

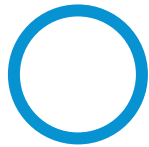
Online Actions with Offline Impact:

How Online Social Networks Influence
Online and Offline User Behavior

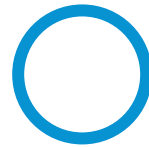
Tim Althoff, Pranav Jindal, Jure Leskovec

 @timalthoff

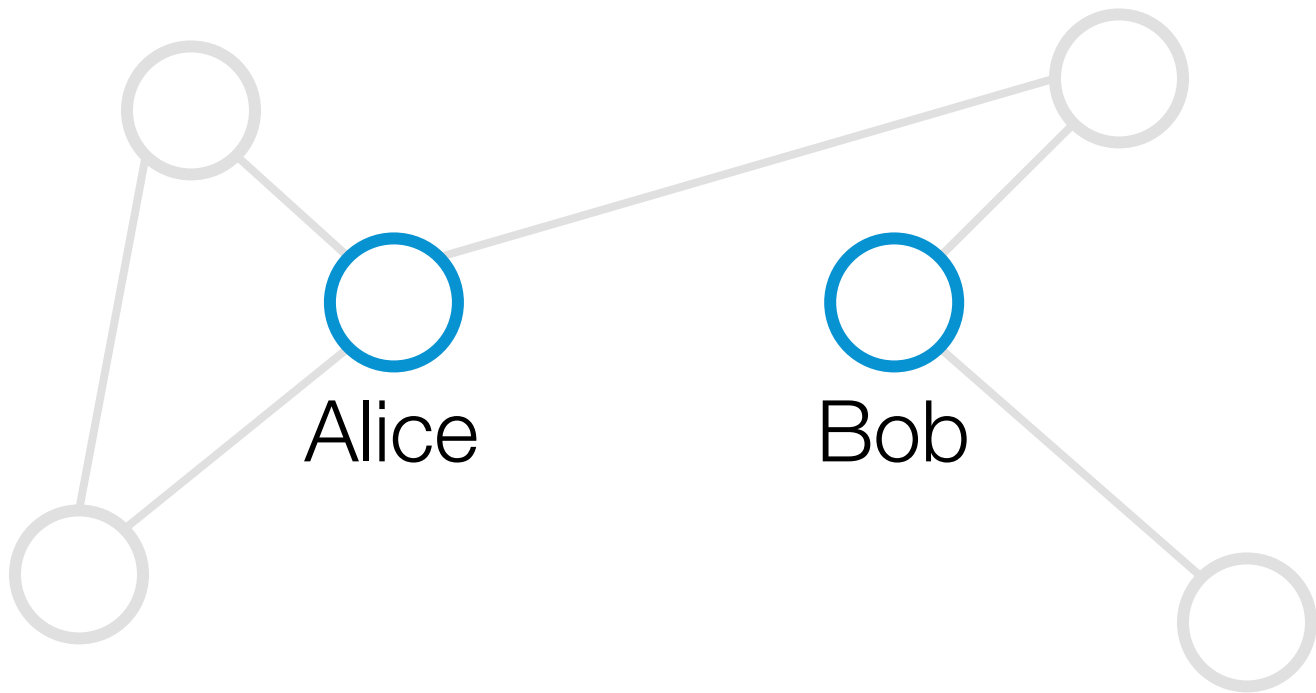




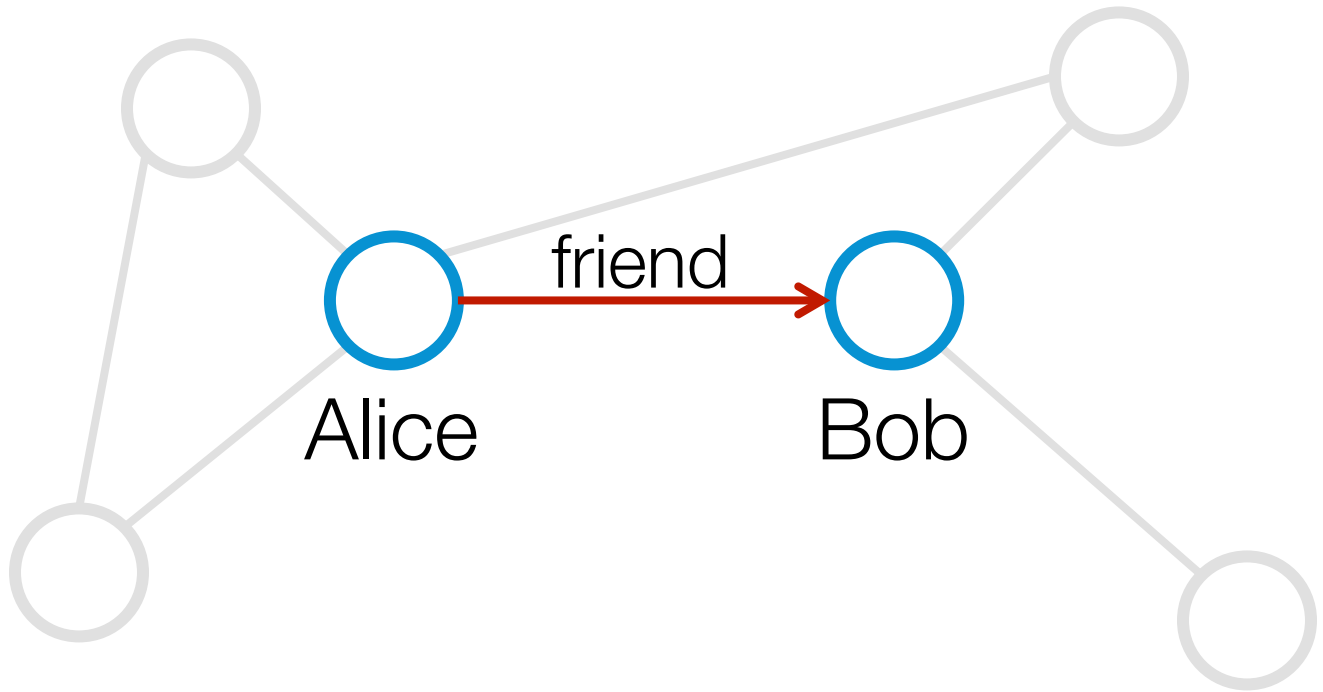
Alice



Bob



What happens to Alice & Bob?



Previous Research: Online Behaviors



- Homophily – user similarity
- Triadic closure – common friends
- Community structure
- Network growth
- ...

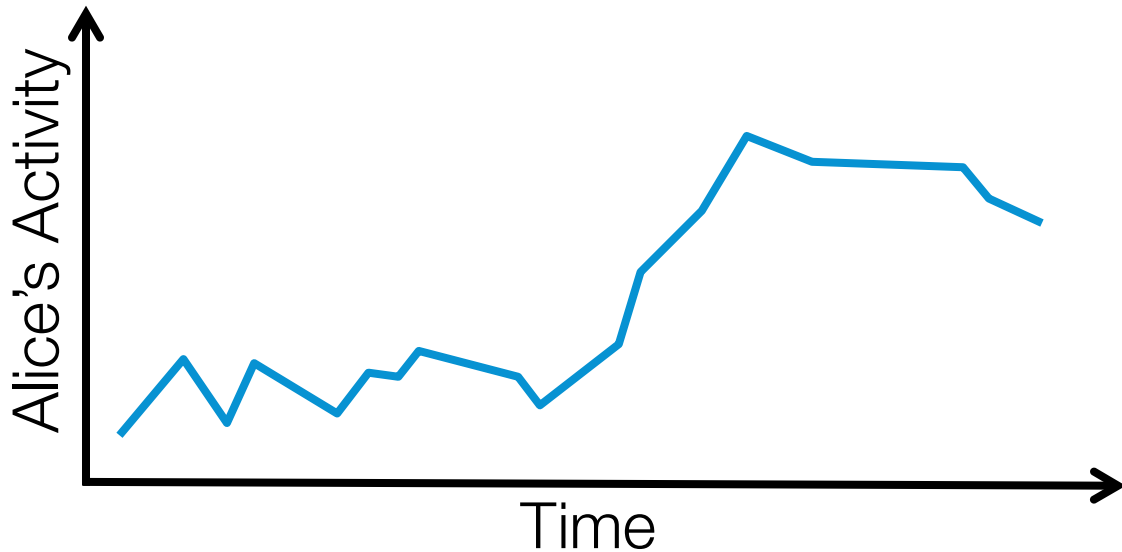
Want to understand online → offline!



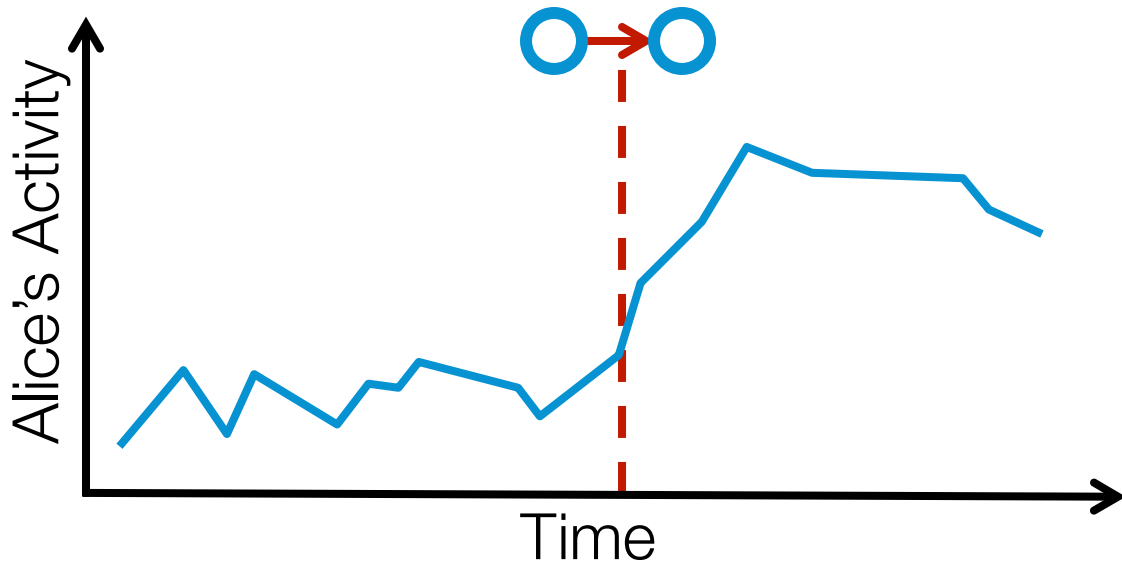
- Homophily – user similarity
- Triadic closure – common friends
- Community structure
- Network growth
- ...

- Physical activity
- Diet
- Smoking
- Political mobilization
- ...

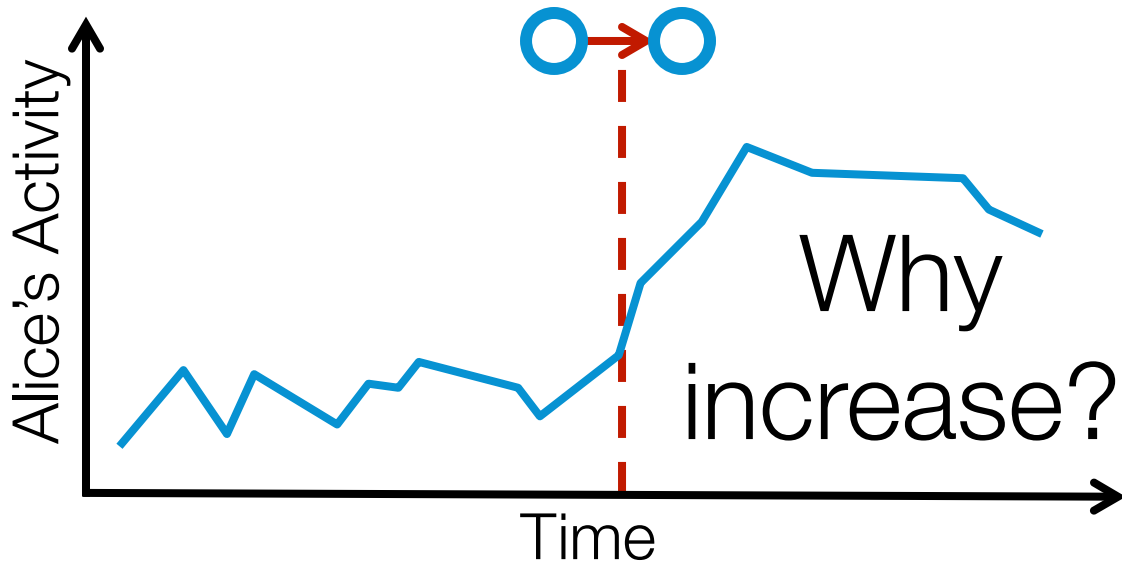
What causes change in behavior?



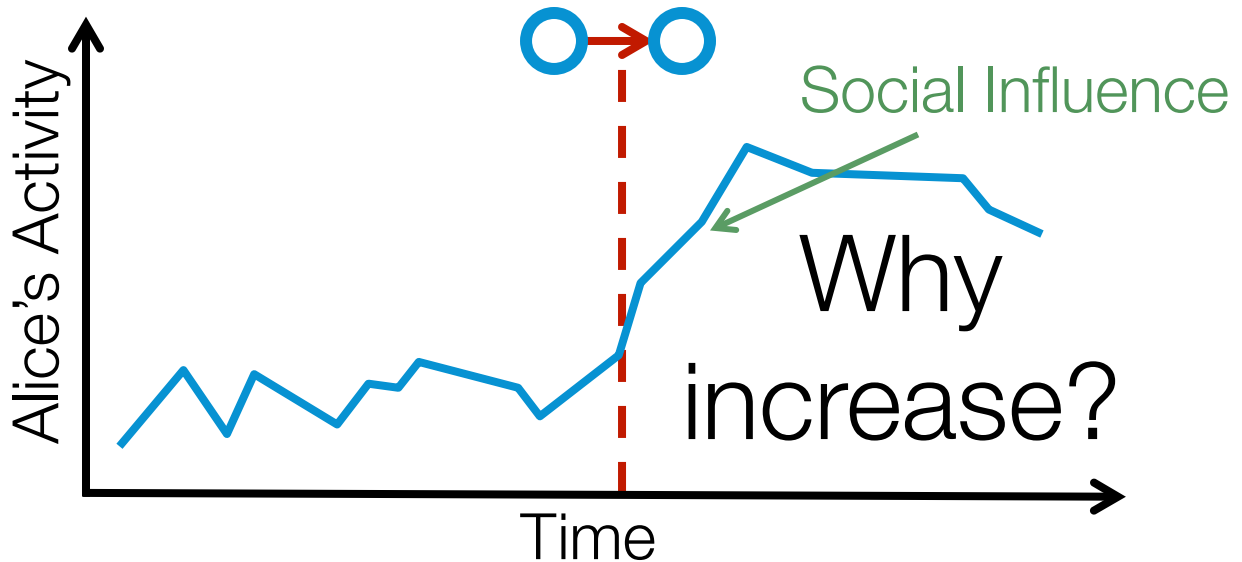
What causes change in behavior?



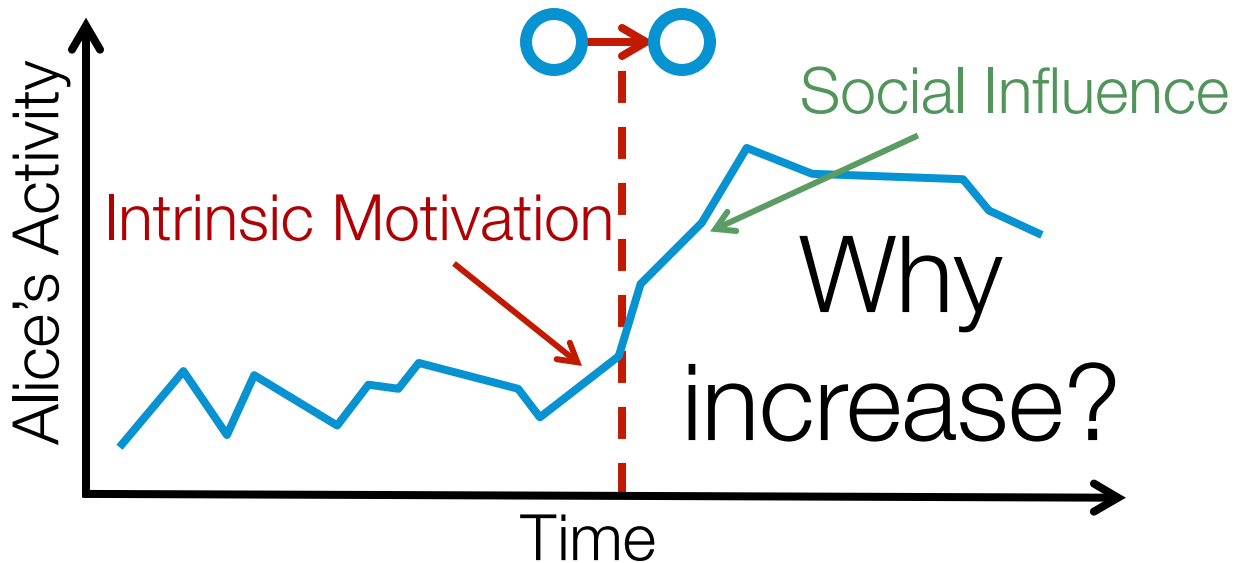
What causes change in behavior?



What causes change in behavior?



What causes change in behavior?



Main Research Question

- Do online social networks influence offline (real-world) behavior?
- Challenge: How to disentangle social influence from intrinsic motivation?
 - Never observe alternate universe where the friendship did not happen

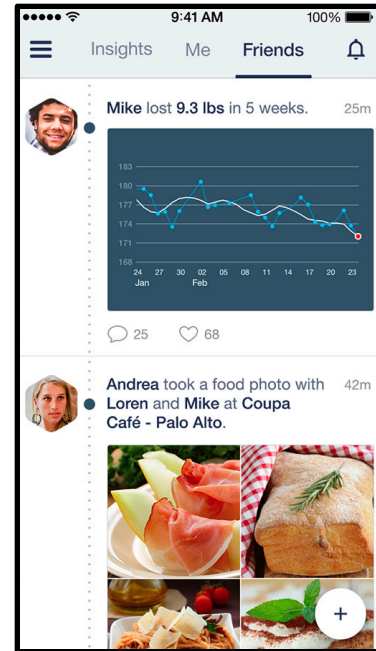
Our Contributions

1. New method for **causal identification of social influence**
 - A natural experiment exploiting delay of friendship acceptance
2. Social networking leads to a **5 months long increase of up to ~350 daily steps**
3. Can **predict** which users will be most influenced by new social network connections **with 79% accuracy**

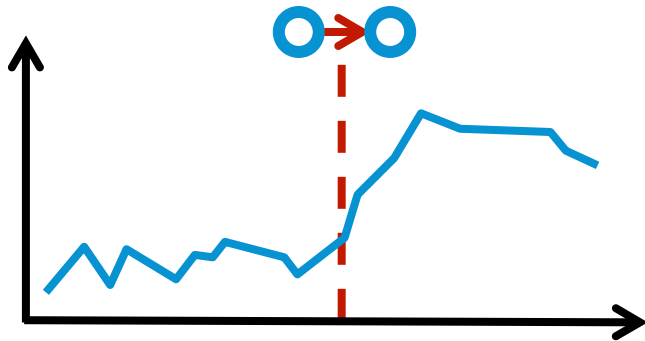


Activity Tracking Dataset

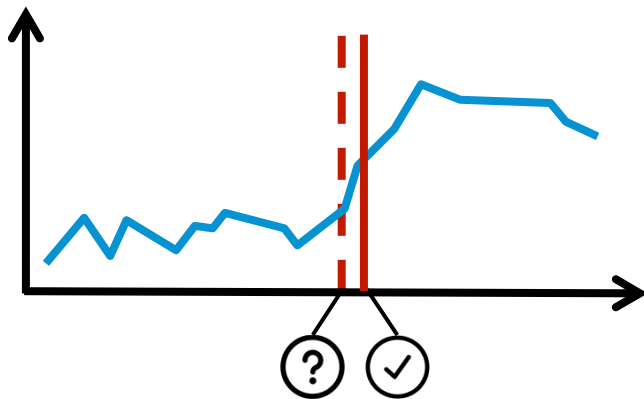
- Azumio's Argus activity tracking app (iOS/Android)
- 6 million users
 - 211k users join social network
 - Enables interaction & notifications
- 791 million actions
 - online (posts)
 - offline actions (physical activity; accelerometer-based)
- 5 year timespan



Disentangling Motivation & Influence

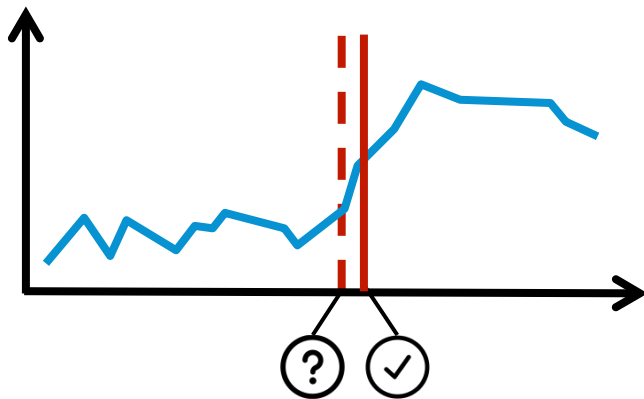


Disentangling Motivation & Influence

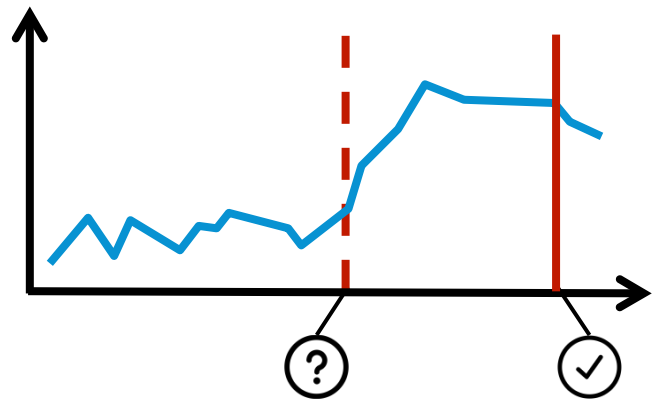


Disentangling Motivation & Influence

Direct accept

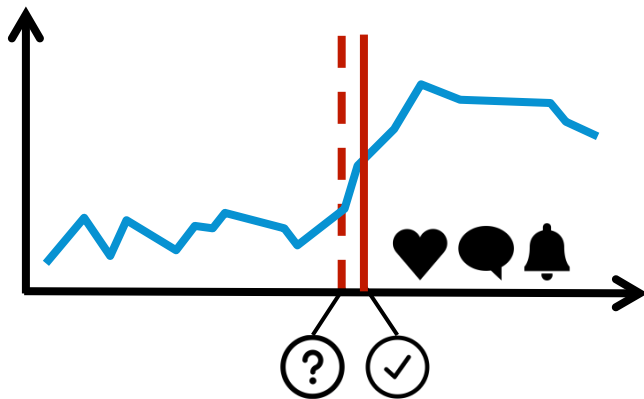


Delayed accept

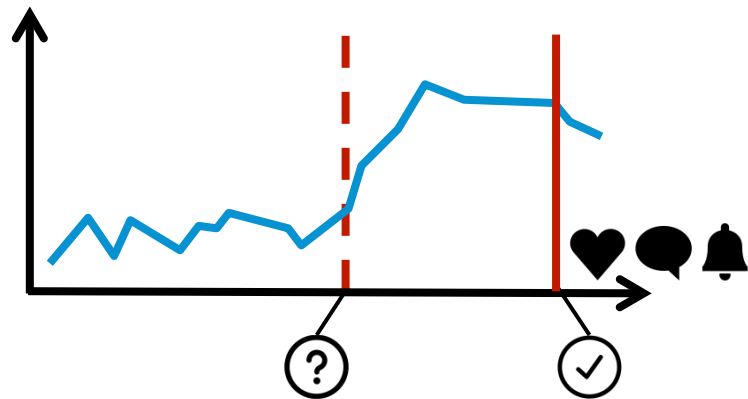


Disentangling Motivation & Influence

Direct accept

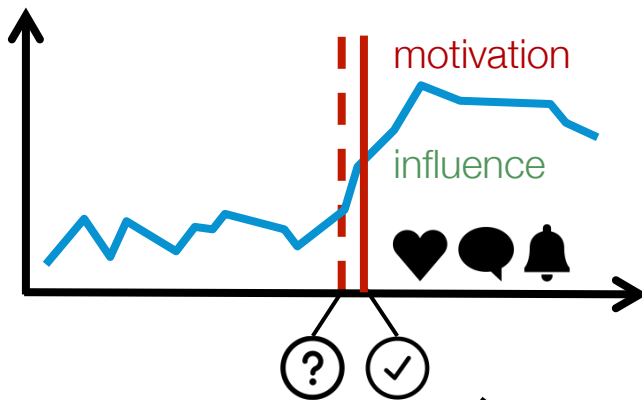


Delayed accept

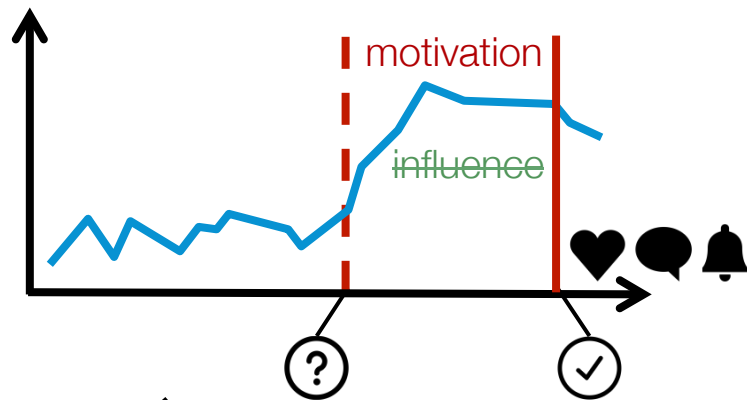


Disentangling Motivation & Influence

Direct accept



Delayed accept



Difference isolates social influence

A natural experiment for Alice?

- Is assignment to “direct accept” (<1 day) and “delayed accept” (>7 days) as if random?
- Groups would be indistinguishable or **balanced**
- **Balancing criterion:** Covariates within standardized mean difference (SMD) of 0.25 SD [Stuart, 2010]



Testing Alternative Hypotheses

Maybe direct accepters are...

- ...more active?
 - Avg. daily steps 7 days before
 - $0.07 \text{ SD} < 0.25 \text{ SD} \rightarrow \text{No}$
- ...closer friends?
 - # common friends at request
 - $0.08 \text{ SD} < 0.25 \text{ SD} \rightarrow \text{No}$
- ...newer to social network?
 - # days since joining
 - $0.179 \text{ SD} < 0.25 \text{ SD} \rightarrow \text{No}$

+19 further hypotheses in paper; all balanced

Testing Alternative Hypotheses

Maybe direct accepters are...

- ...more active?

▪ Average delay before

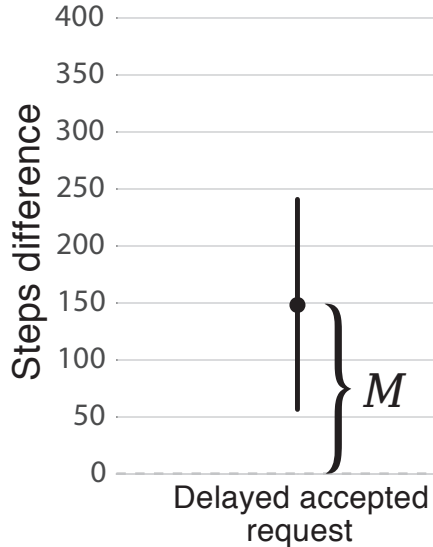
- “True” natural experiment!

- ...newer to social network?

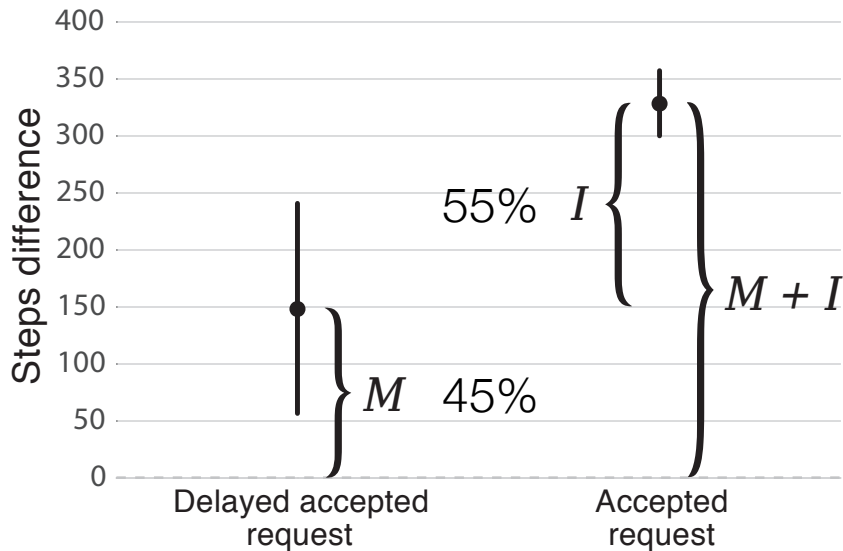
- # days since joining
- $0.179 \text{ SD} < 0.25 \text{ SD} \rightarrow \text{No}$

+19 further hypotheses in paper; all balanced

Experimental Results



Experimental Results

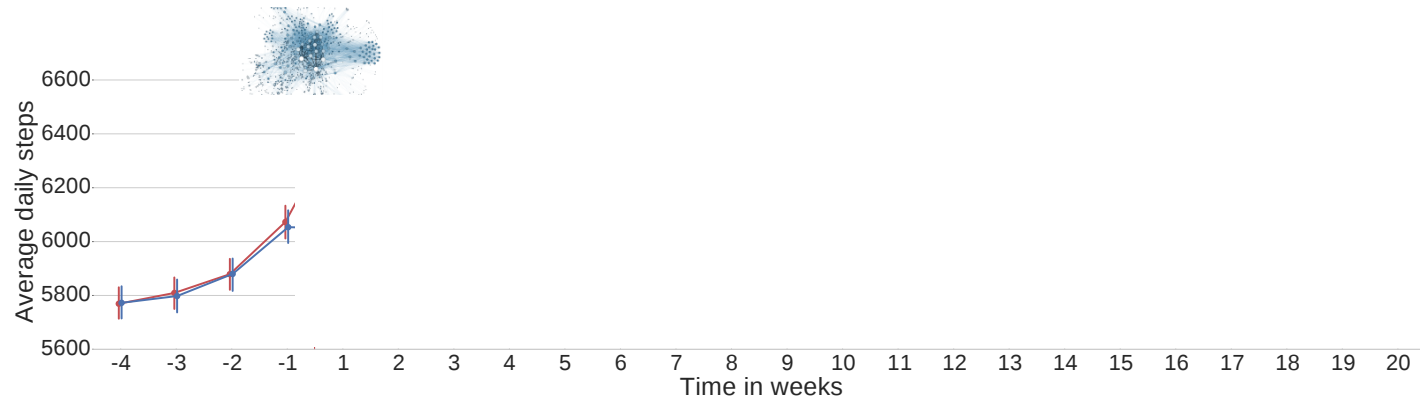


Experimental Results

Causal effect of increasing
real-world activity
due to online social network
by ~350 steps/day

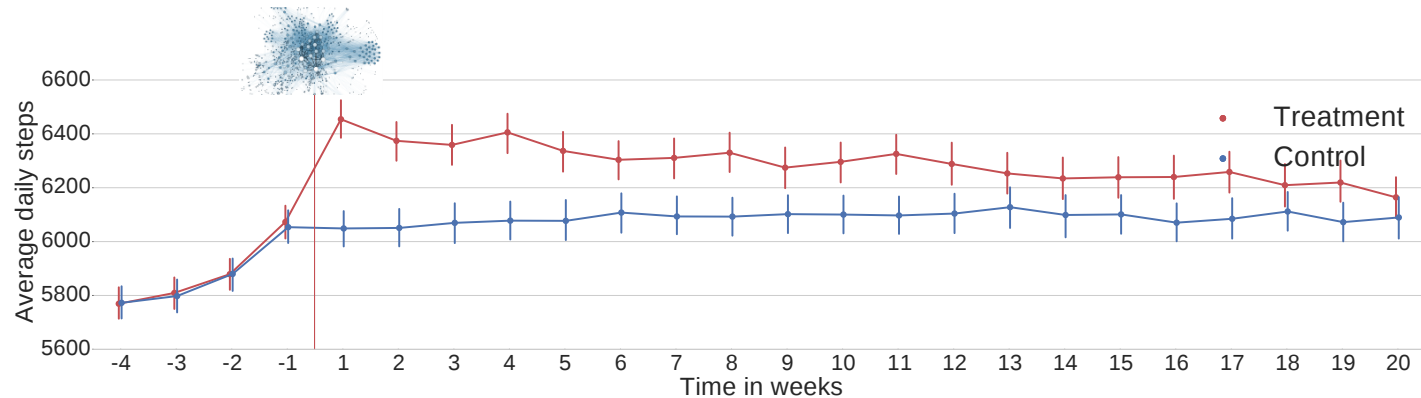
Effect of Social Network Over Time

- Longitudinal study with Difference-in-Differences design and matched control group



Effect of Social Network Over Time

- Longitudinal study with Difference-in-Differences design and matched control group







- Online* social networks significantly increase *offline* physical activity for ~5 months

Heterogeneous Effects

- **Robust:** Several additional experiments all reveal similar effects
- Joining network also affects *online behavior*
 - App usage (increased 30%)
 - One-year retention (increased 17%)

Heterogeneous Effects

- **Robust:** Several additional experiments all reveal similar effects
- Joining network also affects *online behavior*
 - App usage (increased 30%)
 - One-year retention (increased 17%)
- **Repeatability:** 1st friend > 2nd friend
- **Tie Strength:** friend > follower
- **Initiator:** sender > receiver
- **Demographics:**  ➤  >  ➤  (52% more!)

Heterogeneous Effects

- **Robust:** Several additional experiments all reveal similar effects

Can use these insights to predict behavior change!

- **Repeatability:** $1 - \text{inert} > 2 - \text{inert}$
- **Tie Strength:** friend > follower
- **Initiator:** sender > receiver
- **Demographics:**  \Rightarrow  >  \Rightarrow  (52% more!)

Predicting Behavior Change

- Which individuals will be most influenced by new social network connections?
- Binary prediction task: Will you increase your activity over next 7 days? (55.4% do)
 - Short-term behavior change
- Dataset: 432k new friendships
- Gradient Boosted Tree models

Predicting Behavior Change

- Which individuals will be most influenced by new social network connections?

Can predict positive behavior change with 79% ROC AUC

- Dataset: 432k new friendships
- Gradient Boosted Tree models

Summary & Conclusions

Findings

- Social networks influence behavior – online & offline
- Can predict which users will be most influenced by new social network connections

Implications

- How to *design & maintain* social networks as effective support communities that lead to healthier lifestyles?
 - Group composition
 - Friendship recommendation algorithms
 - Enabling supportive and encouraging interactions

Acknowledgements

- We thank Azumio for donating data from their Argus app for independent research.



Ask me anything!

@timalthoff

althoff@cs.stanford.edu

www.timalthoff.com