

AdFisher

Information Flow Experiments on Ad Privacy Settings

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'We'll be back': Hong Kong protesters chant as camp site dismantled

Reuters | Dec 12, 2014, 08.39 AM IST

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Police officers stand guard before they move on to remove protesters from a road written 'We Will Be Back' with tarps at an occupied area outside government headquarters in Hong Kong.

HONG KONG: Hong Kong police arrested pro-democracy activists and cleared most of the main protest site on Thursday, marking an end to more than two months of street demonstrations in the Chinese-controlled city, but many chanted: "We will be back".

Most activists chose to leave the Admiralty site, next to the Central business area, peacefully, despite their demands for a free vote not being met. But the overall mood remained defiant.

Hong Kong Federation of Students leader Alex Chow said: "You might have the clearance today but people will come back on to the streets

RELATED

another day."

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LIVE
1ST TEST

 **517/7 dec** **57.2 Ov**

AUS & 207/3

444  IND

Day 4: 3rd Session - Australia lead by 280 runs

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About 674,000,000 results (0.29 seconds)

Ads related to **health insurance** ⓘ

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www.ehealthinsurance.com/

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california.healthcare.com/

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www.gohealthinsurance.com/

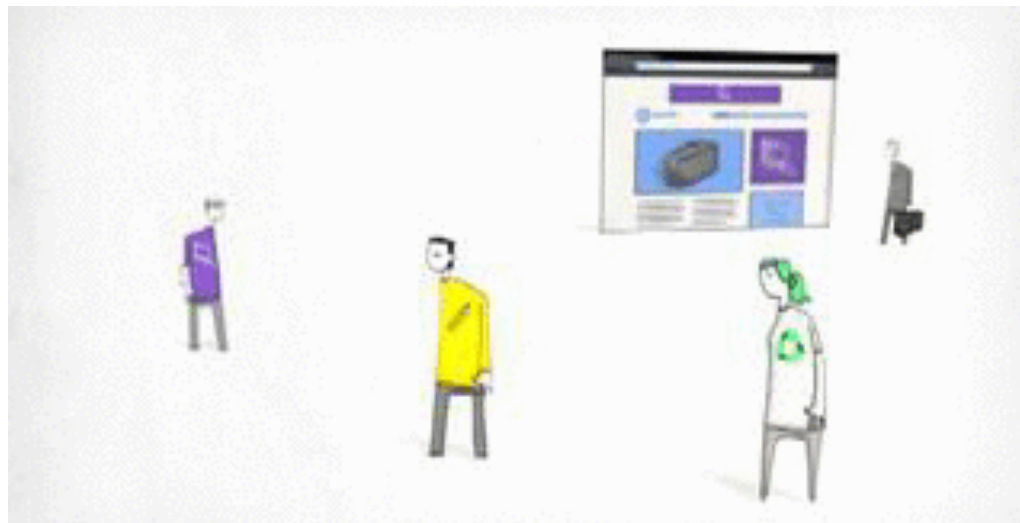
Blue Cross, United, Aetna, & CIGNA. See Rates by Your State or Zip!

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[Health Insurance - Find Affordable Health Insurance Plans and Buy ...](#)

Google AdSense

- Website owner (Publisher) wants to earn money
- Registers website with Google AdSense
- Google runs word analysis on website and figures out keywords related to page



Google AdWords

Getting started



1. Choose your budget



2. Create your ads



3. Select keywords that match your ads to potential customers



4. Enter your billing information.

Keywords

[Select keywords](#)

Enter one keyword per line.

dog toy
puppy toy
pup

Sample keywords,
No sample keywor

[Advanced option: match types](#)

Important note: We cannot guarantee that these keywords will improve your campaign performance. You are responsible for the keywords you select and for ensuring that your use of them complies with applicable laws and regulations.

Ad Targeting

Google automatically delivers ads that are targeted to your content or audience. We do this in several ways:

- **Contextual targeting**

Our technology uses such factors as keyword analysis, word frequency, font size, and the overall link structure of the web, in order to determine what a webpage is about and precisely match Google ads to each page.

- **Placement targeting**

With placement targeting, advertisers choose specific ad placements, or subsections of publisher websites, on which to run their ads. Ads that are placement-targeted may not be precisely related to the content of a page, but are hand-picked by advertisers who've determined a match between what your users are interested in and what they have to offer.

- **Interest-based advertising**

Interest-based advertising enables advertisers to reach users based on their interests and demographics (e.g. 'sports enthusiasts'), and allows them to show ads based on a user's previous interactions with them, such as visits to advertiser websites. To complement interest-based advertising, [Ads Settings](#) lets users view and edit their interest categories.

Google's Privacy Policy

When showing you tailored ads, we will not associate a cookie or anonymous identifier with sensitive categories, such as those based on race, religion, sexual orientation or health.

Settings for Google ads

Ads enable free web services and content. These settings help control the types of Google ads you see.

Ads on Google



Search

Google ads across the web ?



Google ads across the web



YouTube

Gender

N/A

Female [Edit](#)

Based on the websites you've visited

Age

N/A

25-34 [Edit](#)

Based on the websites you've visited

Languages

N/A

English [Edit](#)

Based on the websites you've visited

Interests

N/A

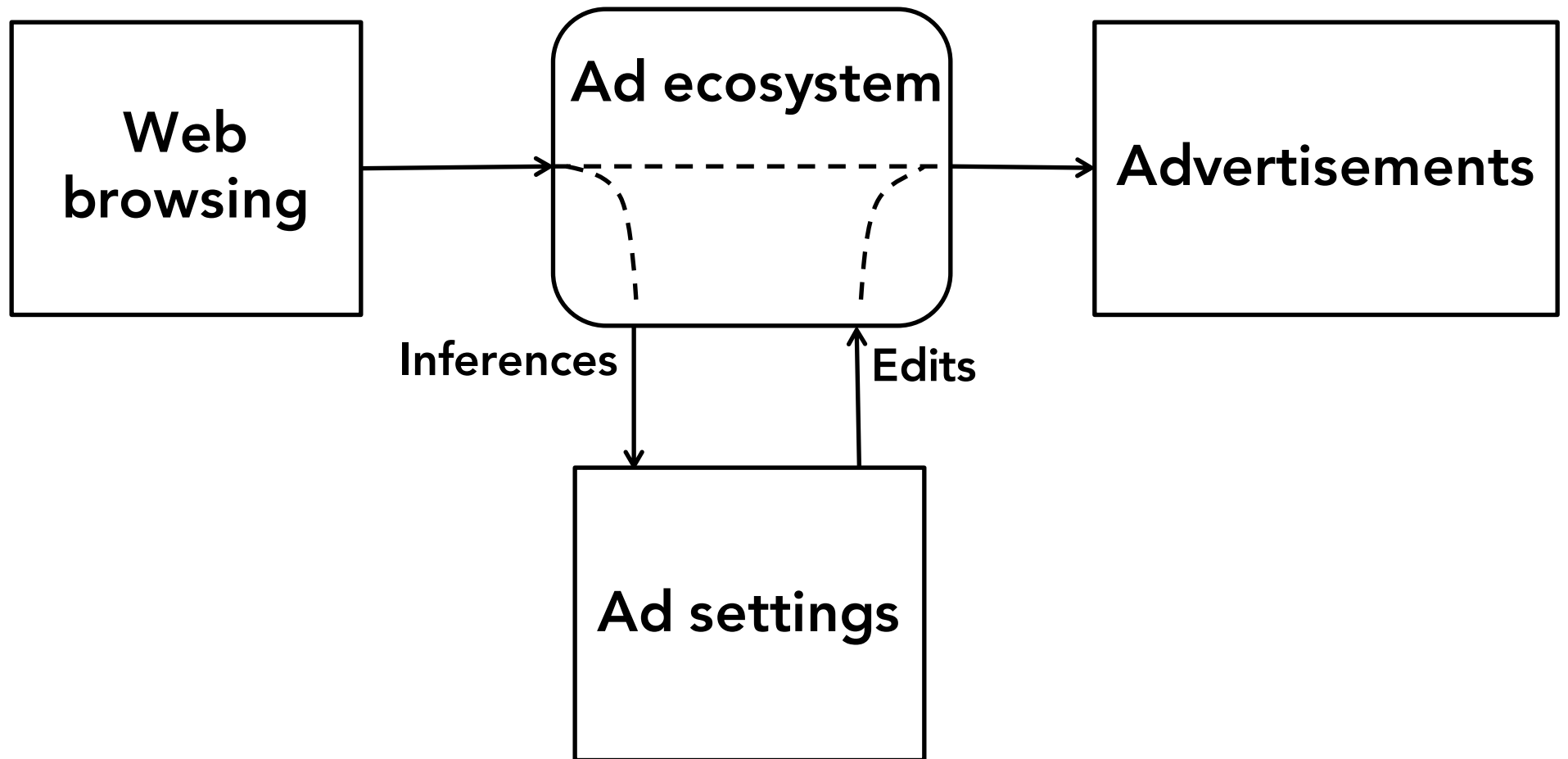
Air Travel, and 30 more [Edit](#)

Based on the websites you've visited

Opt-out settings

You've opted out of *interest-based* ads on Google.
[Opt in](#) to *interest-based* ads on Google

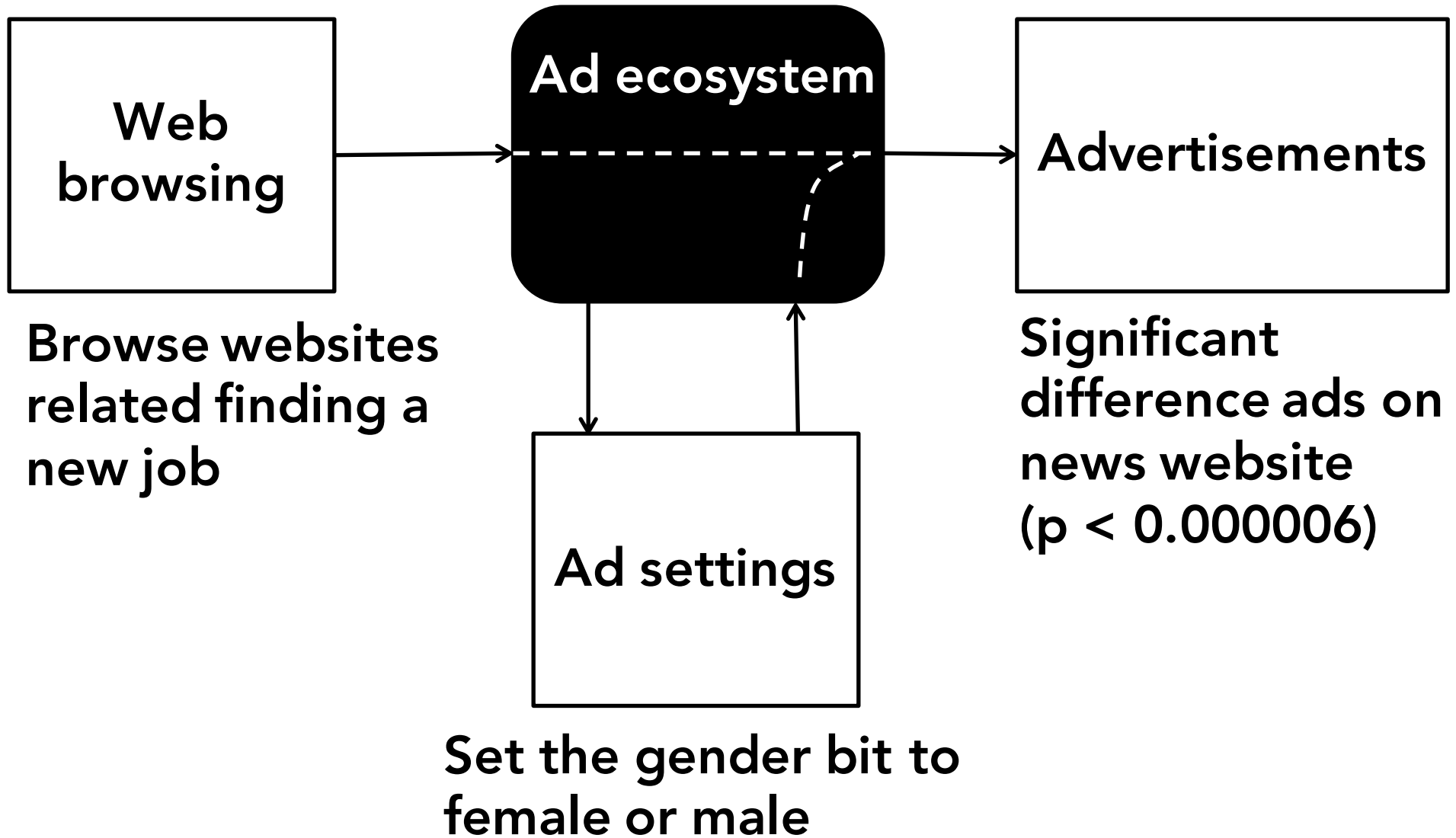
[Opt out](#) of *interest-based* Google ads across the web



AdFisher

- Emulates users with fresh browser instances
- Randomized assignment
- Statistical analysis to find causal relations
- **Open source:** github.com/tadatitam/info-flow-experiments

Discrimination



Discrimination Explanation

Female Group

Jobs (Hiring Now)

www.jobsinyourarea.co

45 vs. 8

4Runner Parts Service

www.westernpatoyotaservice.com

36 vs. 5

Criminal Justice Program

www3.mc3.edu/Criminal+Justice

29 vs. 1

Male Group

\$200k+ Jobs - Execs Only

careerchange.com

311 vs. 1816

Find Next \$200k+ Job

careerchange.com

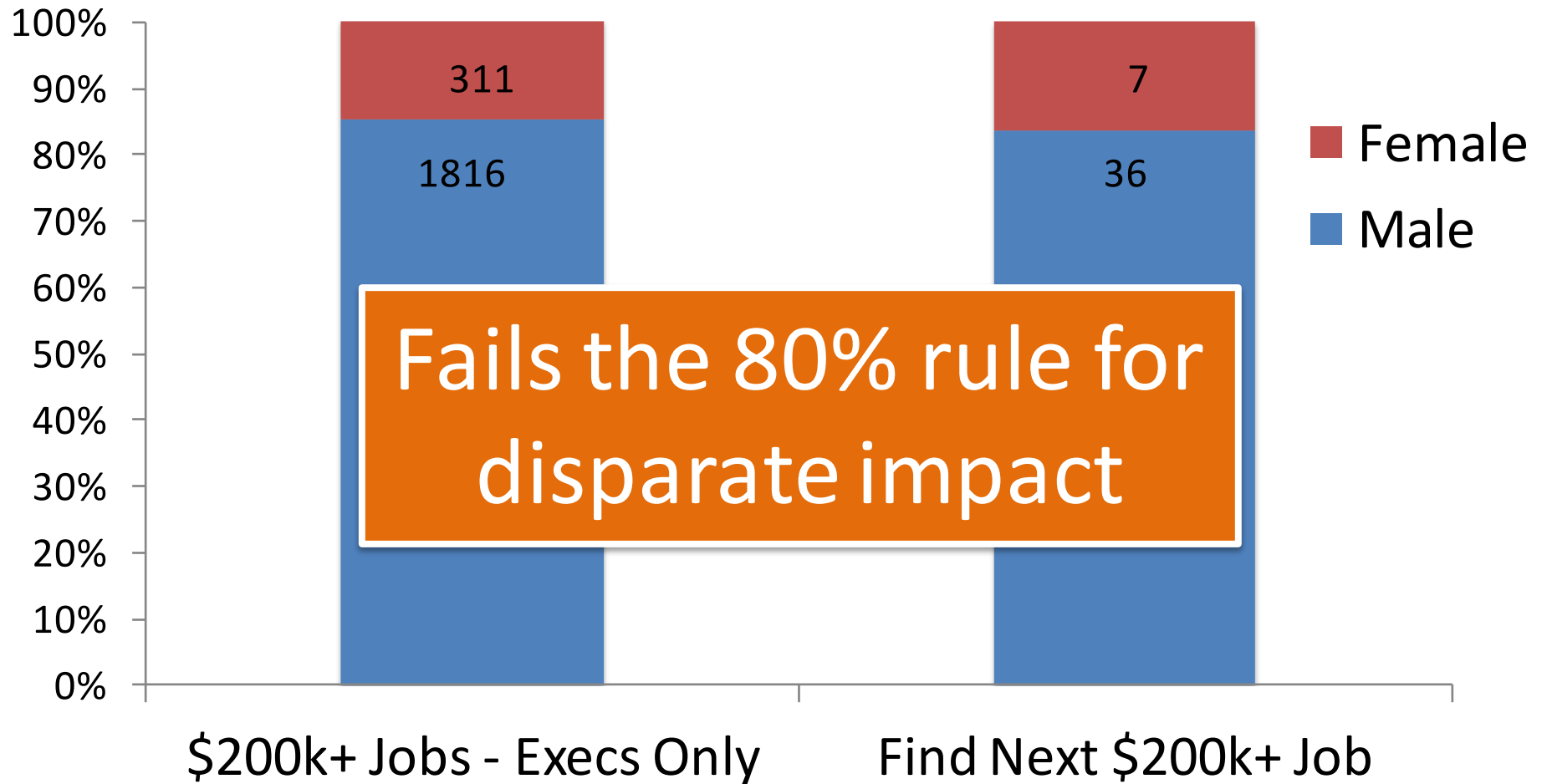
7 vs. 36

Become a Youth Counselor

www.youthcounseling.degreeleap.com

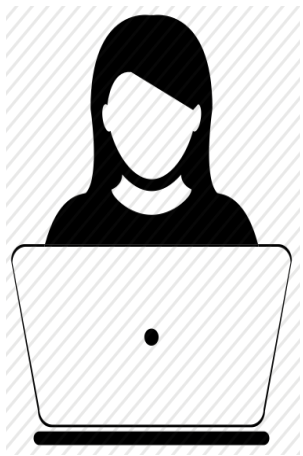
0 vs. 310

Discrimination Explanation



Findings and Non-Findings

- **An instance of discrimination**
- ~~**Policy Violations**~~
 - No claims that Google or anyone else violated any policies
- ~~**Generalization**~~
 - These results might not generalize to other settings
- ~~**Blame**~~
 - We do not assign blame



Input →

← Output

**The Barrett
Group**

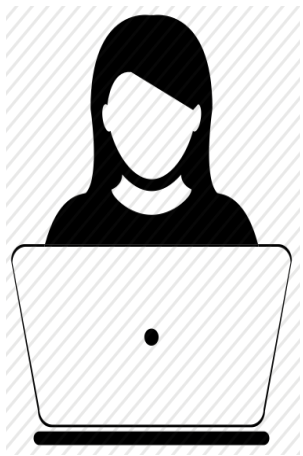
**Other
advertisers**

Google

Websites

**Male
users**

**Female
users**



Input →

← Output

The Barrett Group

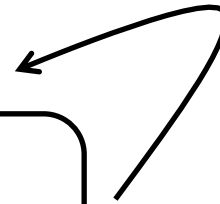
Other advertisers

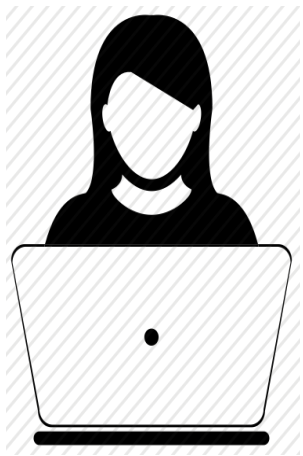
Google

Websites

Male users

Female users





Input →

← Output

The Barrett Group

↓ Show to males

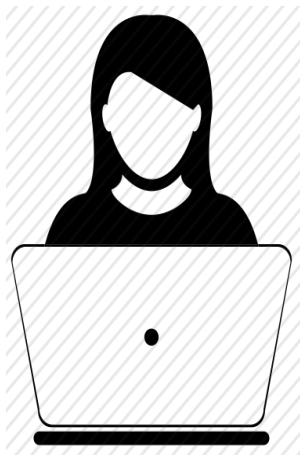
Google

Male users

Other advertisers

Websites

Female users



Input →
← Output

The Barrett Group

Other advertisers

↓ Show to high earners

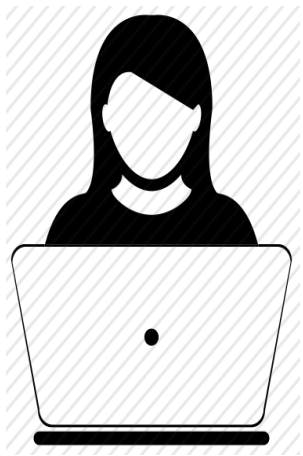
Google

Websites

High earners are male

Male users

Female users



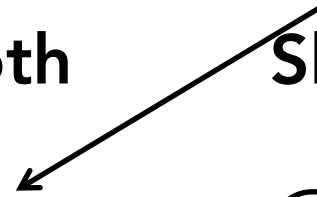
Input →
← Output

The Barrett Group

Other advertisers



Show to both



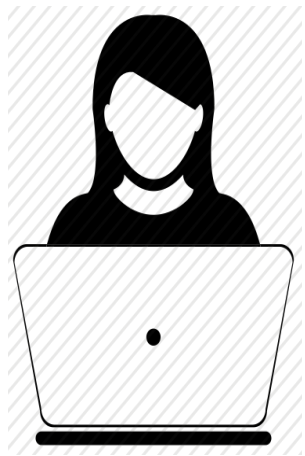
Show to females

Google

Websites

Male users

Female users



Input →
← Output

The Barrett Group

Other advertisers

↓ Show to both

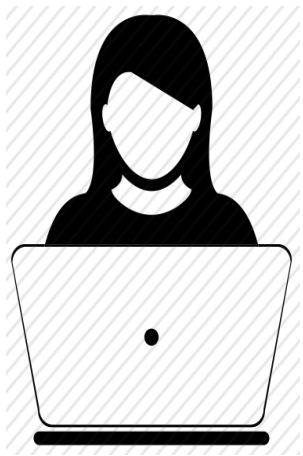
Google

Websites

↑ Clicking
Not clicking

Male users

Female users



Input →
← Output

The Bartlett Group

Other advertisers

Google

Websites

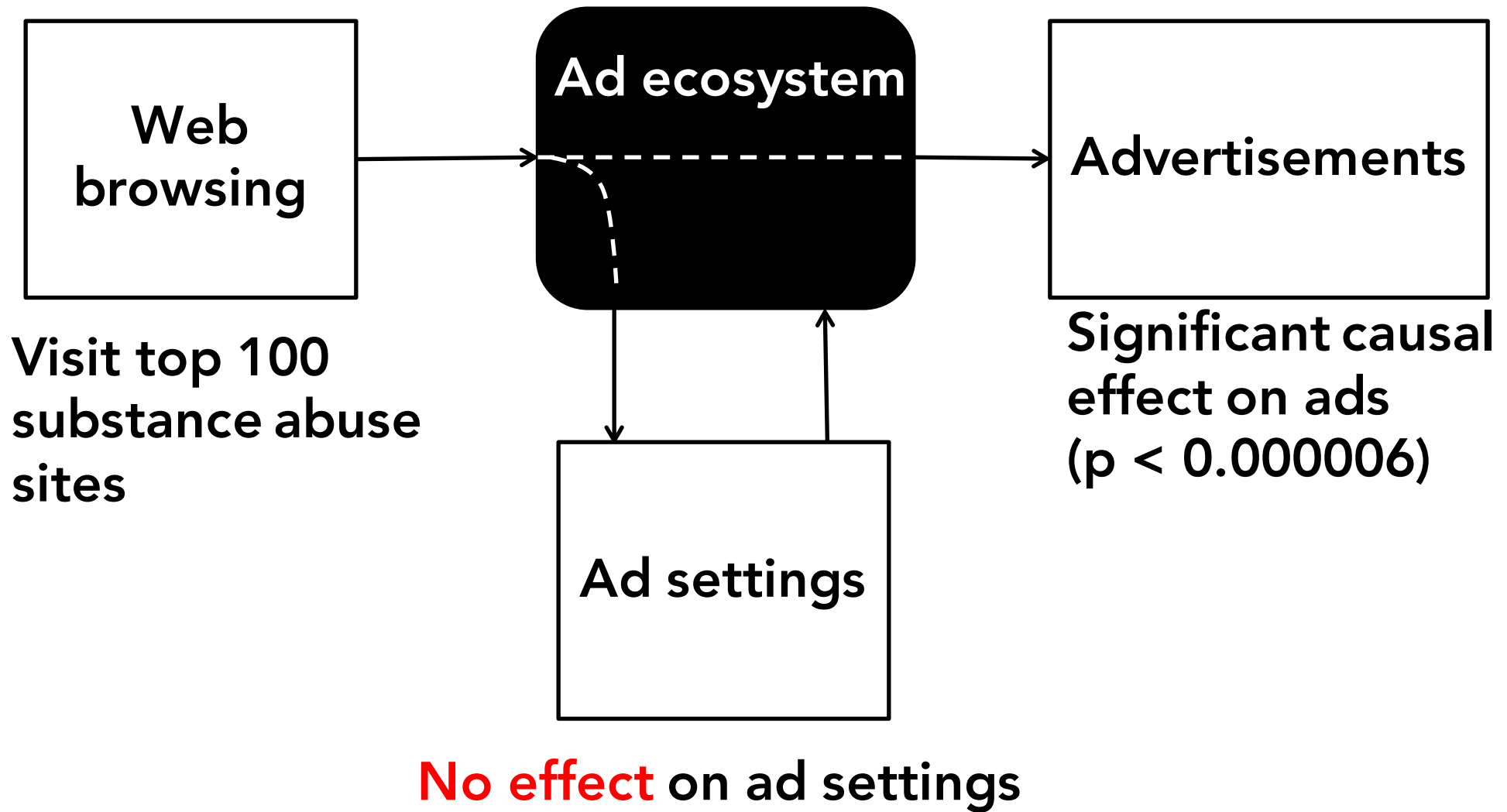
↑
Not clicking
other ads

← Clicking other ads

Male users

Female users

Transparency



Transparency Explanations

Substance Abuse Visitors

The Watershed Rehab
www.thewatershed.com/Help
2276 vs. 0

Watershed Rehab
www.thewatershed.com/Rehab
362 vs. 0

The Watershed Rehab
(none)
771 vs. 0

Control Group

Alluria Alert
www.bestbeautybrand.com
0 vs. 9

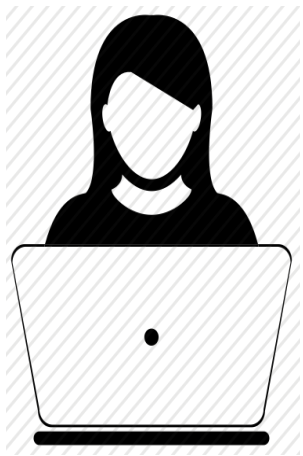
Best Dividend Stocks
dividends.wyattresearch.com
24 vs. 54

10 Stocks to Hold Forever
www.streetauthority.com
76 vs. 118

The Watershed Rehab

www.thewatershed.com/Help - Drug & Alcohol Rehabilitation Call Today For Help Now!

Ads by Google



Input →
← Output

**The
Watershed
Rehab**

↓ Show prior
visitors

Google

**Substance-
abuse users**

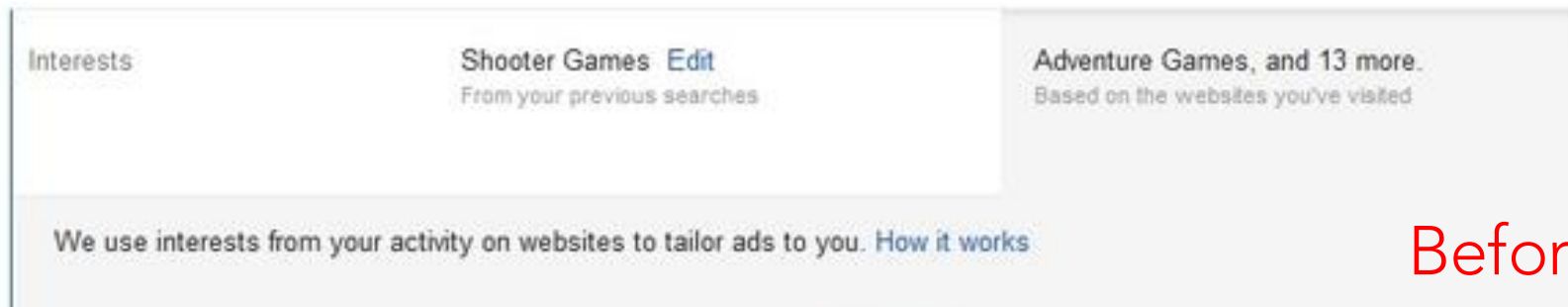
**Other
advertisers**

Websites

Other users

Additional Notice on Ad Settings

Ads Settings



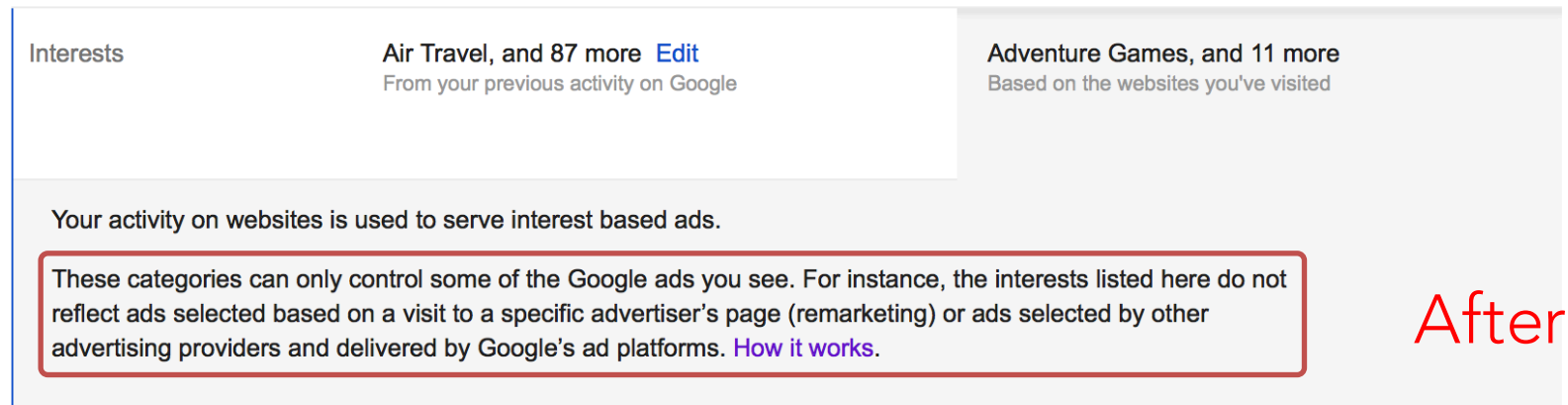
Interests

Shooter Games [Edit](#)
From your previous searches

Adventure Games, and 13 more.
Based on the websites you've visited

We use interests from your activity on websites to tailor ads to you. [How it works](#)

Before



Interests

Air Travel, and 87 more [Edit](#)
From your previous activity on Google

Adventure Games, and 11 more
Based on the websites you've visited

Your activity on websites is used to serve interest based ads.

These categories can only control some of the Google ads you see. For instance, the interests listed here do not reflect ads selected based on a visit to a specific advertiser's page (remarketing) or ads selected by other advertising providers and delivered by Google's ad platforms. [How it works](#).

After

Additional Notice on Ad Settings

Interests

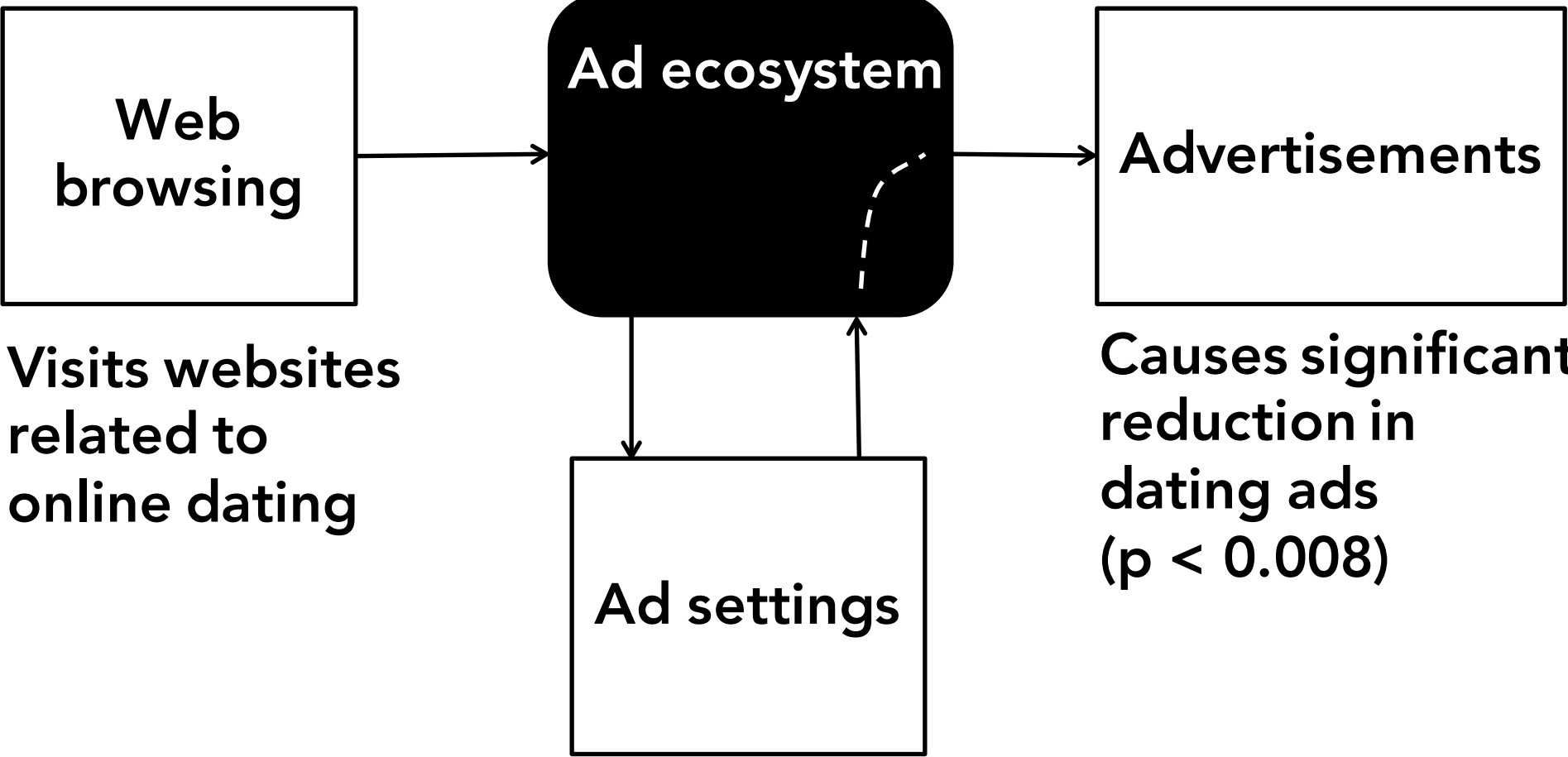
Air Travel, and 87 more [Edit](#)
From your previous activity on Google

Adventure Games, and 11 more
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Choice



Visits websites related to online dating

Causes significant reduction in dating ads ($p < 0.008$)

Removes interests related to online dating

Choice Explanation

Keeping Dating Interest

Are You Single?

www.zoosk.com/Dating

2433 vs. 78

Top 5 Online Dating Sites

www.consumer-rankings.com/Dating

408 vs. 13

Why can't I find a date?

www.gk2gk.com

51 vs. 5

Removing Dating Interest

Car Loans w/ Bad Credit

www.car.com/Bad-Credit-Car-Loan

8 vs. 37

Individual Health Plans

www.individualhealthquotes.com

21 vs. 46

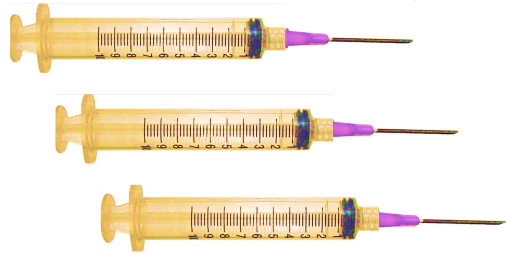
Crazy New Obama Tax

www.endofamerica.com

22 vs. 51

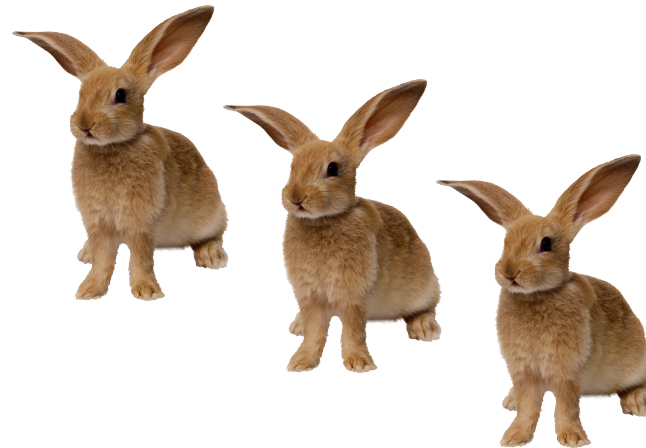
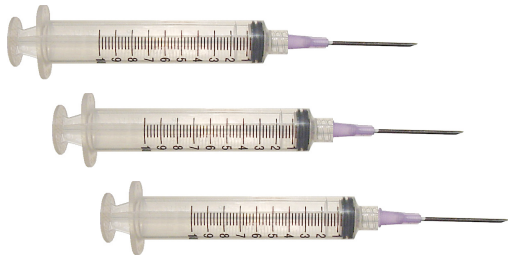
Experimental Design

Treatment 1 (Drug)



Experimental Group

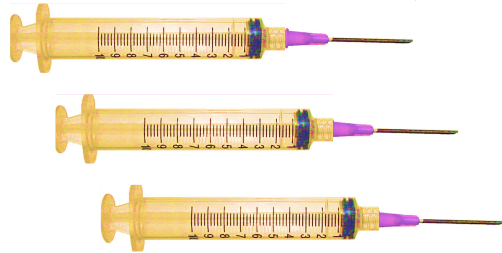
Treatment 2 (Placebo)



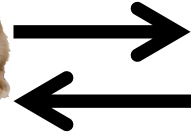
Control Group

Experimental Design

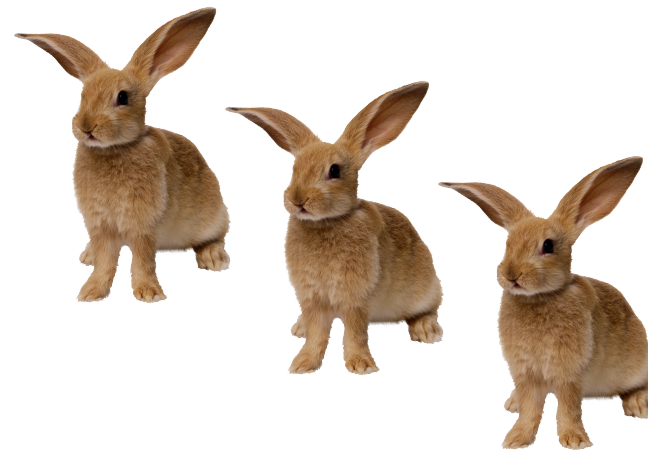
Treatment 1 (Drug)



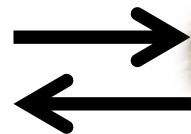
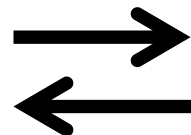
Experimental Group



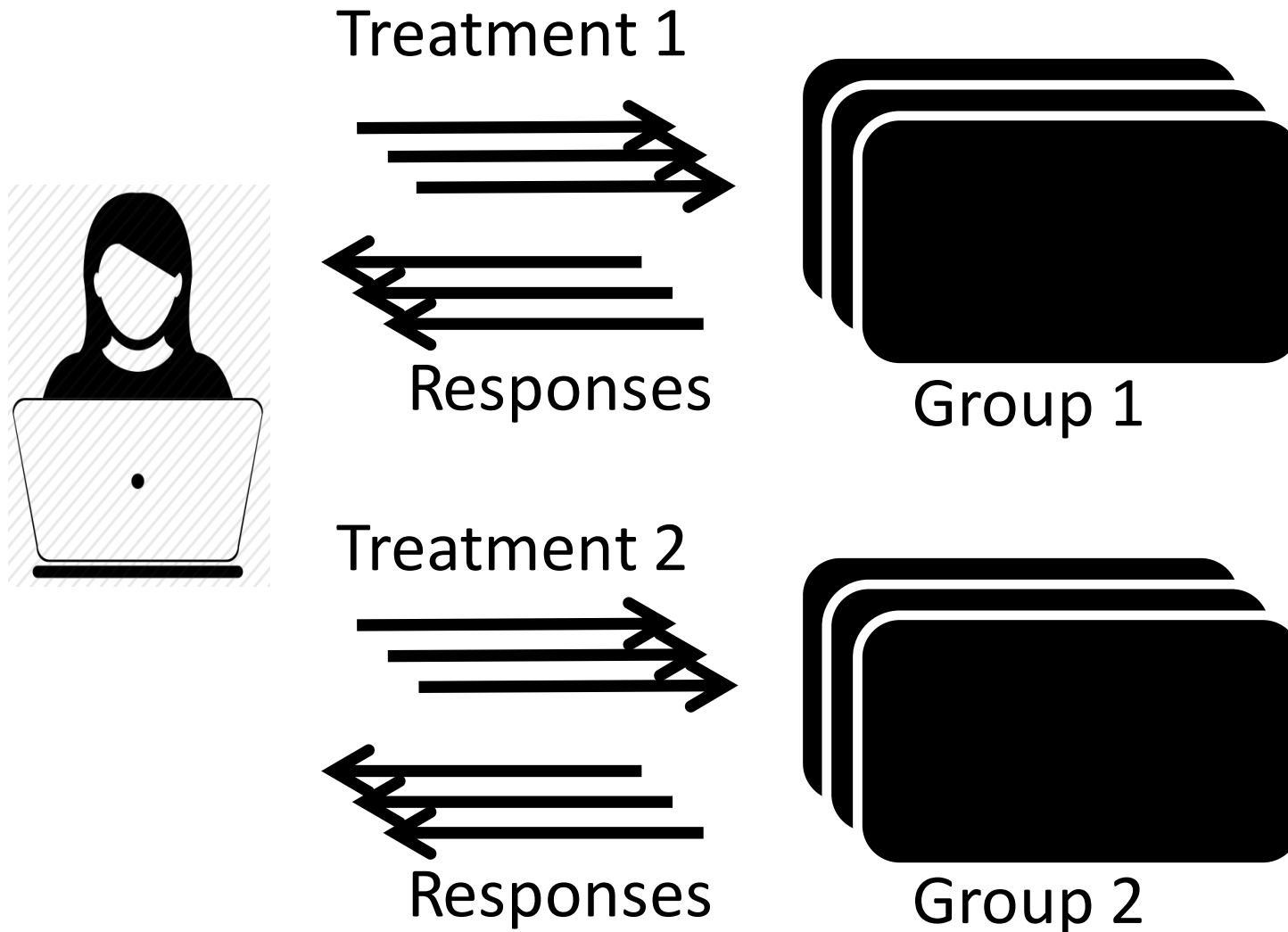
Treatment 2 (Placebo)



Control Group

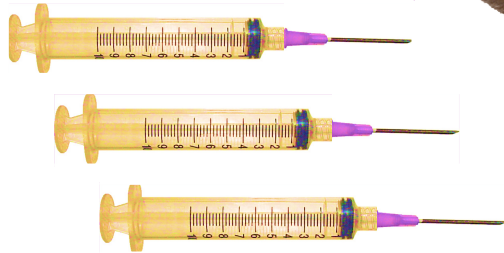


Information Flow Experiment



Experimental Design

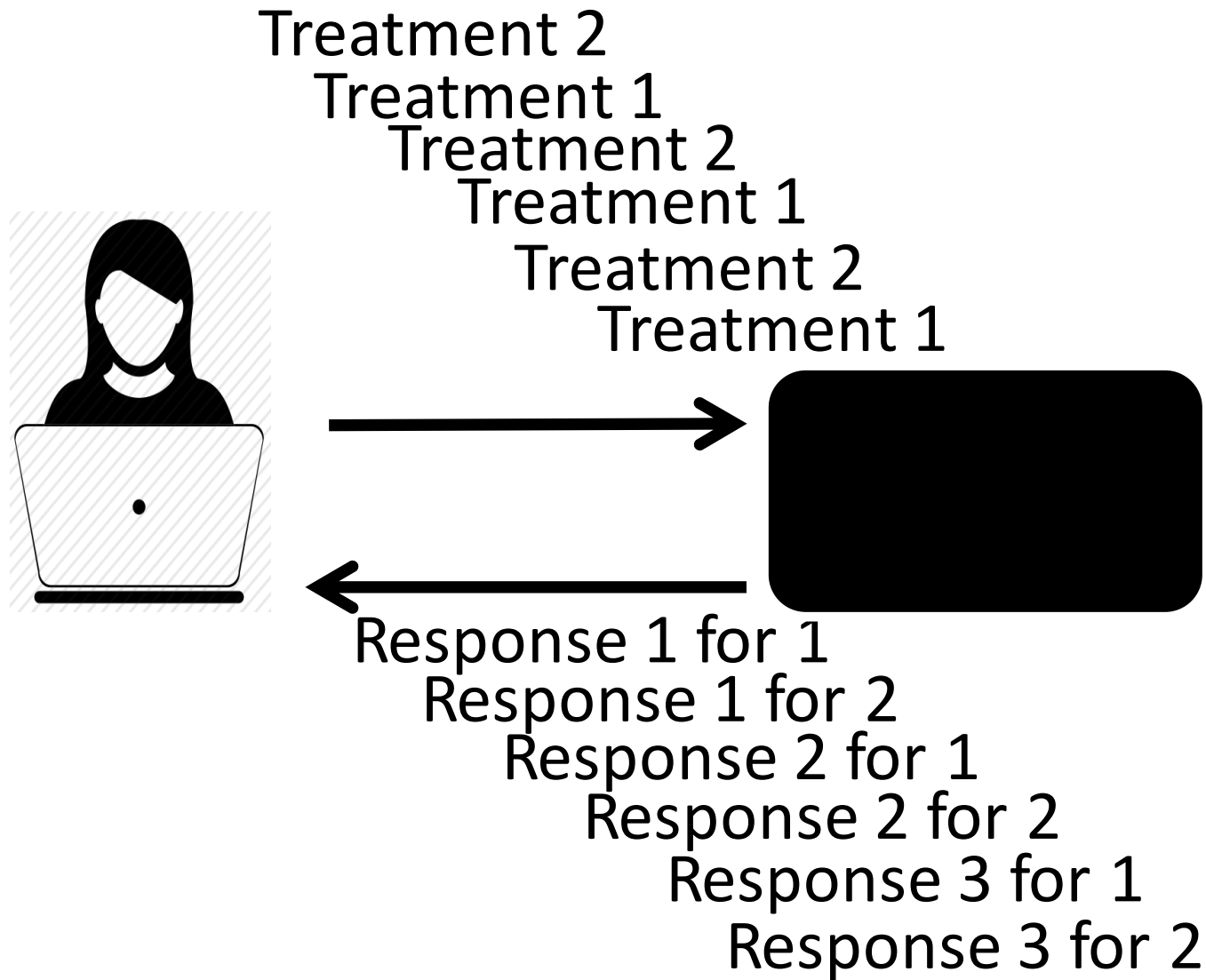
Drug



Placebo

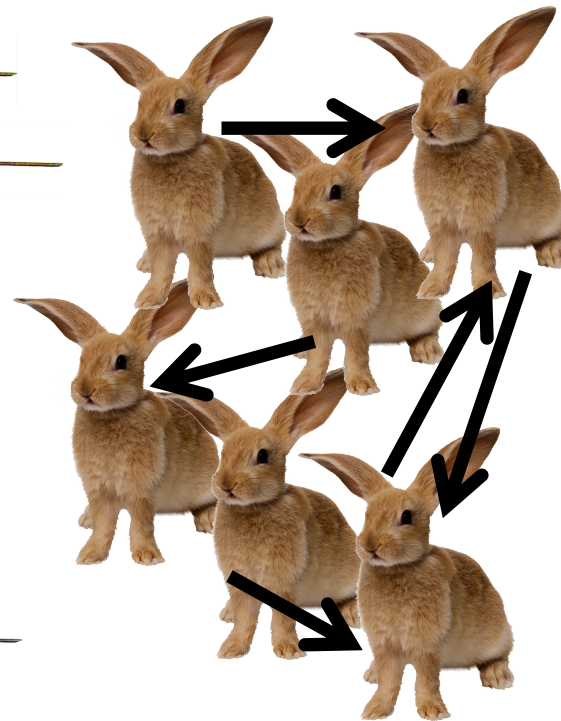


Information Flow Experiment



Cross-Unit Effects

Drug



Placebo

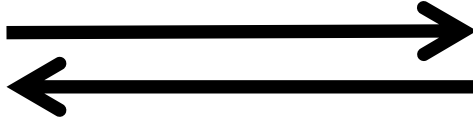




Treatment 1



Treatment 1



Treatment 1



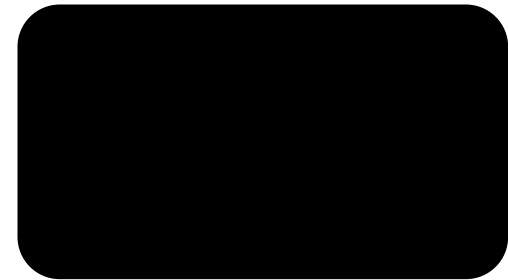
Treatment 2



Treatment 2



Treatment 2



Information Flow Experiments

Natural Sciences

Natural process

Population of units

Treatments

Responses

...

Causation

Information Flow

System in question

Subset of interactions

Inputs

Outputs

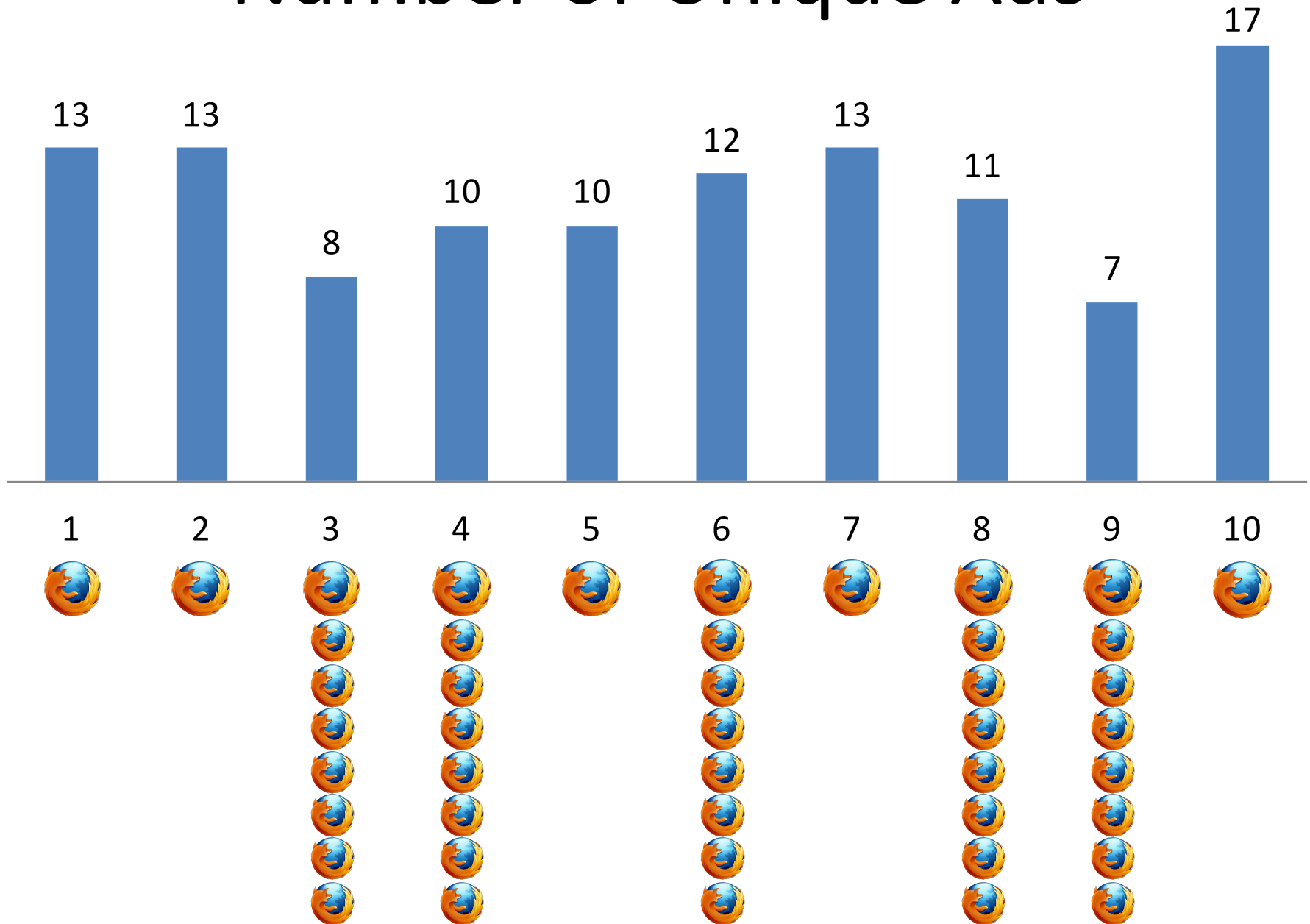
...

Information flow

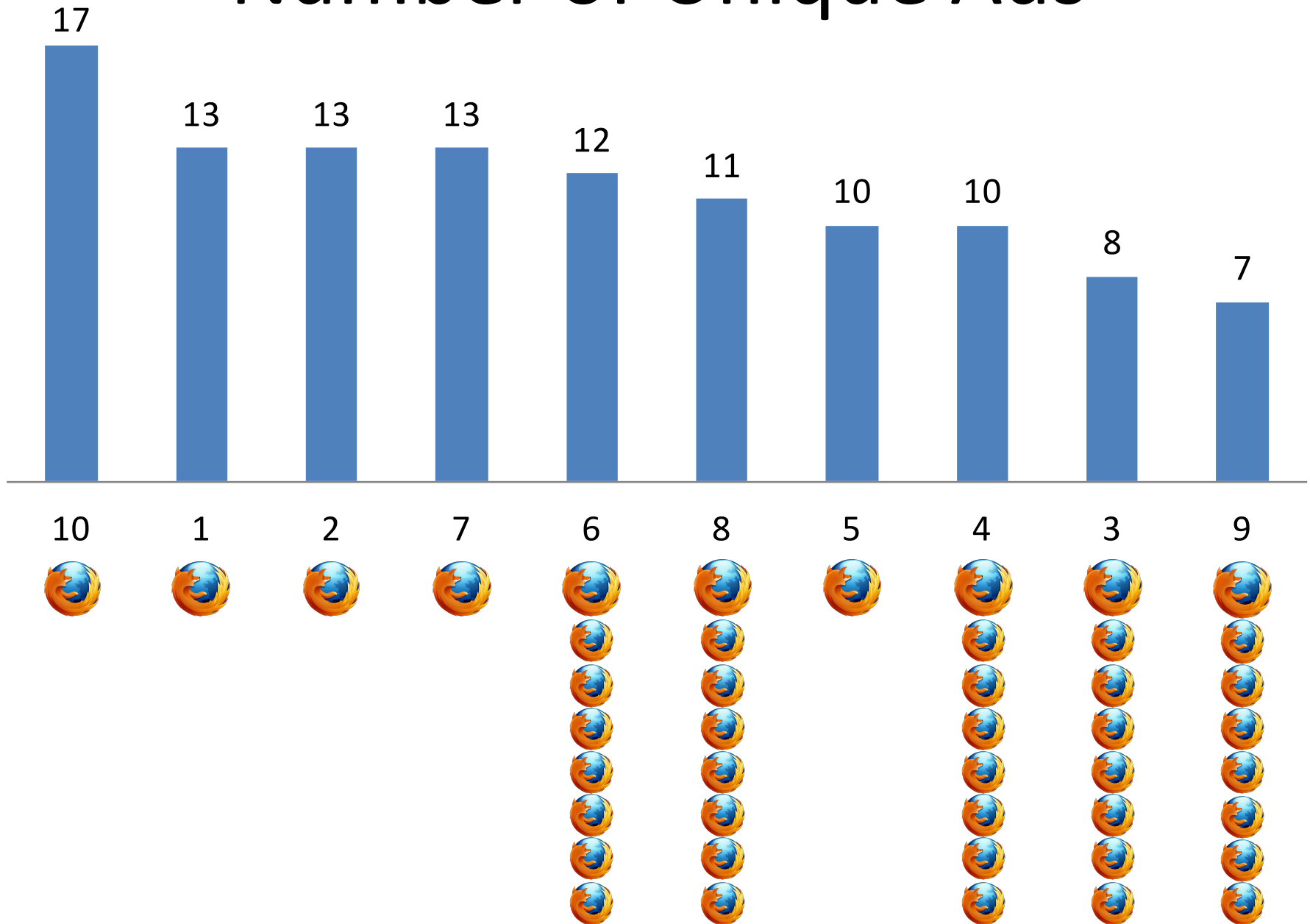


Theorem

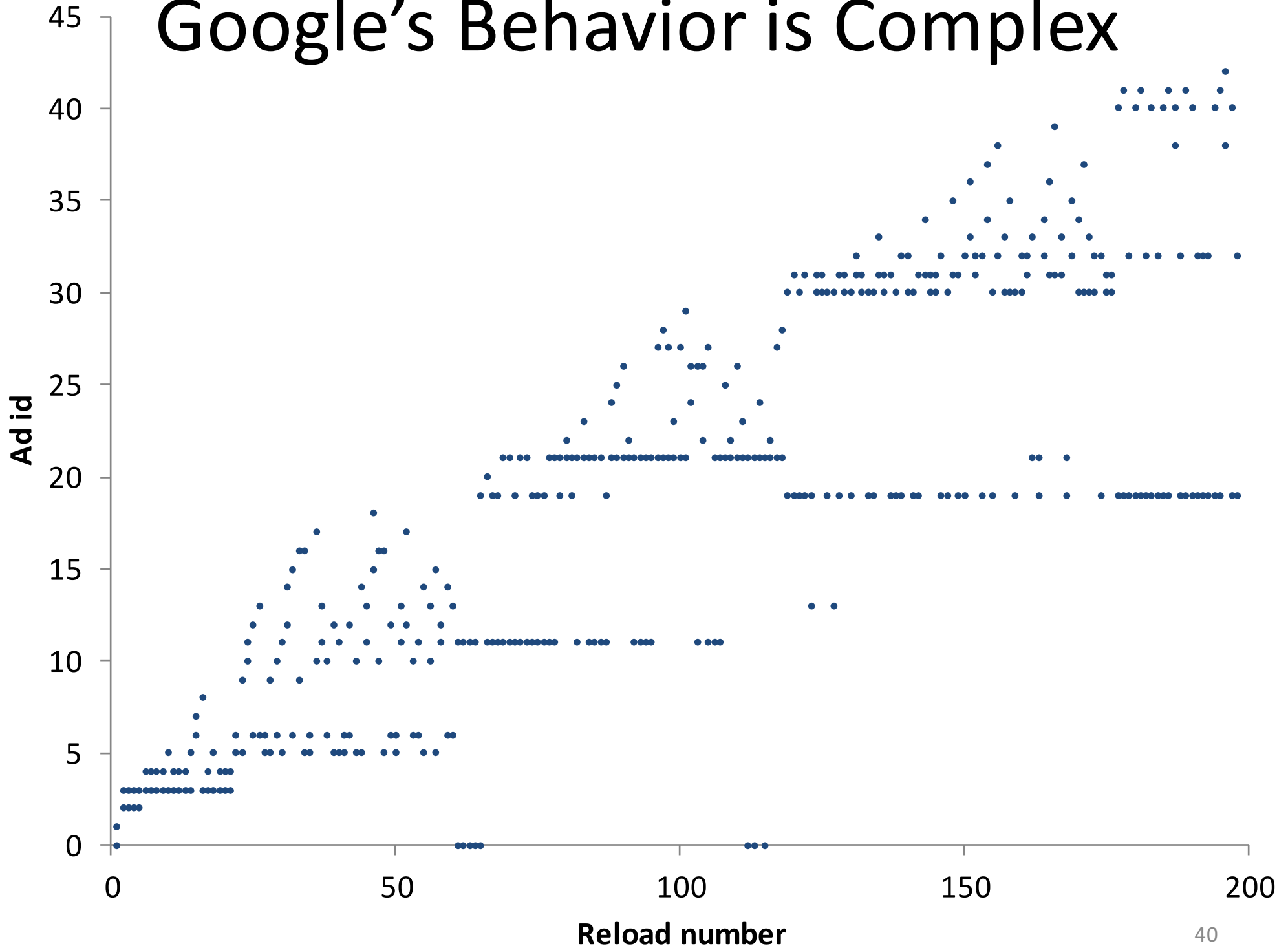
Number of Unique Ads



Number of Unique Ads



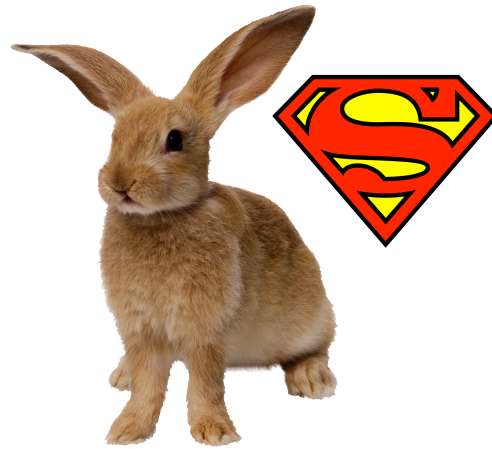
Google's Behavior is Complex



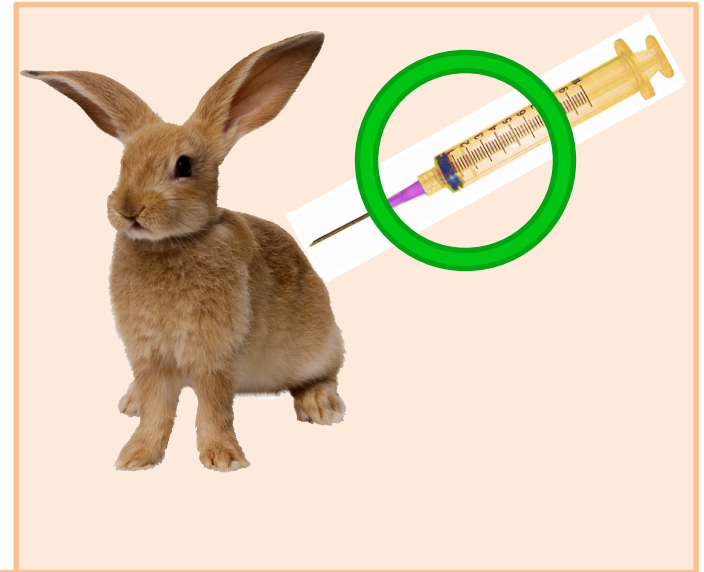
Prior Work on Behavioral Marketing

- No statistical test
 - Guha⁺ 10
 - Balebako⁺ 12
 - Wills & Tatar 12
 - Liu⁺ 13 AdReveal
- Assumptions about ads
 - Barford⁺ 14 AdScape
 - Lecuyer⁺ 14 XRay
 - Englehardt⁺ 14 OpenWPM

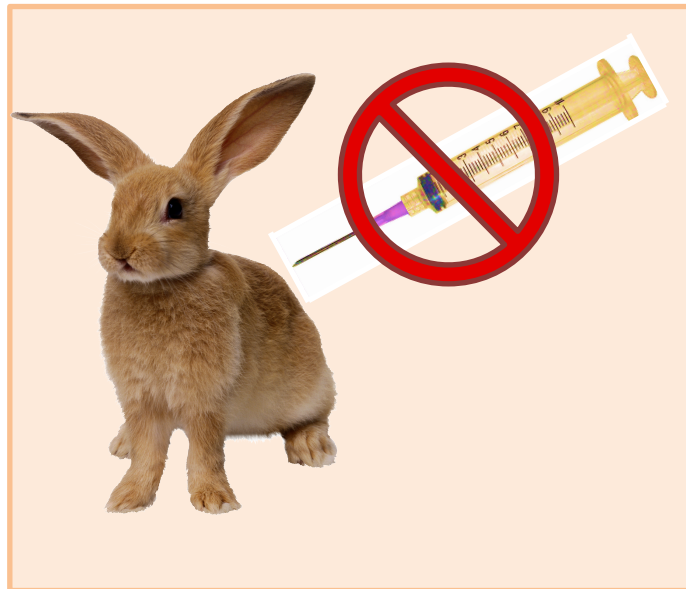
Lives under
Placebo



Dies under
Placebo



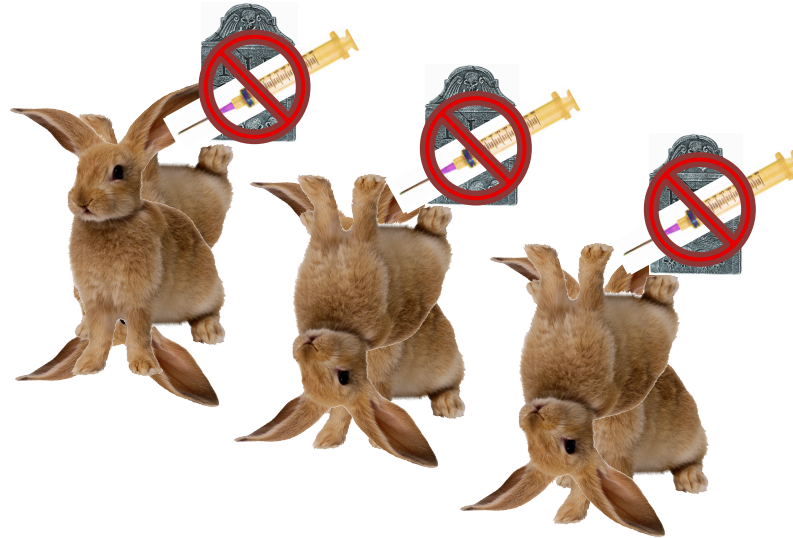
Lives under
Drug



Dies under
Drug

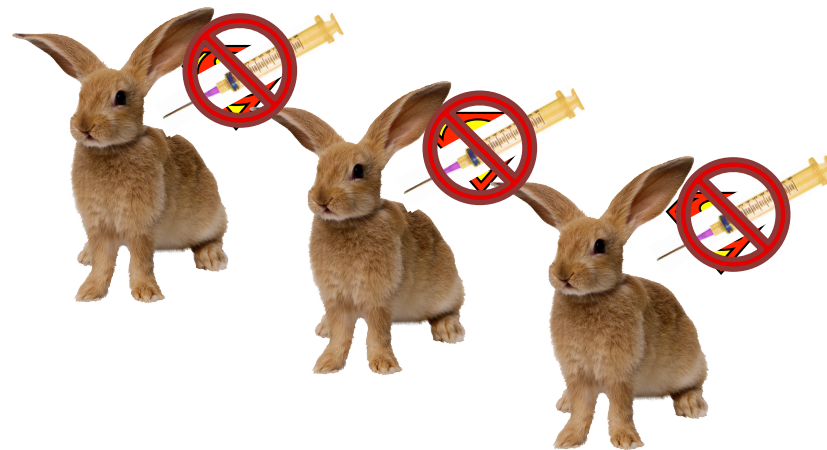


Drug



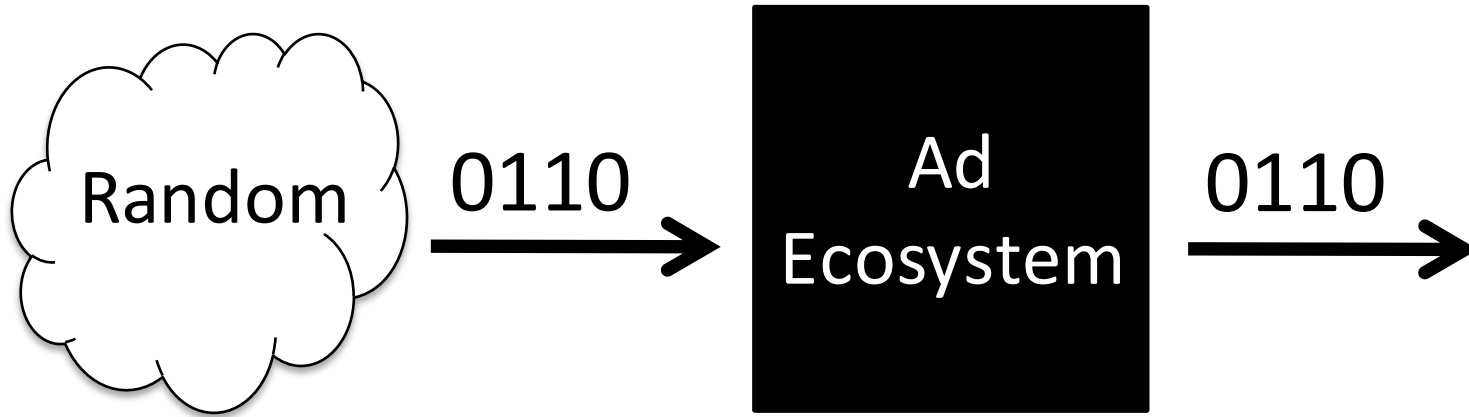
Experimental Group

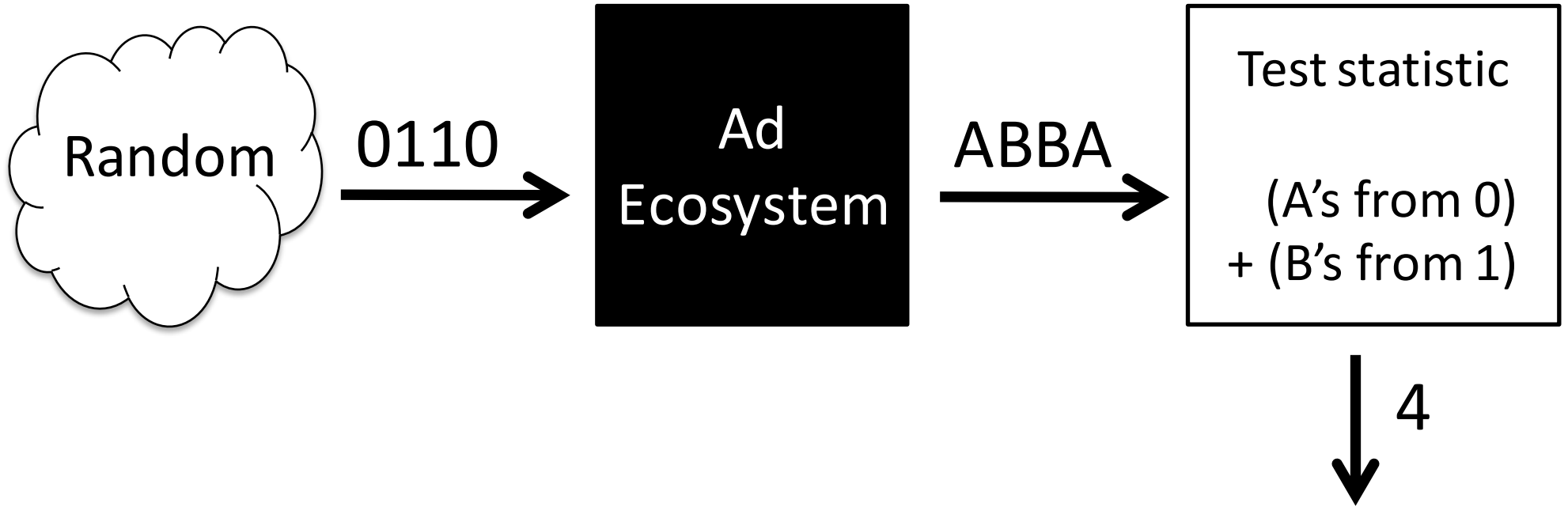
Placebo

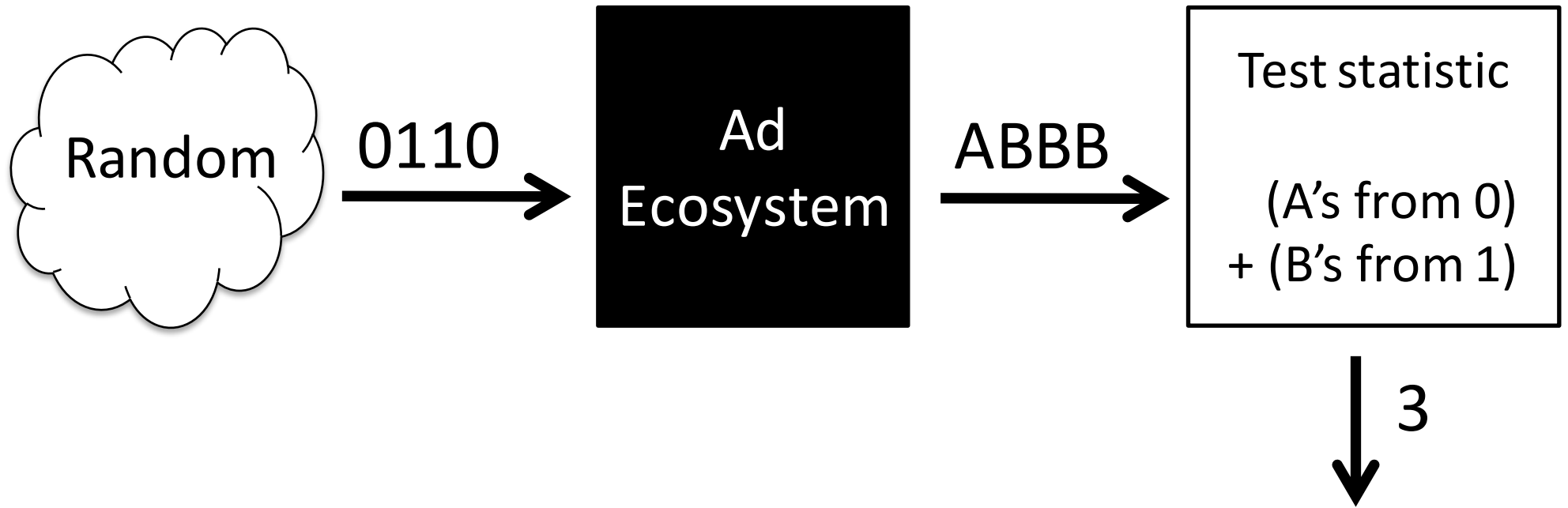


Control Group

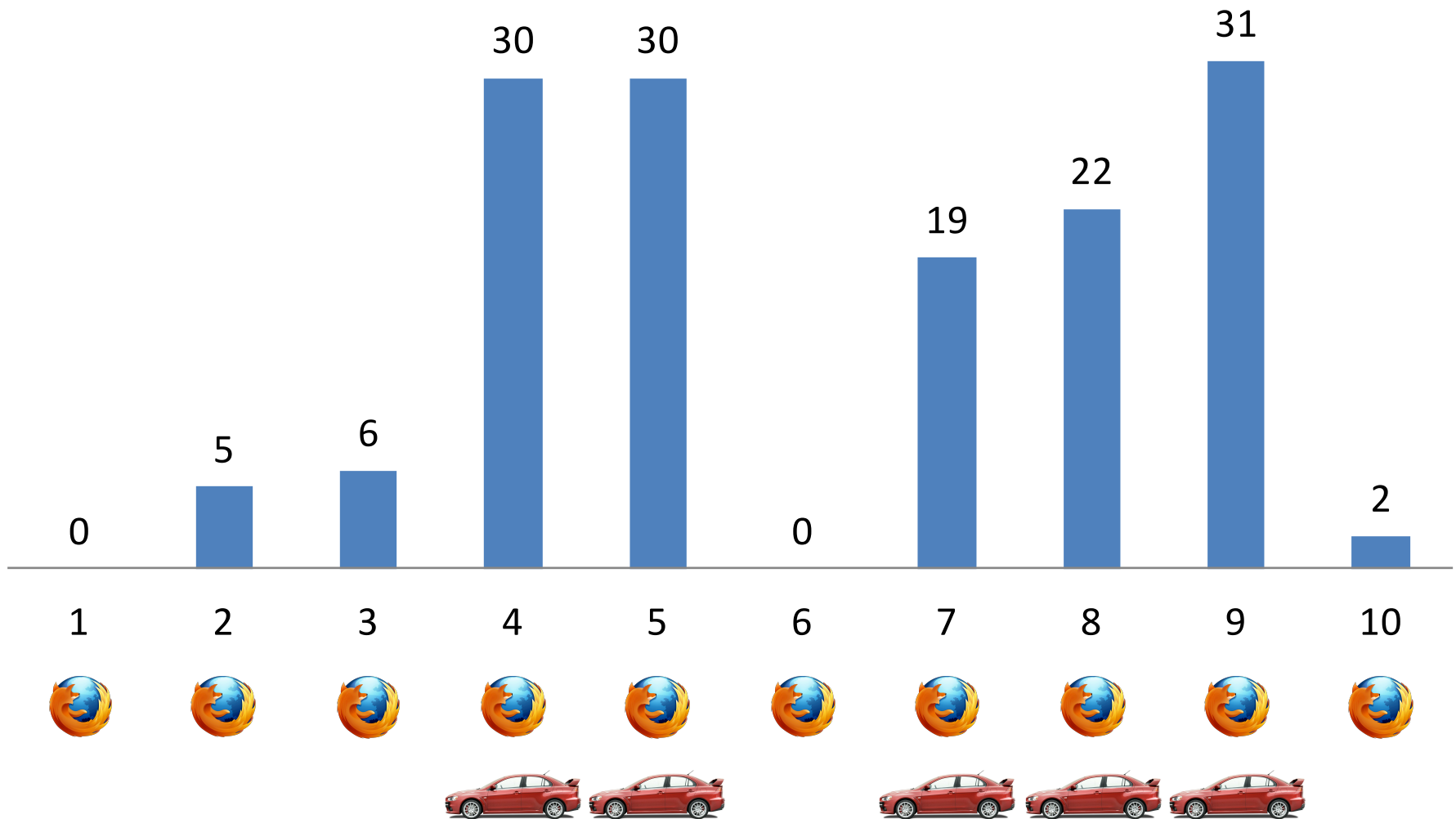




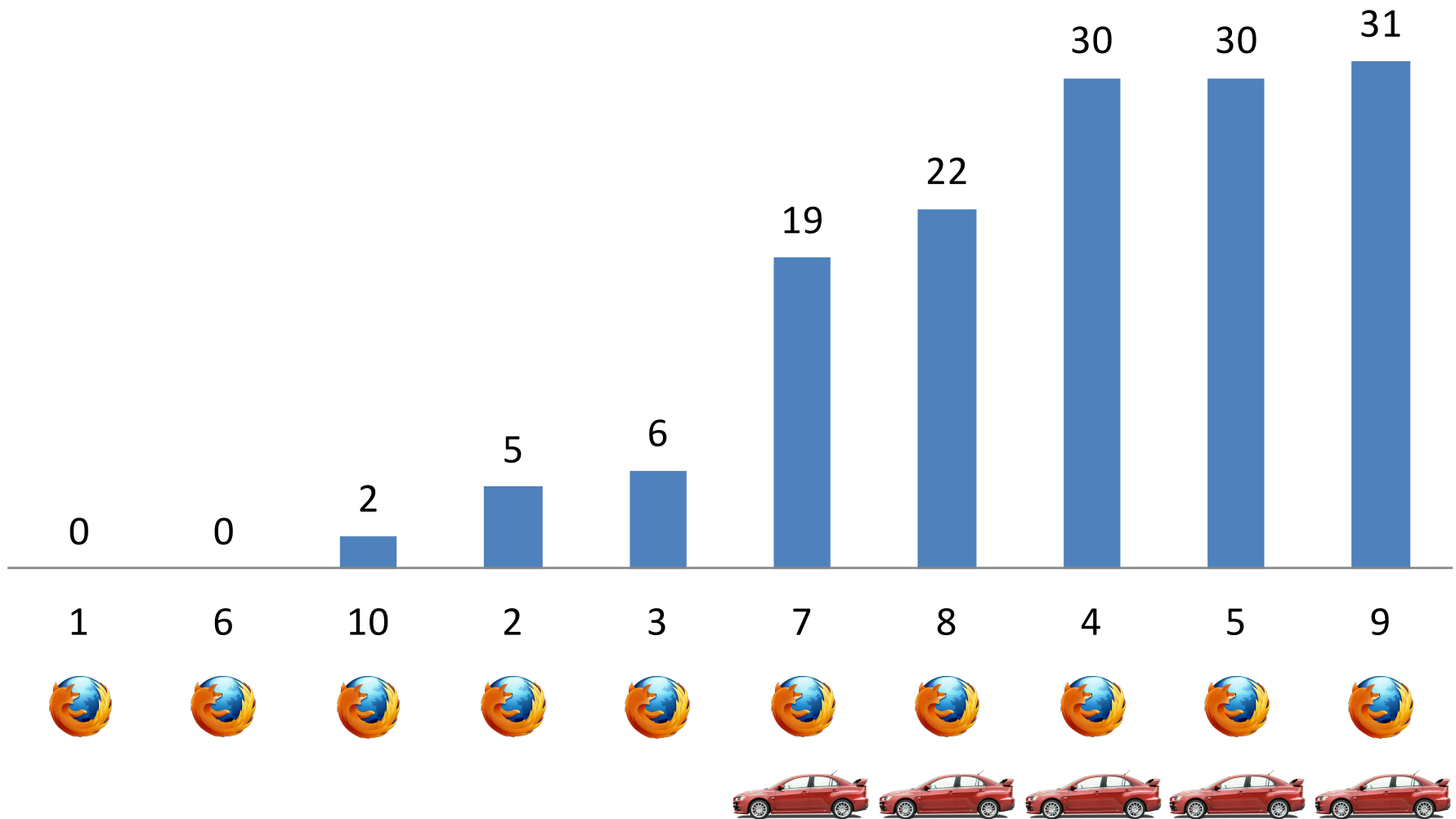




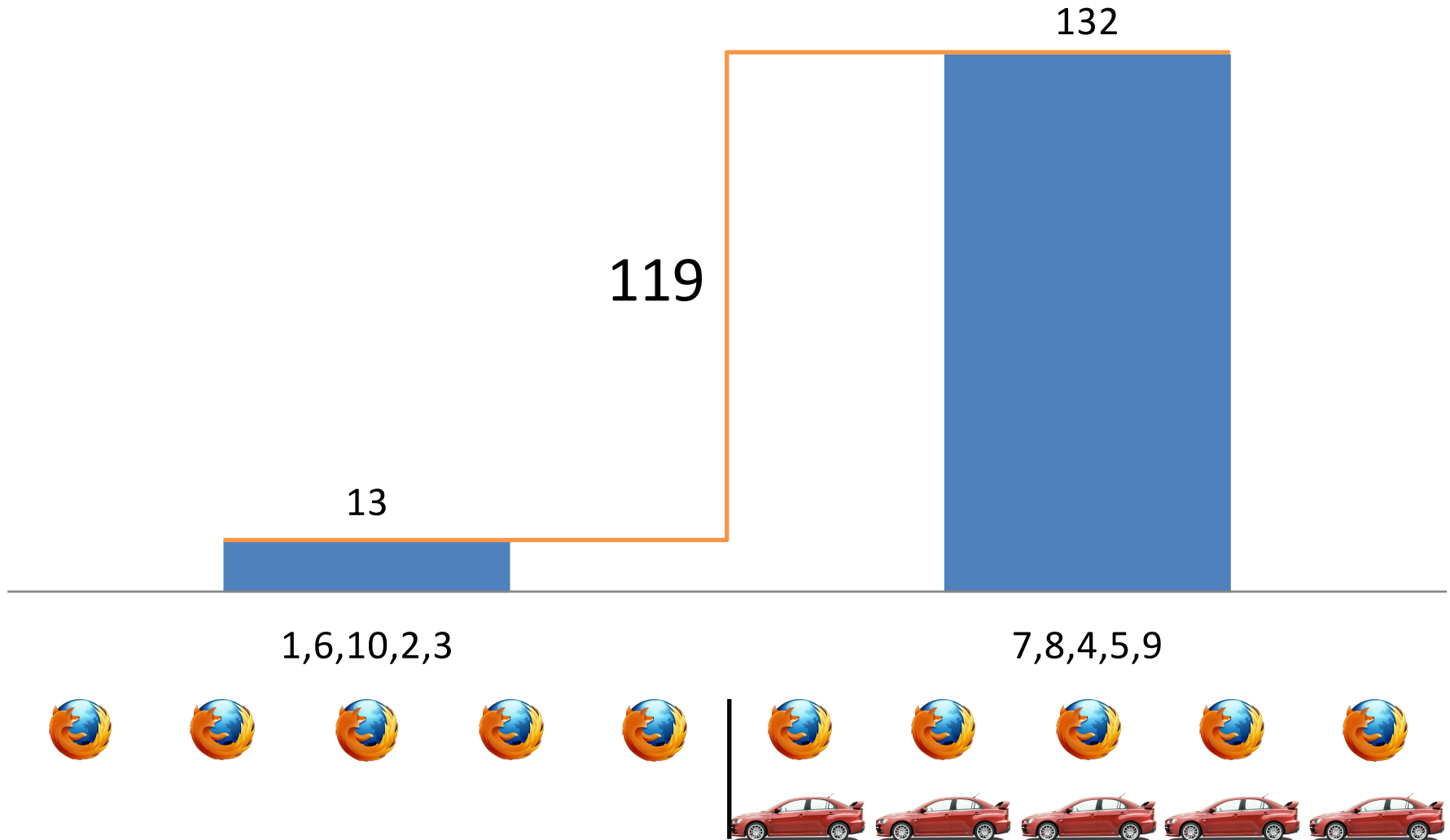
Permutation Test over Keywords



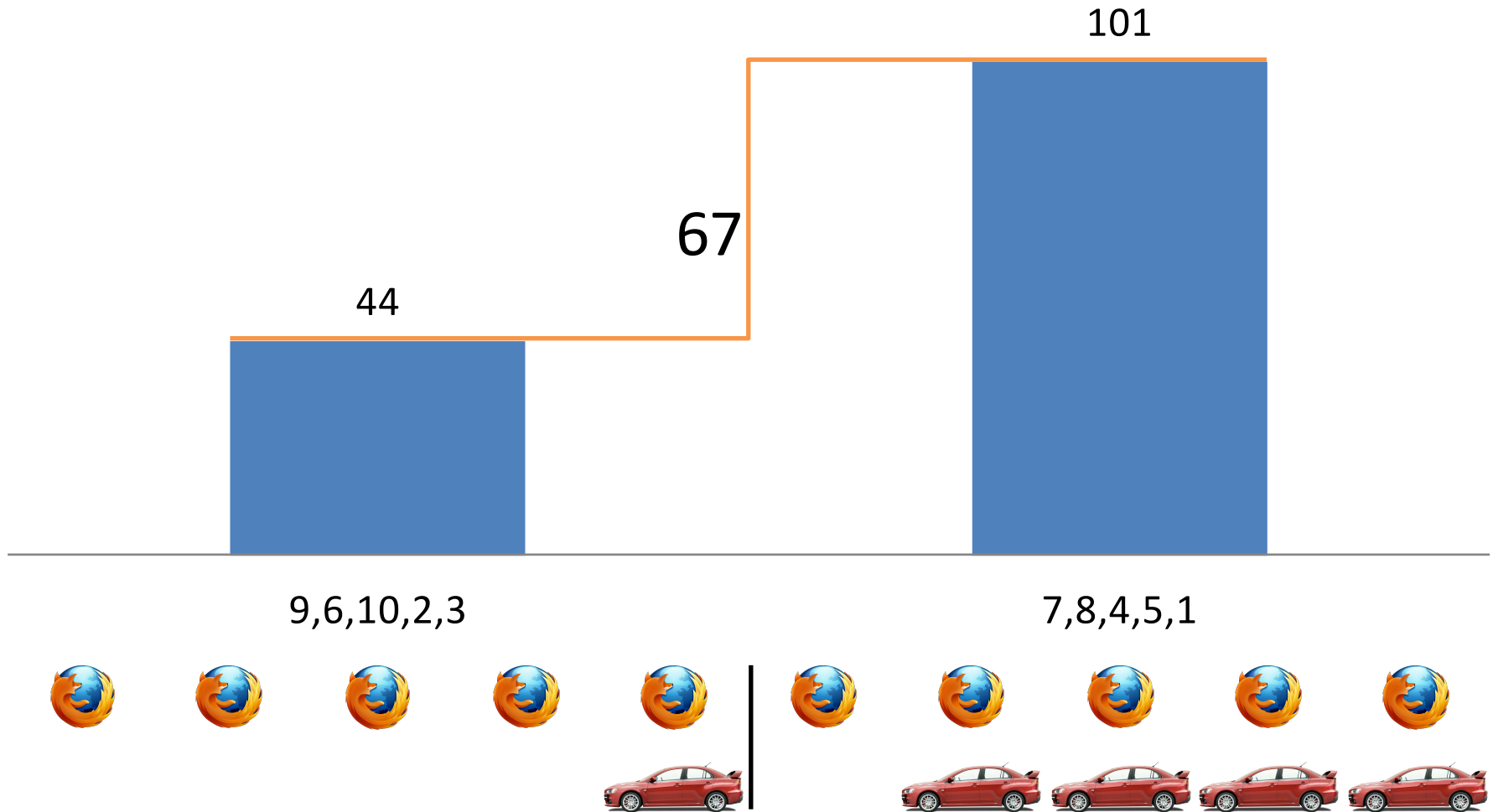
Permutation Test over Keywords



Permutation Test over Keywords



Permutation Test over Keywords

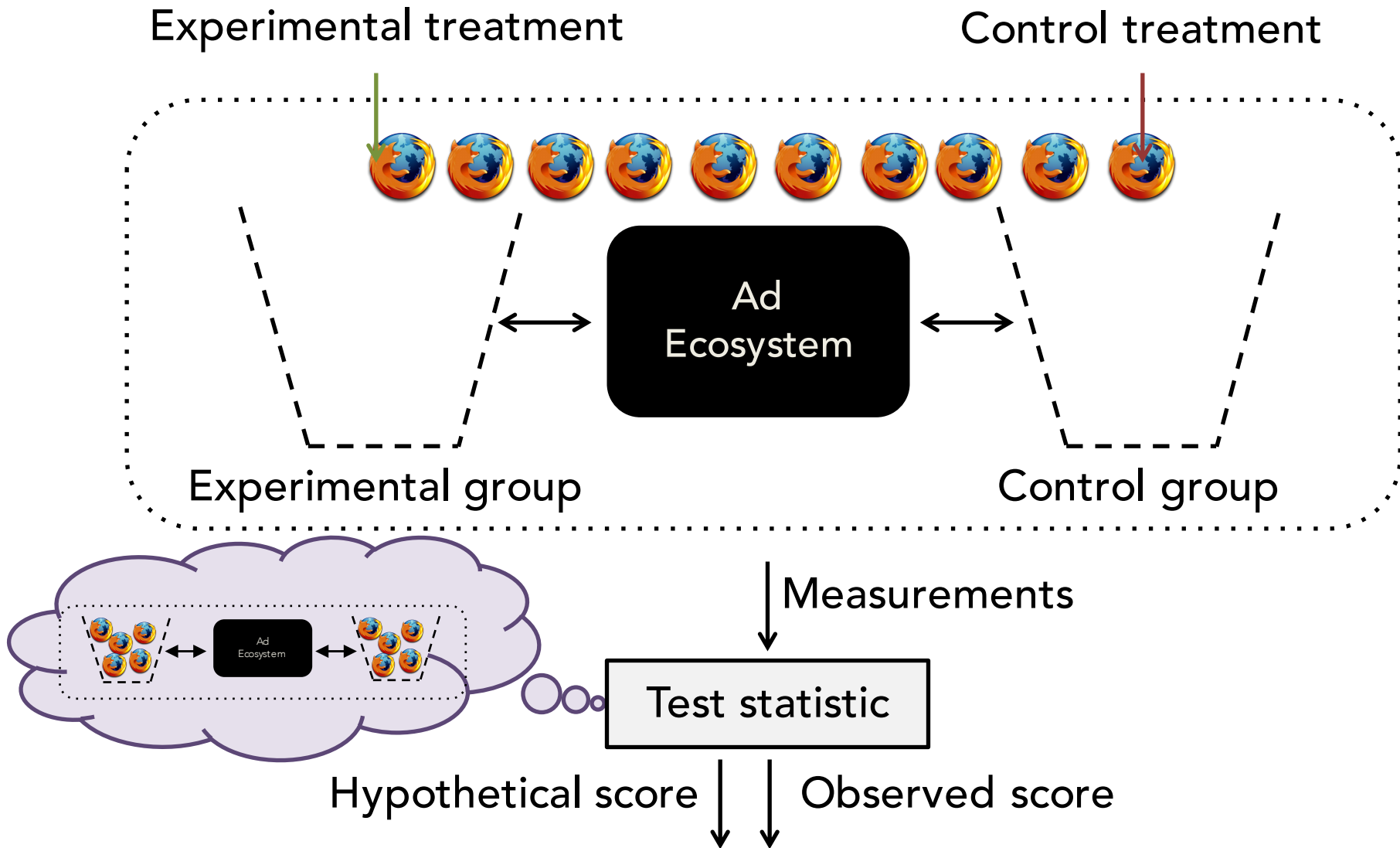


Look at all permutations

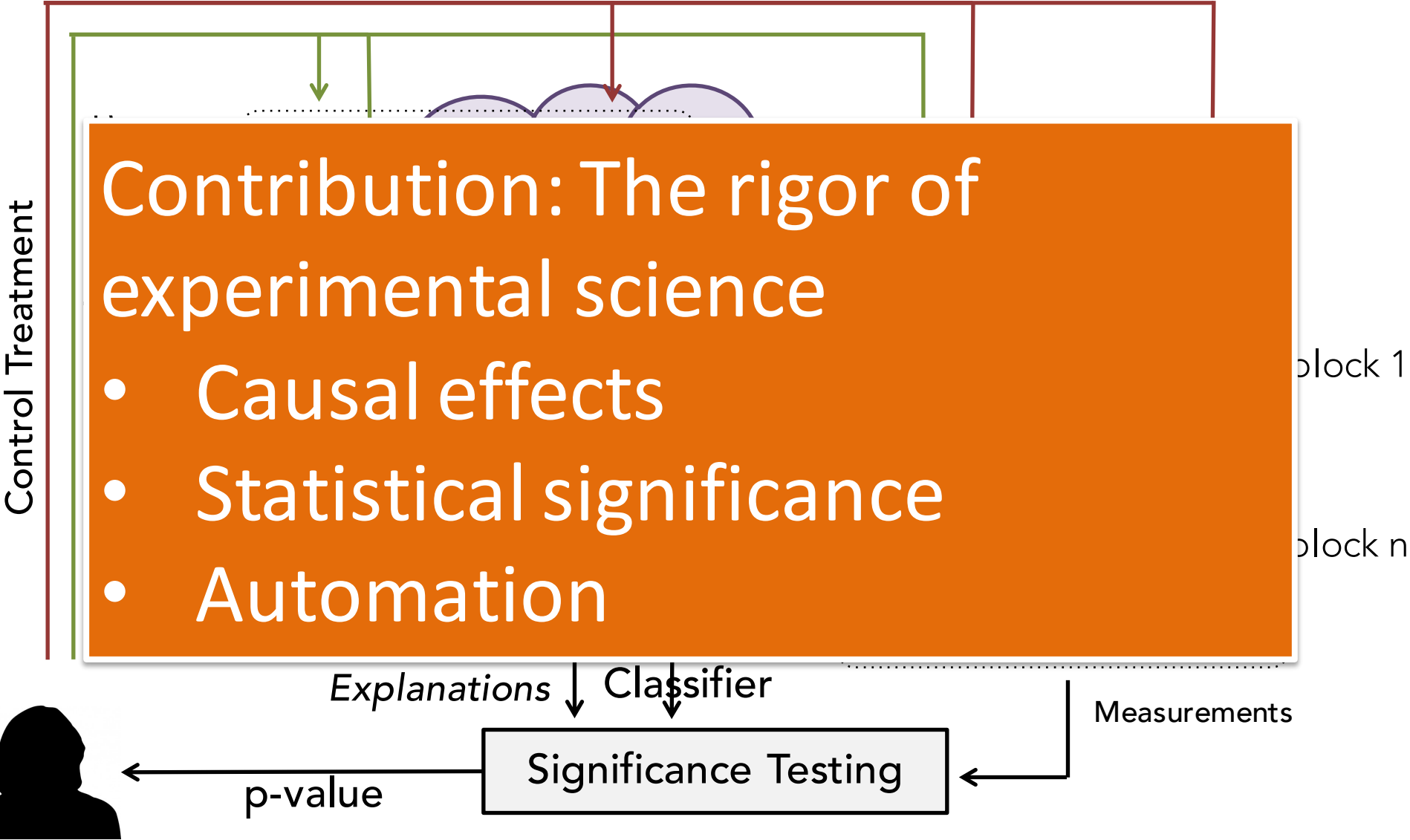


And so forth...

Randomized Controlled Trials



Our Methodology



Interference

System has *interference* from High inputs to Low outputs iff there exists $H1$, $H2$, $O1$, $O2$, and L such that $O1 \neq O2$ and:



and



\neq

Definition of Interference

High has *probabilistic interference* with Low
iff

there exists $H1$, $H2$, and L such that
the distribution of Low's outputs in
 $Q(H1, L)$
equals not the distribution of Low's outputs in
 $Q(H2, L)$

Information Flow Problems

Analyst

Adversary

Protects

Confidentiality Has program

Low user

High input

Taint analysis Has program

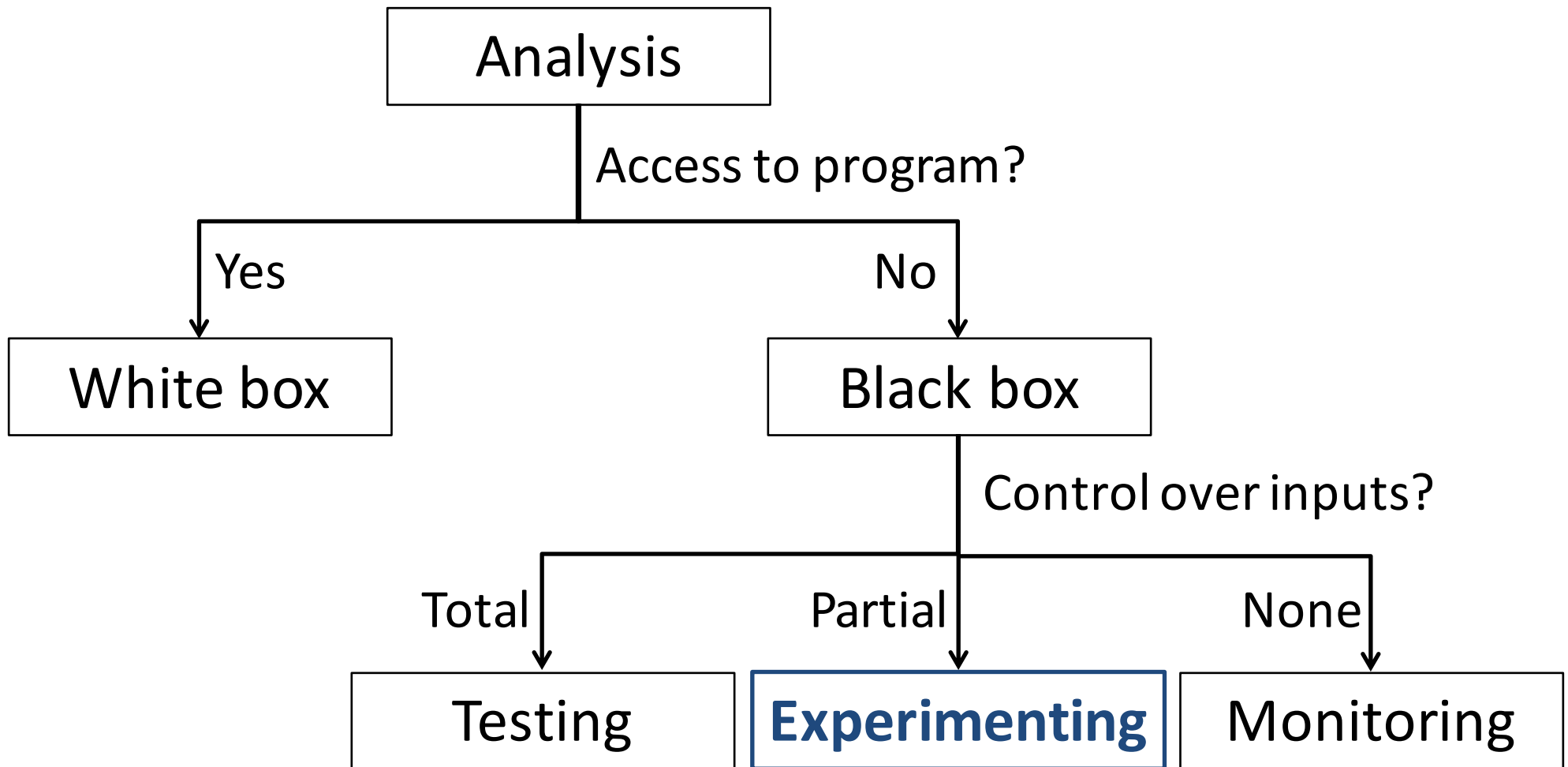
Low user

High output

Information
usage Outside
access

System

High input



Impossibility Results

- No sound experiments for interference
- No sound experiments for noninterference
(except degenerate ones)

Structural Equation Models

Let M be a Structural Equation Model defined by

- $\text{State}_0 := s_0$
- $\text{Input}_1 := i_1$
- $\text{State}_1 := \text{transition_function}(\text{State}_0, \text{Input}_1)$
- $\text{Output}_1 := \text{output_function}(\text{State}_0, \text{Input}_1)$

Structural Equation Models

Let M be a Structural Equation Model defined by

- $\text{State}_0 := s_0$
- $\text{Input}_1 := i_1$
- $\text{State}_1 := \text{transition_function}(\text{State}_0, \text{Input}_1)$
- $\text{Output}_1 := \text{output_function}(\text{State}_0, \text{Input}_1)$

$M[\text{Input}_1 := i']$ is M except with

- $\text{Input}_1 := i'$

Definition of Effect

The factor X has an *effect* on Y given $Z:=z$
iff

there exists $x1$ and $x2$ such that
the distribution of Y in

$$M[X:=x1][Z:=z]$$

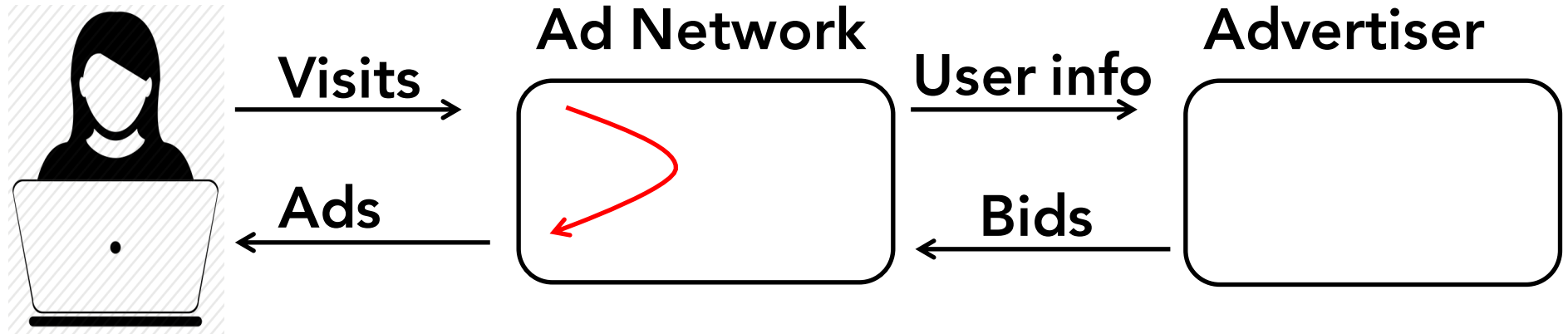
equals not the distribution of Y in

$$M[X:=x2][Z:=z]$$

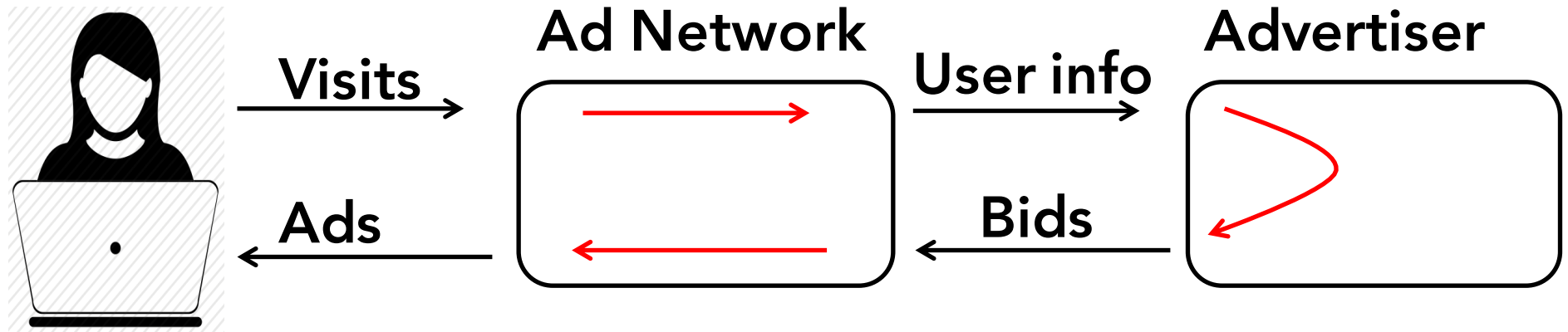
Theorem

- Let M_Q be an SEM representation of an automation Q
- Q has probabilistic interference iff there exists a value li for low inputs such that High_inputs have an effect on low_outputs given Low_inputs := li in M_Q

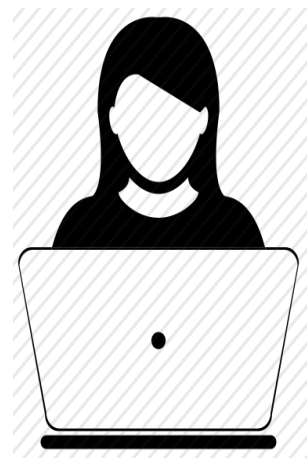
Ad Network has interference



Ad Network has noninterference



Ad ecosystem



Input



Output



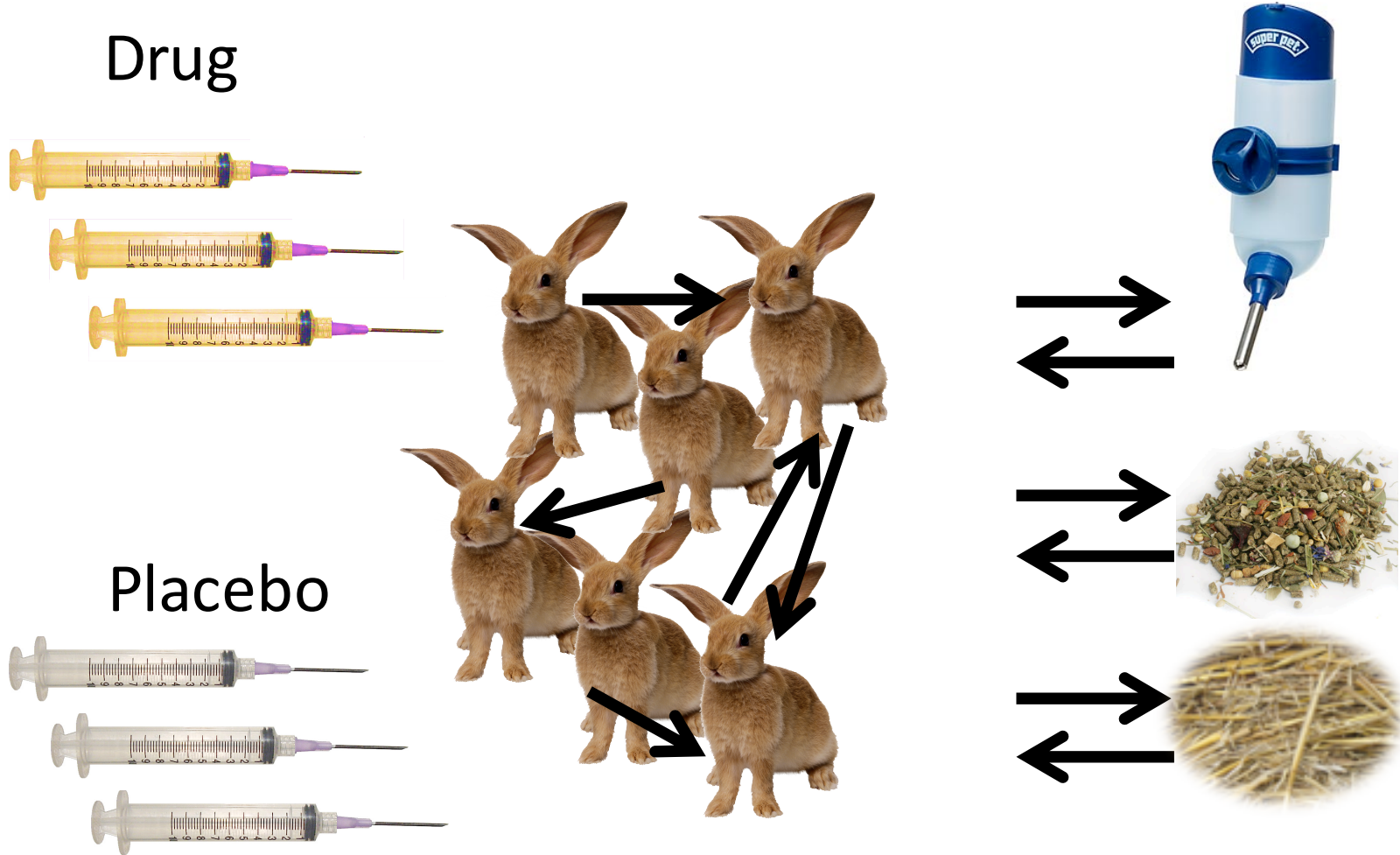
Ad
networks

Advertisers

Websites

Other users

Cross-Unit Effects with Environment



Rigorous Information Flow Experiments

1. Problem: blackbox information flow analysis
2. Interference = Pearl's causation
3. Experimental design and statistical analysis for adversarial setting based on permutation testing
4. Experimental results showing uses of information by Google

Future Work

- Effect size
- Generalization
- Assigning blame
- Finding noninterference

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Multiple Treatments

Visit jobs website

Yes

No

Visit cooking
website

Yes

No

Group Y, Y

Group Y, N

Group N, Y

Group N, N

Multiple Treatments

Visit jobs website

Yes

No

Visit cooking
website

Yes

No

Group Y, Y	Group Y, N
Group N, Y	Group N, N

Multiple Treatments

Visit jobs website

Yes

No

Visit cooking
website

Yes

No

Group Y, Y	Group Y, N
Group N, Y	Group N, N

XRay

- Reduces number of needed tests by assuming
 - Monotonicity: visiting more websites only increases the number of ads targeted to you
 - Identically distributed ads

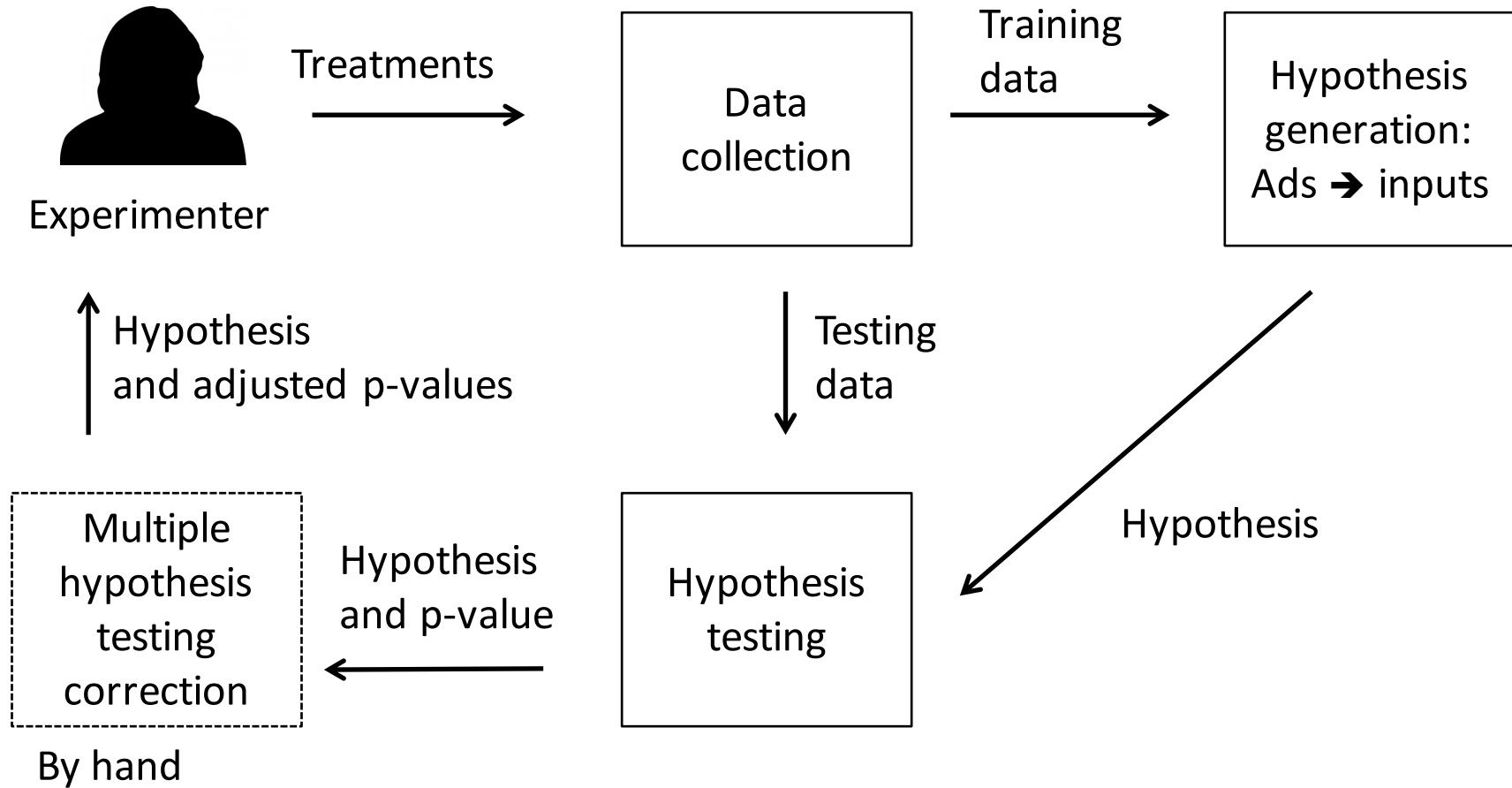
Supported:

		Visit jobs website	
		Yes	No
Visit cooking website	Yes	Group Y, Y	Group Y, N
	No	Group N, Y	Group N, N

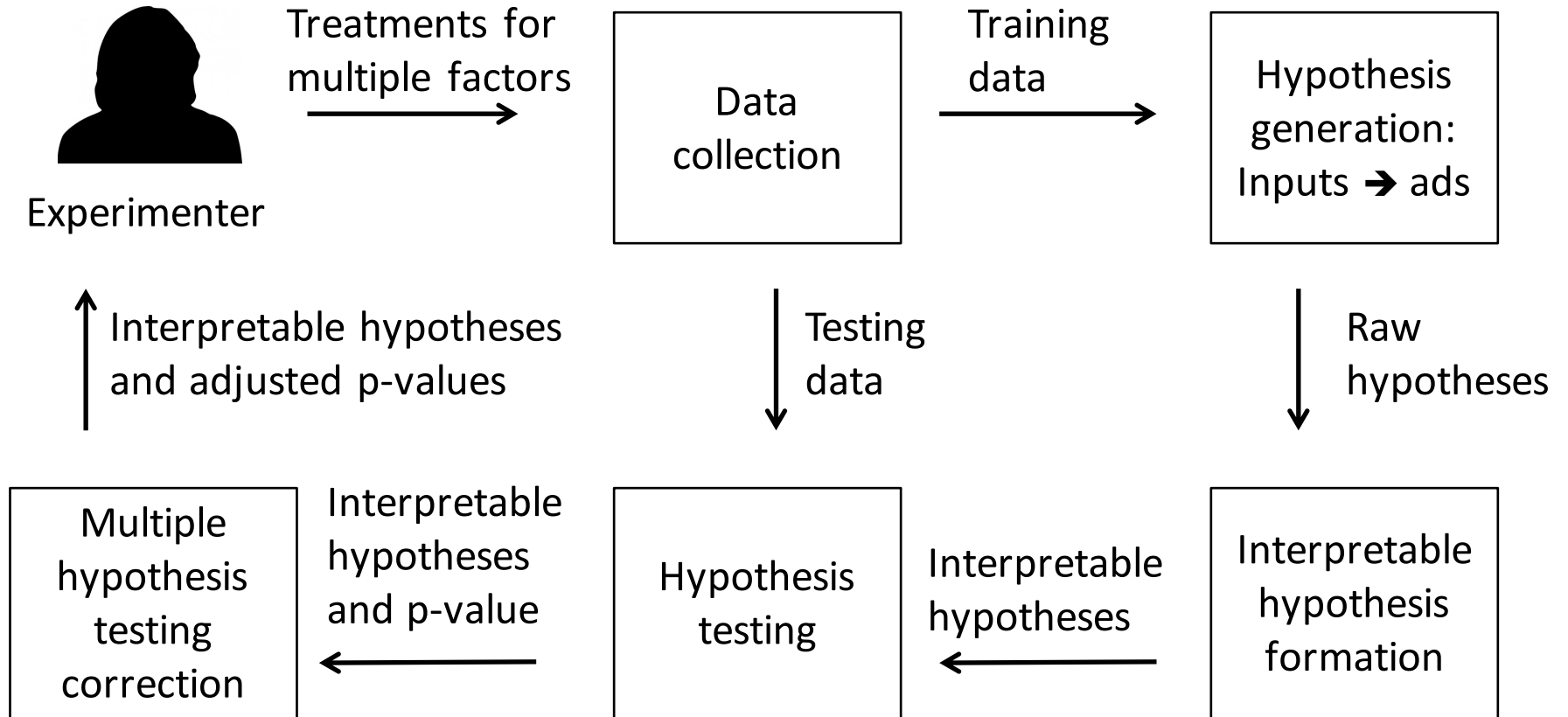
Not supported:

		Visit jobs website	
		Yes	No
Visit cooking website	Yes	Group Y, Y	Group Y, N
	No	Group N, Y	Group N, N

AdFisher



Sunlight



Adapted from Lecuyer et al.

More Information

- M.C. Tschantz, A. Datta, A. Datta, and J.M. Wing.
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- A. Datta, M.C. Tschantz, and A. Datta.
Automated Experiments on Ad Privacy Settings:
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PETS 2015
- <http://www.cs.cmu.edu/~mtschant/ife/>



AdFisher

Information Flow Experiments on Ad Privacy Settings

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