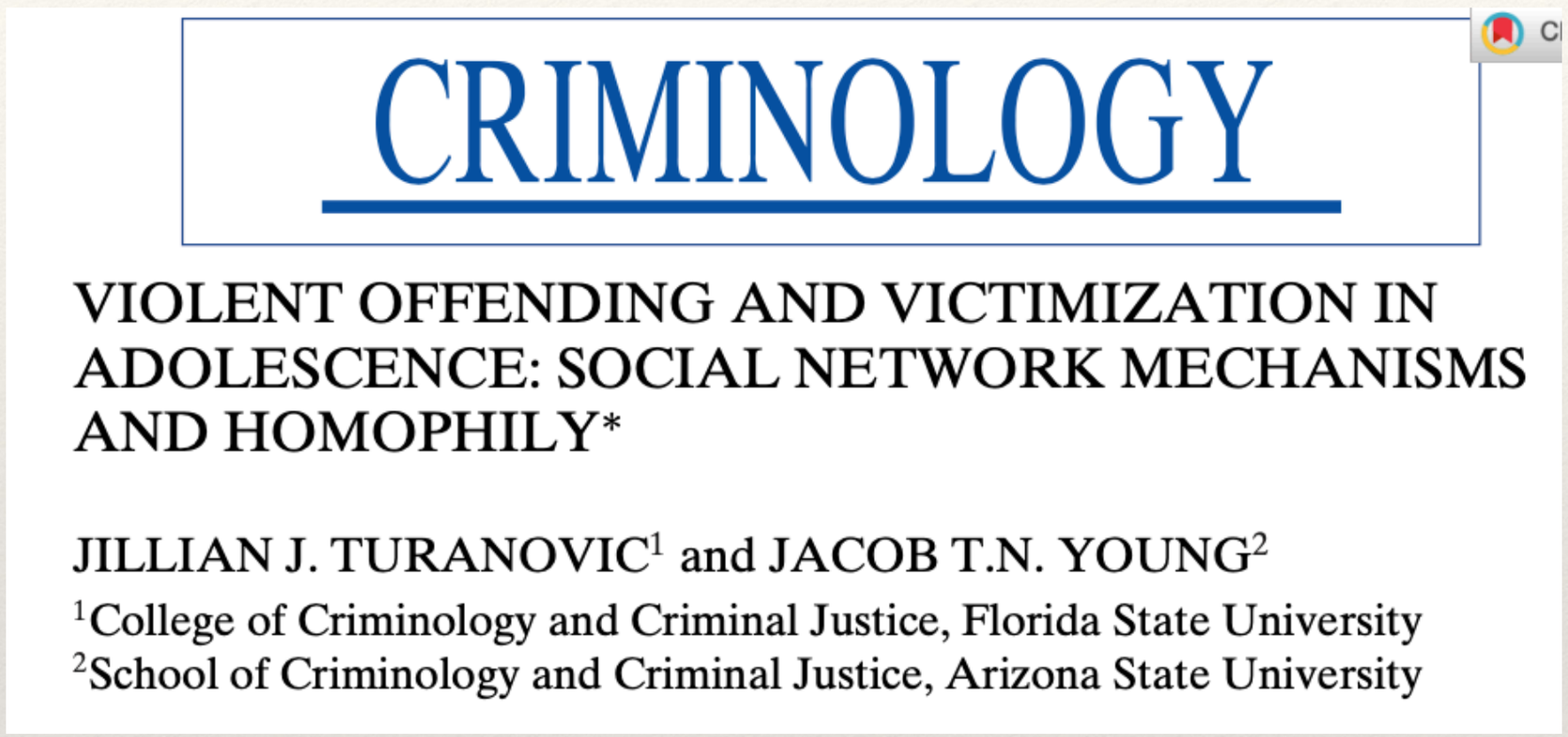
Statistical Analysis of Networks

Introduction to Stochastic Actor-Based Models

Motivating Example

- Victim/Offender overlap: a curious phenomenon
  - Why do victimization and offending tend to co-occur?

Motivating Example



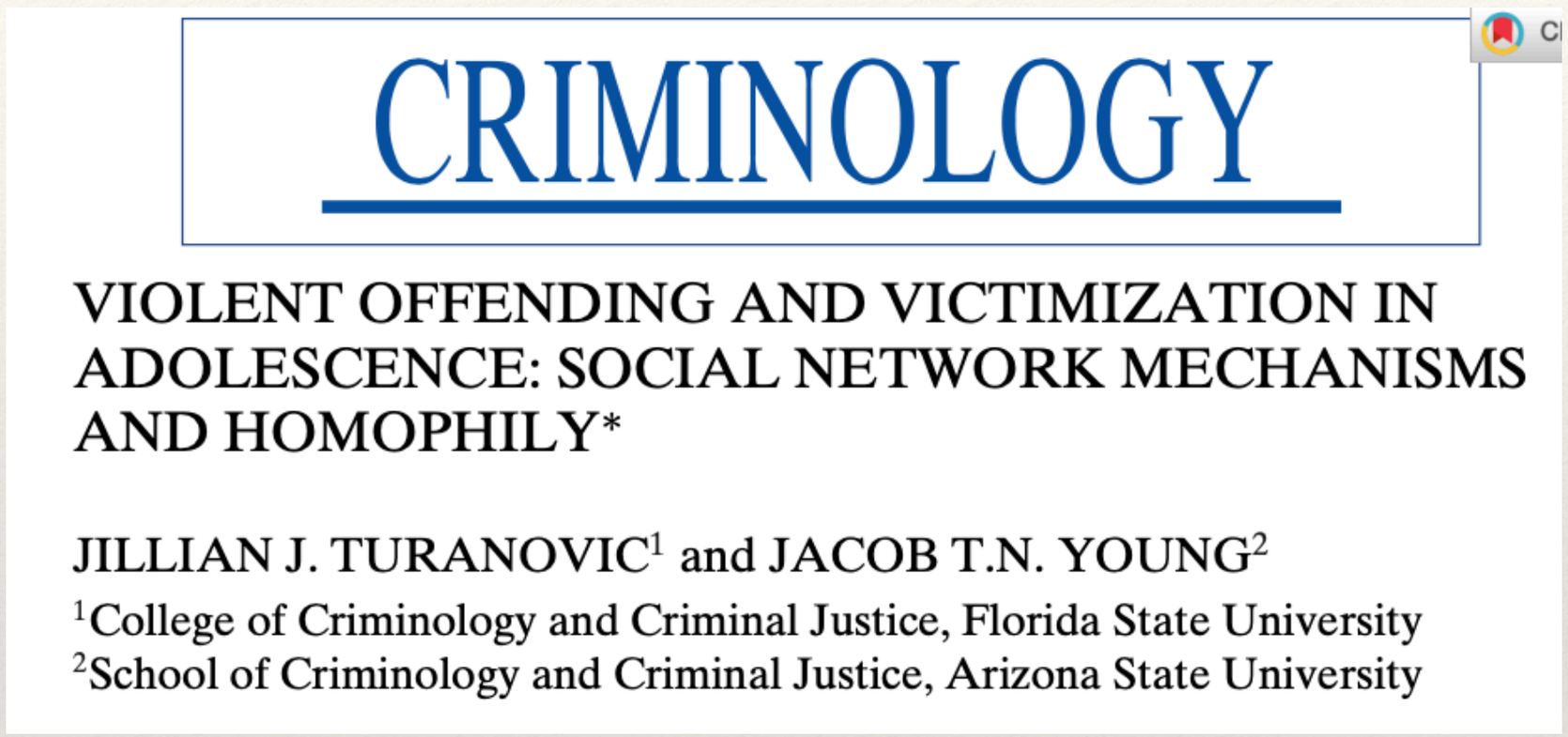
CRIMINOLOGY

VIOLENT OFFENDING AND VICTIMIZATION IN ADOLESCENCE: SOCIAL NETWORK MECHANISMS AND HOMOPHILY*

JILLIAN J. TURANOVIC[1] and JACOB T.N. YOUNG[2]
[1]College of Criminology and Criminal Justice, Florida State University
[2]School of Criminology and Criminal Justice, Arizona State University

- As a network question:
  - Why is there homophily for victimization? Offending?
    - *What do the authors say?*

Motivating Example



CRIMINOLOGY

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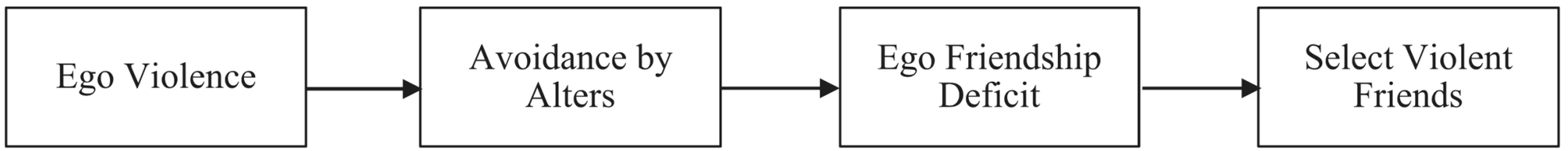
- Interpersonal relational decision making shapes these outcomes.
  - But, this can occur through different mechanisms.

Motivating Example

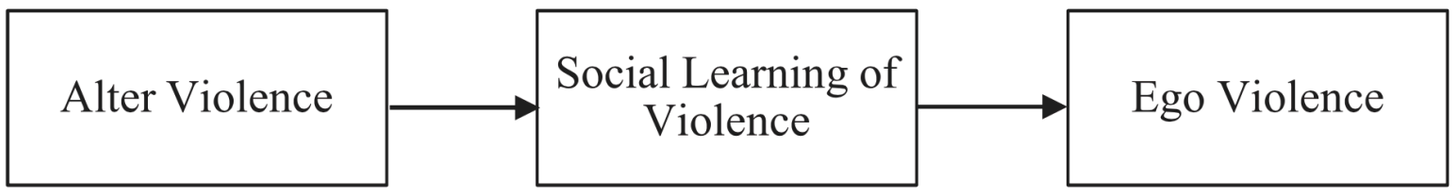
Figure 1. Mechanisms of Violent Offending Homophily

a Violence homophily through preference for similarity:

b Violence homophily through avoidance:



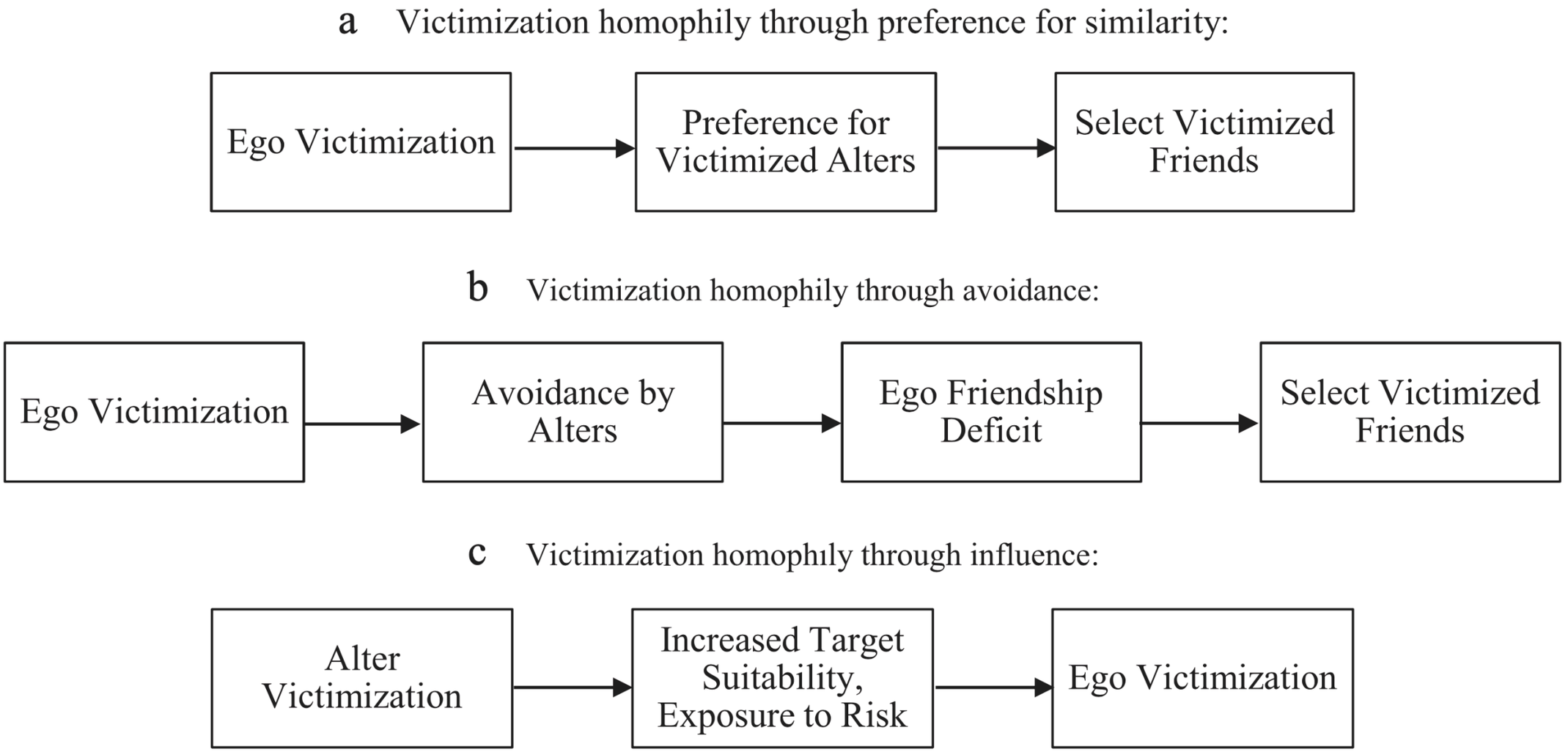
c Violence homophily through influence:



NOTE: "Ego" refers to the focal individual; "alter" refers to potential friends.

Motivating Example

Figure 2. Mechanisms of Violent Victimization Homophily



NOTE: "Ego" refers to the focal individual; "alter" refers to potential friends.

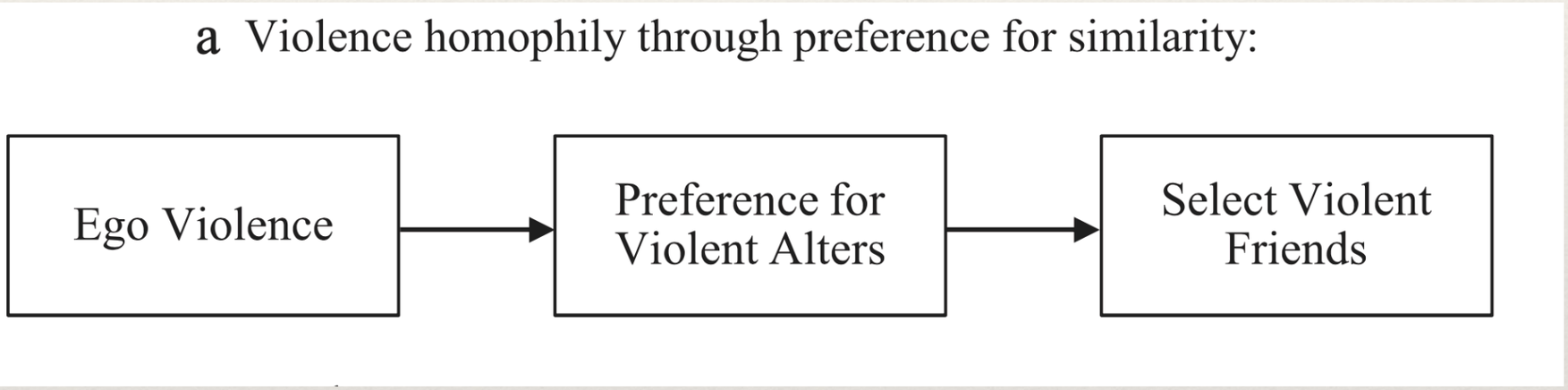
Motivating Example

- What are the findings?

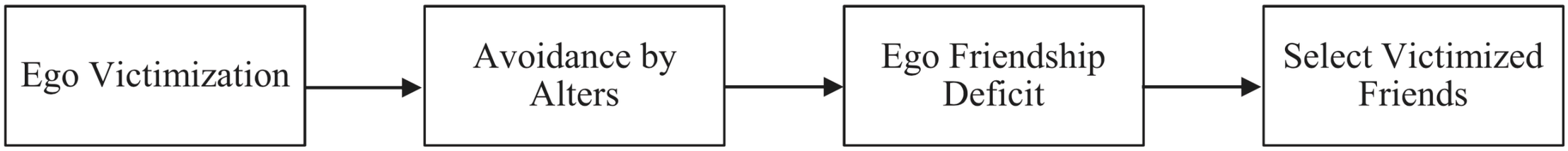
Motivating Example

- What are the findings?

a Violence homophily through preference for similarity:



b Victimization homophily through avoidance:



Motivating Example

- How did the authors go about coming to these conclusions?
- Stochastic Actor-Based Models!

Statistical Analysis of Networks

Introduction to Stochastic Actor-Based Models

Learning Goals

- By the end of this lecture, you should be able to answer these questions:
  - What is the difference between Exponential Random Graph Models (ERGMS) and Stochastic Actor-Based Models (SABMs)?
  - What is the logic of *micro-steps* and the simulation of networks using the **rate** function?
  - What is the logic of *preferences* and the simulation of networks using the **objective** function?

Introduction

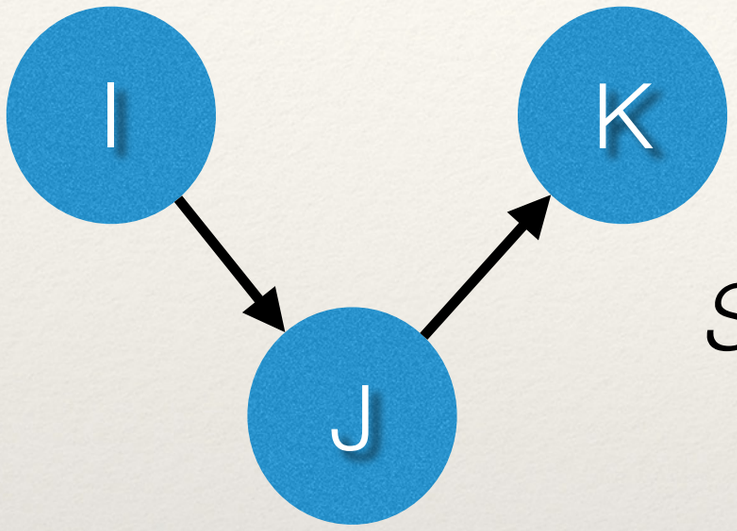
- With ERGMs, we asked: "what are the network configurations that generated this network?"
- We reviewed models that are "edge-based" in the sense that the probability of an edge is dependent (or not) on other edges in the network.
  - Remember *dyadic-dependence*?

Introduction

- ERGMs are for a single cross-section of a network.***
  - But, what if we have a **panel** of networks?

What do we mean by “network dynamics”?

Network Dynamics



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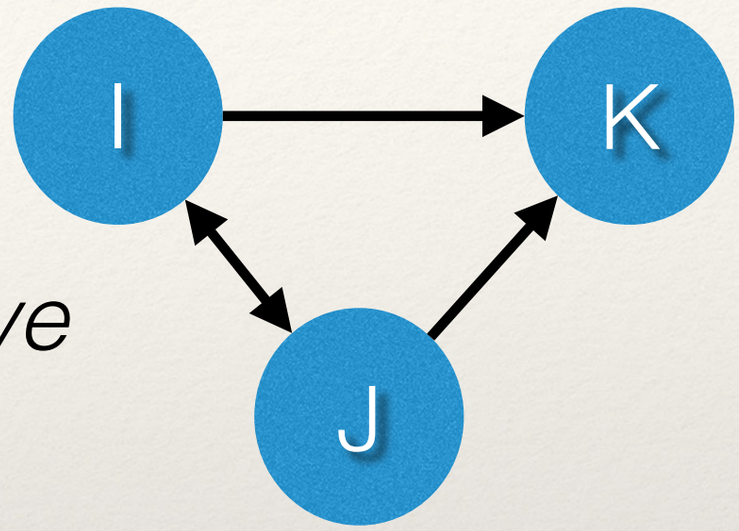
Suppose we observe two discrete time points.



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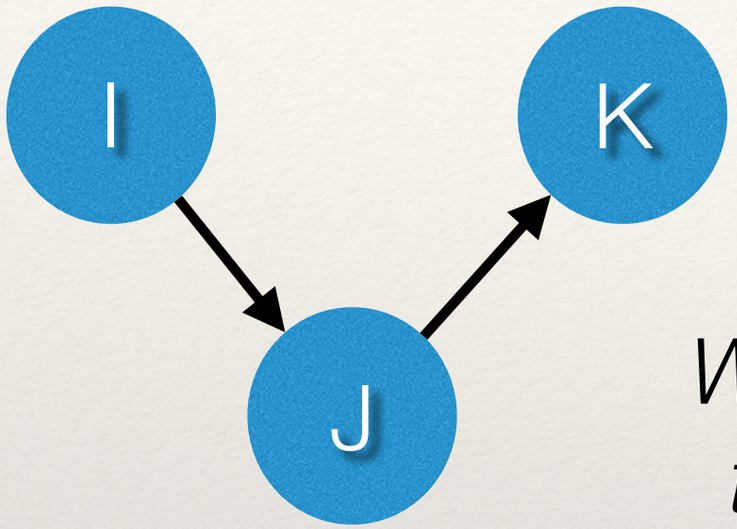
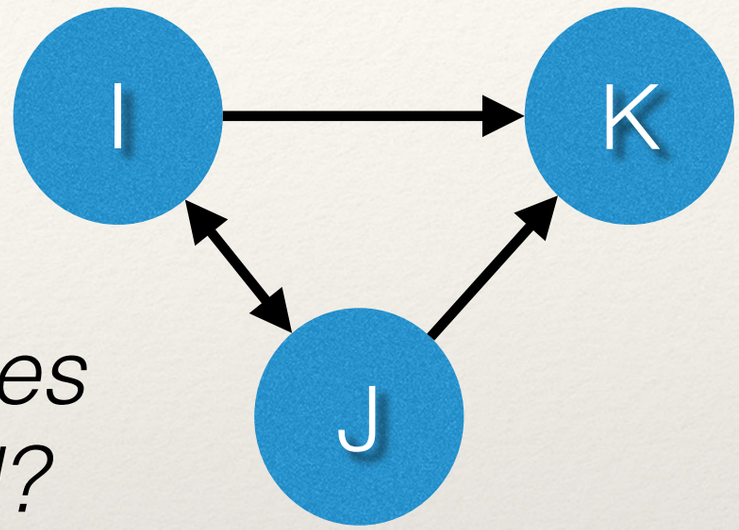
Network Dynamics



What are the changes that have occurred?



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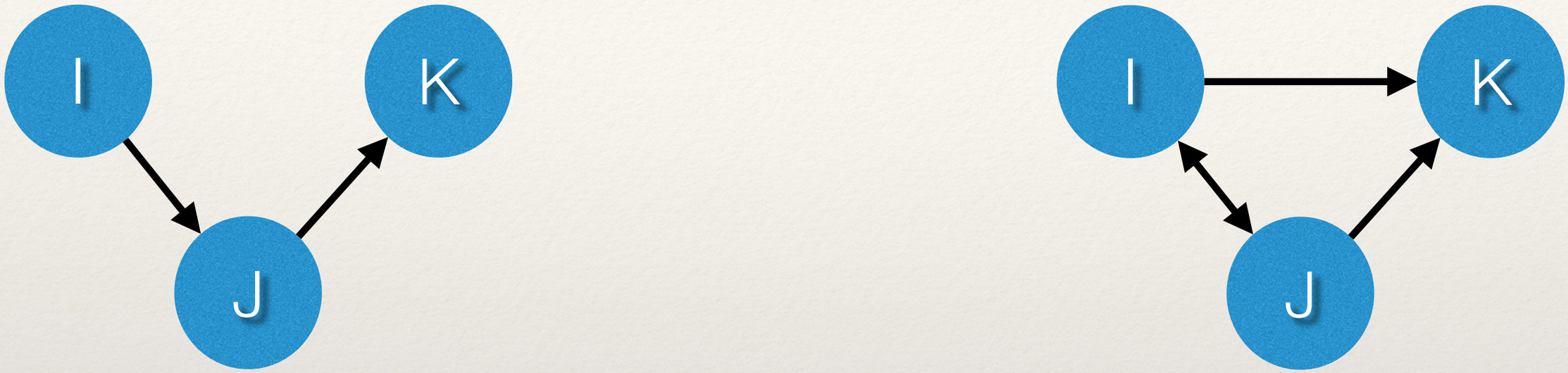
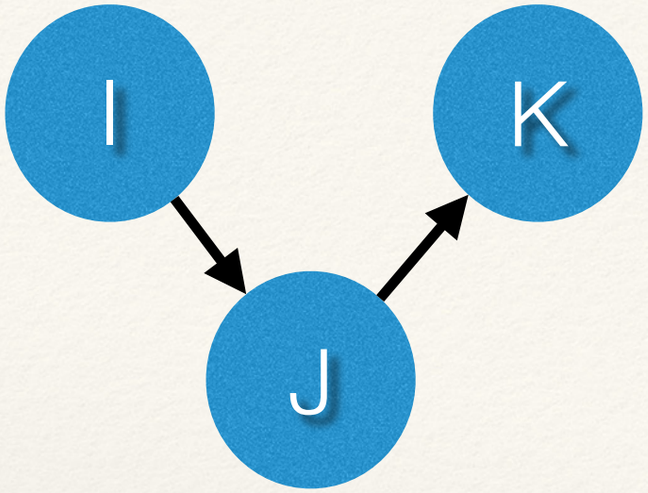
Network Dynamics



t *t + 1*

How did those changes happen?



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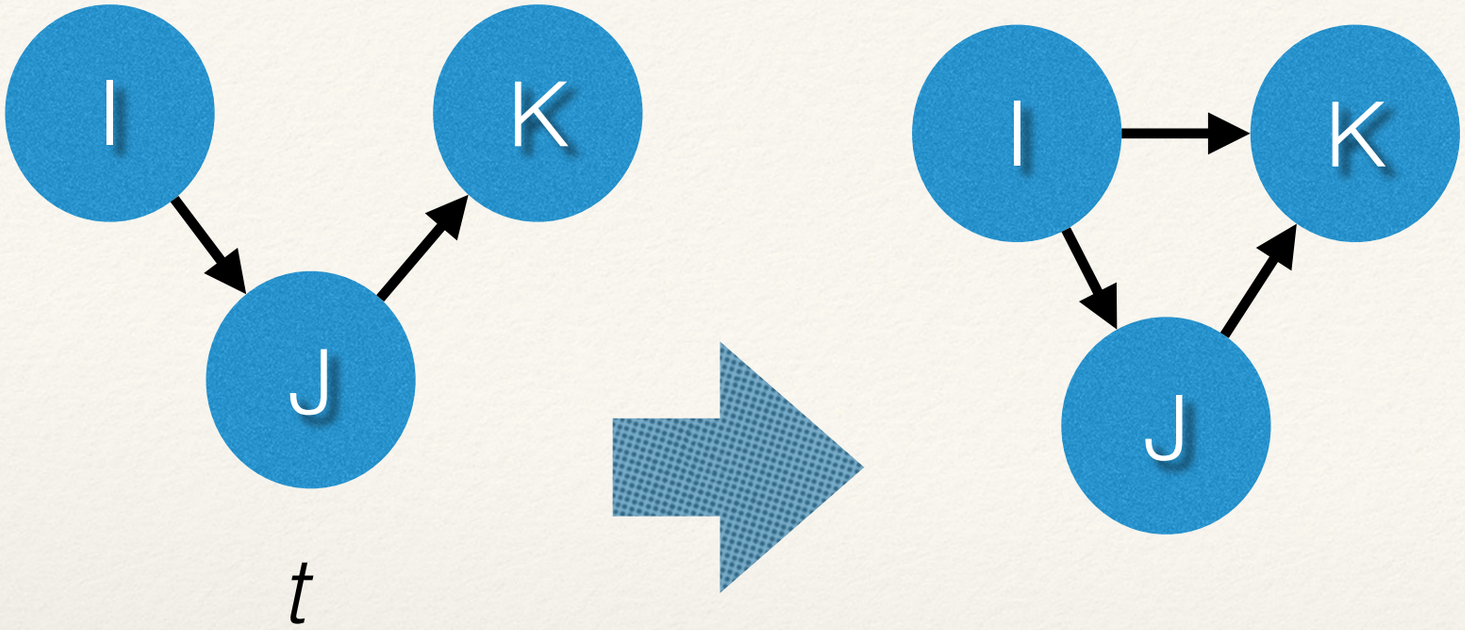

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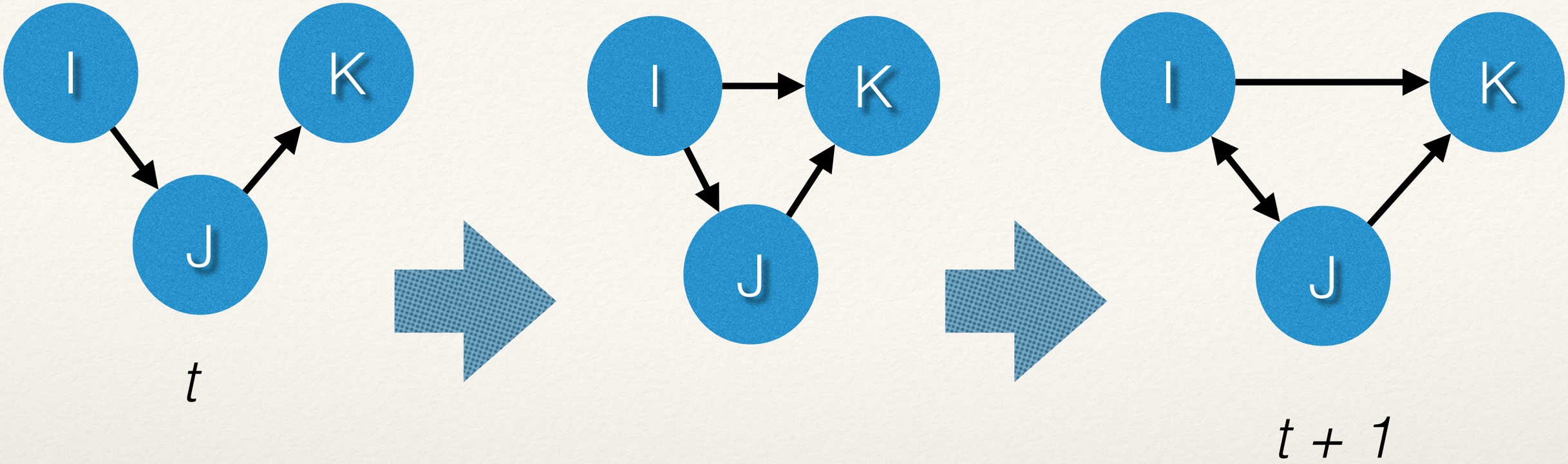

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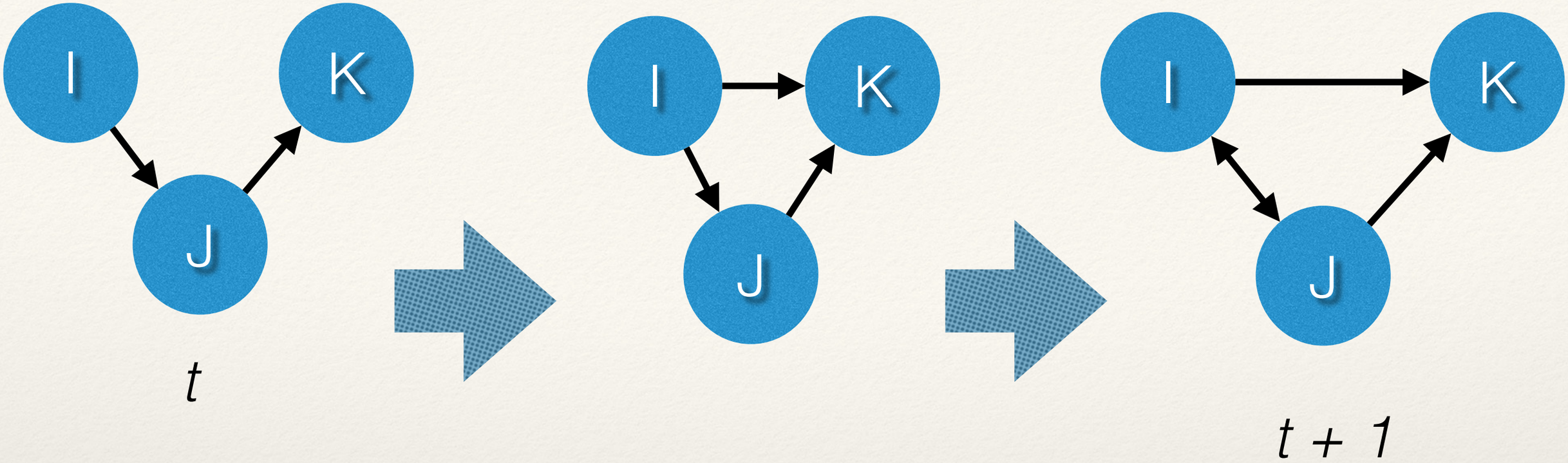

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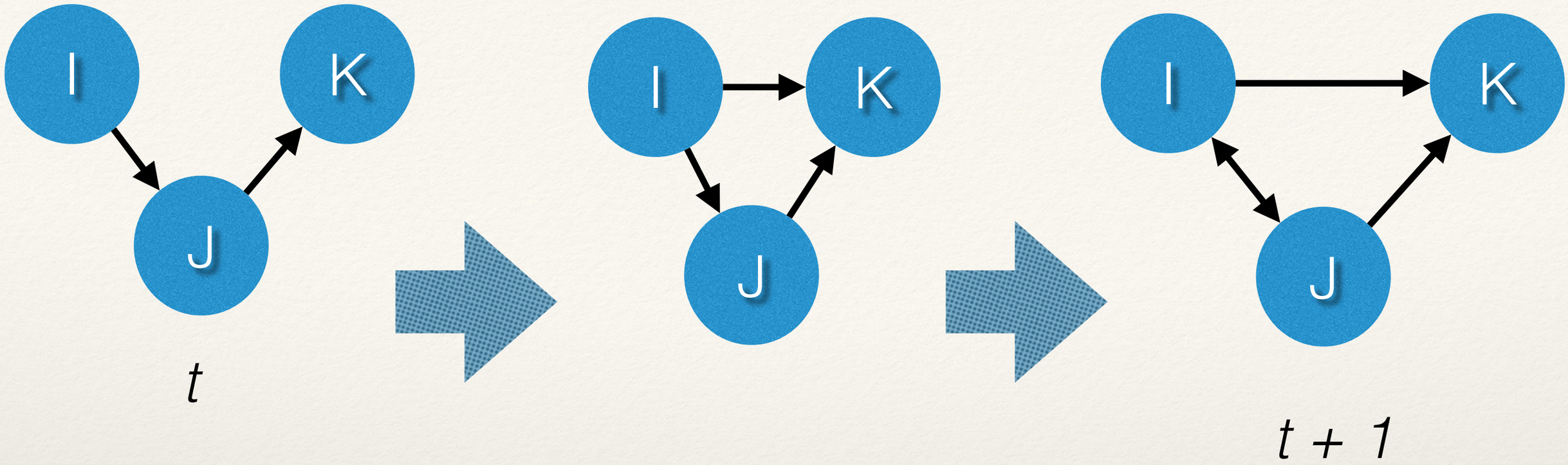
Or…



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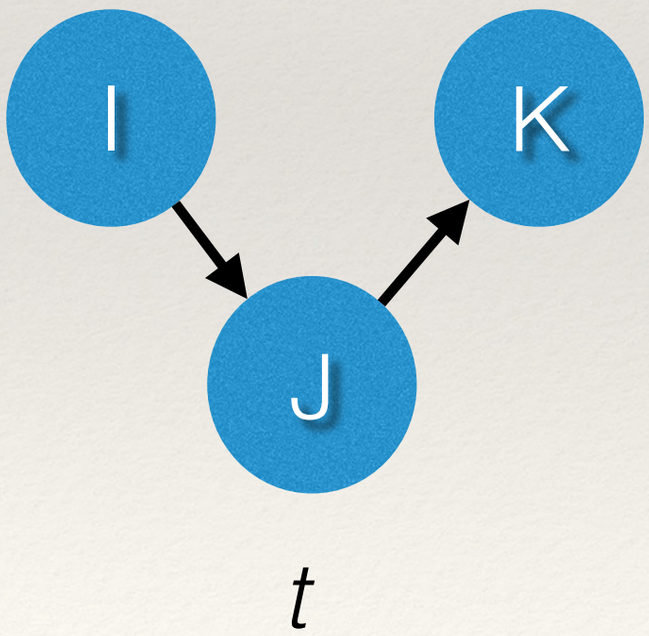

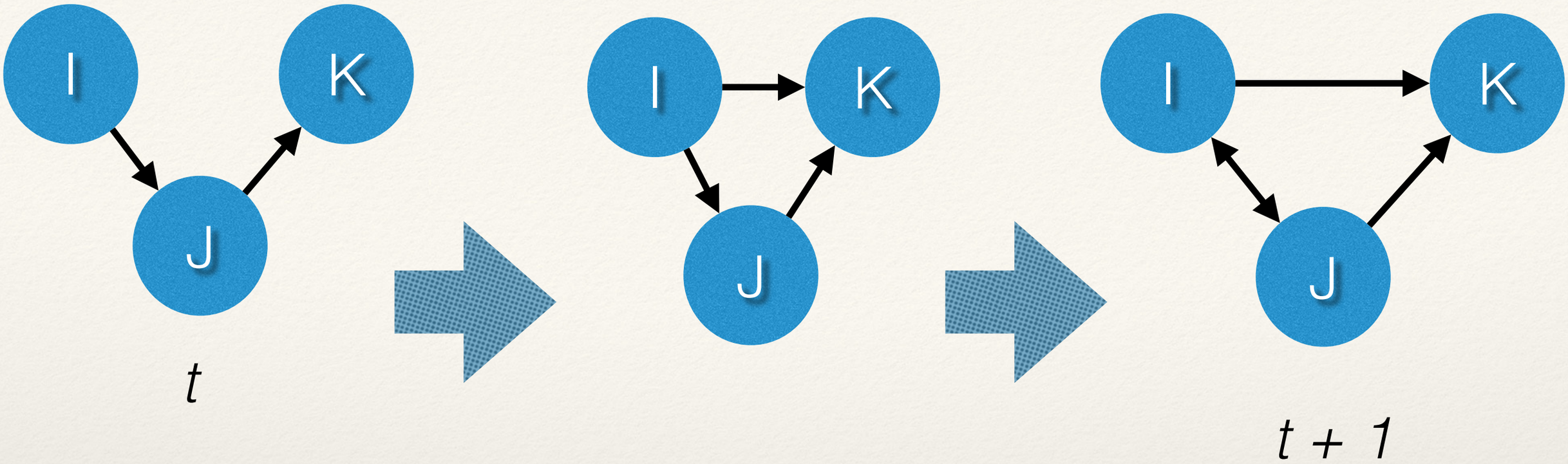

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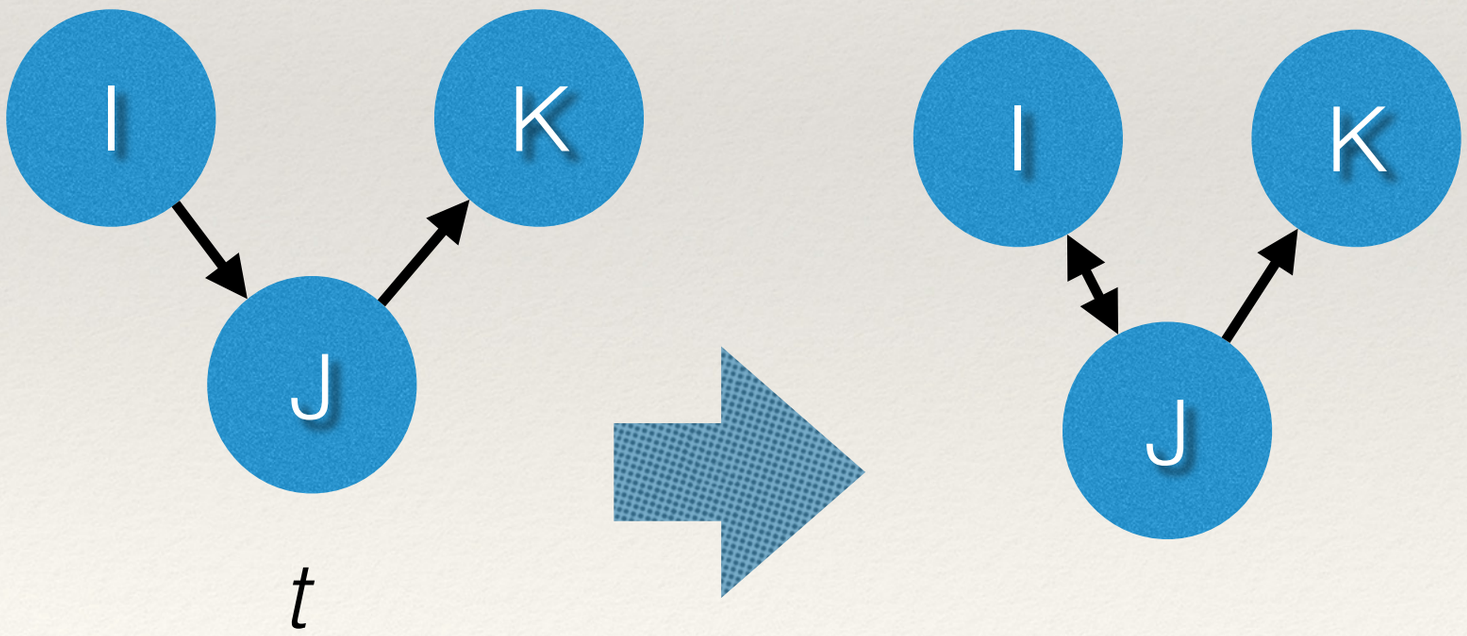

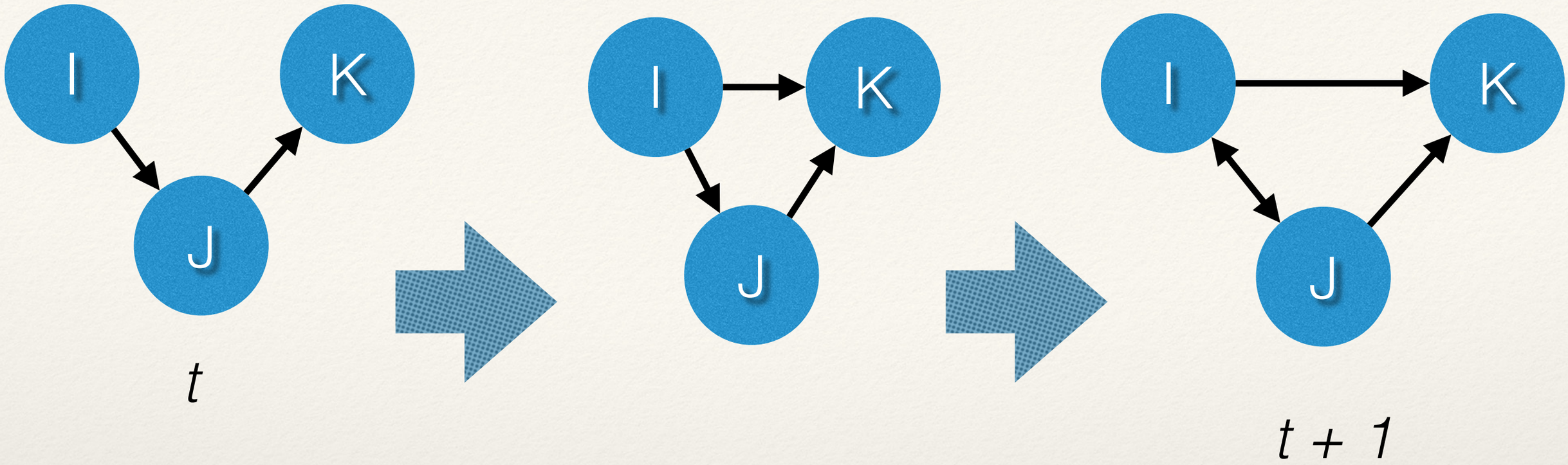

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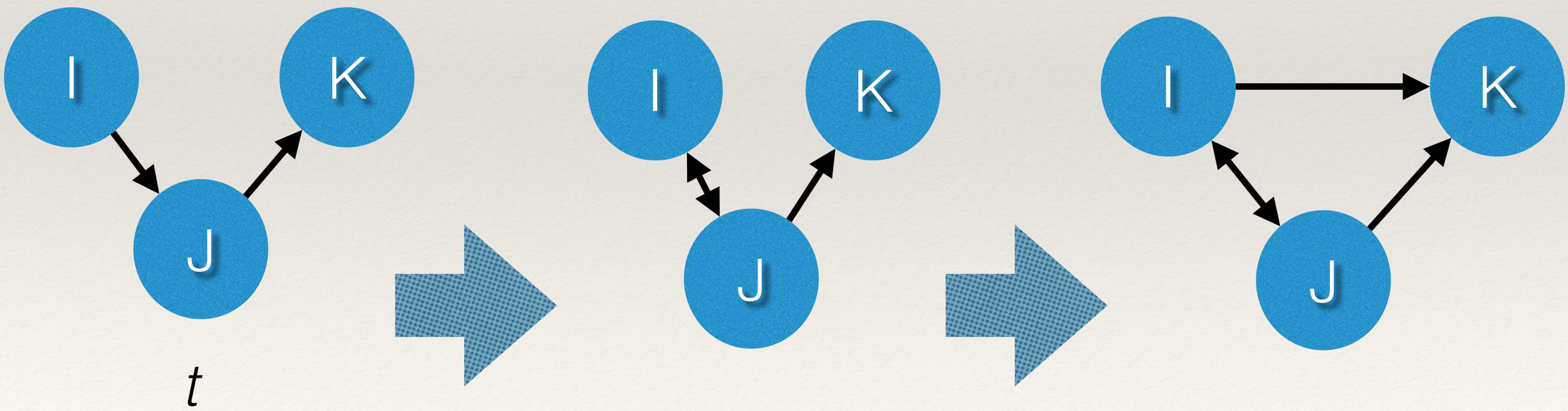
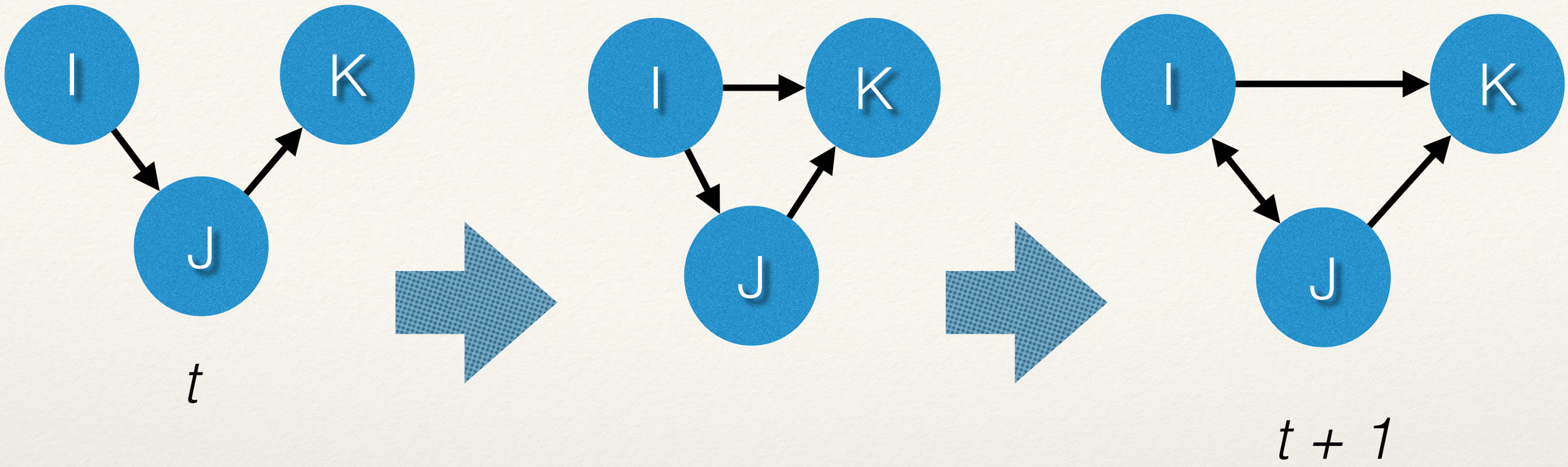
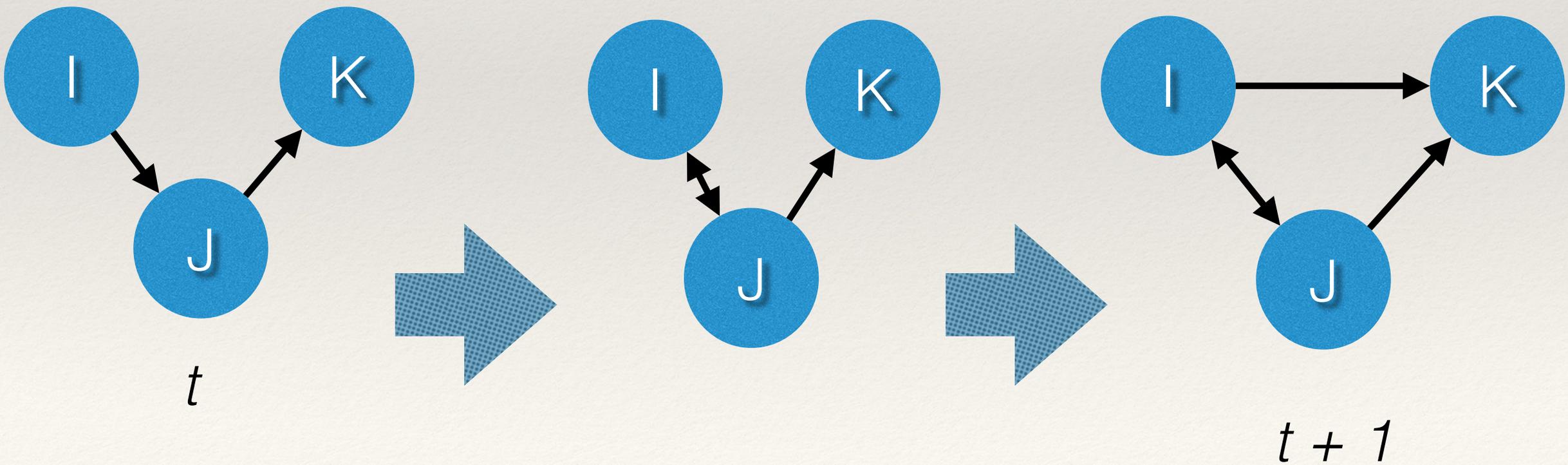
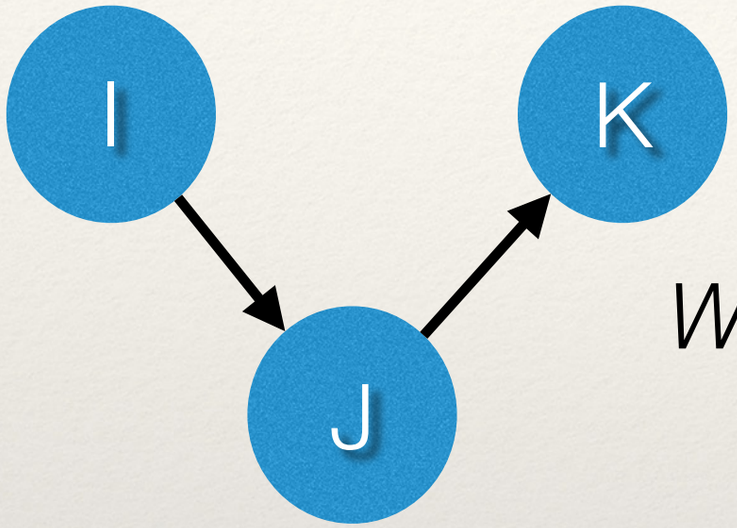




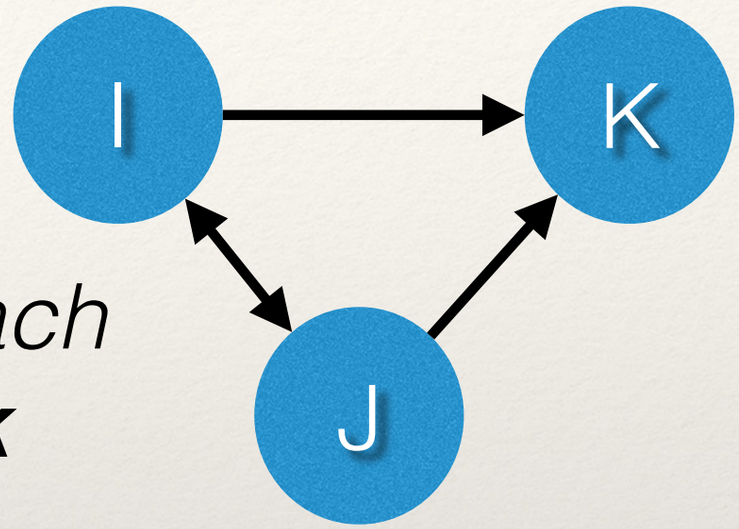
Both are different sequences.



Network Dynamics



We don't observe each step with ***network panel data***



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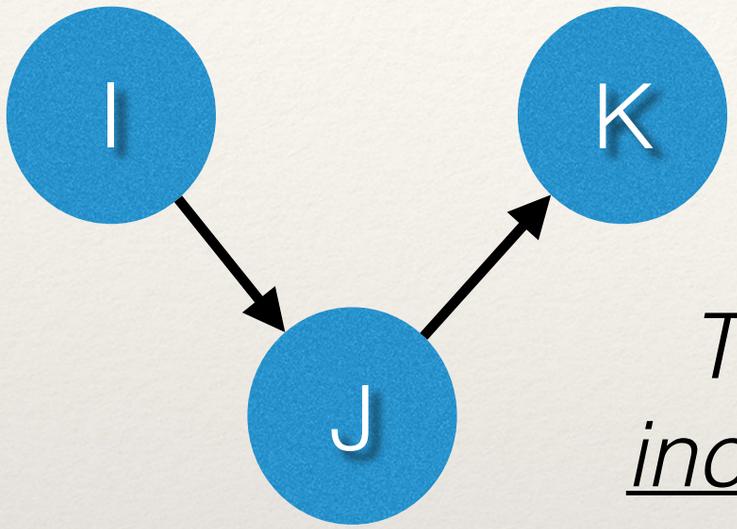
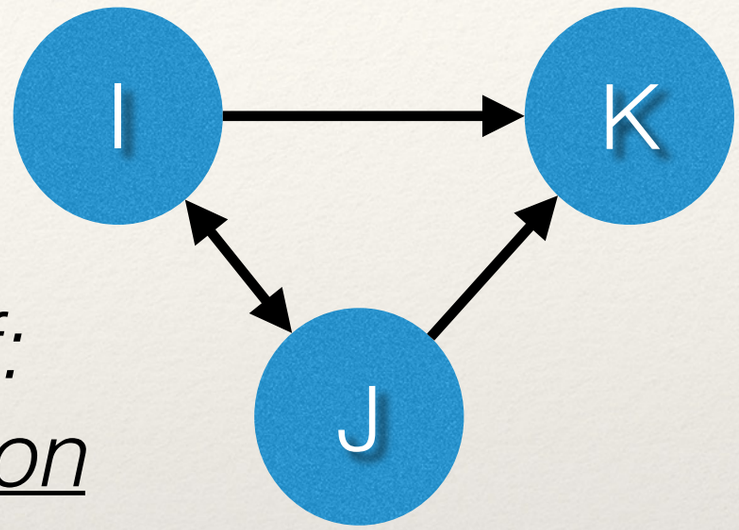
t + 1

Network Dynamics





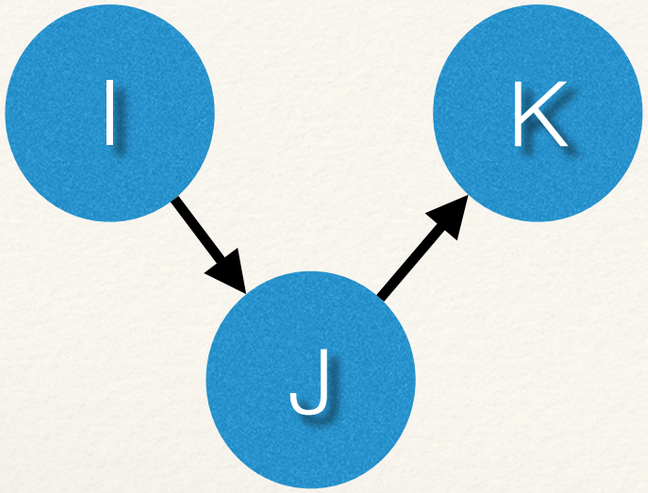
This is a problem of:
<u>incomplete observation</u>
<u>of change</u>

t *t + 1*

We want to model
these dynamics as
<u>micro steps</u>

What is a "micro-step"?

- Uniquely identify actors
- Actors control and decide about the tie variable
  - (*Note the difference from an ERGM*):
    - "actor-based" vs. "edge-based"



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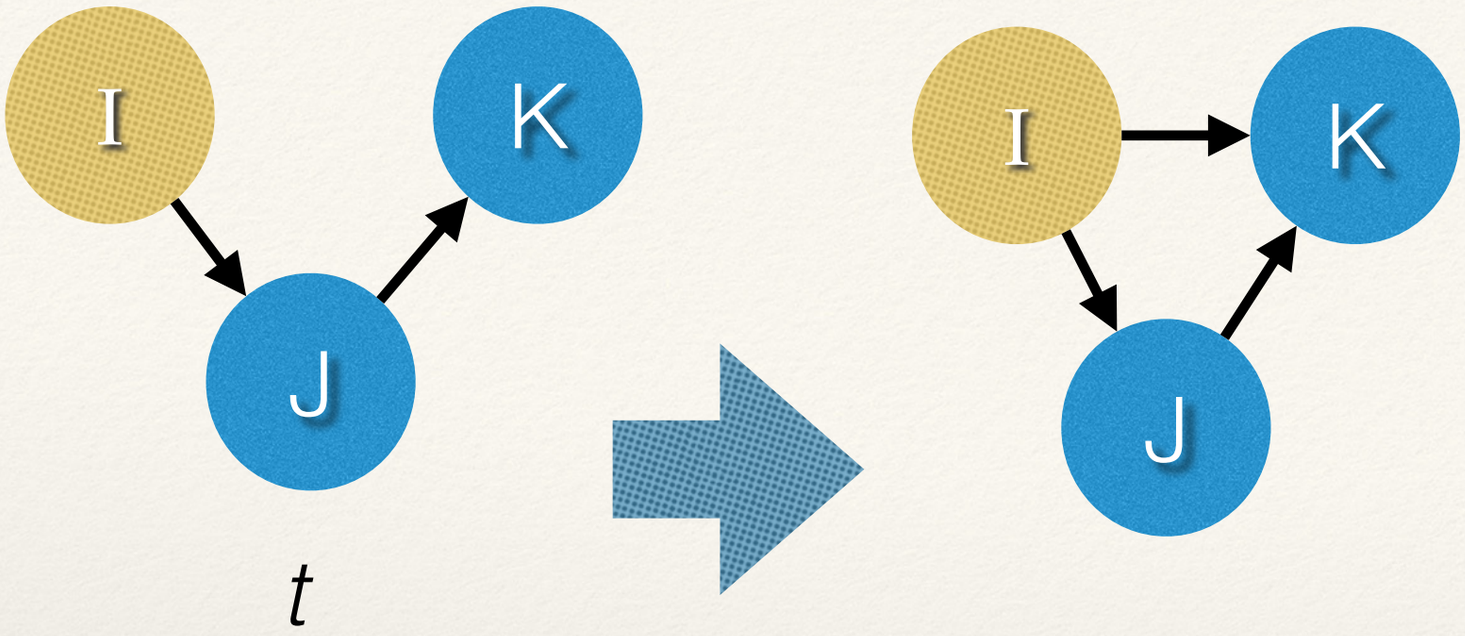

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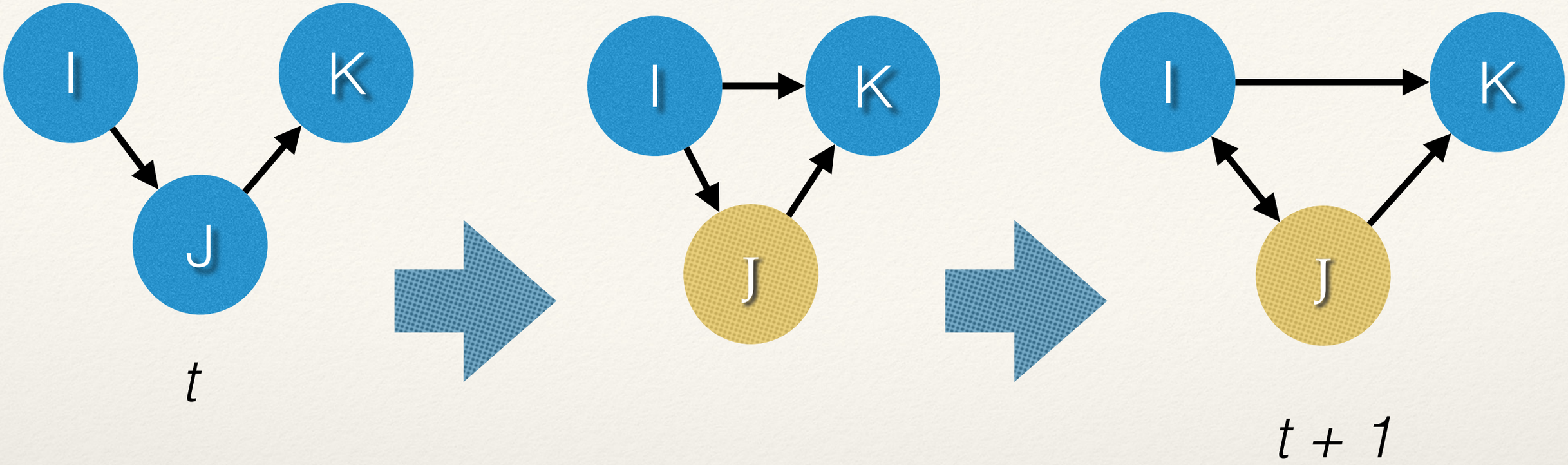
In the first micro-step, the yellow node makes a decision.

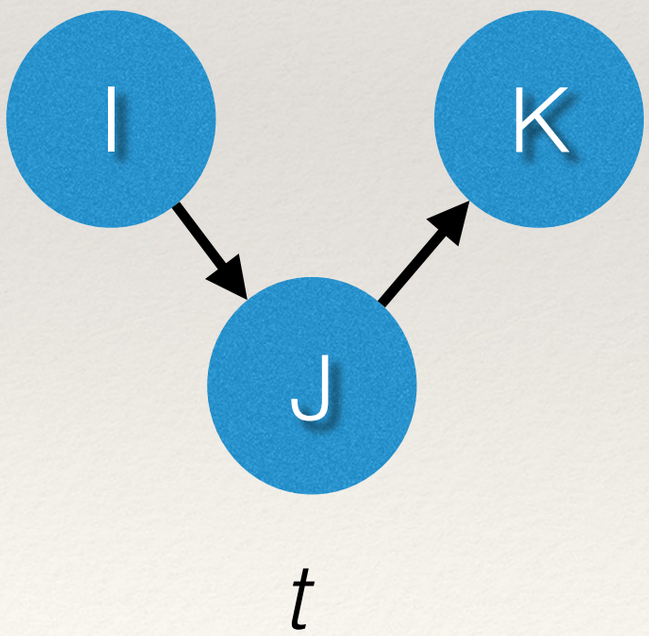
Specifically, add a tie.



In the second micro-step, the yellow node makes a decision.

Specifically, reciprocate a tie.

But, there are different ***sequences*** *of decisions that occur by which we would reach the second network.*



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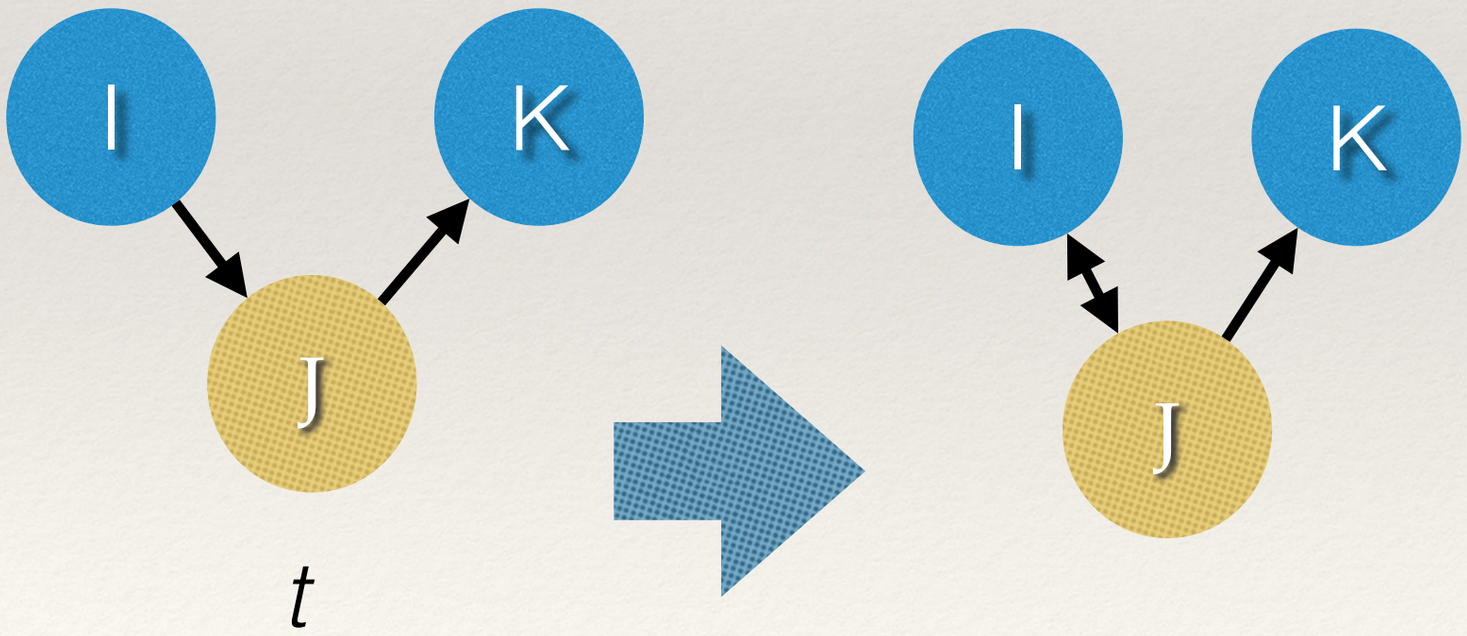

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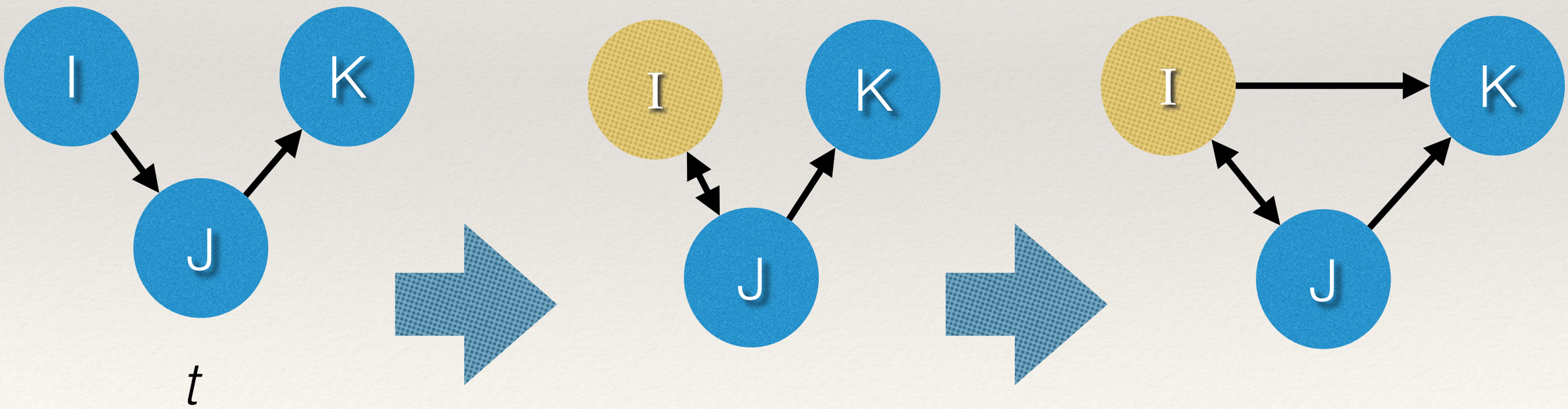


t

t + 1

Why ‘actor-based’?

- Actors make decisions which drive change in the network (i.e. actor-driven or agent-based model).
- ERGMs are ***edge***-based models in that we parameterize the configurations of edges that characterize the network.

Why ‘actor-based’?

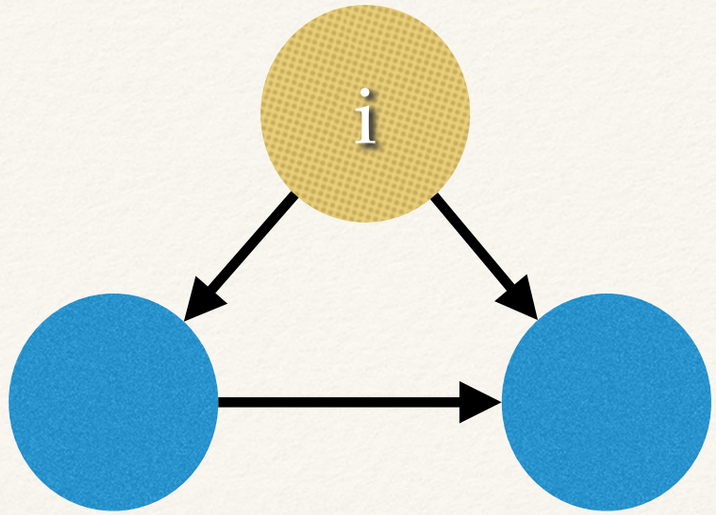
- The SABM has 2 sub-models (called **functions**):
  - When can actor *i* make a decision? (**rate**)
  - Which decision does actor *i* make? (**objective**)

Simulating Network Evolution

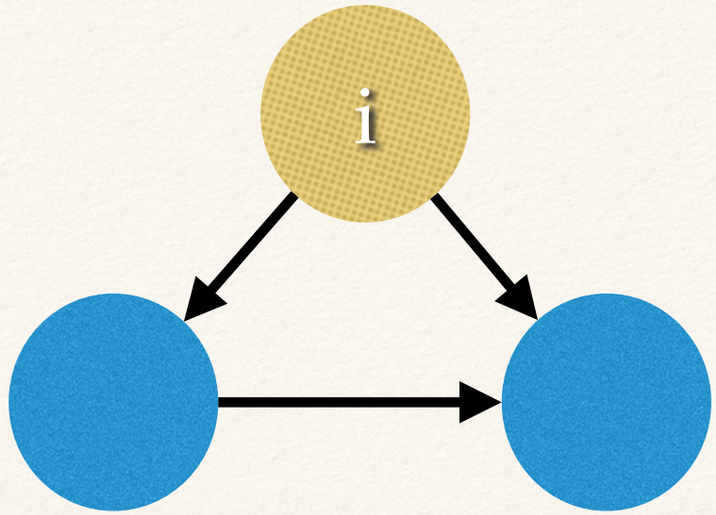
- The SABM logic goes like this:
  - Start with a network at t_0 and run an algorithm to t_1.
  - For all actors, a *waiting time* is sampled according to the *rate function*.
  - Take the actor with the shortest waiting time and allow the actor to set a *micro step*.

Objective Function

- The **rate** function determines how many decisions actors make.
- The **objective** function expresses how likely it is for an actor to change his/her network in a particular way.
  - Represents the short-term *objectives* of the actor (hence the name).
    - "defined on the set of possible states of the network, as perceived from the point of view of the focal actor" (Snijders et al. 2010).



What can *i* do?



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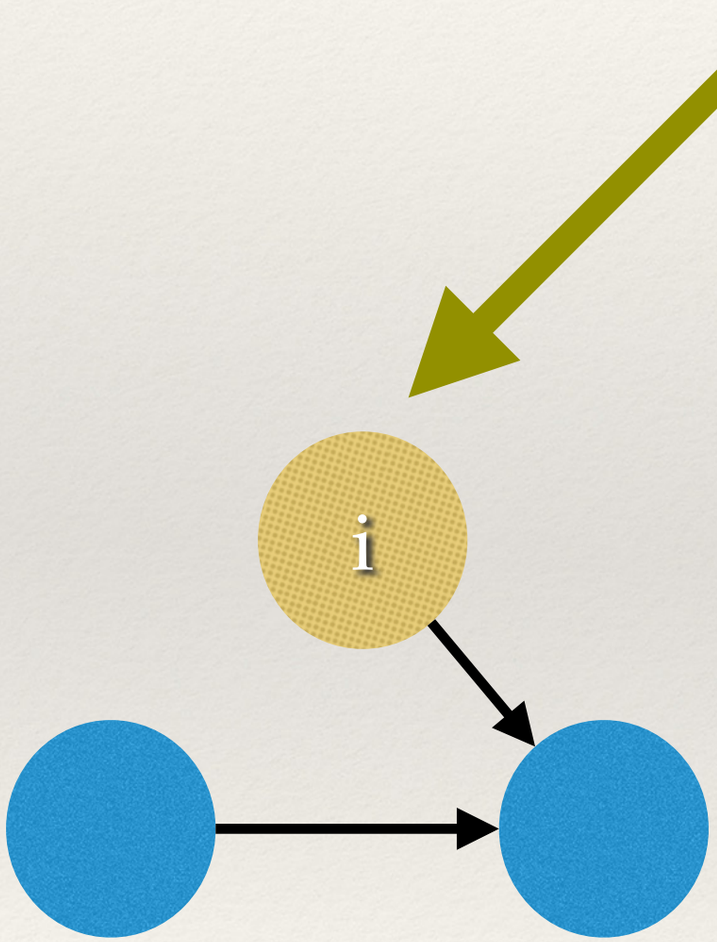
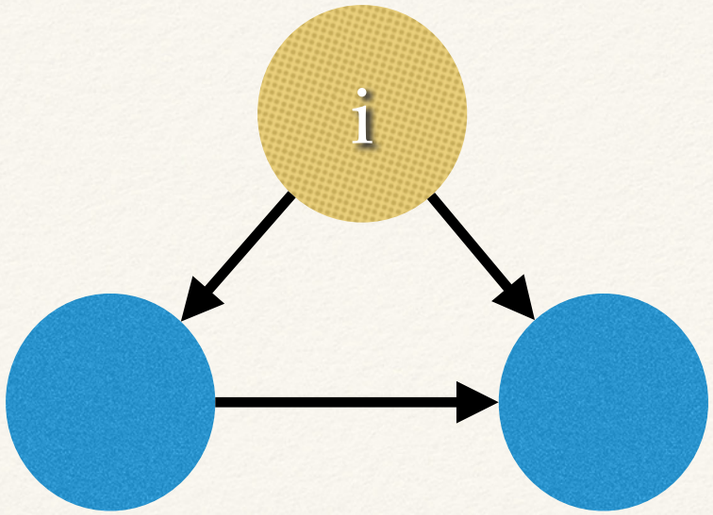


Drop an existing tie



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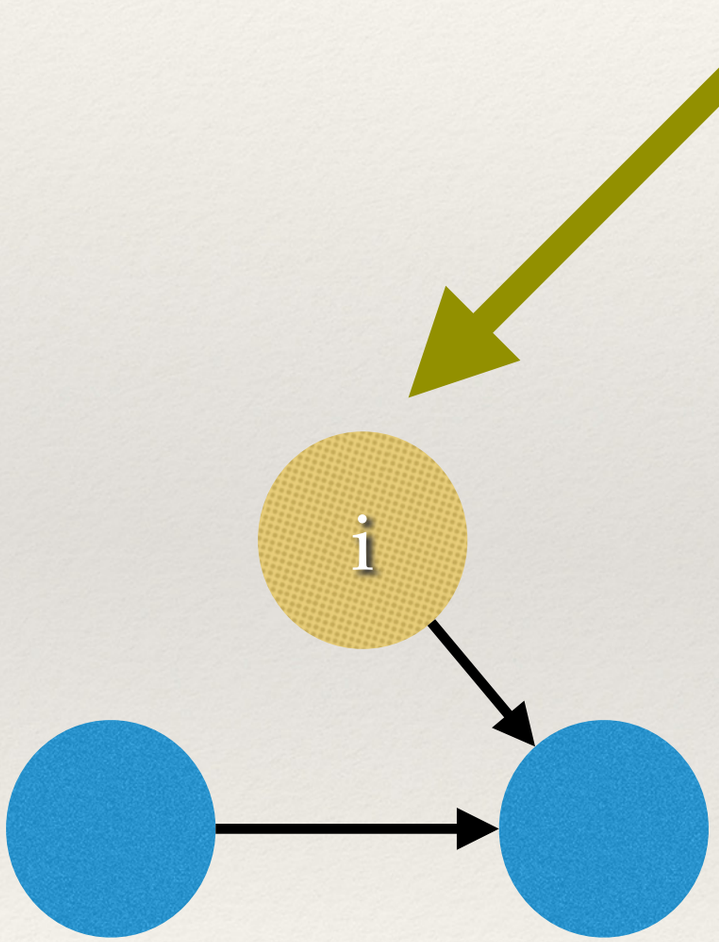

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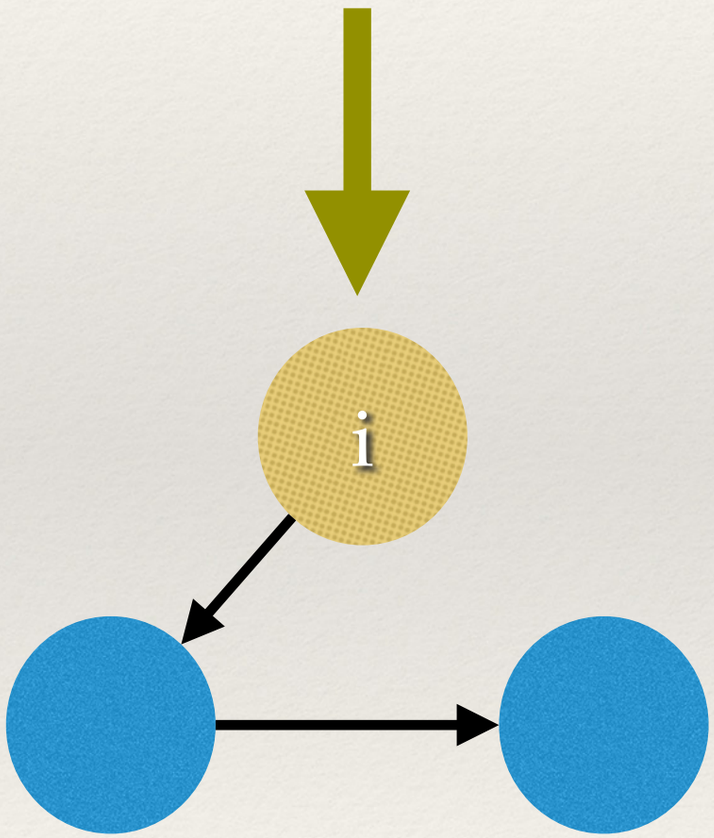
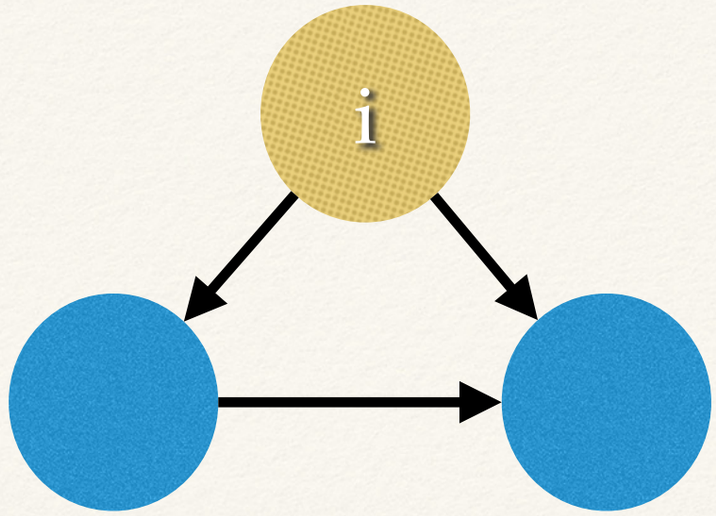
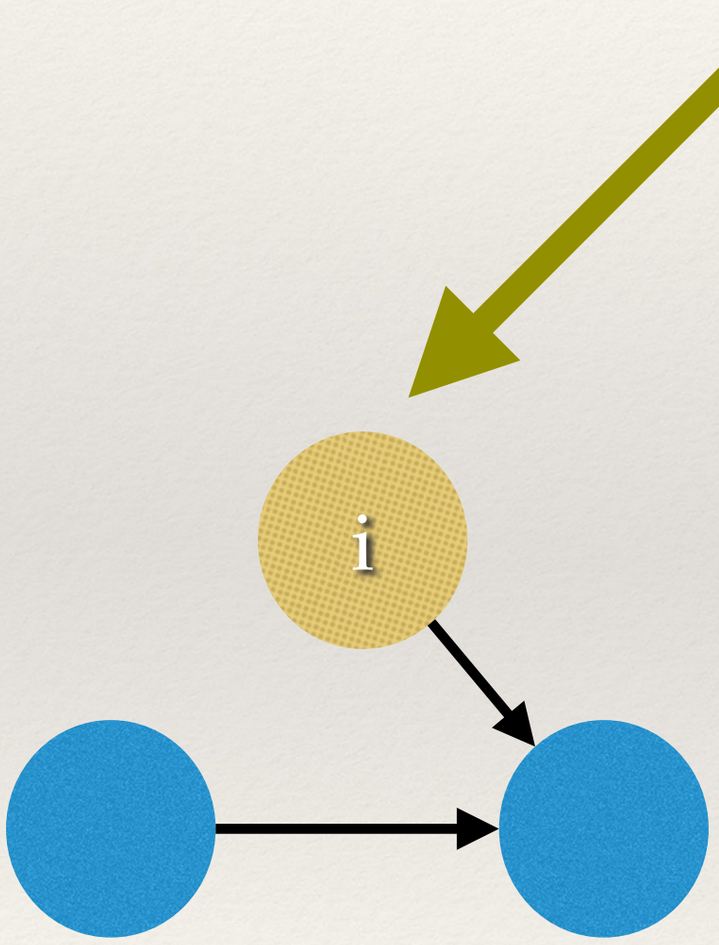


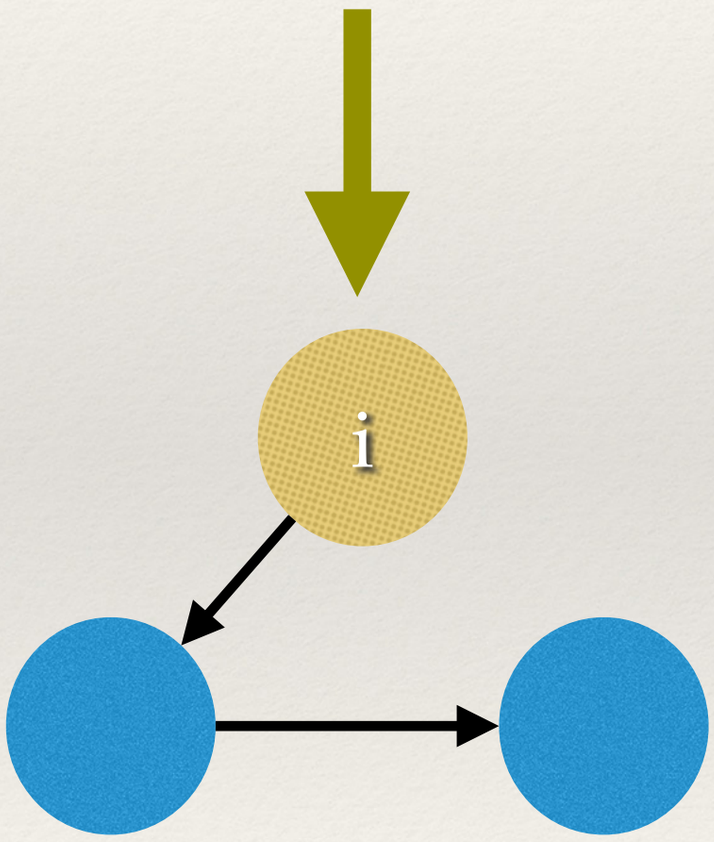
Or…drop a different tie



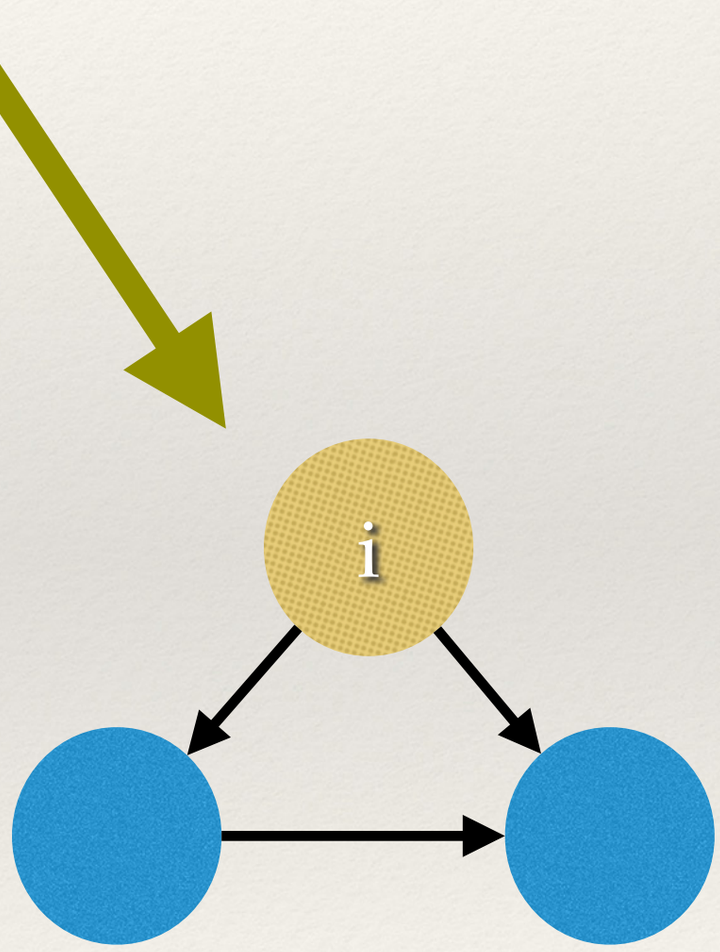
What can *i* do?



Drop an existing tie



Or…drop a different tie



Or…stay the same

Objective Function

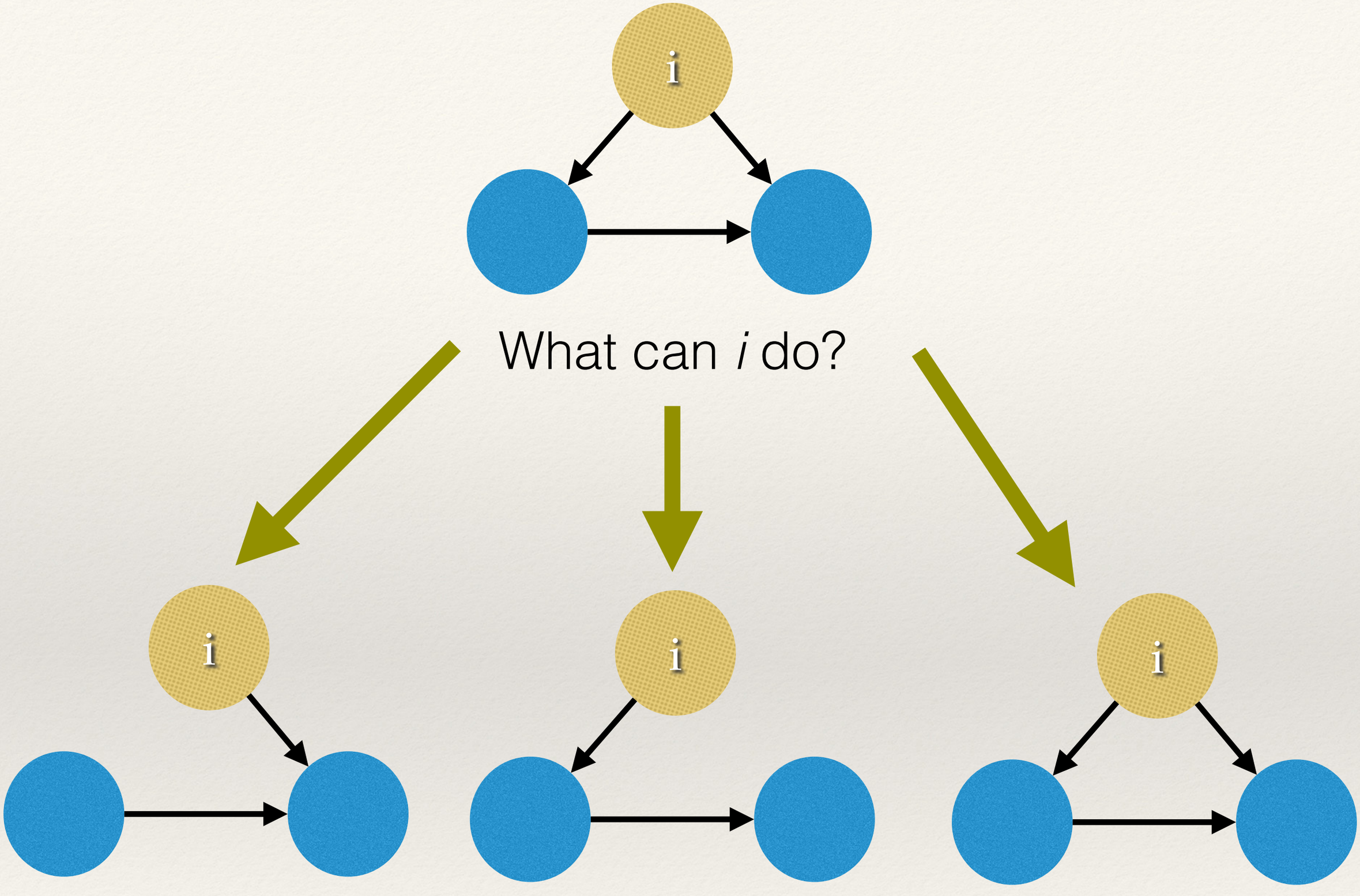
- The SABM simulates networks and compares them to the observed network.
- Basically, optimizing a random utility function.
  - Take an actor, evaluate what he/she can do, determine which is most likely.

Objective Function

- The estimated model then yields estimates about actors' preferences
  - **Positive** effects that are large and significantly different from zero indicate a preference over available alternatives for that particular configuration.
  - The opposite for **negative** effects that are large and significantly different from zero.

Objective Function

- As with ERGMs, network configurations operationalize the process in which we are interested.
- Thus, we can test hypotheses regarding actor-based mechanisms.
- Again, the difference is about what actors "want to do" or "prefer" (which is different from ERGMs).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What can *i* do?
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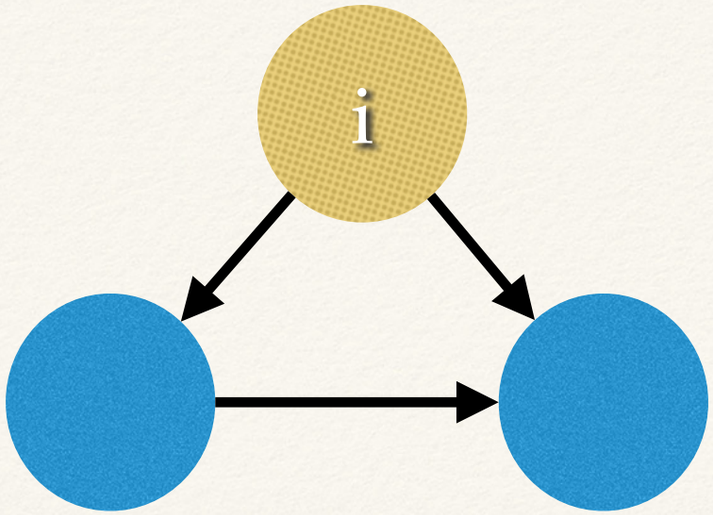
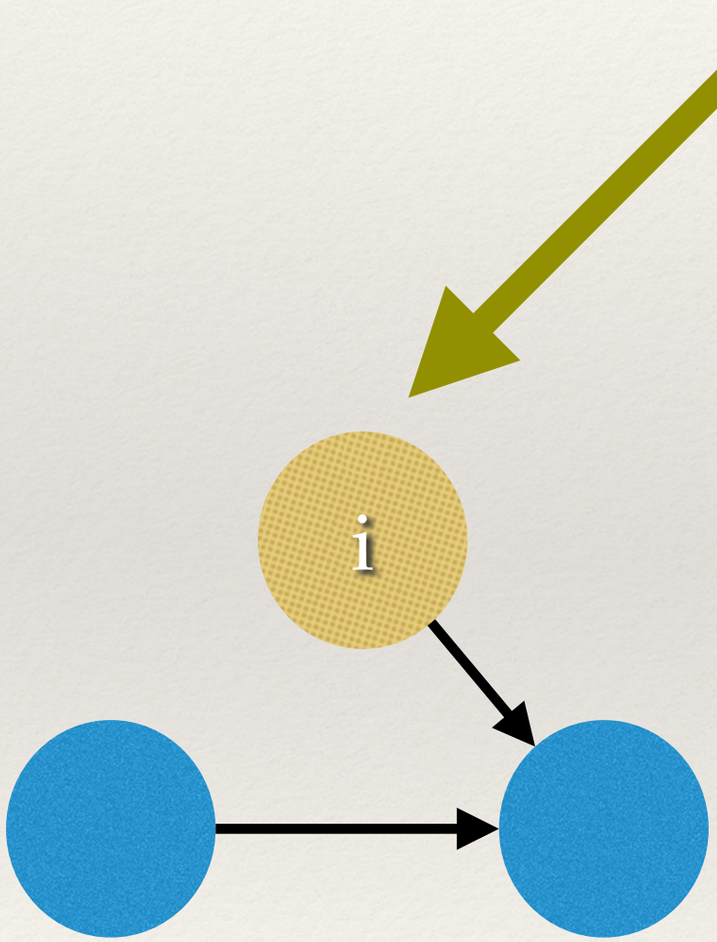
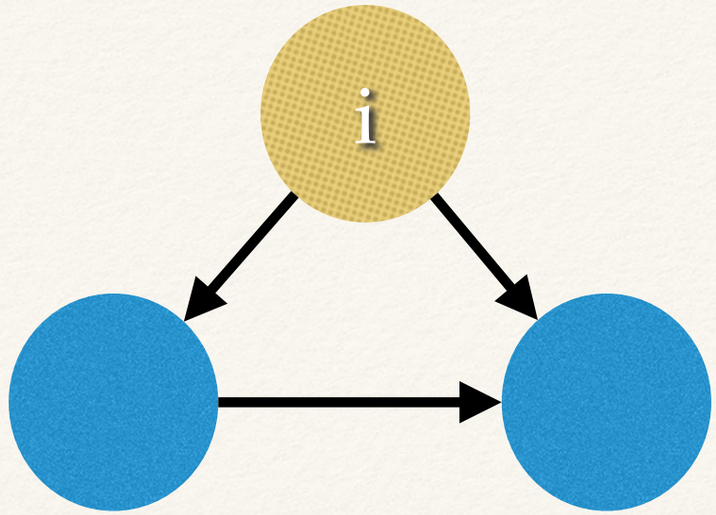


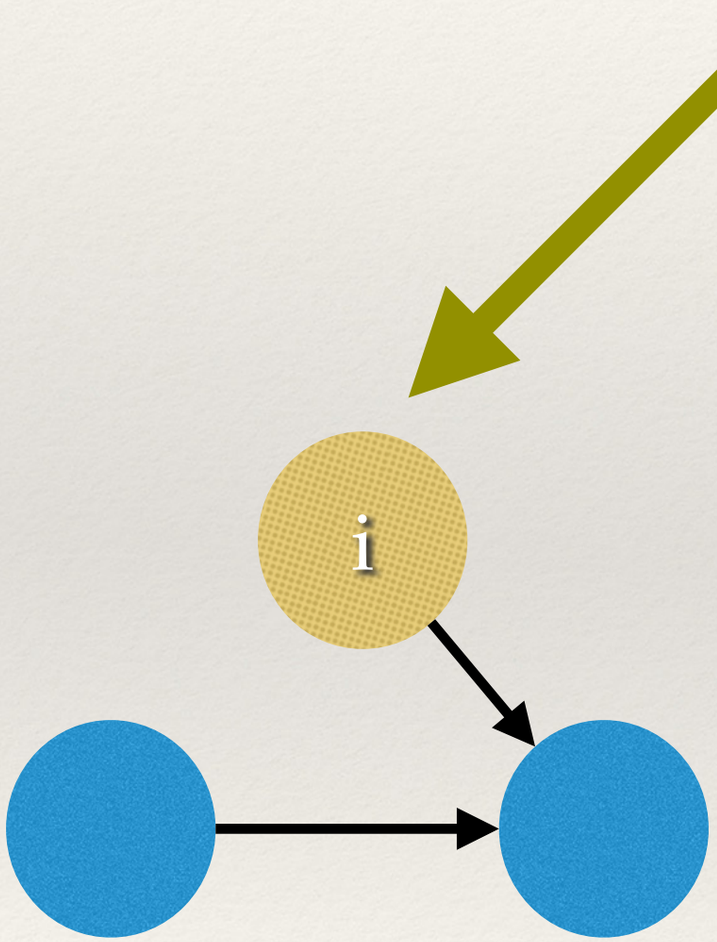
What can *i* do?



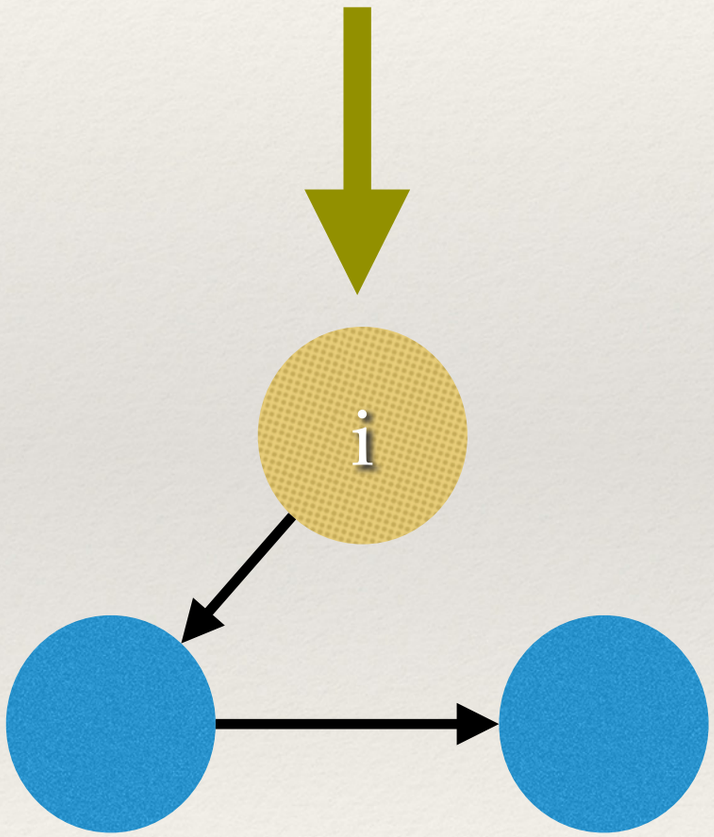
Drop ties to unpopular others



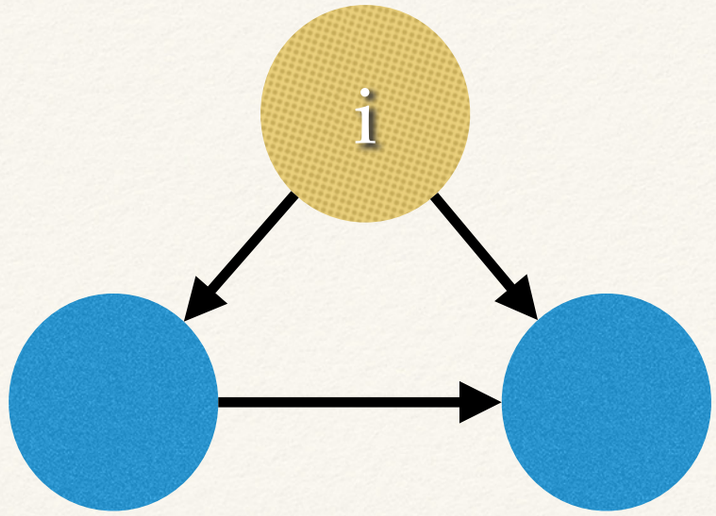
What can *i* do?



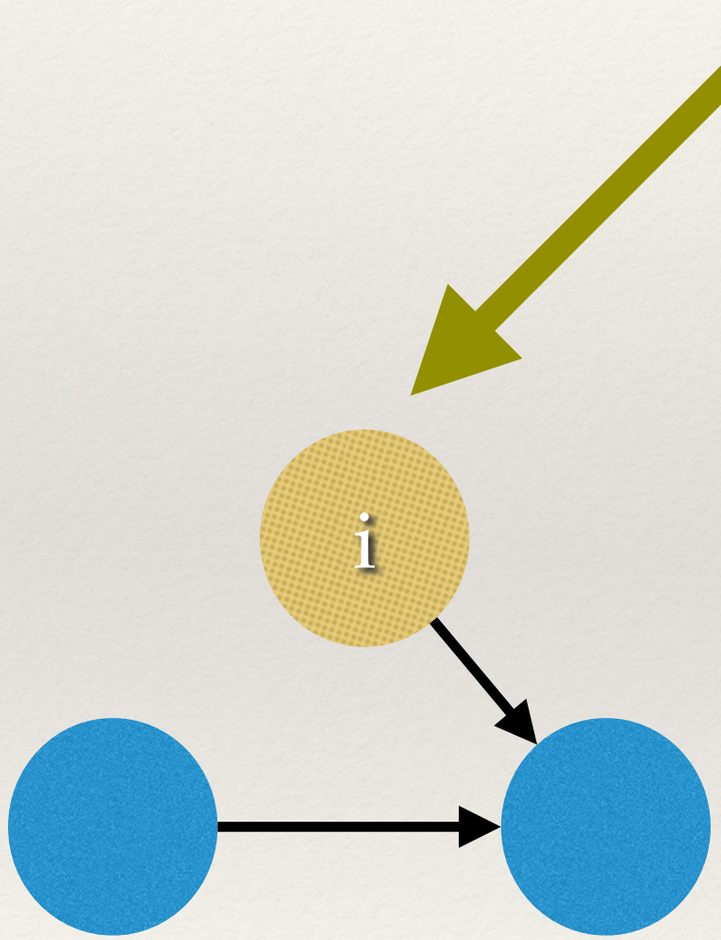
Drop ties to unpopular others



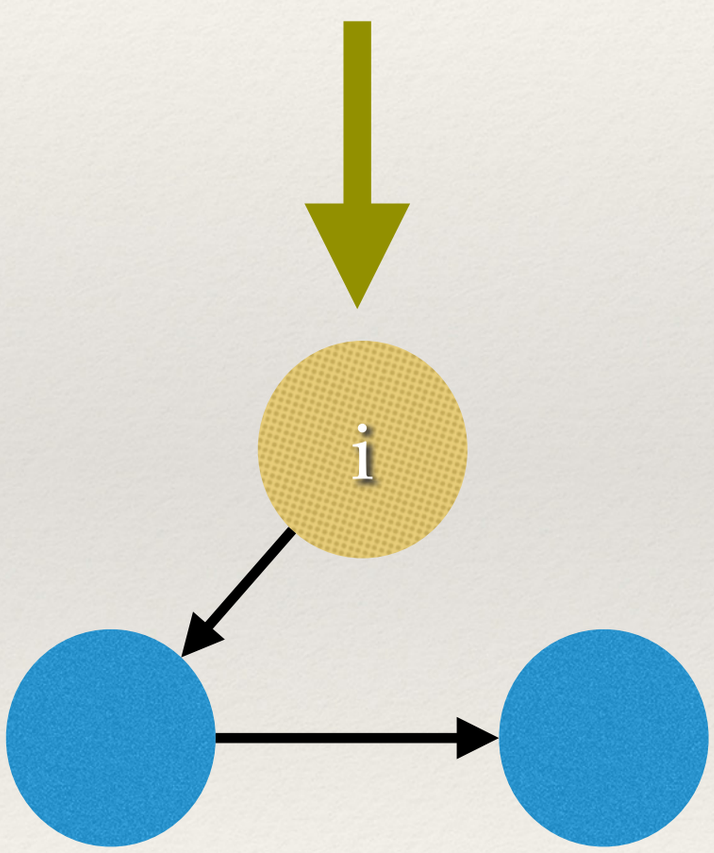
Drop ties to popular others



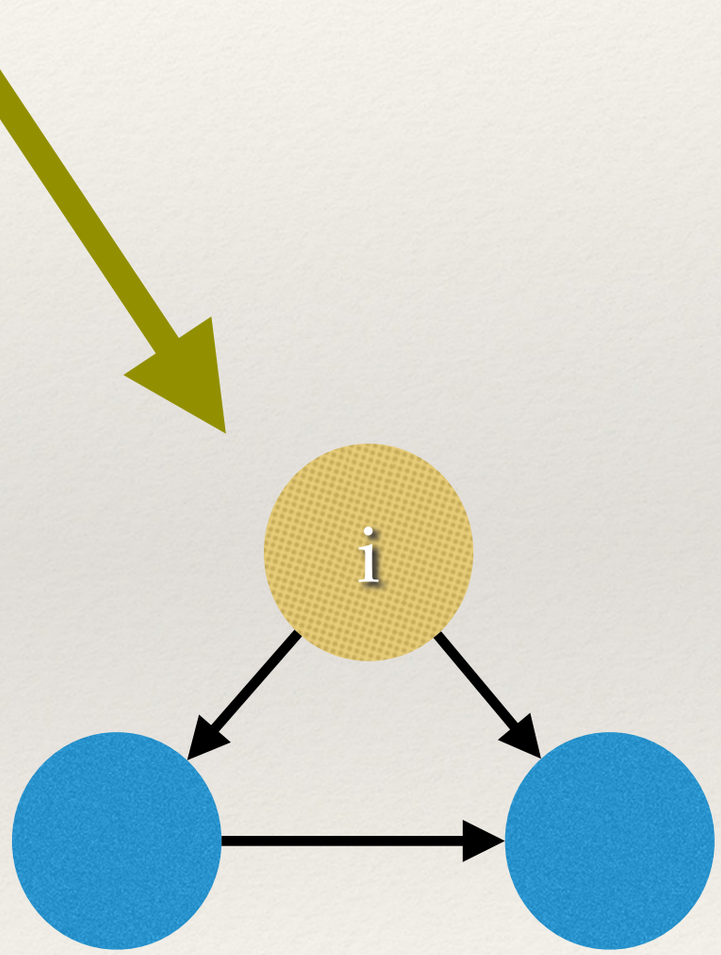
What can *i* do?



Drop ties to unpopular others



Drop ties to popular others

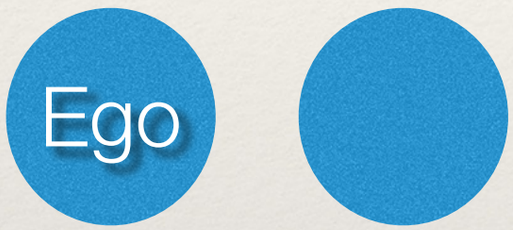
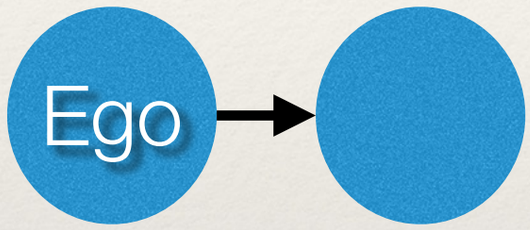


Be happy with 2 friends :)

Basic Effects

t	*t+1*	Effect (RSiena term)	Preference

Basic Effects

t	*t+1*	Effect (RSiena term)	Preference
			to form ties

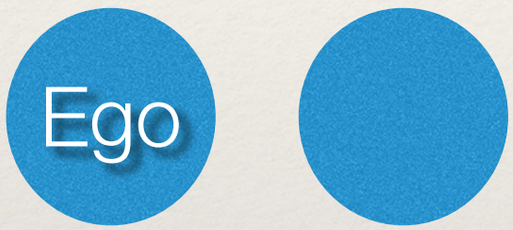
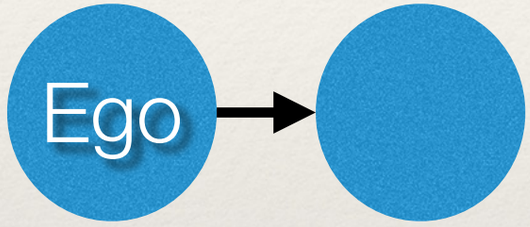
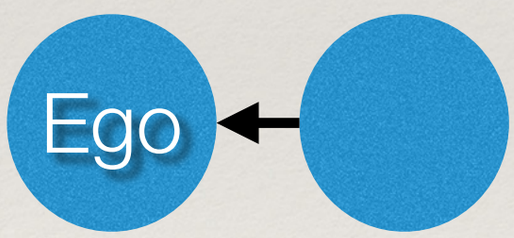
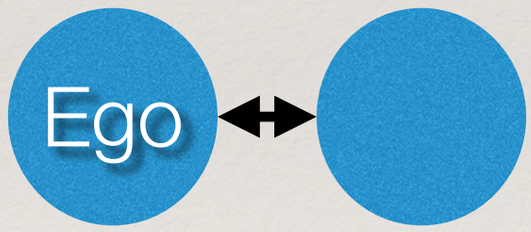
Basic Effects

Effect (RSiena term)	Preference
Outdegree (default)	to form ties

Basic Effects

t	*t+1*	Effect (RSiena term)	Preference
Ego	Ego →	Outdegree (default)	to form ties
Ego ←	Ego ↔		to reciprocate ties

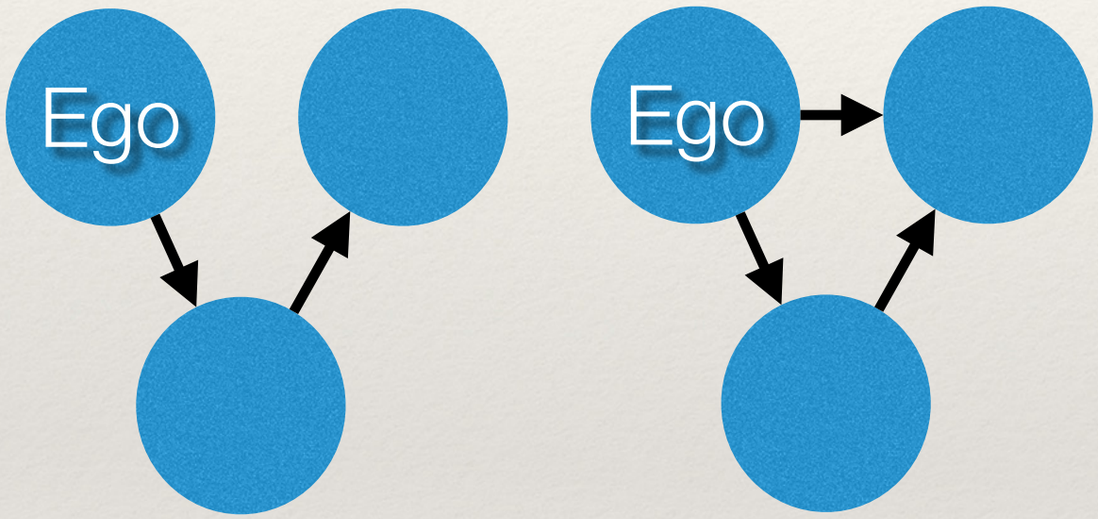
Basic Effects

t	*t+1*	Effect (RSiena term)	Preference
		Outdegree (default)	to form ties
		Reciprocity (default)	to reciprocate ties

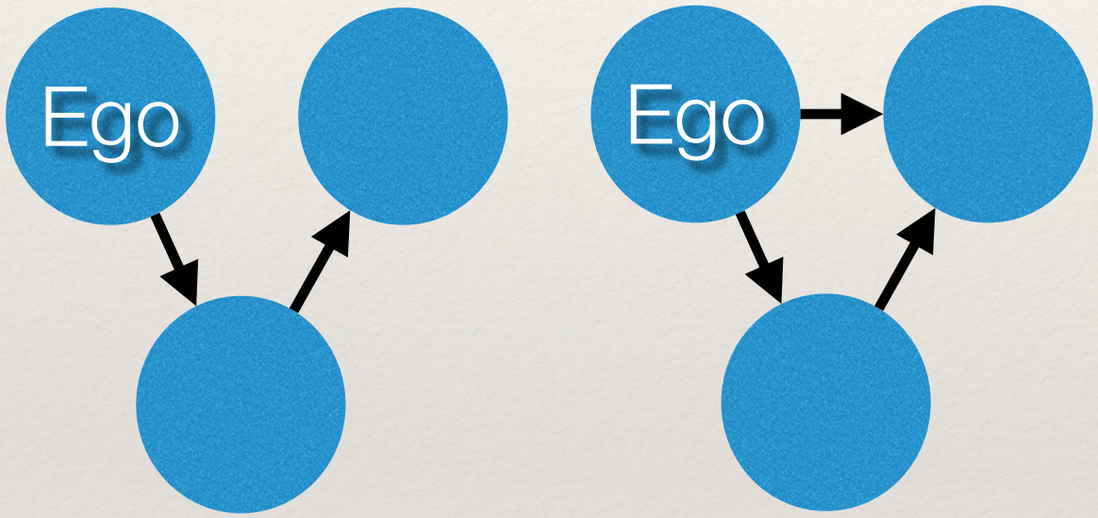
Additional Effects

t	*t+1*	Effect (RSiena term)	Preference

Additional Effects

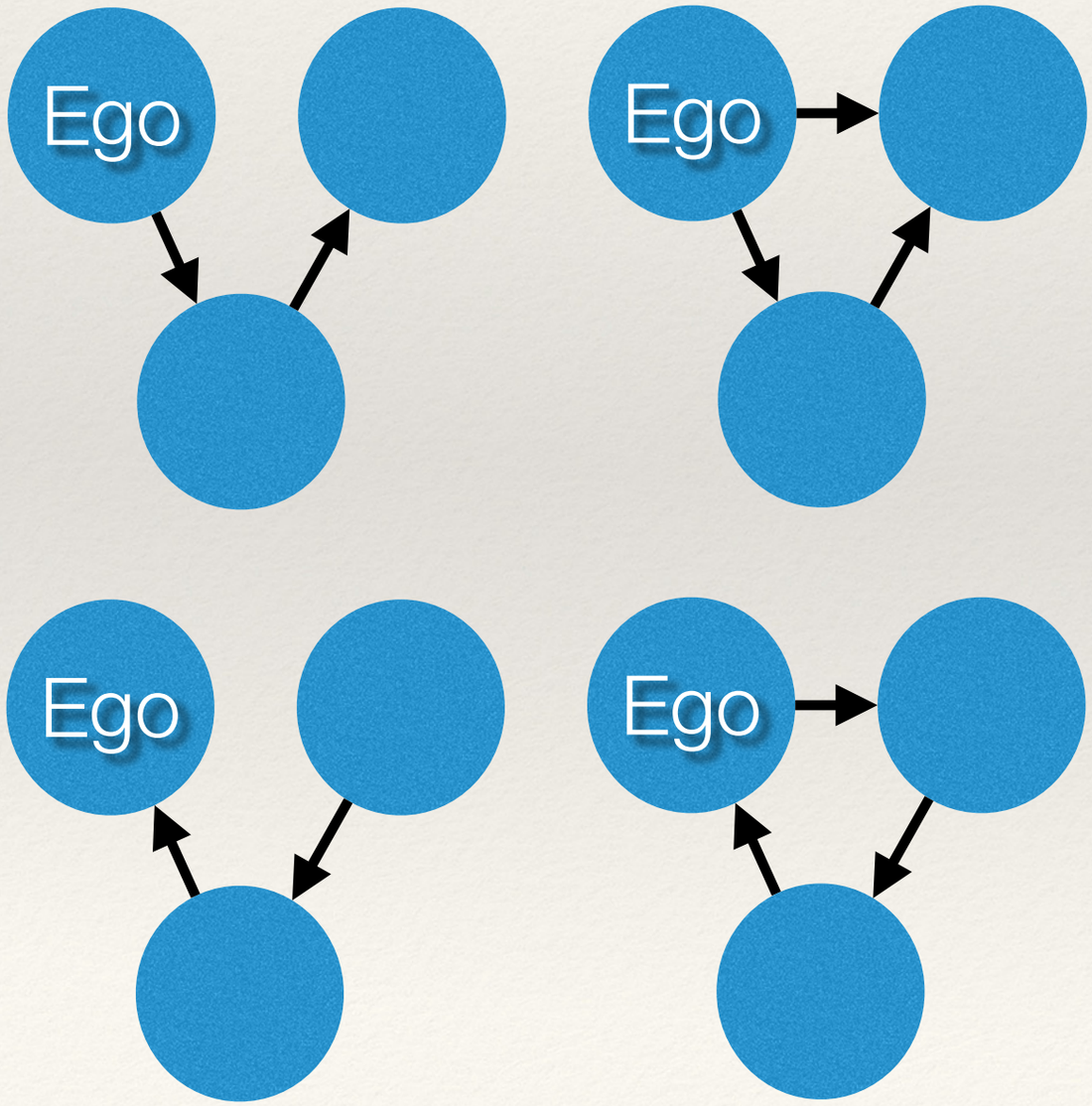
t	*t+1*	Effect (RSiena term)	Preference
			for being friend of the friend's friends

Additional Effects



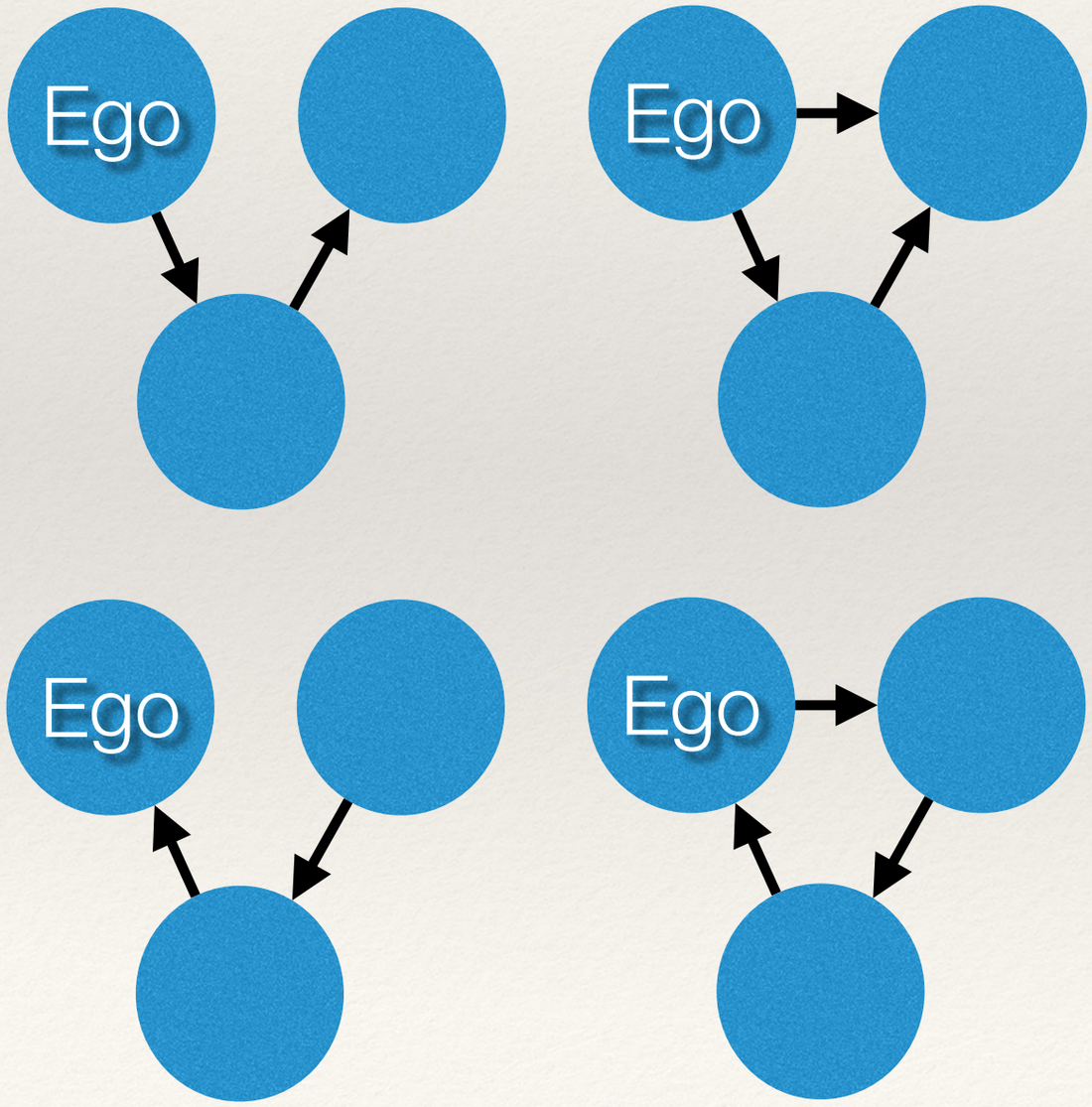
Effect (RSiena term)	Preference
Transitive Triplets (transTrip)	for being friend of the friend's friends

Additional Effects



Effect (RSiena term)	Preference
Transitive Triplets (transTrip)	for being friend of the friend's friends
	for forming cycles

Additional Effects

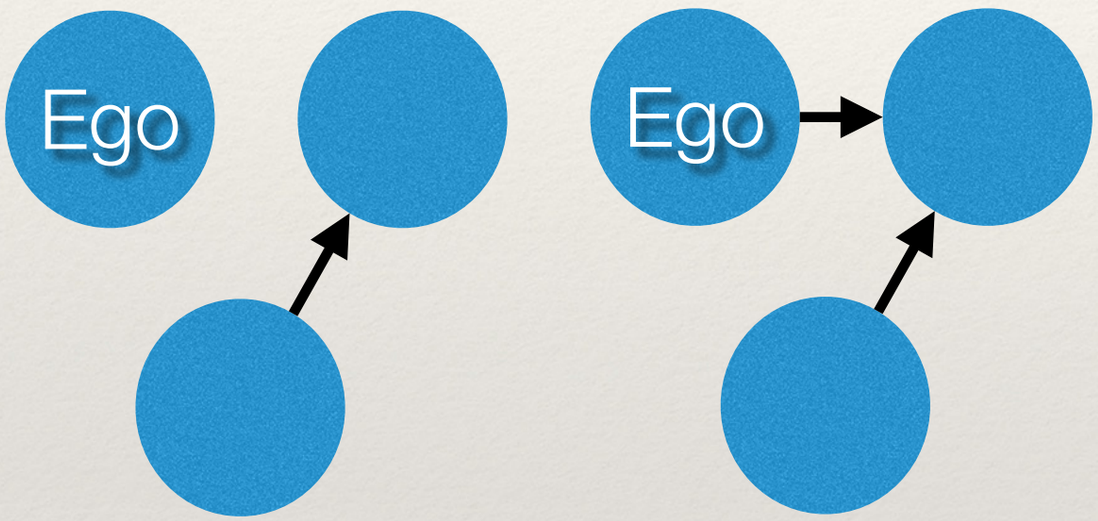


Effect (RSiena term)	Preference
Transitive Triplets (transTrip)	for being friend of the friend's friends
Cyclical Triad (cycle3)	for forming cycles

Additional Effects

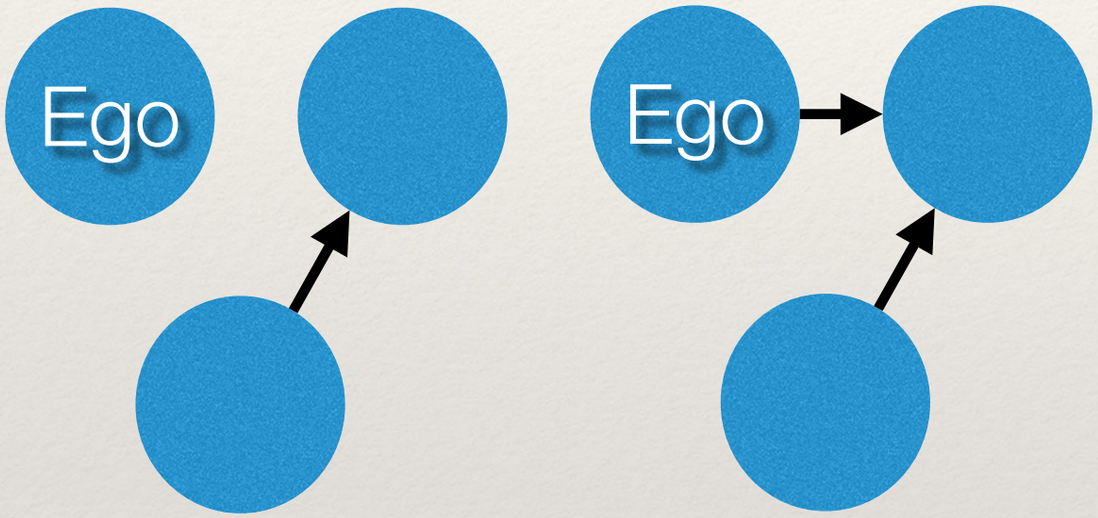
t	*t+1*	Effect (RSiena term)	Preference

Additional Effects



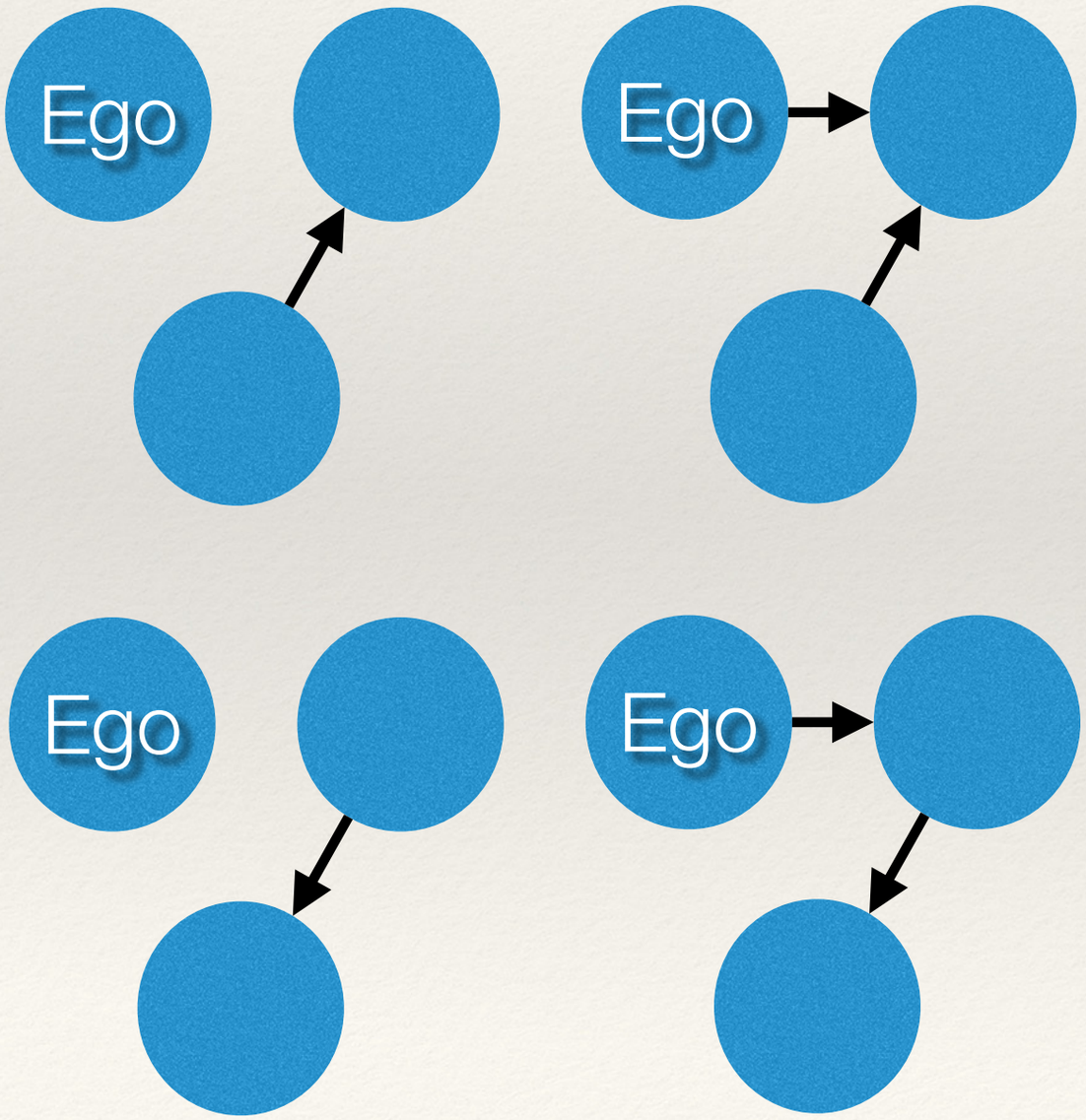
Effect (RSiena term)	Preference
	for being friend of popular alters

Additional Effects



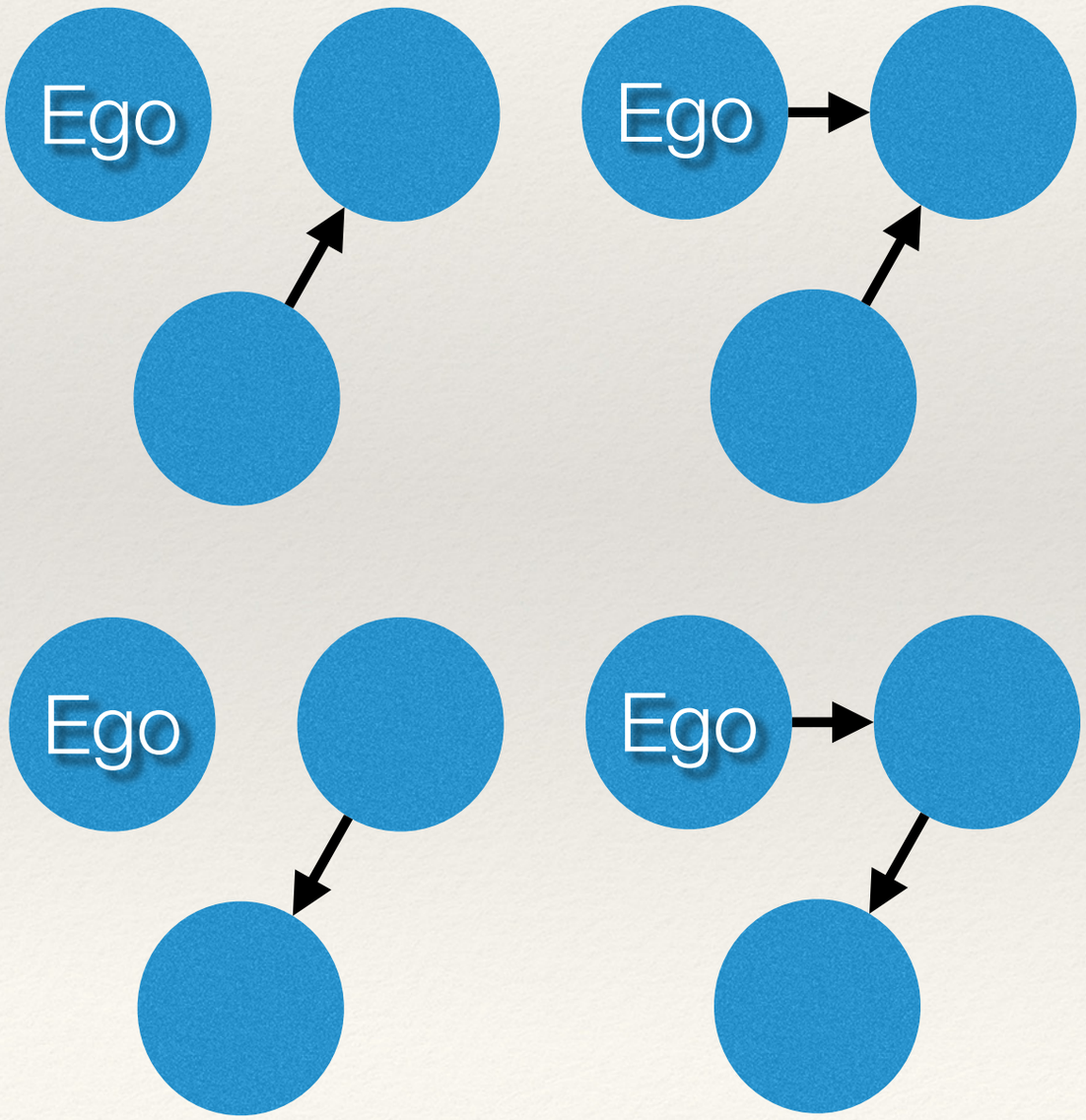
Effect (RSiena term)	Preference
Popularity (inPop)	for being friend of popular alters

Additional Effects



Effect (RSiena term)	Preference
Popularity (inPop)	for being friend of popular alters
	for being friend of active alters

Additional Effects

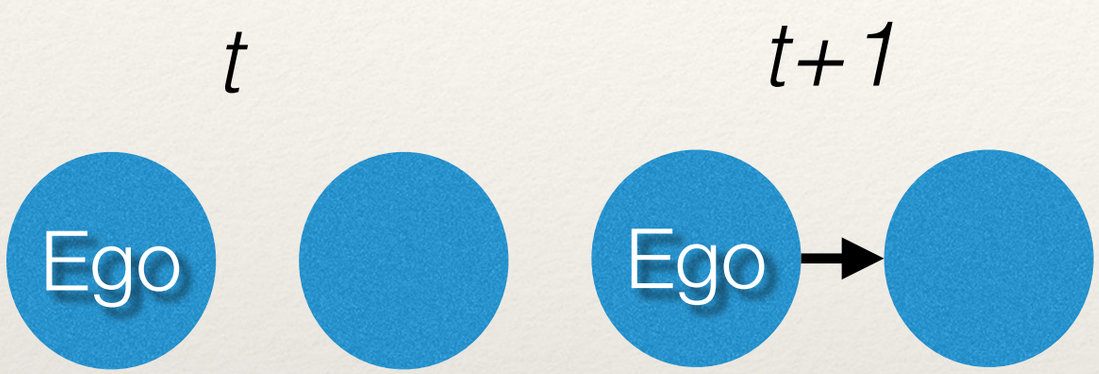


Effect (RSiena term)	Preference
Popularity (inPop)	for being friend of popular alters
Activity (outPop)	for being friend of active alters

Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference

Interactions w/ Covariates



Effect
(RSiena term)

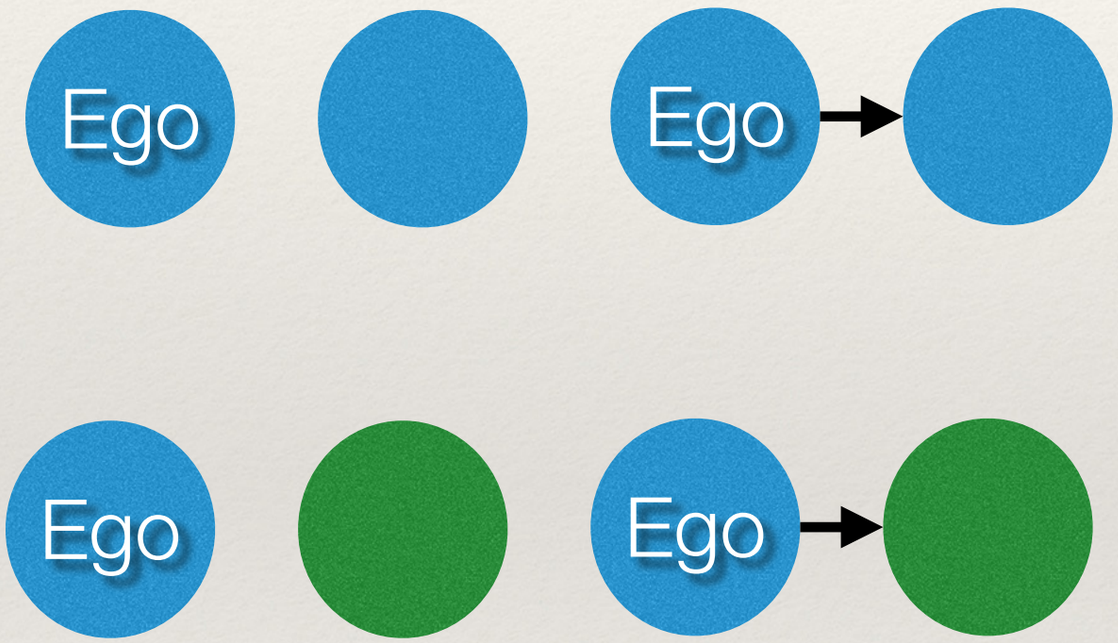
Preference

for ties to similar alters

Interactions w/ Covariates

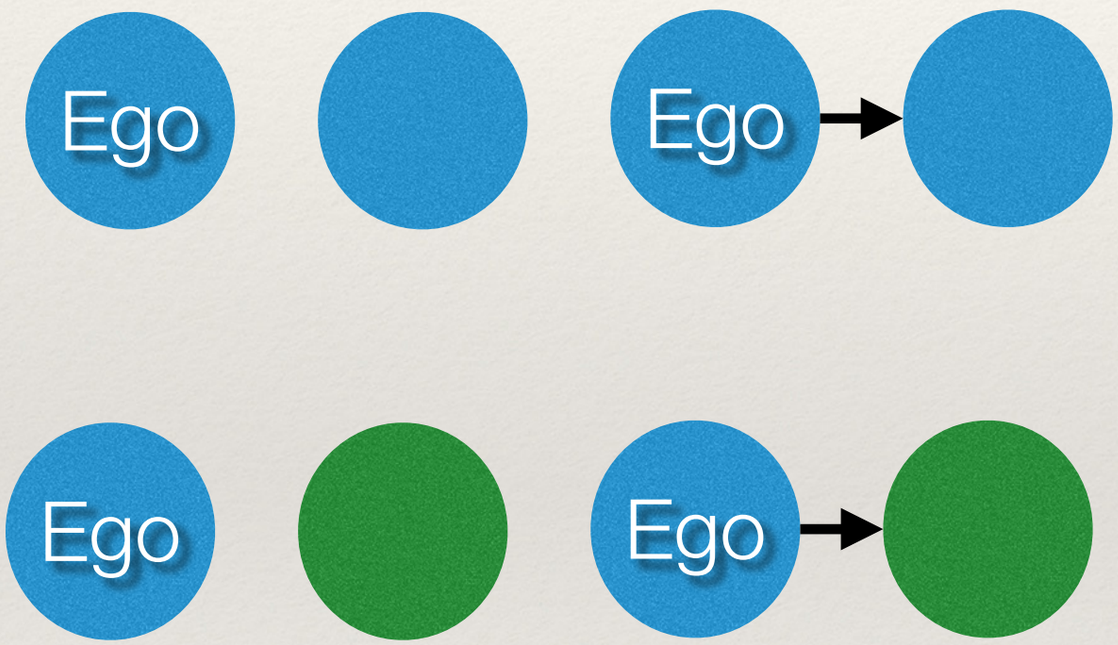
Effect (RSiena term)	Preference
Similarity (sameX or simX)	for ties to similar alters

Interactions w/ Covariates



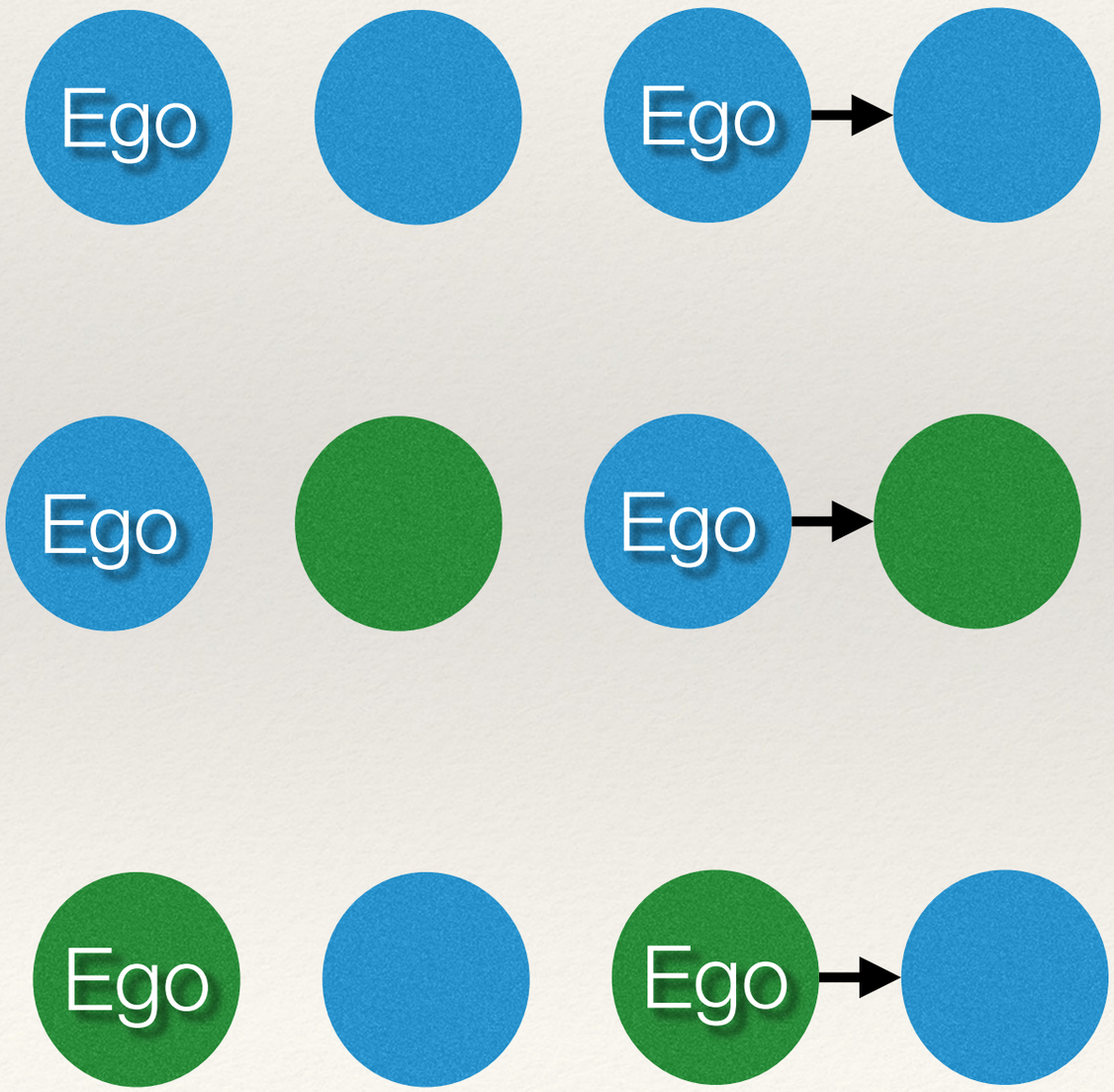
Effect (RSiena term)	Preference
Similarity (sameX or simX)	for ties to similar alters
ego's covariate effect on preference	

Interactions w/ Covariates



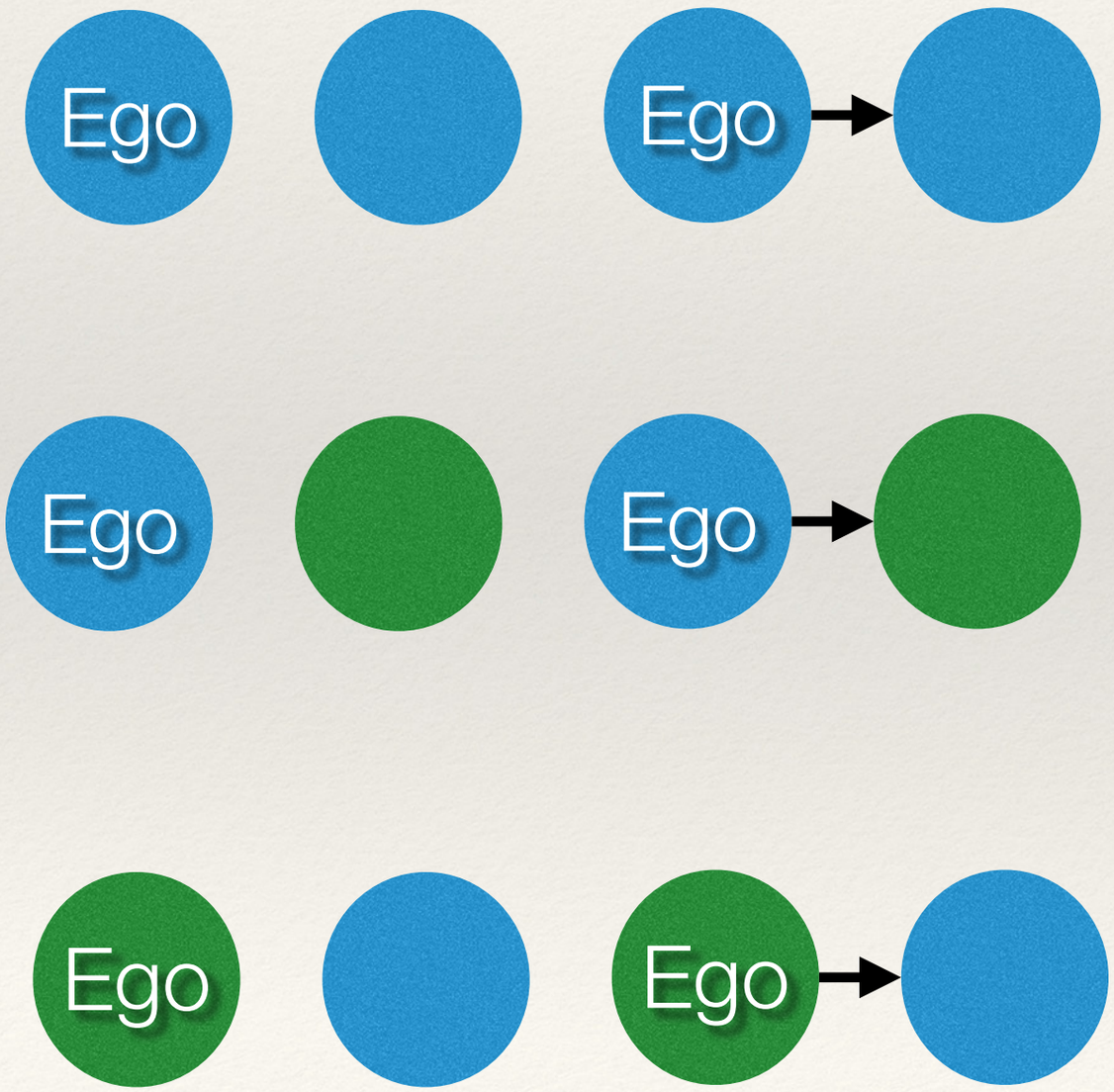
Effect (RSiena term)	Preference
Similarity (sameX or simX)	for ties to similar alters
Behavior Ego (EgoX)	ego's covariate effect on preference

Interactions w/ Covariates



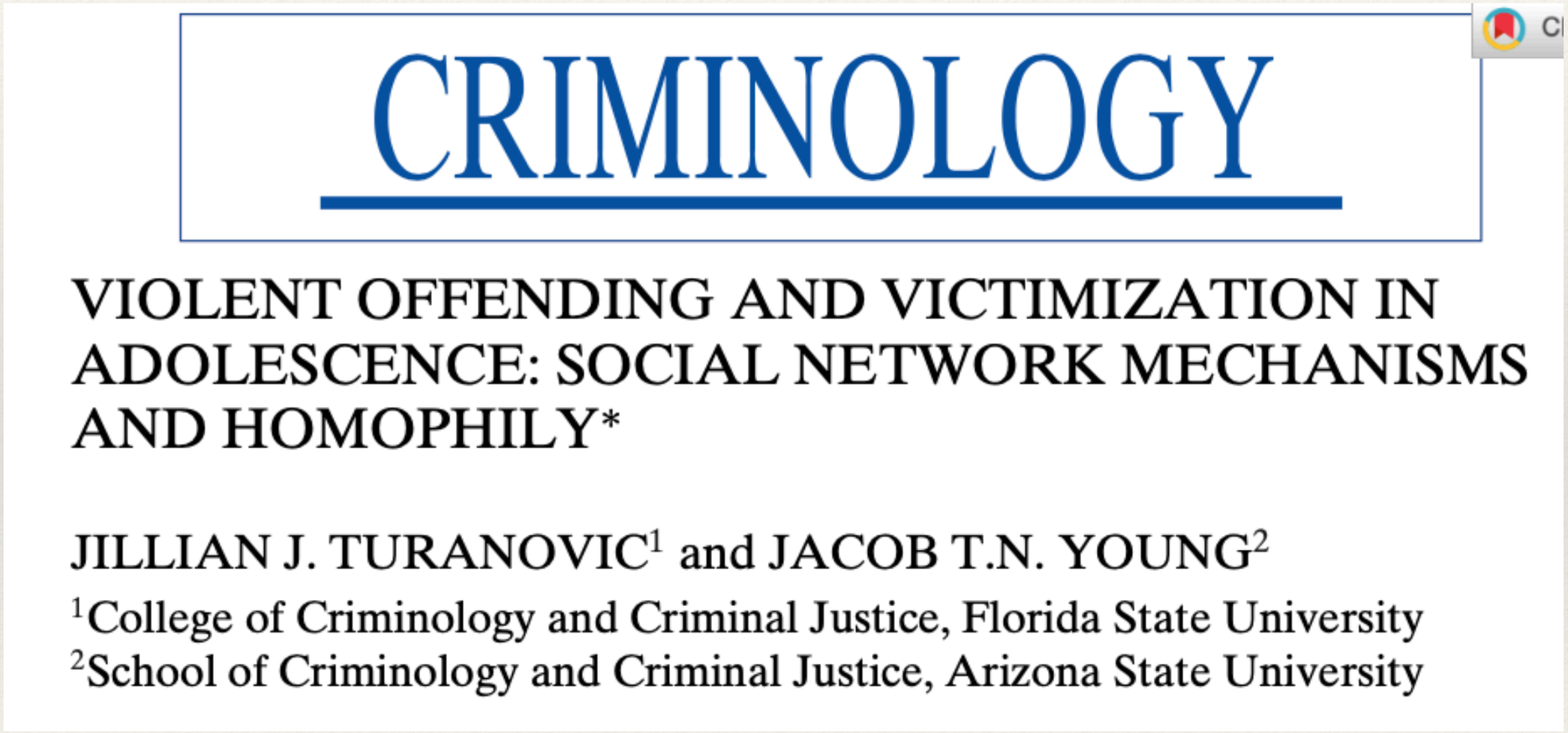
Effect (RSiena term)	Preference
Similarity (sameX or simX)	for ties to similar alters
Behavior Ego (EgoX)	ego's covariate effect on preference
	alter's covariate effect on preference

Interactions w/ Covariates



Effect (RSiena term)	Preference
Similarity (sameX or simX)	for ties to similar alters
Behavior Ego (EgoX)	ego's covariate effect on preference
Behavior Alter (AltX)	alter's covariate effect on preference

Motivating Example



CRIMINOLOGY

VIOLENT OFFENDING AND VICTIMIZATION IN ADOLESCENCE: SOCIAL NETWORK MECHANISMS AND HOMOPHILY*

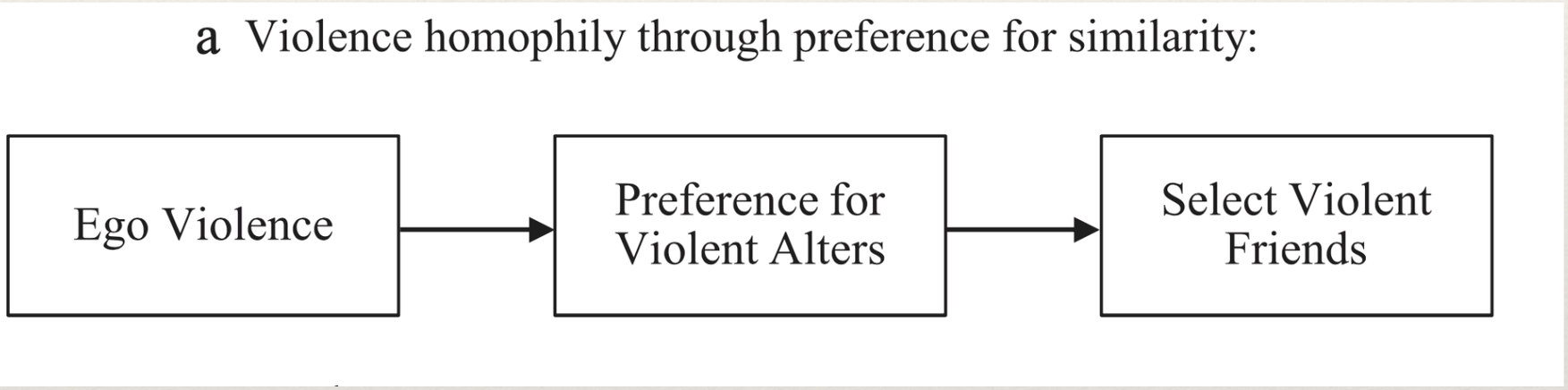
JILLIAN J. TURANOVIC[1] and JACOB T.N. YOUNG[2]

[1]College of Criminology and Criminal Justice, Florida State University
[2]School of Criminology and Criminal Justice, Arizona State University

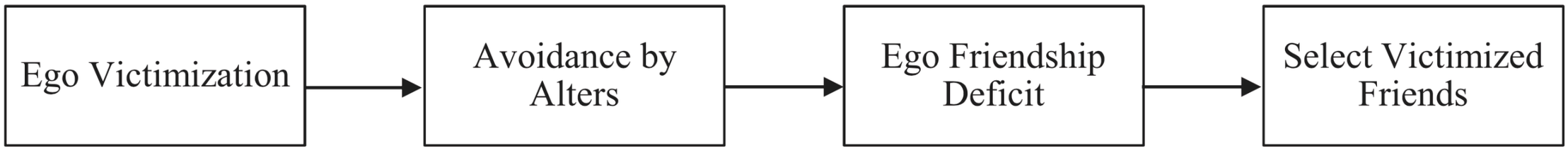
Motivating Example

- What are the findings?

a Violence homophily through preference for similarity:



b Victimization homophily through avoidance:



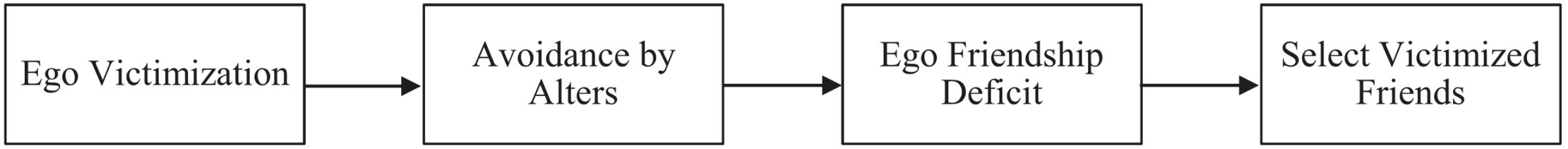
Motivating Example

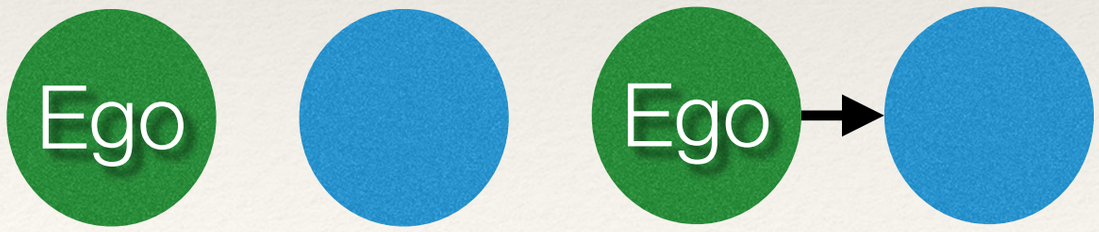
a Violence homophily through preference for similarity:

Similarity (sameX or simX) for ties to similar alters

Motivating Example

b Victimization homophily through avoidance:





Behavior Alter (AltX)

alter's covariate effect on preference

Learning Goals

- By the end of this lecture, you should be able to answer these questions:
  - What is the difference between Exponential Random Graph Models (ERGMS) and Stochastic Actor-Based Models (SABMs)?
  - What is the logic of *micro-steps* and the simulation of networks using the **rate** function?
  - What is the logic of *preferences* and the simulation of networks using the **objective** function?

Questions?