# Non-linear interaction between network structure randomness and probabilistic contagion dynamics

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1) Abstract:

Graphs can be used to model spreading of contagious units, both of biologic (i.e. diseases) and cultural (i.e. memes) nature. Recently, Centola and Macy (2007) have shown, that while simple contagion spreads more efficiently in ordered networks, complex contagion (i.e. one that requires contact with more than one spreader to infect another node in the network) spreads more efficiently in more randomly connected networks. Inspired by their work, I investigated, how network structure (non-random vs highly random) interacts with infectiousness of a probabilistic contagion in shaping its pattern of spreading.

Demonstrative graphs of varying randomness (R):

R = 0   R = 0.2   R = 0.4

R = 0.6   R = 0.8   R = 1
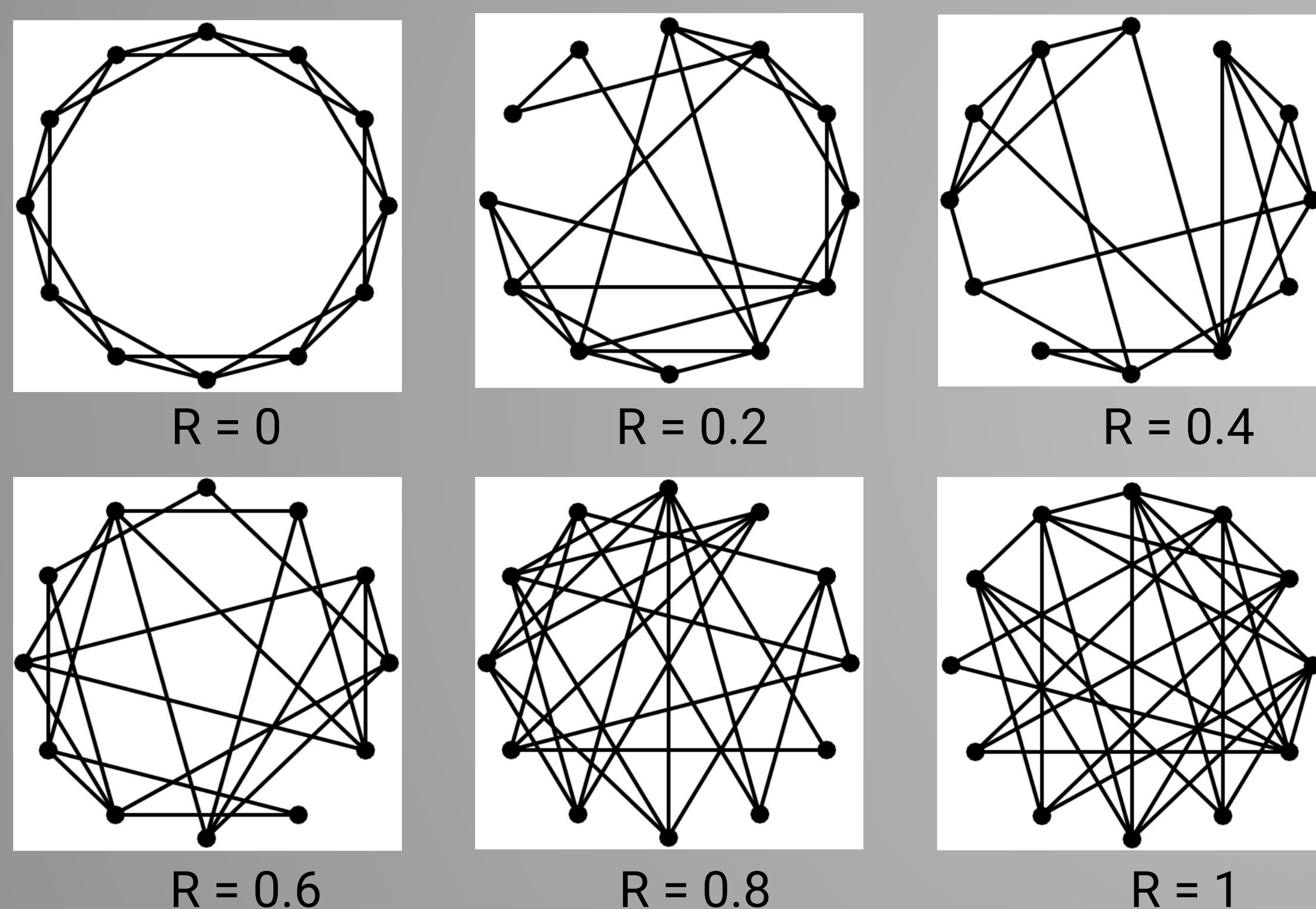
2) Hypothesis:

The prediction was that probabilistic contagion (i.e. one that spreads to neighboring nodes with some probability between 0 and 1) would spread more efficiently in more random networks.

3) Method:

- We create the basic graph with 100 nodes and randomness R=0, such that each node is connected to 4 other nodes (look at example R=0 on the left). To obtain a graph with R randomness ($0 \leq R \leq 1$), we iterate through nodes of the basic graph and randomly change their connections (with probability R)
- All nodes are intially "infected" with "healthy contagion" C1, whose infectiousness I1 = 0.4
- 5 randomly chosen nodes are infected with a "disease" contagion C2, with infectiousness I2, such that $0.2 \leq I2 \leq 0.9$
- For each experimental condition: (15 values of I2 and 21 values of R), we create 10 graphs and run 10 simulations for each one of them (up to 1000 steps)
- 15 * 21 * 10 * 10 = 31500 simulations

4) Results

- At I2<I1, C1 often wins, but when I2>I1, simulations almost always end either with C2 triumph or without any conclusion reached in first 1000 steps
- Regardless of its infectiousness (I2) probabilistic contagion favors either very low or very high network randomness
- However, in more random graphs, C2 requires less steps on average to reach fixation (it triumphs faster over C1)
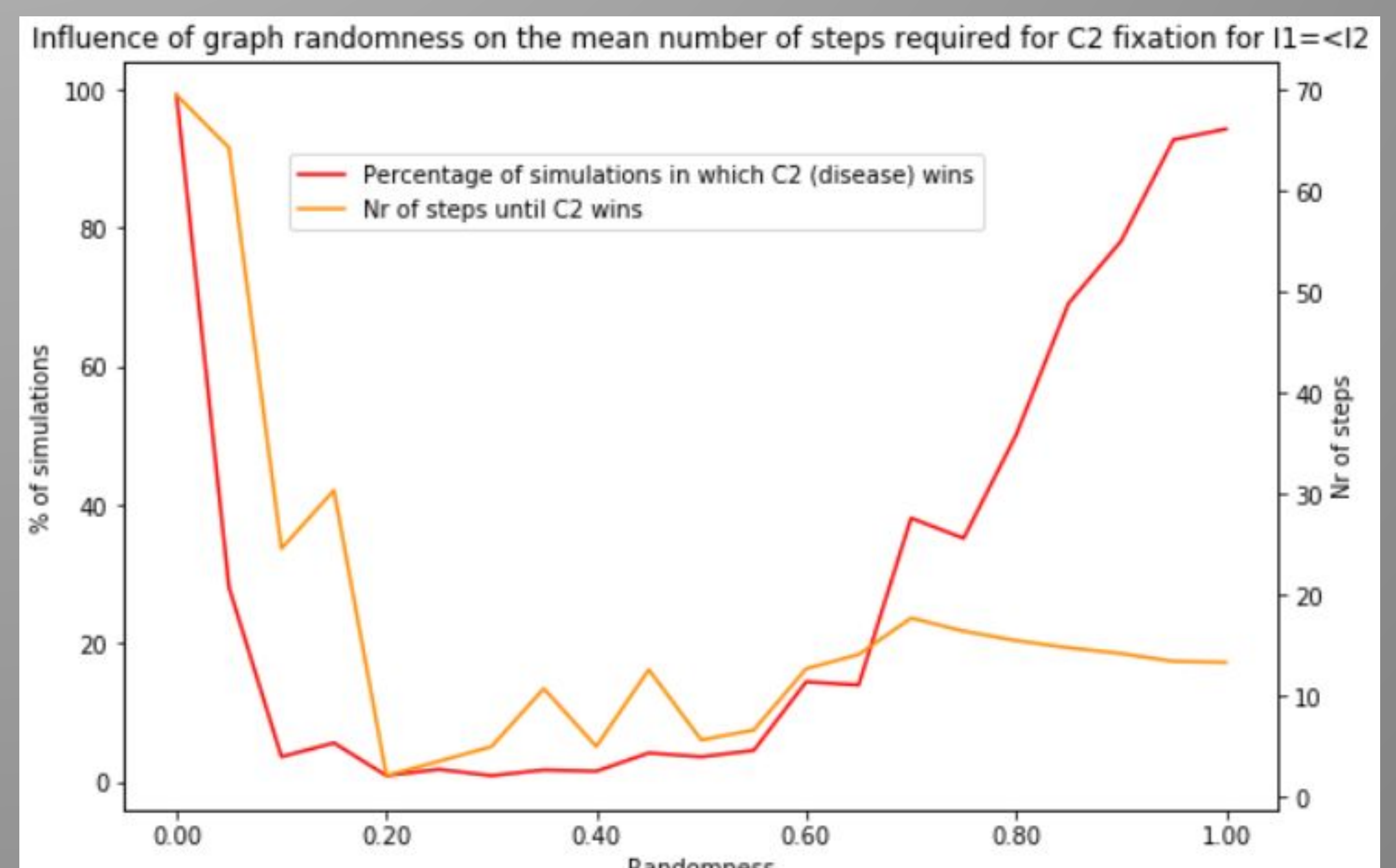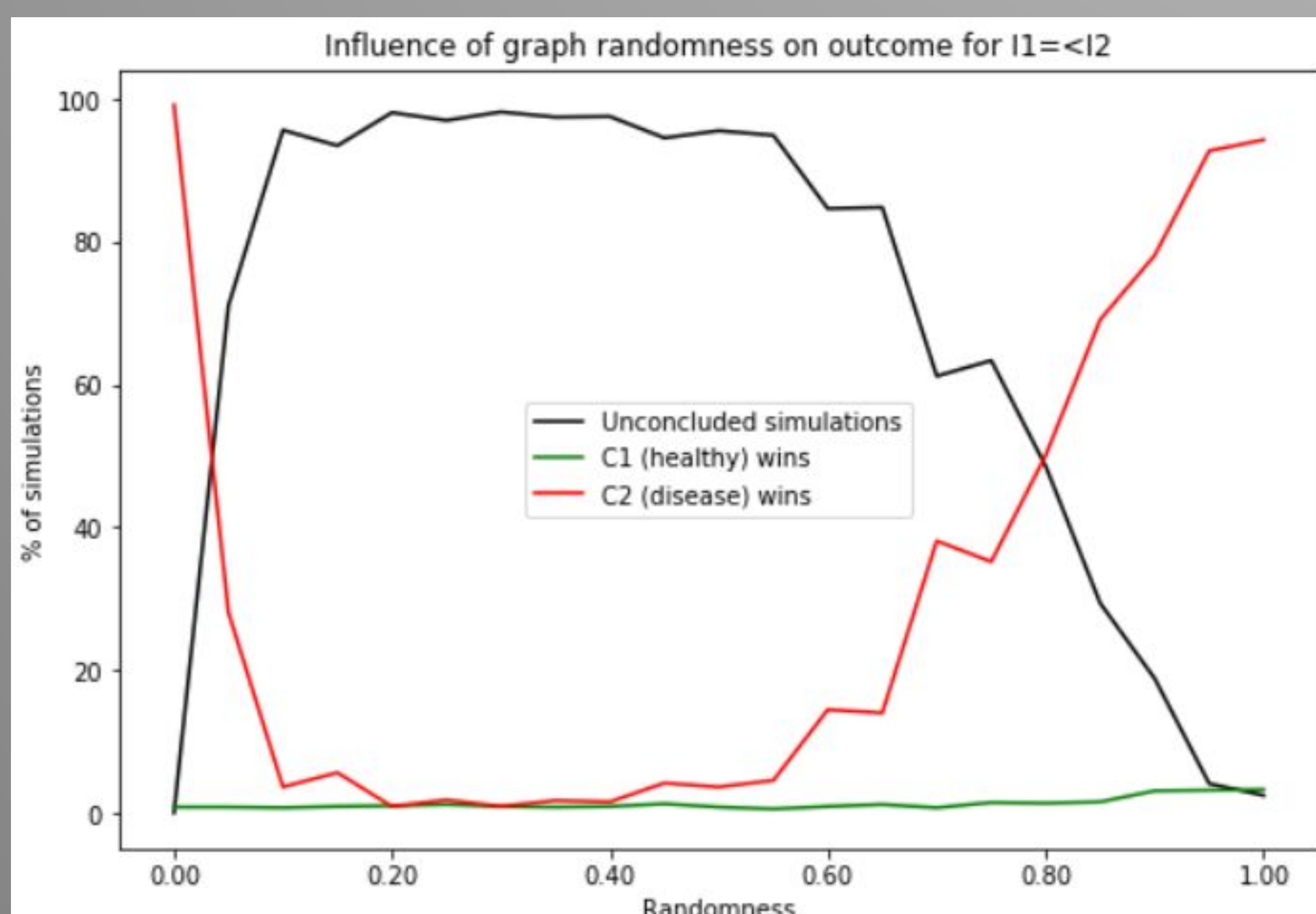
References

[1] Centola, D., & Macy, M. (2007). Complex contagions and the weakness of long ties. *American Journal of Sociology, 113(3),* 702-734

Please contact me at bagginsmatthew@gmail.com, if you'd like to take a closer look at my data and Python code