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Role of time scales in coupled epidemic-opinion dynamics on multiplex networks

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Motivations and main objectives

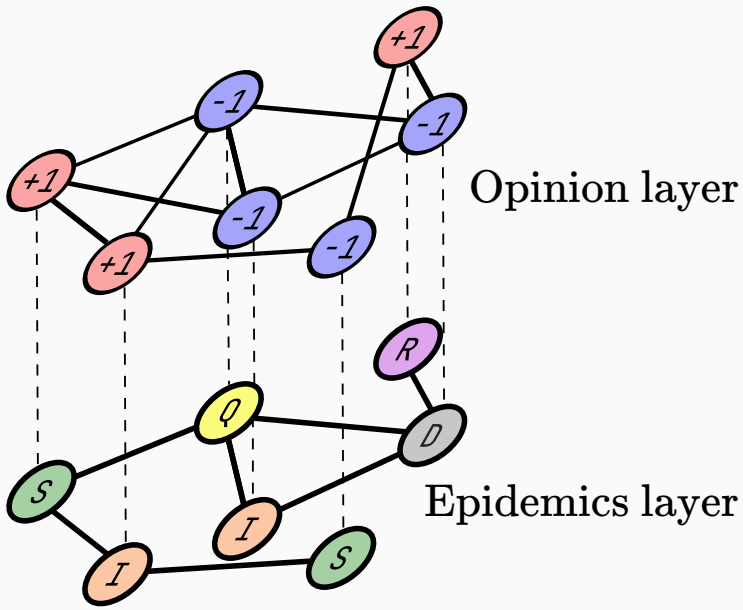
- Consequences of COVID-19, e.g., polarization of beliefs, anti-science movements

Q1: How do people who respect restrictions prevent the spread of an epidemic?

Q2: How to properly align two distinct processes, epidemic spreading and opinion dynamics?

Model overview

- Top (opinion) layer – q-voter model
- Bottom (epidemic) layer – SIQRD model
- Network topology – Holme-Kim Network[1] (preferential attachment with triad formation)



[1] Holme, P., & Kim, B. J. (2002). Growing scale-free networks with tunable clustering. Physical review E, 65(2), 026107.

Opinion layer – q-voter model

Each agent has a binary opinion: $S_i = +1(o_+)$ or $S_i = -1(o_-)$.

1. Choose a random node i.
2. With probability p it acts independently
3. Otherwise (conformism) it selects randomly q neighbours and adapts to the group only if that group is unanimous.
4. Repeat step 1.

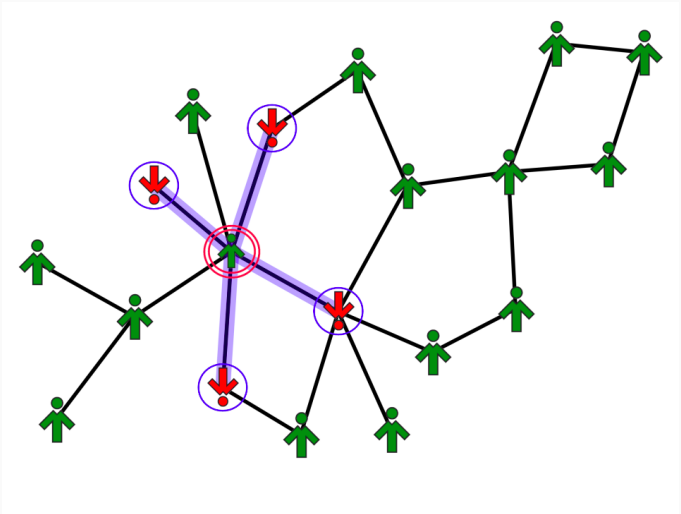
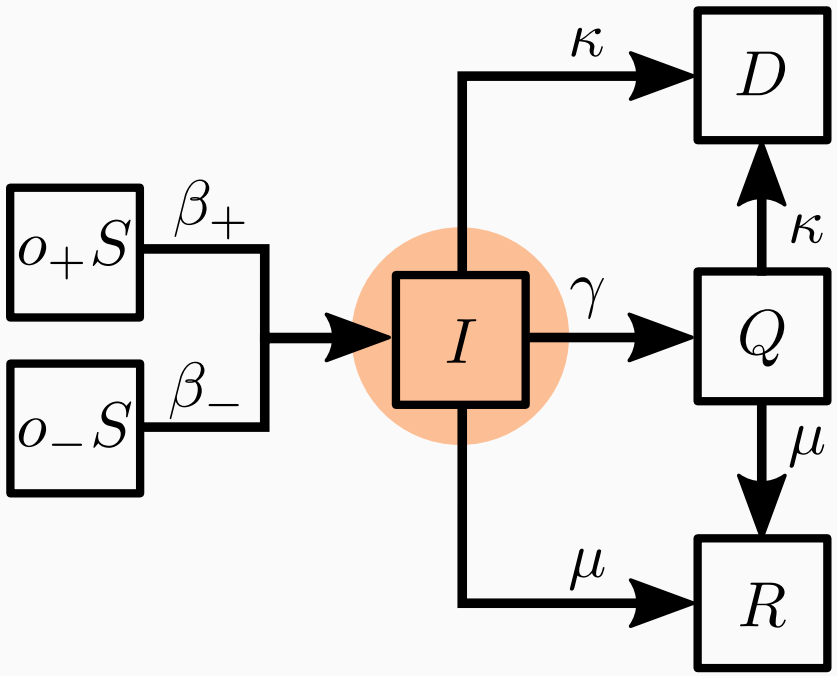


Figure 1: Choice of the q-lobby (here $q = 4$)[2].

[2] Jędrzejewski, A., Sznajd-Weron, K., & Szwabiński, J. (2016). Mapping the q-voter model: From a single chain to complex networks. Physica A: Statistical Mechanics and its Applications, 446, 110-119.

Epidemic layer – SIQRD model



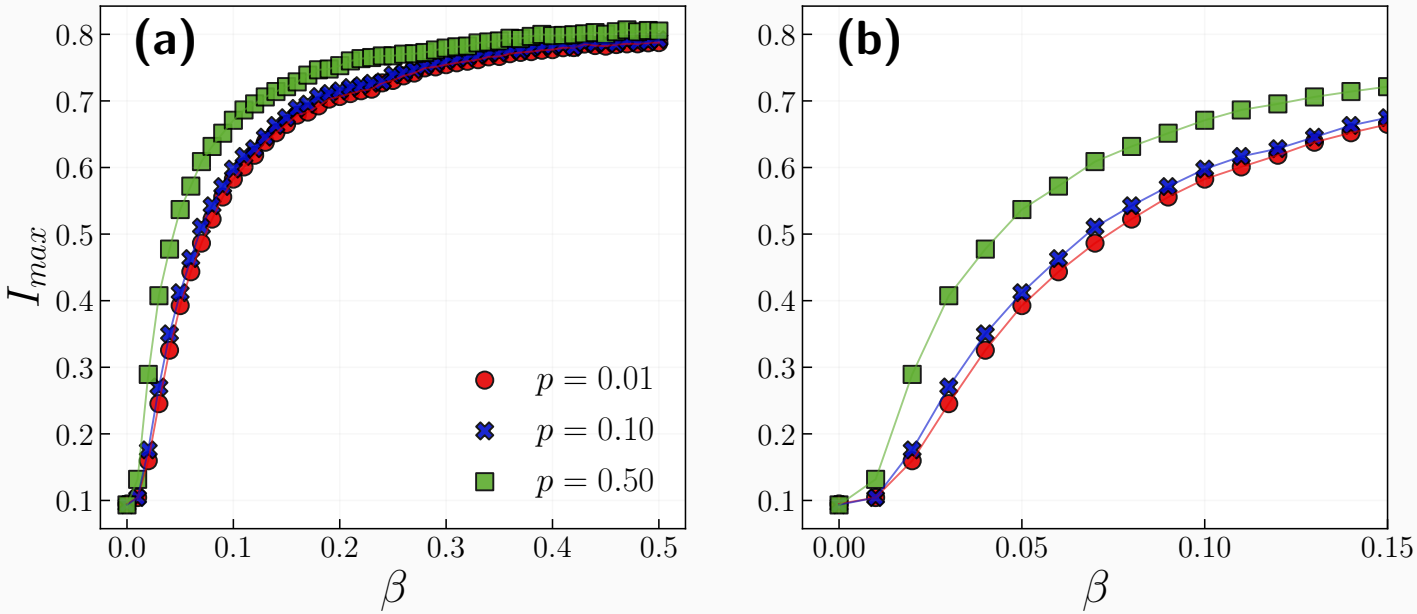
Agents with positive opinion are willing to respect the restrictions and have

- the infection probability decreased $\beta_+ = \beta/2$,
- the time in infection state reduced $t_i(o_+) = t_i/2$ ($t_i \sim \mathcal{N}(10, 5)$).

Impact of the opinion on epidemic spreading

Impact of independence probability

I_{max} – the peak of infection



- the strength of the interplay opinion-epidemic deteriorates with a larger infection probability β

Impact of the initial positive opinions

o_{init} is a fraction of agents with initial positive opinion

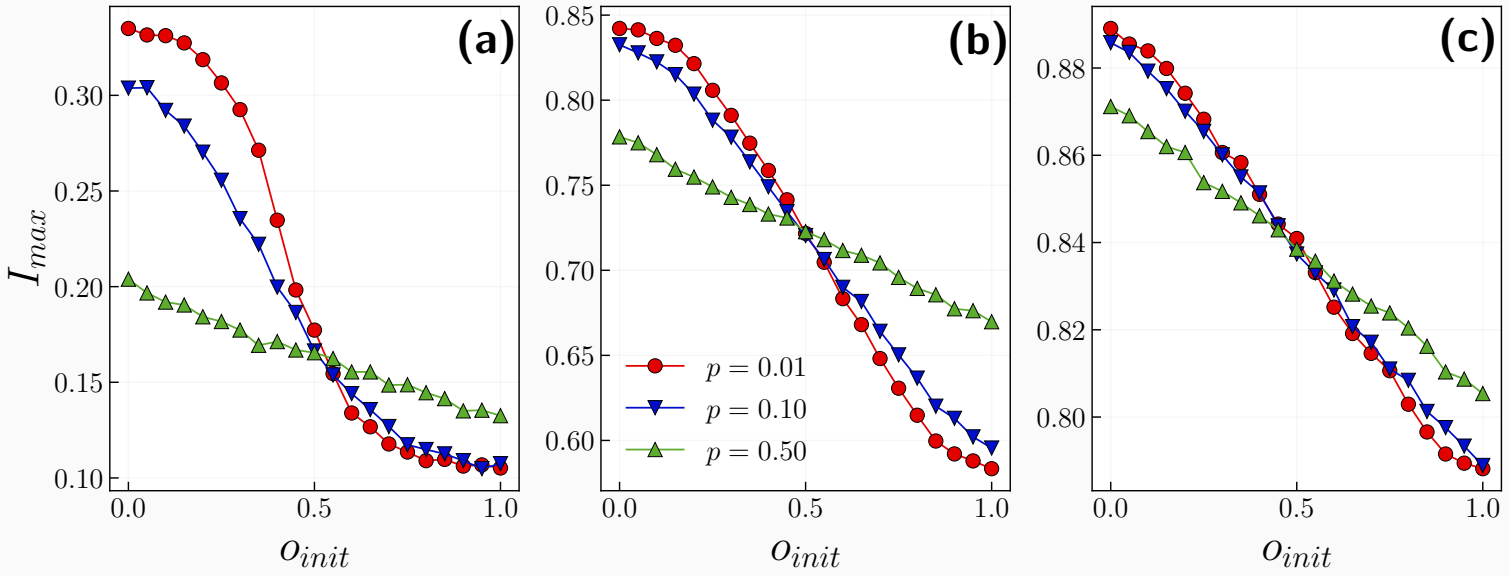


Figure 2: (**a**) $\beta = 0.01$, (**b**) $\beta = 0.1$, (**c**) $\beta = 0.5$

Best strategies:

- be conformist (individualist) in society with positive (negative) opinion,
- for more contagious diseases the outcome is less pronounced.

Role of time scales

Interplay between p and the infection peak.

One epidemic update per ν_{step} opinion updates.

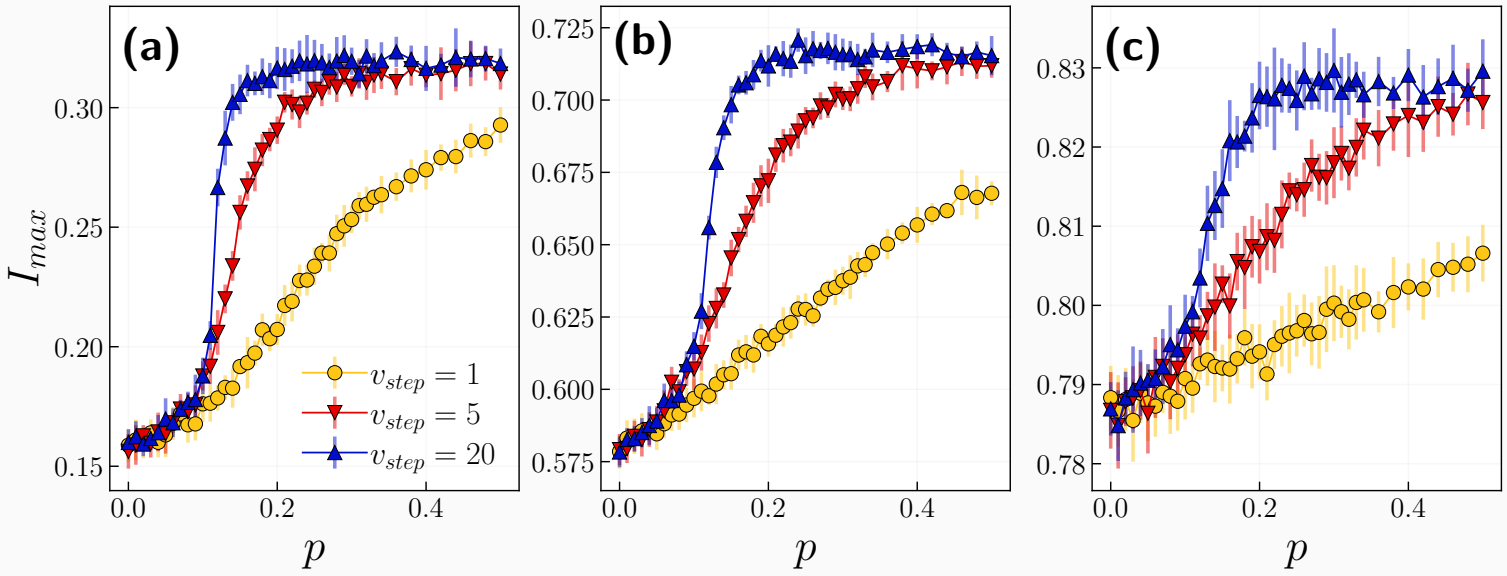
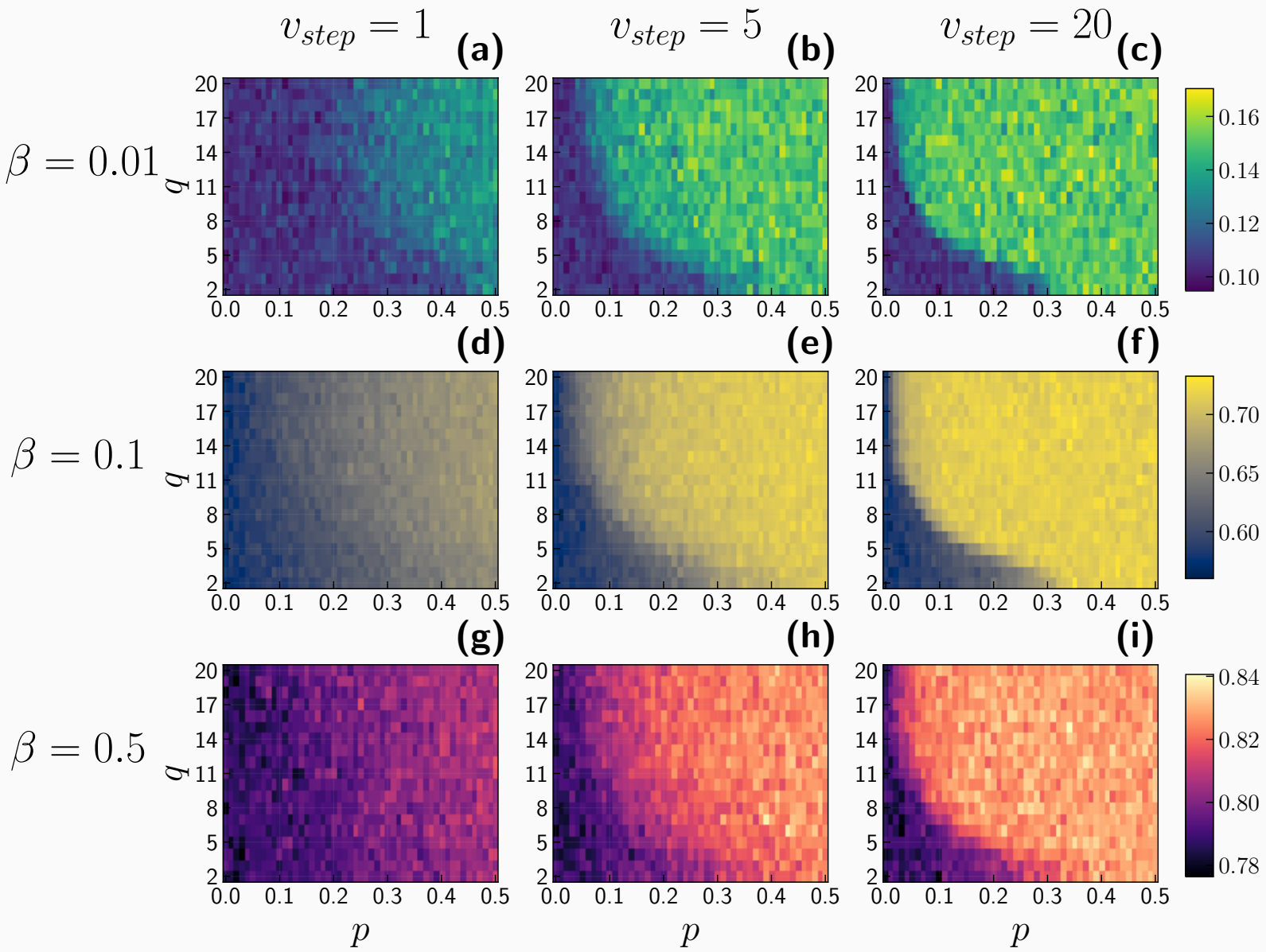


Figure 3: (**a**) $\beta = 0.02$, (**b**) $\beta = 0.1$, (**c**) $\beta = 0.5$

- We observe a saturation of the peak of infection $\mathrm{I_{max}}$ for greater value of the relative rate ν_{step} regardless of infection probability β.

Interplay between q-voter parameters and the infection peak.



Conclusions

Impact of the opinion on epidemic spreading

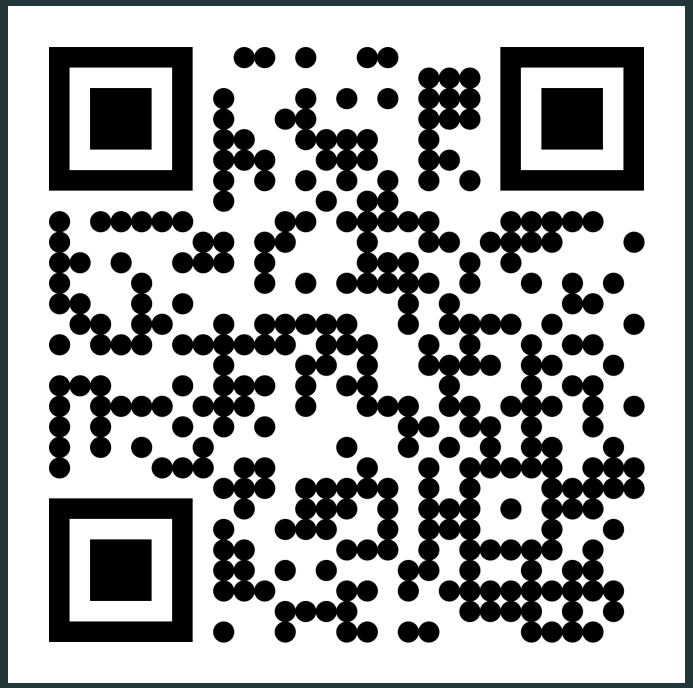
- Opinion has the strongest impact on the less infectious diseases.
- The government should take steps to convince the negative part of society.

Role of time scales

- Assuming the same time scales may lead to misleading conclusions.
- Selecting relative rate between two processes ν_{step} would require the empirical dataset.

Thank you for your attention ☺

For more information:



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