

Epidemic Control under Exploration and Return Dichotomy

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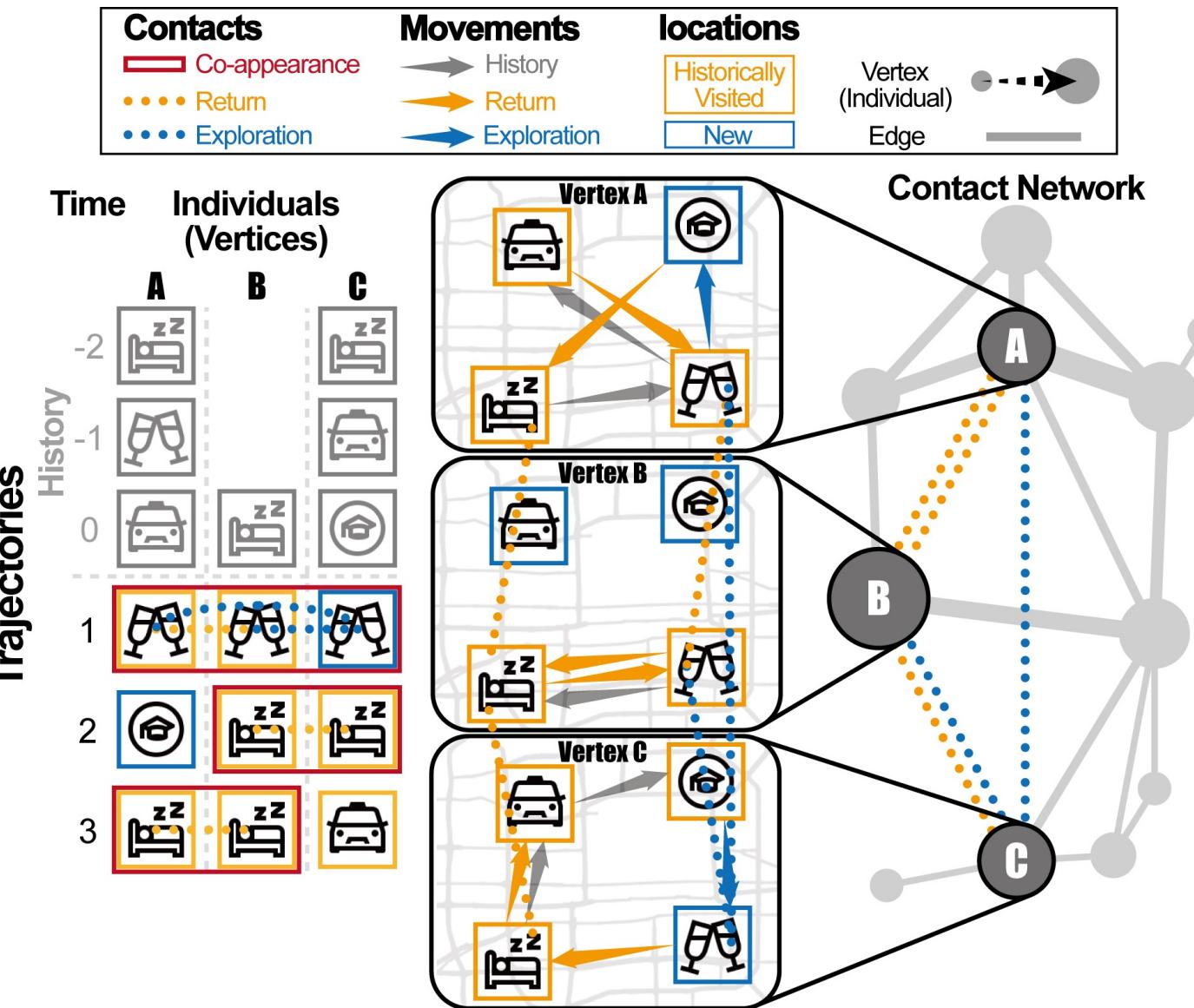
Future works

Construct Agent-based Contact Network

- Dataset:

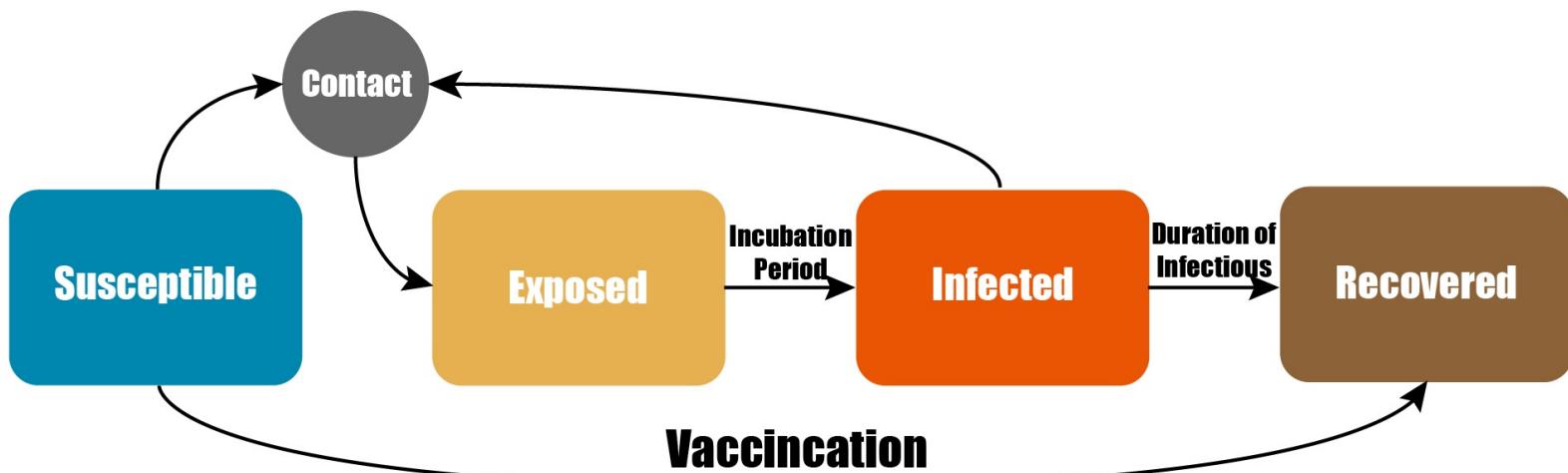
City	Population	Movements
Beijing	208,204	52,699,911
Shanghai	222,990	39,721,698
Shenzhen	232,392	40,735,530

- Historical Trajectories: 1 Week
- Future Trajectories: Remaining 3 Weeks
- Temporal Resolution: 1 Hour
- Spatial Resolution: 50m x 50m



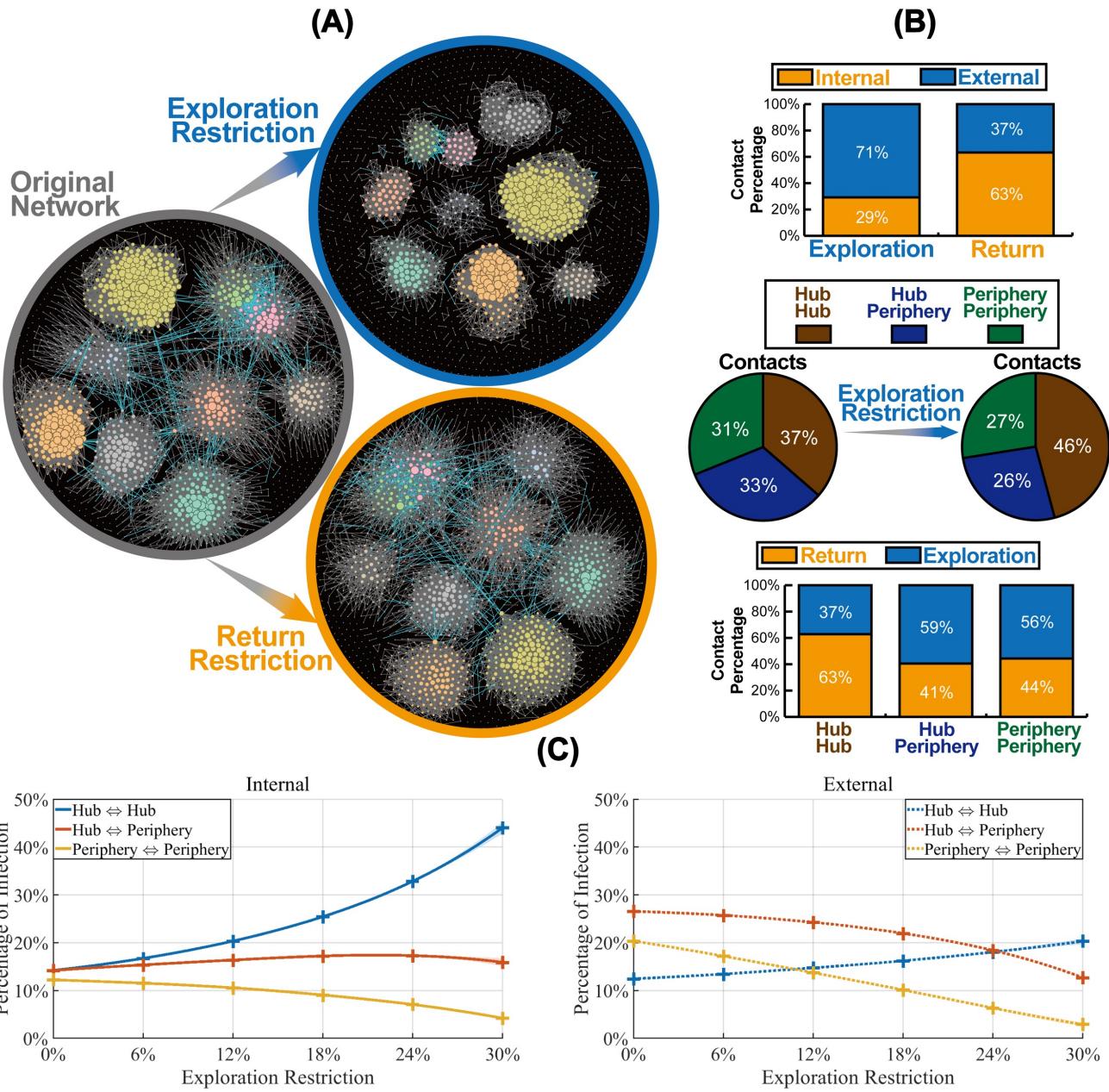
Agent-based SEIR Model

- $P(S \rightarrow E) = 1 - (1 - \beta)^k$
- $P(E \rightarrow I) = \frac{1}{d_L}$, $d_L = 6.4$ days (*Average Incubation Period*)
- $P(I \rightarrow R) = \frac{1}{d_I}$, $d_I = 3$ days (*Average Duration of Infectious*)
- β : *Transmission Rate* = $\frac{R_0}{N*d_I}$, $R_0 = 2.5$, N = *Average Degree*
- k : *Contact Number*



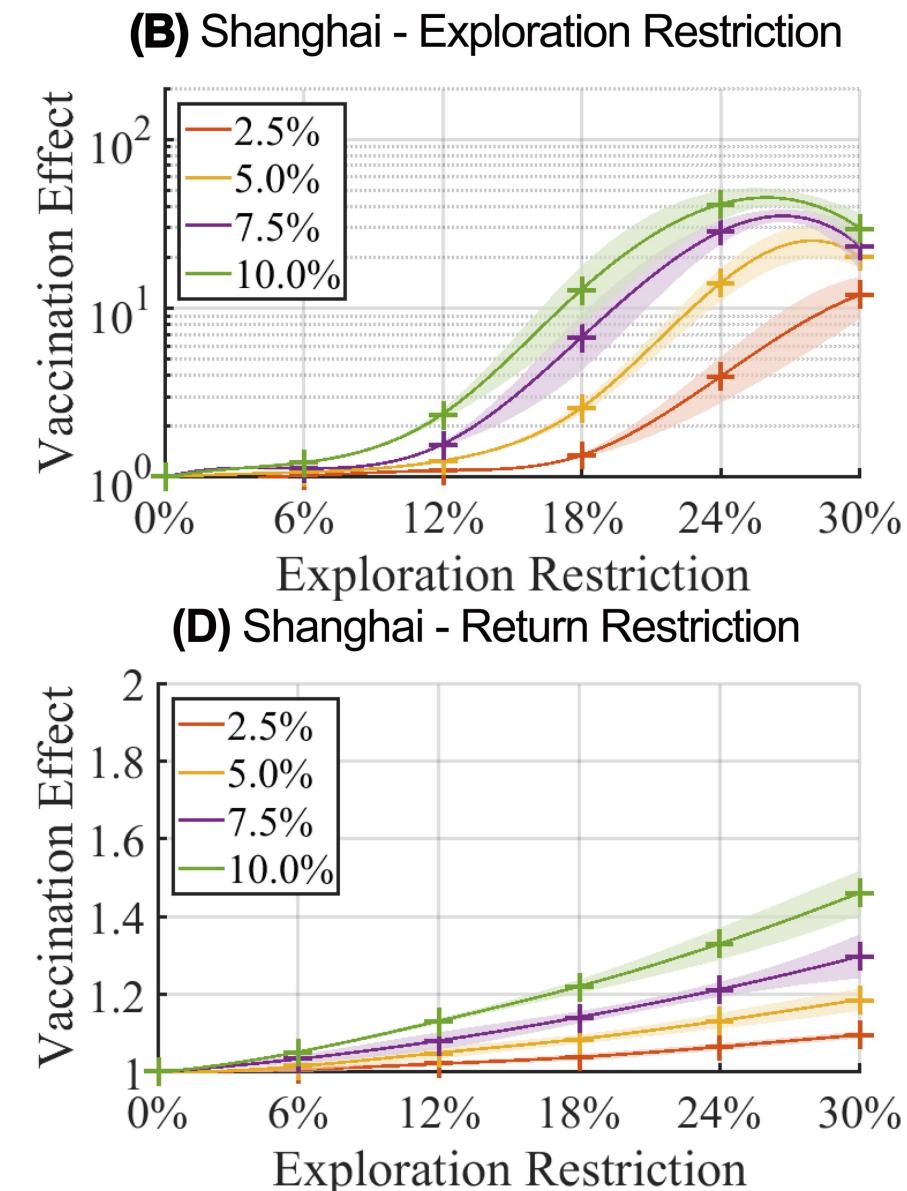
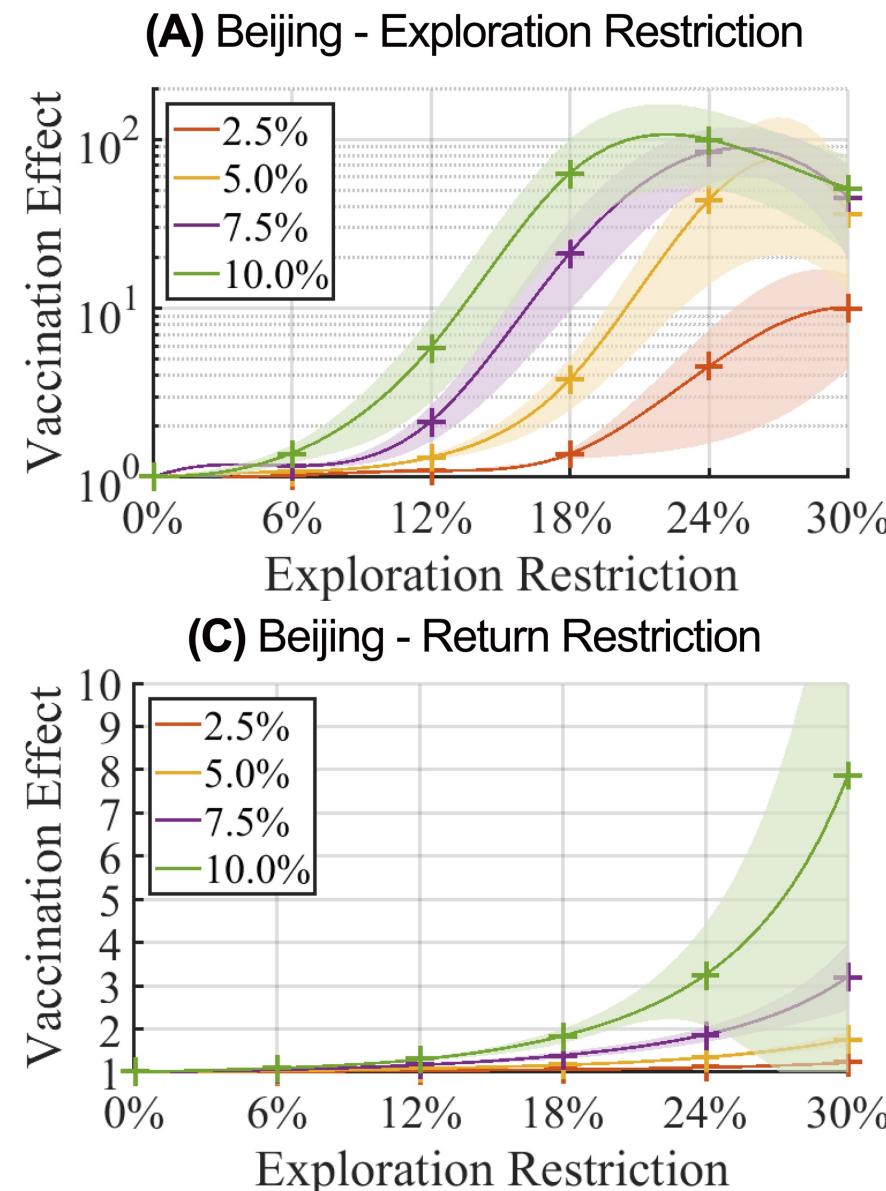
The Performance of Exploration Restriction Policy

- **Observations:**
- (A): Exploration restriction would significantly reduce the connection across communities, while return restriction will reduce the hub in communities.
- (B): 1) External connection are mainly constructed by Exploration Movements. 2) Exploration restriction will improve the significance of hub-hub connection. 3) Hub-hub connections are mainly constructed by return movements. That makes them less affected by exploration restriction and be improved by exploration restriction.
- (C): The statistics of infection, which is categorized into 6 categories (hub-hub/hub-periphery/periphery-periphery × internal/external). Results shows that the infection between hub-hub vertices will dominate the whole network under exploration restriction.
- **hub/periphery:** top 20% degree / last 80% degree
- **Internal/external:** For any contact or edge, its 2 endpoints are in **same/different** community.



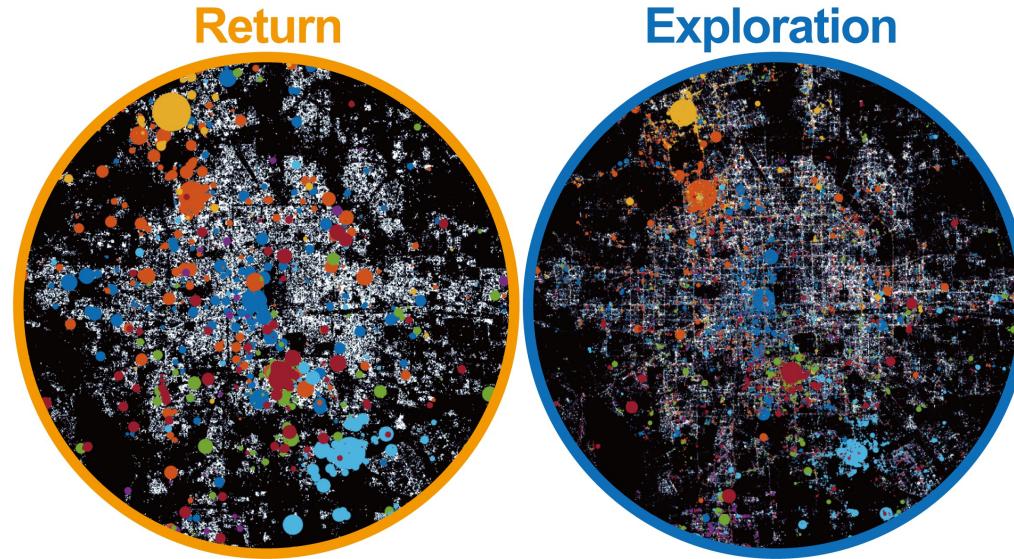
The Amplification of Vaccination under Exploration Restriction

- Relative Effectiveness of Vaccination, defined as: $E_{1+1>2} = (I_r/I_{r,v})/(I/I_v)$, also designated as 1+1>2 effect
- I represents the infected population, r and v represent mobility restriction and vaccination.
- Experiments in Beijing and Shanghai shows exploration restriction will significantly reinforce the relative effect of hub-prioritized vaccination, while this effect is much less significant under return restriction.

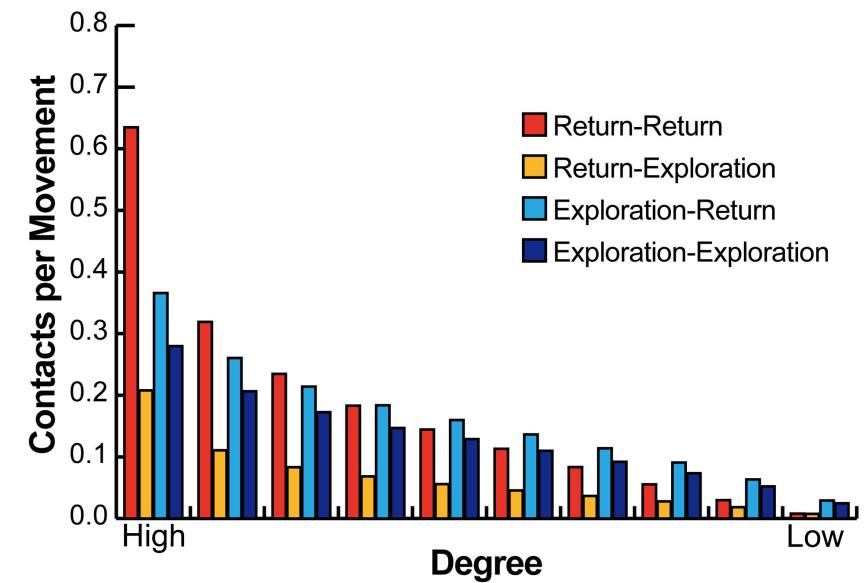


The Origin of Community Structure and Hub/Periphery Dichotomy

(A) The Clustering of Return Movements

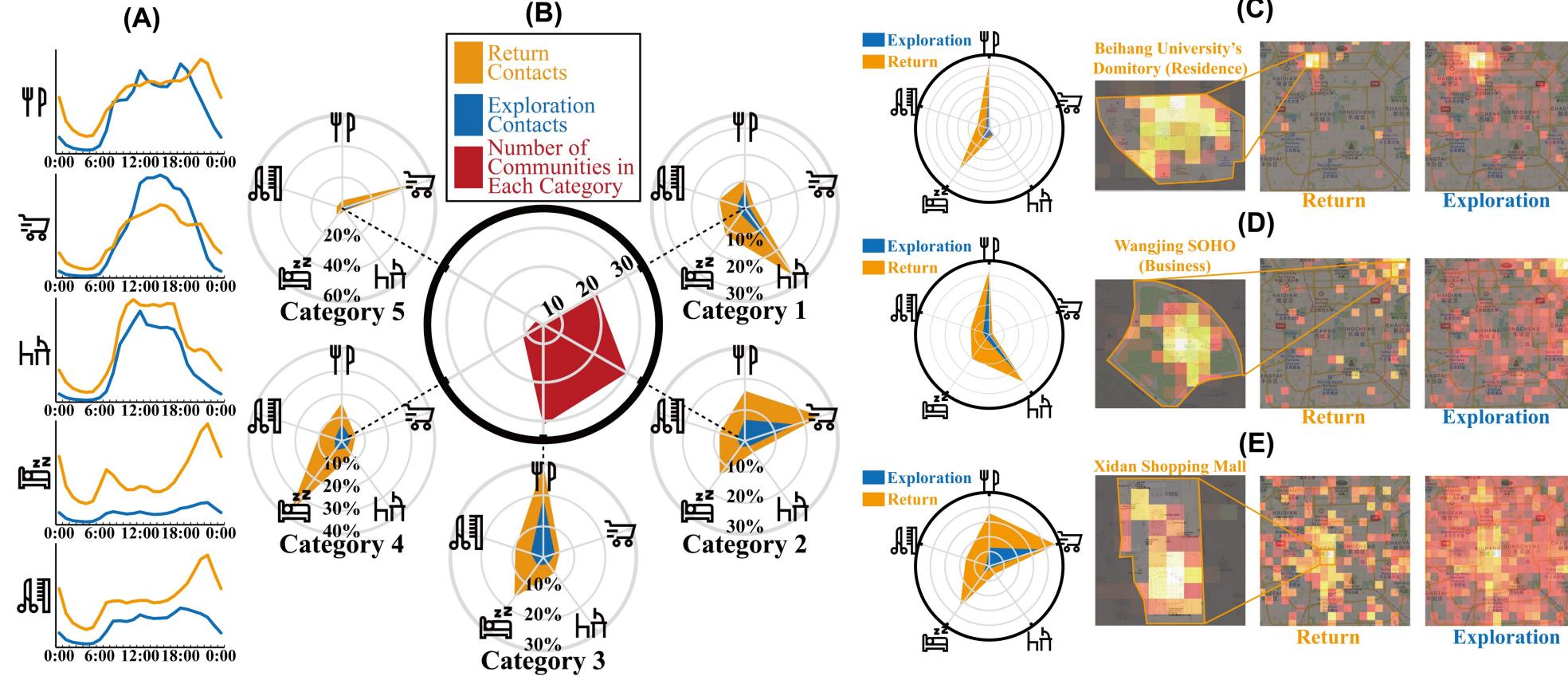


(B) The Concentration of Hub's Return.



- A. Compared with exploration, return movements is more concentrated, the clustering of return movements create dense connections among groups of vertices and forms communities in contact network
- B. The return movements of hub vertices is especially concentrated and effective to generate contacts among them. That shows the concentration of return movements is the origin of hub/periphery dichotomy.

Case Studies



- A. Most contacts are generated in 5 categories of locations, including, **Restaurant**, **Shopping**, **Business**, **Residence**, and **Life Services**.
- B. Figure shows the motif of contact in communities. We employ kNN to cluster communities by the distribution of their contacts.
- C. Case studies of 3 typical communities in Beijing city.

Future Works

- It's not realistic to assume 100% of citizens will completely obey the exploration restriction policy. Several experiments are already conducted to