

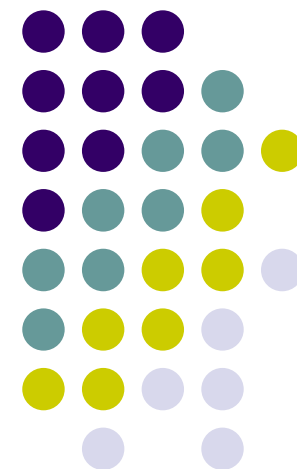
Longitudinal Changes in Friendship Networks: An Approach from Exponential Random Graph Models

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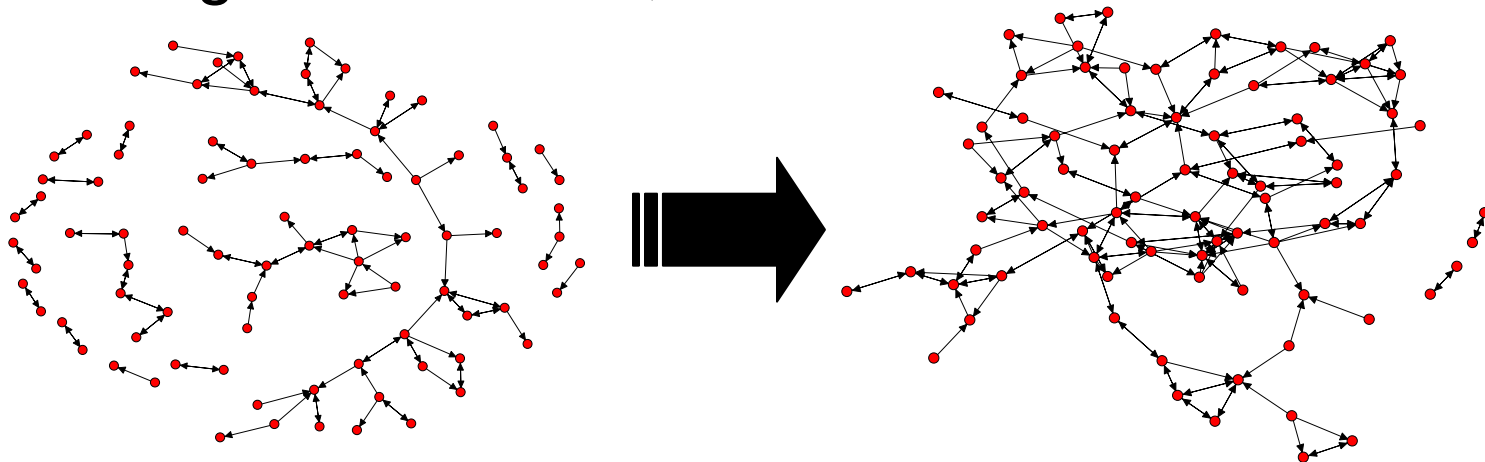
Overview

- Network dynamics
 - stationary or non-stationary?
- Research topic
 - friendship network (re)assessment
- Method
 - exponential random graph models (ERGM) for longitudinal social networks
- Application
 - friendship networks among first year undergraduates in Japan
- Summary and future implications



Dynamics of social networks

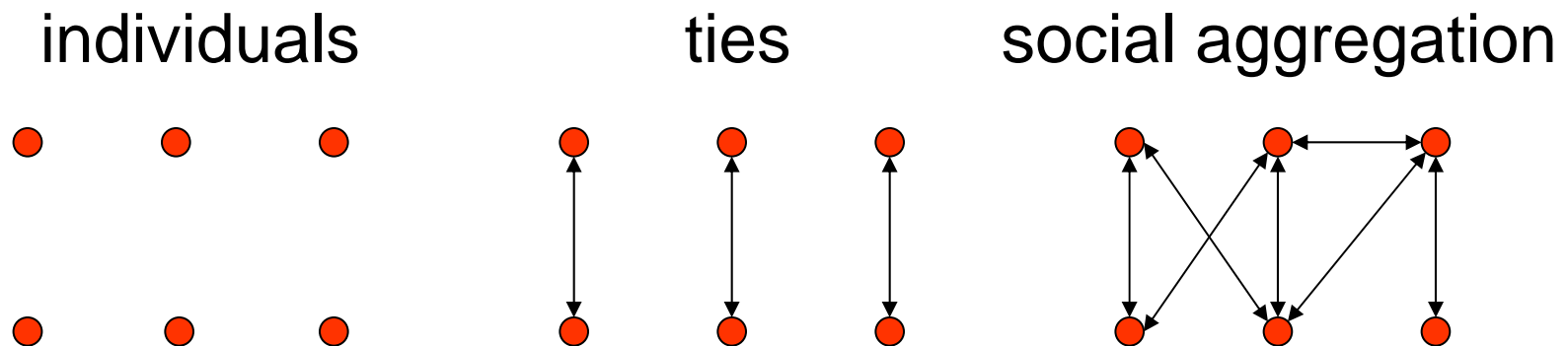
- Social networks change over time.
 - Criticism on previous studies
 - an individual, cross-sectional view
(see Burt, 2000; McPherson et al., 2001)
 - Cross-sectional analyses may miss the important change in networks, and its effects.





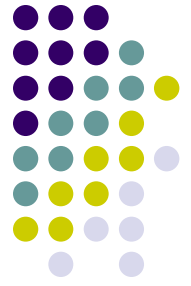
Transition in networks

- **Micro-macro dynamics** of social selection processes in a network



- **In friendship networks, do social selection processes change over time?**
 - think about the way in which people form relationships in a network

(Re)assessment of relationships



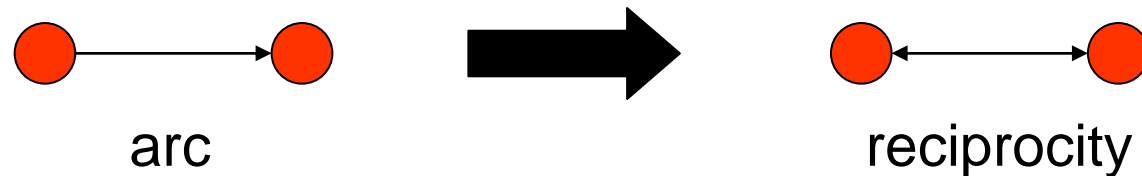
- Micro-level: **Hamming distance**
 - the number of ties that were changed during transitions
 - the degree in which each individual maintains the same relationships over time
 - When does relationships become stable?
- Macro-level: **network stationarity**
 - **no systematic changes in network processes in a time series**
 - no matter how each individual changes his/her relationships
 - meta-systems of relationship formation embedded in a network



Network processes

- **Dyad: a basis of relationships**

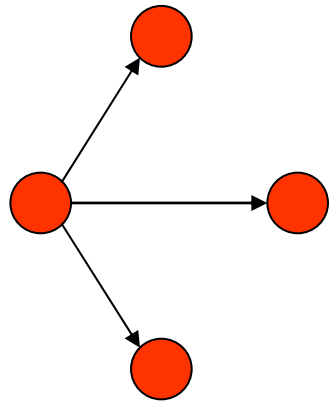
- mutual relationships: could be more intimate than non-mutual ones
- When do relationships become more mutual in a network?



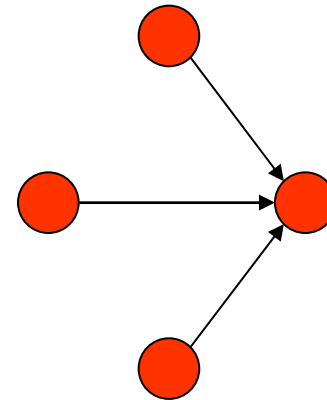


Network processes

- **Star: spreading/gathering relationships**
 - How do people become hubs in a network?



Out-star:
expansiveness

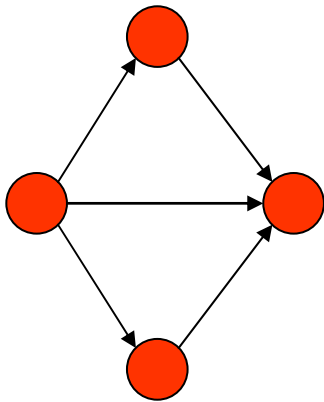


In-star:
popularity

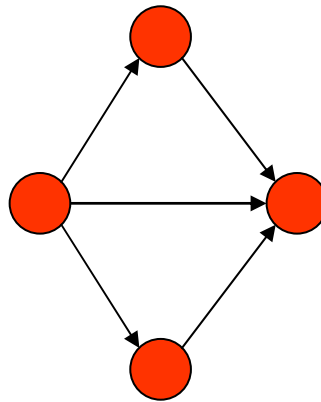


Network processes

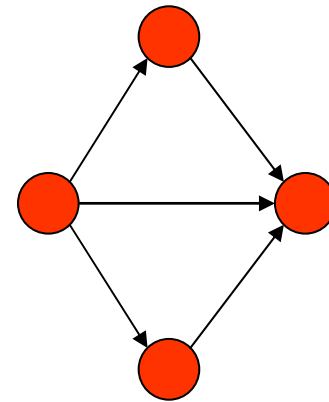
- **Triangulation: a basis of clustering**
 - How is a group formed?



In-star triangulation
(popularity effects)



Out-star triangulation
(expansiveness effects)



2-path triangulation
(indirect effects)

Types of friendship networks



- **Mediated communication**

- Compared to face-to-face relationships, how do relationships via mediated communication develop?

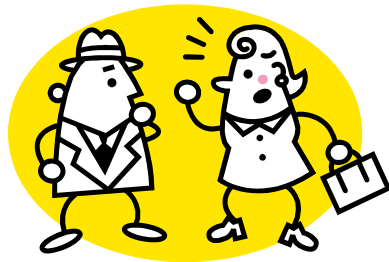
- **Message contents**

- Do self-disclosing relationships become more mutual/dyadic than greeting relationships? And how?
- Are greeting relationships more expanded than self-disclosing relationships? And how?



Mediated communication

- **Face-to-face communication**



- Verbal/nonverbal cues
- Synchronous
- Time/place constraint
- Much information
- Personal/public

- **Mobile phone text messages**



- Lack of nonverbal cues
- Asynchronous
- Anytime/anywhere
- Uncertainty
- Personal/dyadic



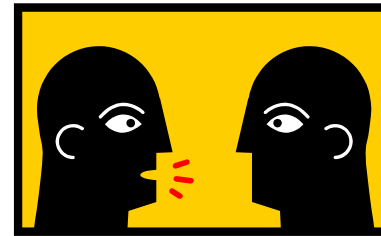
Message contents

- **Greeting**
(weak ties)



- Superficial
- Social/casual

- **Self-disclosing**
(strong ties)



- Intimate
- Personal/serious

Four types of friendship networks



		Contents	
		Greeting	Self-disclosing
Media	Face-to-face	Acquaintance relationships	Closest relationships
	Text messages	Superficial relationships	Close relationships

- We compared network processes in the four networks.

Network processes in each network

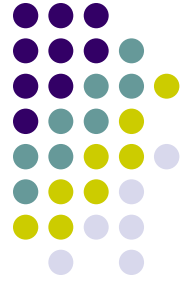


		Contents	
		Greeting	Self-disclosing
Media	Face-to-face	clustering →clustering (acquaintance)	clustering →reciprocal, dyadic (closest)
	Text messages	spreading →clustering (superficial)	spreading →dyadic (close)



How to examine?

- **Exponential random graph (p^*) models** (ERGM; Wasserman & Pattison, 1996)
 1. **probability models** that can effectively capture structural properties in social networks
 2. **simplify a complex structure** down to a combination of basic parameters
 3. **go beyond a dyadic independence assumption**
 4. recently expanded from Markov models to **higher-order models** (Snijders, Robins, Pattison, & Handcock, 2006)



ERGM

- **Advantage**

- beyond descriptive statistics
 - allow us to test significance of structural parameters
- theory-driven modeling

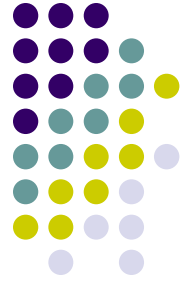
- **Disadvantage**

- estimation time
- difficult to get convergence (sometimes)
- interpretations of parameter combination



Longitudinal ERGM

- Models for longitudinal networks
 - Actor-oriented models
 - “**The actors** in the network evaluate the network structure and try to obtain a pleasant configuration of relations (Snijders, 2001, p. 363).”
 - **Network-oriented models (this study)**
 - **Surroundings** in the network affect existence of ties.
 - parameter estimation
 - Parameters describe changes in a network from t_{k-1} to t_k
 - **Not modeling a network at t_{k-1} , but modeling the transition to t_k given a started network at t_{k-1}**
 - based on multiple simulation



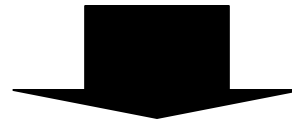
Evidence for stationarity

Cross-sectional ERGM

based on a single observation of a network

Longitudinal ERGM

based on evolution from a fixed initial network to a target network

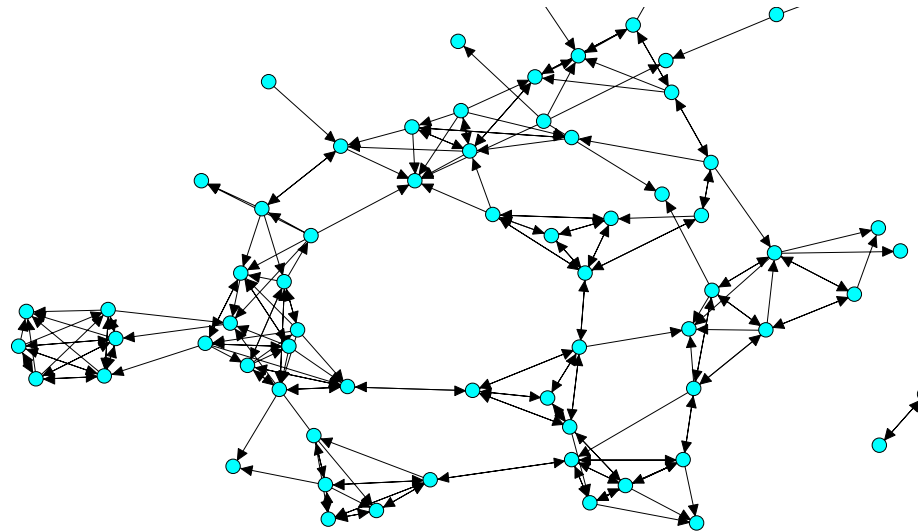


If the parameter estimates in cross-sectional ERGM are different from those in longitudinal ERGM, network processes at each period would be changed;
evidence for non-stationarity

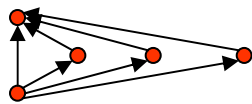
If the parameter in cross-sectional ERGM correspond with those in longitudinal ERGM, network processes would be consistent;
evidence for stationarity.



Example



T1



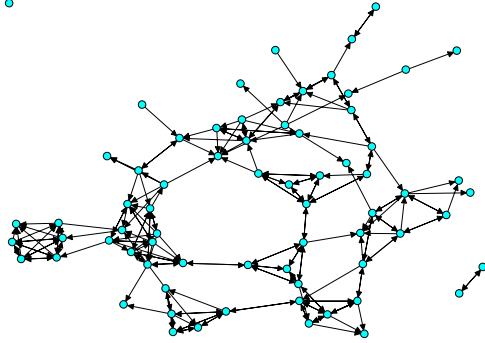
TK-triangle

estimates in cross-sectional ERGM: **positive**

- more triangles in the network than by chance, but unsure if the triangulation tendency is consistent over time

TK-triangle estimates

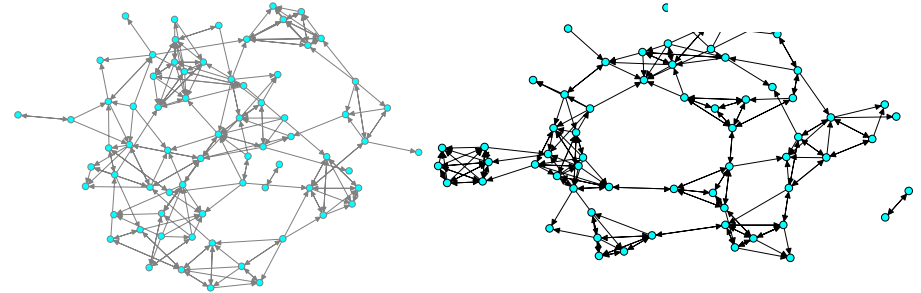
Cross-sectional ERGM



T1

no assumptions about an initial state of a network

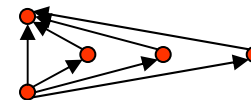
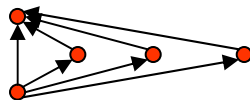
Longitudinal ERGM



T0

T1

modeling the transition to T1 given a started network at T0



an increased tendency of triangulation during the transition
(changes in network process)

→ failed to capture

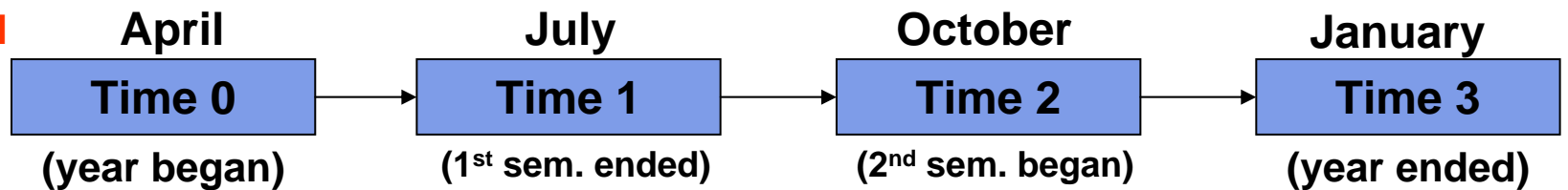
→ successfully captured

Dataset

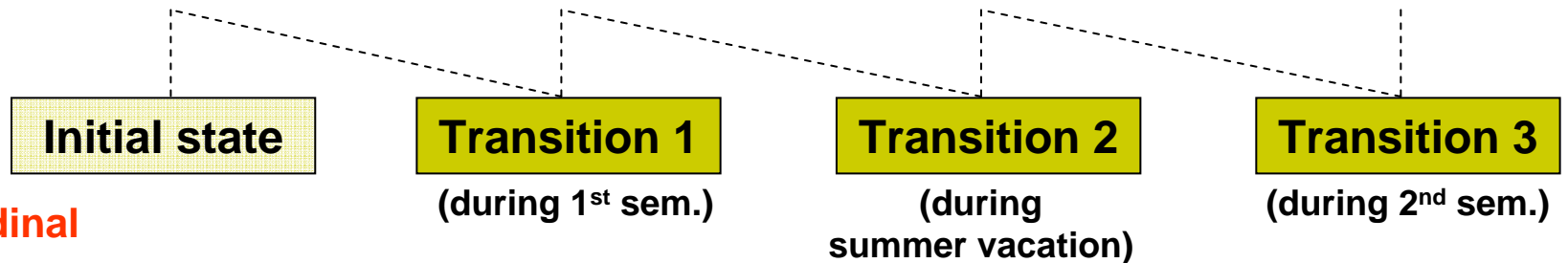


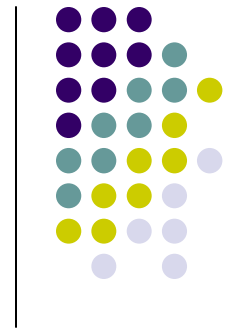
- 70 first year education undergraduates (11 M, 59 F) in central Japan (no missing values)
- chose up to five friends at each of the four periods

cross-sectional

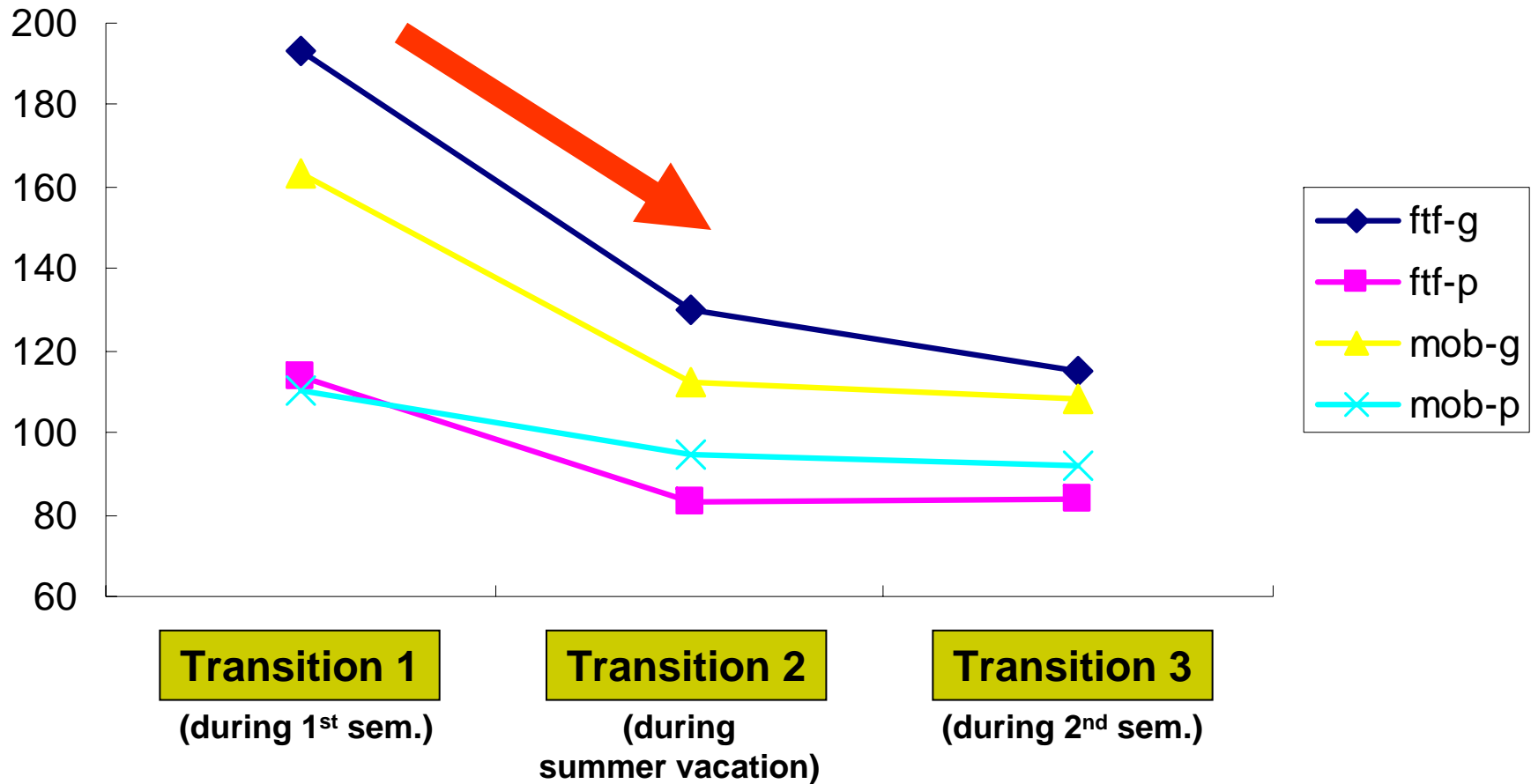


longitudinal





Hamming distance

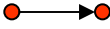
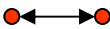
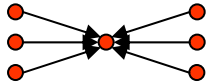
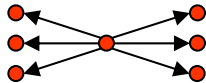
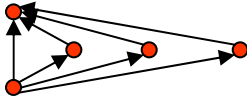
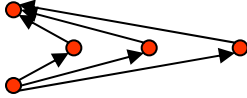




Comparing the estimates of cross-sectional ERGM to those of longitudinal ERGM

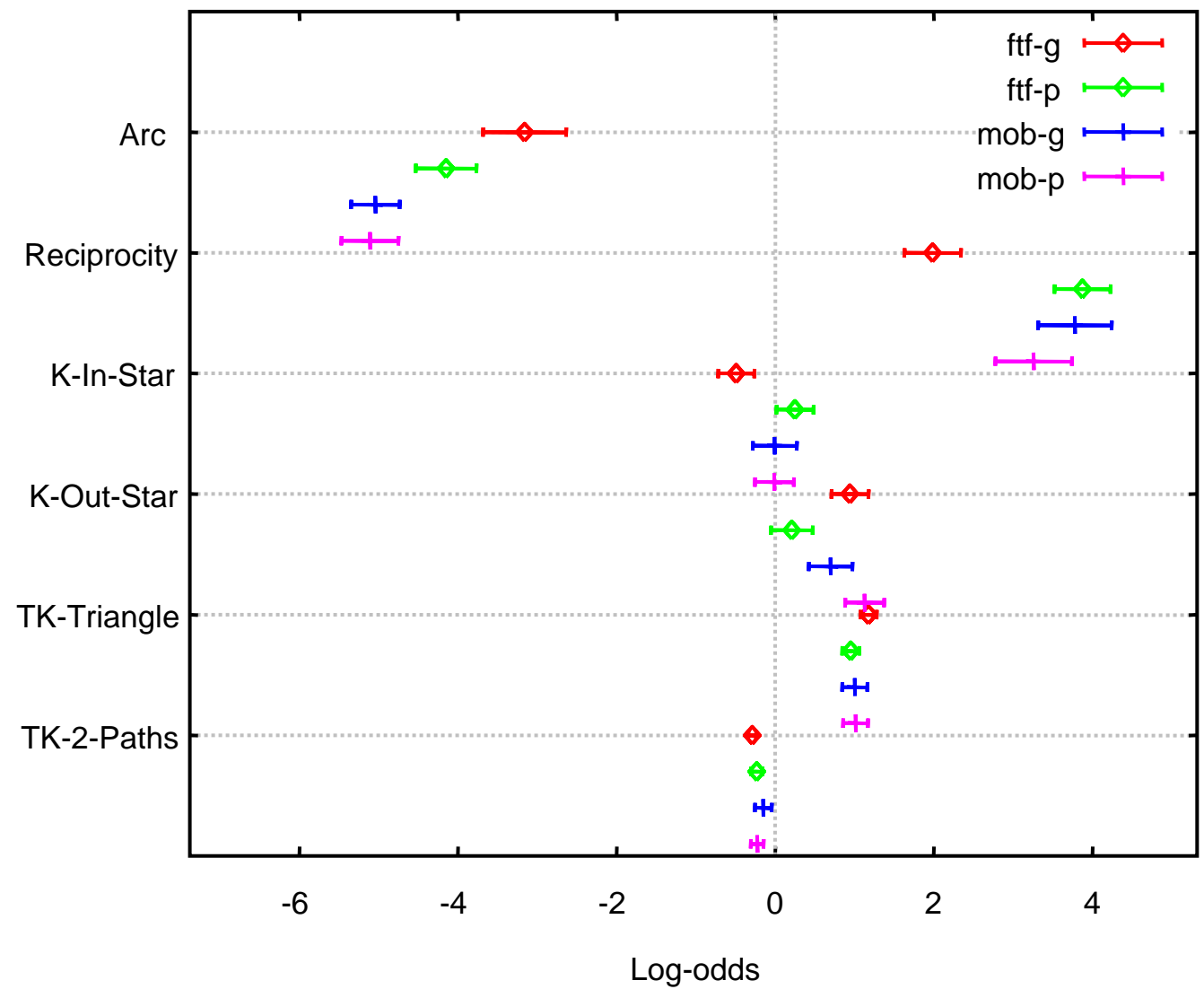
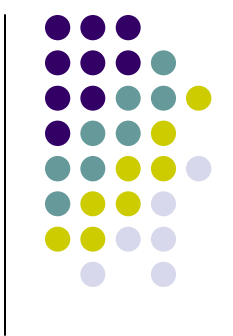


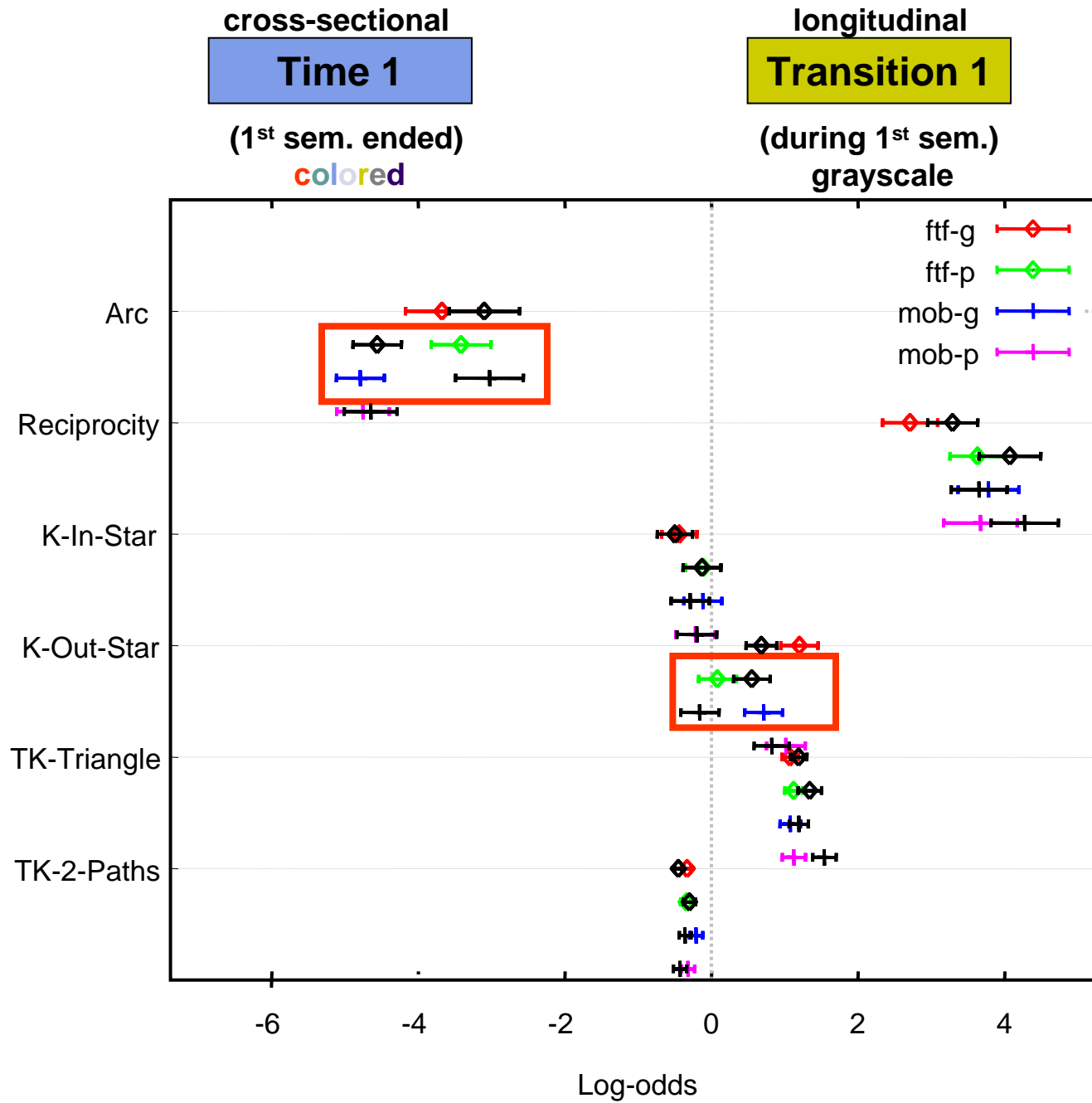
Parameters in the model

Arc (<i>nomination without mutuality</i>)	
Reciprocity (<i>mutuality</i>)	
K-in-star (<i>popularity</i>)	
K-out-star (<i>expansiveness</i>)	
TK-Triangle (<i>transitive triangles</i>)	
TK-2-path (<i>transitive indirect paths</i>)	

Estimated by Pnet and LPnet (Wang, Robins, & Pattison, 2005)

cross-sectional
Time 0
(year began)



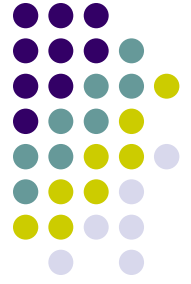


Transition 1 (during 1st semester)



- Face-to-face self-disclosing networks
 - Compared to longitudinal estimates, cross-sectional estimates were
 - **higher: arc**
 - **lower: K-out-star**
 - Time 0: some hubs but not many
 - **From Time 0 to Time 1, more hubs were newly formed during the transition.**
 - Some individuals were becoming more active to form self-disclosing ties.
 - might try to find a “good mate” among new friends

Transition 1 (during 1st semester)



- Text-messaging greeting networks
 - Cross-sectional estimates were
 - **higher: K-out-star**
 - **lower: arc**
 - **Negative estimates of K-out-star: some declines in hubs during the 1st semester**
 - No additional hubs were created.

cross-sectional

Time 2

(2nd sem. began)

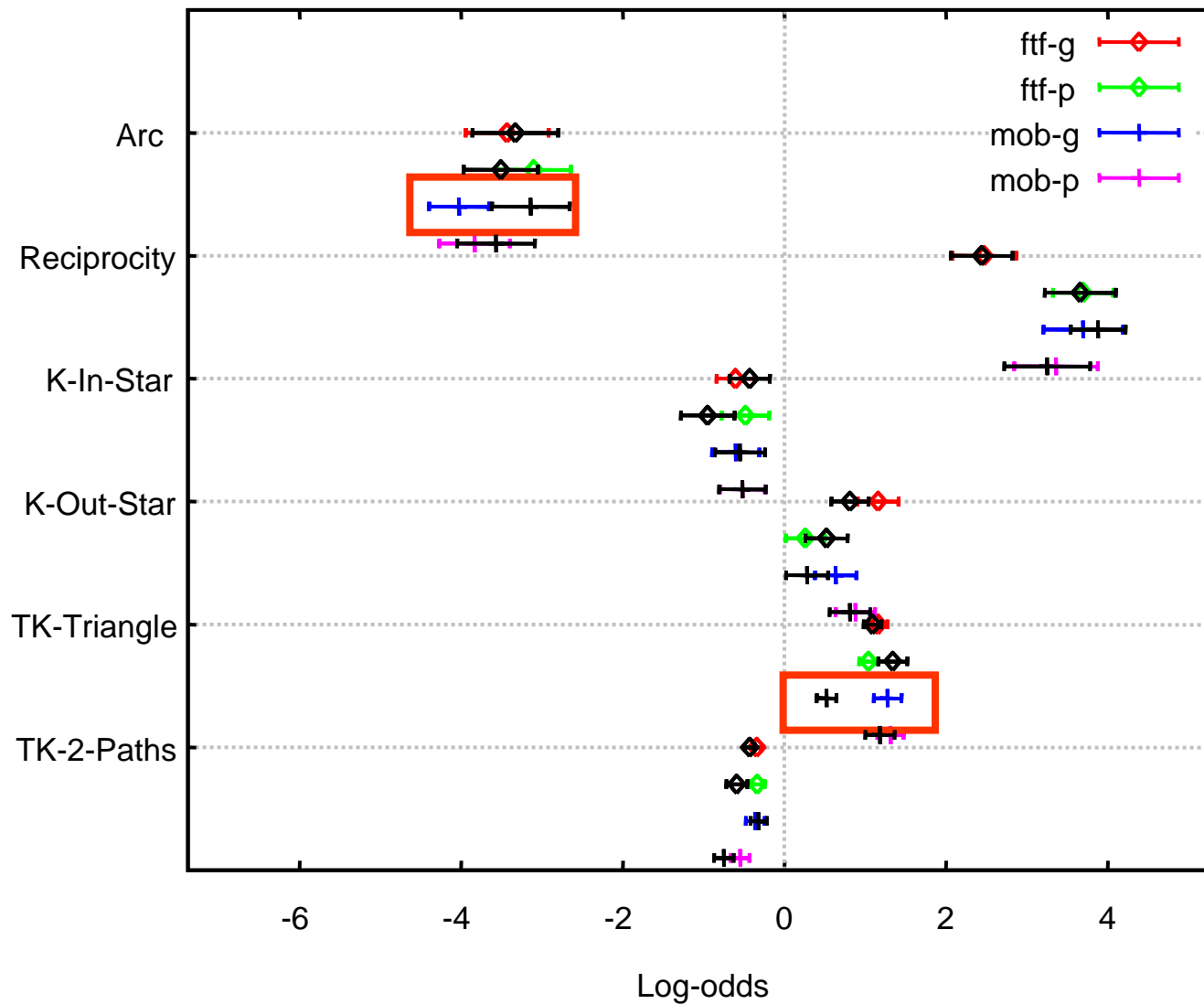
colored

longitudinal

Transition 2

(during summer vacation)

grayscale



Transition 2 (during summer vacation)



- Text-messaging greeting networks
 - Cross-sectional estimates were
 - **higher: TK-triangle**
 - **lower: arc**
 - During the summer vacation, some of triangulations via text messages were breaking down, though there were still a lot of triangulations (i.e. the positive estimate of TK-triangle).
 - easily re-assessed superficial and casual relationships
- In other networks, network processes were stationary (not changed) during the summer vacation.

cross-sectional

Time 3

(2nd sem. ended)

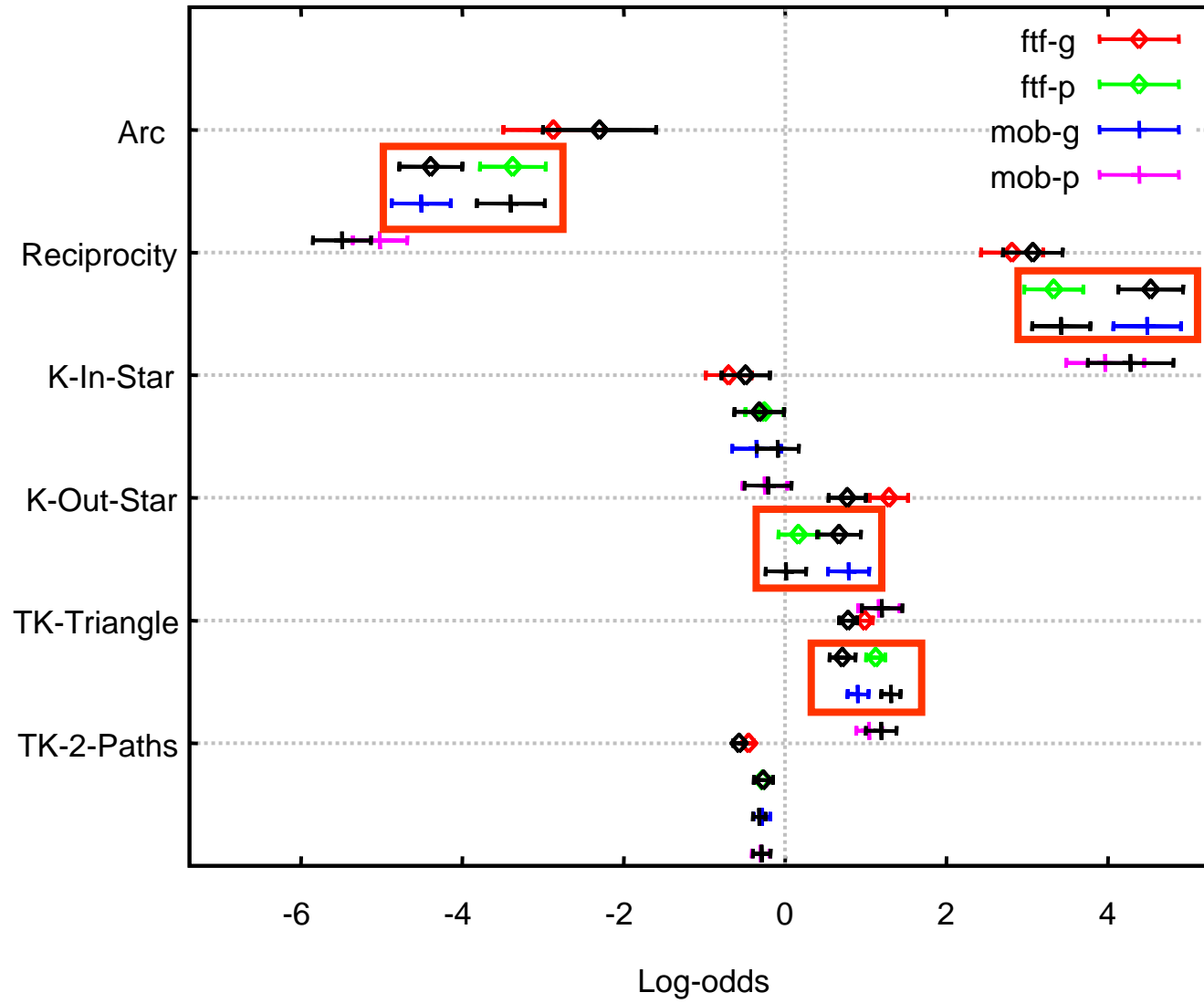
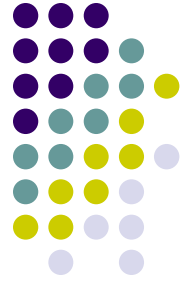
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longitudinal

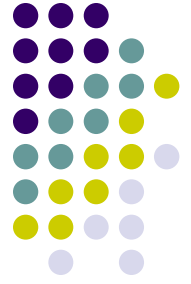
Transition 3

(during 2nd sem.)

grayscale

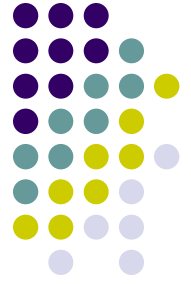


Transition 3 (during 2nd semester)

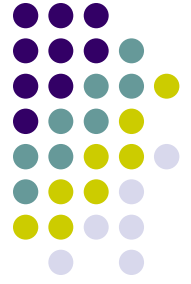


- Face-to-face self-disclosing networks
 - Cross-sectional estimates were:
 - **higher: arc, TK-triangle**
 - **lower: reciprocity, K-out-star**
 - Triangulation was breaking down during the 2nd semester, whereas hubs were newly created.
 - emerging from triangulation into dyadic relationships (more reciprocated and expanded)

Transition 3 (during 2nd semester)

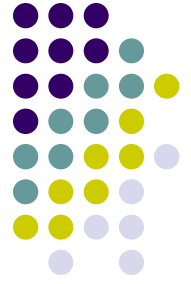


- Text-messaging greeting networks
 - Cross-sectional estimates were:
 - higher: **reciprocity, K-out-star**
 - **lower: arc, TK-triangle**
 - Once triangulation declined during the summer vacation, more triangles were newly formed again during the 2nd semester.
 - Emerging into clustering with less reciprocal and expanded tendencies



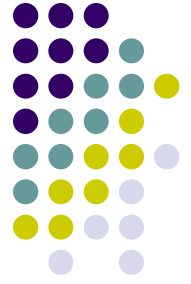
Summary

- individual level (Hamming distance)
 - Friendship nomination of each individual were changed over time, but somewhat stable after Tr2.
- macro level (network stationarity)
 - There were some evidence in stationarity in some networks (face-to-face greeting networks and text-message mediated self-disclosing networks)
 - In all networks, network process (e.g., norms, rules and cultures) were sustained across the summer vacation.



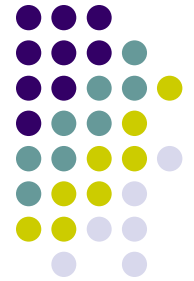
Summary

- Face-to-face greeting networks
 - stationary over time
- Face-to-face self-disclosing networks
 - more hubs → stationary → dyadic, reciprocal, more hubs
- Text-message mediated greeting networks
 - declines in hubs → less clustering → more clustering, non-reciprocal, less hubs
- Text-message mediated self-disclosing networks
 - stationary over time



Future implications

- Multiple networks
 - network overlaps and effects
- Exogenous effects
 - Psychological/cultural/social factors
- Comparison with actor-oriented models



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