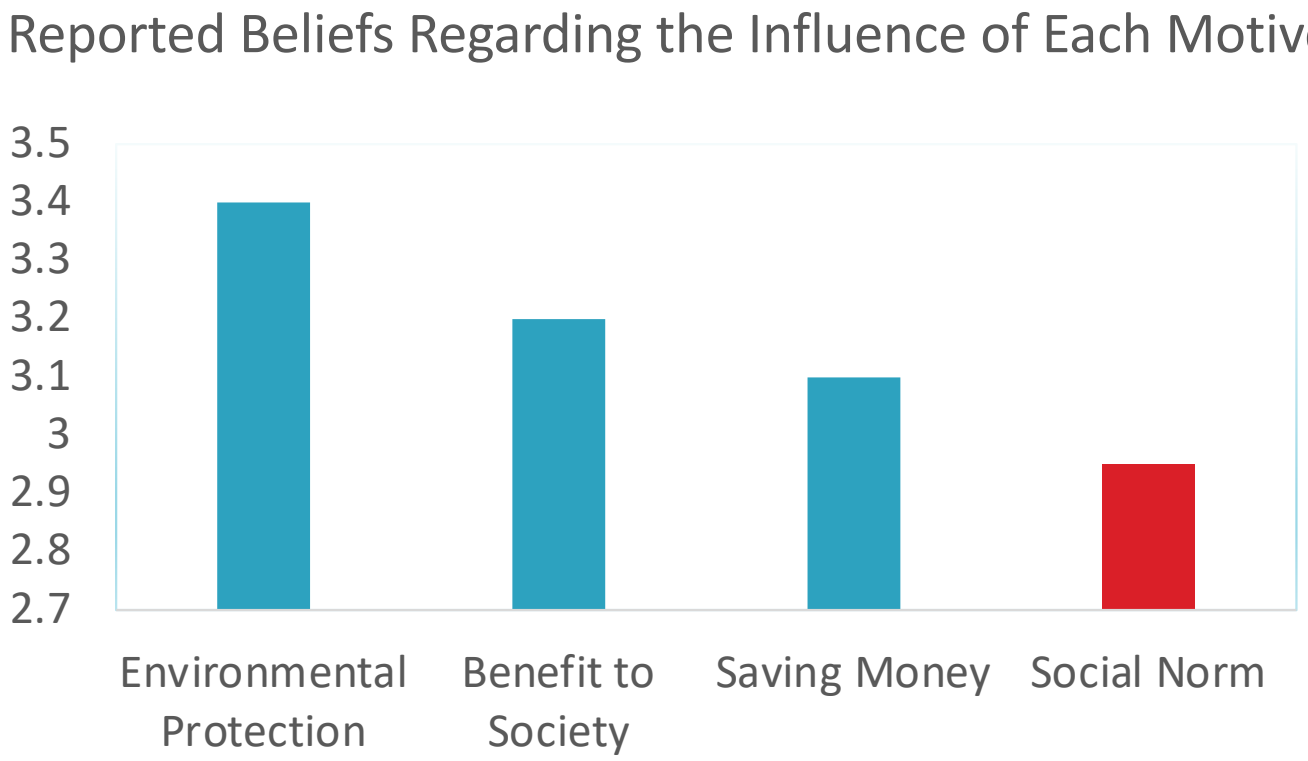

Does This Perception Match with Reality?

- Researchers then conducted an experiment in a California neighborhood
- They placed signs on residents' door encouraging them to conserve energy

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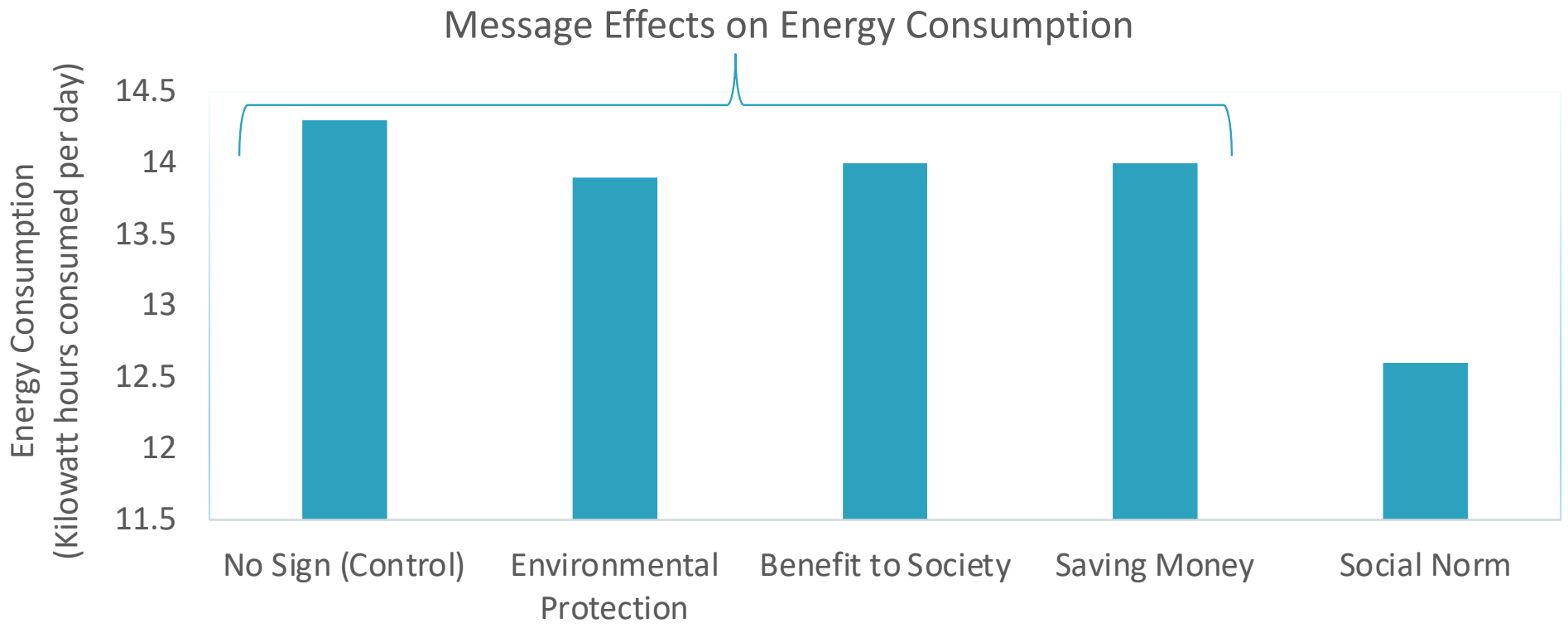
- Researchers varied the reasons for conserving on the signs to be in accordance with the various motivating factors

Results of Field Experiment (Goldstein et al., 2010)



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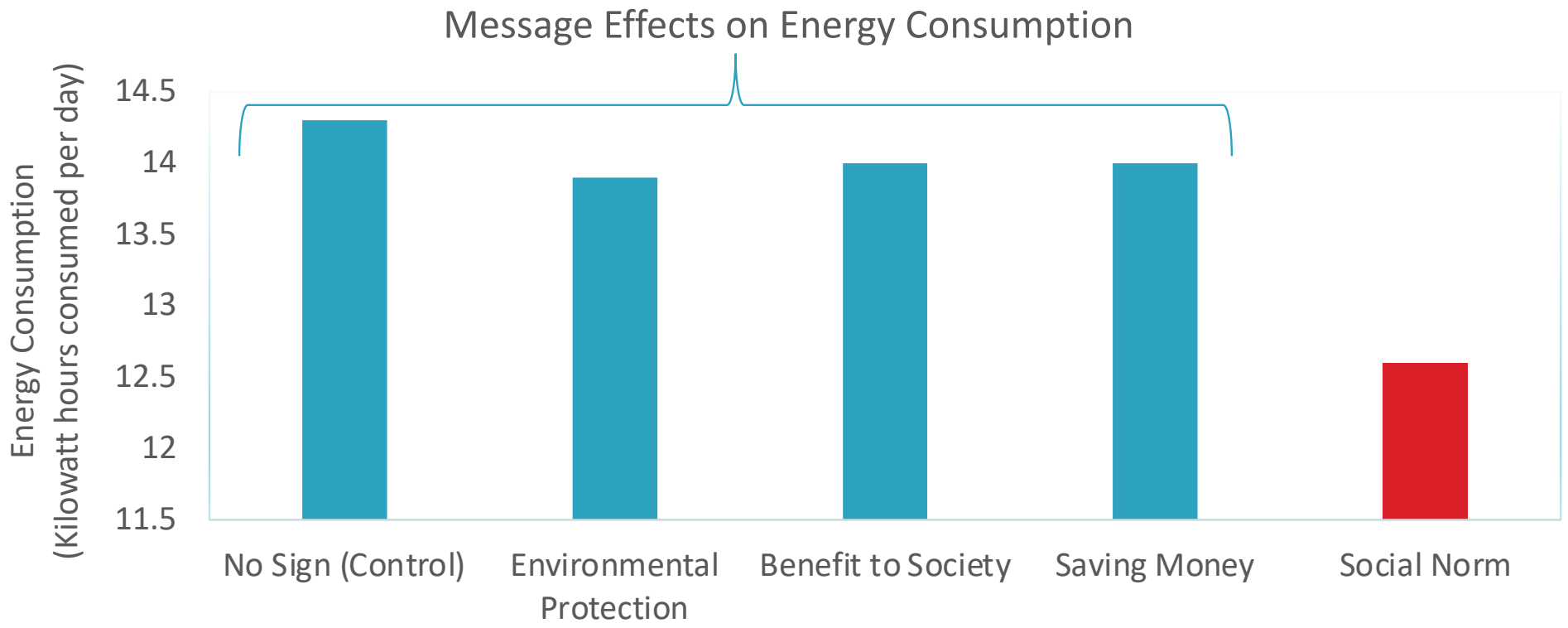


Would it matter what color that the competitors wear as they compete?

Winning Color?

Researchers looked into tone of different games on one-on-one sports: Boxing, Taekwondo, and Wrestling.

They wanted to see if there would be a systematic advantage depending on what color they are wearing.

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This is an interesting and important question, because the IOC has a rule to toss a coin to randomly assign different color uniforms to competitors, to eliminate any systematic advantage.

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That seems fair, but it turns out that the color of uniform one wears, creates systematic advantages and disadvantages for competitors.

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You have a two thirds greater chance of winning changes when you wear red uniforms.

What's the Mechanism?

Wearing red you feel more dominant, and when you see someone wearing red they look more dominant.

To figure this out, researchers showed referees a close match and asked them to judge who won.

They also asked how many points the referees would give.

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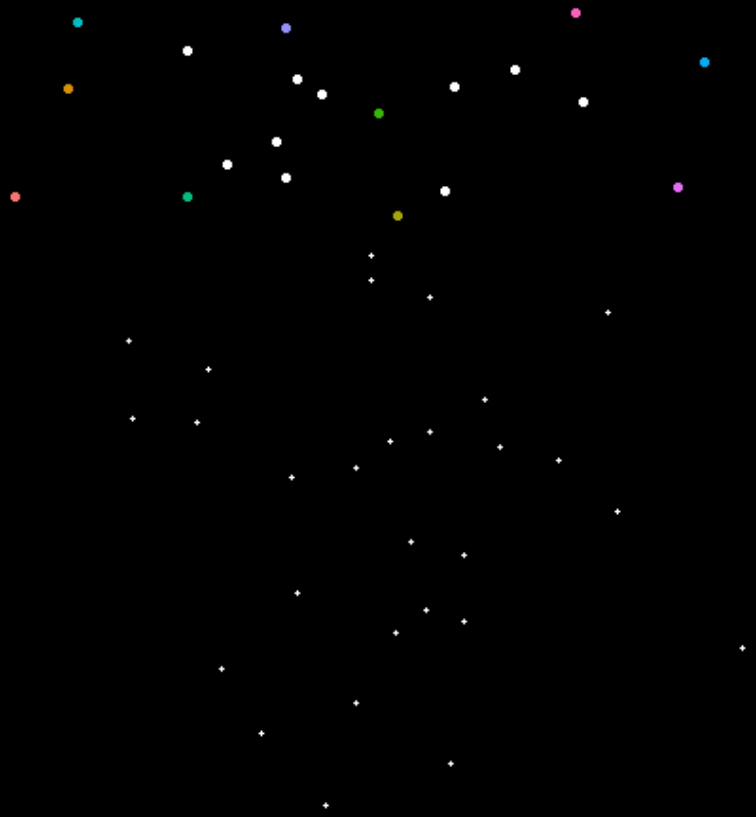
To rule out such an alternative account, the researchers digitally changed the color of uniform and showed the same game to different groups of referees.

What's the Mechanism?

Again, the competitor wearing red received 8 more points on average from referees, although these same competitors received 8 points less in the previous study when they were shown to referees wearing blue.



Analytically Yours,
Prof. Roh