

HOUSEKEEPING

If you are waiting, please:

- Please “git clone” or download this repo:
`https://github.com/alextrickey/adz_demo.git`
- From an R terminal outside of rstudio, run:
`install.packages(“forecasts”)`

DATA SCIENCE APPLICATIONS IN AD TECH

Alex Trickey PhD
2019-04-15

ABOUT ME



I ALSO DO DATA SCIENCE



Provide fit prediction and style matching services to online clothing retailers



Ad Optimization (Today's Topic)



Data and analytics consulting for large media and entertainment companies



PhD Quantitative Psychology

OUTLINE



I - Ad Tech Intro

Data Science in Ad Tech

II - Exploration

Data Exploration, Planning

III - Building a Model

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A/B Testing, Simpson's Paradox

WHAT IS AD TECH?

Advertising technology

The set of tools, analyses, algorithms, strategies, etc used to target and serve ads on the internet

What kinds of companies are in the “Ad Tech” space?

Search Engines: Google, Yahoo, Bing

Ad Trading, Tools and Optimization: Critio, MediaMath, AdRoll, The Trade Desk, Rubicon, etc.

Media and Merchandising: Facebook, Amazon, BuzzFeed, etc.



dental implants



Összes

Képek

Térkép

Videók

Hírek

Egyebek

Beállítások

Eszközök

Nagyjából 164 000 000 találat (0,42 másodperc)

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ADS ARE
EVERYWHERE



Értékelés ▾ Nyitvatartás ▾

Artoral Fogászati Központ

4,7 ★★★★★ (13) · Parodontológia, fogászati implantátumok

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Zárva · Nyitás: H 10:00



WEBHELY



ÚTVONALTERV

Are You Guacamole or Hummus?

BY ZOE SAMUEL



Larissa

DATA SCIENCE QUESTIONS IN AD TECH

How can we...

- get more **traffic**?
- modify **engagement**?

The screenshot shows the Zoo.com website interface. At the top is a blue navigation bar with the 'ZOO' logo, a search bar, and links for Animals, Cars, Trucks & Engines, TV, Film & Music, All About You!, Love & Sex, Sports Trivia, General Trivia, and The World. Below the navigation bar, a banner reads 'made well, they are absolutely delicious!' with a 'Read More' button. A 'Scroll to Begin Quiz ↓' link is present. The main content area features a quiz titled 'Válaszd például a Samsung Galaxy A50 készüléket' (Choose for example the Samsung Galaxy A50 device) with a red background and a Vodafone logo. The first question is '1. How easily irritated are you?' with four response buttons: 'Not at all!', 'Like an open sore', 'I have my moments!', and 'I have the patience of a saint.' Below the quiz is another banner for 'WHAT DO YOU KNOW ABOUT CAR ENGINES?'. On the right side, there is a sidebar with text about the site's goal and a promotion for a smartphone upgrade program.

Our goal at Zoo.com is to keep you entertained in this crazy life we all live.

We want you to look inward and explore new and interesting things about yourself. We want you to look outward and marvel at the world around you. We want you to laugh at past memories that helped shape the person you've become. We want to dream with you about all your future holds. Our hope is our quizzes and articles inspire you to do just that.

Life is a zoo! Embrace it on Zoo.com.

Válts okostelefont a készülékcseré programban



Válts okostelefont a



ADVERTISEMENT

108 országból tarthatja
ügyfeleivel a kapcsolatot

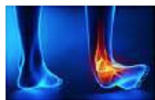
Személyi és utazási célra, a Vodafone
és partnerhálózatain.



A mi korlátlan
Business Red World
csomagunkkal

[Fitness & Exercise](#) > [Guide](#) >

TODAY ON WEBMD

**What's Causing Your Leg Pain?**

Tendinitis, muscle cramp & more.

**Want to Try Yoga?**

What to know about benefits, types, and more.

**Hydration Quiz**

How much water do you need?

**Build a Better Butt**

Workouts for slim and shapely
utes.

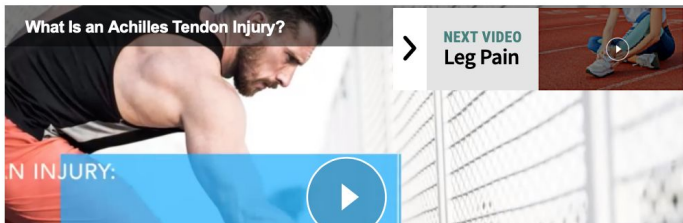
What Is an Achilles Tendon Injury?



What Is an Achilles Tendon Injury?



NEXT VIDEO
Leg Pain



SPONSORED ADS

1

Affordable Senior Dental
Implants



4

Home Remedies for Heel Pain



2

Dental Implant Prices



5

Apple Cider Vinegar Diet



3

Pain Relief Medications



6

Treatments for Hip Pain



Which ads...

- have the highest **value**?
- are the **clickiest**?

DATA SCIENCE
QUESTIONS IN
AD TECH

USEFUL TERMS

Impressions = Number of Times the Ad was Displayed

Clicks = Number of Times the Ad was Clicked

Click-Through-Rate (**CTR**) = Clicks / Impressions

Revenue Per Click (**RPC**) = Revenue / Clicks

Revenue Per Impression (**RPI**) = Revenue / Impressions

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PROBLEM 1

How do different types of ads perform next to the rabbit?

Suppose we have 3 types to choose from:

- dog food
- cat toys
- phone service

Getting a Pet Rabbit? 4 Things to Know First

BY JESSLYN SHIELDS MAY 9, 2019



Rabbits are cute and cuddly, but they require veterinary care just as a dog or cat does. RALPH ORLOWSKI/GETTY IMAGES

Imagine having a pet [bunny](#) to snuggle on the couch while you watch Netflix, or maybe to hop around in your yard, posing for the cameras with your children on Easter morning. All that sounds pretty adorable, if you're into that kind of thing. And yet, like any pet, [rabbits](#) are also a much bigger commitment than you might realize. So, what do you need to know before picking up a rabbit and commencing couch



ISMERJE MEG
ÁLLATELEDEL ÉS
KIEGÉSZÍTŐ
KÍNÁLATUNKAT!



EXPLORE THE AVAILABLE DATA

Open up **problem_set.r** and start an R session.

Take a few minutes to explore:

- A. Load the data from “data/hourly_ad_category_data.csv”.
- B. Are there any problems with the data?
- C. Try to summarize the data with statistics and/or a visualization.
- D. How do the three ads compare?

THINK BEFORE MODELING

Now that we know what data is at our disposal, let's think about it:

- Which of our metrics might be best to model/optimize?

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- How could we test that our optimization working?

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TIME SERIES

What is special about time-series?



Source:

https://www.dailyfx.com/forex/fundamental/article/special_report/2018/11/30/Brexit-Impact-on-GBP-How-the-Pound-Might-Move-After-Parliamentary-Vote.html

TIME SERIES

What is special about time-series?

- Order matters
- Autocorrelation
- Trends
- Seasonality



Source:

https://www.dailyfx.com/forex/fundamental/article/special_report/2018/11/30/Brexit-Impact-on-GBP-How-the-Pound-Might-Move-After-Parliamentary-Vote.html

WHAT KINDS OF MODELS ARE TIME SERIES MODELS?

What kinds of methods can be used to model time series?

- Classical Timeseries Models
- Fourier / Spectral Analysis
- Signal Processing
- Neural Networks / Deep learning
- Structural / Hierarchical Models
- And many more: https://en.wikipedia.org/wiki/Time_series#Tools

We should choose based on the problem we are trying to solve.

STATIONARY VS NON-STATIONARY TIME SERIES

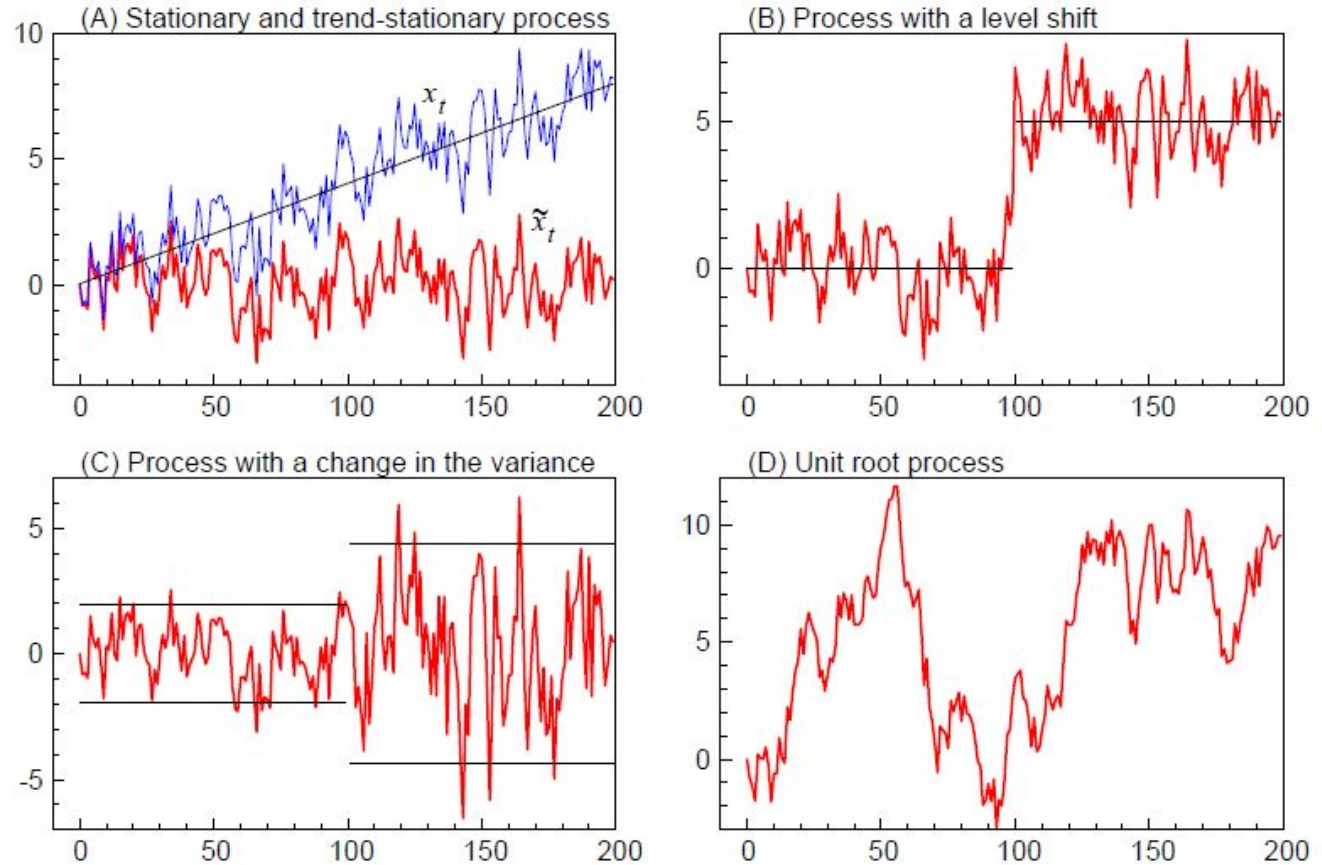


Figure 1: Simulated examples of non-stationary time series.

MODELS OF STATIONARY DATA

Autoregressive Models (AR)

- Current value depends on preceding values
- E.g. Stock prices temperature

$$X_t = 0.9 X_{t-1} + error$$

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- E.g. Demand for a product

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MODELS OF STATIONARY DATA

Autoregressive Models (AR)

- Current value depends on previous values
- E.g. Stock prices

$$X_t = 0.9$$

Both of these models assume the data is stationary.

The main differences between them are the degree and quality of the correlation between current and past events and how the systems respond to sudden changes (shocks).

$$X_t = \mu + \sum_{i=1}^p \varphi_i X_{t-i} + \varepsilon_t$$

Moving Average

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MODELS OF NON-STATIONARY DATA

ARIMA

- ARMA with “differencing” transformations to make it stationary.
- Differencing:
 - Literally subtracting the previous value from the next one:

$$y'_t = y_t - y_{t-1}$$

- Can be repeated multiple times
- Can also be used to account for seasonality:

$$y'_t = y_t - y_{t-m}$$

MODELS OF NON-STATIONARY DATA

BATS:

- **B**ox-Cox transforms the series prior to modeling
- **A**RMA errors
- **T**rend term with damping
- **S**easonal components

MODELS OF NON-STATIONARY DATA

TBATS:

- Trigonometric seasonal components via Fourier Series
- **BATS**

BATS and TBATS References

- White Paper: <https://robjhyndman.com/papers/ComplexSeasonality.pdf>
- Summary of Formulas and Python Implementation:
<https://medium.com/intive-developers/forecasting-time-series-with-multiple-seasonalities-using-tbats-in-python-398a00ac0e8a>

HOW DO WE CHOOSE?

Want to know: **Which will best predict future observations?**

Questions

- How do we usually measure error and evaluate models in machine learning / data science?

HOW DO WE CHOOSE?

Want to know: **Which will best predict future observations?**

Questions

- How do we usually measure error and evaluate models in machine learning / data science?
- What about this process do we need to change for time-series data?

PROBLEM 2: MODEL FITTING AND FORECASTING

Let's jump back into `problem_set.r`.

- First we will walk through an example together.
- Then you can try on your own.

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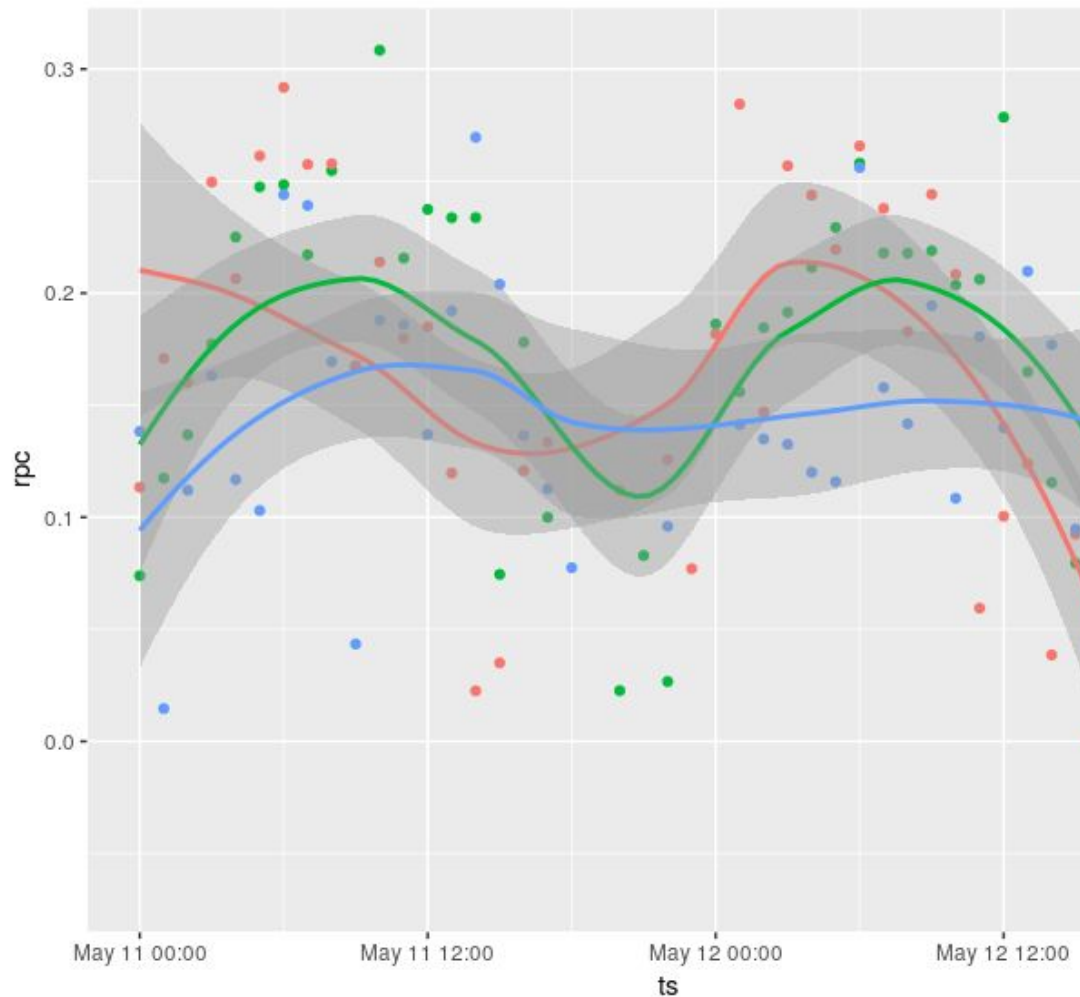
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LET'S THINK
ABOUT
OPTIMIZATION



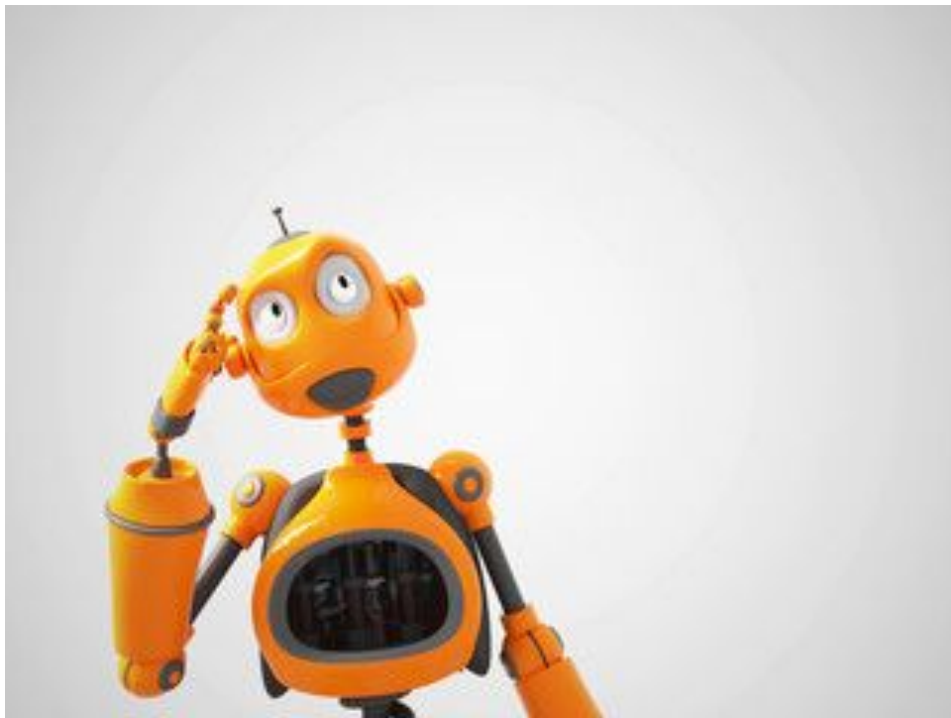
EXPLORE-EXPLOIT DILEMMA

Exploit - We want to take advantage of solutions that we know are more optimal than others.

Explore - However, if do not sufficiently investigate other options we may end up exploiting a suboptimal solution.

Dilemma - How should we balance between these?

REINFORCEMENT LEARNING



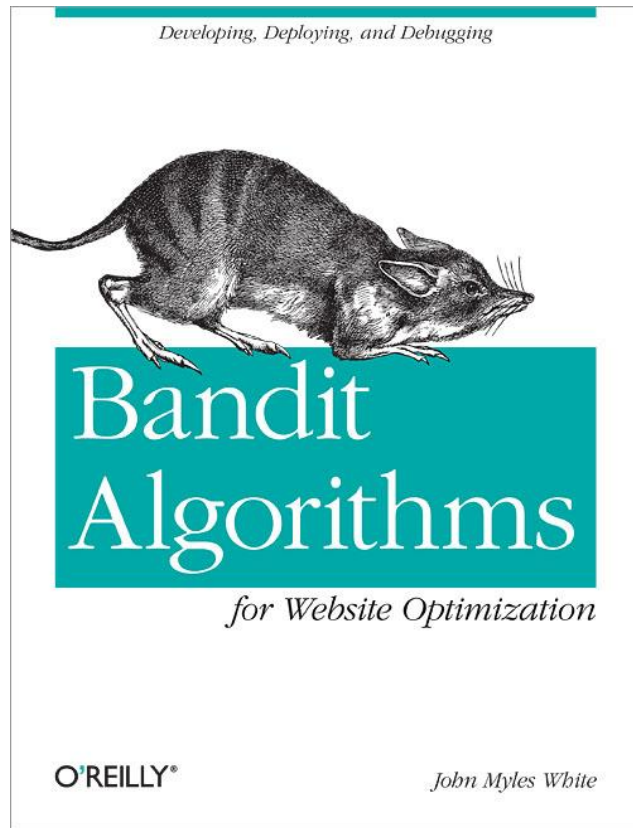
“**Reinforcement learning (RL)** is an area of **machine learning** concerned with how **software agents** ought to take **actions** in an **environment** so as to maximize some notion of cumulative **reward**.”

- Wikipedia Definition

BANDIT ALGORITHMS

Bandits are a simple class of RL agents.

They can help manage the explore-exploit dilemma by giving more weight to good options and less to bad options as information is acquired.

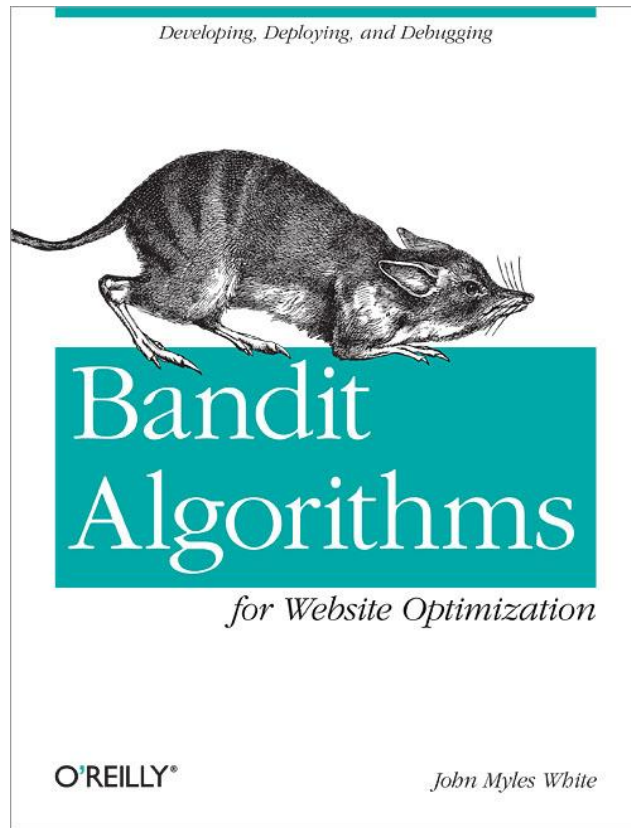


BANDIT ALGORITHMS

Bandits are a simple class of RL agents.

They can help manage the explore-exploit dilemma by giving more weight to good options and less to bad options as information is acquired.

What are the actions, environment, reward in the Ads example?



SOME GOTCHAS

These algorithms will shape the data.

Goodhart's Law -- When a measure becomes a target it ceases to be a good measure.

SOME GOTCHAS

These algorithms will shape the data.

Goodhart's Law -- When a measure becomes a target it ceases to be a good measure.

To avoid this, maintain an unbiased baseline, so you and your models will not be misled.

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PROBLEM 3

Suppose, we selected an optimization strategy using our ts model.

We rolled it out on 10% of the traffic.

It's been running for one day.

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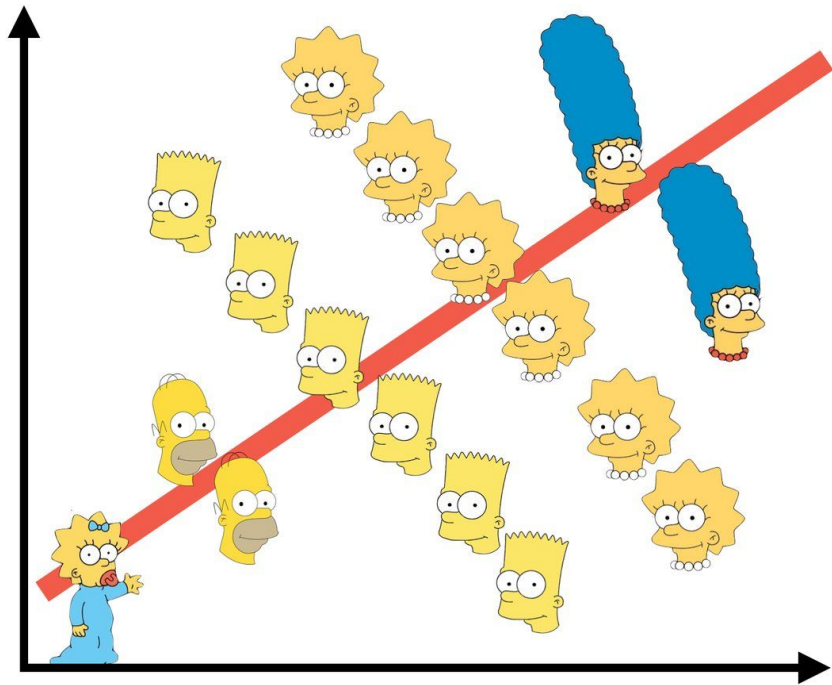
Enter DJ Janos:

Are we making money?



Source: <https://vimeo.com/3109723>

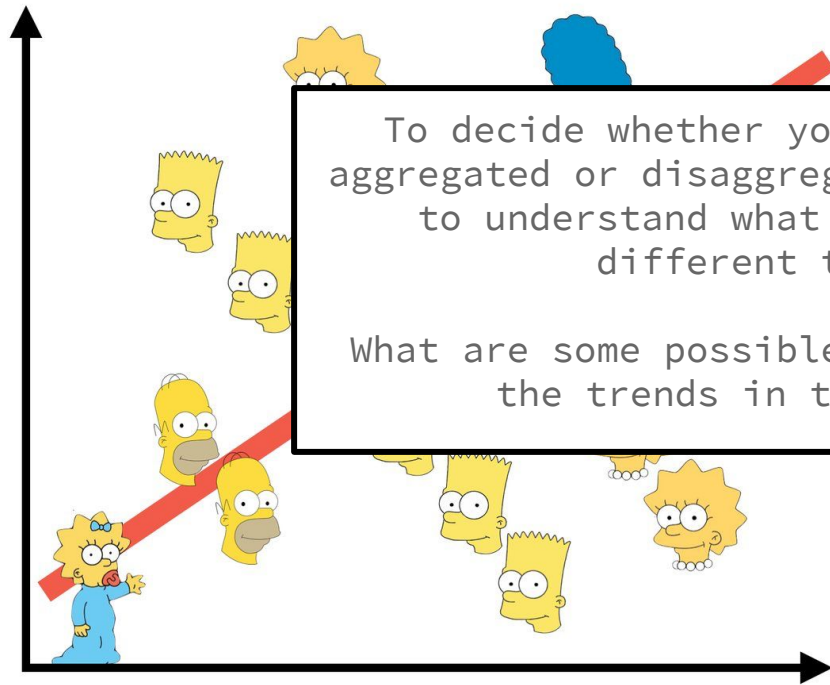
GOTCHAS



“Simpson's paradox is a phenomenon in probability and statistics, in which a trend appears in several different groups of data but disappears or reverses when these groups are combined.”

– Wikipedia Definition

GOTCHAS



To decide whether you should use the aggregated or disaggregated data you have to understand what is **causing** the different trends.

What are some possible explanations for the trends in the Ad Data?

“Simpson's paradox is a phenomenon in probability and statistics, in which a trend that is present in several groups of data disappears or reverses when the groups are combined.”

– Wikipedia Definition

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THANKS!
QUESTIONS???