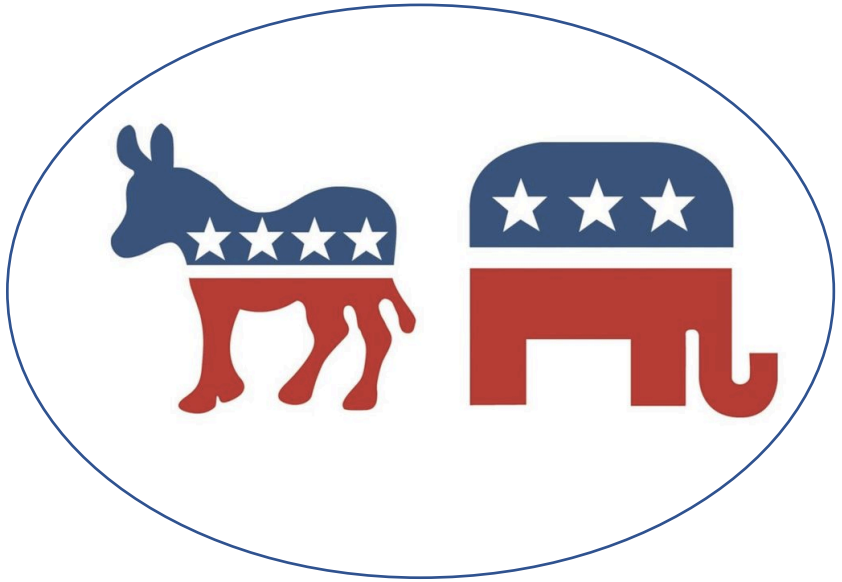
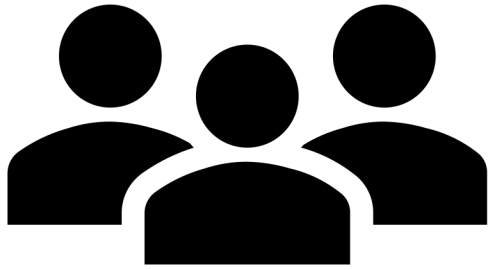
Modeling Opinion Dynamics Using the Affine Boomerang Model

Emily Lopez (CCS Mathematics)

Mentor: Elizabeth Y. Huang

Principal Investigator: Professor Francesco Bullo





People’s Opinions Around You Matter

Goal: Study Human Behaviors not Demonstrated by Classical Models

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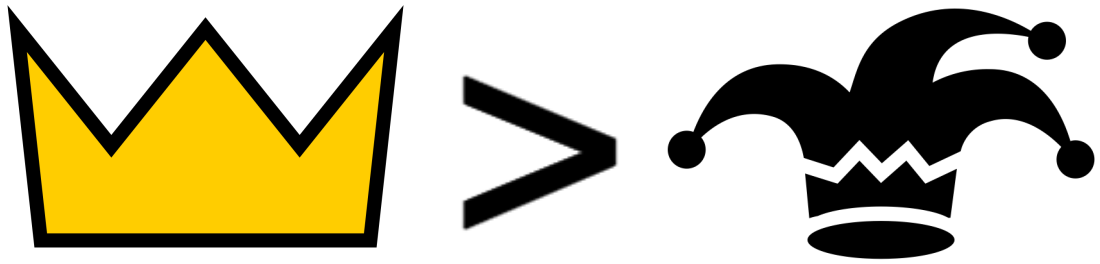
DeGroot Model (1974)



- An individual's social power can influence group's opinion
- Fails to acknowledge the types of relationships between individuals

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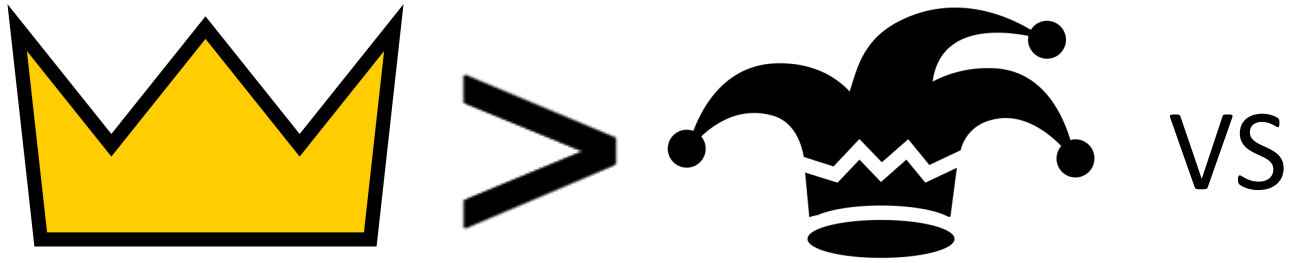

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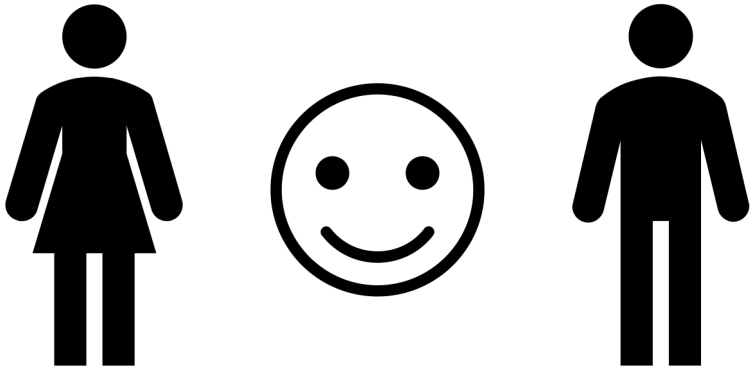
Affine Boomerang Model



- People's relationships can impact group's opinion
- **Friendly relationships** result in coming closer to agreement
- **Unfriendly relationships** result in increasing disagreement

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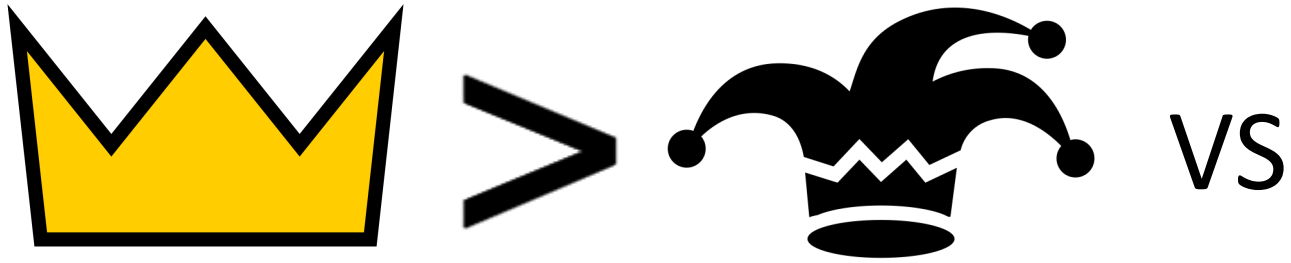

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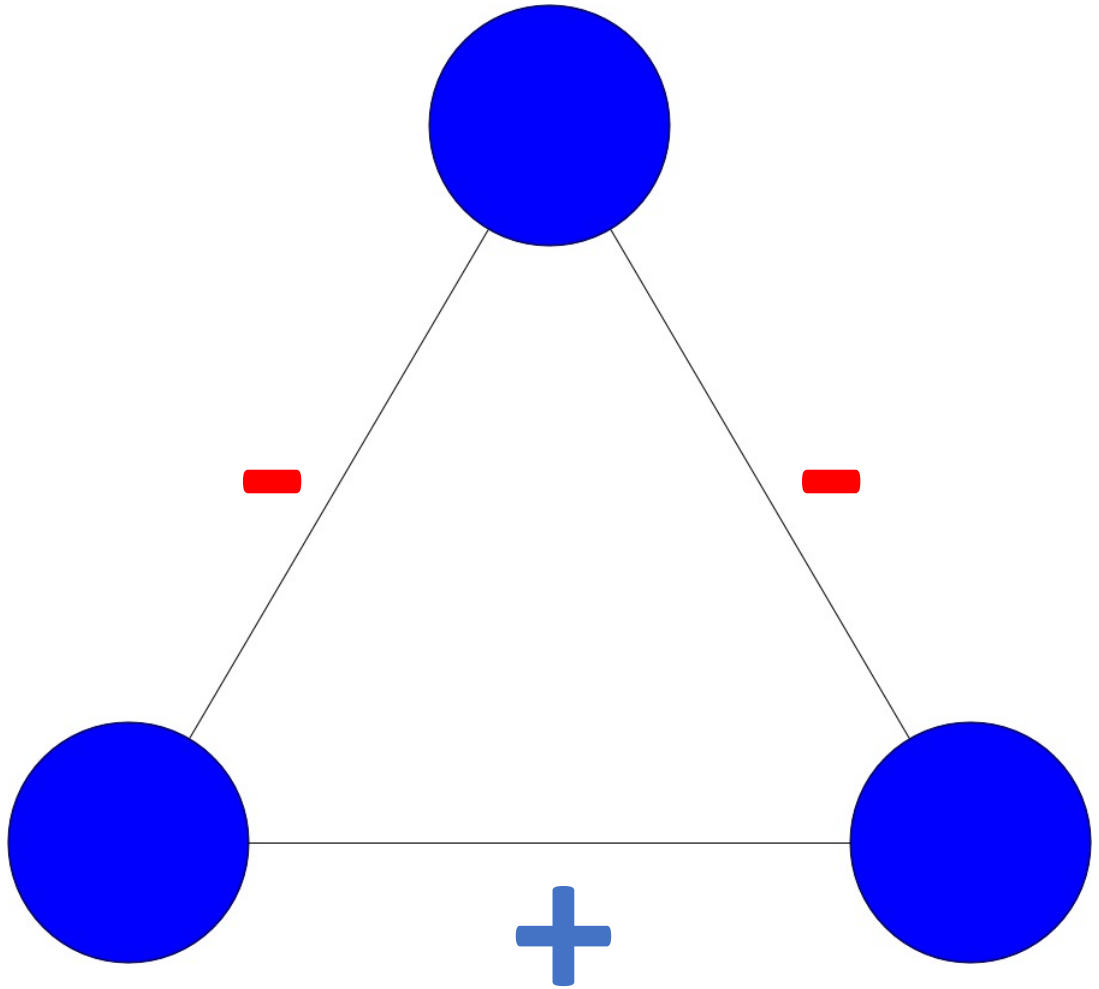
Graph Theory

- Nodes = Individuals
- Edges = Relationship
  - (+) = Friendly
  - (-) = Unfriendly



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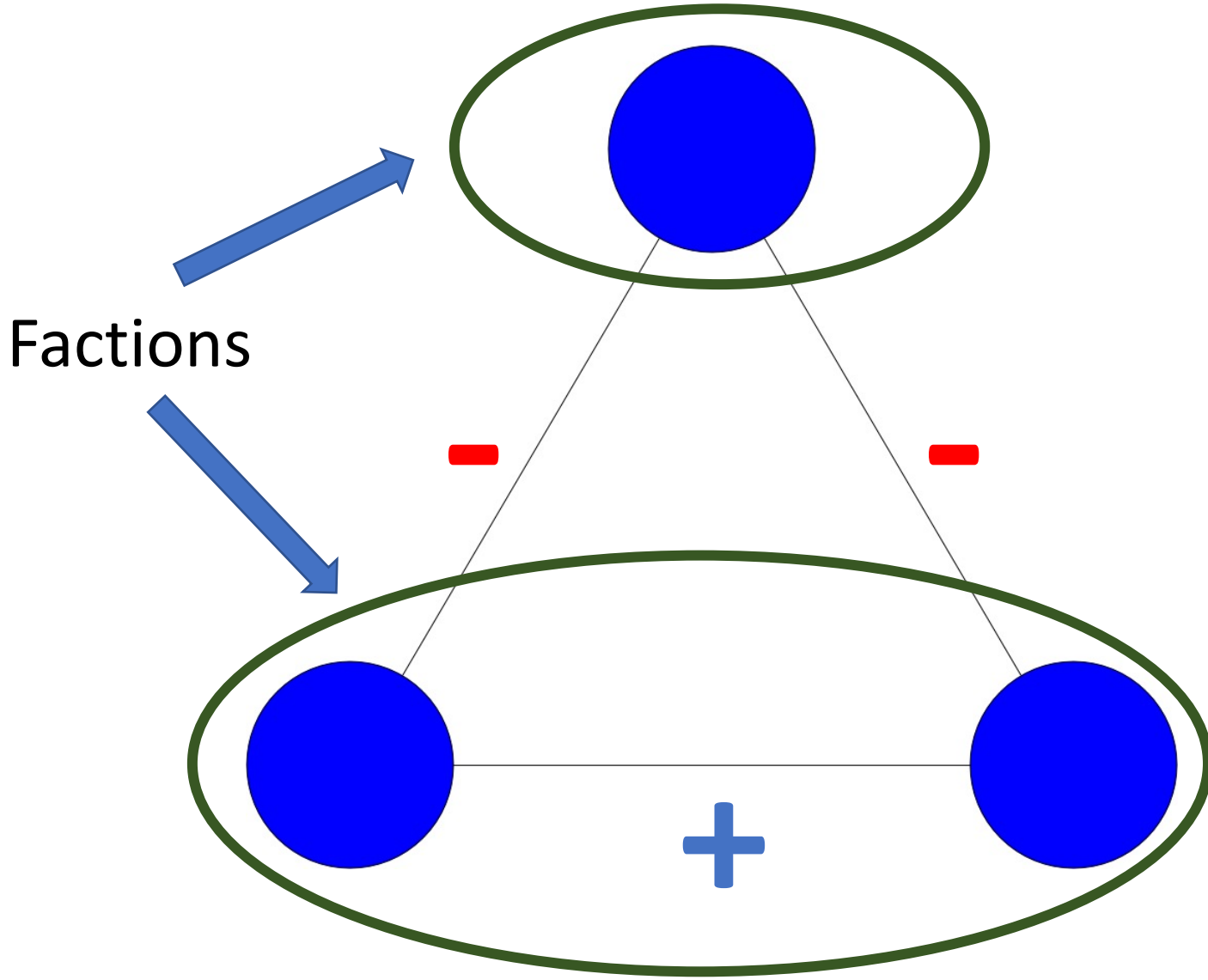
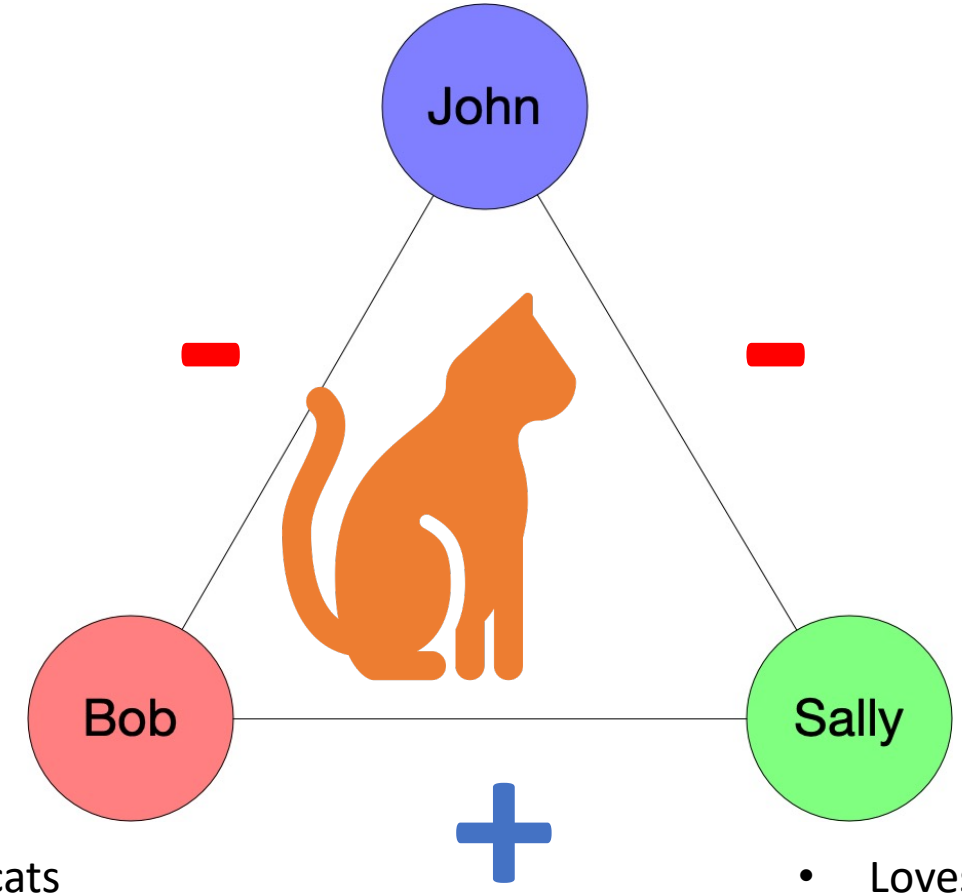


Affine Boomerang Model

x_{person} (t) = person's opinion

a_{person} = person's attachment to their initial opinion

- Hates cats
- Moderate-minded



- Likes cats
- Open-minded

- Loves cats
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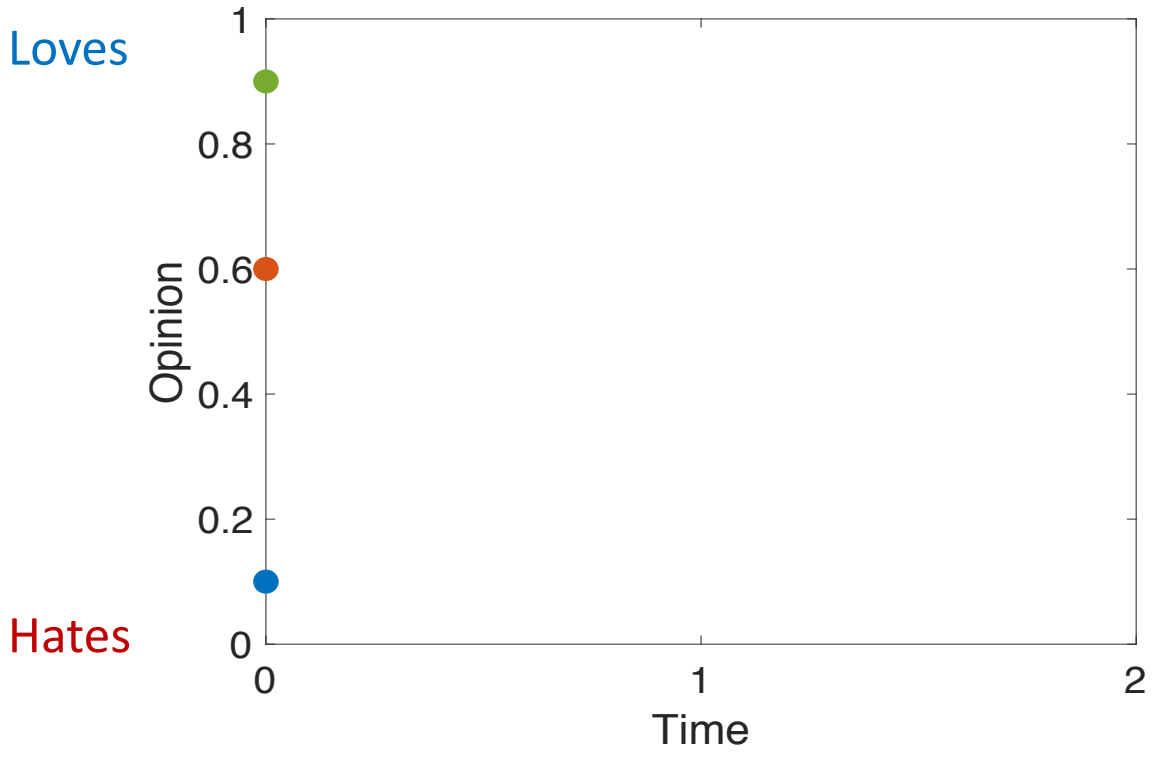

Affine Boomerang Model

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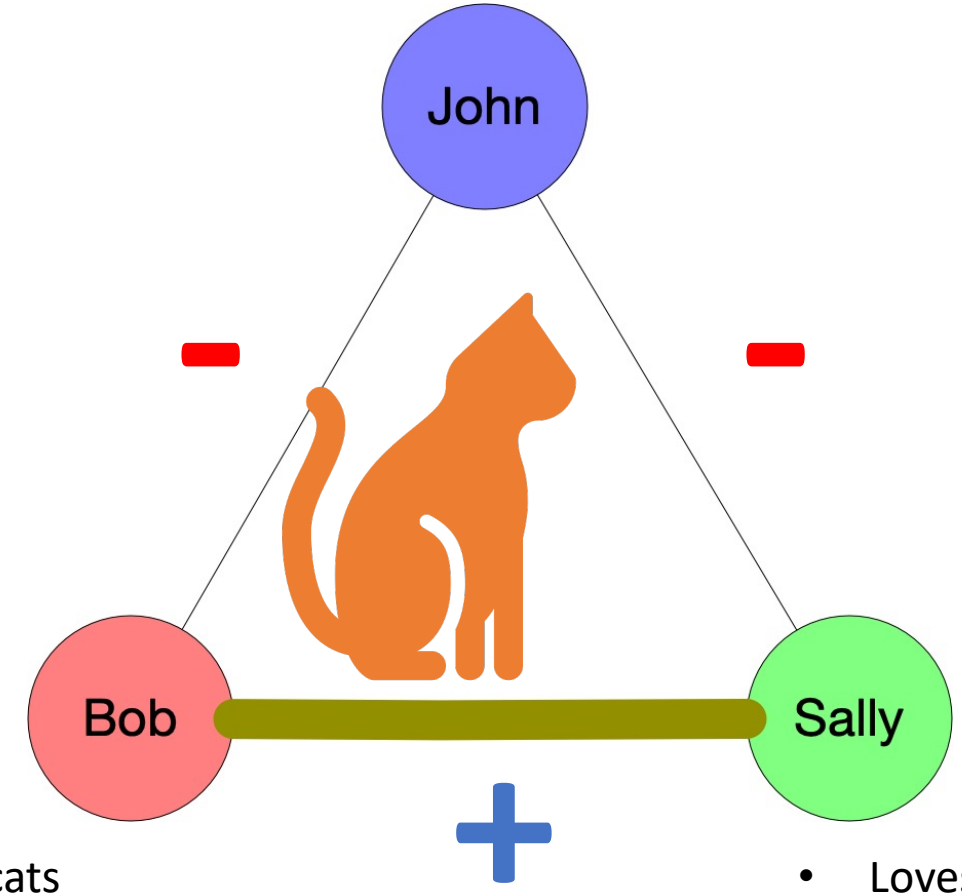
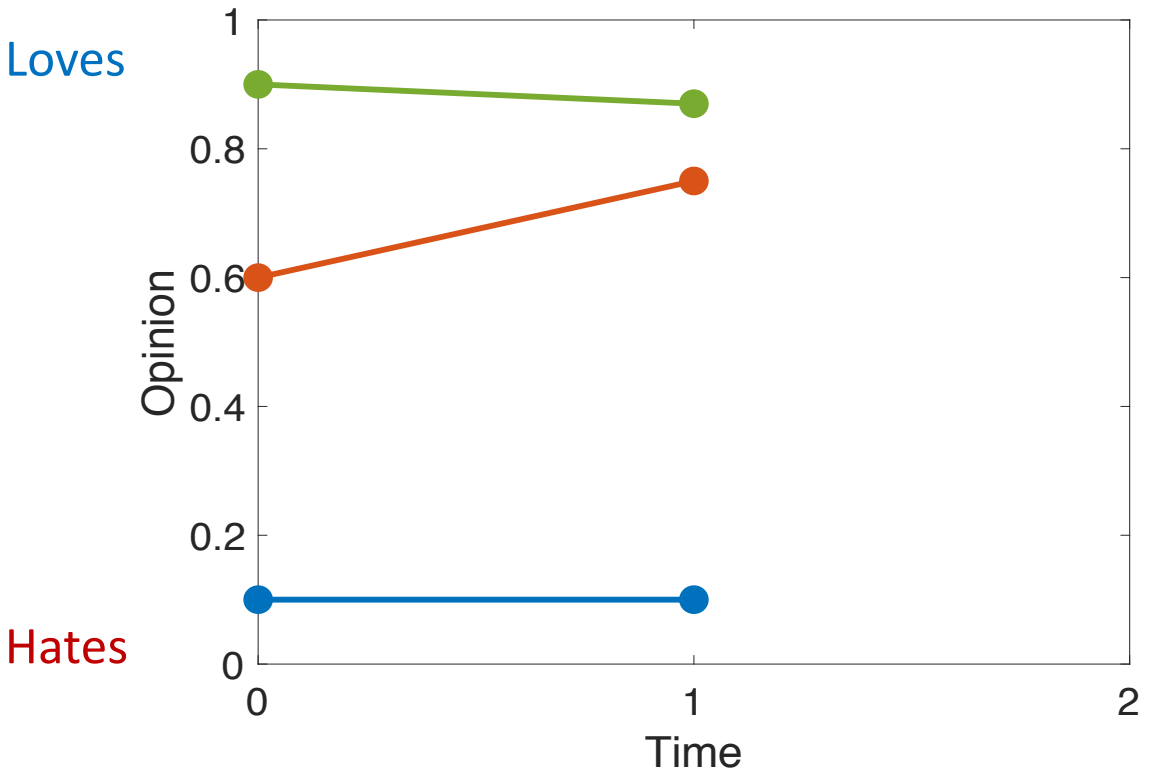
$$x_{\text{Bob}}(1) = a_{\text{Bob}}\, x_{\text{Bob}}(0) + (1 - a_{\text{Bob}})\, x_{\text{Sally}}(0)$$

$$x_{\text{Sally}}(1) = a_{\text{Sally}}\, x_{\text{Sally}}(0) + (1 - a_{\text{Sally}})\, x_{\text{Bob}}(0)$$





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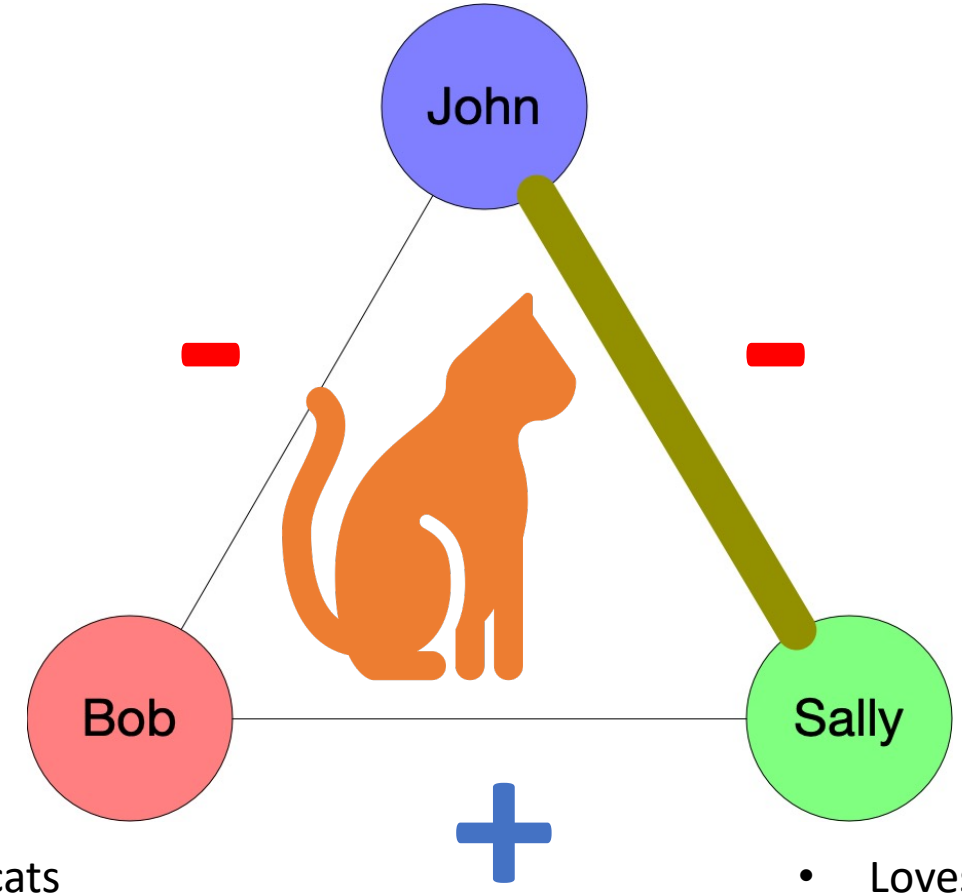
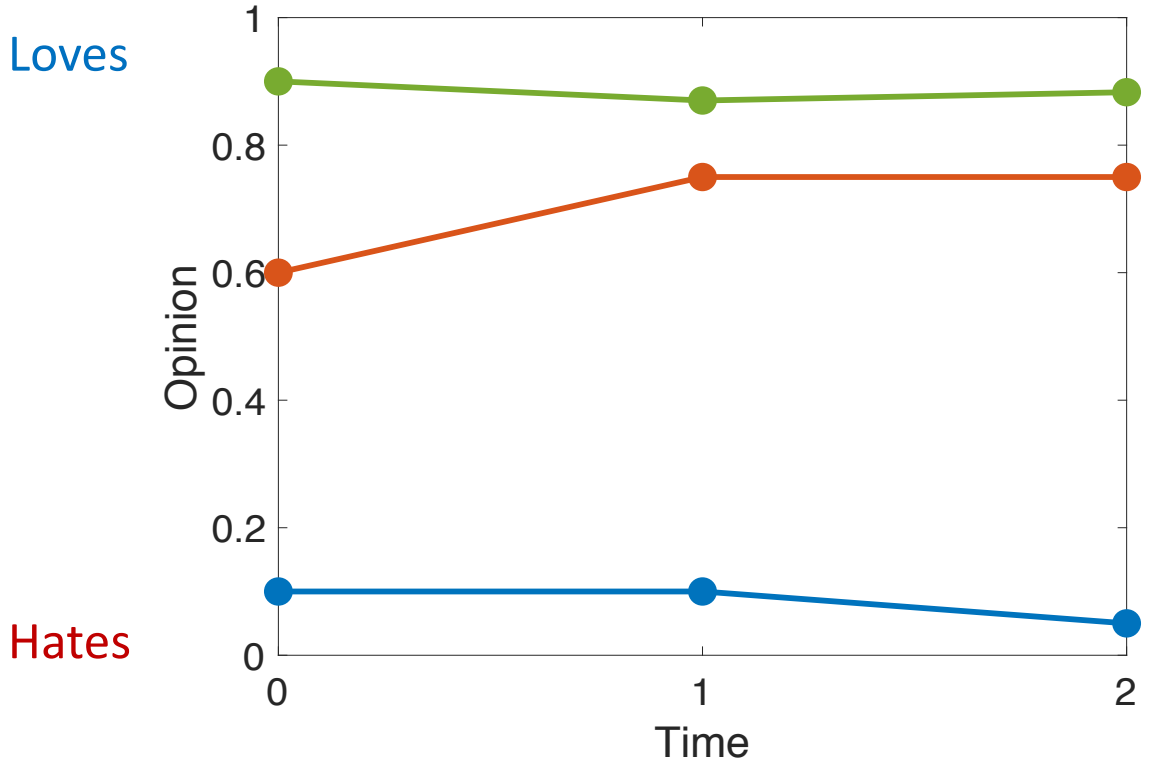
$$x_{\text{John}}(2) = a_{\text{John}}\, x_{\text{John}}(1) + (1 - a_{\text{Bob}})(0)$$

$$x_{\text{Sally}}(2) = a_{\text{Sally}}\, x_{\text{Sally}}(1) + (1 - a_{\text{Sally}})(1)$$





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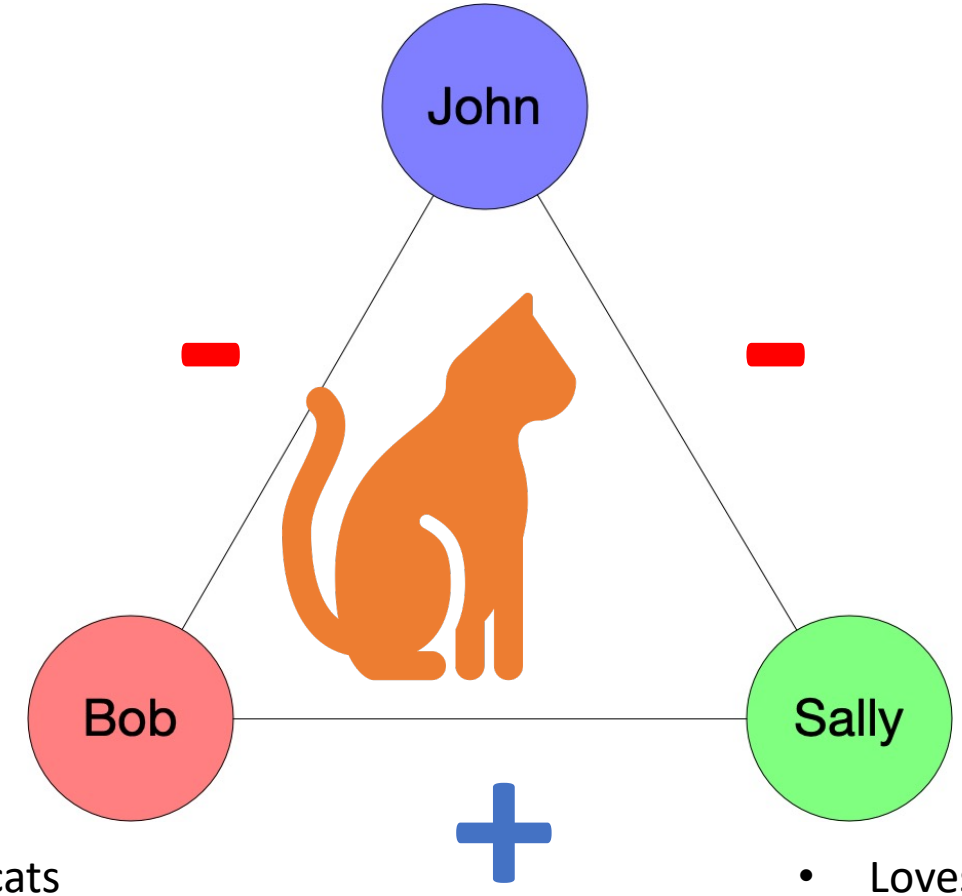

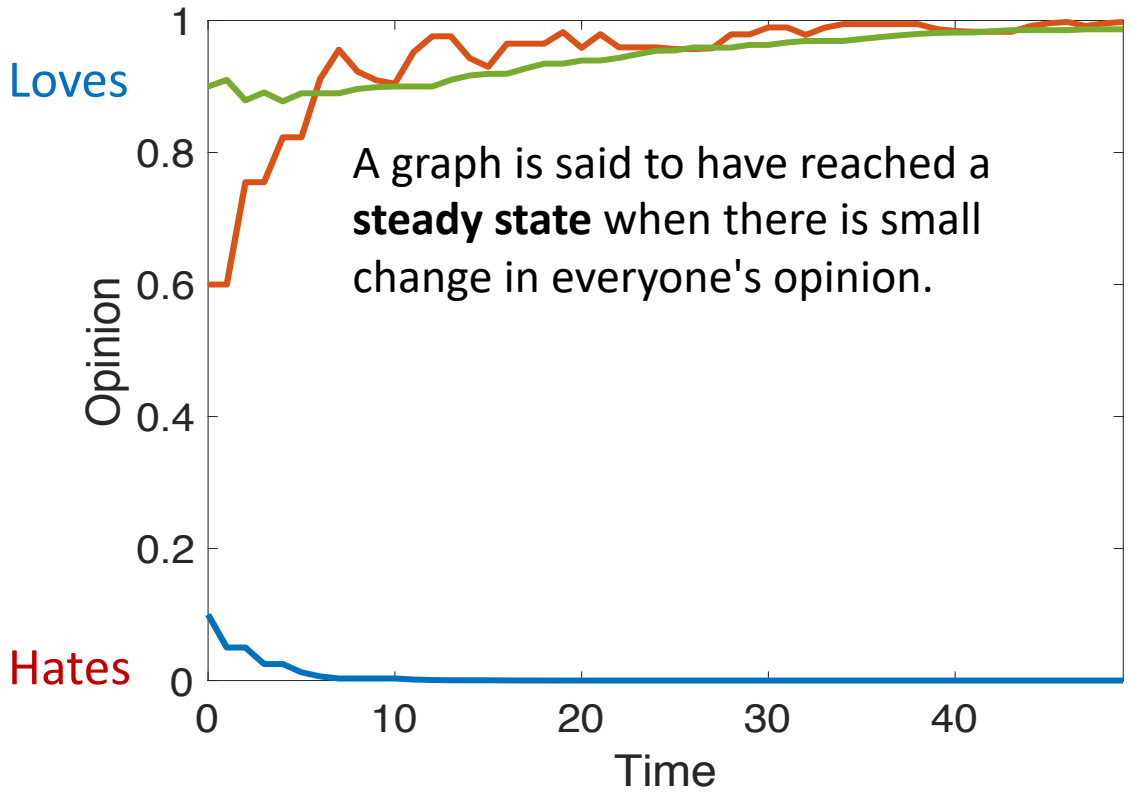

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Underlying Questions

- Which conditions promote polarization?

- If polarization occurs, what factors increase the time individuals reach this complete polarization?

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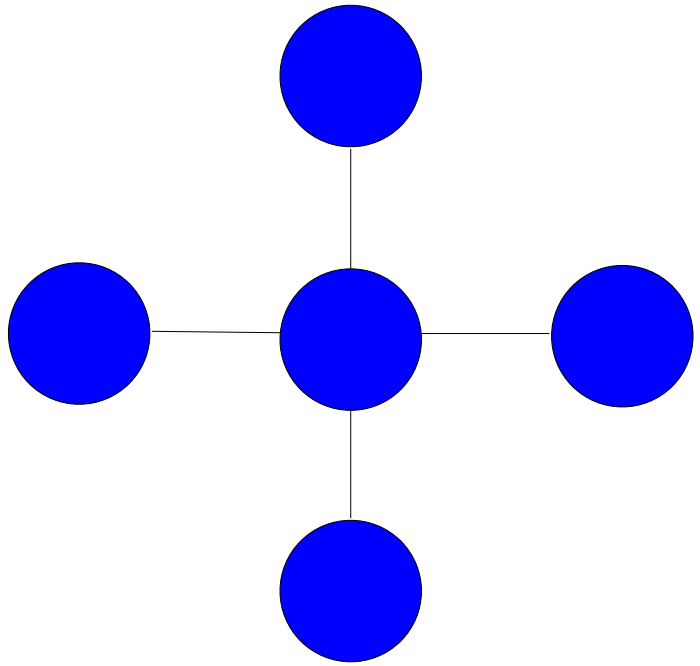
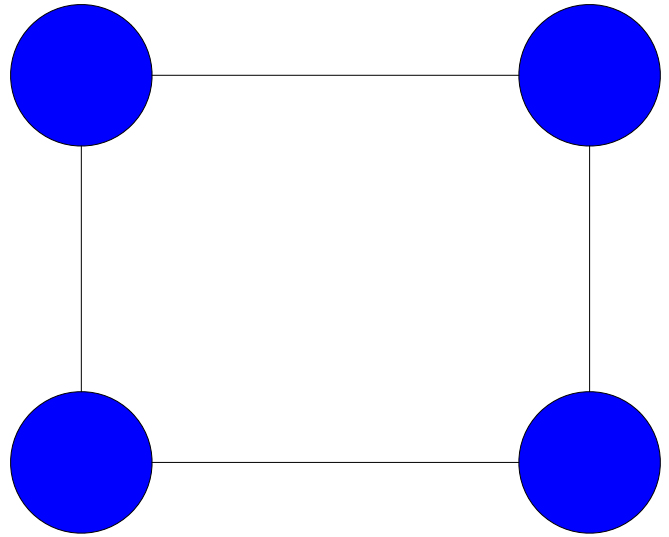
Star Graphs vs. Cycles





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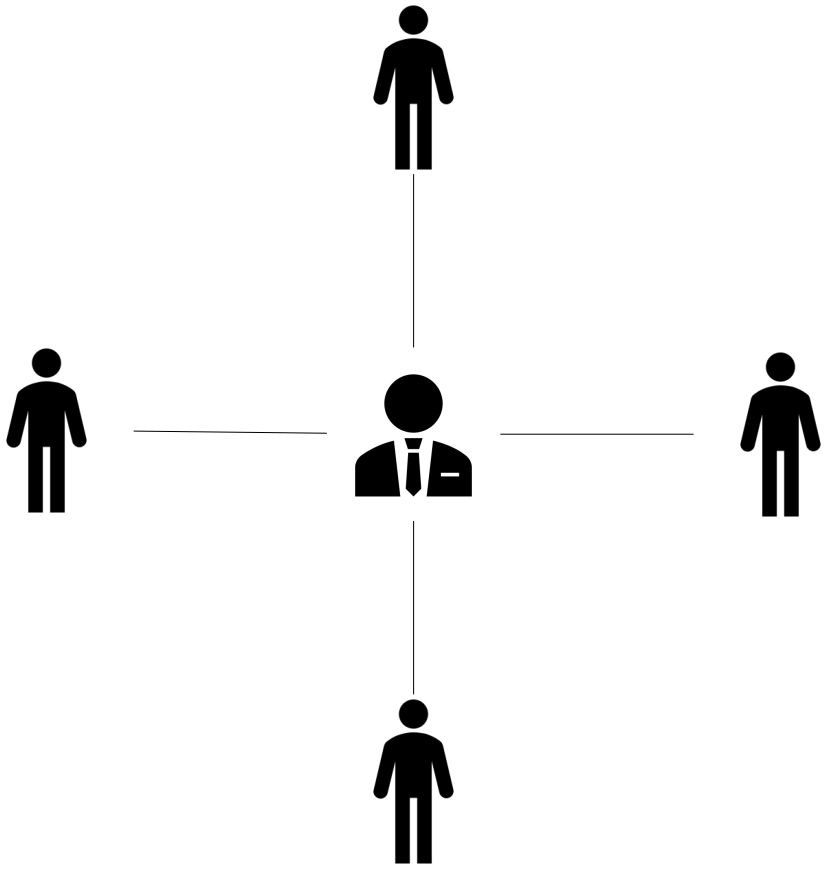

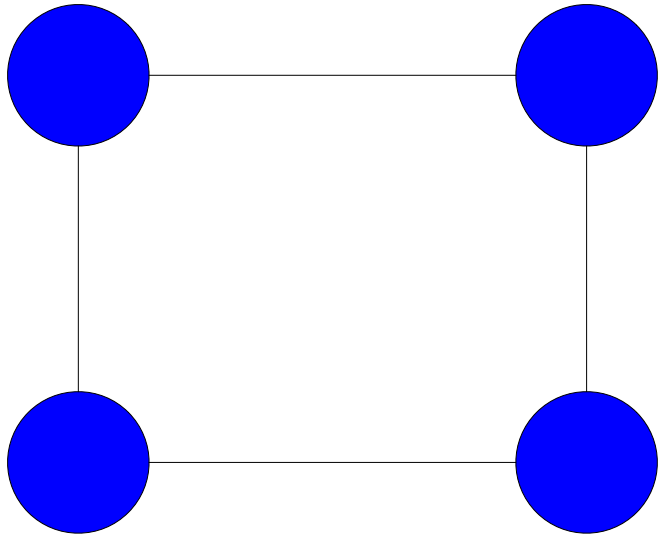

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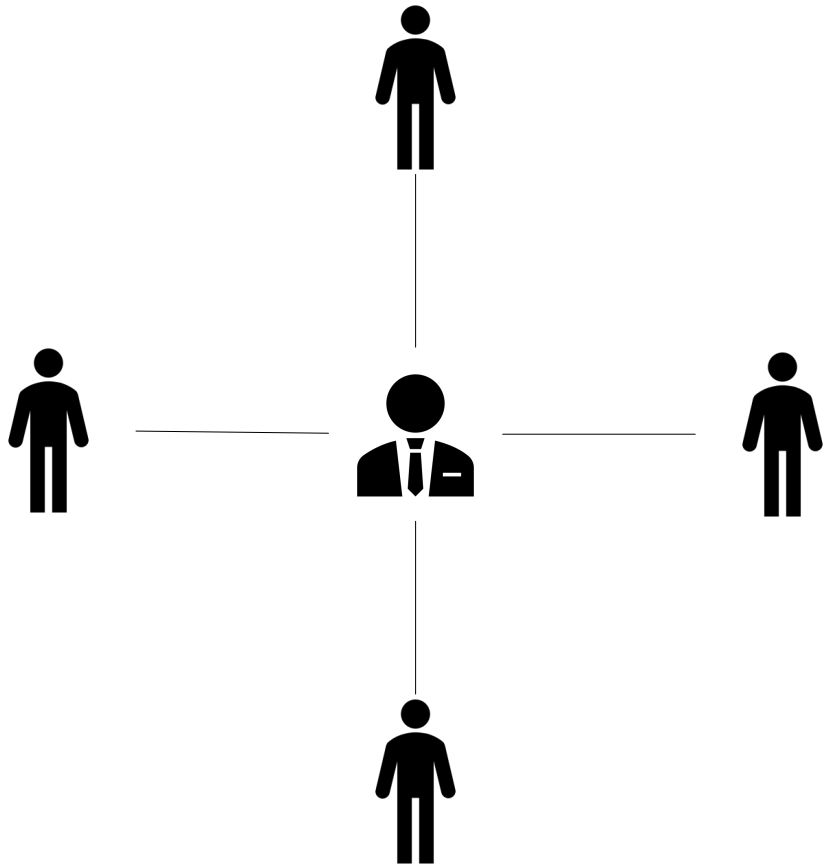
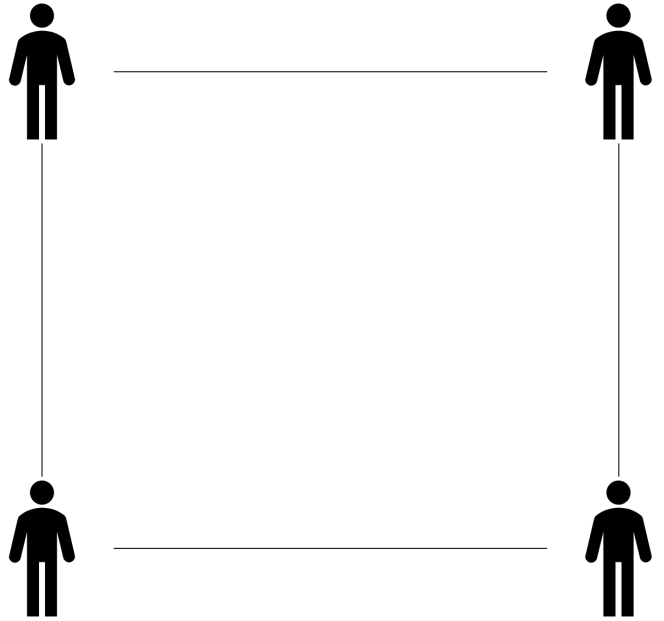
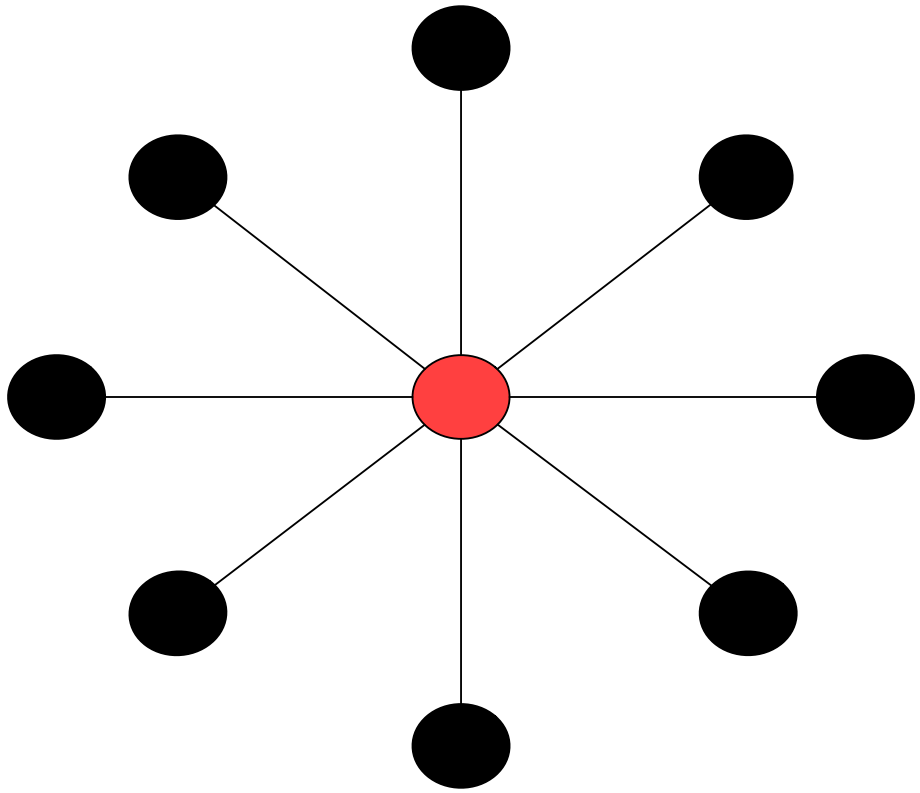


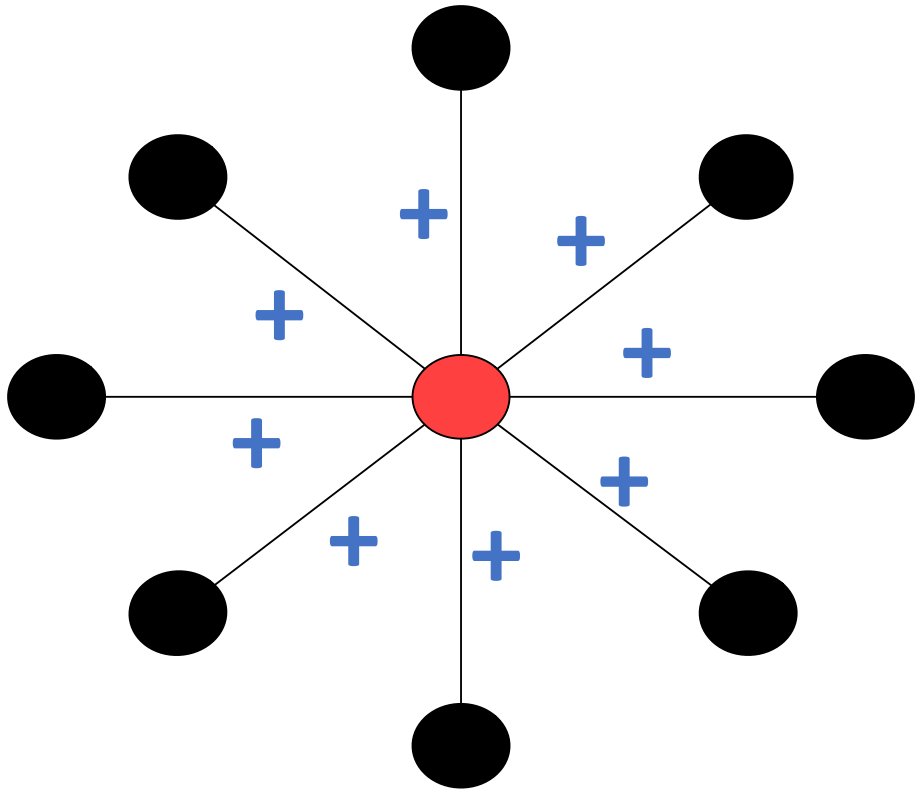


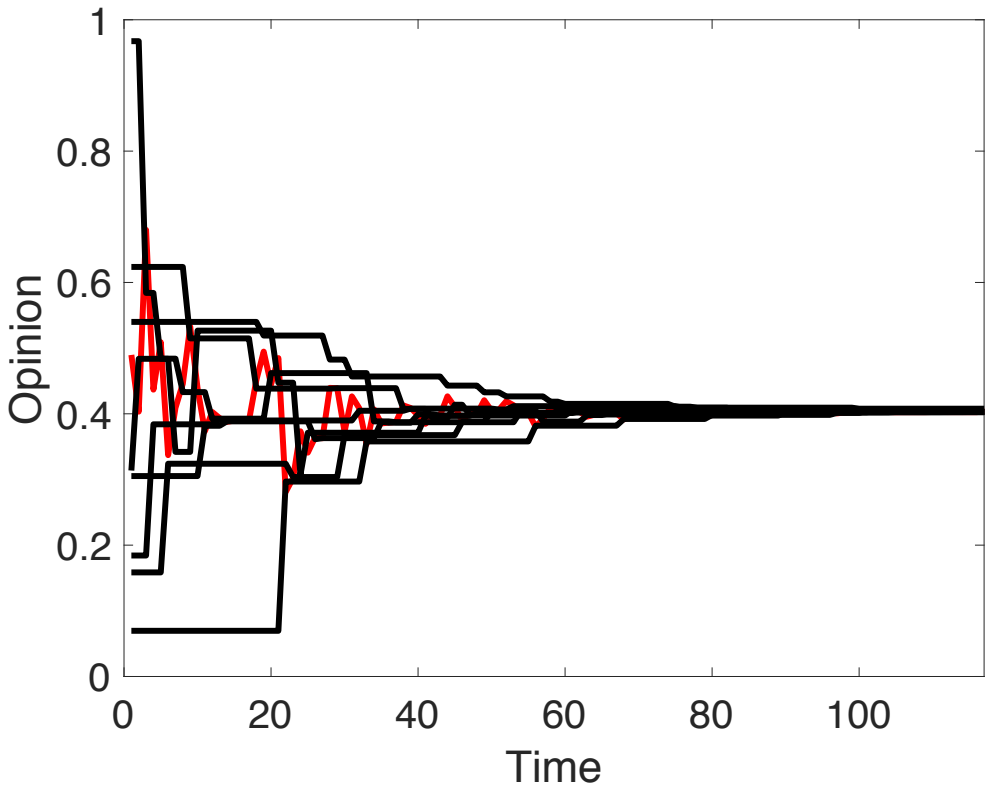
Star Graphs



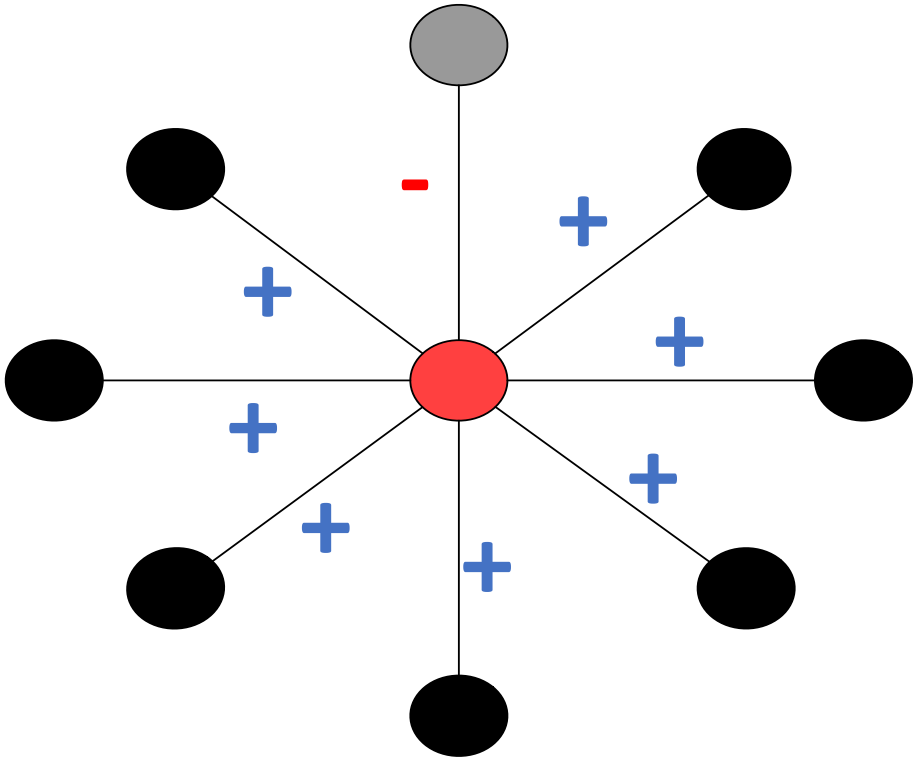
- Everyone is assumed to be moderate minded
- Initial opinions are randomized
- We study the behavior of the opinions as we increase the number of factions

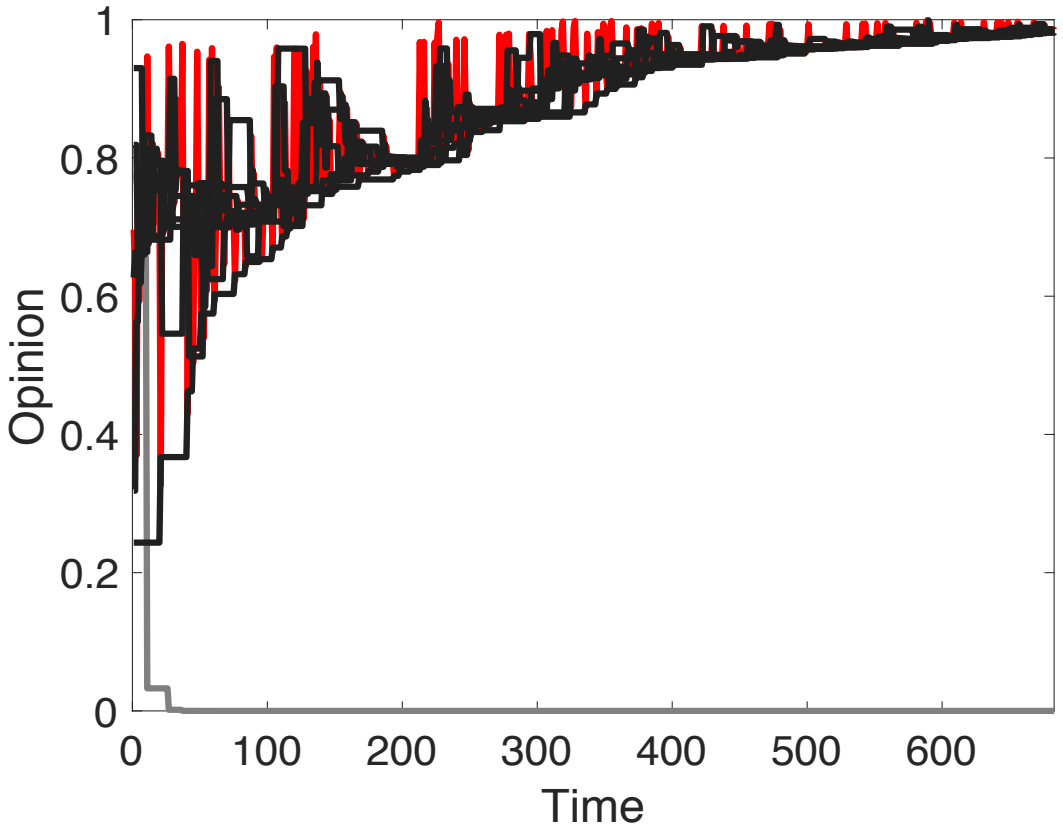
1 Faction Star Graph Comes to Agreement



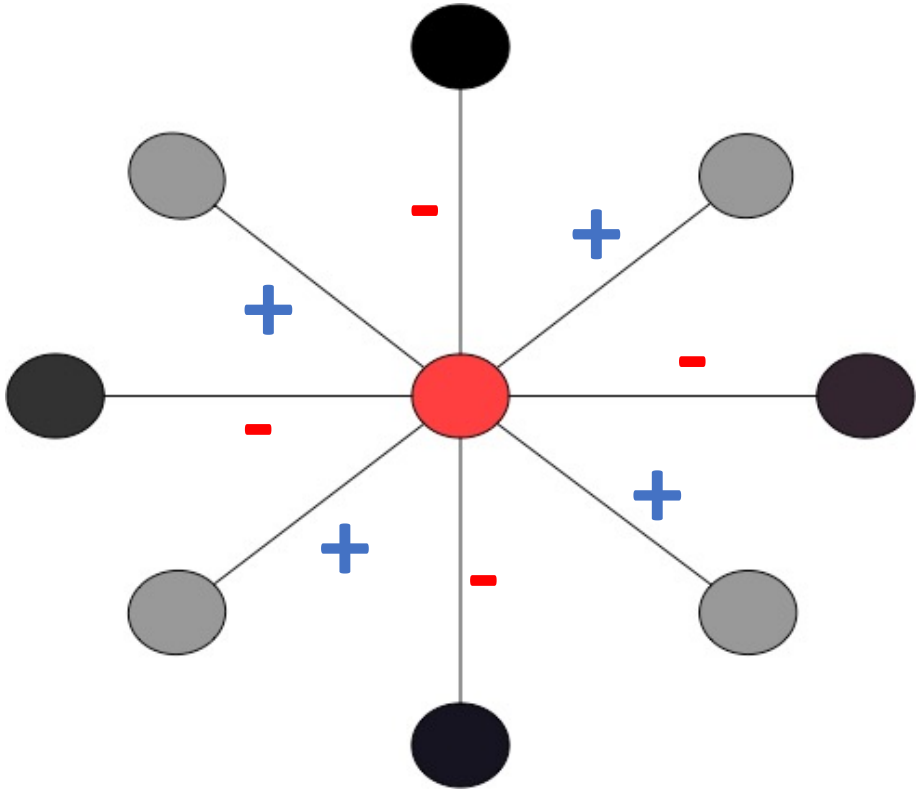


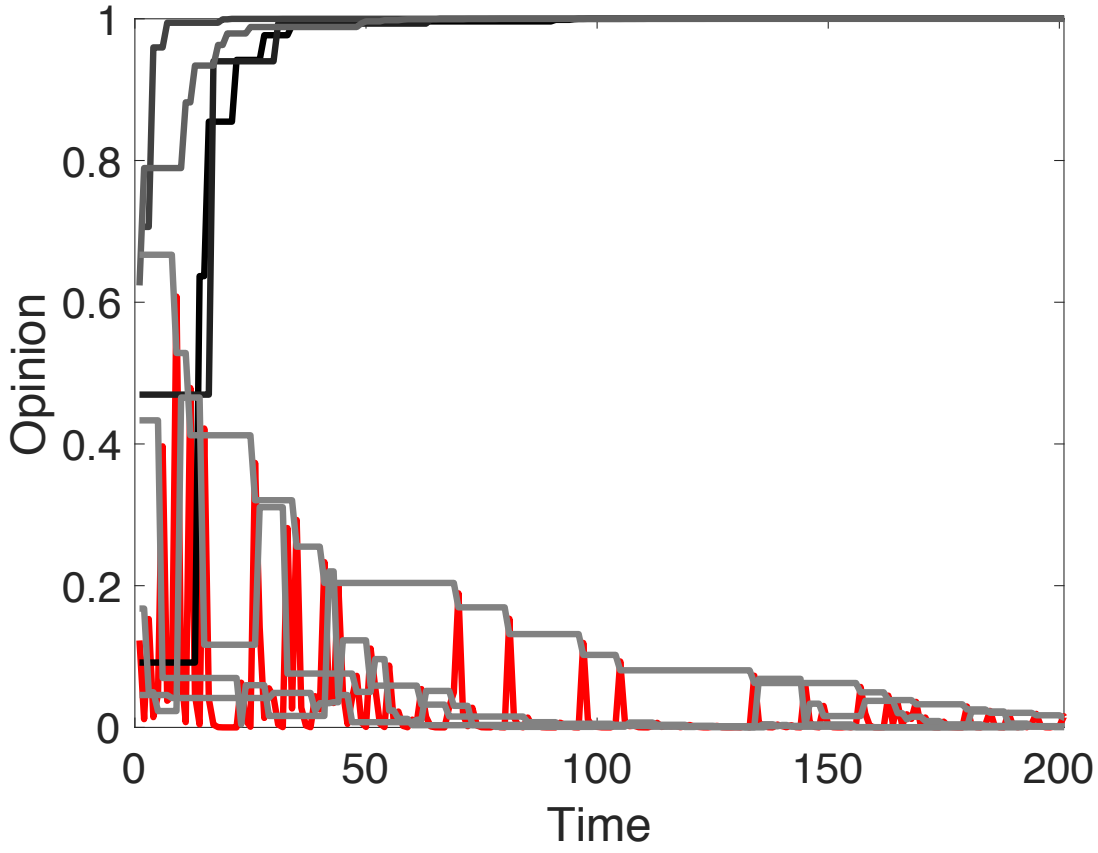
2 Faction Star Graph Polarizes





3 or More Faction Star Graph do not Always Polarize





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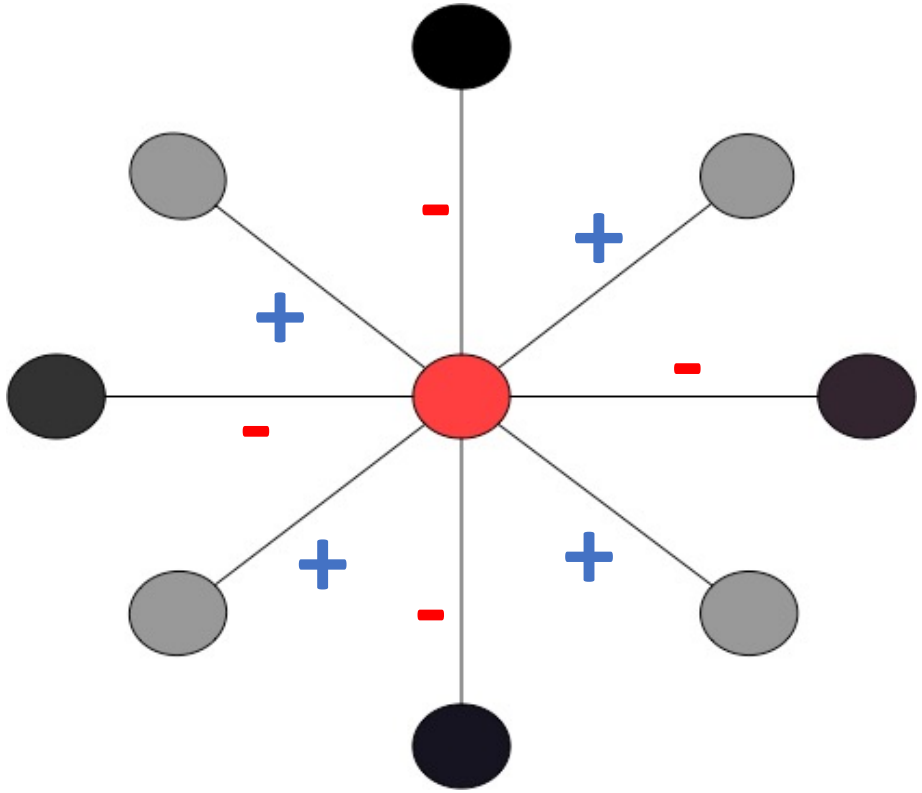
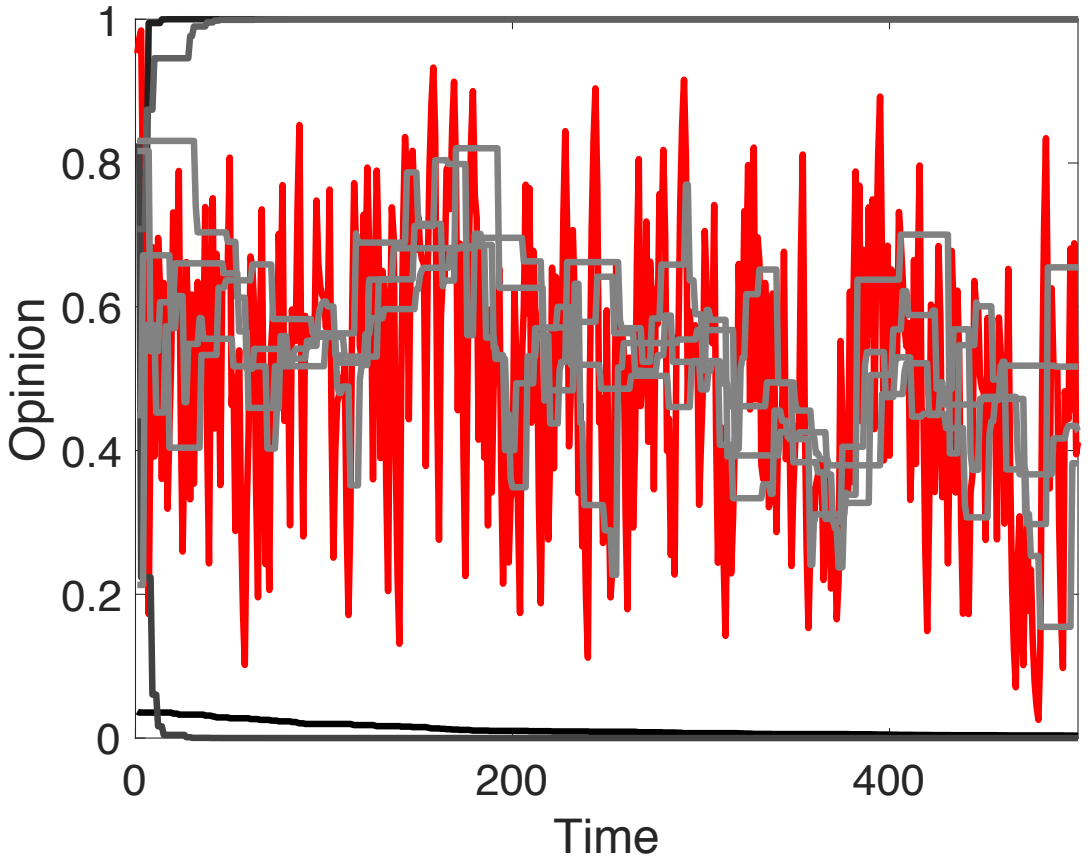
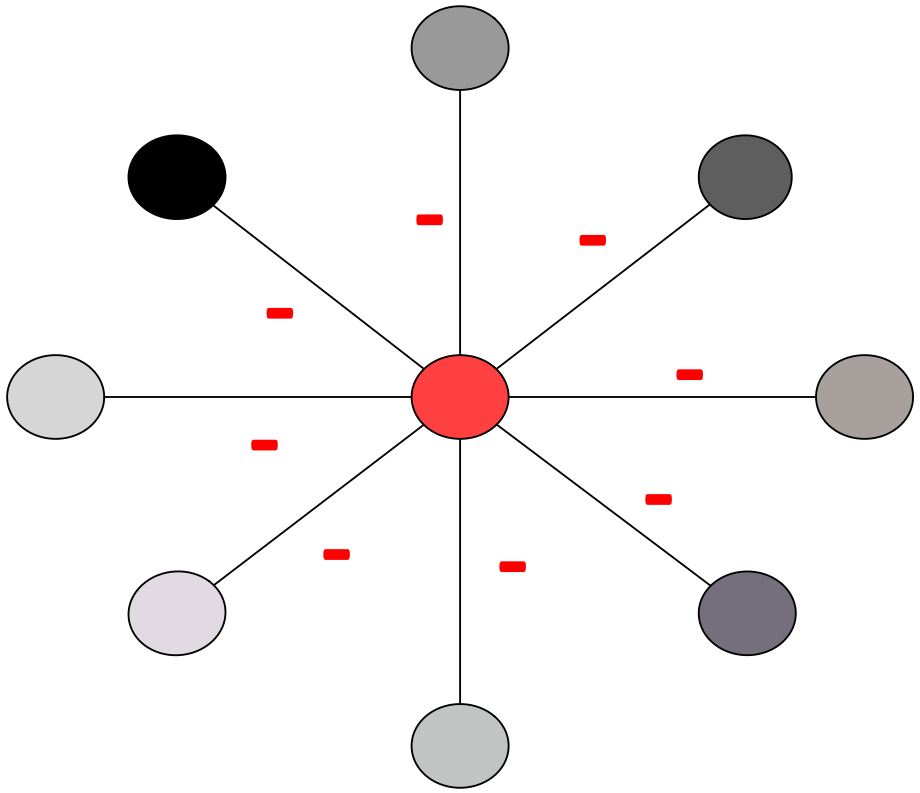
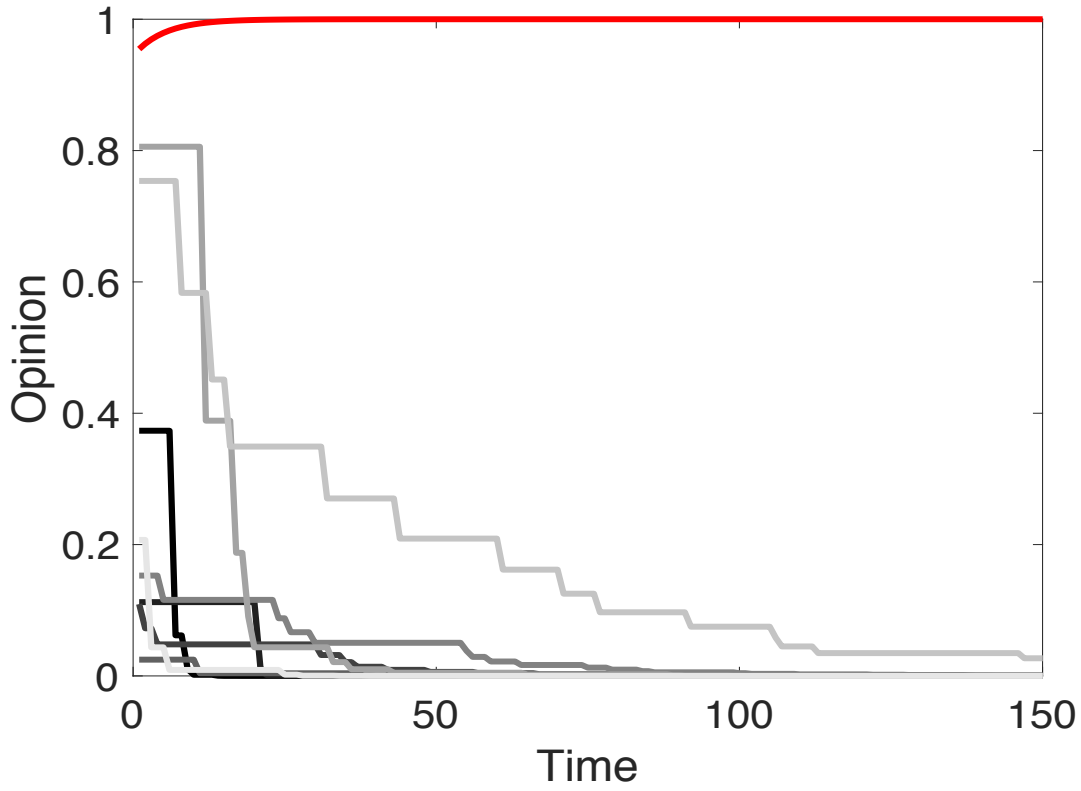




Star Graph where all Relationships are Unfriendly Polarize

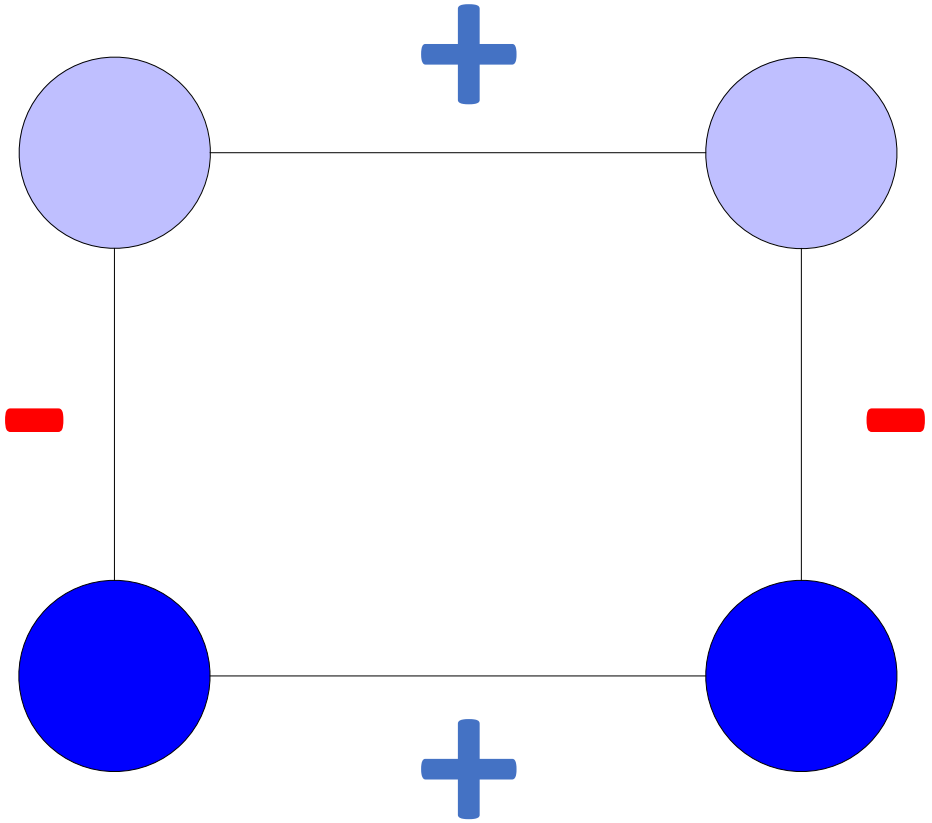


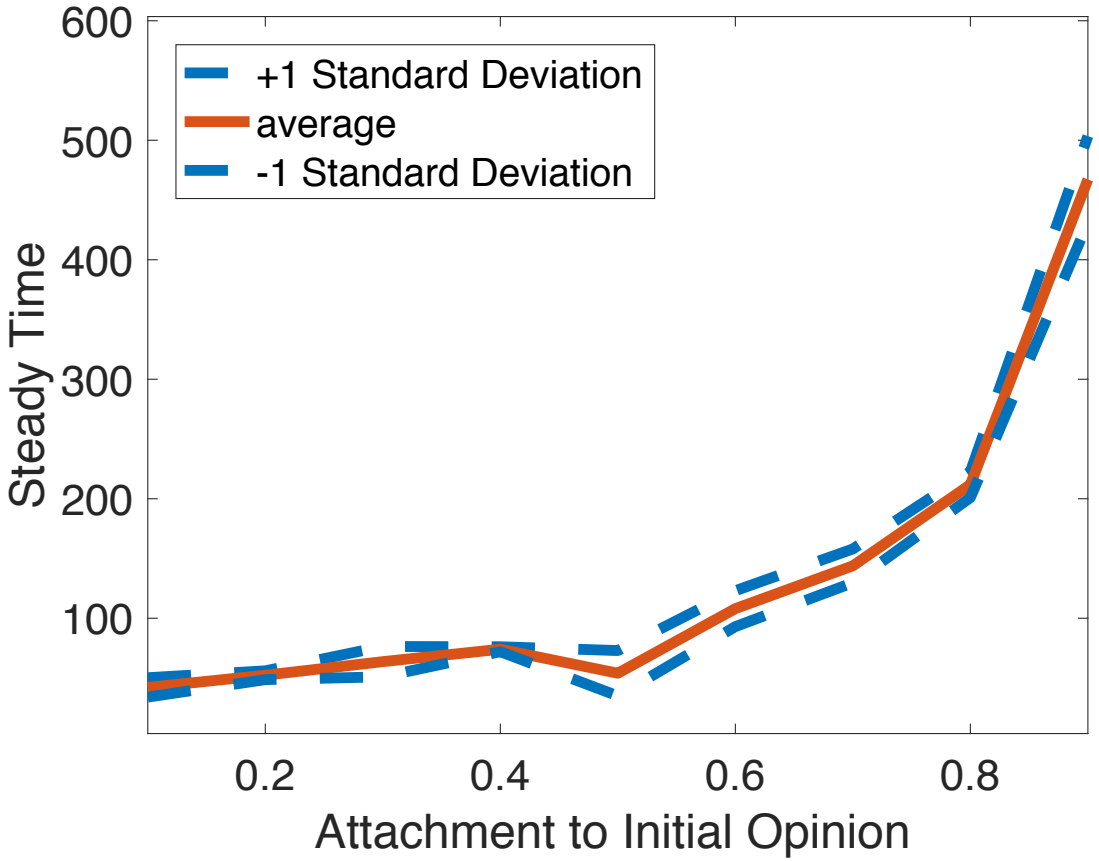


Underlying Questions

- Which conditions promote polarization?
    - The number of factions can influence whether a star graph polarizes.
- If polarization occurs, what factors increase the time individuals reach this complete polarization?

Cycle with Two Factions' Steady State Increases as Attachment Increases





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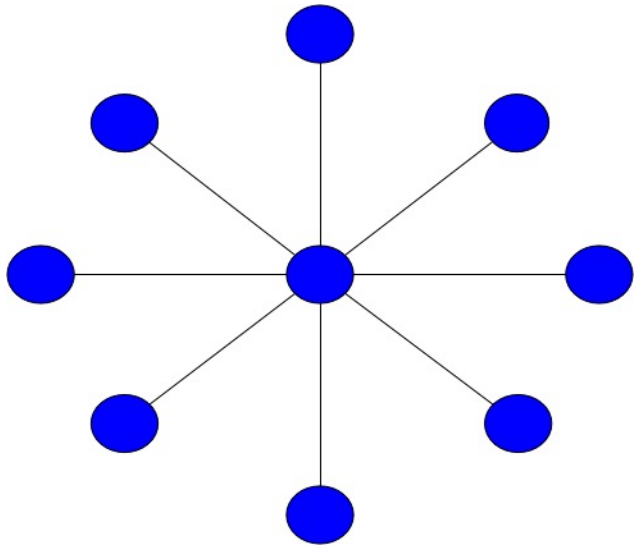
  - The number of factions can influence whether a star graph polarizes.
- If polarization occurs, what factors increase the time individuals reach this complete polarization?
  - The more individuals are attached to their opinion, the longer it takes to polarize.

Future Directions

- Prove my observations and see if they are scalable

- See whether there is a correlation with the number of factions and the probability of a star graph polarizing



Acknowledgements

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- **Elizabeth Y. Huang**
- **Pedro Velarde**
- **EUREKA! and the CSEP family**

References

[1] P.C. Velarde, K.S. Chan, F. Bullo. Polarization and fluctuations in signed social networks, 2019.

[2] C. Altafini. Consensus problems on networks with antagonistic interactions. *IEEE Transactions on Automatic Control,* 58(4):935-946:2013.

[3] D. Acemoglu, G. Como, F. Fagnani, A. Ozdaglar. Opinion fluctuations and disagreement in social networks. *Mathematics of Operations Research.*

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