

Social contagion theory: examining dynamic social networks and human behavior

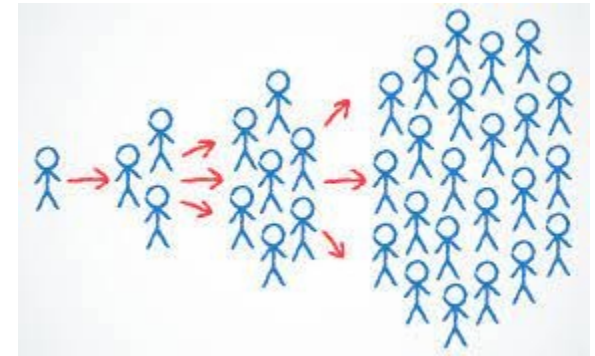
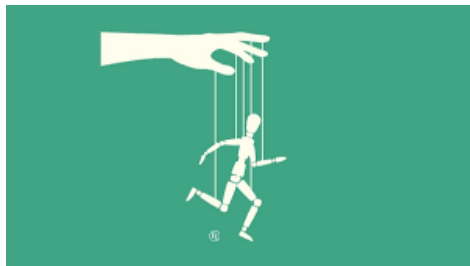
Nicholas A. Christakis^{a,b,*†} and James H. Fowler^{c,d}

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Detecting Emotional Contagion in Massive Social Networks

Lorenzo Coviello¹, Yunkyu Sohn², Adam D. I. Kramer³, Cameron Marlow³, Massimo Franceschetti¹, Nicholas A. Christakis^{4,5}, James H. Fowler^{2,6*}



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A 61-million-person experiment in social influence and political mobilization

Robert M. Bond¹, Christopher J. Fariss¹, Jason J. Jones², Adam D. I. Kramer³, Cameron Marlow³, Jaime E. Settle¹, and James H. Fowler^{1,4}

Charles-Marie Gustave Le Bon was a leading French polymath whose areas of interest included anthropology, psychology, sociology, medicine, invention, and physics. He is best known for his 1895 work *The Crowd: A Study of the Popular Mind*, which is considered one of the seminal



Social contagion / behavior contagion

- The spread of ideas, attitudes, or behaviour patterns in a group through imitation and conformity.
- the propensity for a person to copy a certain behavior of others who are either in the vicinity, or whom they have been exposed to

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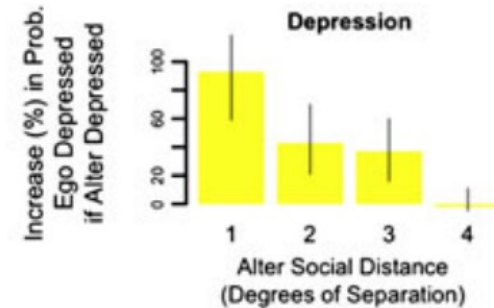
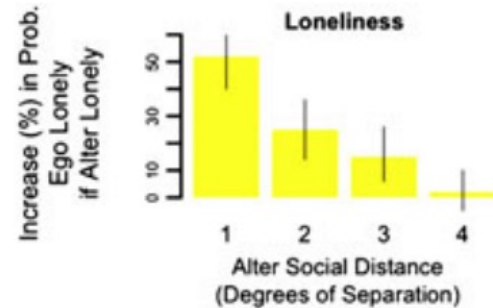
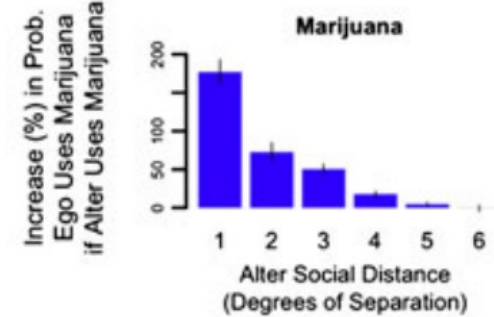
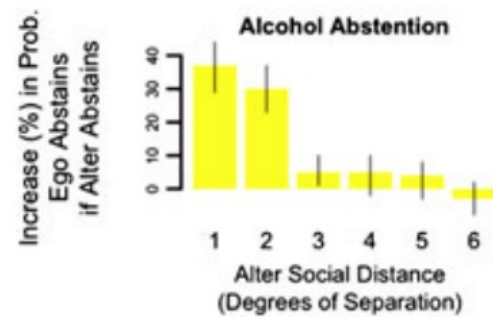
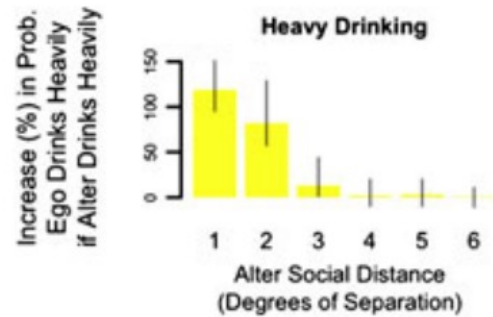
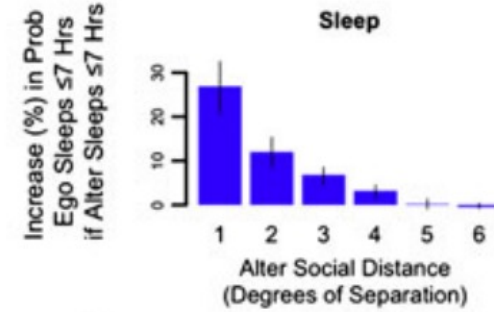
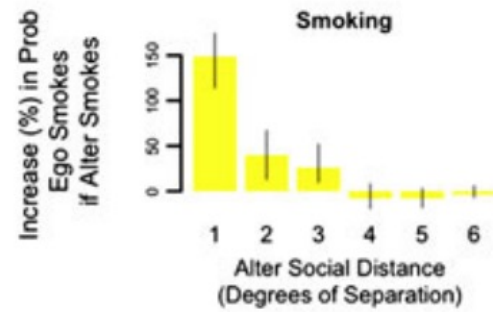
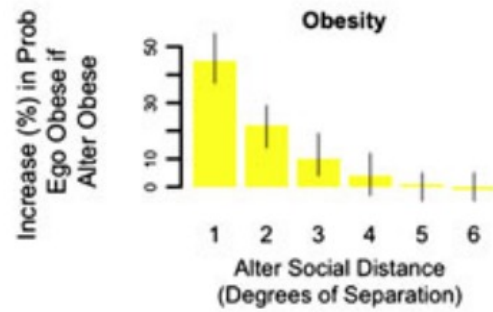
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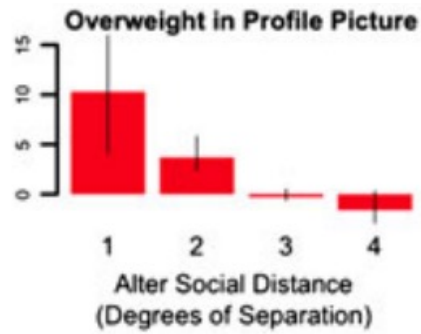
Nicholas A. Christakis^{a,b,*†} and James H. Fowler^{c,d}

Here, we review the research we have conducted on social contagion. We describe the methods we have employed (and the assumptions they have entailed) to examine several datasets with complementary strengths and weaknesses, including the Framingham Heart Study, the National Longitudinal Study of Adolescent Health, and other observational and experimental datasets that we and others have collected. We describe the regularities that led us to propose that human social networks may exhibit a ‘three degrees of influence’ property, and we review statistical approaches we have used to characterize interpersonal influence with respect to phenomena as diverse as obesity, smoking, cooperation, and happiness. We do not claim that this work is the final word, but we do believe that it provides some novel, informative, and stimulating evidence regarding social contagion in longitudinally followed networks. Along with other scholars, we are working to develop new methods for identifying causal effects using social network data, and we believe that this area is ripe for statistical development as current methods have known and often unavoidable limitations. Copyright © 2012 John Wiley & Sons, Ltd.

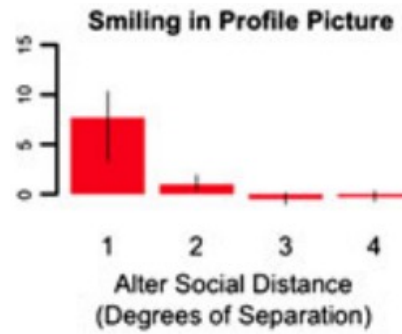
Keywords: social networks; contagion; human behavior; homophily; causal interence



Increase (%) in Prob.
Ego Overweight
if Alter Overweight



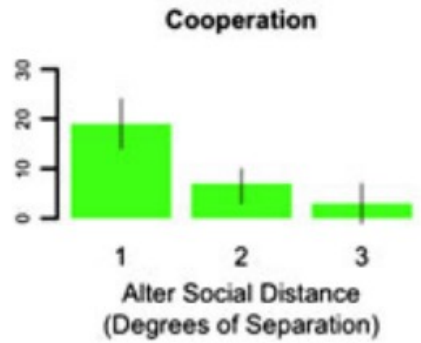
Increase (%) in Prob.
Ego Smiling
if Alter Smiling



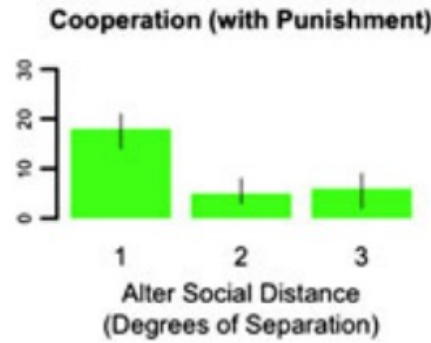
Increase (%) in Prob.
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if Alter Divorced



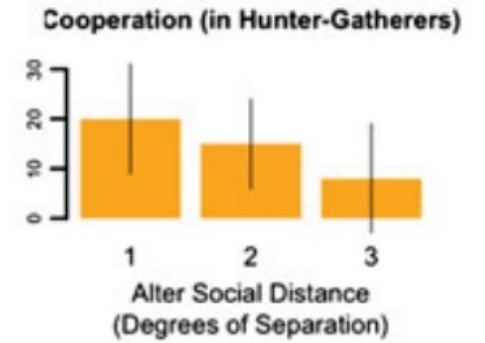
Increase (%) in
Ego Giving for
Each \$ Alter Gives



Increase (%) in
Ego Giving for
Each \$ Alter Gives



Increase (%) in
Ego Giving for
Each \$ Alter Gives





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PLOS ONE

Detecting Emotional Contagion in Massive Social Networks

Lorenzo Coviello¹, Yunkyu Sohn², Adam D. I. Kramer³, Cameron Marlow³, Massimo Franceschetti¹, Nicholas A. Christakis^{4,5}, James H. Fowler^{2,6*}

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- data collected for 1180 days on **Facebook** from January 2009 to March 2012.
- To measure emotional expression, we use “**status updates**” (also called “posts”) which are undirected text-based messages that a user’s social contacts (Facebook friends) may view on their own News Feed.
- **Linguistic Inquiry Word Count**
 - *Posts’ words express positive or negative emotions*

The Facebook logo, consisting of the word "facebook" in white lowercase letters on a blue rectangular background.A blue header bar for a Facebook post, containing a back arrow icon and the text "Hi friends, guess what? I'm gettin..."

Hi friends, guess what? I'm getting married!

Just kidding, I just needed to trick the Facebook algorithm to stick this post to the top of your news feed. I need a favor for a story I'm working on: Do you live in Maryland? Does literally any human being you know live in Maryland? If so, please send me a message.

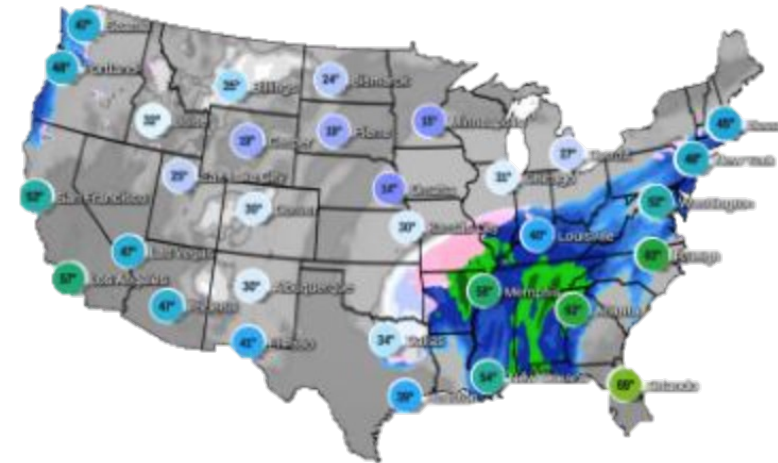
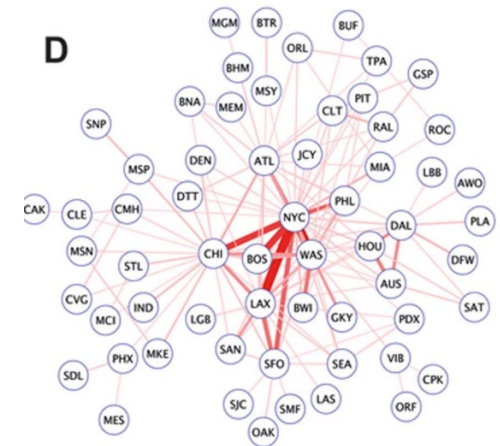
Thanks. I love you. Goodbye!



- aggregate individual observations by city and day, restricting our attention to all English-speaking Facebook users residing in the 100 most populous US cities.

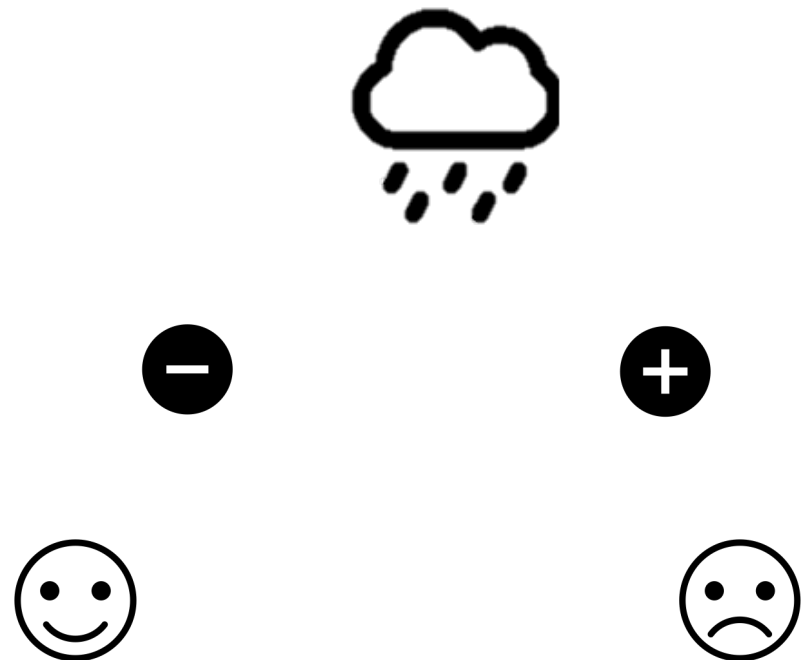


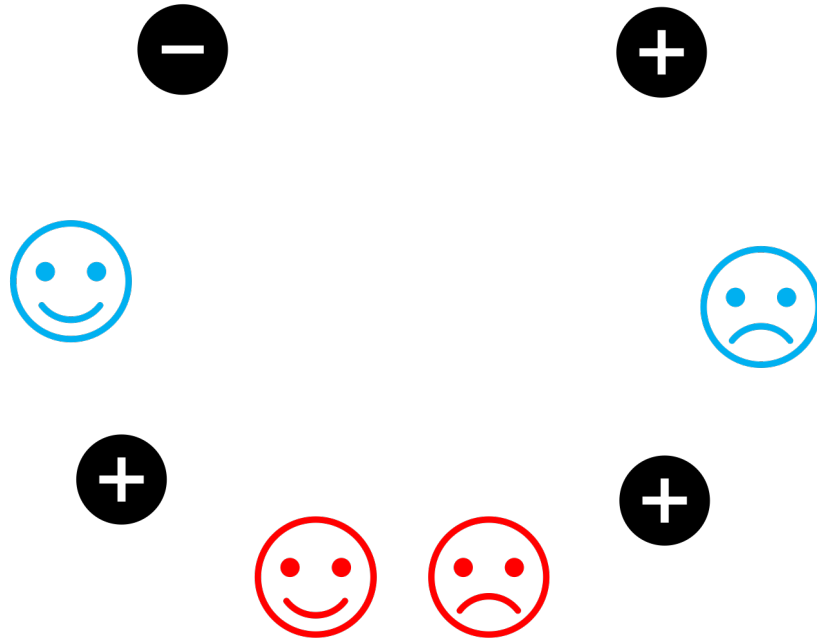
- We matched these observations to publicly available meteorological records that indicate total precipitation for each day in each of these cities



Difference in
emotional expression
between days with
and without rain.


An average rainy day
decreases the
number of positive
posts by 1.19% and
also increases the
number of negative
posts by 1.16%



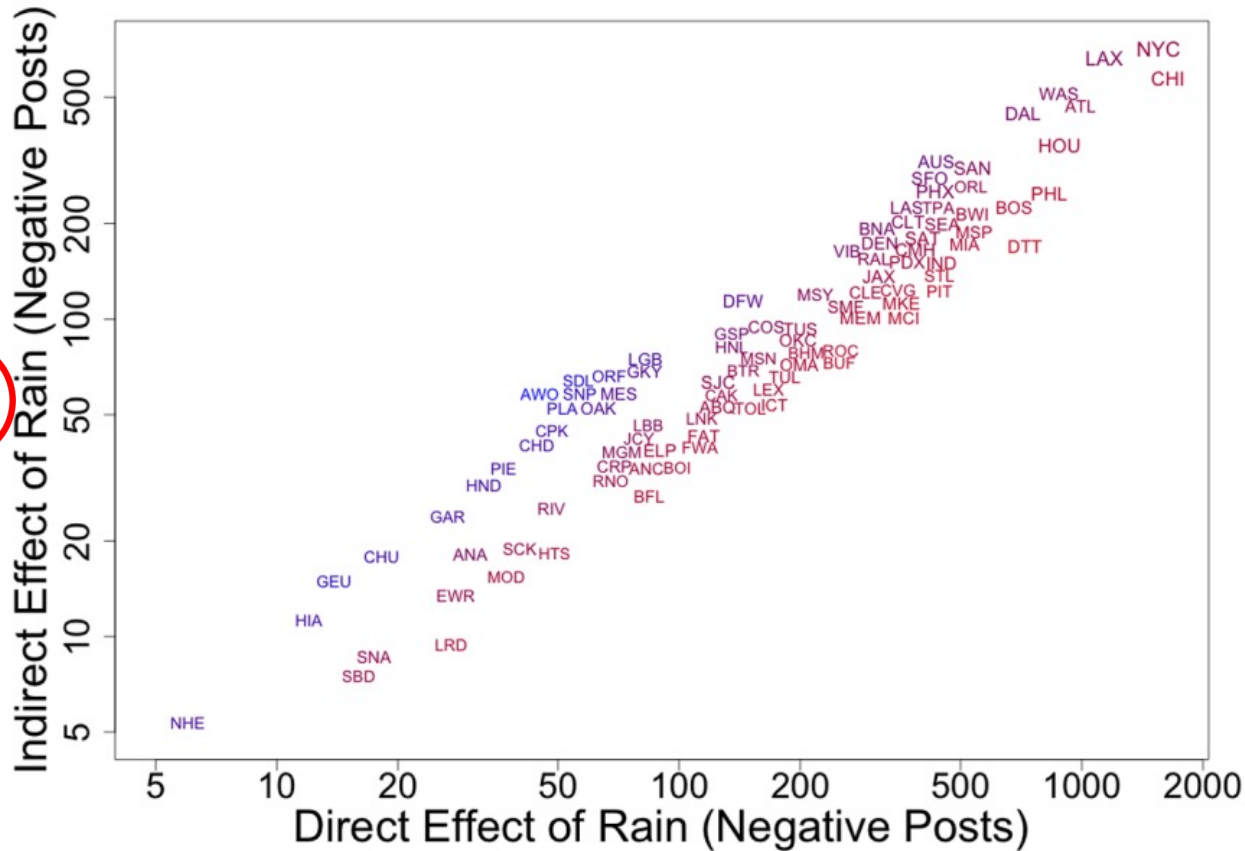


Estimates of emotional contagion between friends

Rain affects emotional expression, both positive and negative posts are contagious, and positive posts tend to inhibit negative posts and vice versa

- 
- each additional **positive post** yields an additional 1.75 positive posts amongst one's friends.
 - each additional negative post yields 1.29 more negative posts by friends.

In other words, the total effect of rainfall on emotional expression is about 150% larger than we would expect if we were only measuring the direct effect on users and ignoring the indirect effect on their friends.

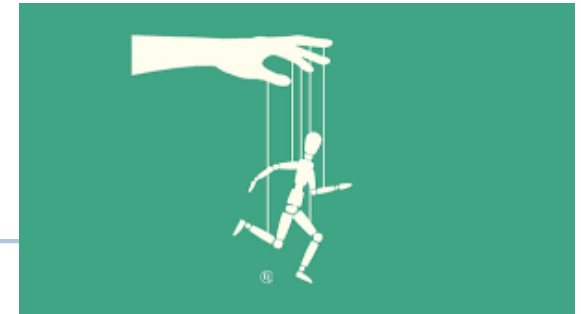


Predicted effects.

Total number of negative posts generated by a day of rainfall within a city (direct) and in other cities via contagion (indirect). Blue colors indicate higher indirect/direct effect ratio. Larger labels indicate larger population.

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A 61-million-person experiment in social influence and political mobilization

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⁴Medical Genetics Division, University of California, San Diego, La Jolla, California 92093, USA


nature



Main research question:

Can political behaviour spread through an online social network ?

-> whether online networks can be used effectively to increase the likelihood of behaviour change and social contagion



Field of application: voting behavior in national election (USA congressional election 2010)

- Voter turnout is significantly correlated among friends, family members and co-workers
- Voter mobilization efforts are effective at increasing turnout, particularly those conducted face-to-face and those that appeal to social pressure and social identity
- BUT: meta-analysis of email experiments suggests that online appeals to vote are ineffective

Small effects...yet remarkable

- most methods of contacting potential voters have small effects (if any) on turnout rates, ranging from 1% to 10%.
- However, the ability to reach large populations online means that even small effects could yield behaviour changes for millions of people.
- These changes could affect electoral outcomes.
 - *For example, in the 2000 US presidential election, George Bush beat Al Gore in Florida by 537 votes (less than 0.01% of votes cast in Florida). Had Gore won Florida, he would have won the election.*

Specific sample

- USA Facebook users aged >18
- All users who accessed the Facebook website on 2 November 2010 (congressional election day)

EXPERIMENTAL DESIGN

3 random groups

- «Social message» (n=60,055,176)
- «Informational message» (n =611,044)
- Control: no message (n=613,096)

EXPERIMENTAL DESIGN

- SM group:
 - *invite people to vote at the top of their News Feed*
 - *providing a link to local polling*
 - *Clickable button reading «I Vote».*
 - *shows how many other Fb users vote*
 - *displayed six randomly selected profile from Facebook friends.*
- IM group: no friends faces shown.

Social message

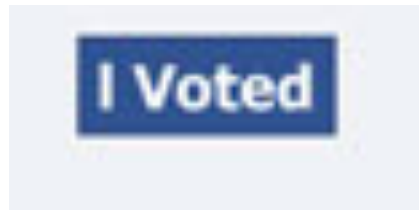


a

Informational message



Dependent Variable: direct effects



Find your polling place on the U.S. Politics Page and click the "I Voted" button to tell your friends you voted.



- Clicking the I Vote button (political self-expression)
- Clicking the polling-place link (user's desire to seek information about the election)
- Voting in the election (validated voting behaviour of 6.3 million users matched to publicly available voter records)

Network Definition

- Friendship network of Facebook users
- Average degree $K=149$ Facebook friends
- with whom users share social information

Hypothesis

Past research indicates that close friends have a stronger behavioural effect on each other than do acquaintances or strangers

- We therefore expected mobilization to spread more effectively online through 'strong ties'.



Network boundaries

friends who interacted with each other at least once during the three months prior to the election.

Strenght of ties' operationalization

- As individuals vary in the degree to which they use the Facebook

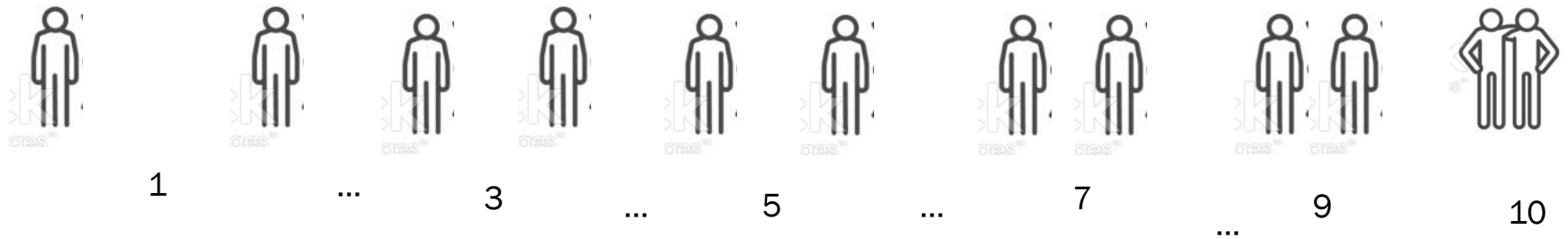
-> Normalization for each user:

$$\frac{\text{N}^\circ \text{ of interactions with a specific friend}}{\text{N}^\circ \text{ of interactions with all friends}}$$

- This gives a measure of the percentage of a user's interactions accounted for by each friend (for example, a user may interact 1% of the time with one friend and 20% of the time with another).

Strenght of ties' ranking

- We then categorized all friendships in our sample by decile, ranking them from lowest to highest percentage of interactions. Each decile is a subset of the previous decile.
- For example, decile 5 contains all friends at the 40th percentile of interaction or higher while decile 6 contains all friends at the 50th percentile of interaction or higher, meaning that decile 6 is a subset of decile 5.



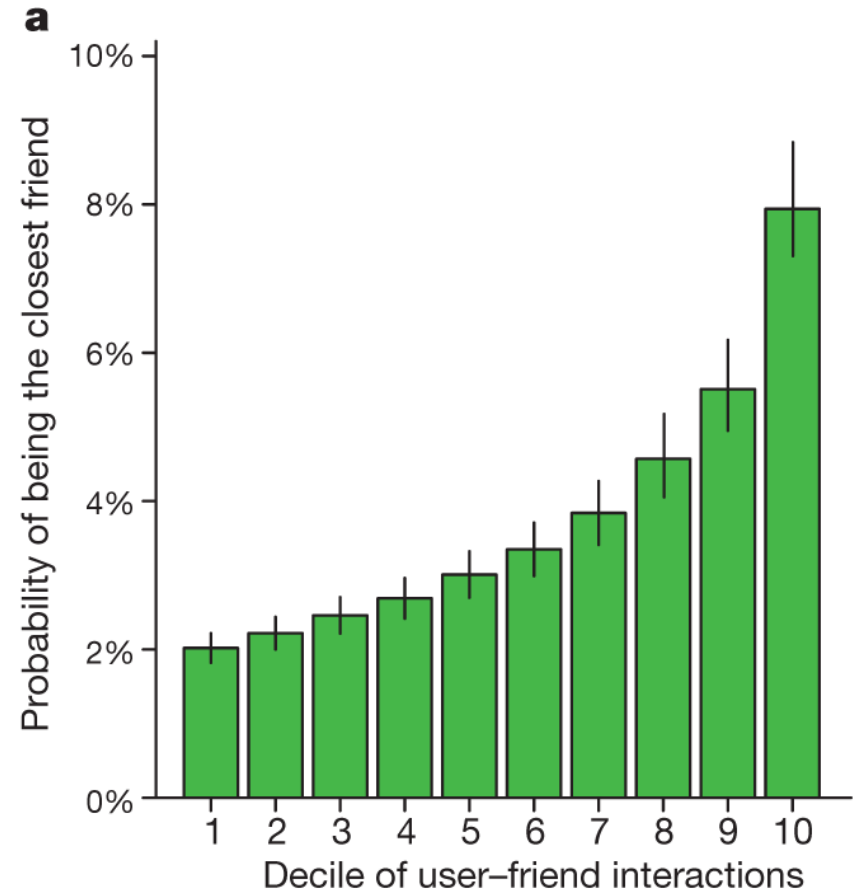
Justify the boundaries: validation study

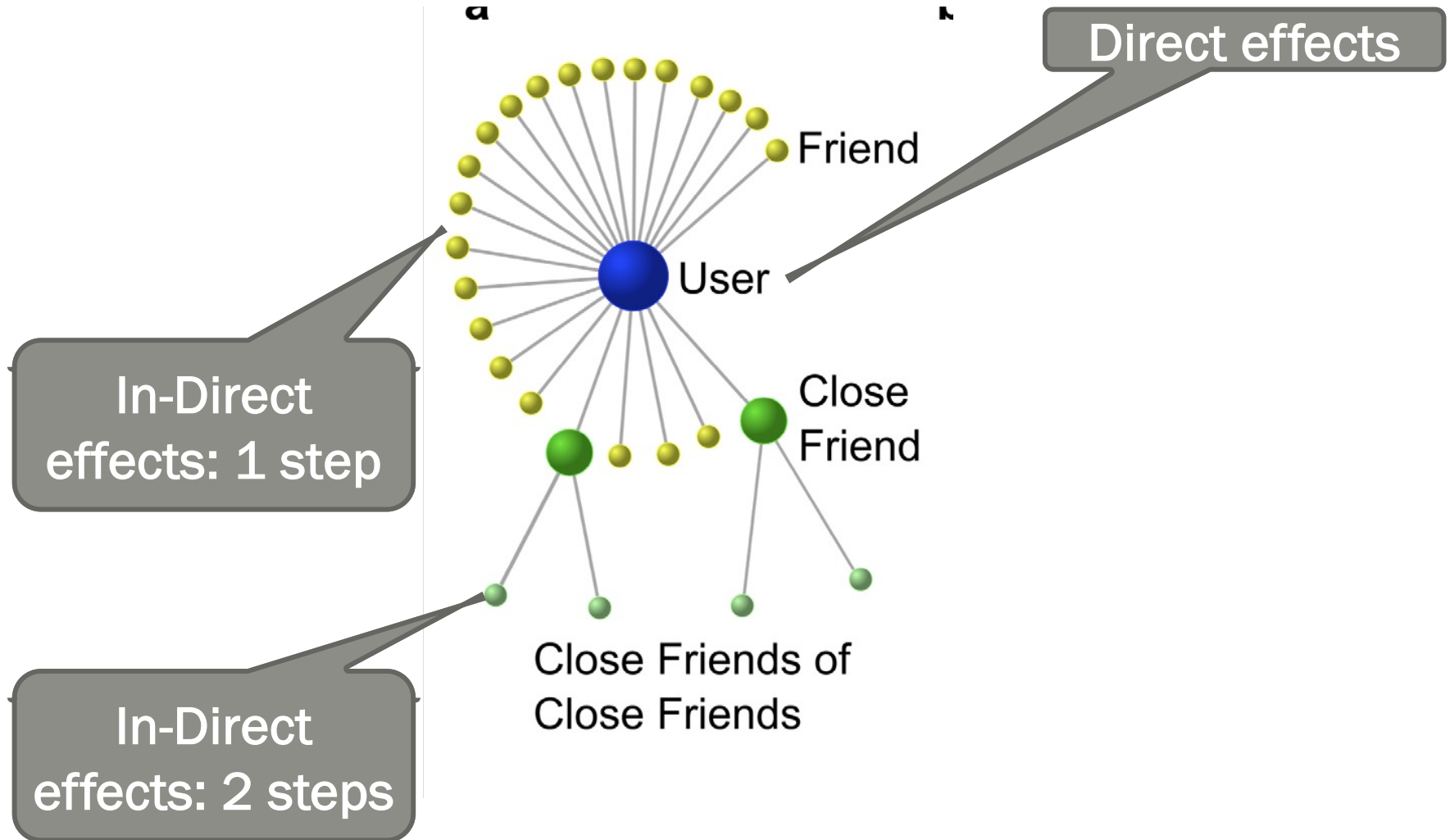
- measure of tie strength validated with a survey.
- N= 1656 users_between october 2010-jan 2011
- *“Think of the people with whom you have spent time in your life, friends with whom you have a close relationship. These friends might also be family members, neighbors, coworkers, classmates, and so on.
Who are your closest friends? “*
- list of closest friends by pairing each survey respondent with the first friend named in response to the prompt.

Hyp: N° interactions is a good predictor of named closest friends.

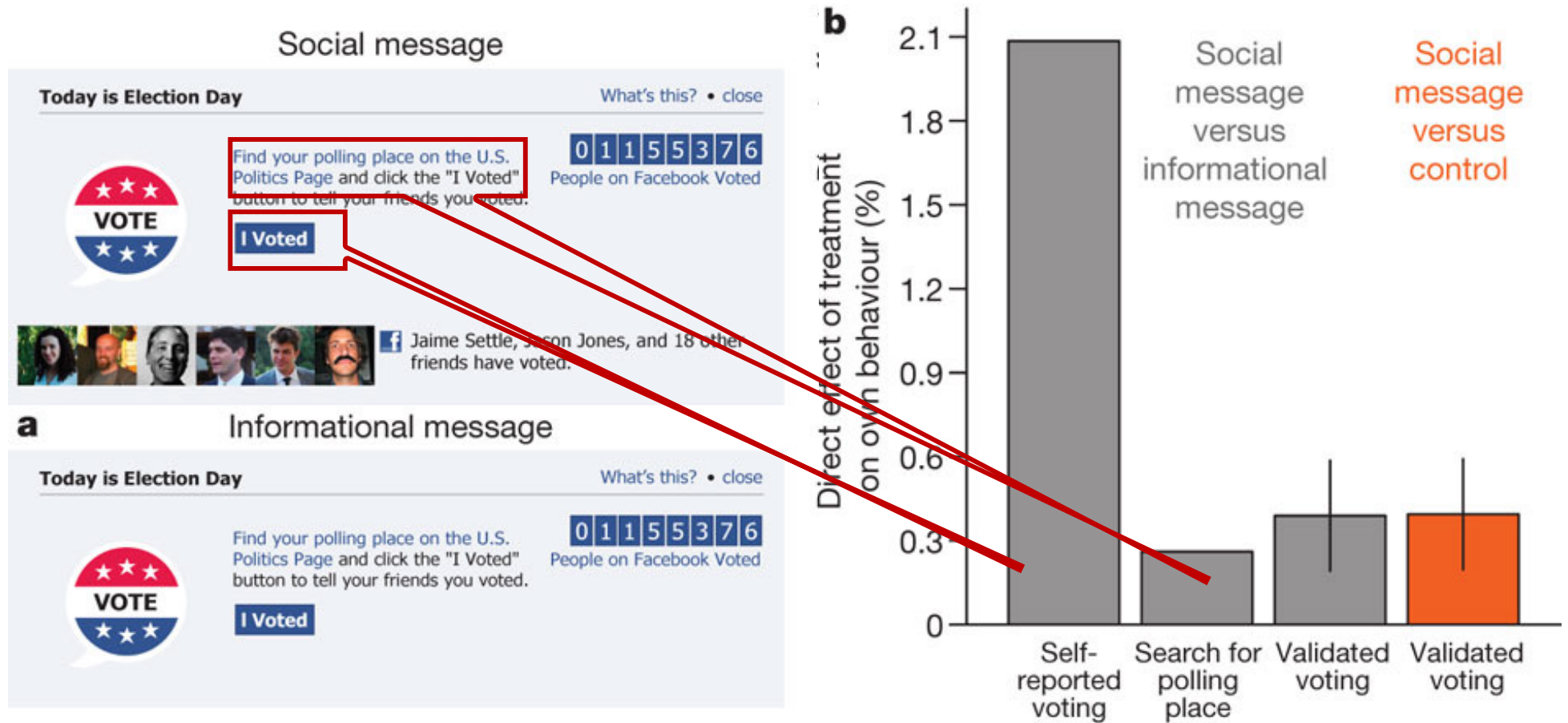
Justify the boundaries: validation study

Facebook friends
are more likely to
have a close real-
world relationship





DIRECT EFFECTS: Facebook behaviors



social mex 2.08% more likely to click on the I Voted button than info mex

social mex 0.26% more likely to click the polling-place information link than info mex

Direct effects: ACTUAL VOTING

- Social mex + 0.39% more likely to vote than control
- Social mex + 0.39% more likely to vote than informational mex
- Control = informational mex

-> seeing faces of friends significantly contributed to the overall effect of the message on real-world voting.



a

Informational message

Today is Election Day[What's this?](#) • [close](#)



Find your polling place on the U.S. Politics Page and click the "I Voted" button to tell your friends you voted.

[I Voted](#)

0	1	1	5	5	3	7	6
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People on Facebook Voted

Social message

Today is Election Day[What's this?](#) • [close](#)



Find your polling place on the U.S. Politics Page and click the "I Voted" button to tell your friends you voted.

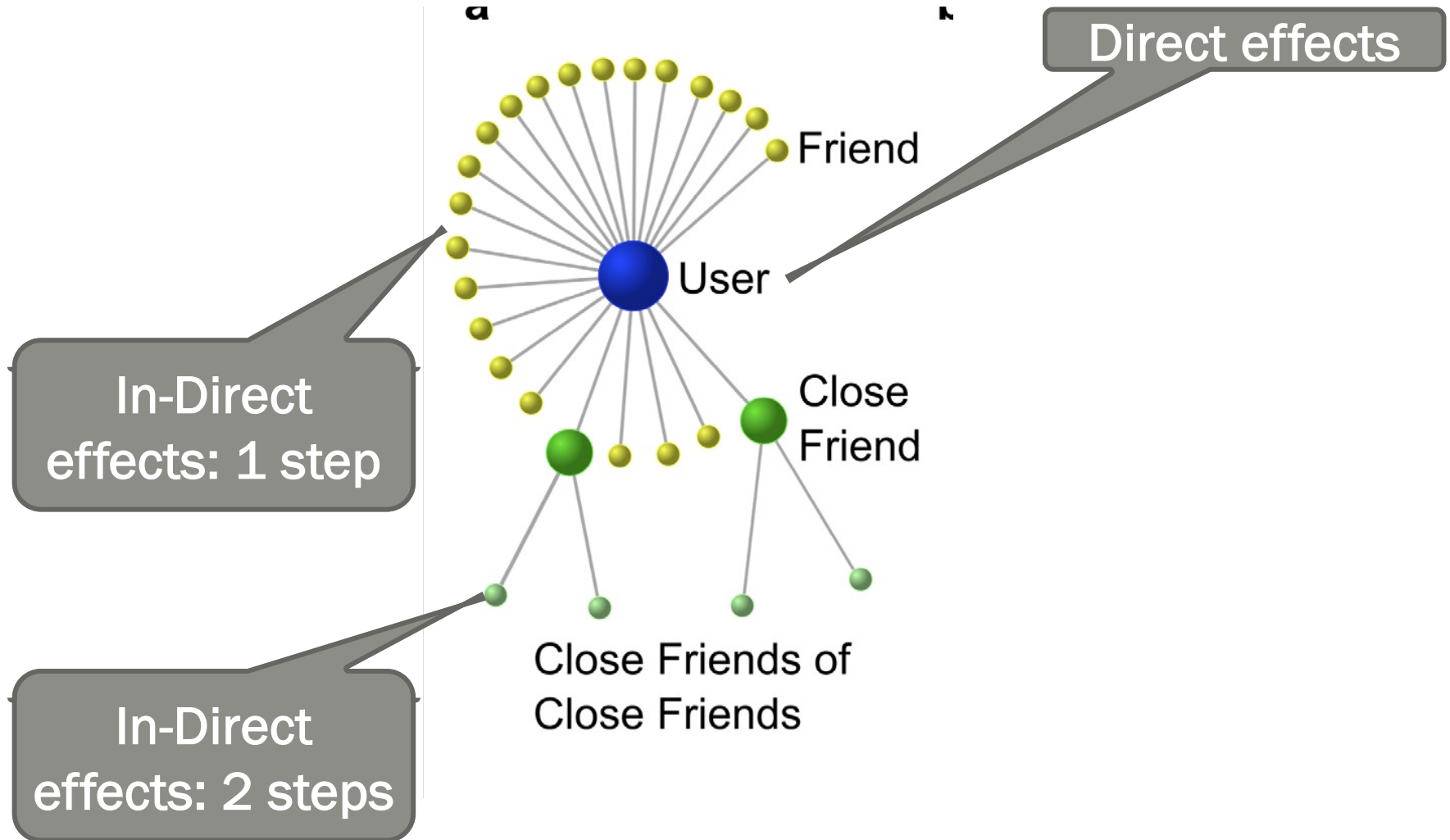
[I Voted](#)

0	1	1	5	5	3	7	6
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People on Facebook Voted



 Jaime Settle, Jason Jones, and 18 other friends have voted.

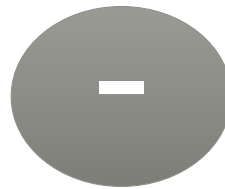


INDIRECT EFFECTS 1 step: per friend treatment

- mean rate of behaviour for each user conditional on their friend's experimental condition
 - *Possible processes: imitation (social contagion)*
 - *Discussion (persuasion)*

per-friend treatment effect=

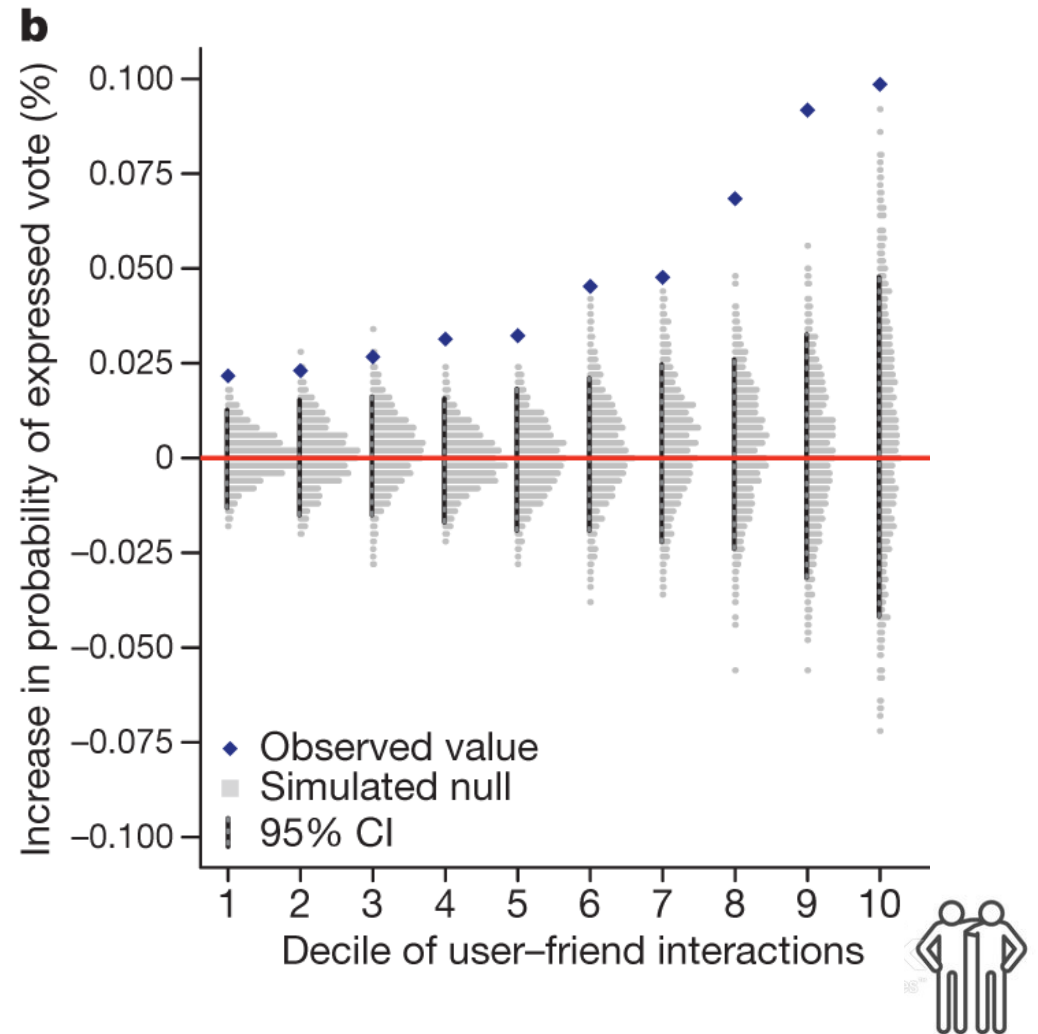
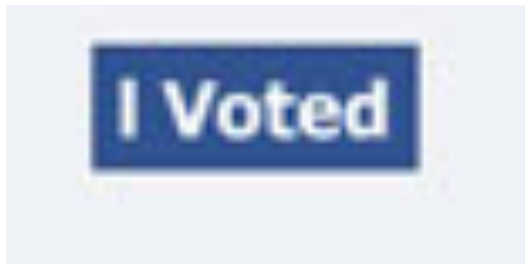
the rate of behaviour of
the users whose friends
were in the **treatment**
condition



the rate of behaviour of
the users whose friends
were in the **control**
condition

Indirect effects

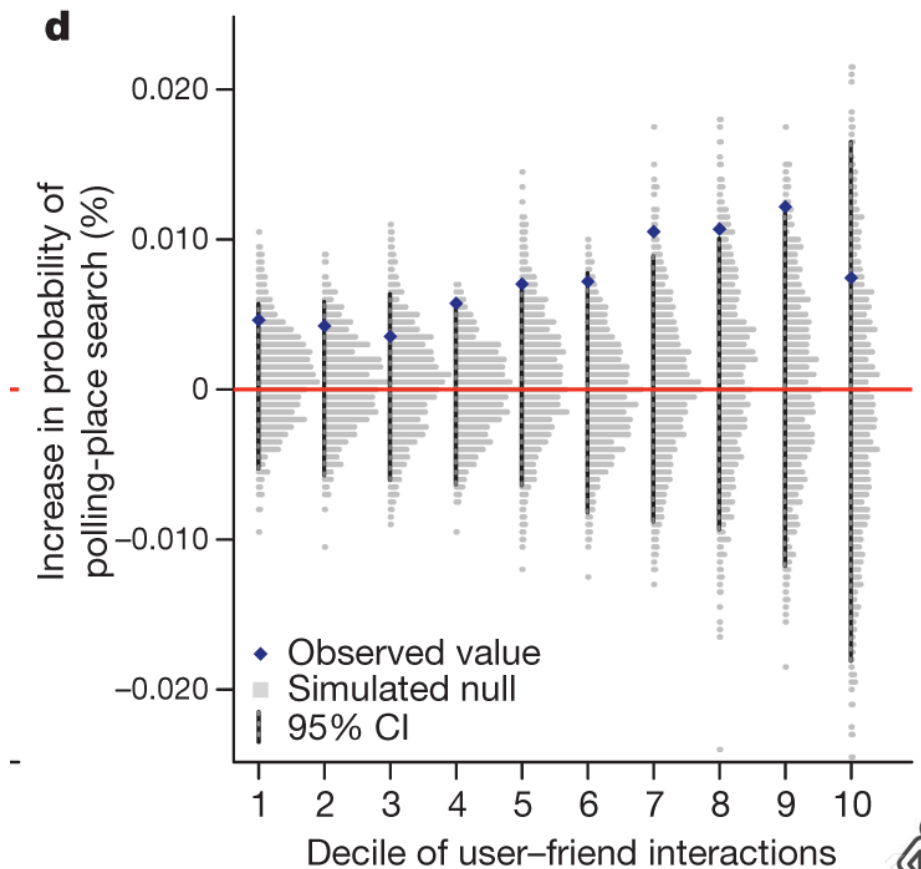
As the interaction increases, so does the observed per-friend effect of friend's treatment on a user's expressed voting



INDIRECT EFFECTS

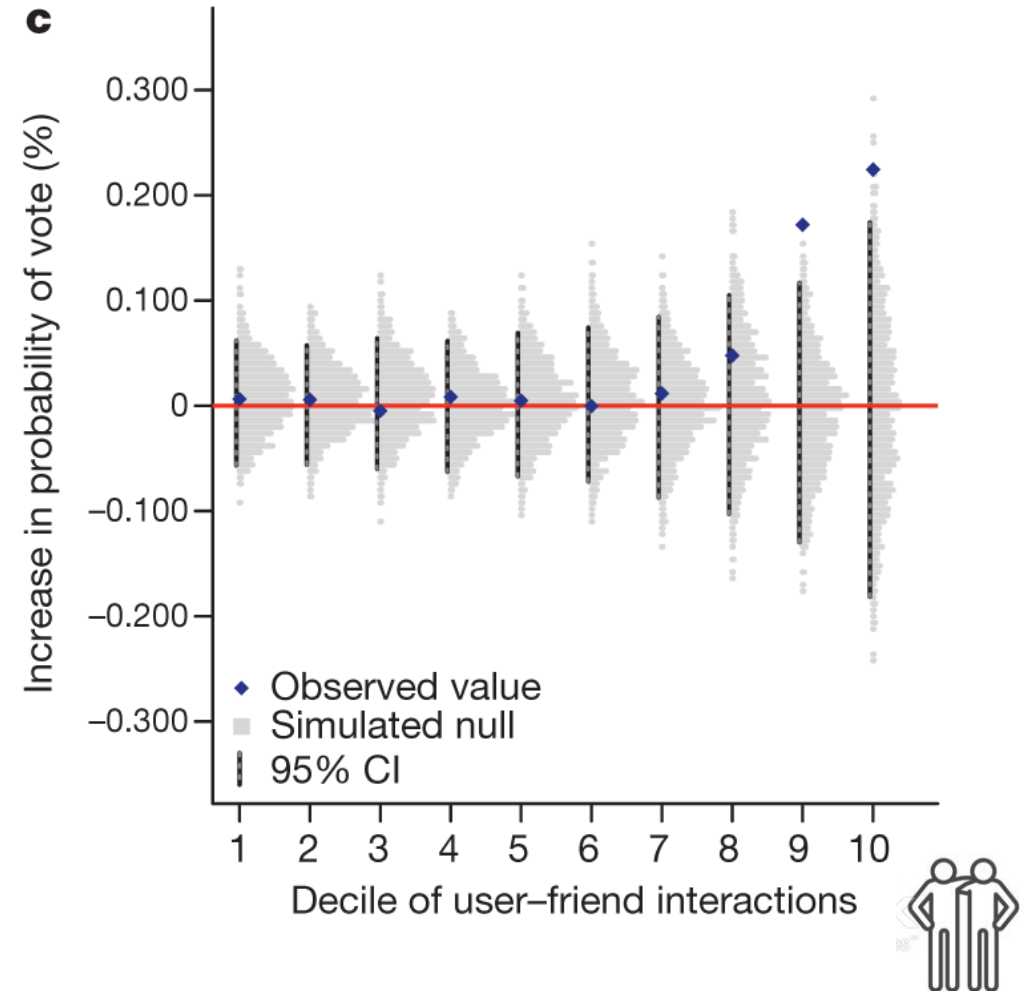
As the interaction increases, so does the observed per-friend effect of friend's treatment on a user's polling-place search

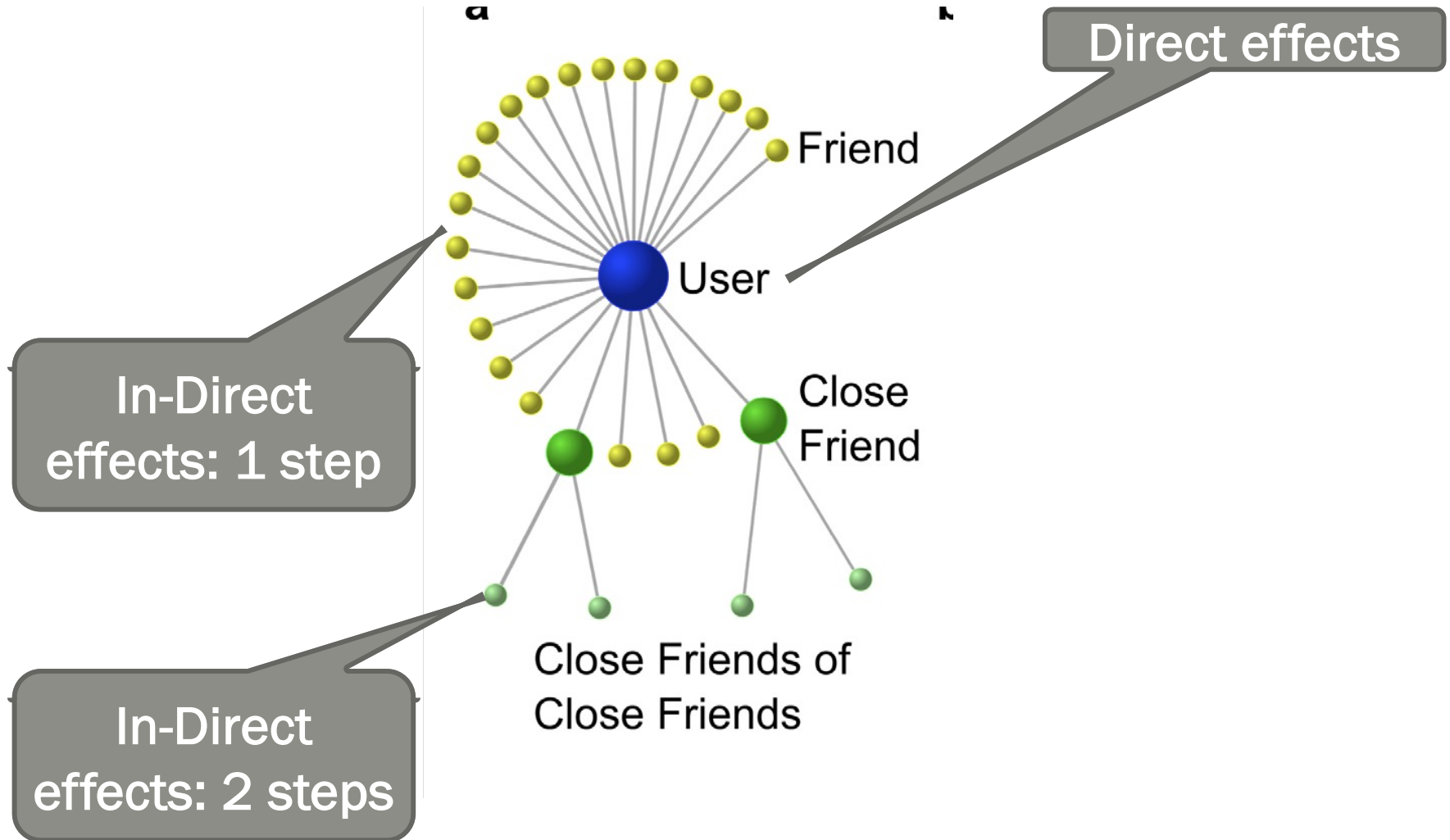
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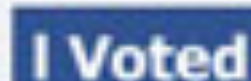
INDIRECT EFFECT

As the interaction increases, so does the observed per-friend effect of friend's treatment on a user's validated voting





Close friends of close friends

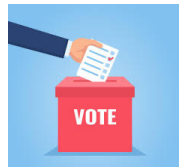
A blue rectangular button with the text "I Voted" in white, set against a light blue background.

- expressed voting: the treatment effects were strong enough to be detectable at two degrees of separation.

For each *close friend of a close friend* who saw the social message, an individual was 0.022% more likely to express voting.

-> the treatment caused 1,025,000 close friends of close friends (2 degrees of separation) to express voting

Close friends of close friends



Find your polling place on the U.S. Politics Page and click the "I Voted" button to tell your friends you voted.

- For **validated voting** and **information seeking** we did not find significant effects for close friends of close friends

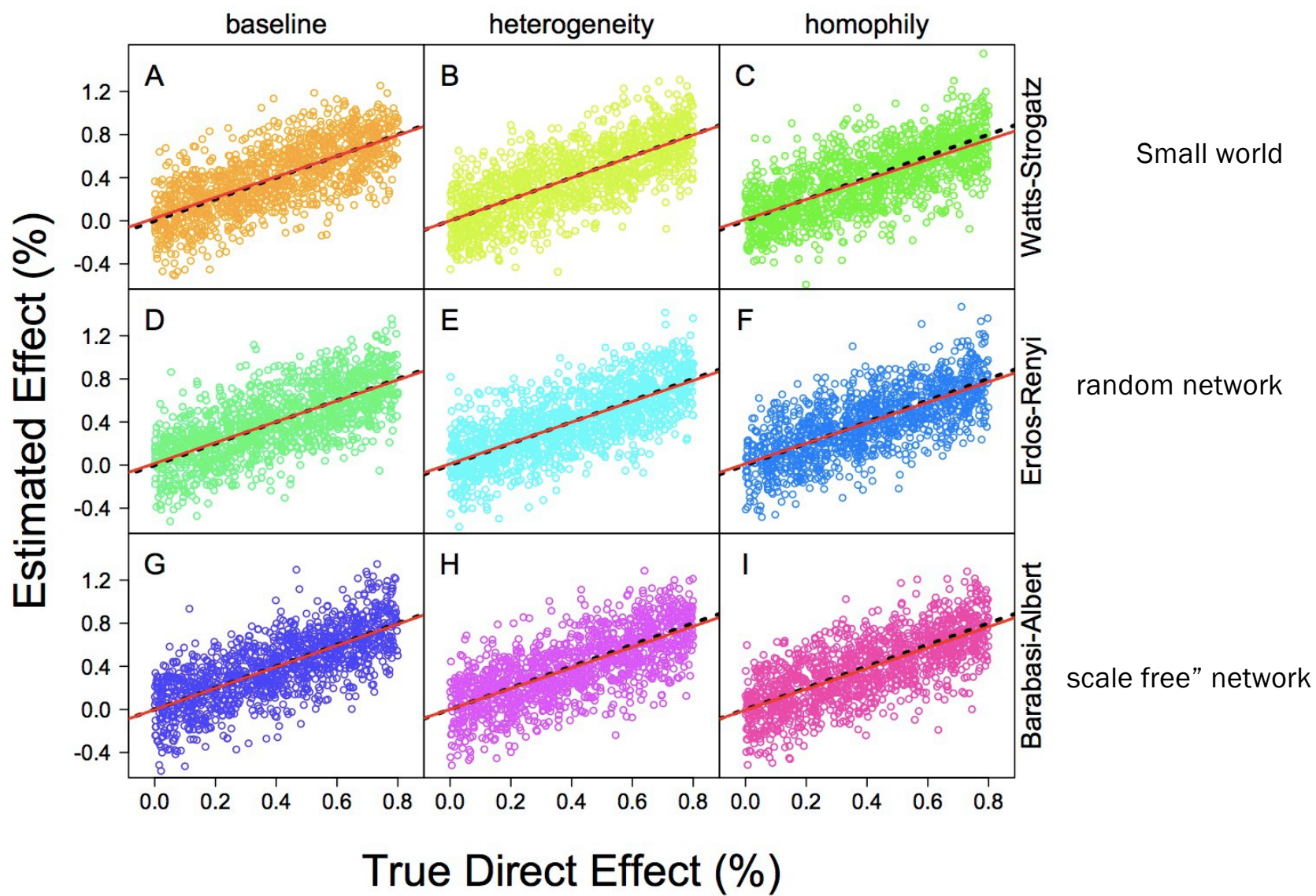
Network permutation

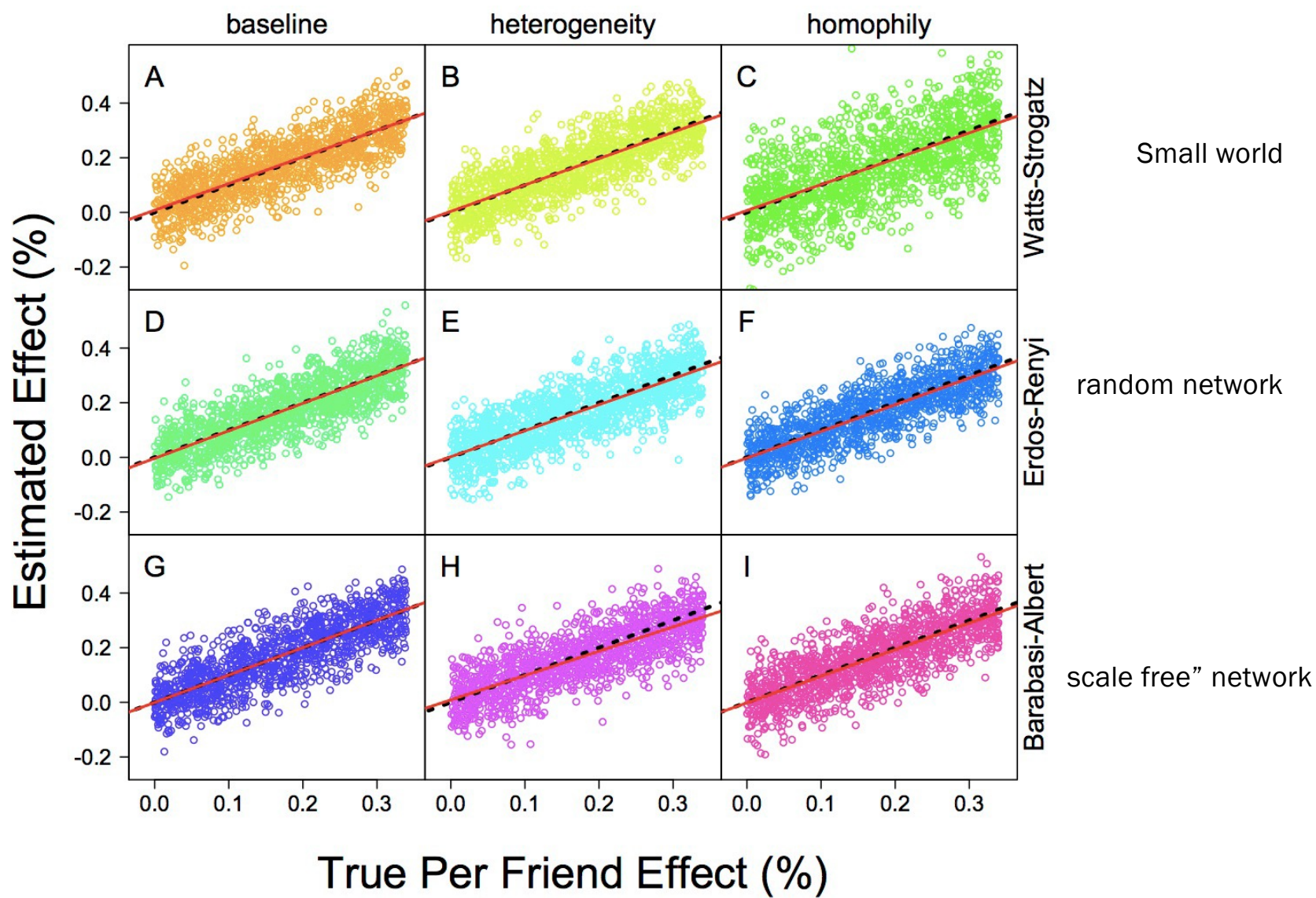
- the network permutation method allows to evaluate an observed correlation between a *treatment variable* and a *resulting behaviour* in the treated individual, the treated individual's friends, and the treated individual's friends of friends
- -> measure the likelihood that a correlation in observed behaviour between connected individuals in the network is due to chance

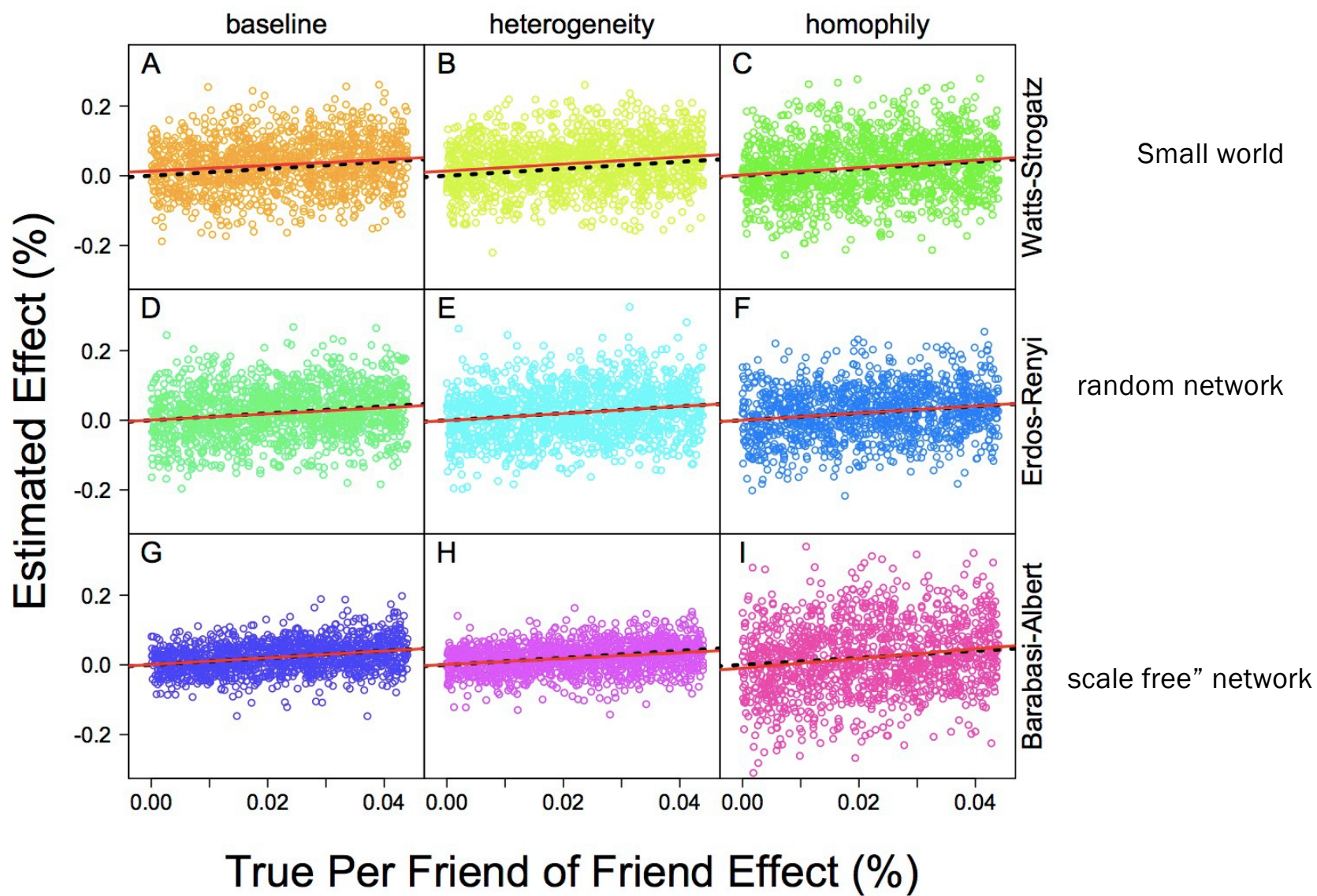
Montecarlo procedure


- 1) generates a network
- 2) endows individuals within the network with an initial likelihood of a behaviour
- 3) randomly assigns them to treatment and control groups
- 4) updates their likelihood of the behaviour according to treatment effects that we can assign (the “true” effects)
- 5) uses these probabilities to determine which individuals exhibit the behaviour.


-> test the permutation procedure to see whether or not there is bias in the estimated treatment effects and the rate at which our estimation procedure produces false positives.







- 
- The dotted line is the theoretical relationship between the “true” values we set and the values estimated by our method one would expect if there were no bias in the procedure, and the solid line is the actual relationship estimated by ordinary linear regression.
 - in all cases the solid line lies very close to the dotted line.
 - Conclusion: the estimates were not biased, no overestimation, no underestimation.

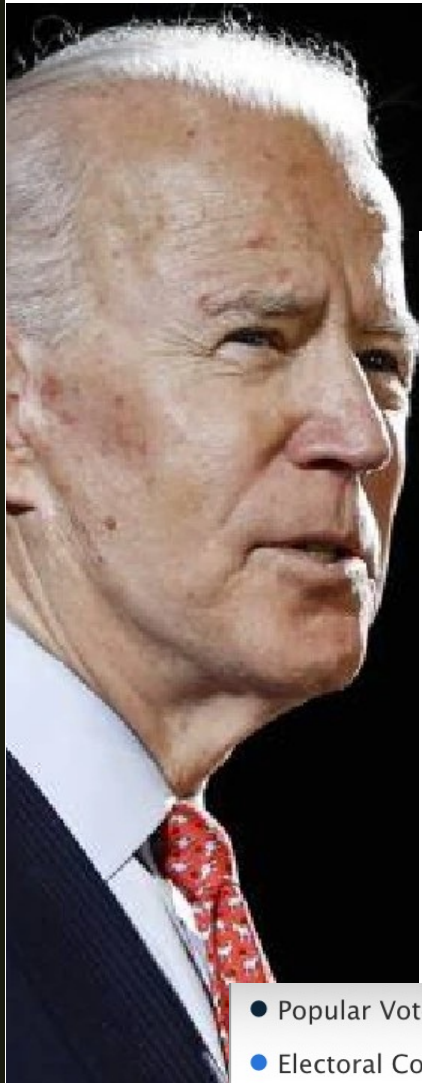
- 
- Online political mobilization works.
 - It induces political self-expression, but it also induces information gathering and real, validated voter turnout.



- Voters aged under 30 became even “less enamoured of President Trump than before”.
- “The other age groups, 30-44, 45-64, 65 and over, it’s a pretty close divide between Biden and Trump. So it’s really young people who are overwhelmingly anti-Trump and that’s really noticeable.”
- Tens of millions of dollars were spent by Democratic and Republican campaign groups over the past couple of years to register voters and help increase turnout, especially among Latino communities.
- Grassroots Latino activism in states such as Arizona and Georgia, which are historically Republican, appear to have boosted Biden significantly.

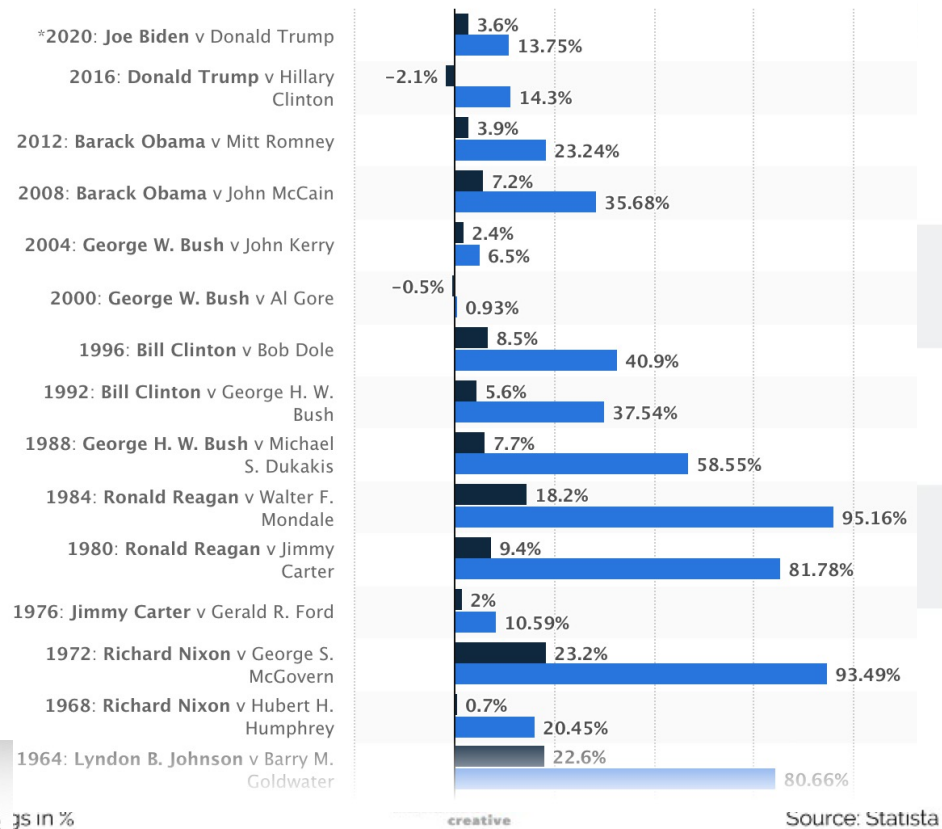
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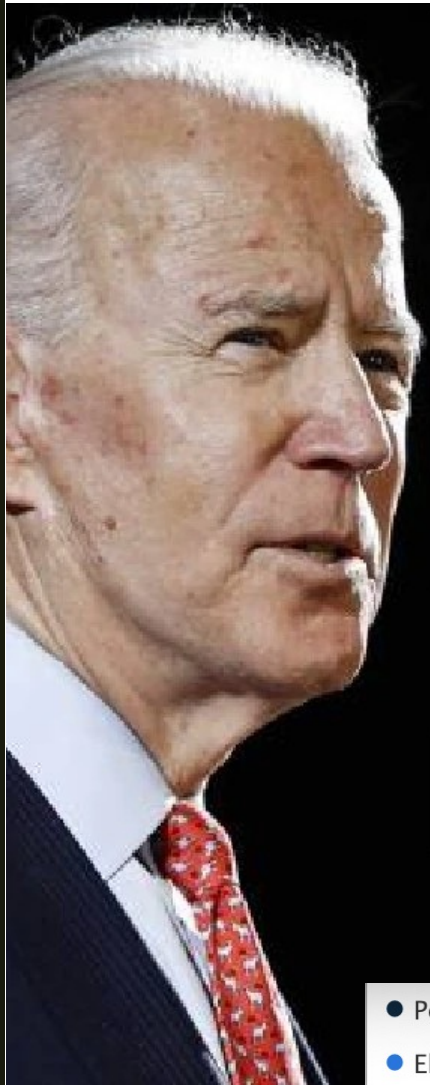




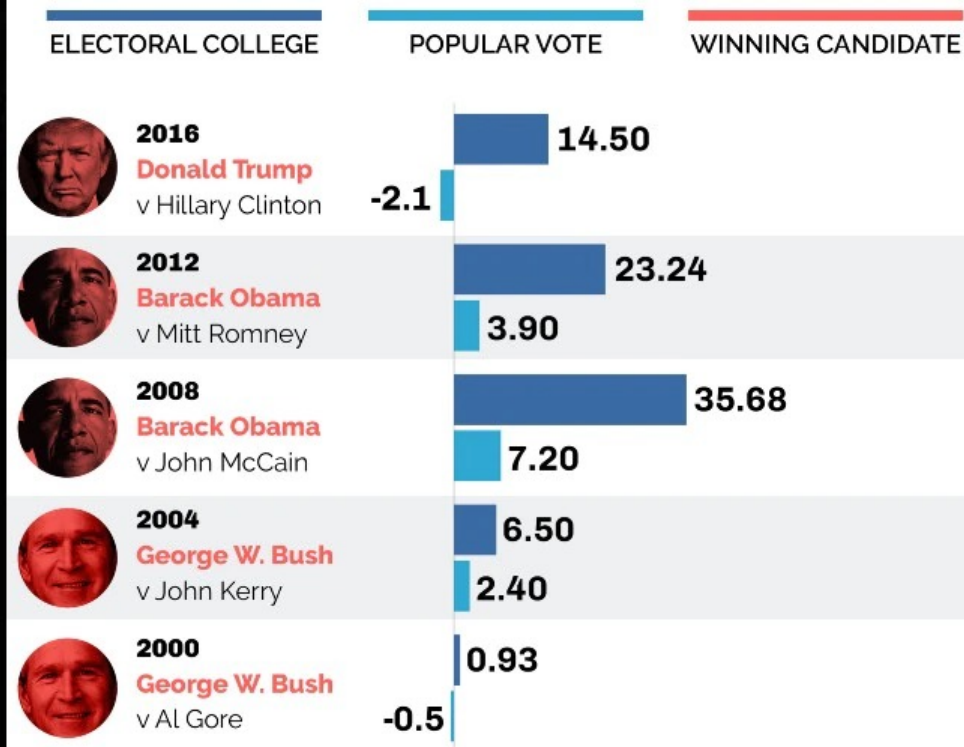
UNITED STATES PRESIDENTIAL ELECTIONS WINNING MARGINS IN THE LAST 100 YEARS

- Popular Vote
- Electoral College





UNITED STATES PRESIDENTIAL ELECTIONS WINNING MARGINS IN THE LAST 100 YEARS



- Popular Vote
- Electoral College

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