Social Contagion and Associative Diffusion in Multilayer Network

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Investigating culture evolution using computer simulation.

- Cultural evolution: how culture emerges, change, and be shaped temporally
  - Often studied in sociology, anthropology, cultural studies, evolutionary biology, evolutionary game theory
- Computer simulation: use computer to experiment *in silico*
  - Can manipulate variables and conditions at will
  - Study causal explanation

The Sociology of Culture

- Culture: a system of shared understanding (Goldberg and Stein 2018)
- A common focus is on institutions.
  - Religion, education, mass media ...
- This work will focus on the individuals and their interactions
  - Can be traced back to as early as De Tarde (1903).

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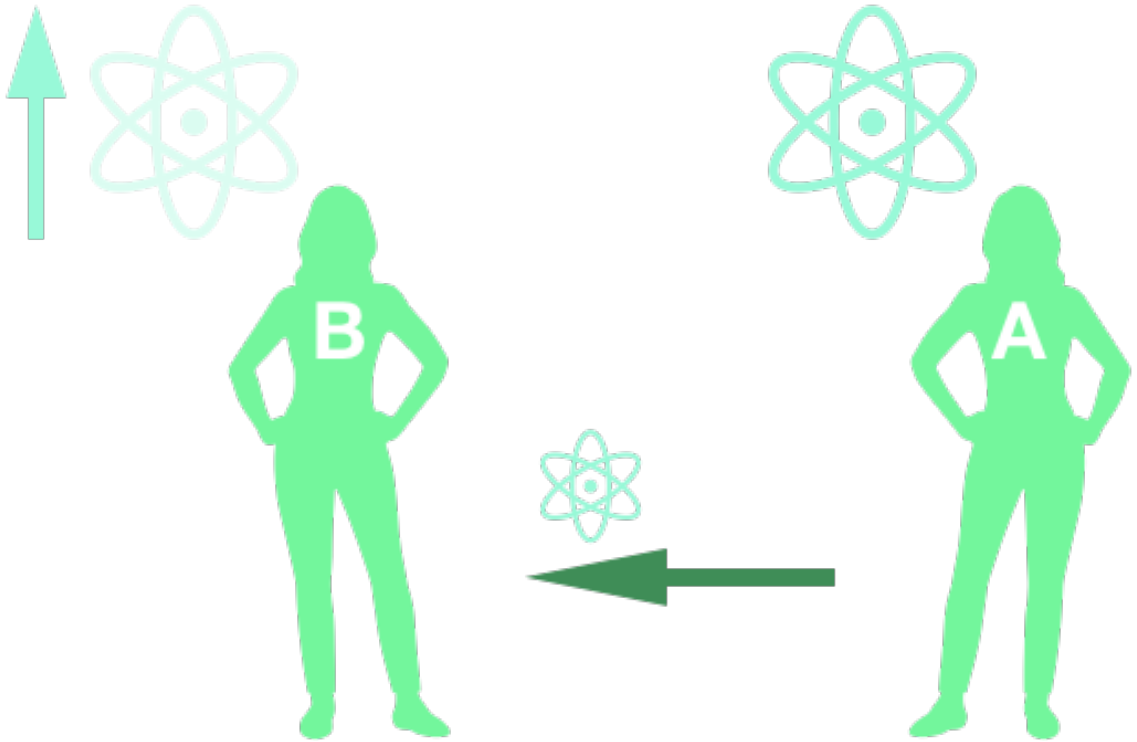
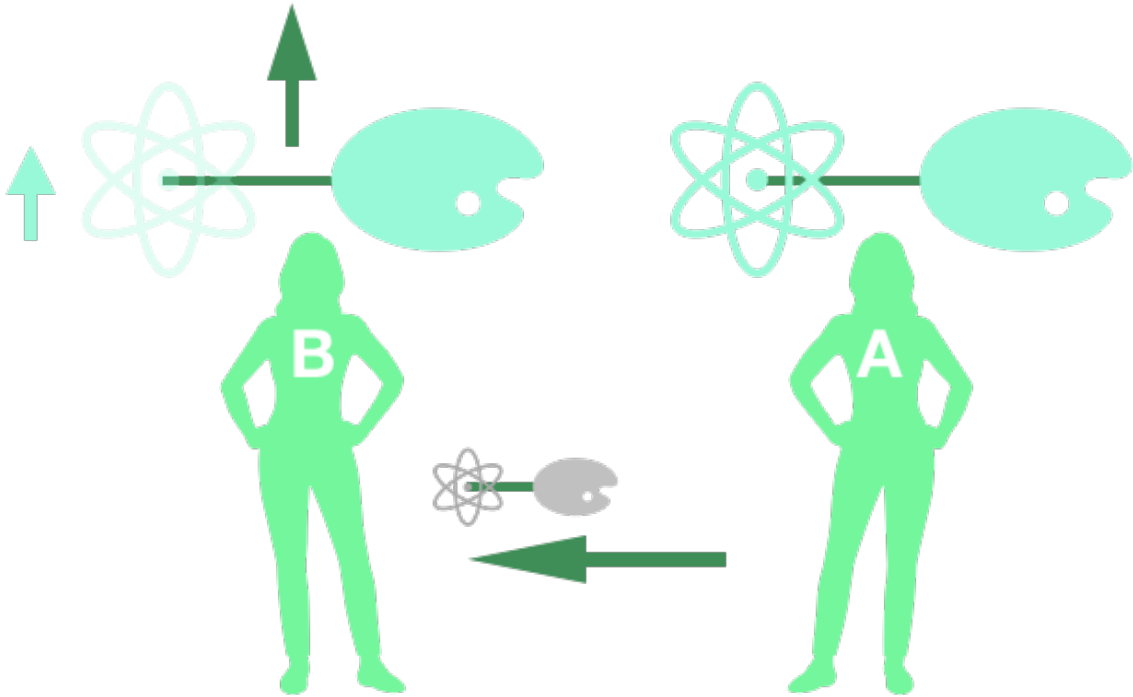
The Social Contagion Models



- Ideas, opinions, and behaviors spread like pathogens.
- The spread relies on strong and enduring relationship (e.g. friendship).
- Implicitly, the preferences toward certain cultural practices/ objects/ behaviors are transmitted.
- Cultural variation is epiphenomenal to the pre-existing social structure (Goldberg and Stein 2018).

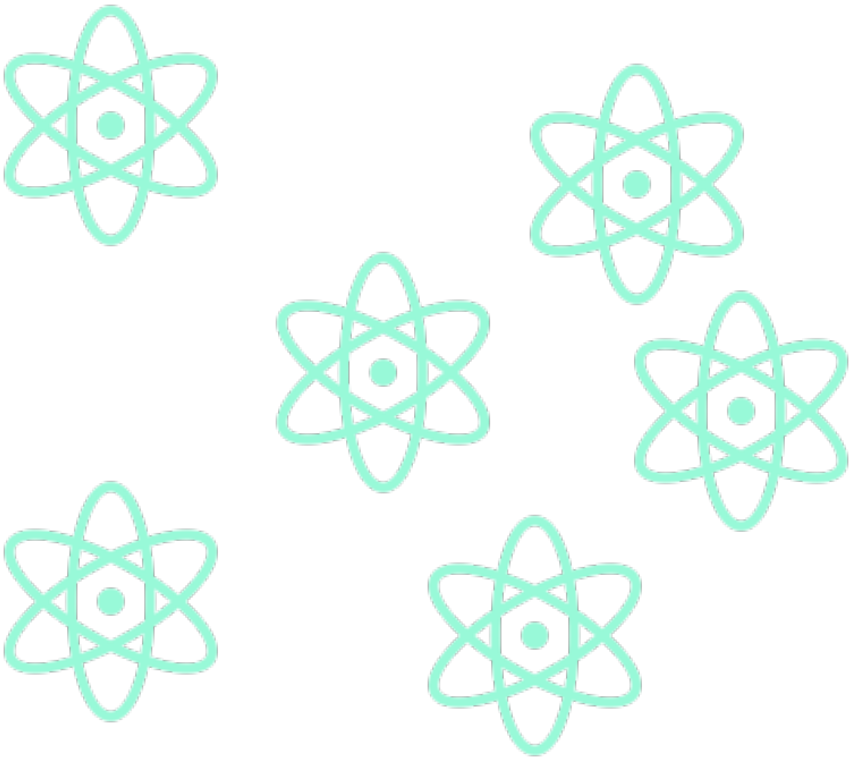
The Associative Diffusion (Goldberg and Stein 2018)

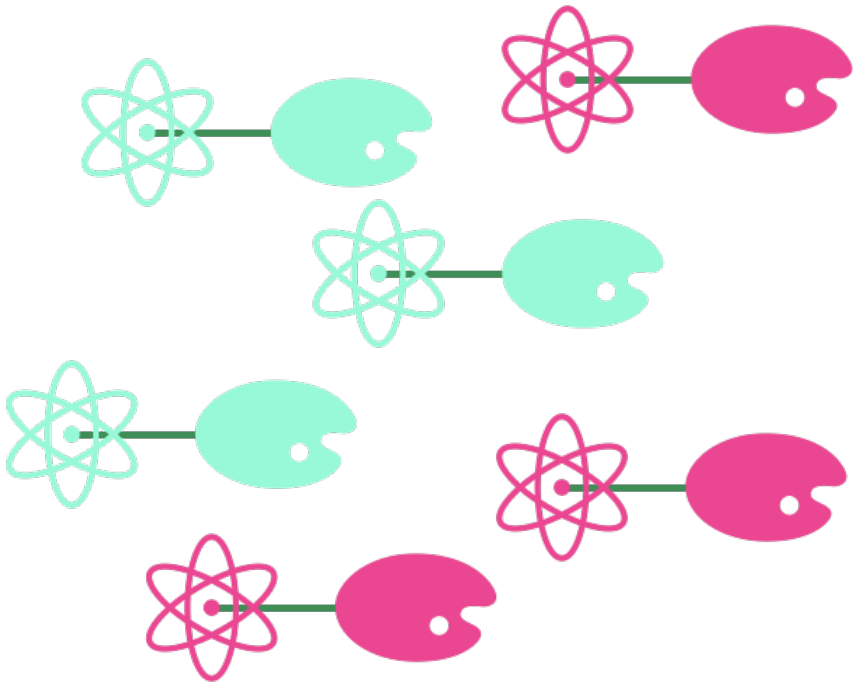


- Instead of the preference, the association is transmitted.
- The diffusion needs on superficial interaction.
- Individuals adapt their preference to stay consistent with the perceived association (solving cognitive dissonance).
- Cultural segregation emerges even with no constraint on communication.

Comparison

- Transmitted: preference vs. association
- Medium: strong and enduring relationship vs. superficial interaction
- Resulting dynamics: all-or-none vs. segregation





A "Centrist" Path?

- Both types of relationship/ interaction exist most of the time.
- What if both kinds of dynamics function simultaneously in a given population?

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The Multilayer Network Framework

- Networks with multiple "layers"
  - Friends, passerby, ...
- In our model
  - One layer for superficial interaction (e.g. between passerby)
  - Another layer for the interaction exist only in strong and trustful relationship (e.g. between friends)

Modeling

- In each rounds,
  - With probability $1 - \alpha$, a pair of agents transmit the association;
  - with probability α, a pair of agents transmit the preferences.
- After transmission, agents will update their association/ preference to stay consistent.

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Results on Duplicated Networks

Preference Similarity

The preference similarity is defined as $\text{Average}_{\forall A \neq B} \rho(\boldsymbol{V}_A, \boldsymbol{V}_B)$

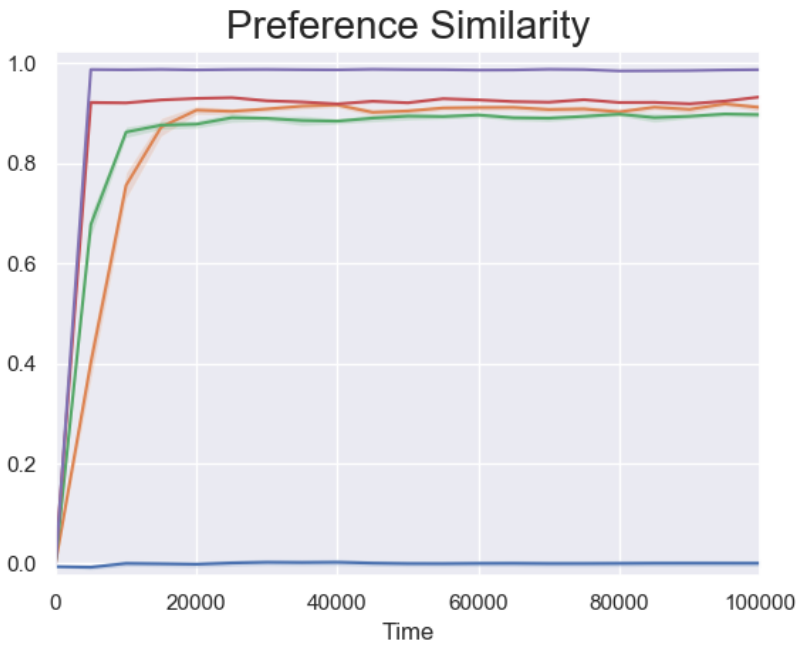


Figure: Fully-connected Networks

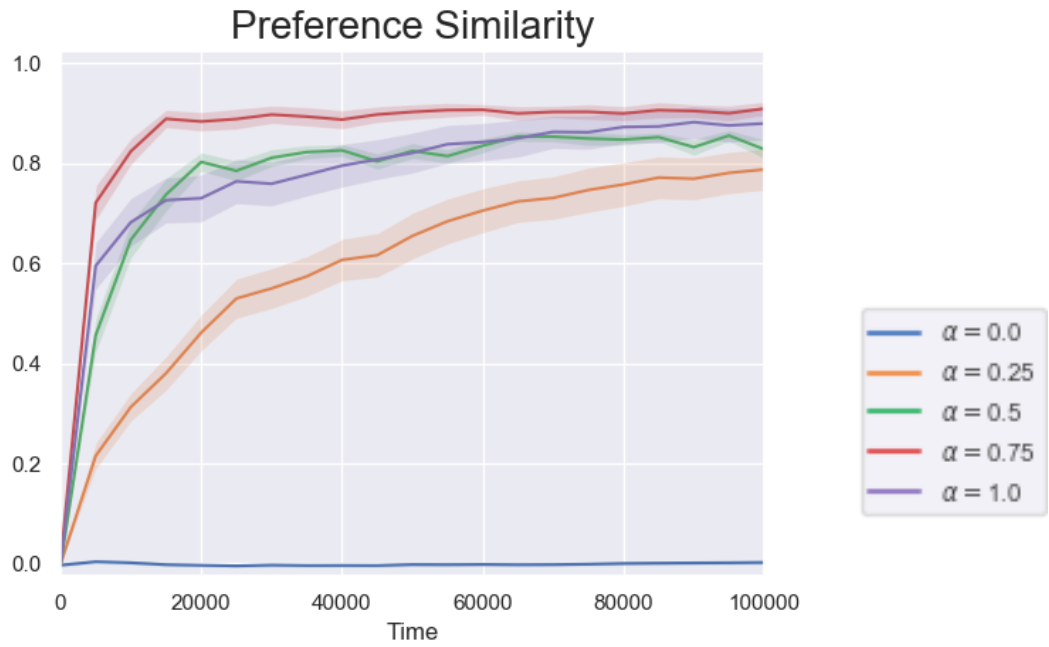
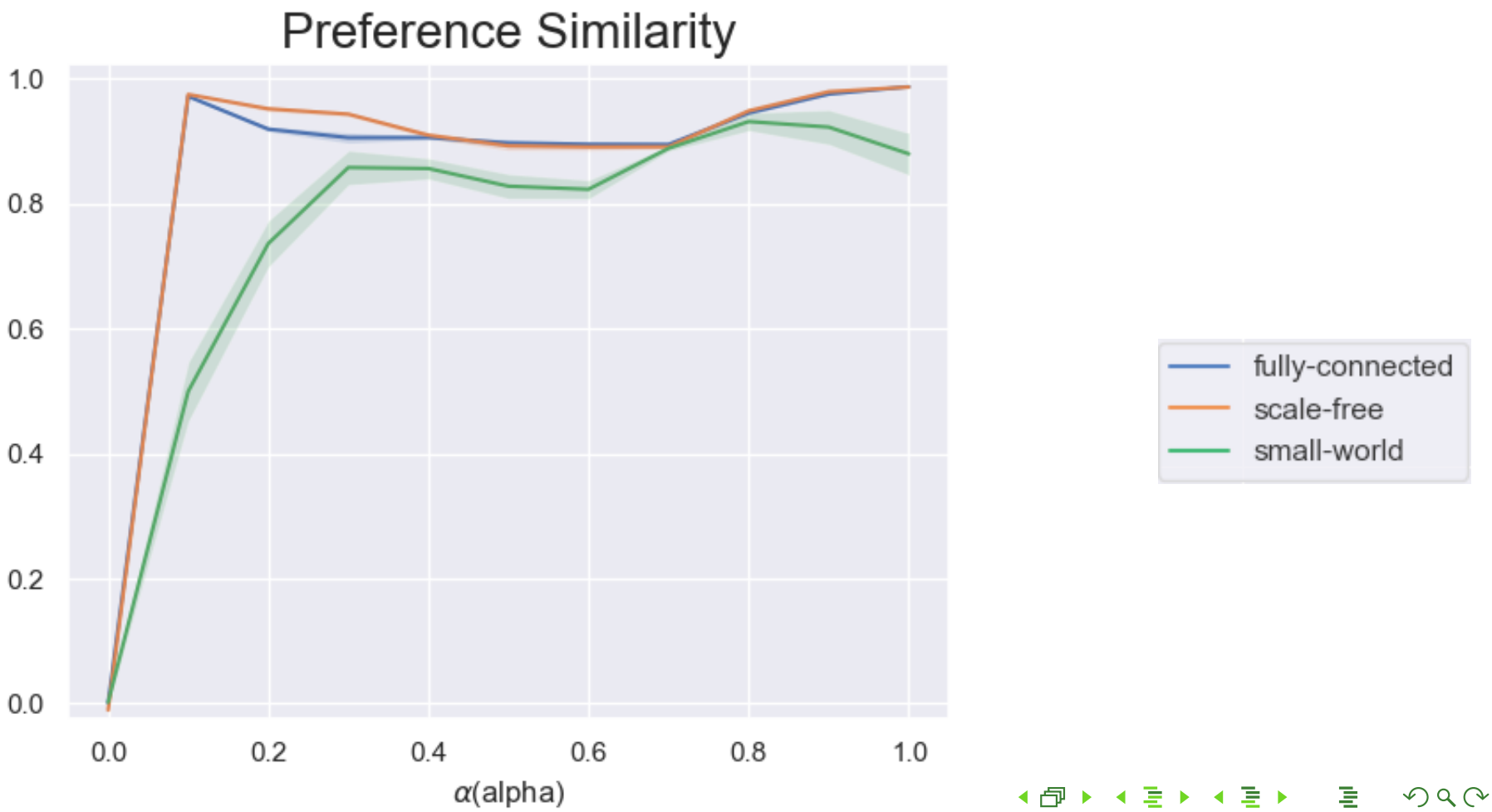


Figure: Small-world Networks

Results on Duplicated Networks

Preference Similarity

The preference similarity is defined as $\mathrm{Average}_{\forall A \neq B} \rho(\boldsymbol{V}_A, \boldsymbol{V}_B)$



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Future Work

- Number of clusters as indicator of cultural variation
- Dynamics of different composition of layers
  - Independent and identical processes to generate layers
  - Different processes to generate layers
  - Correlated processes to generate layers

Conclusion

- We devise a model to combine social contagion and associative diffusion in multilayer setting.
- Preliminary results show nontrivial dynamics between the two extremes.
  - The combination of two models can speed up the preference spread in small-world networks.
  - Can serve as guidelines in call for socio-political change
- We hope this work can encourage more sociology practitioner to embrace the use of computer simulation.

Reference I

De Tarde, Gabriel. 1903. *The laws of imitation.* H. Holt.

Goldberg, Amir, and Sarah K Stein. 2018. "Beyond social contagion: Associative diffusion and the emergence of cultural variation." *American Sociological Review* 83 (5): 897–932.

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