Network Analysis:

The Hidden Structures behind the Webs We Weave

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Exemplary Studies and Extensions

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2-min Quiz, on Canvas

Exemplary Studies

What are the uses?

In previous weeks, we explored specific quantitative measures, models, and methods for studying social phenomena through the lens of networks

- Homophily and degree assortativity
- Power and centrality
- Social groups
  - Cohesive subgroups
  - Structural equivalence
  - Affiliation networks

Let’s look at effective uses of these methods and how the core insights of the methods can be adapted given the constraints of the study (e.g., data, population)

Biology and Social Networks

Relationship between social networks and biology

Networks and health
Heritability of networks
Hunter-gatherer networks
Social networks and microbiome

Network Position and Sexual Dysfunction

“Betweenness” of the spouse correlates with sexual dysfunction of older men
Masculinity norms expect autonomy and independence of men

Network Position and Sexual Dysfunction

"Betweenness" of the spouse correlates with sexual dysfunction of older men
Masculinity norms expect autonomy and independence of men

Q: Which structure below poses a threat to masculinity from ego's perspective?

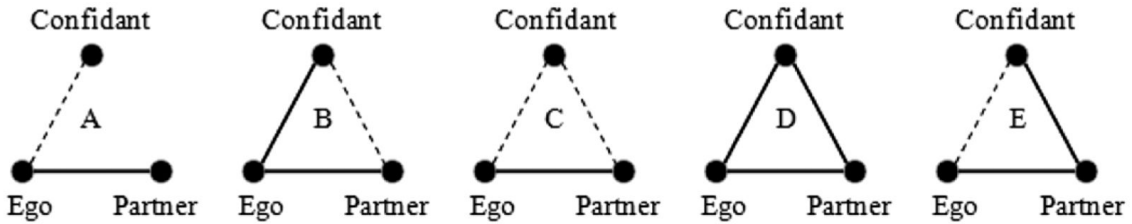
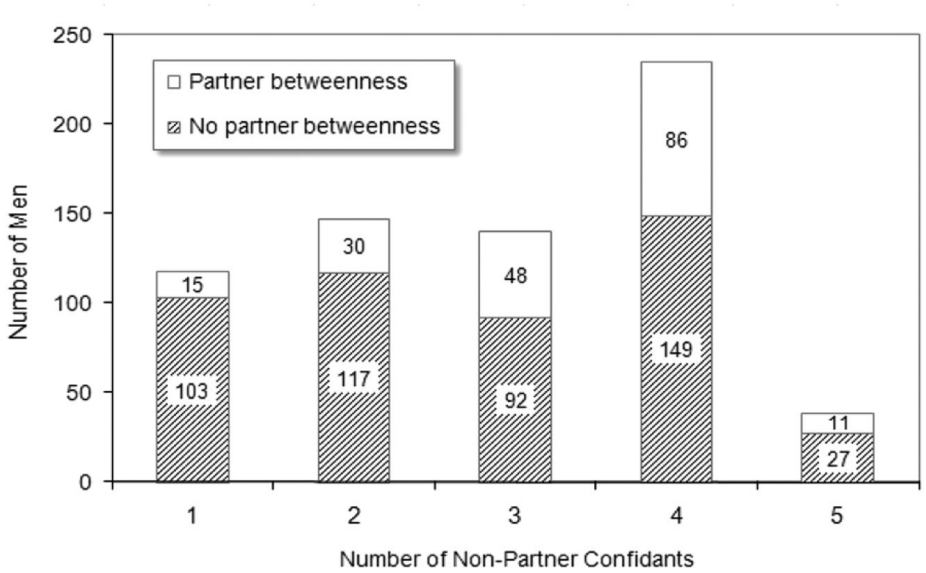


FIG. 1.—Five possible ego-partner-confidant triads, based on contact frequency. Solid lines represent frequent contact. Dashed lines represent (relatively) infrequent contact.

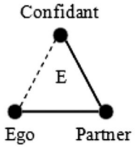
Cornwell and Laumann 2011

Network Position and Sexual Dysfunction



Data: National Social Life, Health, and Aging Project (2005~2006) Survey of 3K older adults in the U.S.

Partner betweenness:

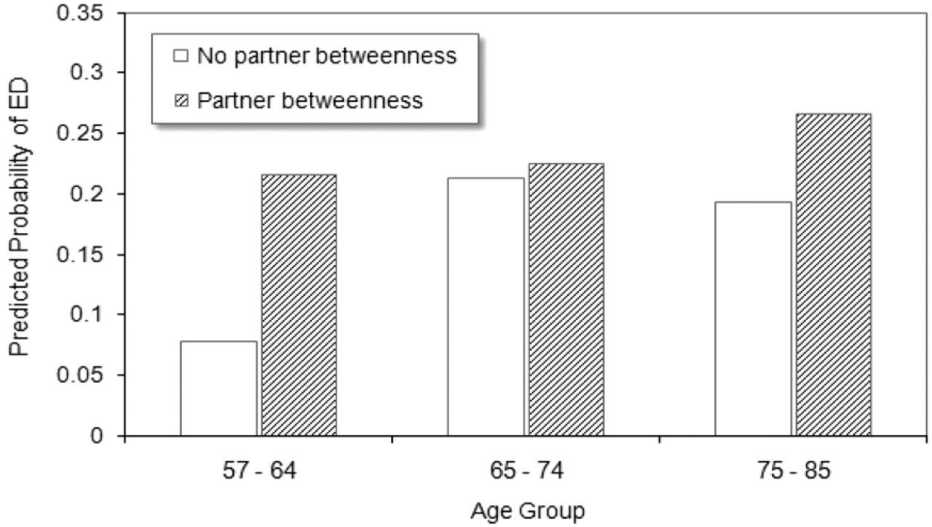


For older men, female spouses can become more central in the men's confidant network

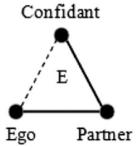
- Their networks overlap at old age
- Men's deteriorating health facilitates more frequent contact between spouse and confidant

Cornwell and Laumann 2011

Network Position and Sexual Dysfunction



Partner betweenness:



Probability of erectile dysfunction is significantly higher for men with partner betweenness

The study adapts the idea of betweenness centrality, given egocentric network data

Cornwell and Laumann 2011

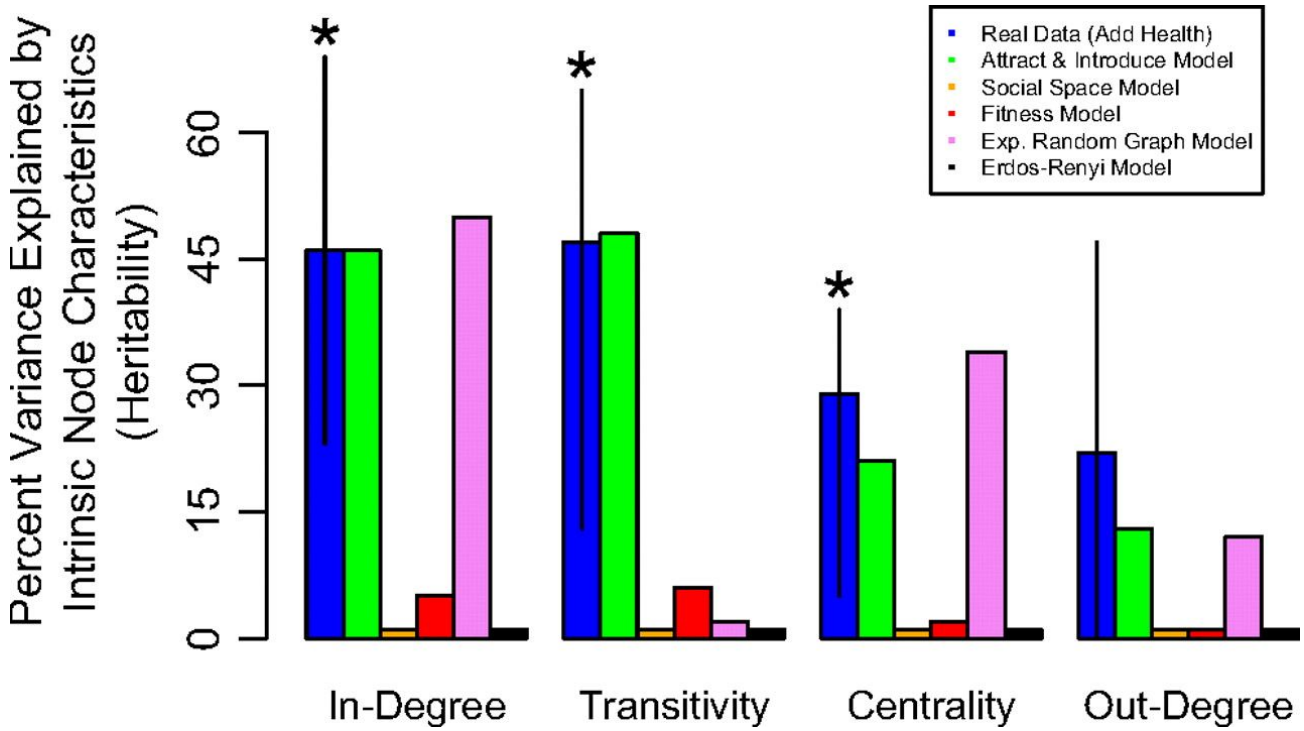
Nature vs. Nurture

Is social network biologically determined or socially determined?

The logic of twin study design

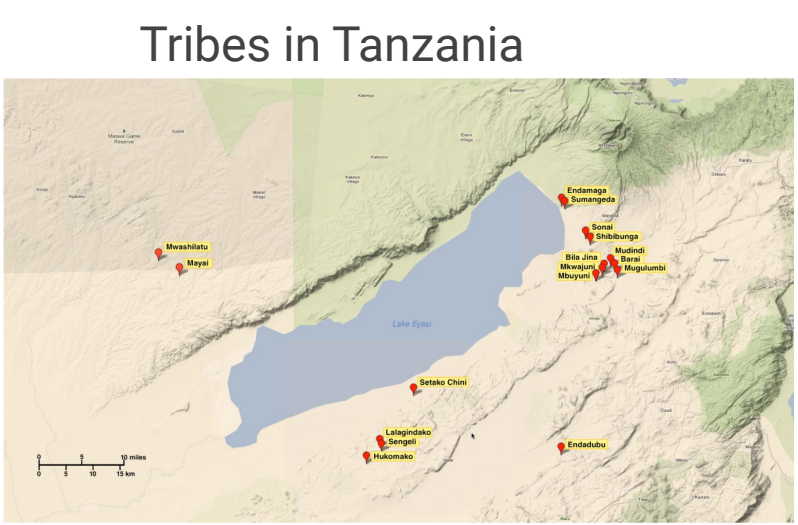
- Identical twins share exactly the same genes (100%)
- Same-sex fraternal twins share 50% of their genes
- The effect of genes can be estimated by the extent to which identical twins are more similar than fraternal twins in egonetwork characteristics

Nature vs. Nurture



Data: Identical and fraternal twins from Add Health
Source: Fowler et al., 2009

Hunter-Gatherer Networks



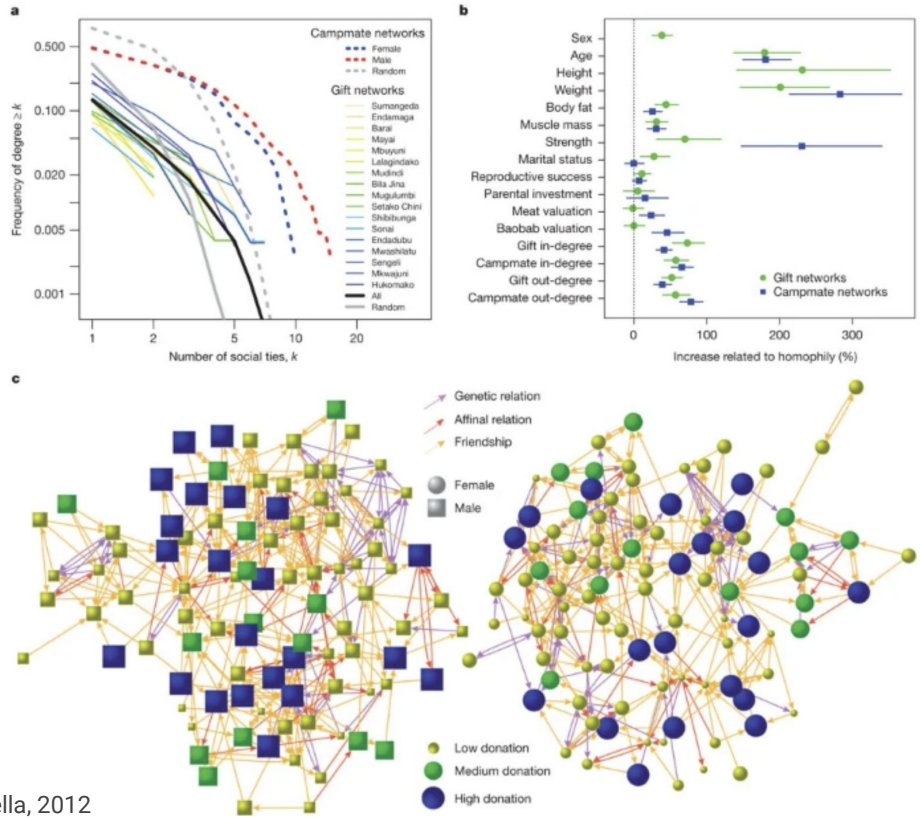
Supplementary Figure S1: Map showing the location of 17 different Hadza camps visited around Lake Eyasi in Tanzania.

Source: Apicella, 2012

Supplementary Figure S2: Example of one poster set for one sex (women). These posters were used to elicit social ties.

Hunter-Gatherer Networks

Figure 1: Structural features of modern social networks also exist in Hadza networks.

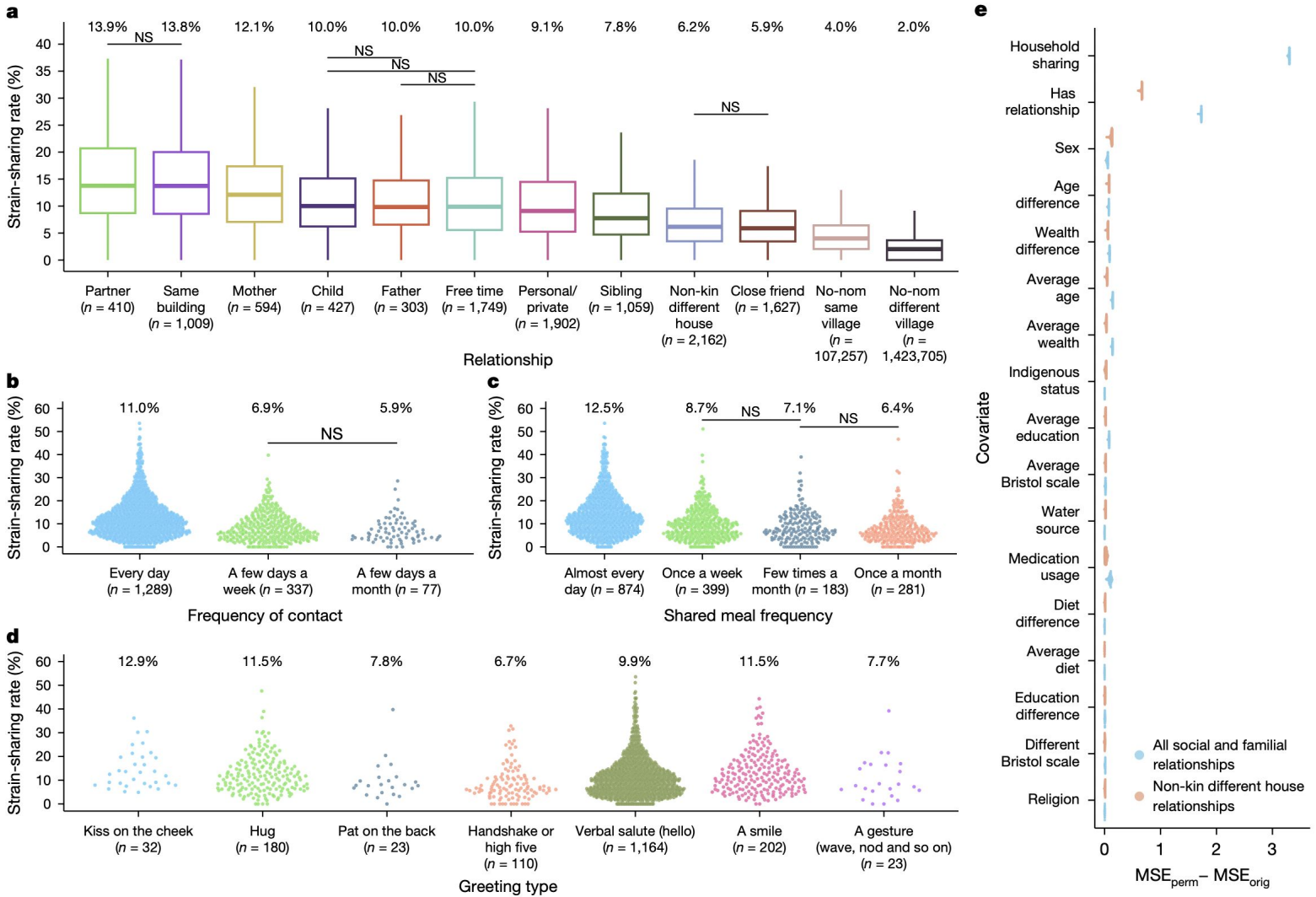


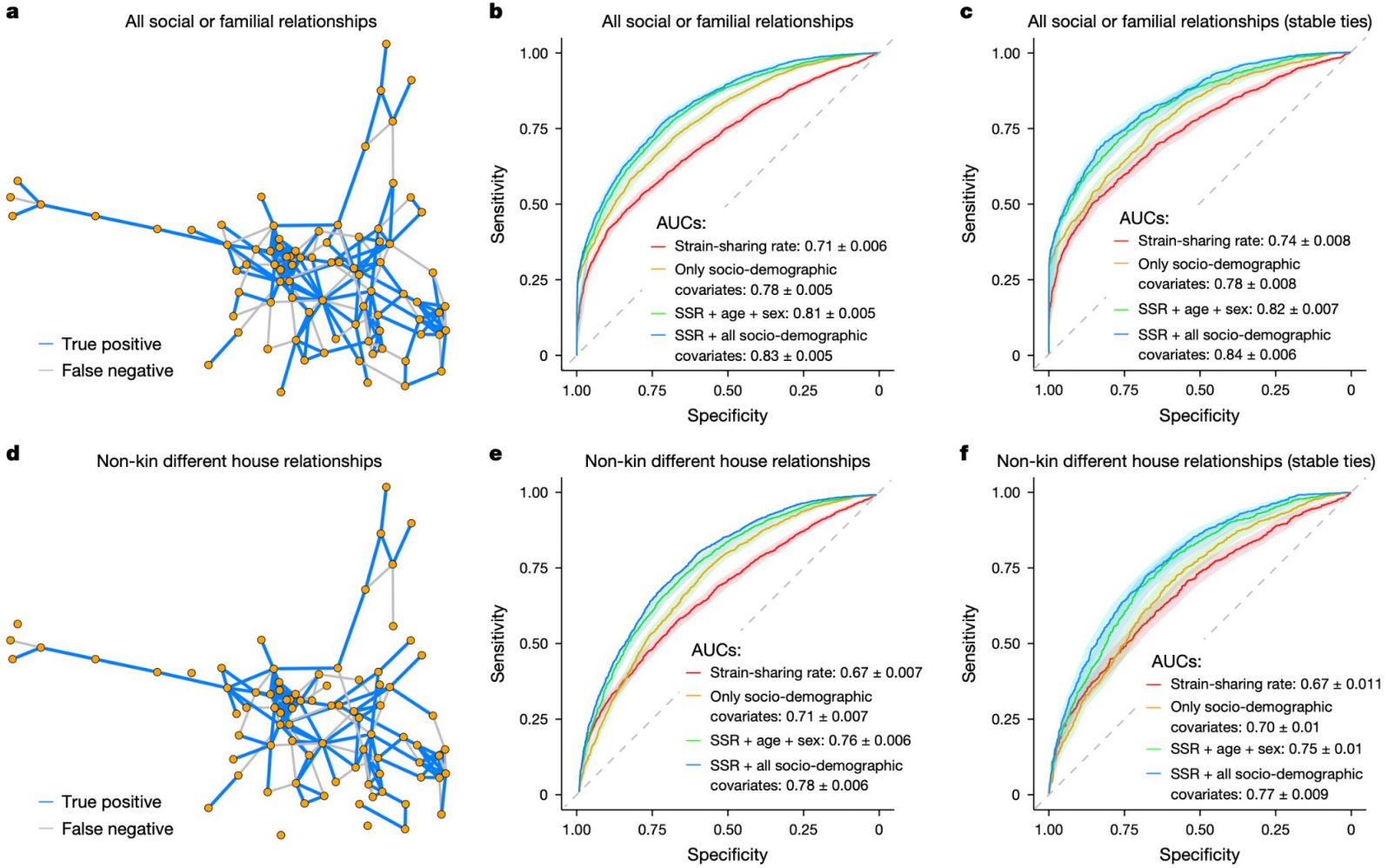
Similar network characteristics as modern social networks

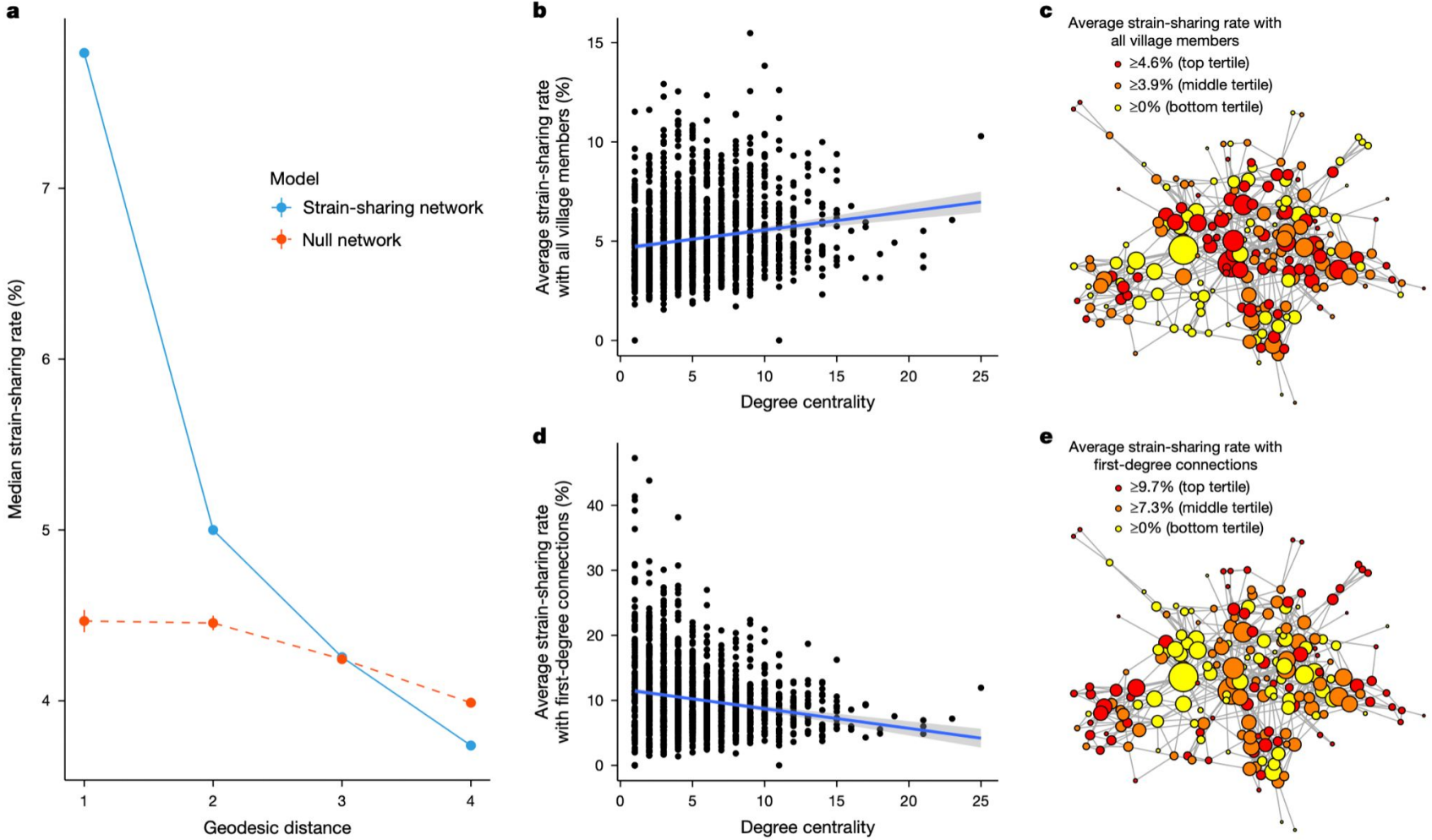
- Degree distribution
- Homophily
- Clustering

Source: Apicella, 2012

Gut microbiome strain-sharing within isolate village social networks




a
All social or familial relationships
True positive
False negative
b
All social or familial relationships
Sensitivity
Specificity
1.00
0.75
0.50
0.25
0
AUCs:
Strain-sharing rate: 0.71 ± 0.006
Only socio-demographic covariates: 0.78 ± 0.005
SSR + age + sex: 0.81 ± 0.005
SSR + all socio-demographic covariates: 0.83 ± 0.005
c
All social or familial relationships (stable ties)
AUCs:
Strain-sharing rate: 0.74 ± 0.008
Only socio-demographic covariates: 0.78 ± 0.008
SSR + age + sex: 0.82 ± 0.007
SSR + all socio-demographic covariates: 0.84 ± 0.006
d
Non-kin different house relationships
True positive
False negative
e
Non-kin different house relationships
AUCs:
Strain-sharing rate: 0.67 ± 0.007
Only socio-demographic covariates: 0.71 ± 0.007
SSR + age + sex: 0.76 ± 0.006
SSR + all socio-demographic covariates: 0.78 ± 0.006
f
Non-kin different house relationships (stable ties)
AUCs:
Strain-sharing rate: 0.67 ± 0.011
Only socio-demographic covariates: 0.70 ± 0.01
SSR + age + sex: 0.75 ± 0.01
SSR + all socio-demographic covariates: 0.77 ± 0.009

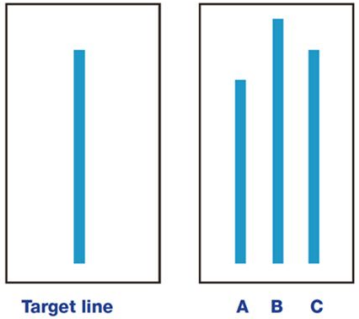

a
Median strain-sharing rate (%)
Geodesic distance
Model
Strain-sharing network
Null network
b
Average strain-sharing rate with all village members (%)
Degree centrality
c
Average strain-sharing rate with all village members
≥4.6% (top tertile)
≥3.9% (middle tertile)
≥0% (bottom tertile)
d
Average strain-sharing rate with first-degree connections (%)
Degree centrality
e
Average strain-sharing rate with first-degree connections
≥9.7% (top tertile)
≥7.3% (middle tertile)
≥0% (bottom tertile)

Higher-Order Interactions

Co-presence is fundamental to social interaction

- Co-presence: the simultaneous gathering and interaction of several actors
- Co-presence produces dynamics that are very different from 1:1 interactions
- Collection of edges ≠ co-presence

Co-presence generates collective effervescence, leading to group solidarity (Collins, 2005)

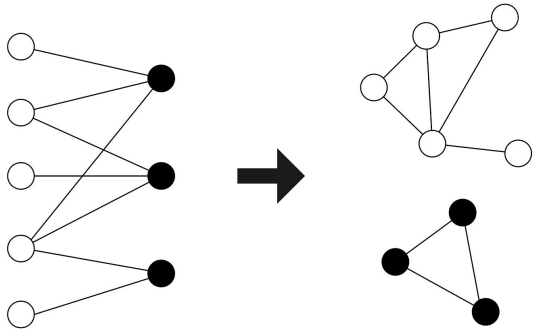


Asch (1951) famously noted that group interactions facilitate social pressure to conform.

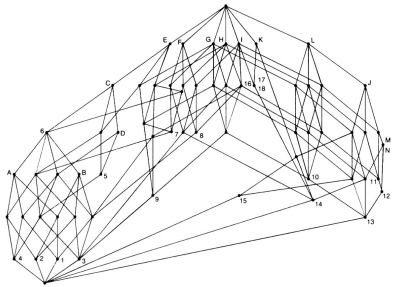
Network Analysis of Group Interactions

- Several models of co-presence have been discussed in the literature, including affiliation (two-mode) networks and Galois lattices

- In graph-based models, co-members form cliques regardless of actual dyadic relationship/interaction



Duality of persons and groups (Breiger, 1974)



Galois lattices to represent social structure (Freeman and White, 1993)

Group Affiliation ≠ Presence of Dyadic Ties

Dense collaboration ties

Sparse ties

Ties prohibited

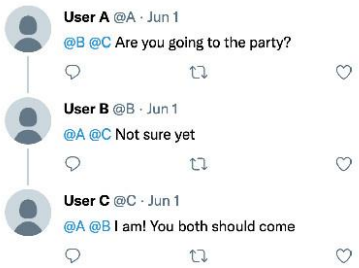
- Membership in a group does not necessarily mean all dyads will have ties with one another (Monasteries, fraternities discourage 1:1 friendships)
- Graph representations may not accurately encode higher-order interactions
- Affiliation network data may not capture the intersubjective perceptions of the actors

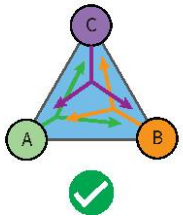
Question: The Effects of Higher-Order Interactions

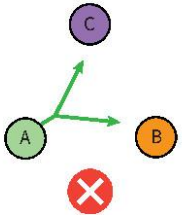
- Can we detect qualitative difference in nodes engaged in higher-order interactions?
  - Strong bonds with members
  - Ritualistic qualities
    - Shared sense of a group
    - Strong emotions (i.e., collective effervescence)

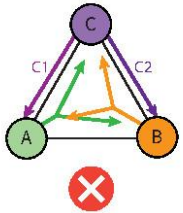
- How are these groups connected to one another?

Defining Higher-Order Interaction Triangles (Twitter)







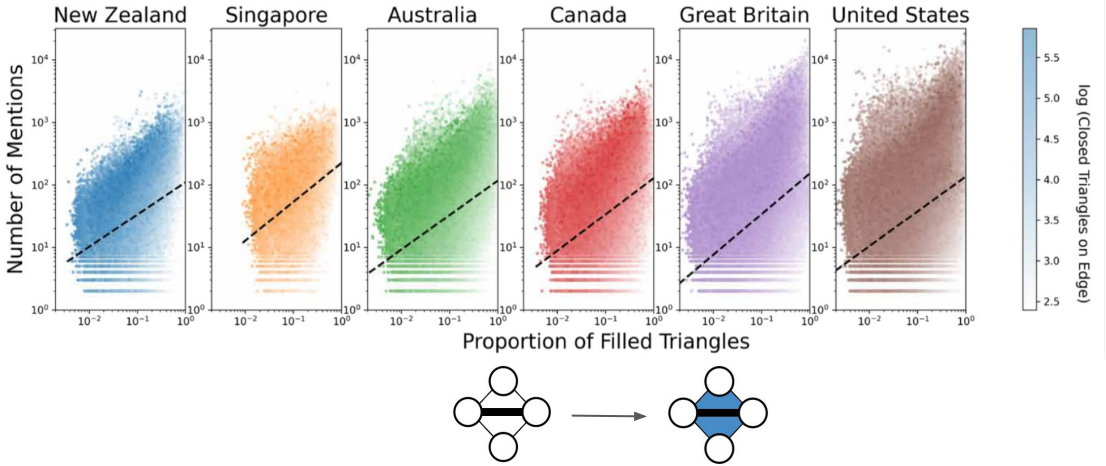


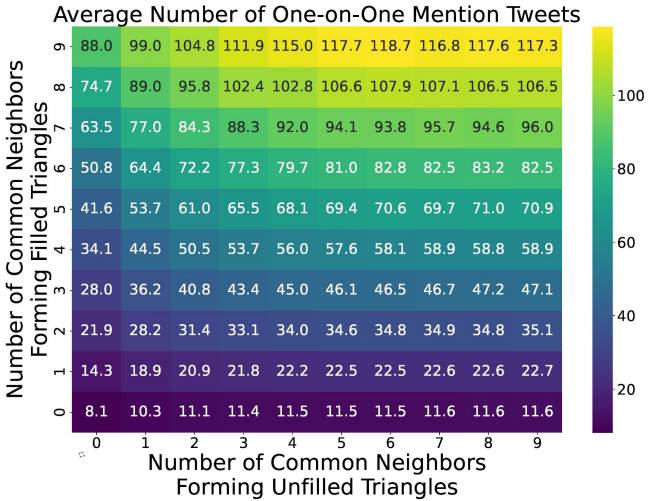
Explicit acknowledgement: A higher-order interaction triad should have three-way co-mentions

- Don’t assume membership
- Ensure all members are orienting their actions to the other two
- We will call these triads “filled triangles”

Results: Strength of Ties

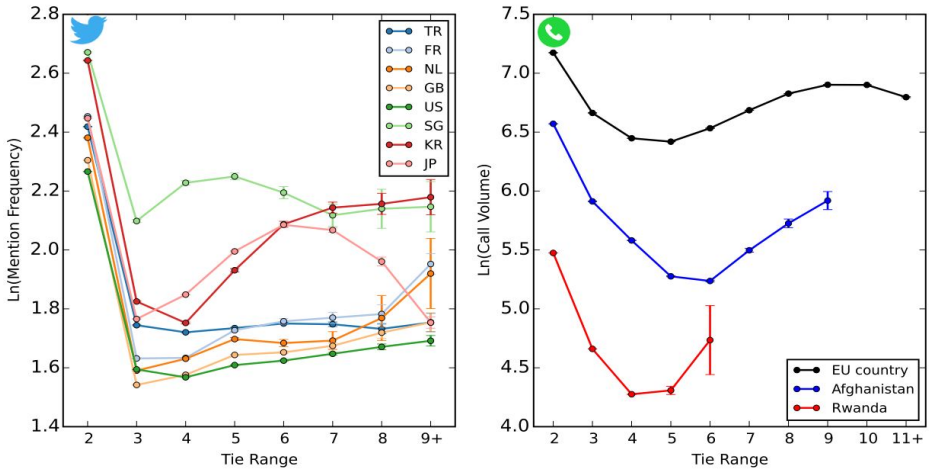
A





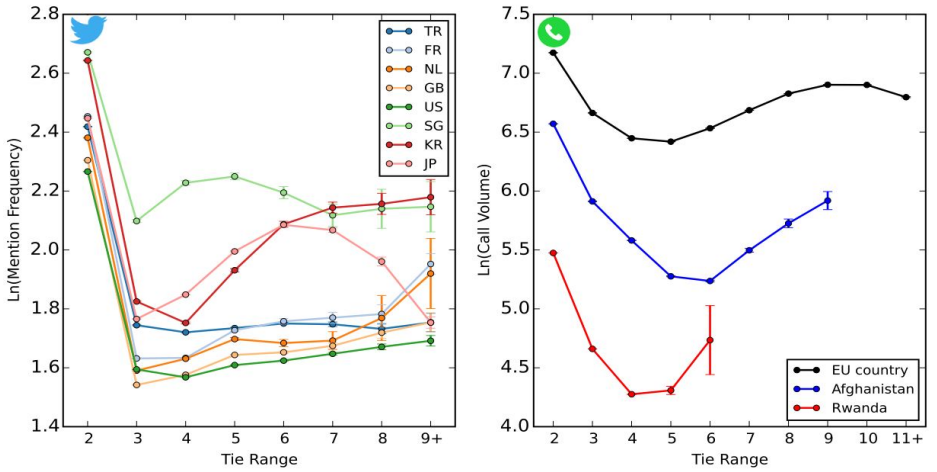
- Two Twitter users who form multiple filled triangles are relationally strong
- In fact, tie strength is more correlated with filled triangles than unfilled triangles

Results: Strength of Long Bridging Ties



Remember the puzzling U-shape of the strength of long-range ties?

Results: Strength of Long Bridging Ties



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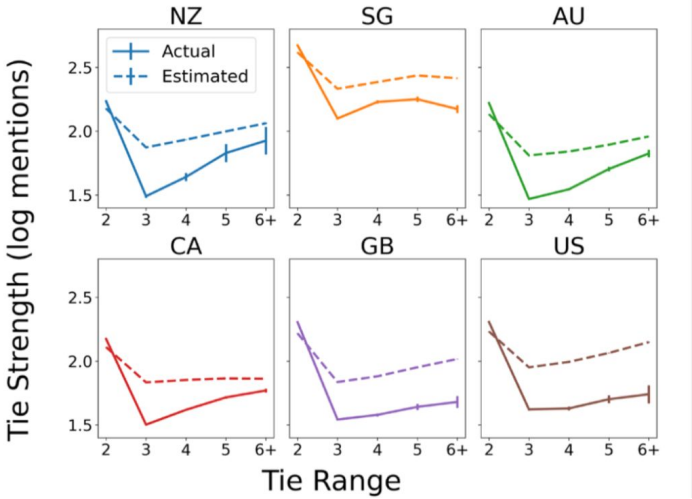
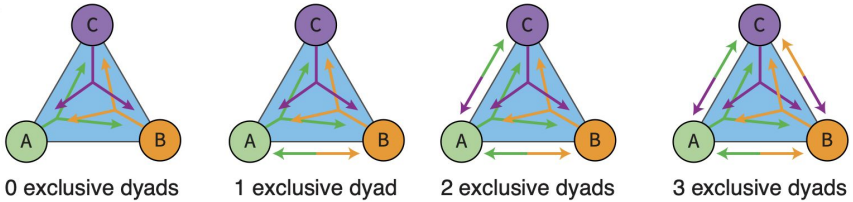


The ties' positions in higher-order interaction space predicts the U-shape pattern

Results: Ritualistic Qualities of Filled Triangles

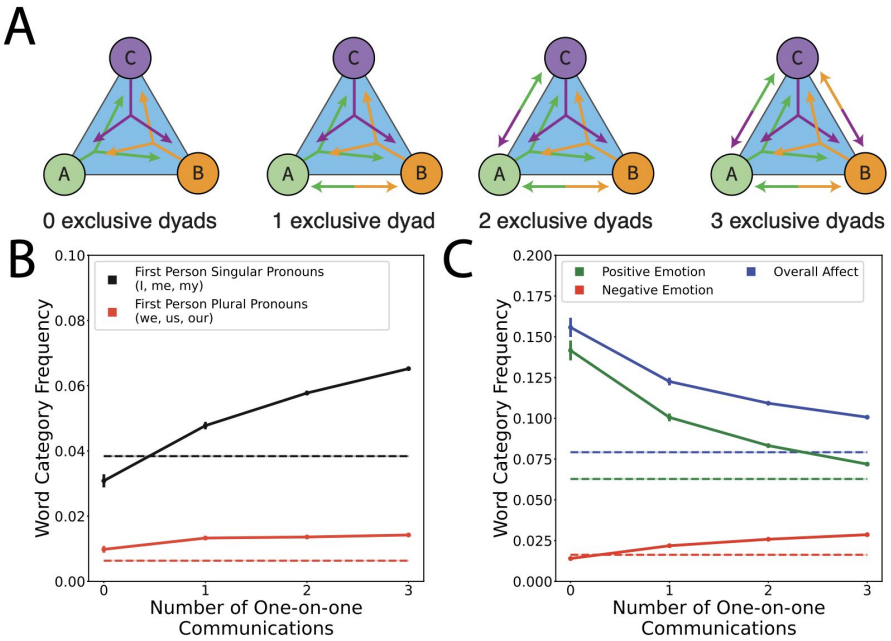
A



Ideal types of filled triangles:

- Purely higher-order (no 1:1)
- Higher-order + 1:1 interactions

Results: Ritualistic Qualities of Filled Triangles



Ideal types of filled triangles:

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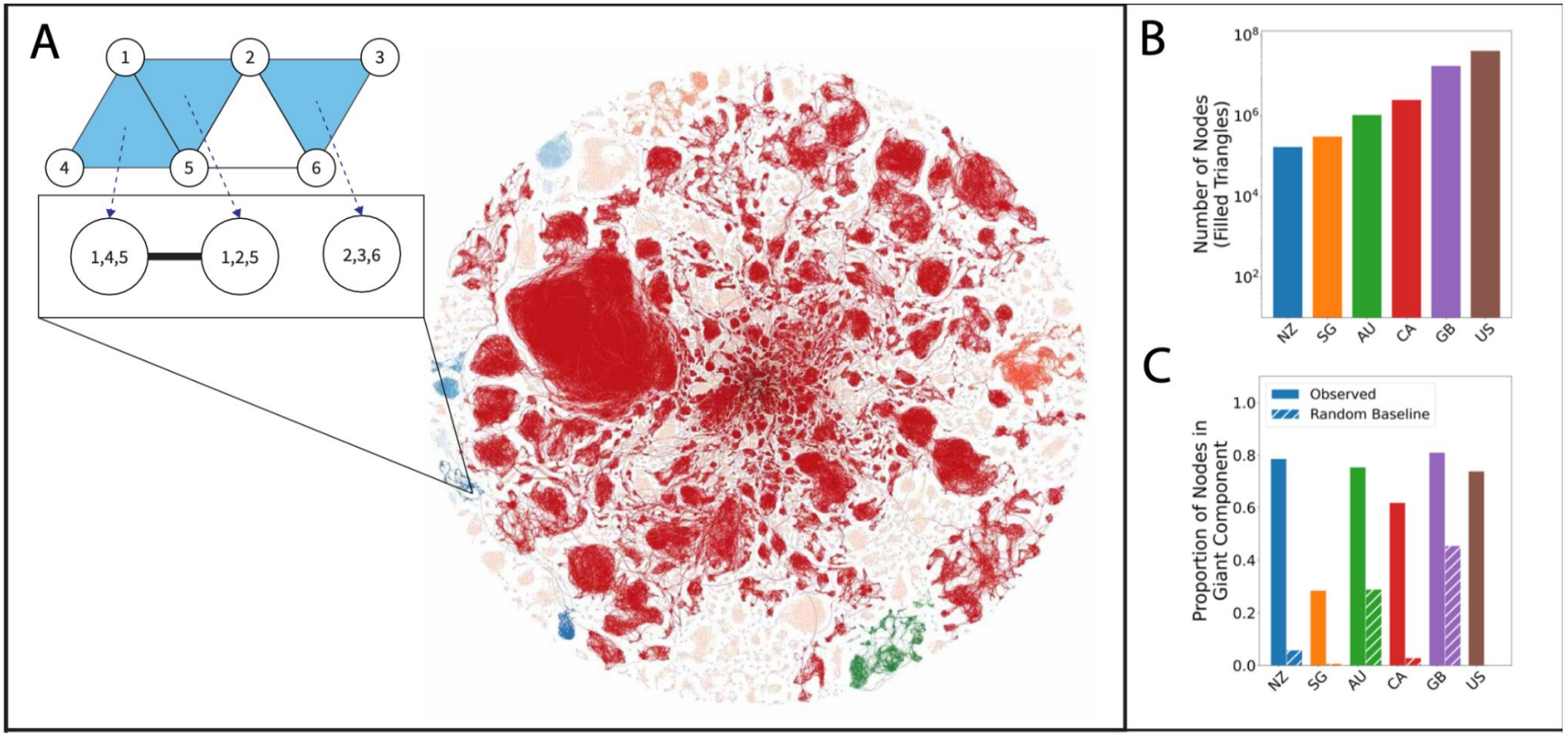
Results: Cohesion of Higher-Order Interactions



Summary

Social networks appear to have biological roots

Higher-order interaction networks are at the research frontier in network science