Get to the Bottom
Causal Analysis for User Modeling

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Motivation

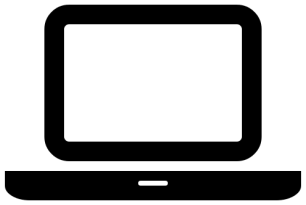
- Weather affects our mood and behavior

Sunny

- Higher temperatures bring a depressed person up
- People tend to go outside when it is sunny

Rainy

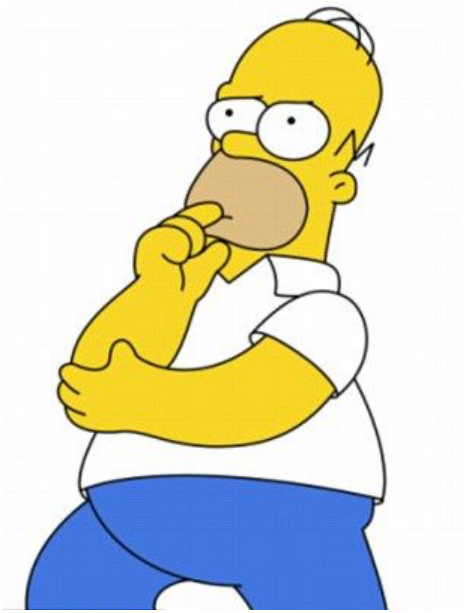
- A lack of sunlight could make you sad (Seasonal Affective Disorder)
- Rain can cause pain



Causal Analysis – An Example

Goal: Study relations between weather and user TV watching patterns

Question: Does high temperature cause watching more Drama?



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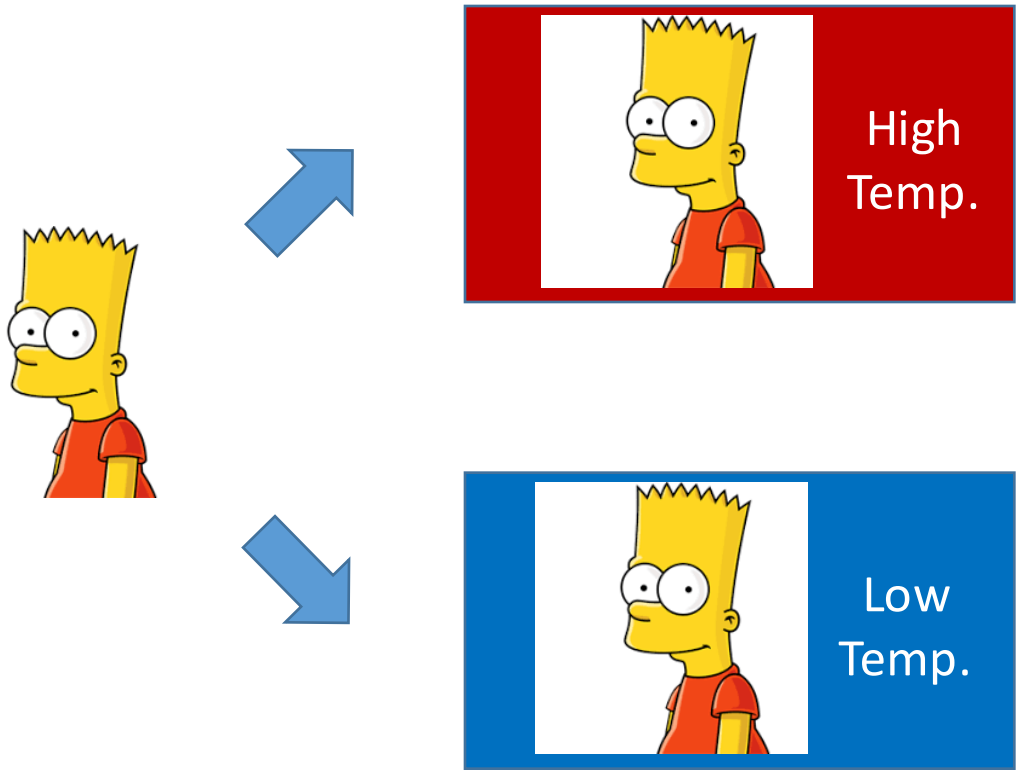

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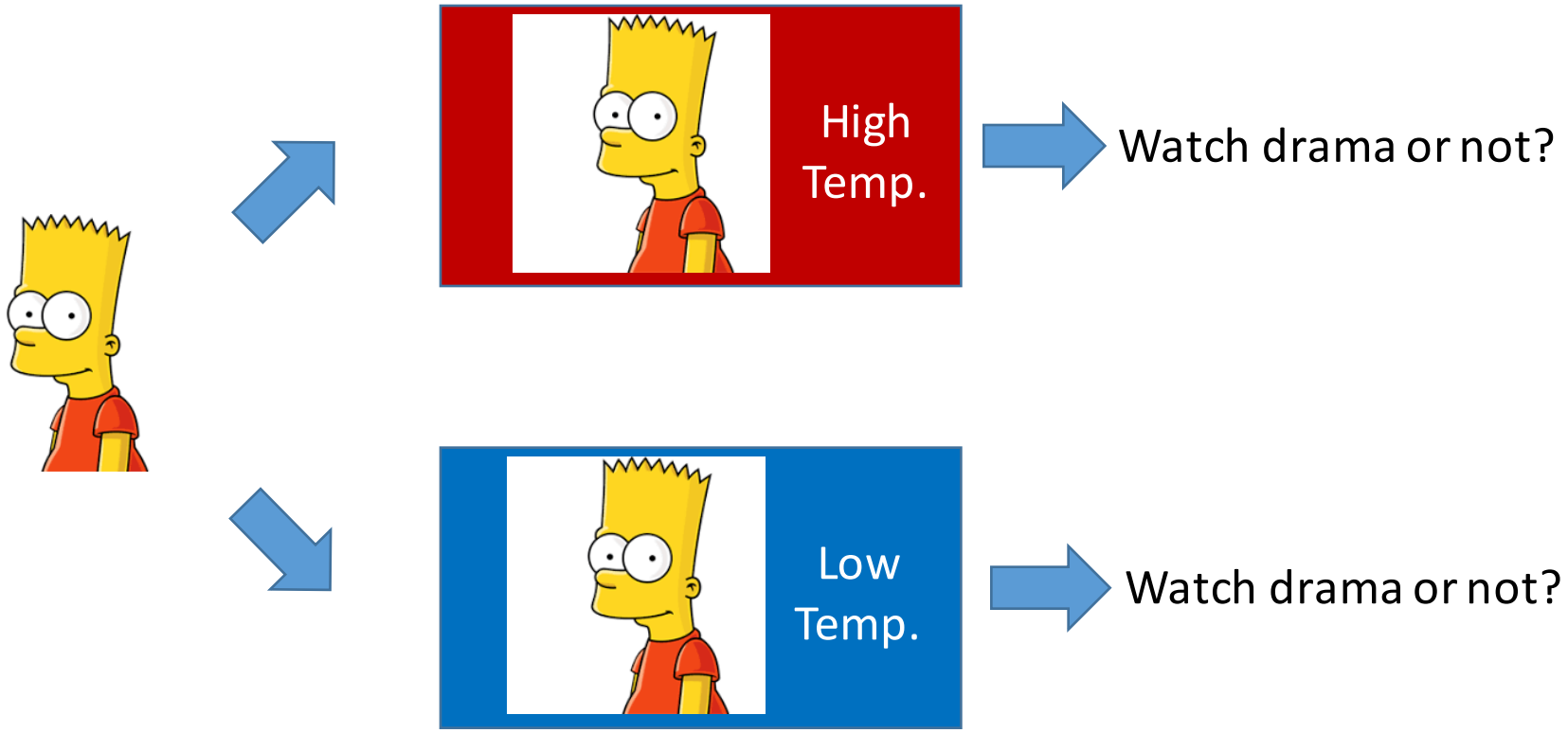

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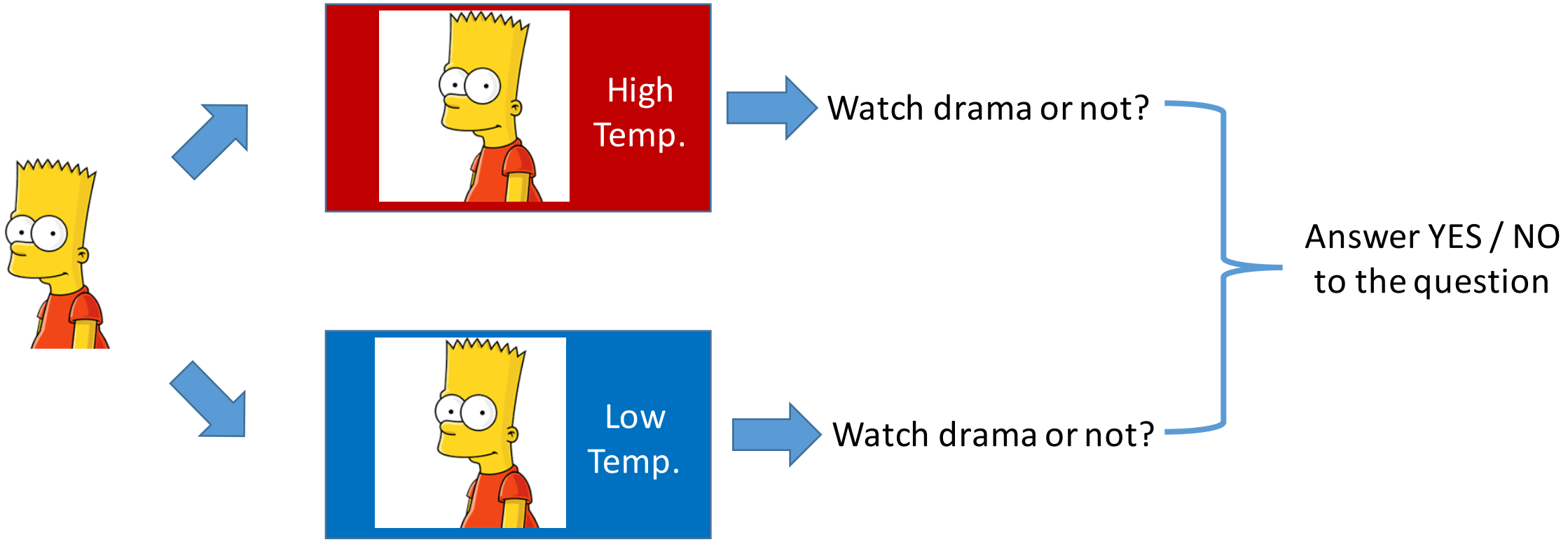
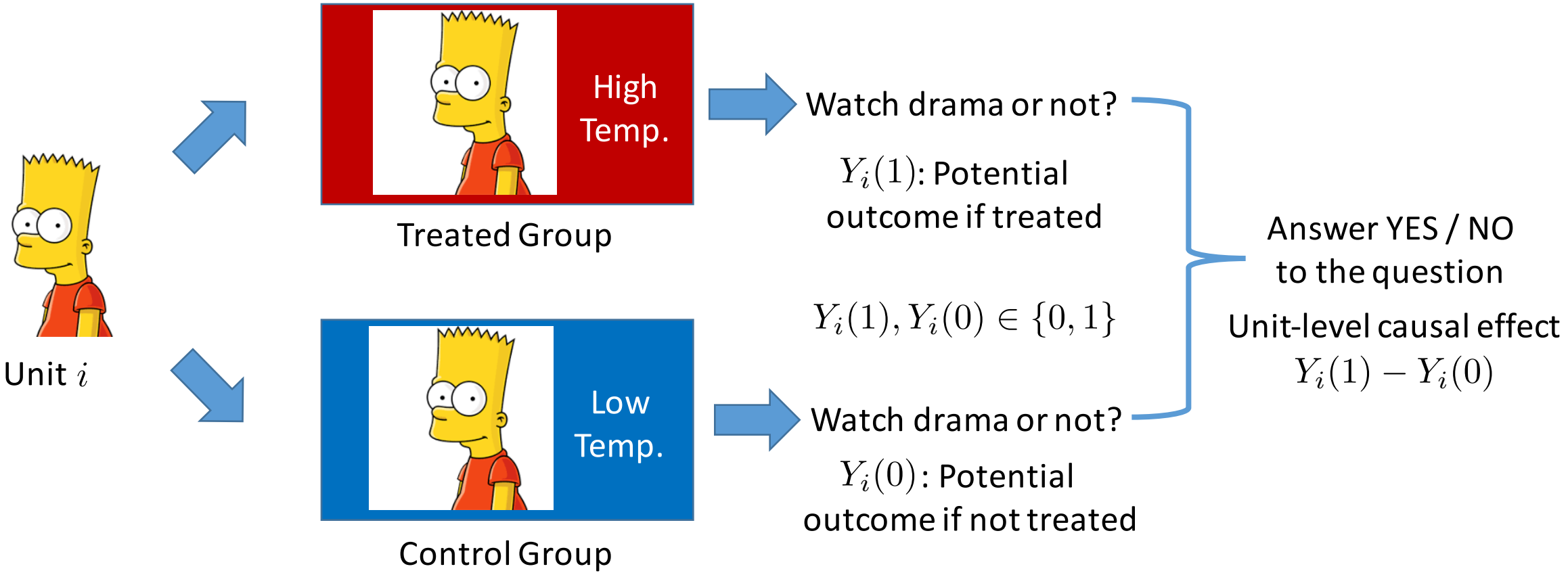


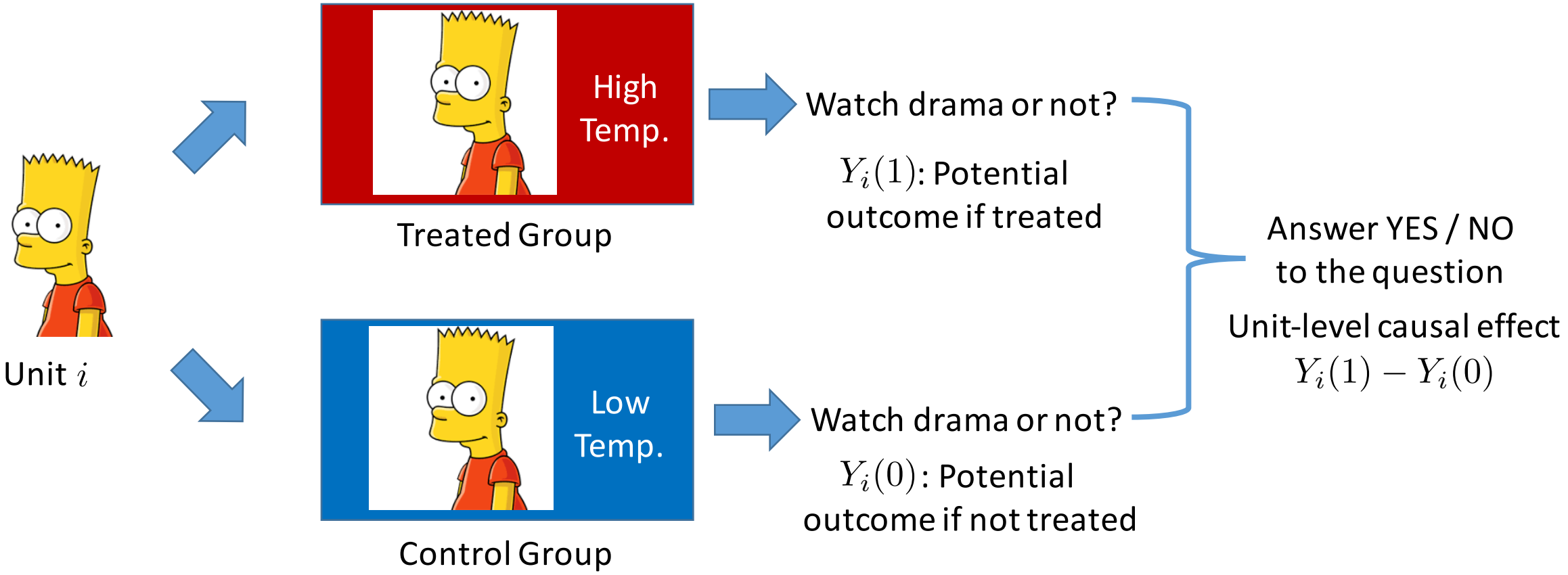
Causal Analysis – Some Terminologies

- Does high temperature cause watching more Drama?



Causal Analysis – Main Problem

- Missing Counterfactuals
  - Individual can't be observed with and without treatment at the same time



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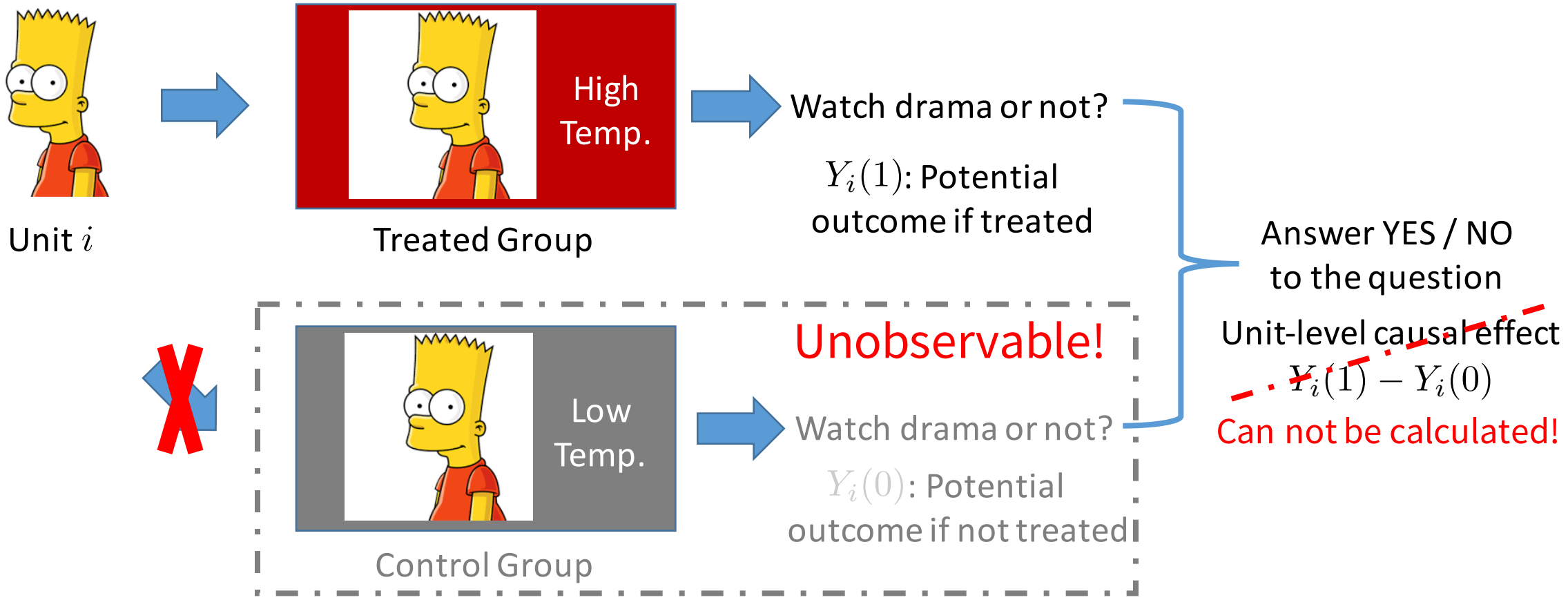
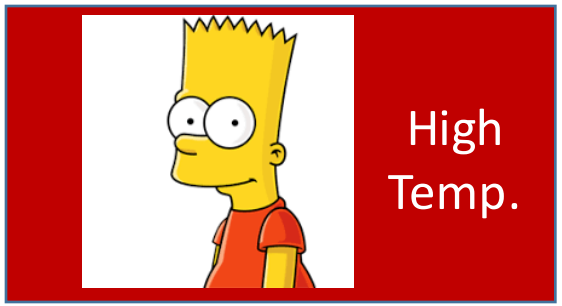


Solution: Find a Similar "Control" Person!

- Matching treated units with units that are similar to treated units (matching on covariates)

Unit i

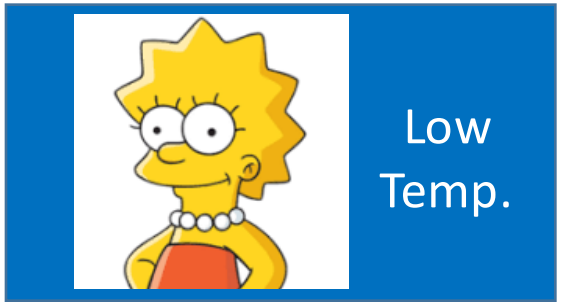


Treated Group

Watch drama or not?

$Y_i(1)$: Potential outcome if treated

Matched Unit $\pi(i)$



Control Group

Watch drama or not?

$Y_{\pi(i)}(0)$: Potential outcome if not treated

Answer YES / NO to the question

Unit-level causal effect

$Y_i(1) - Y_{\pi(i)}(0)$

Measuring Group Effect of Treatments

- Average treatment effect on treated (ATT)

Unit i

Unit-level causal effect

$$Y_i(1) - Y_{\pi(i)}(0)$$

Potential outcome if treated

All treated units

$$i : T_i = 1$$

ATT

$$\frac{1}{n_T} \sum_{i:T_i=1} \left(Y_i(1) - Y_{\pi(i)}(0)\right)$$

Potential outcome if not treated

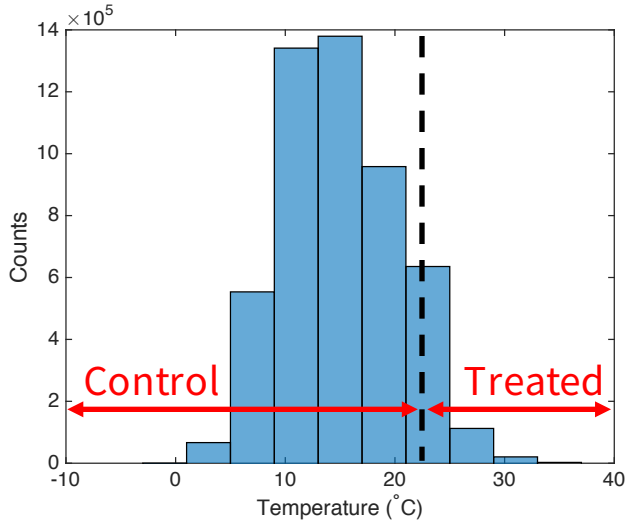
Number of treated units

- Interpretation
  - Expected increase/decrease in the frequency of watching due to treatment

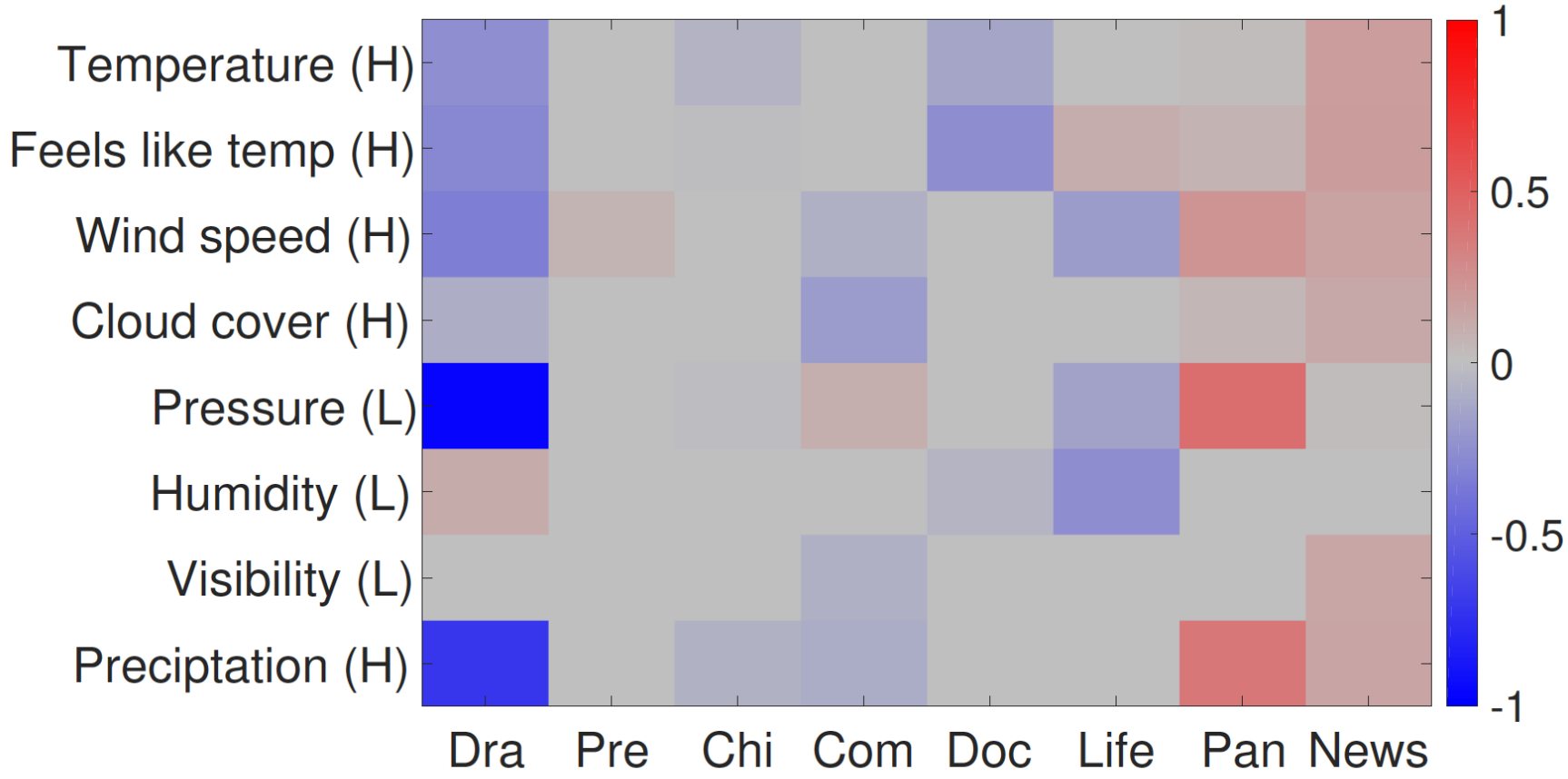
Value	Meaning
Significantly larger/smaller than 0	Significant positive/negative causal effects observed
Near 0	No causal effects observed

Our Modeling Assumptions

- Matching on covariates (measuring similarity)
  - A popular method is *Nearest-Neighbor Matching* (NNM)
  - In our work, covariates are chosen as *location*, *time* and *user preferences*
- Building treated group and control group
  - Treated group: top 20% of values for a specific attribute
  - Control group: others



Experimental Results – Whole Population (~2M treated units)



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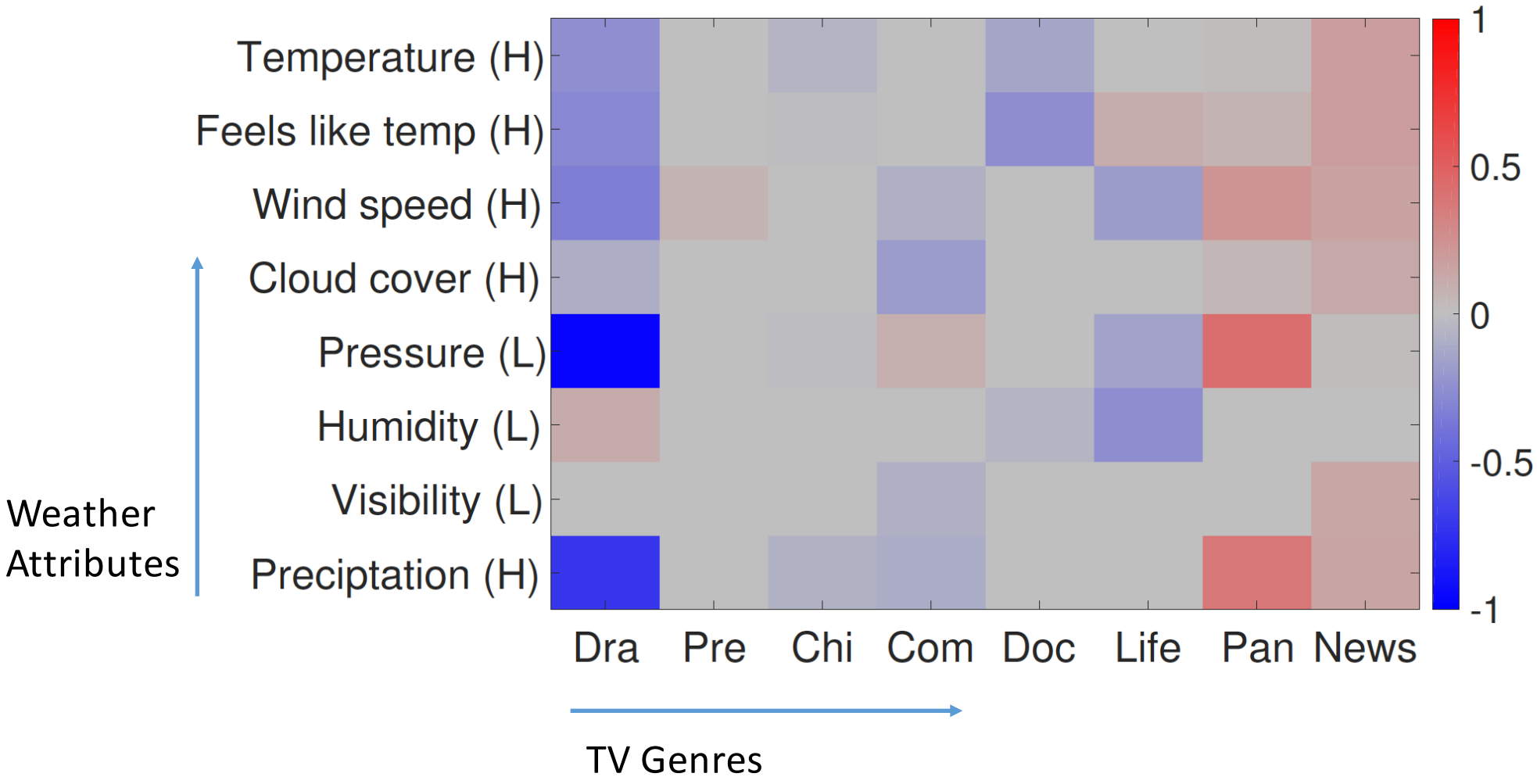

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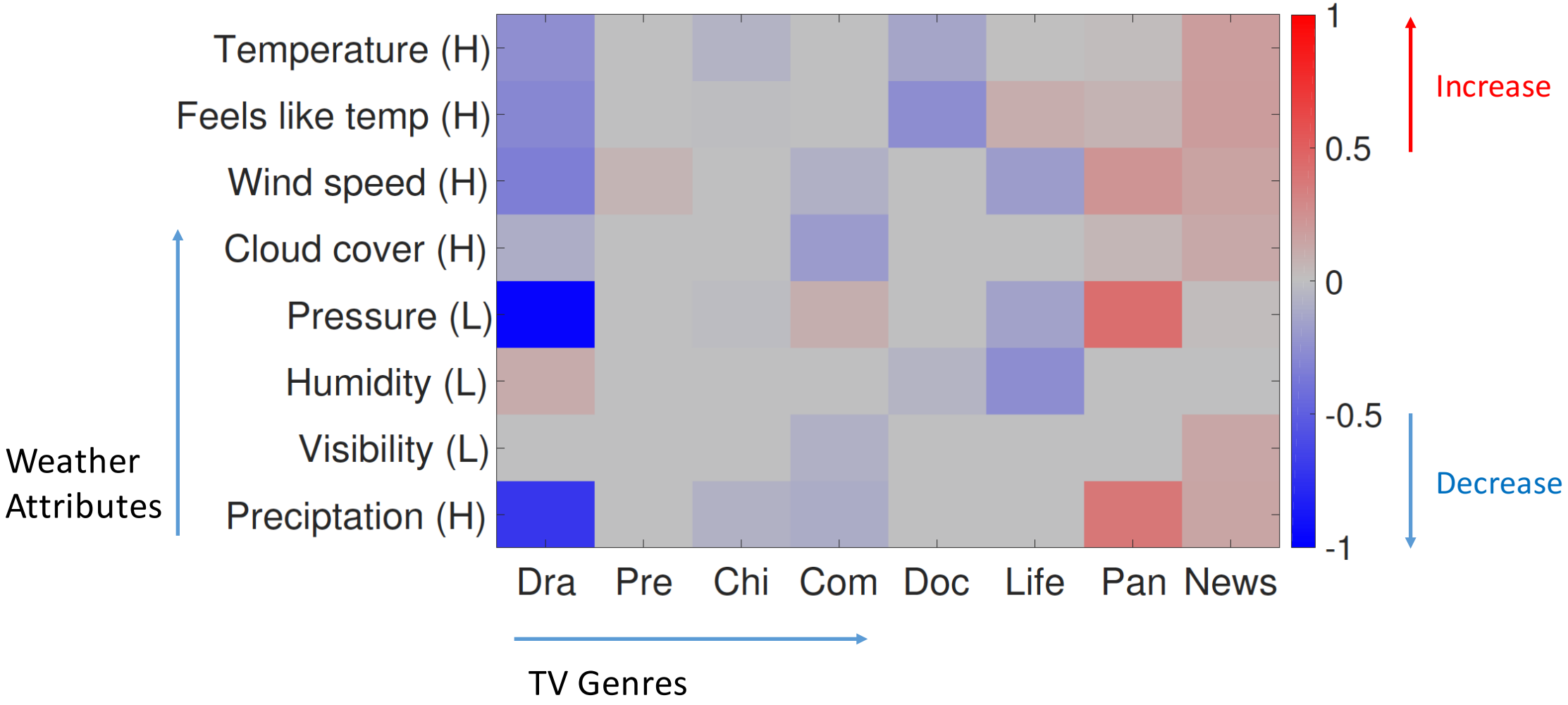

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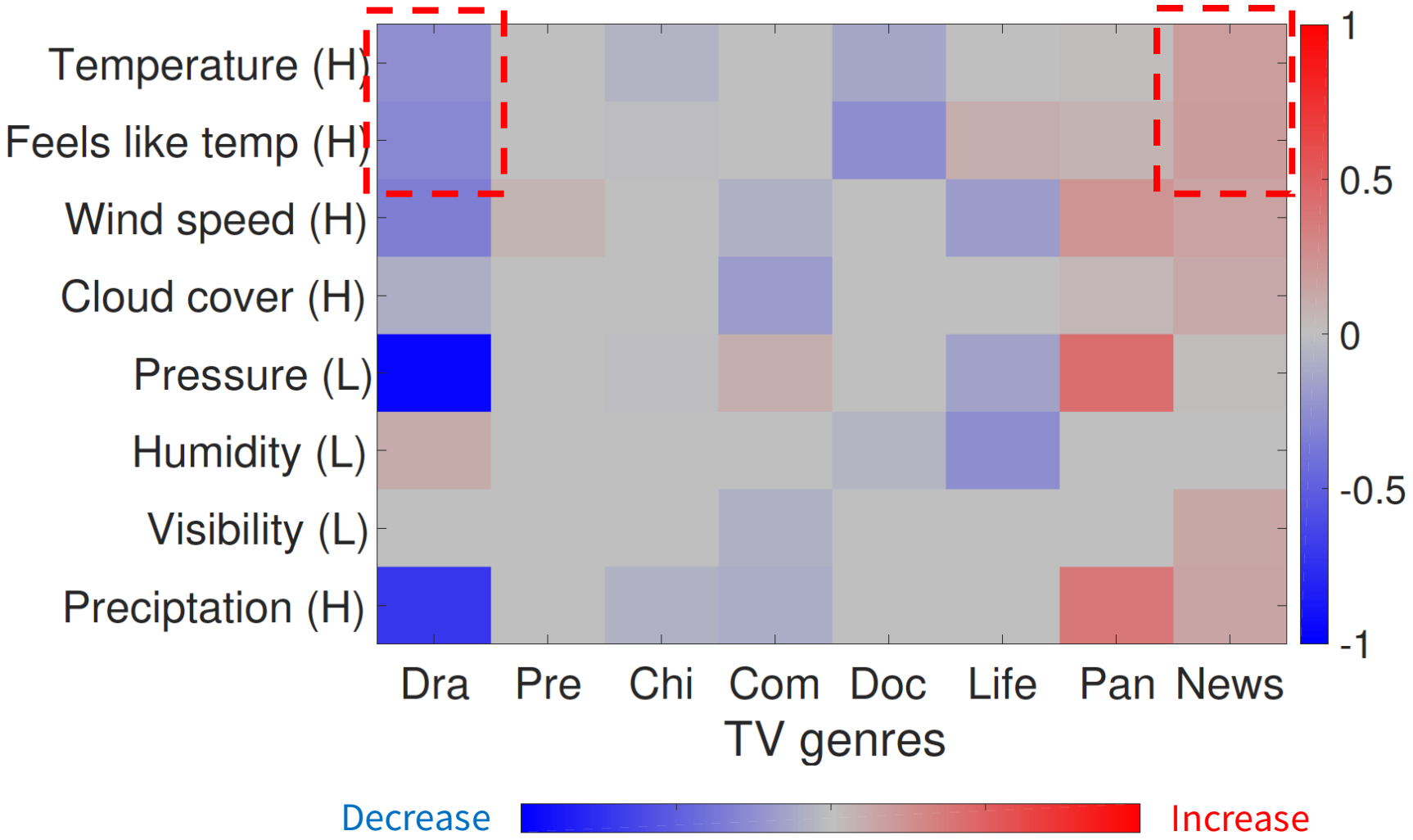

- When it is hot …
  - People prefer watching *News*, rather than *Drama*

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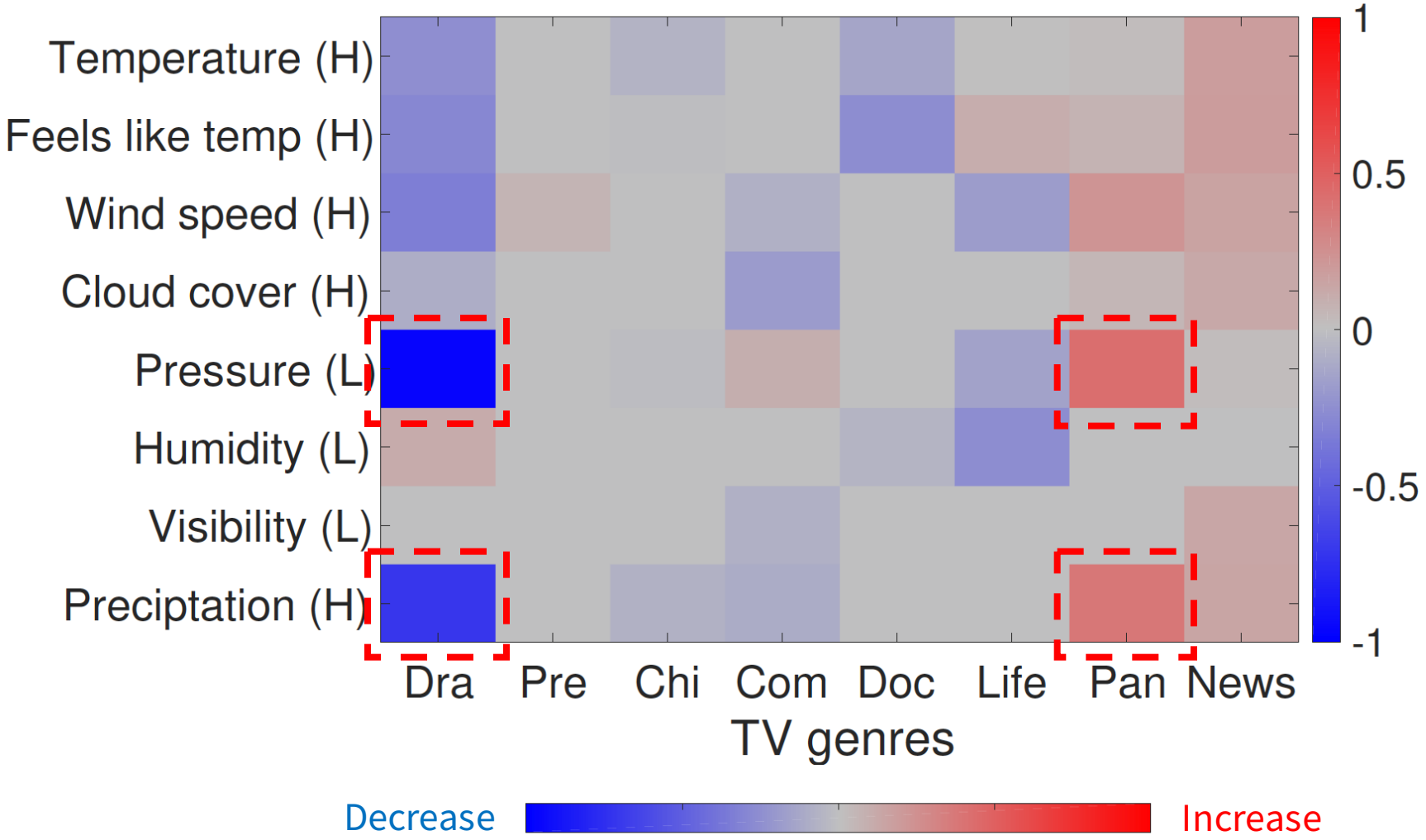

- When it is hot …
  - People prefer watching *News*, rather than *Drama*
- When it is rainy …
  - People tend to watch *Panels*, instead of *Drama*

Conclusion

- Take-home message
  - Observe causal relations between weather and user TV watching behavior
  - Next-generation recommender system design may take weather into consideration
- Contribution
  - First large-scale formal causal analysis
    -- Some weather attributes cause significant changes in TV watching patterns
  - User modeling based on causal analysis
    -- We compare between different levels of user granularity and different types of users

- Thanks!

Dataset

- Newly-built large-scale dataset of Australia watching events in 2012
  - 1,296,392 household level participants
  - 21,406,768 records of people watching events
  - 8 attributes of weather
- Rich information of user behavior & weather
  - User behaviors: date, anonym IP address, watching video ID
  - Weather attributes: temperature, feels like temperature, wind speed, cloud cover, pressure, humidity, visibility, precipitation