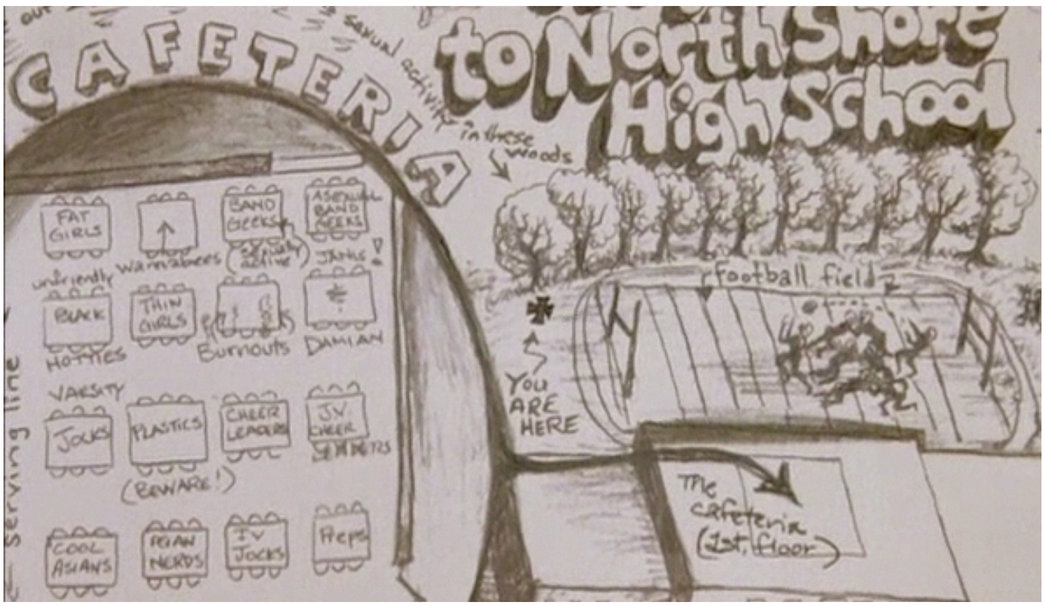
How to Succeed in High School: An Analysis of the Effects of Popularity on the Spread of Rumors



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Introduction

Imagine that you are in high-school and you want to spread a juicy rumor that will reach the most people. Intuitively, the most effective strategy would be making up a rumor about the least popular person in school and telling it to the most popular person. The popular person will spread it quickly, because they have a large number of friends, while the unpopular person will be unable to quash the rumor because they only have a few friends through which to spread the truth.

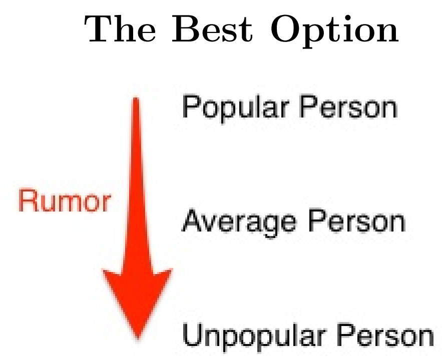


Figure 1: A rumor about an unpopular person being spread by a popular person

Now, suppose the popular person does not care enough about the unpopular person to be willing to spread your rumor. Instead, you need to choose between two options: tell the popular person a rumor about an average popularity person or tell an average popularity person a rumor about the unpopular person. Our model aims to answer the question of which option is better and provide insight into the dynamics of information diffusion on a network.

The Two Possible Choices

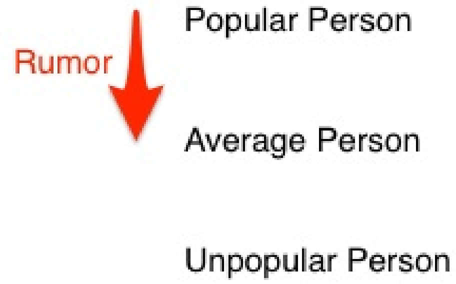


Figure 2: A rumor about an average person being spread by a popular person

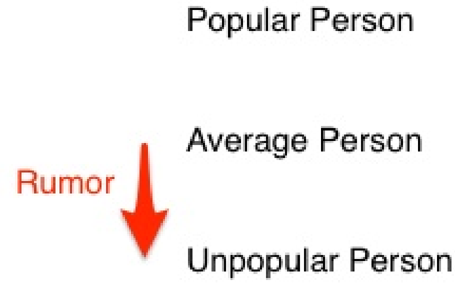


Figure 3: A rumor about an unpopular person being spread by an average person

Model and Assumptions

Rumor

A rumor begins in the population with some agents who completely believe it, others who completely disbelieve it, and a majority who have some belief in between. We assume that everyone has some initial belief about the rumor and that belief can change as they interact with others. Treating the rumor as a piece of information about which some agents have some prior knowledge seems to be a good approximation of people's perception of the veracity of rumors. In this model, we will always assume that the rumor is started by someone at least as popular as the person the rumor is about.

Agents

The model consists of n people within a spatially clustered network with an average degree γ. Each person has two properties: a belief, β, about the rumor and a propensity, π, to update their belief. It is a heterogeneous population with $n -$

$m - q$ normal people (white) whose belief and propensity are both drawn from independent standard uniform distributions. There are m mongers (red) with belief 1 and propensity 0, they completely believe the rumor and never change their belief. There are also q quashers (blue) with belief 0 and propensity 0, they fully disbelieve the rumor and never change their belief. Figure 4 gives a visual representation of the agents in the network.

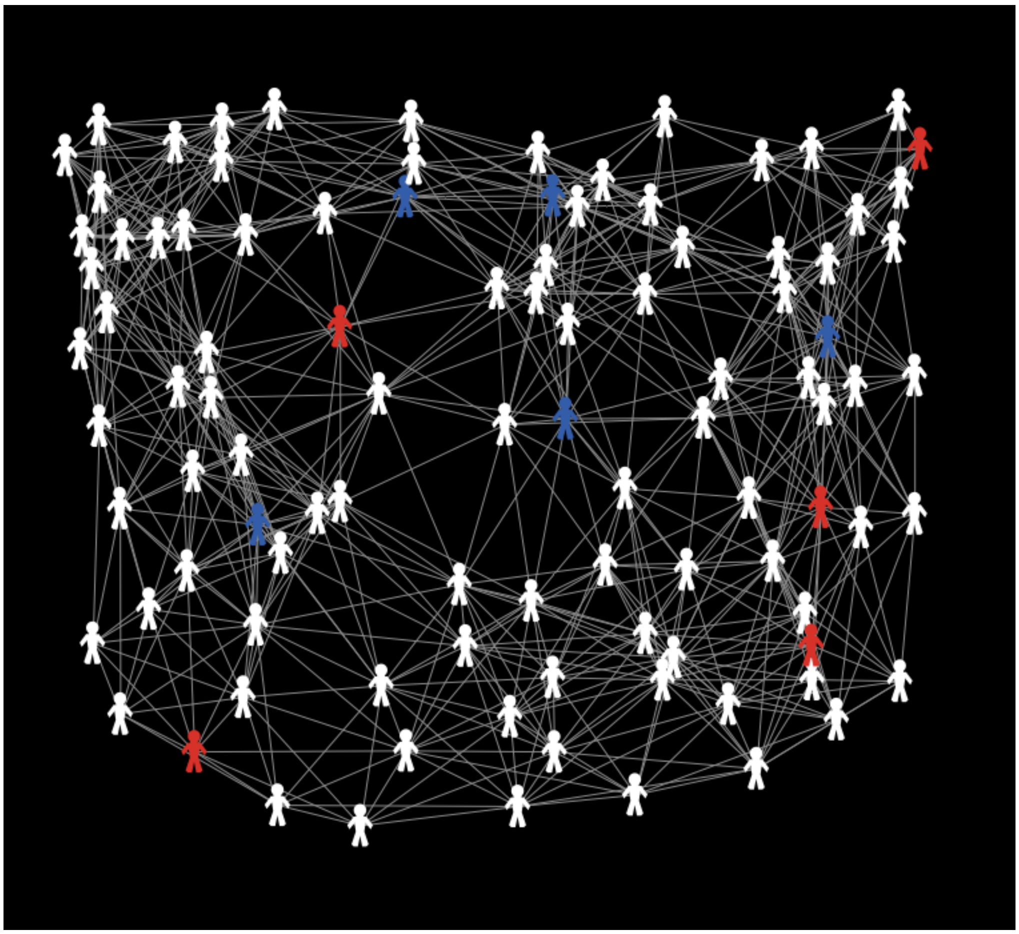


Figure 4: Graphical Representation of the Network

Spread of the Rumor

At each time step, each person receives information regarding the rumor from each of their connections. They update their belief subject to:

$$\beta_i' = (1-\pi)\beta_i + \pi \frac{1}{L} \sum_{j \in N(i)} \beta_j \tag{1}$$

where L is the number of connections.

Research Question

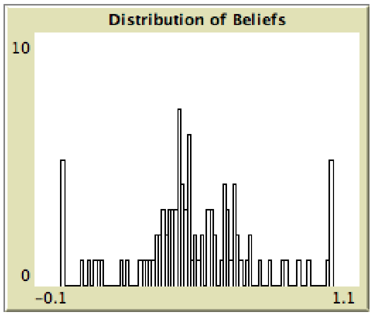
How does the popularity (connectedness) of an individual trying to spread a rumor affect the spread of the rumor and a population's perception of the rumor? How does the popularity of the person whom the rumor is about affect the spread and perception of the rumor?

Results

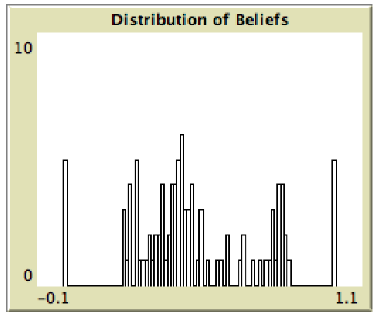
For all runs $n = 100$, $\gamma = 15$, and $t = 1000$. For our baseline model we draw both mongers and quashers from the full population. In this model the average belief in the rumor converges to approximately 0.5; neither mongers nor quashers are able to affect the overall belief, though they are able to polarize the distribution a little bit.

In order to explore the effects of popularity on the spread of the rumor, we start by fixing the quashers to be very unpopular and vary the popularity of the mongers. We select five quashers from the 10 least popular people. We also select five mongers based on popularity. First, we randomly draw them from the population, then we restrict them to be at least as popular as the bottom decile, next, at least as popular

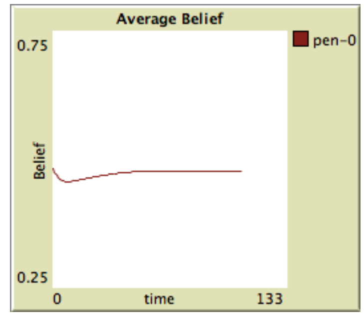
Results of the Baseline Model



Initial Distribution



Final Distribution



Average Belief

as the second decile, etc. This gives us 10 different popularities of the mongers relative to the unpopular quashers. Our results are shown in Figure 5.

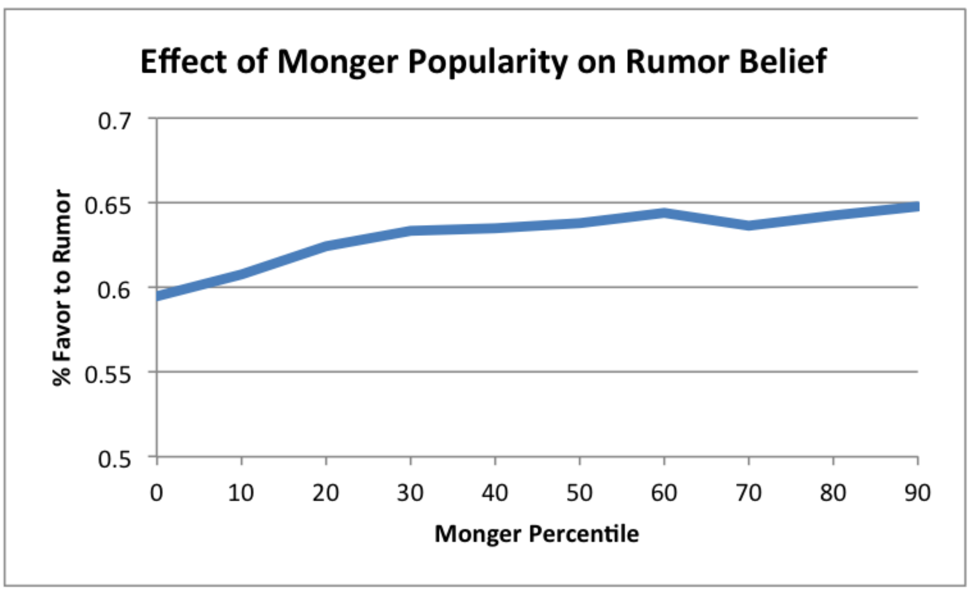


Figure 5: Quashers drawn from the bottom decile

We can see that varying the mongers popularity affects the overall belief approximately linearly. As the popularity of the mongers increases, the overall belief in the rumor also increases.

Next, we hold the mongers' popularity fixed and vary the popularity of the quashers.

We select five mongers from the top 10 most popular people. We then select five quashers in a similar fashion as above but in the opposite direction. First, from the full population, next, from the bottom 90 most popular, then the bottom 80 most popular, etc. This gives us 10 different popularities of quashers relative to the popular mongers. Our results are shown in Figure 6.

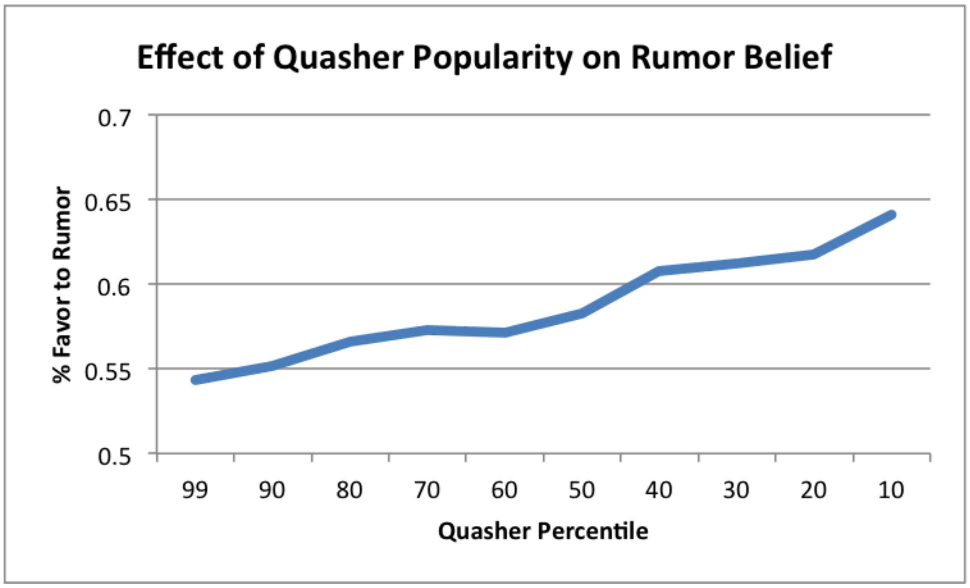


Figure 6: Mongers drawn from the top decile

Once again, we can see that varying the popularity affects the overall belief in a linear fashion. Intuitively, making the quashers less popular increases the overall belief in the rumor. Comparing Figure 5 and Figure 6 we can see that varying quasher popularity results in a much greater effect on the average rumor belief of the population.

To answer the question posed in the introduction, we only need to look at the two leftmost points from the two figures. In Figure 5 this point represents a rumor being spread by an average person about an unpopular person, while in Figure 6, this point represents a rumor being spread by a popular person about an average person. Our results indicate that, as quashers are drawn from potentially more popular members of the population, the negative beliefs toward the rumor increase more significantly than when mongers are chosen from among the most popular members of the population.

Future Directions

There are obvious extensions for further exploring the effects of popularity on the spread and perception of rumors using this model. A few possible future directions include:

- Adding weights to the updated formula to reflect varying strength of links between agents. In a real world scenario, the strength of relationships between individuals would be a key factor in one's belief or skepticism toward the rumor.
- Varying the number of mongers and quashers to observe the effects of more or fewer of each type of agent.
- Exploring the amount of time it takes for the model to converge on an average belief given different popularity levels of either mongers or quashers and the number of these agents types in a given simulation.

Social Science Applications

- Disease: the underlying structure of this model could easily be used to model the spread of disease throughout a population. Mongers could be considered those who are infectious, quashers those who vaccinate or otherwise confer immunity to people, belief could represent a transmission probability (i.e., those with belief > 0.5 would be infected while those with belief < 0.5 would not be infected). The standard uniform distribution from which the belief is drawn for the majority of the population could represent health, age, or underlying factors that influence susceptibility to disease. The results of our rumor simulations suggest that active vaccinators drawn from a larger proportion of the population would have more effects than well-connected infectors.

- Political campaigns: because we have modeled a rumor as a piece of information about which agents in the network have some prior opinion, the model is easily converted to model of political campaigns. If we consider the rumor to be a piece of negative information about a particular candidate, we can use the structure of this model to determine both effective methods of spreading or quashing the negative ads, depending on which side of the campaign one is on. Our model suggests one reason why attack ads may be effective: it is much harder to rebut a negative ad in an area where your beliefs are in the minority.