Visualizing Social Interactions in Social Networks

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Introduction to Slide Notes:

This was a 45 minute talk on visualizing social network data. Some examples were taken from other tutorials, blogs and papers. Others were based on my own research.

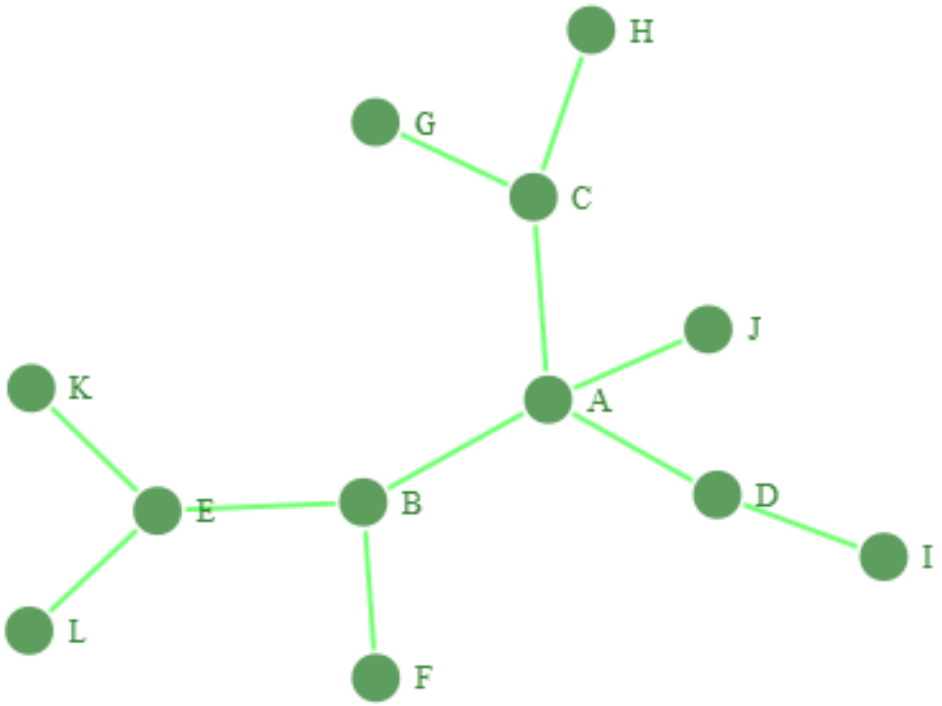
The main aim of this talk was to get over some big picture ideas about network visualization rather than being a "how-to" exercise.

Nevertheless, the lecture was very interactive including live coding demos and many browser based examples – I include these links at the end

I clearly did not have time to engage with many possible examples. Lots of potential examples were missed out – some of these you can find in my

"Interactive and Dynamic Network Visualization" tutorial here: http://curleylab.psych.columbia.edu/netviz/

What is a Social Network ?



Data Structures

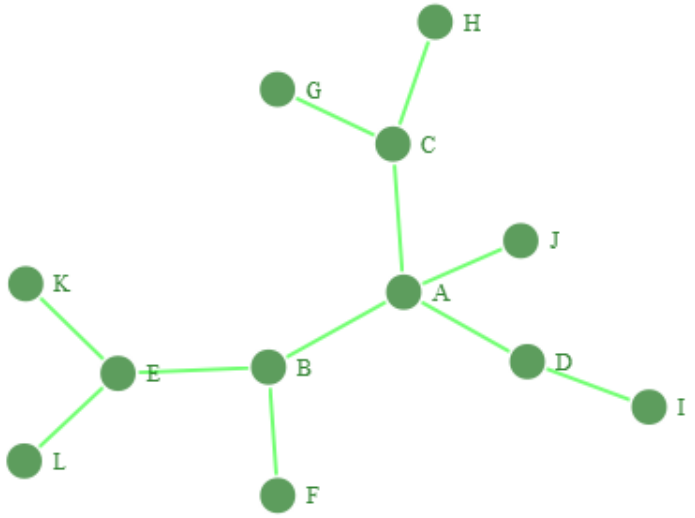
Edgelist

A	B
A	C
A	D
A	J
B	E
B	F
C	G
C	H
D	I
E	K
E	L

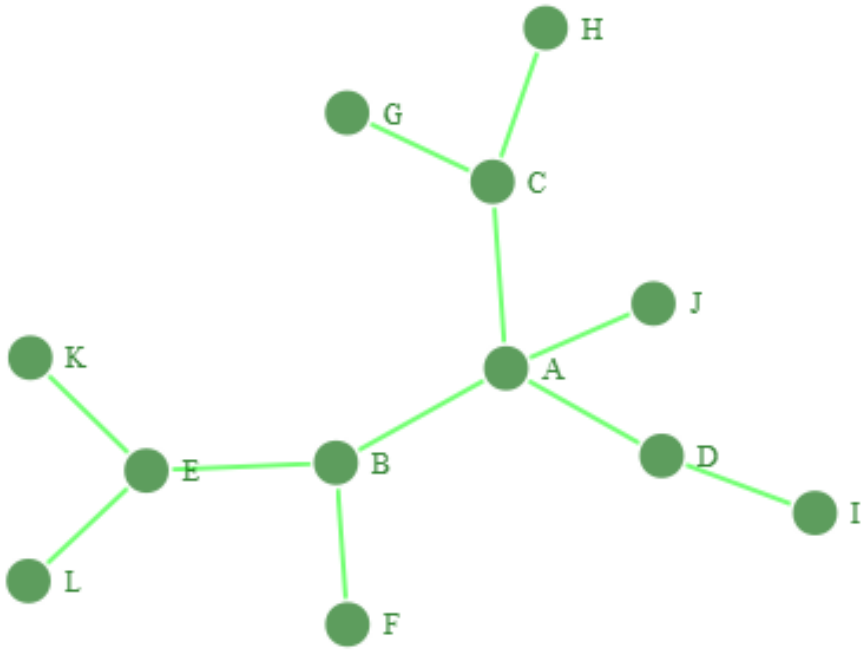
Sociomatrix / Adjacency Matrix

	A	B	C	D	E	F	G	H	I	J	K	L
A	.	1	1	1	0	0	0	0	0	1	0	0
B	1	.	0	0	1	1	0	0	0	0	0	0
C	1	0	.	0	0	0	1	1	0	0	0	0
D	1	0	0	.	0	0	0	0	1	0	0	0
E	0	1	0	0	.	0	0	0	0	0	1	1
F	0	1	0	0	0	.	0	0	0	0	0	0
G	0	0	1	0	0	0	.	0	0	0	0	0
H	0	0	1	0	0	0	0	.	0	0	0	0
I	0	0	0	1	0	0	0	0	.	0	0	0
J	1	0	0	0	0	0	0	0	0	.	0	0
K	0	0	0	0	1	0	0	0	0	0	.	0
L	0	0	0	0	1	0	0	0	0	0	0	.

Network / Sociogram



Social associations that are observed between individuals over time …



… how to best visualize these sociotemporal patterns ?

What to visualize ?

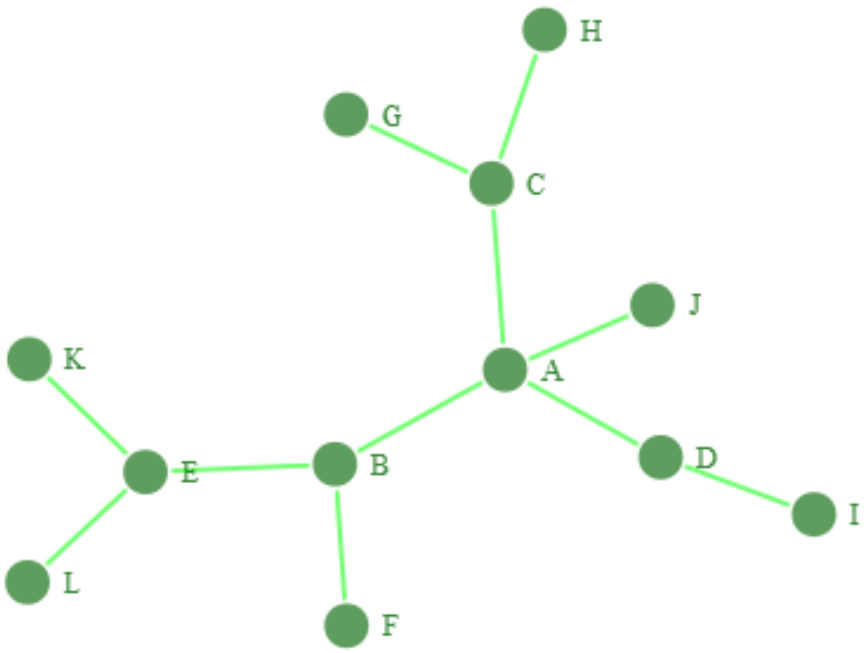
What questions are you interested in?

What do we want to communicate ?

Who is the audience ?

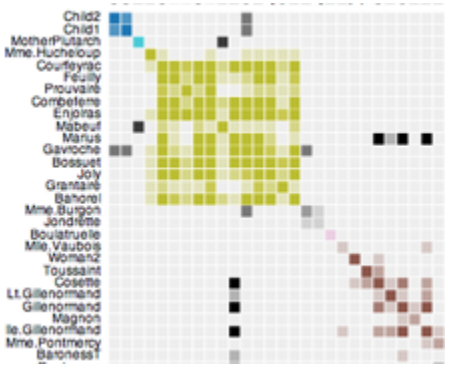
How do you want it to be viewed ?

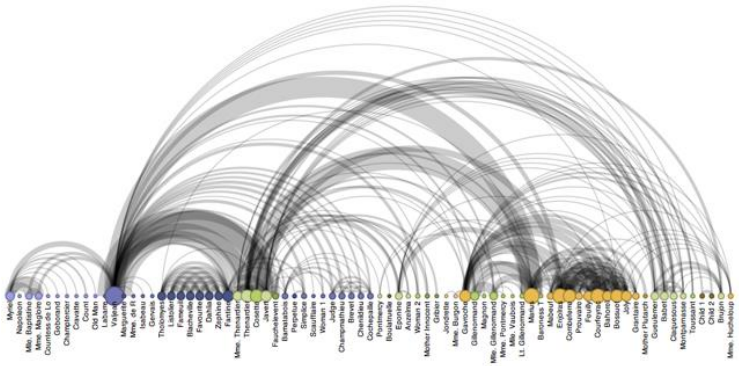
What works best for your particular workflow?

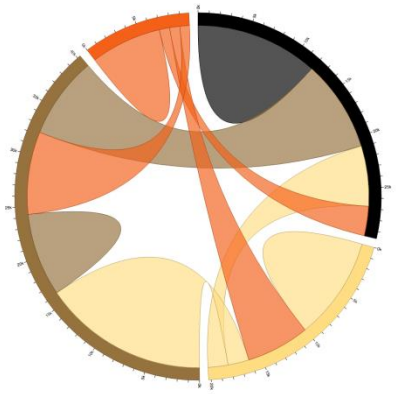


What to visualize ?

- Sociomatrices
- Social Networks
- Social Atom
- Chord diagrams
- Arc diagrams
- Hierarchical trees
- Timeline/Time-ordered networks
- etc.







How to visualize ?

R

Pajek

D3

JointJS

python

UCI

sigmajs

p5*

Gephi

NetDraw

three.js

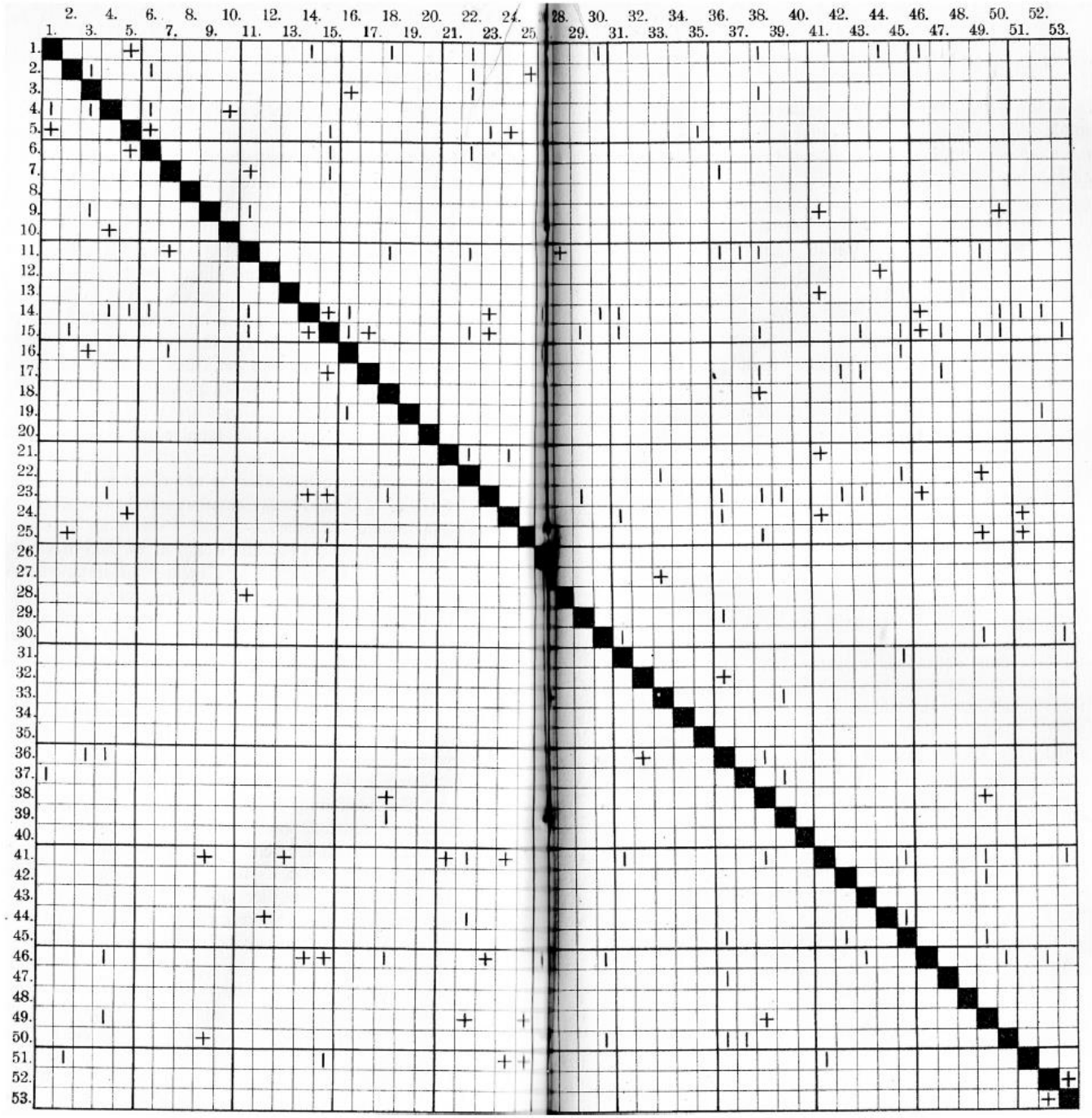
P

arbor.js

Cytoscape

vis.js

History of Network Visualization



Data from 1880–1881

German teacher Johannes Delitsch published in 1900 in ‘Zeitschrift für Kinderforschung’ (‘Journal of Child Study’).

| = Ingoing friendship relations (“angebotene Freunschaften”) - Child in column befriends child in row.

+ = Reciprocated friendships (“geschlossene Freundschaften”)

Helen Bott 1928

Observation of play activities in a nursery school.

(1) talked to another
(2) interfered with another
(3) watched another
(4) imitated another
(5) cooperated with another

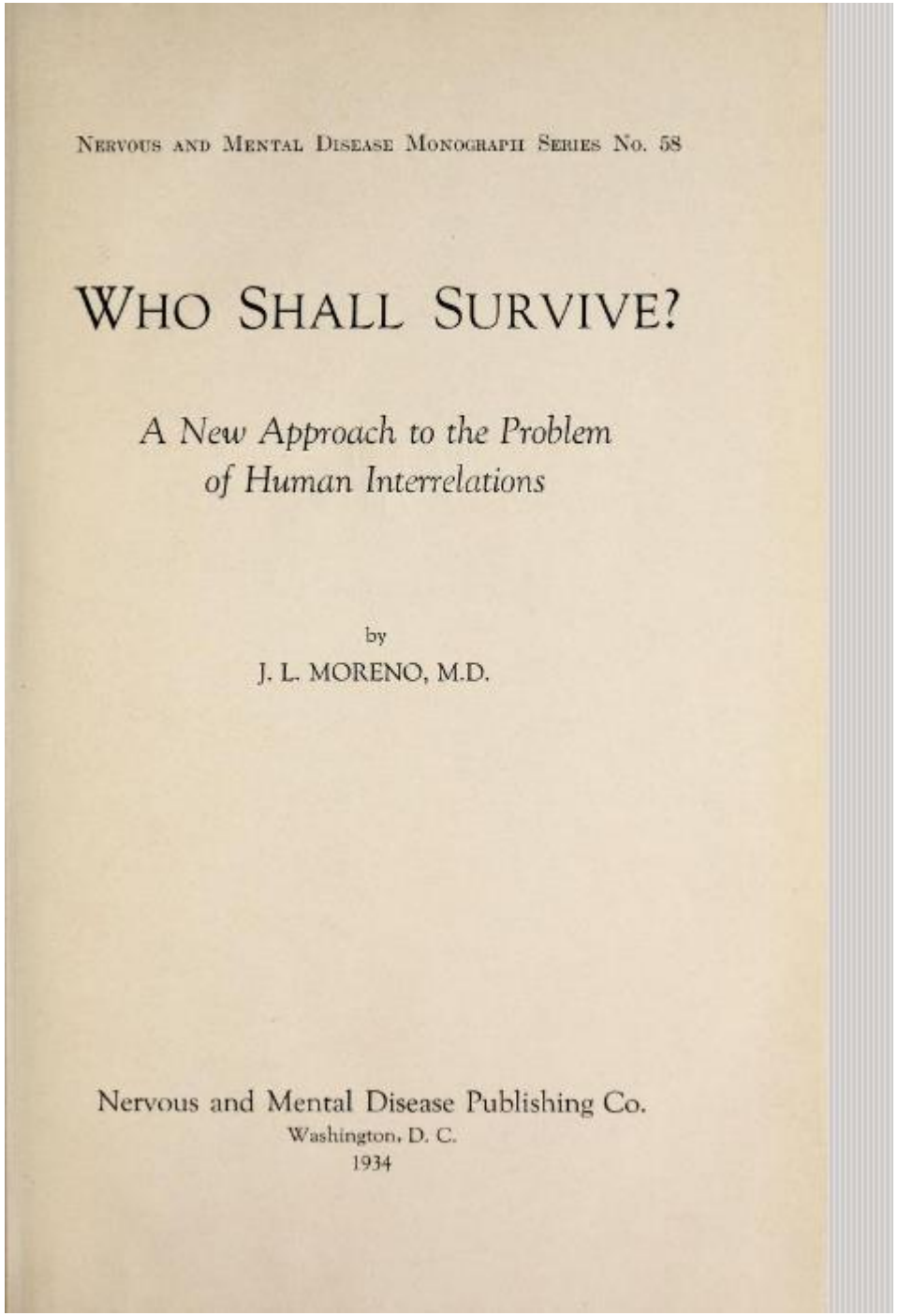
TABLE 2

SOCIAL RESPONSES AMONG ELEVEN CHILDREN UNDER FIVE CATEGORIES

Talking, Interference, Watching, Imitation, Cooperation

Observed behavior of each child towards his fellows

Child	Age (months)	Response	Children played with A	D	E	F*	G	H*	J*	K	M	N*	O*	All Responses	Total
A	26	Ta.		5	2	1			1	15	1		1	64	49
		Int.			5	1			1	5		1	1	12	
		Wa.		1	1	1				1				5	
		Im.			1					3				5	
		Co.			1					3				3	
D	29	Ta.	4		2	1		2		1	1	1		11	53
		Int.	1		1	1		2		2	5		6	8	
		Wa.	2		3	3	2	1	1	5	5	1		23	
		Im.				1				2				9	
		Co.						2		4				8	
E	31	Ta.	3	4		3	1	1	5	4	4	1	4	24	104
		Int.	6	7	12	12	1	2	1	7	5	7	5	57	
		Wa.		2				1	3	1	3	1	2	9	
		Im.		1		1							2	12	
		Co.											1	2	
E*	36	Ta.		3	1		2		2		3	2	11	23	53
		Int.		2	2		2				3		2	10	
		Wa.		1	1			1			2	2	6	10	
		Im.											3	3	
		Co.											1	1	
G	37	Ta.	2	2	1	1		2		5	3	4	2	16	55
		Int.		2	1	1		3		2	5		4	21	
		Wa.				1			1		1		3	10	
		Im.				4					2			3	
		Co.								2	2		1	5	
H*	38	Ta.	1	2	3		3			5	1	1		3	40
		Int.		2	2	3	3			1	4	4		9	
		Wa.									1			24	
		Im.												2	
		Co.												2	
J*	40	Ta.	4		16					1	20	7	5	57	86
		Int.	3	1	6	2				2	3	1	3	18	
		Wa.	1							1	2	2	1	9	
		Im.										1		2	
		Co.												0	
K	45	Ta.	5	2	2	3	4		1		20	2	3	42	73
		Int.	2	1	3	1	2		2		6	1	1	19	
		Wa.												0	
		Im.												2	
		Co.												10	
M	52	Ta.		3	3	1	2			6		3	7	27	69
		Int.		1		2				1			3	7	
		Wa.				1	1		1				4	4	
		Im.											18	21	
		Co.												10	
N*	53	Ta.	2	1	3	5	10	1	10	8	6		18	64	104
		Int.	4	2	4	8	2			1	1		2	22	
		Wa.	5	2		1					1		3	12	
		Im.											2	4	
		Co.												2	
O*	54	Ta.	1	1	4	11	2	1	4	3	65	25		85	143
		Int.	1	1	2	1			1	2	7	3		18	
		Wa.				1					1			5	
		Im.									3			1	
		Co.												4	
Responses of Companions		Ta.	21	18	36	26	18	6	18	45	123	41	54	406	
		Int.	16	18	23	28	12	7	9	21	31	18	18	201	
		Wa.	9	9	7	10	5	1	4	15	19	6	28	111	
		Im.	3	2	4	3	5	2	5	7	8	4	27	70	
		Co.	1	2	1	1	4	2	1	10	10	2	13	47	
Totals			50	49	71	68	42	18	37	98	188	71	140	855	



Nervous and Mental Disease Monograph Series No. 58

WHO SHALL SURVIVE?

A New Approach to the Problem of Human Interrelations

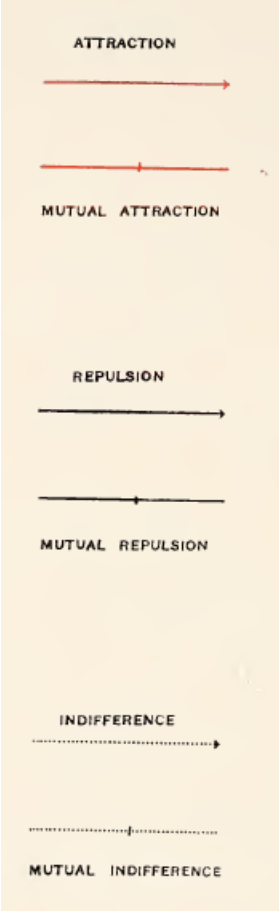
by

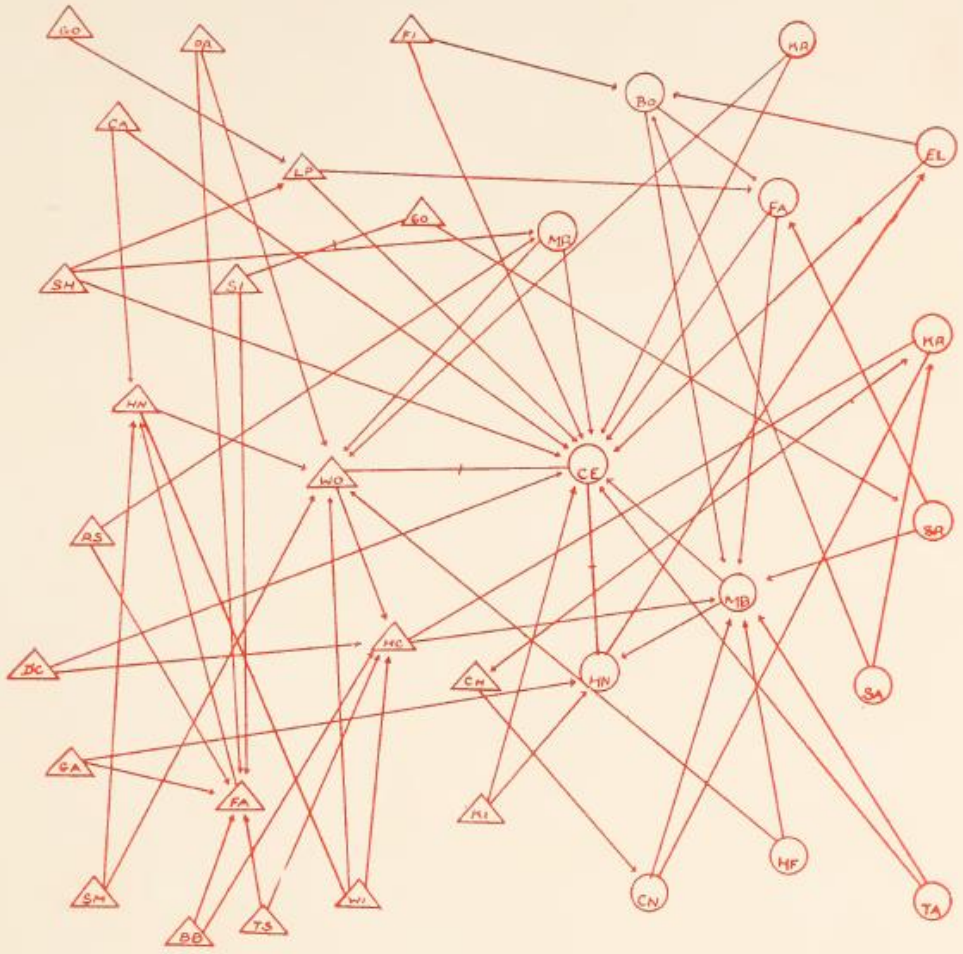
J. L. MORENO, M.D.

Nervous and Mental Disease Publishing Co.
Washington, D. C.
1934

Jacob Levy Moreno

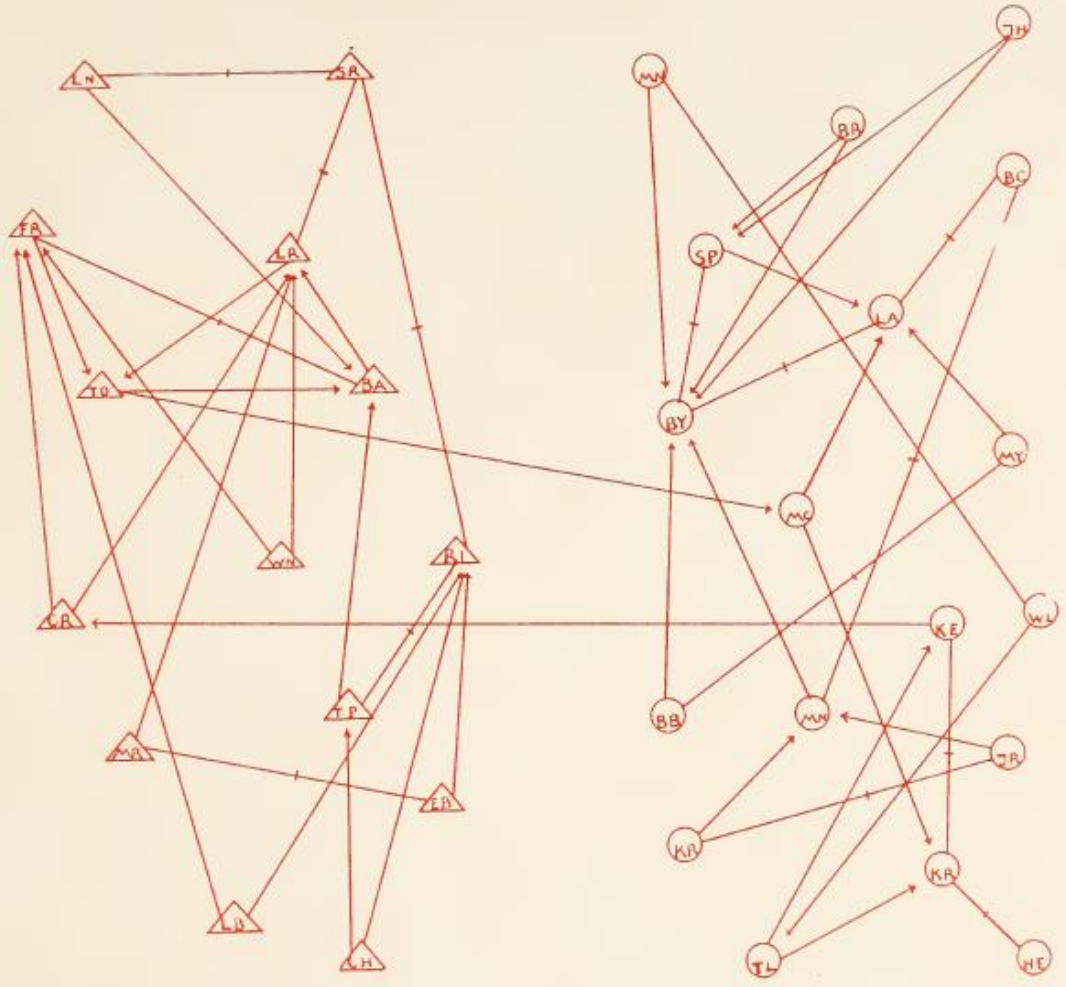
1934





Class Structure, 1st Grade

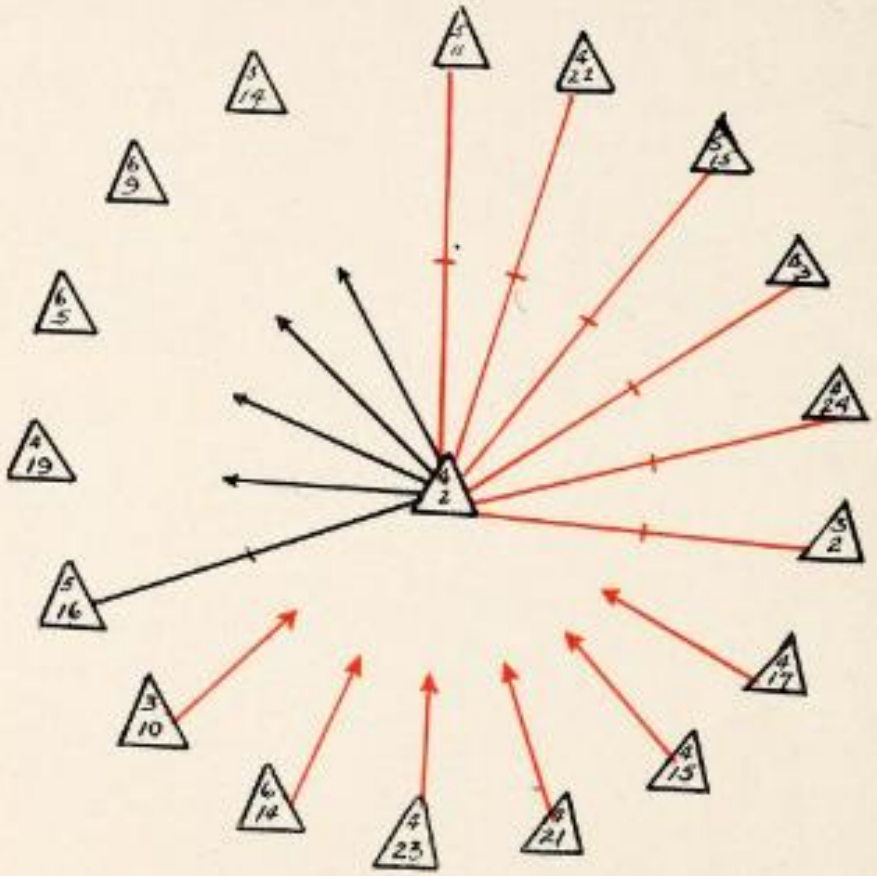
21 boys and 14 girls. *Unchosen*, 18, GO, PR, CA, SH, FI, RS, DC, GA, SM, BB, TS, WI, KI, TA, HF, SA, SR, KR; *Pairs*, 3, EI-GO, WO-CE, CE-HN; *Stars*, 5, CE, WO, HC, FA, MB; *Chains*, 0; *Triangles*, 0; *Inter-sexual Attractions*, 22.



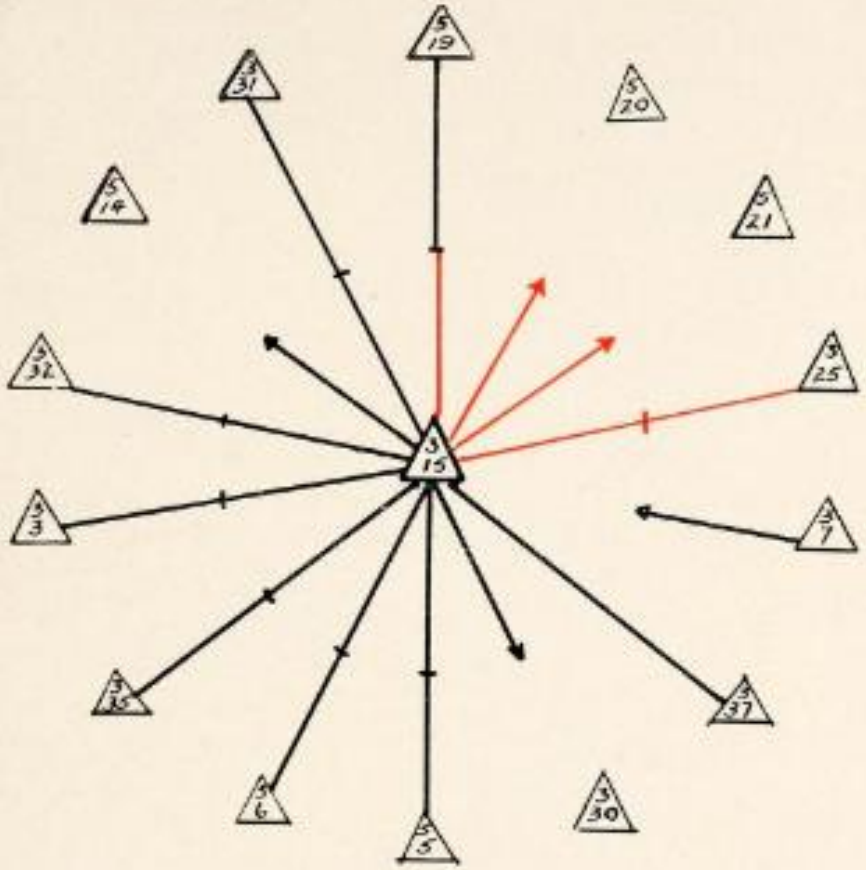
Class Structure, 7th Grade

14 boys and 18 girls. *Unchosen*, 5, WN, CH, LB, JH, BR; *Pairs*, 15, LN-SR, SR-LR, SR-RI, FR-BA, RI-TP, MR-EB, KR-HE, KR-JR, KR-KE, BB-MY, WL-MN, MN-BC, BY-LA, LA-BC, BY-SP; *Stars*, 5, LR, RI, BY, LA, MR; *Chains*, 2, SP-BY-LA-BC-MN-BY, LN-SR-RI-TP-BA; *Triangles*, 0; *Inter-sexual Attractions*, 2.

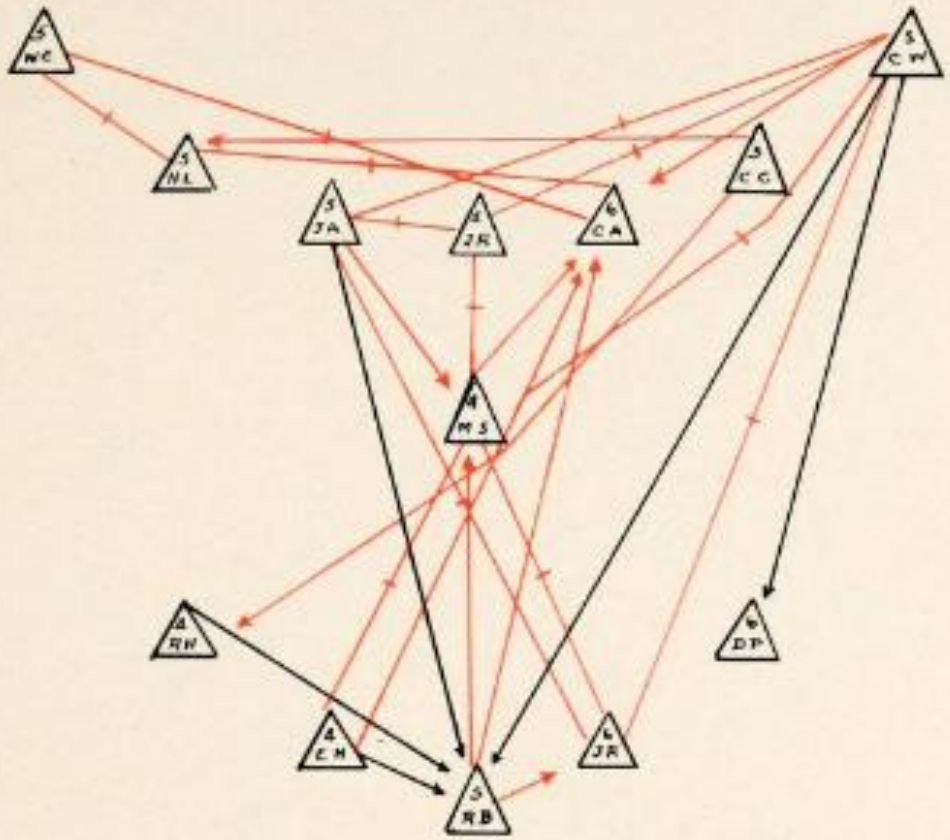
Social atom



The chart shows the position occupied by a typical leader in the school. Note that 4/2 has six reciprocal attractions; six additional attractions toward him by individuals to whom he is indifferent; one mutual dislike and four additional dislikes, each of whom feels neutral toward him. This is a high "batting average." The total number of individuals (17) toward whom relations have been expressed in the course of the survey, distributed over four forms, indicates that 4/2 takes an active attitude toward his fellow students and to life and is not on the "side lines."



The chart depicts an isolated individual. The student 3/15 arouses active feelings—he is the focus of a great deal of antipathy; he likes 3/25, and is accepted by him; he also likes two others, 5/20 and 5/21 who, significantly are new boys and who are indifferent to him, and he also likes 5/19, who, however, dislikes him. This shows that 3/15 has formed only one satisfactory contact in the whole school, while there are seven mutual dislikes, two dislikes for persons who are indifferent to him, and one dislike toward him from a person toward whom he is indifferent.



A Football Team

The chart shows the football team which includes two substitute backs. Note that the quarterback 4/MS is the focus of attraction forces on team, as he should be, but that fullback 5/RB is liked by nobody on the team, and is disliked by four: 4/RH and 4/EH of the back field, and 5/JA and 5/CW of the line. It is easy to see that when 5/RB is running with the ball he is not apt to get the maximum of coöperation in interference and blocking.

(See Map of a School Community, pp. 49–50)

Beiträge zur Sozialpsychologie des Haushuhns.

Von

THORLEIF SCHJELDERUP-EBBE.[1]

Anhang: **Tierpsychologie und Soziologie des Menschen.**

Von

DAVID KATZ.

1. Kapitel.

Die soziale Stellung jedes Individuums.

Thorleif Schjeldrup-Ebbe 1922

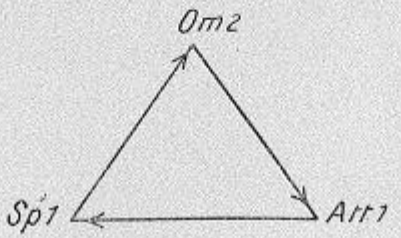
First demonstration of a social hierarchy in animals (chickens)

Demonstrated transitivity as feature of linear social hierarchies

Hackliste Nr. 2. 10 Hennen: Om2, Attl, Spl, Gaml, P2, Lvkl, Sm2, Bll, Gr, Hv2.

Om2	hackt	alle aufser Spl.
Attl	„	alle aufser Om2.
Spl	„	alle aufser Attl.
Gaml	„	P2, Lvkl, Sm2, Bll, Gr, Hv2.
P2	„	Lvkl, Sm2, Bll, Gr, Hv2.
Lvkl	„	Sm2, Bll, Gr, Hv2.
Sm2	„	Bll, Gr, Hv2.
Bll	„	Gr, Hv2.
Gr	„	Hv2.
Hv2	„	keine.

Betrachtet man Hackliste 2, so sieht man, dafs hier keine Henne vorkommt, die Despot über alle anderen Hennen ist. Das ist ein Gegensatz zu dem, was wir in Hackliste 1 fanden. 3 Hennen in Hackliste 2, Om2, Attl und Spl, sind gleich günstig gestellt, indem sie alle 3 jede 9 Hennen hacken. Zu einander verhalten sich die 3 Hennen wie die Hennen Pl, Oml und FrSl in Hackliste 1, insofern Om2 die Attl hackt, welche ihrerseits Spl hackt, während Spl Om2 hackt. Diese 3 Hennen hacken sich gegenseitig im Dreieck, was Fig. 1 zu veranschaulichen sucht, bei der die Richtung der Pfeilspitzen die Richtung bezeichnet, in welcher das Hacken verläuft.



Figur 1

Illustration of Network Intransitivity

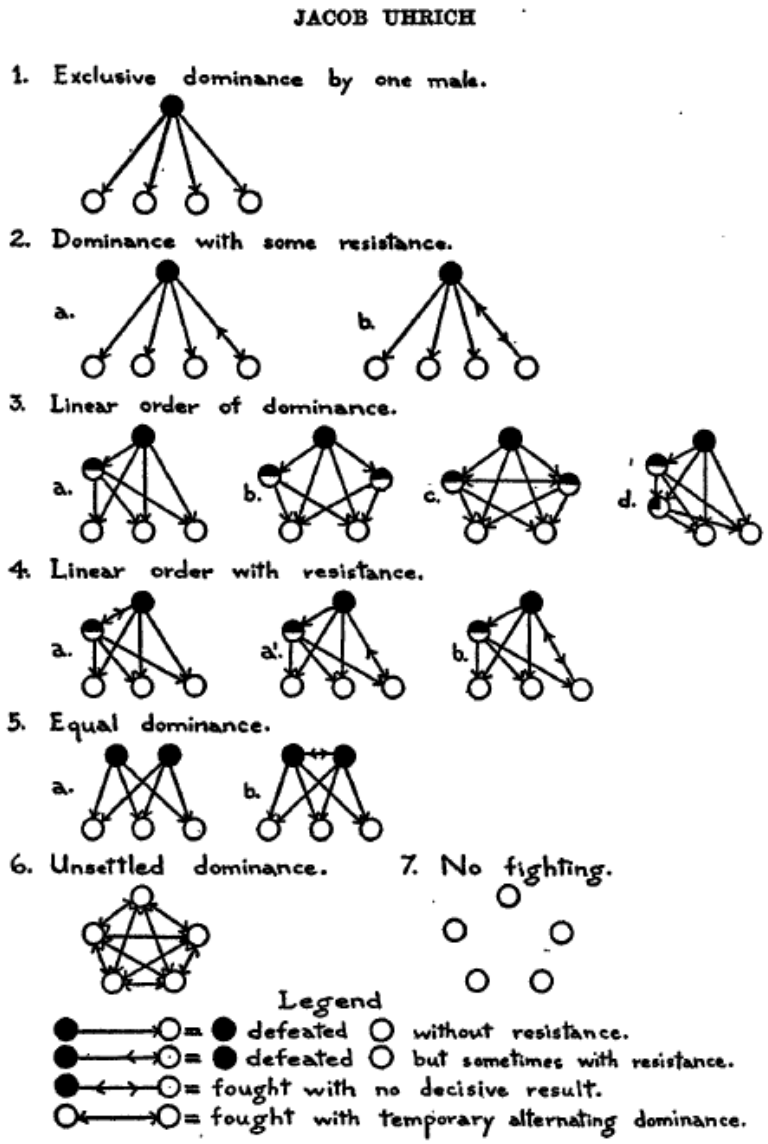


FIG. 1. DIAGRAMS ILLUSTRATING REPRESENTATIVE TYPES OF FIGHTING RELATIONSHIPS AMONG MALE MICE

Jacob Uhrich 1937

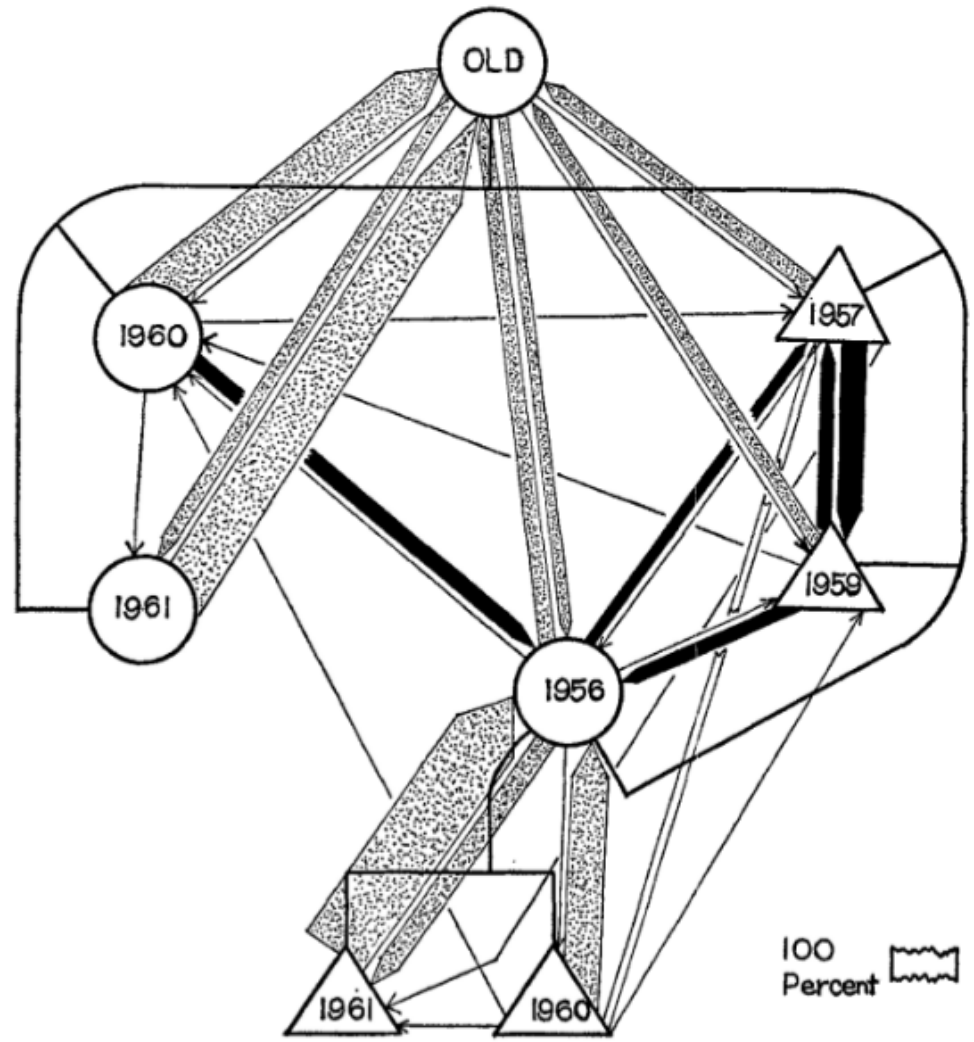


Fig. 3 Grooming relations in genealogy 4 from March 21, 1961 through December 25, 1961. Drawn from the data in table 3. Explanation in text.

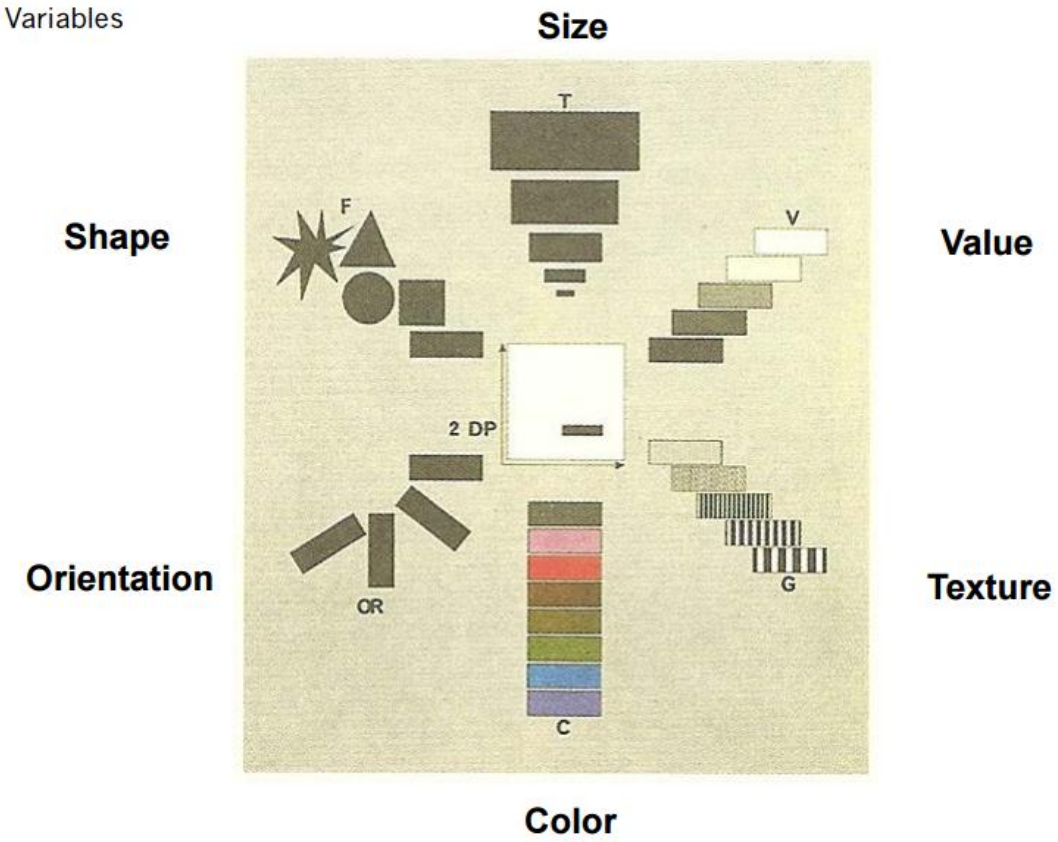
Donald Sade 1965

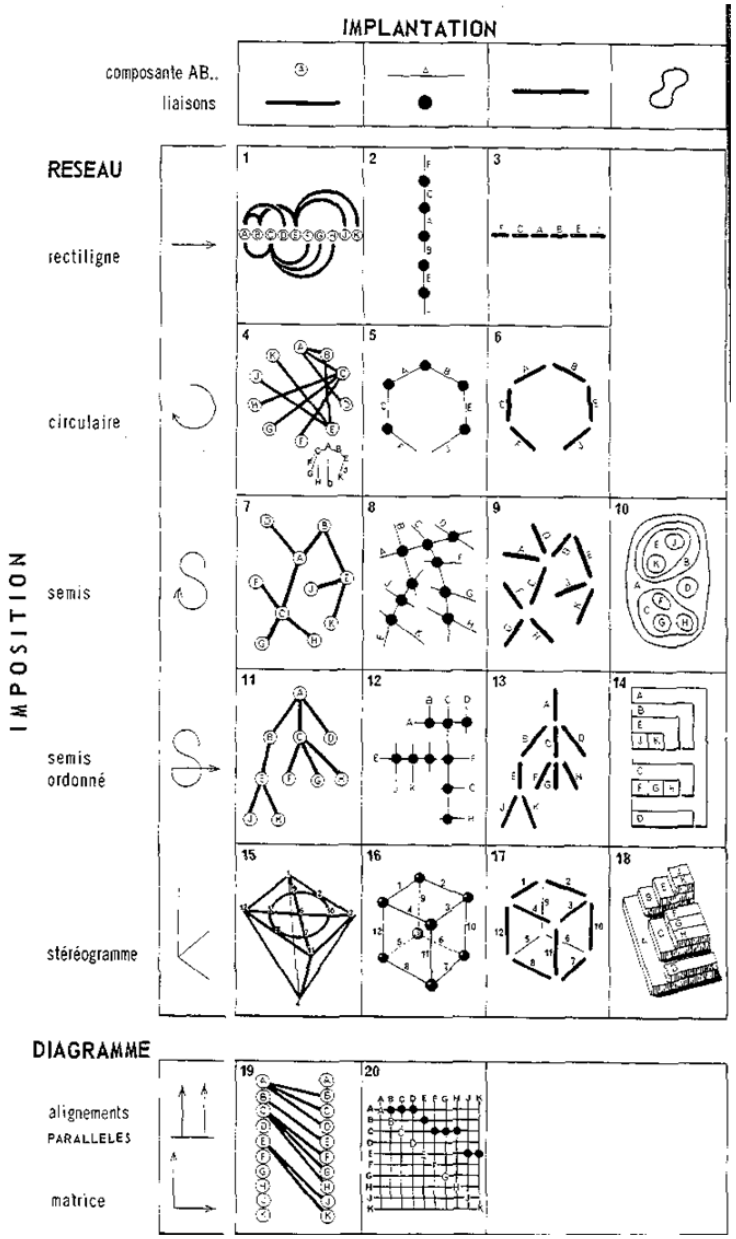
Principles of Network Visualization

Jacques Bertin 1967

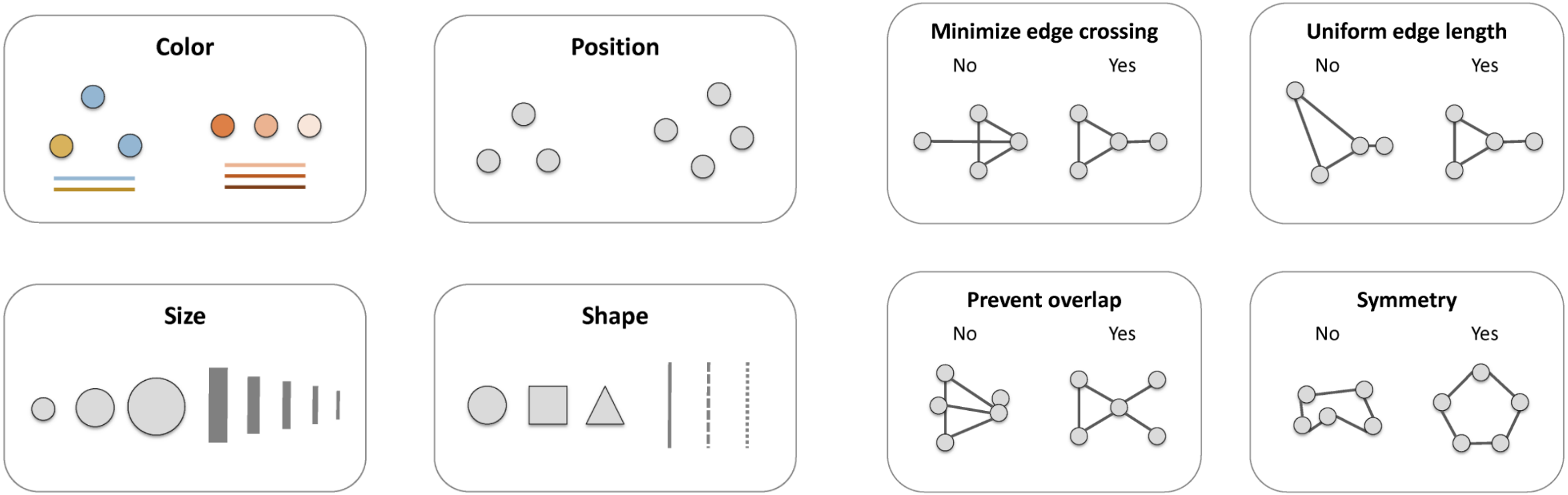
Semiology of Graphics: Diagrams, Networks, Maps

Retinal Variables



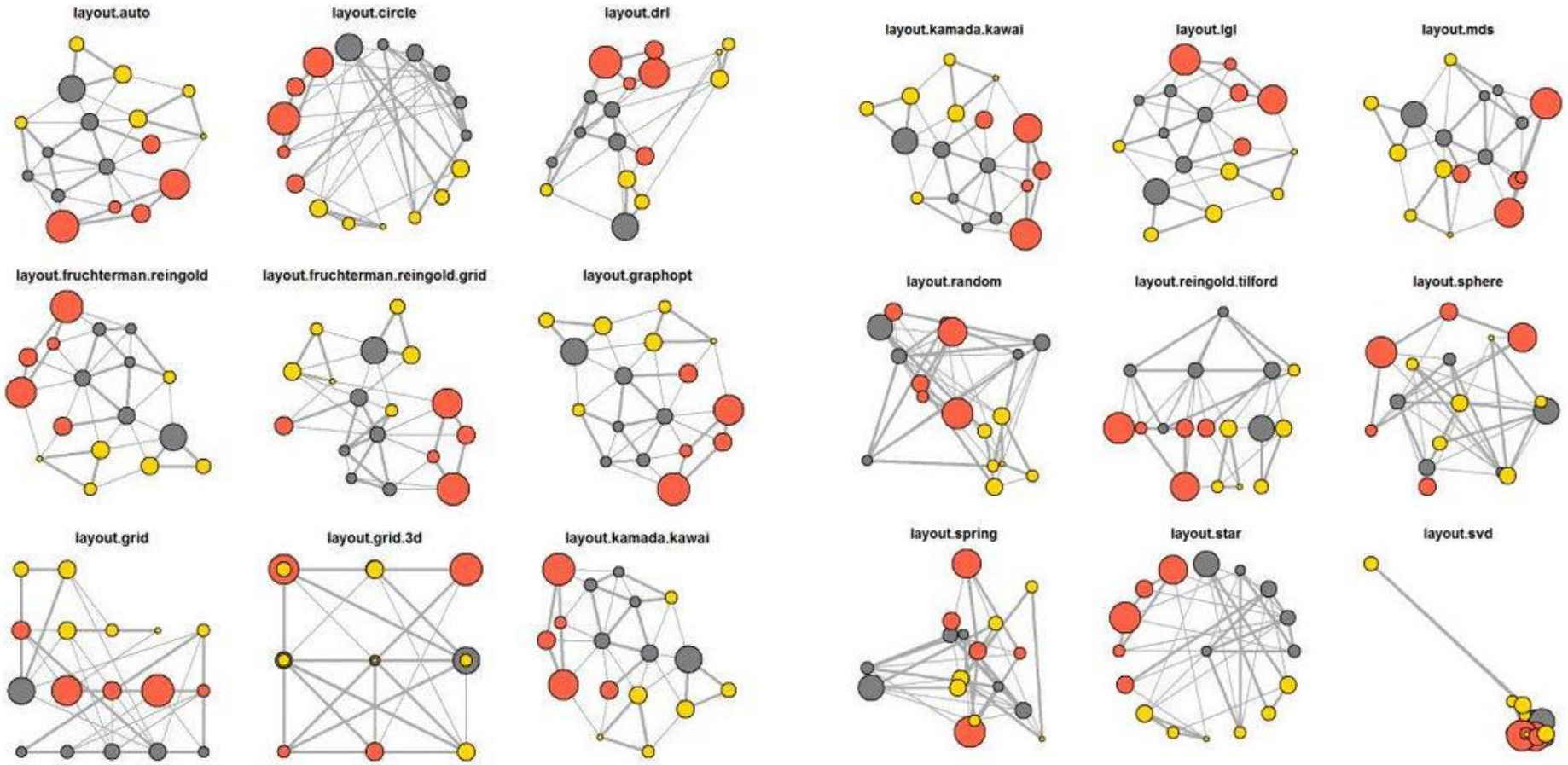


Basic Network Visualization Principles



Katya Ognyanova (Rutgers)

Basic Network Visualization Principles - Layouts

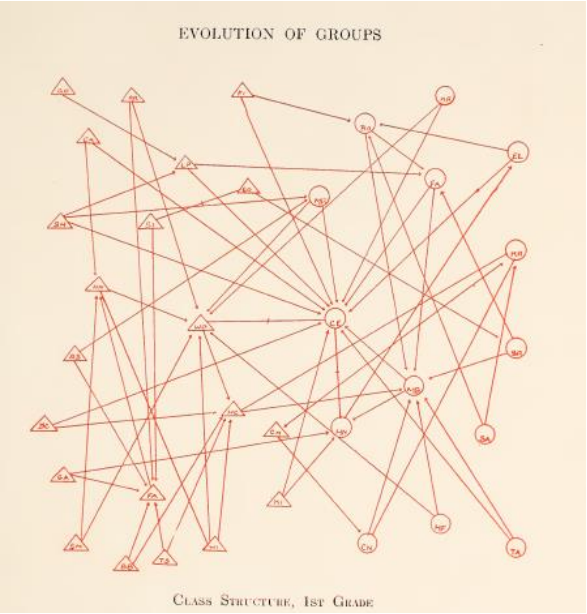


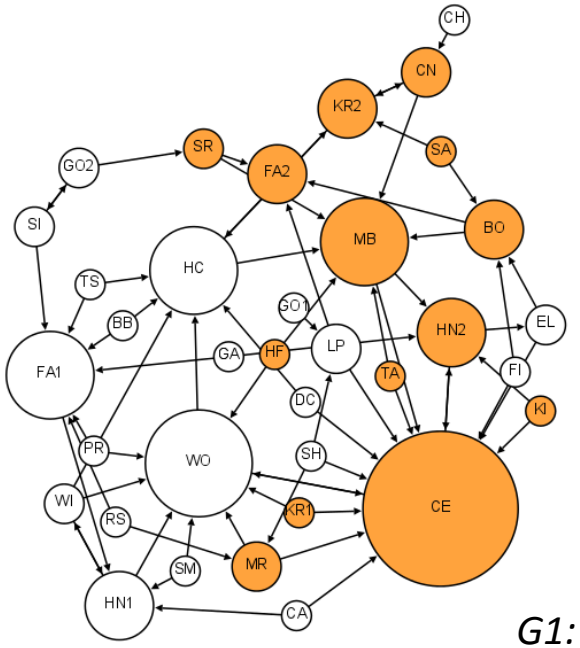
R – igraph package (Gabor Csardi)

Katya Ognyanova (Rutgers)

Identifying Network Structures & key nodes

1st Grade





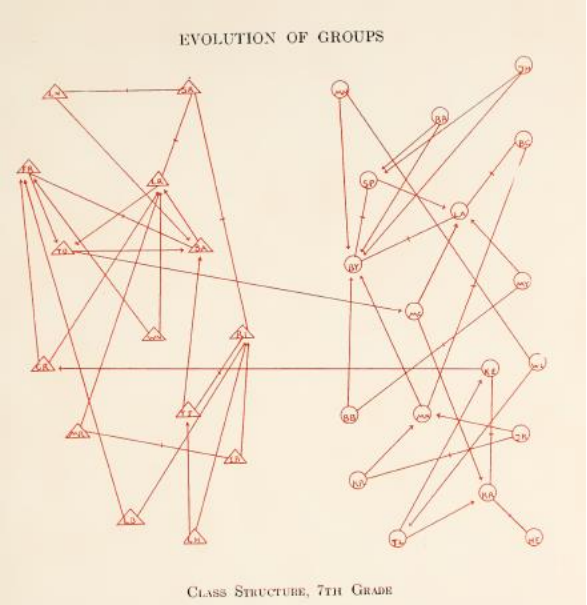
G1: 22 boy-girl edges

Moreno's original visualizations remade in Gephi by [Martin Grandjean]

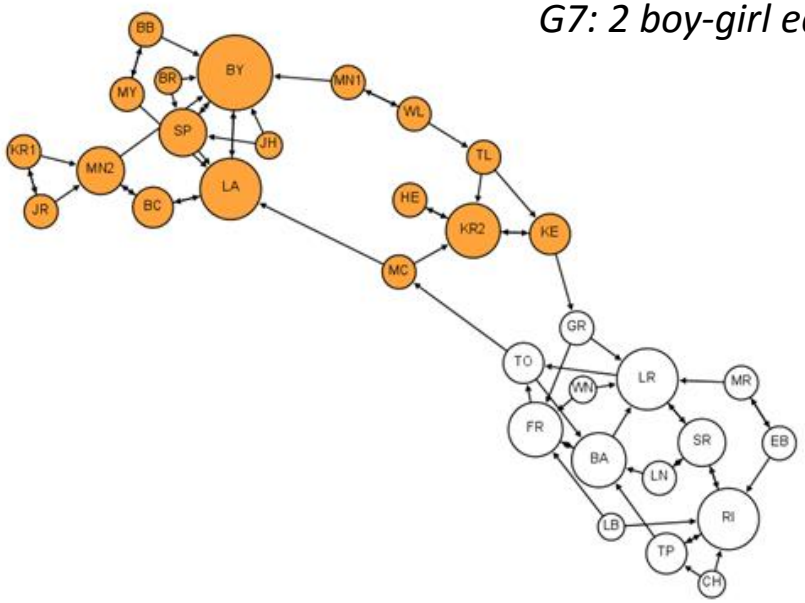
Node size – degree

Node color – gender
orange – girls
white – boys

7th Grade



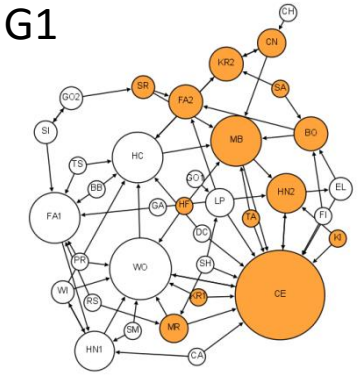
G7: 2 boy-girl edges



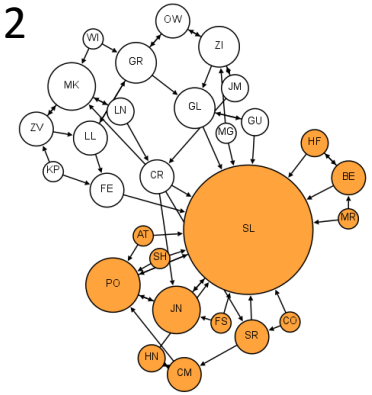
Changes in homophily, reciprocity & community structure across grades

Moreno's original visualizations remade in Gephi by Martin Grandjean

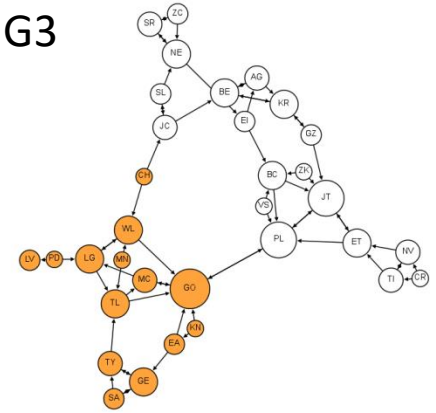
G1



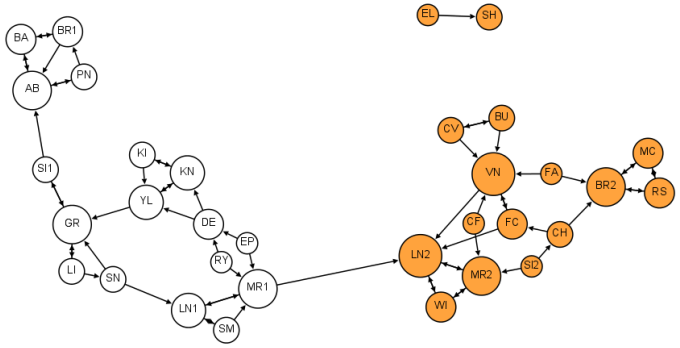
G2



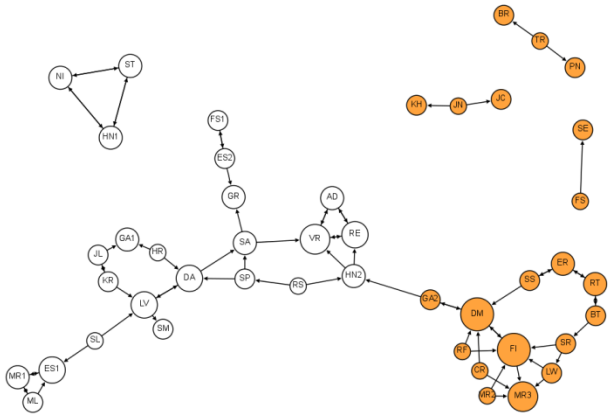
G3



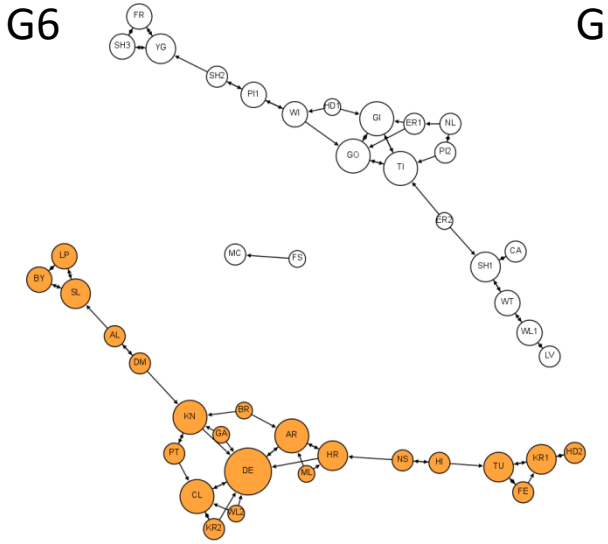
G4



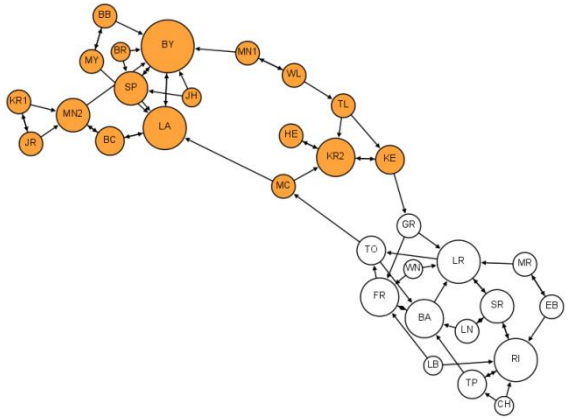
G5



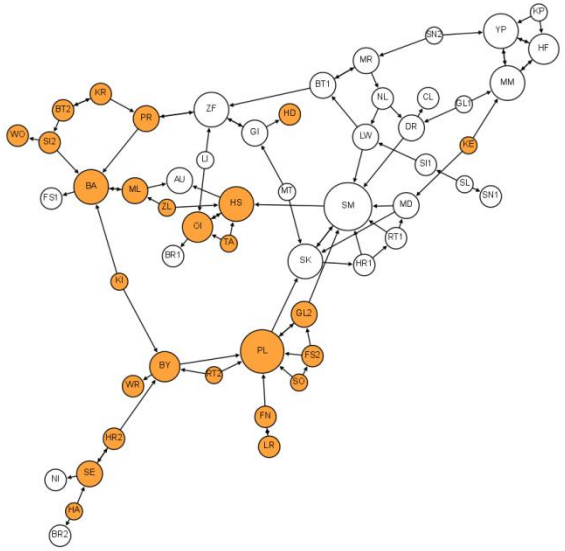
G6



G7



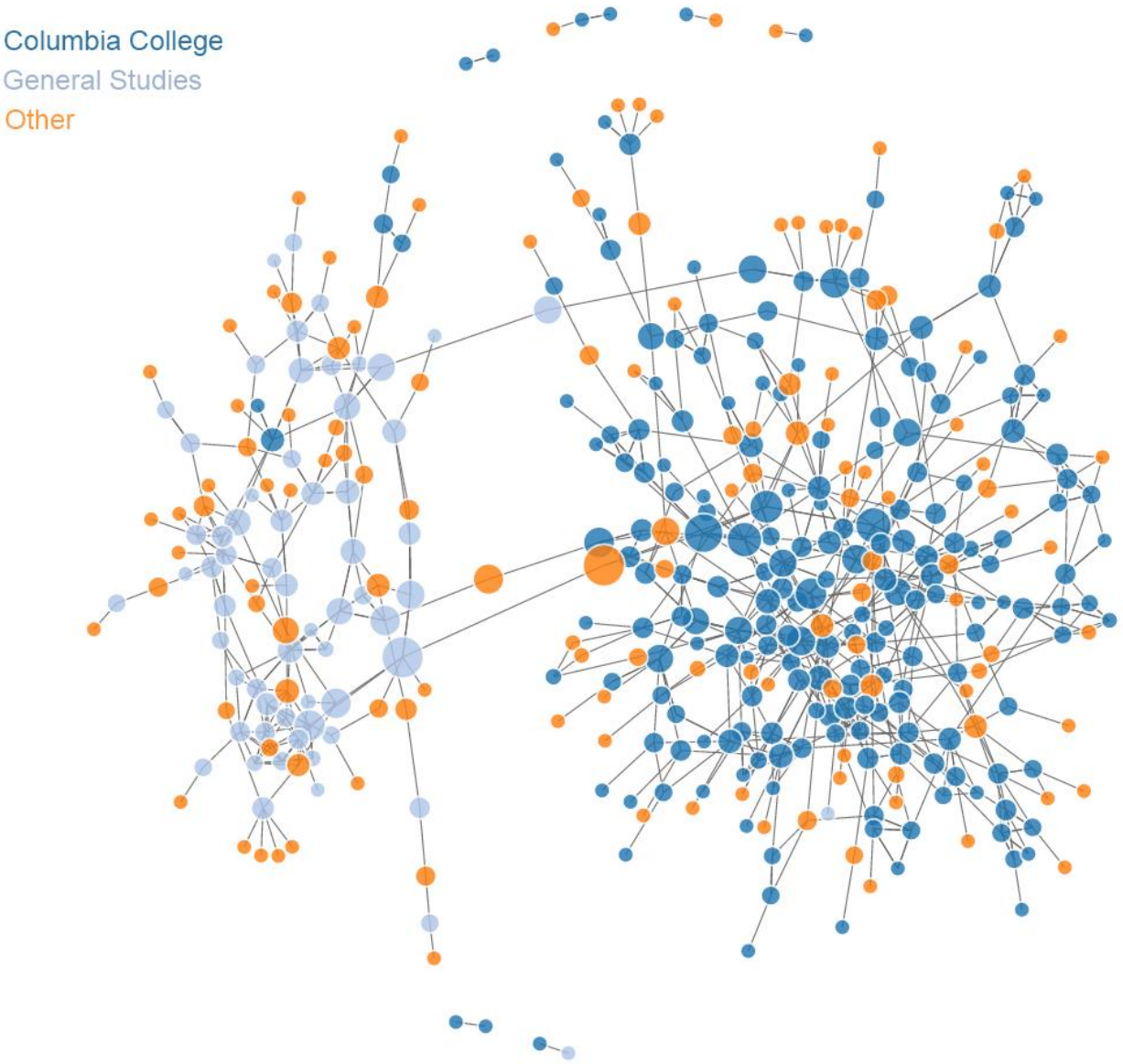
G8



[Friendship Network in Columbia Intro Bio Classes]

(with Kaytee Turetsky)

Made with D3.js & networkD3 R package



Extensions to Network Visualization

Limits to what can be inferred immediately from a static network visualization

Interactivity – users gain more insight through interactivity & can explore data for themselves

Broswer based :

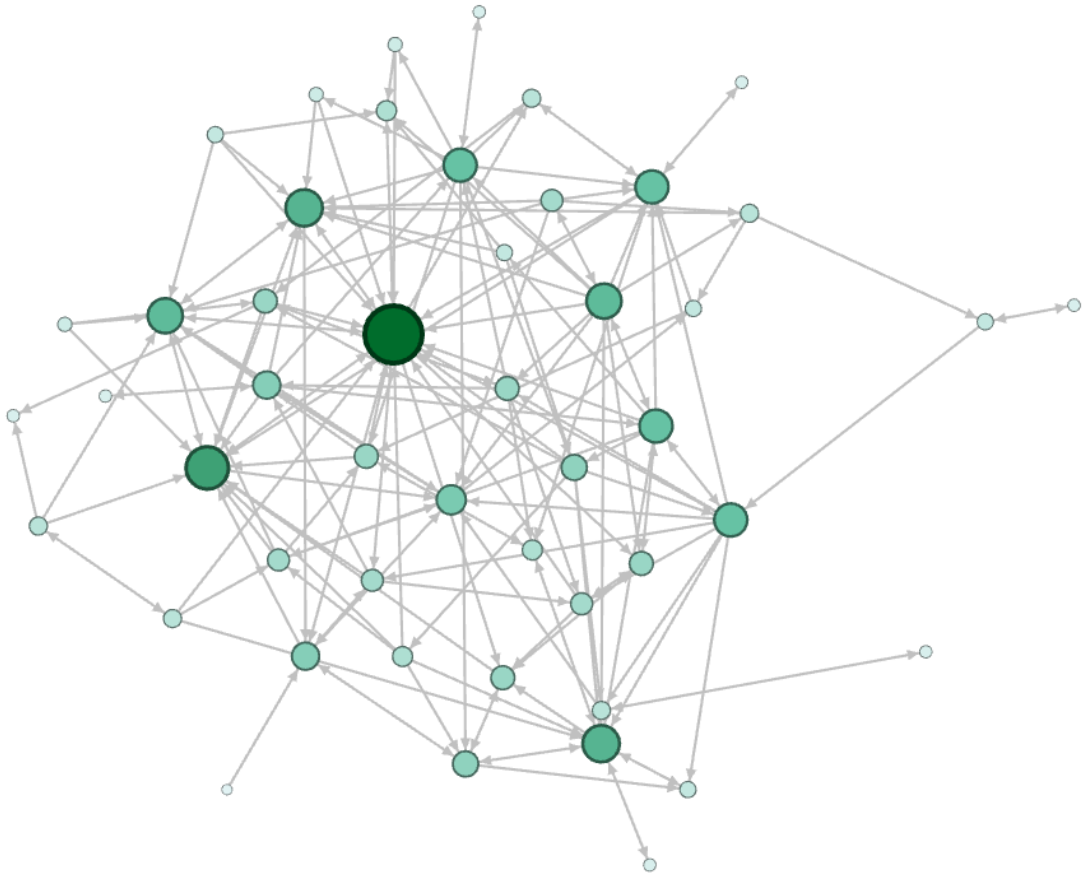
e.g.

- Filtering data
- Mouseover /onClick events
- Linked matrices/networks

Filtering Information - less is more

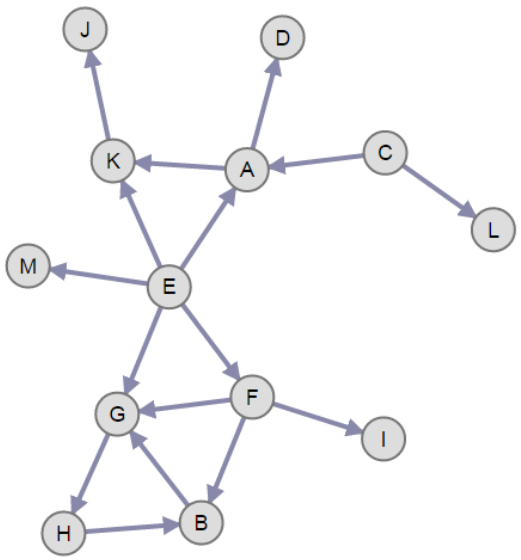
Friendship connections in German school 1880

e.g. identify neighbors in Gephi

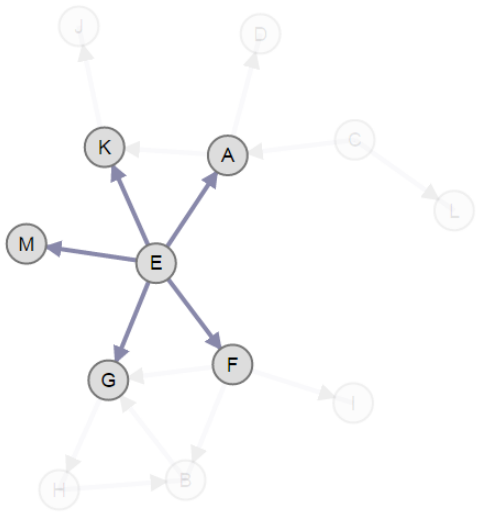


Schmidt has 3 reciprocated friendships, 1 outgoing only & 2 incoming only

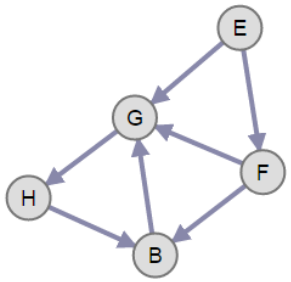
Filtering Information - less is more



e.g. *identify direct neighbors in D3.js*



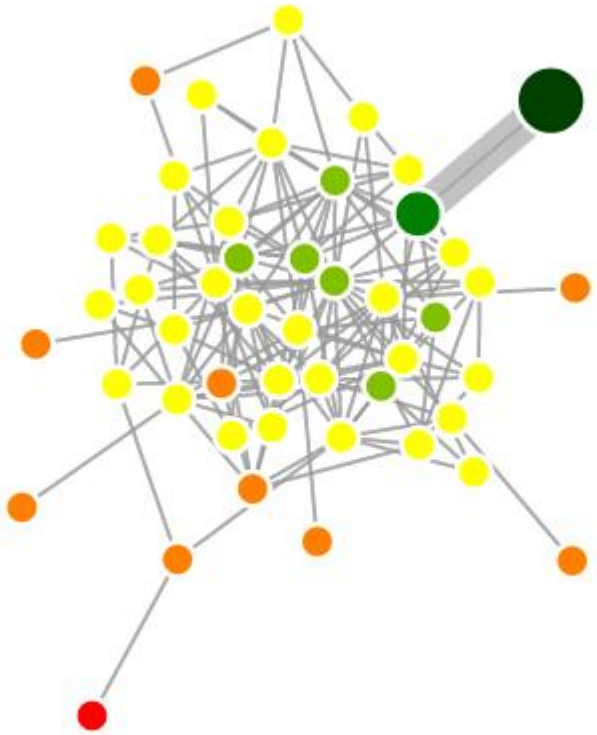
e.g. *identify triads in D3.js*



blockbuilder.org/jalapic

Interactivity

e.g. find geodesic distances in D3.js



Who is 1, 2, 3, 4 geodesic distance from Flach ?

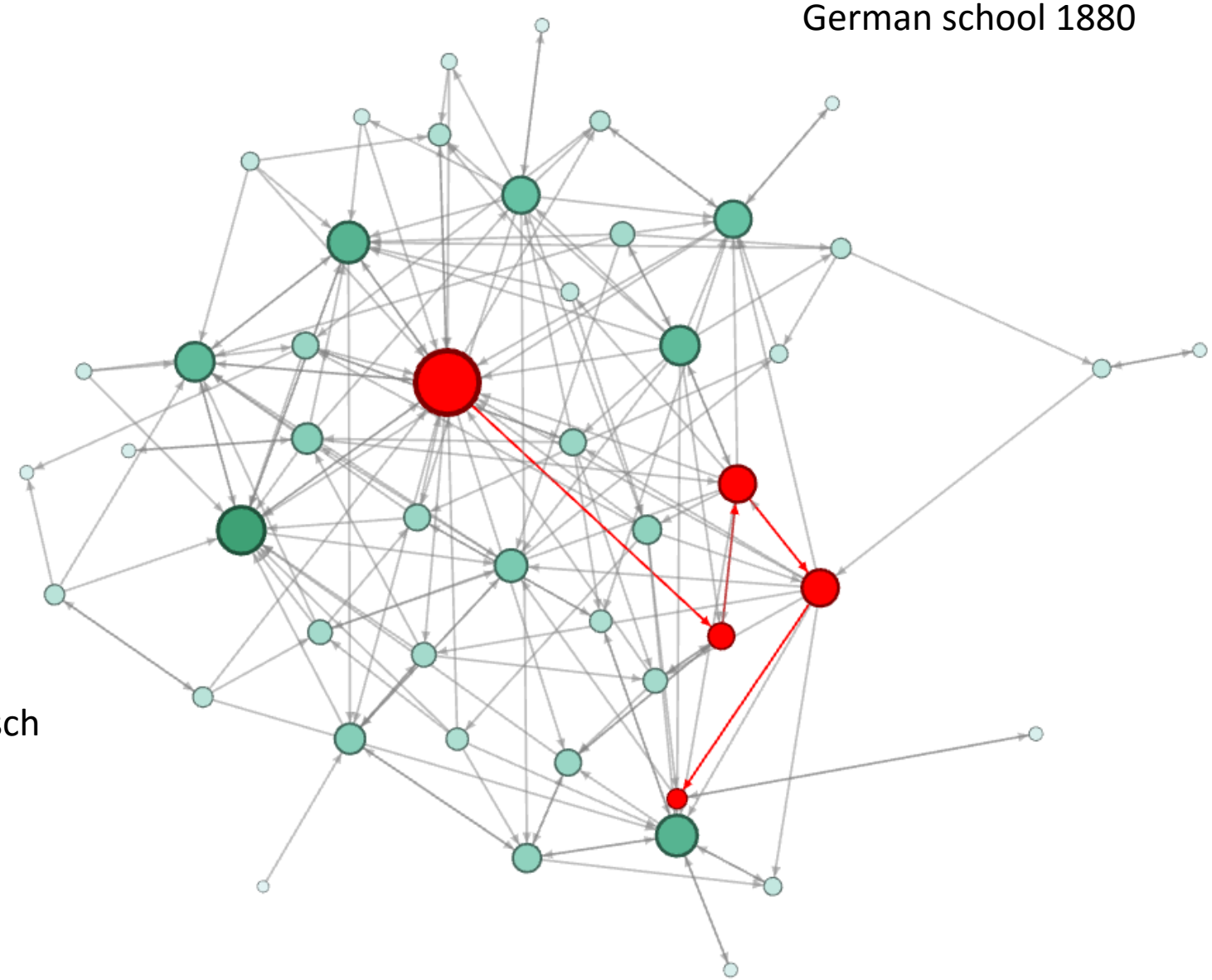
blockbuilder.org/jalapic

Interactivity

e.g. identify shortest paths

Example – Gephi

Friendship connections in German school 1880

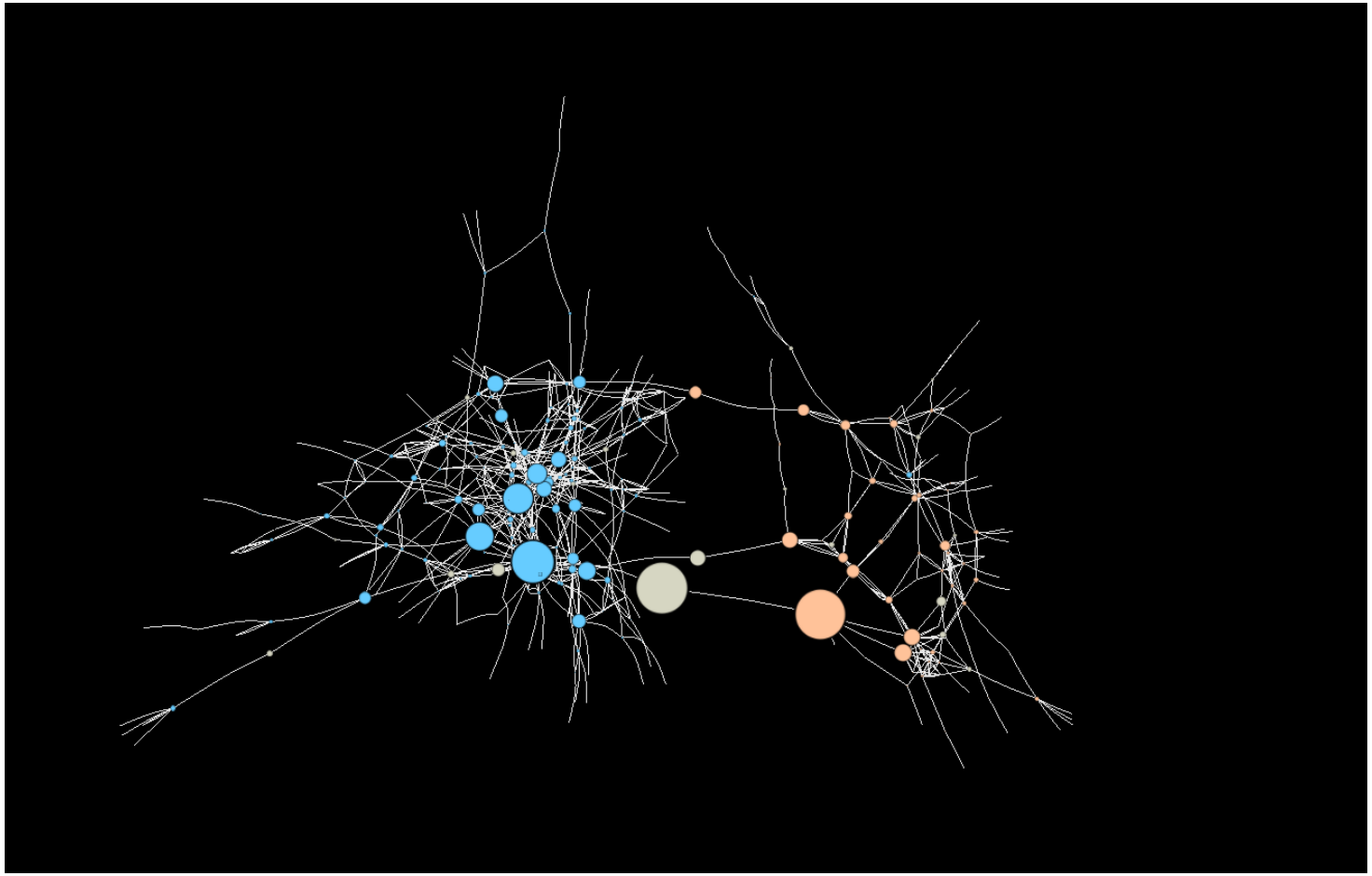


Pfeil → Fritzsche → Fährmann → Stolze → Lasch

Pfeil & Lasch have a geodesic distance of 4

Filtering Information - less is more

e.g. Only showing nodes of high betweenness



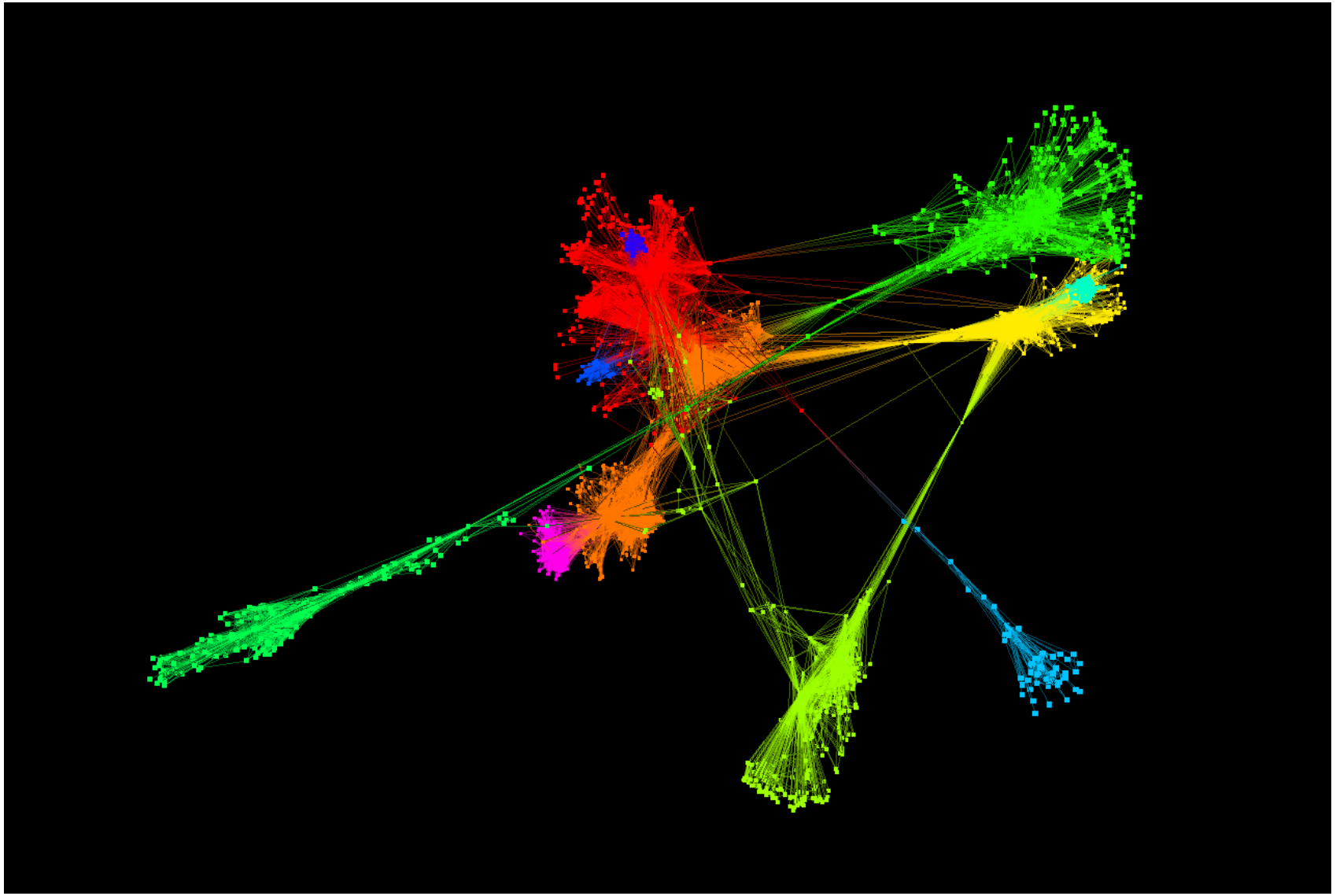
Made using rthreejs

3D Network Representations

Community structure among friends in Facebook data (Stanford SNAP repository)

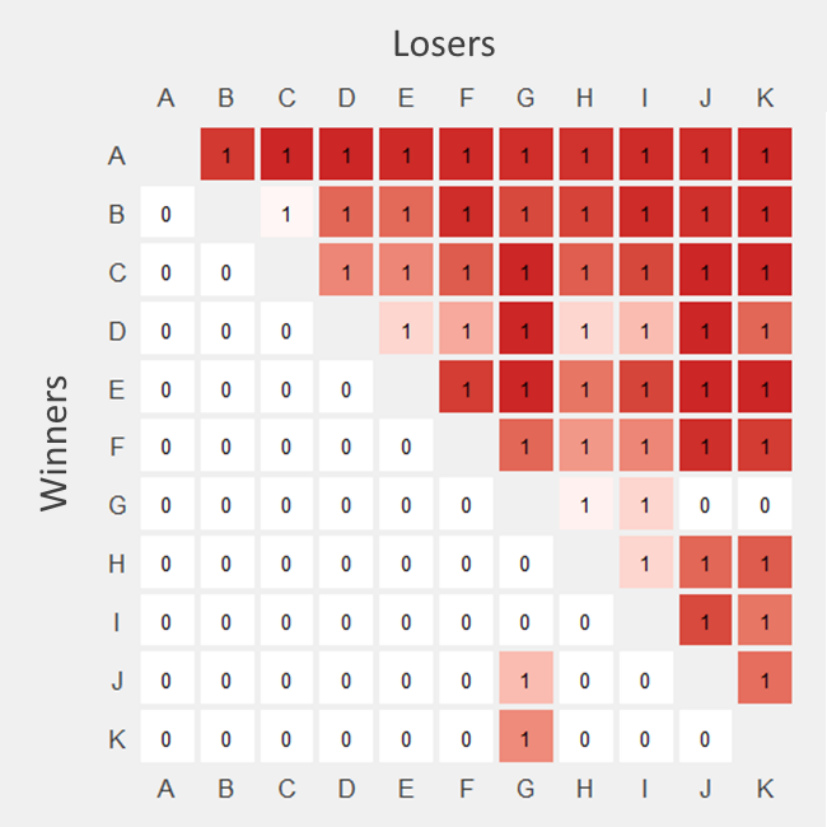
Using rthreejs

Bryan Lewis



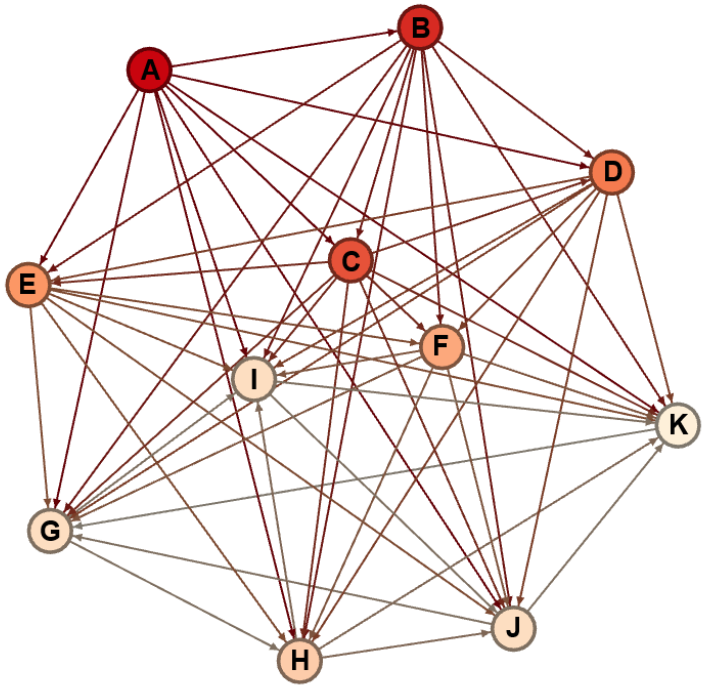
Is a network really the right visualization ?

Social Network Analysis of Social Hierarchies



Winners \ Losers	A	B	C	D	E	F	G	H	I	J	K
A		1	1	1	1	1	1	1	1	1	1
B	0		1	1	1	1	1	1	1	1	1
C	0	0		1	1	1	1	1	1	1	1
D	0	0	0		1	1	1	1	1	1	1
E	0	0	0	0		1	1	1	1	1	1
F	0	0	0	0	0		1	1	1	1	1
G	0	0	0	0	0	0		1	1	0	0
H	0	0	0	0	0	0	0		1	1	1
I	0	0	0	0	0	0	0	0		1	1
J	0	0	0	0	0	0	1	0	0		1
K	0	0	0	0	0	0	1	0	0	0	

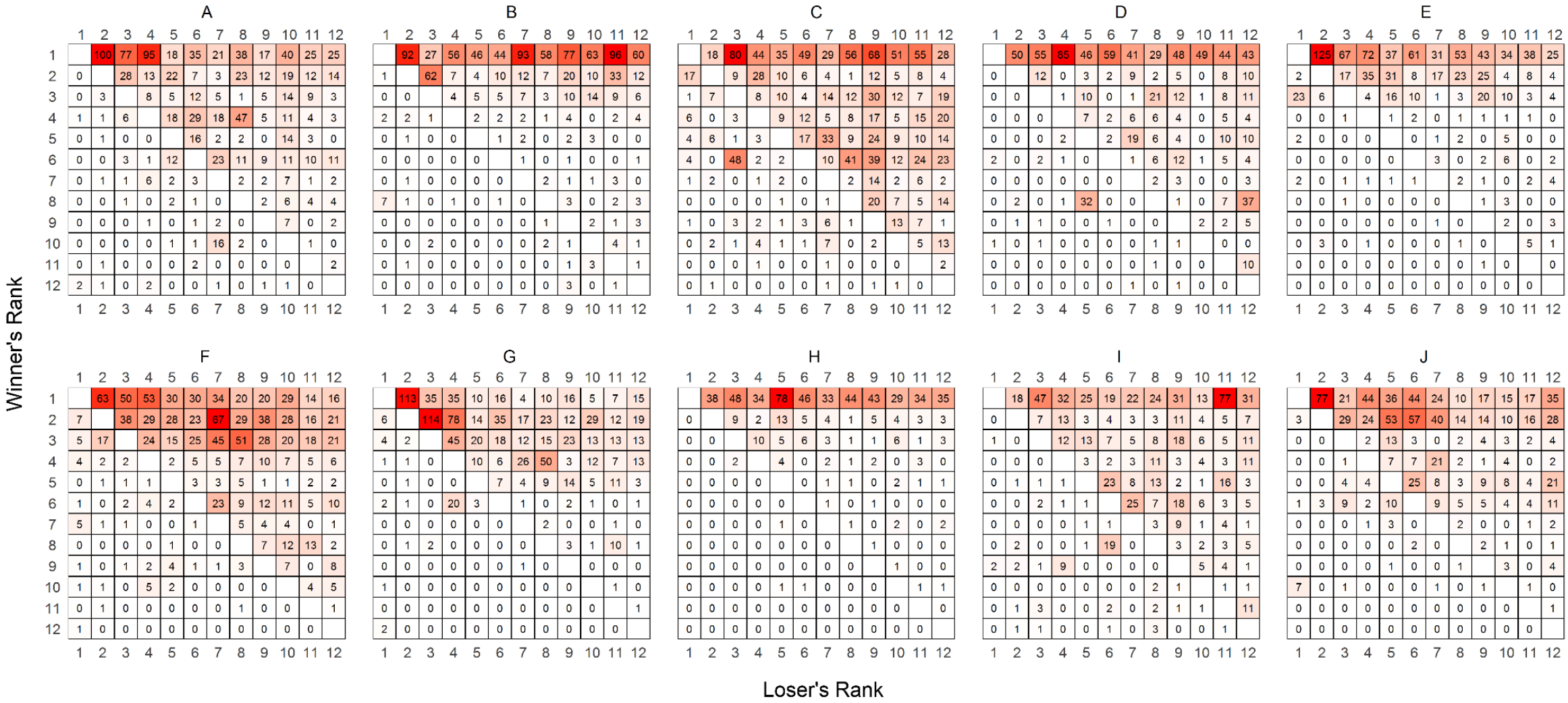
Adjacency Matrix



Network Graph

Comparing many networks by visual inspection may not be that easy or intuitive

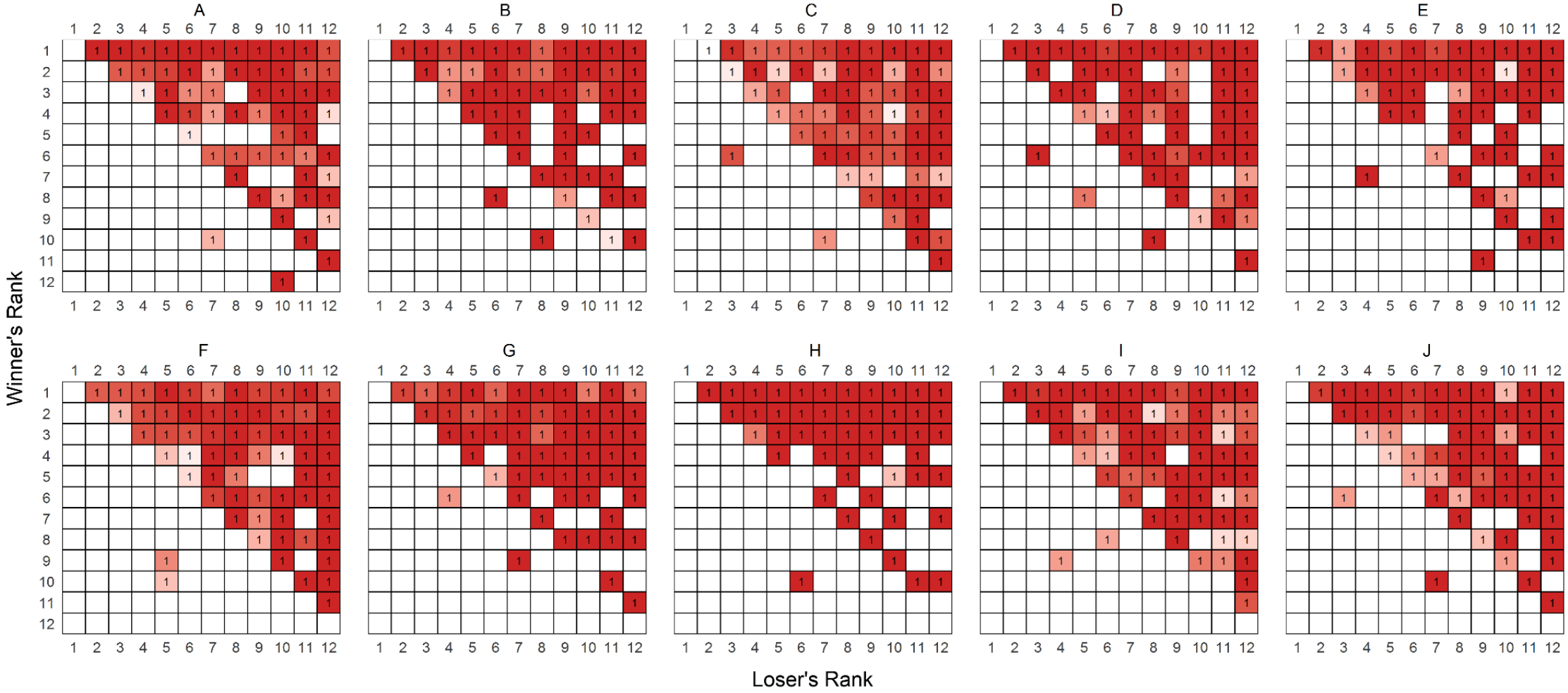
Mouse Social hierarchies are highly linear



R - ggplot2

Williamson et al. *Anim Behav* 2016.

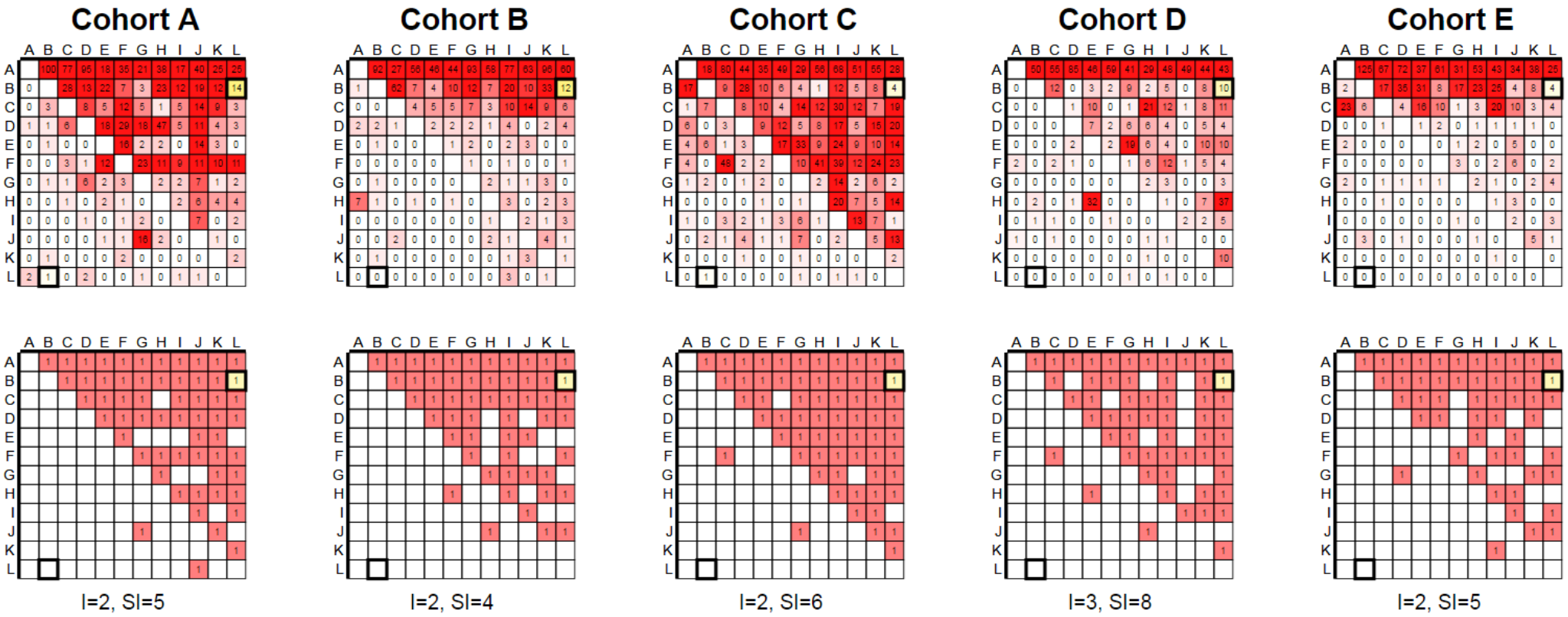
Mice have unique ranks and show high directional consistency of behavior



R - ggplot2

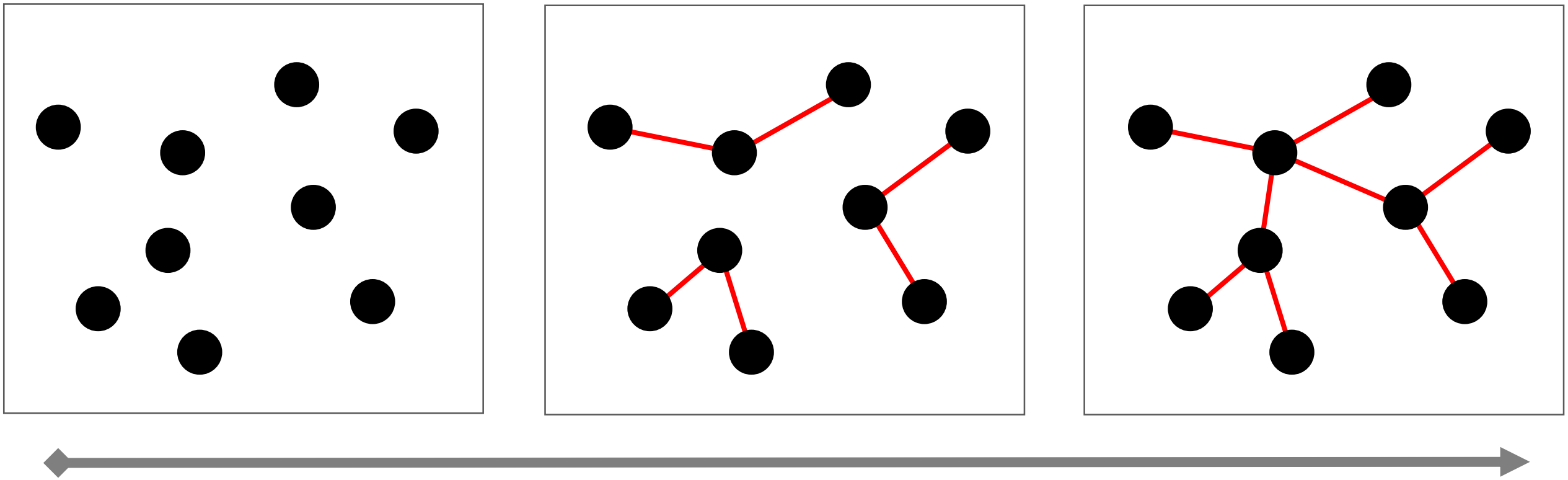
Williamson et al. *Anim Behav* 2016.

D3.js – linked matrices.



http://curleylab.psych.columbia.edu/socdom1.html

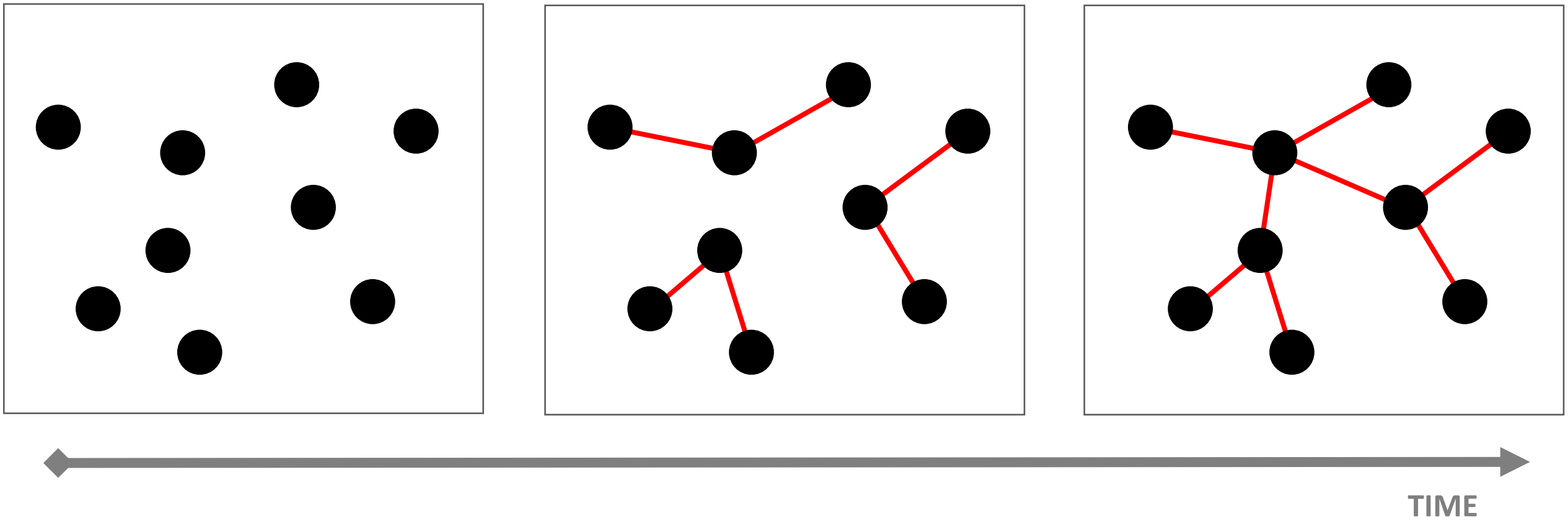
How to encode TIME in Networks ?



Time-ordered network - visualize all observed data for network dynamics for every unit of time

Time-aggregated network - visualize networks within aggregated time windows.

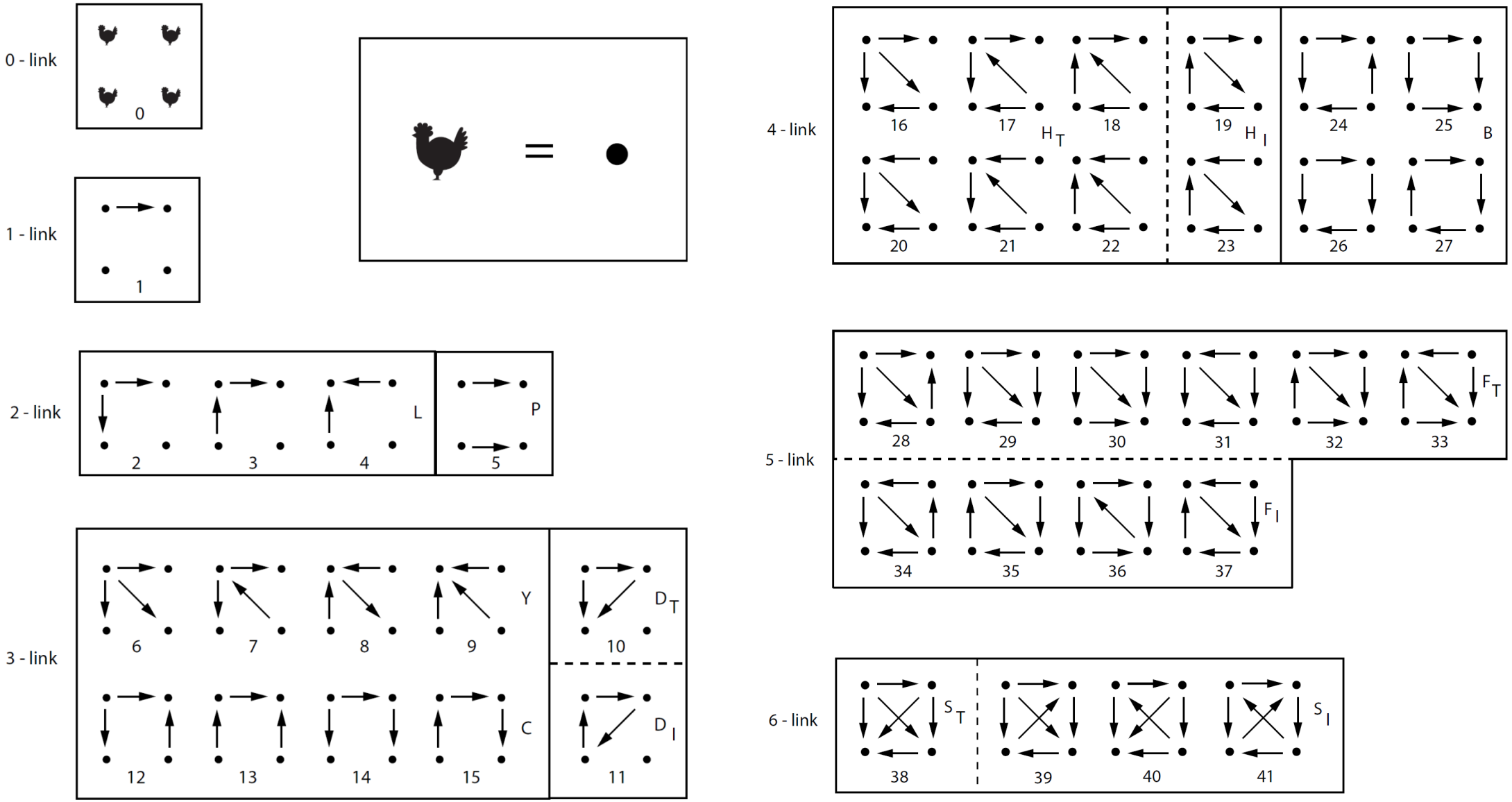
How to encode TIME in Networks ?



SMALL MULTIPLES

ANIMATION

TIMELINES

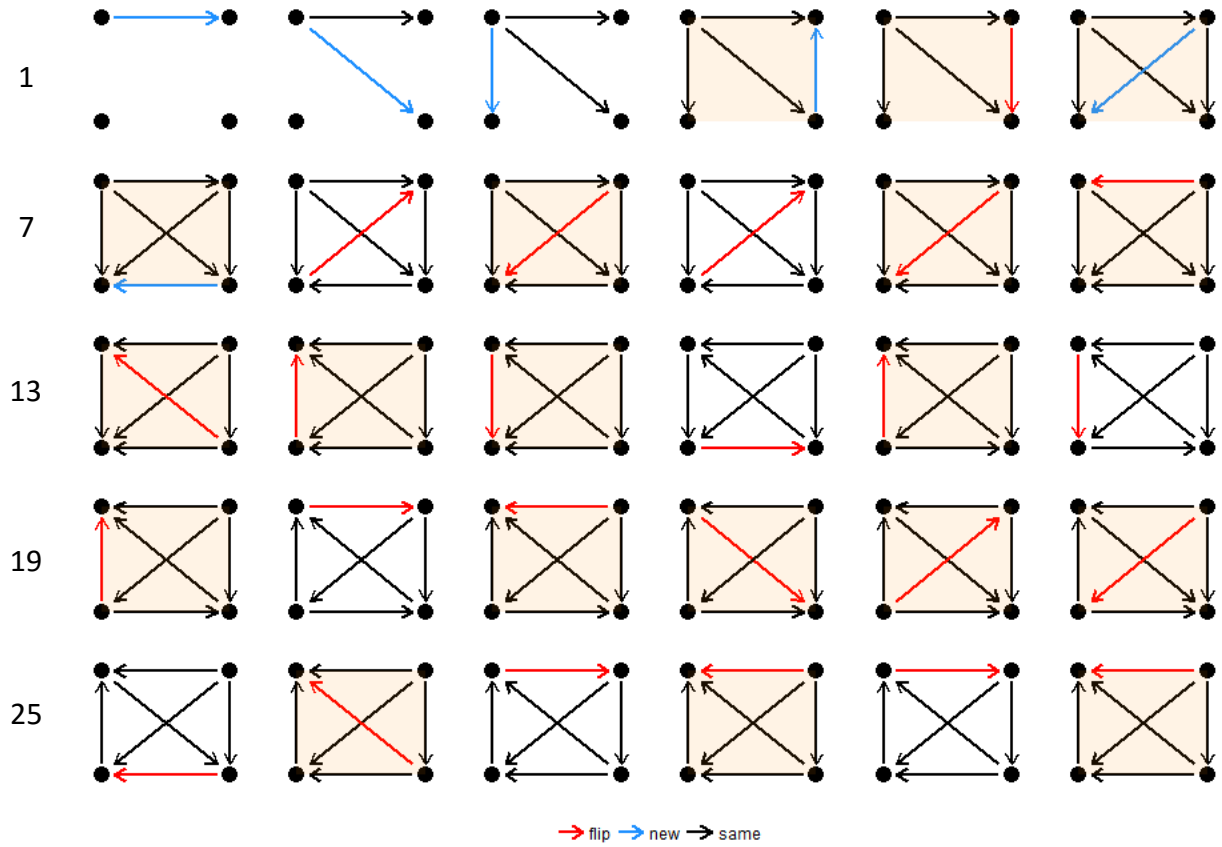


(Collaboration with Prof Ivan Chase – Stony Brook)

R package - hierformR

Small Multiples

Network Formation in African Cichlid Fish



- Every interaction from initial formation through 24 hours
- Proportion of time spent in transitive *vs.* intransitive states
- Likelihood of transitioning between transitivity/intransitivity

Intransitive Transitive

41 unique network types

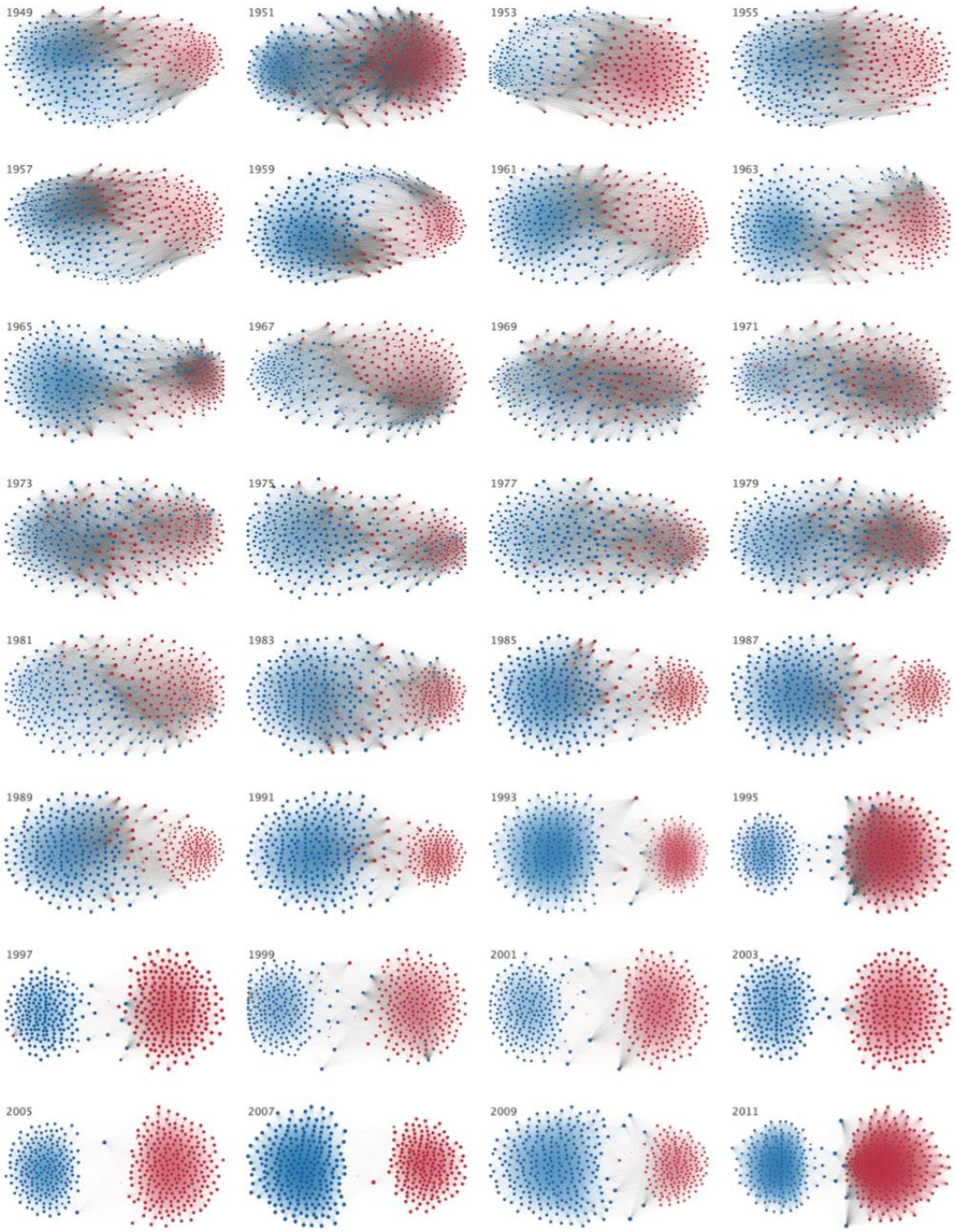
(Collaboration with Prof Ivan Chase – Stony Brook)

R package - hierformR

Small Multiples

The Rise of Partisanship and Super-Cooperators in the U.S. House of Representatives

Andris et al. PlosOne 2015



Small Multiples

Progression of flu contagion in the friendship network over time.

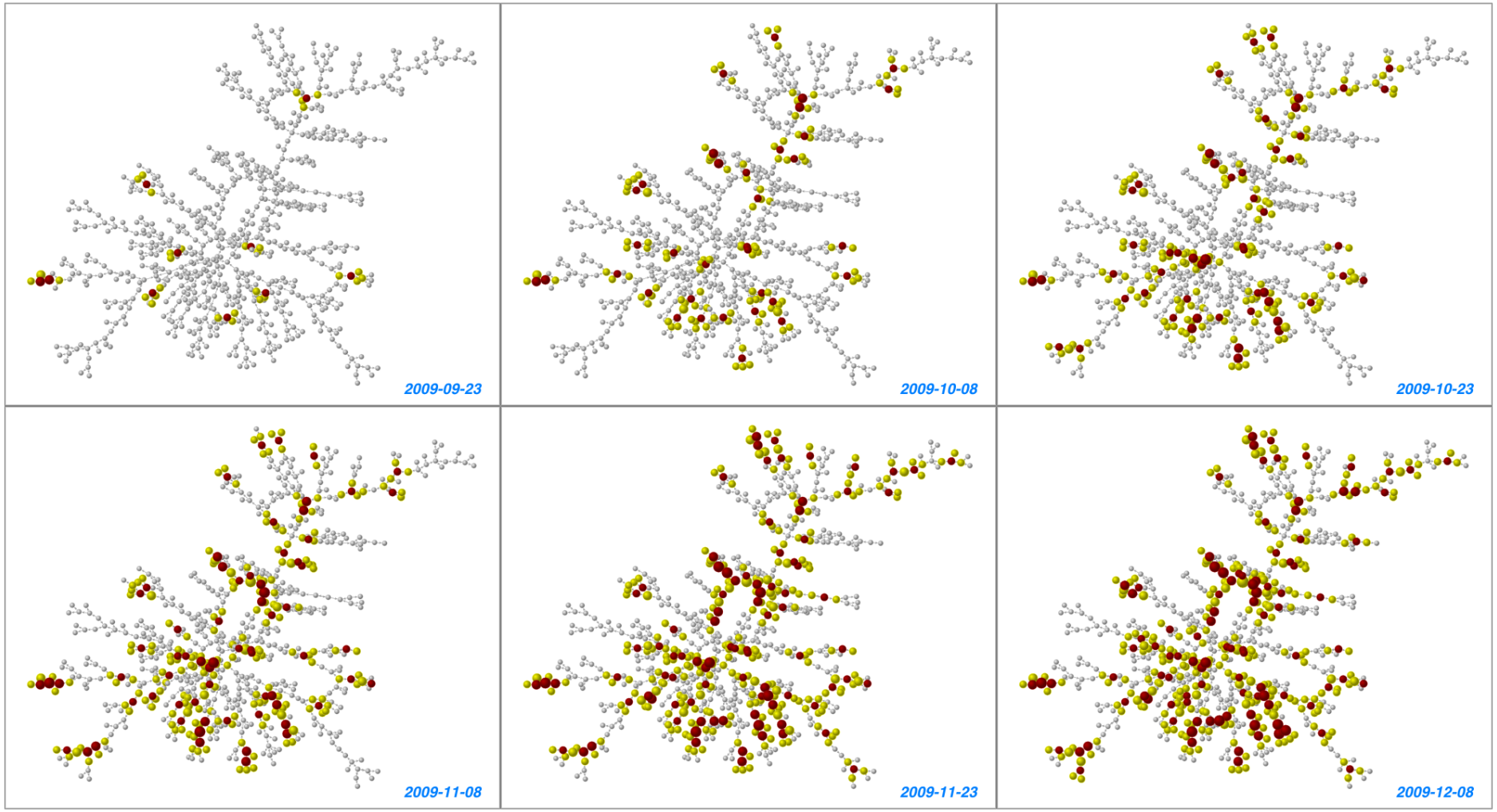
Edges = friendship nomination

White = uninfected individuals/friends

Red = Infected individuals

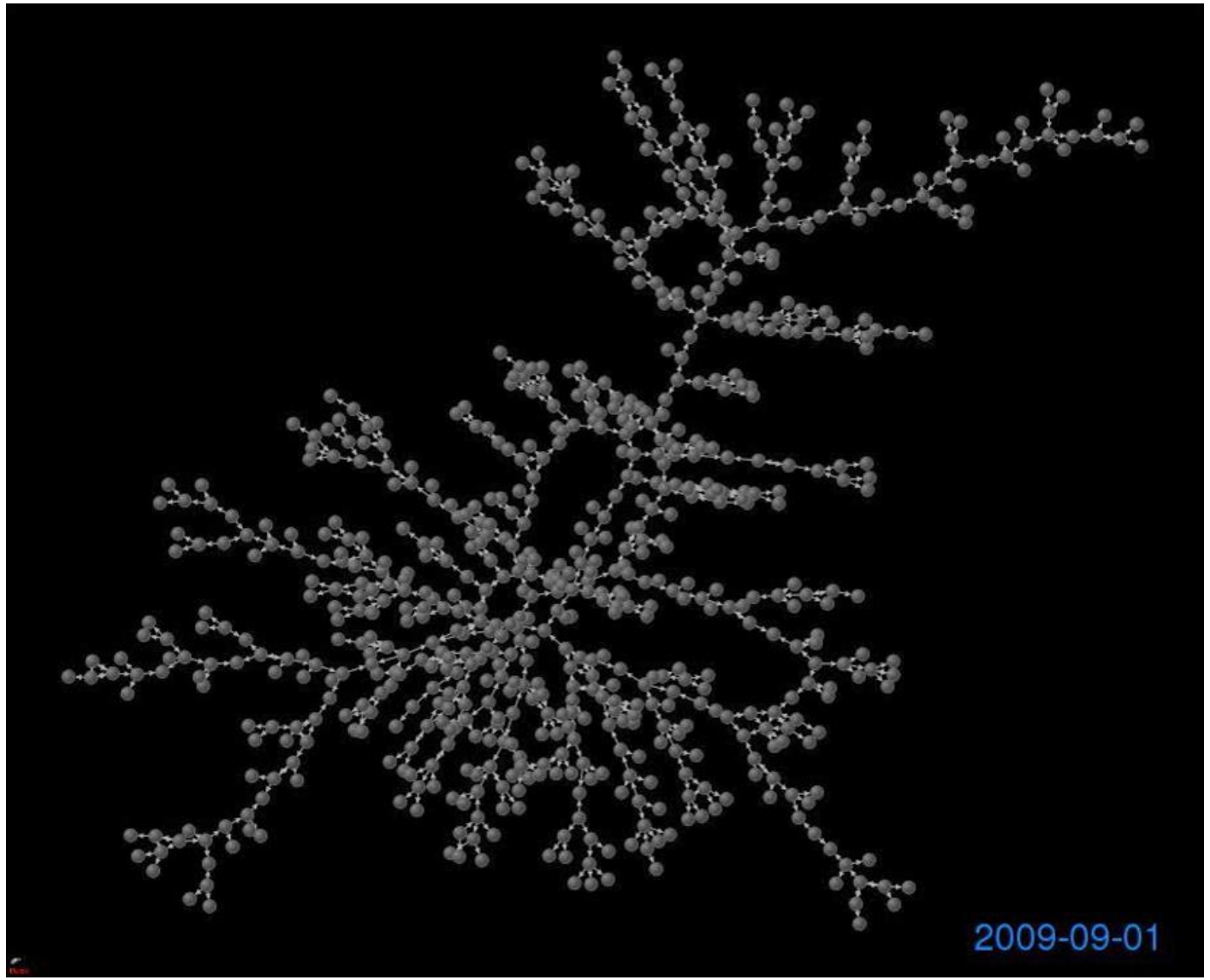
Yellow = friends of infected individuals

Node size = proportional to the number of friends infected.



Christakis & Fowler 2010 PlosOne

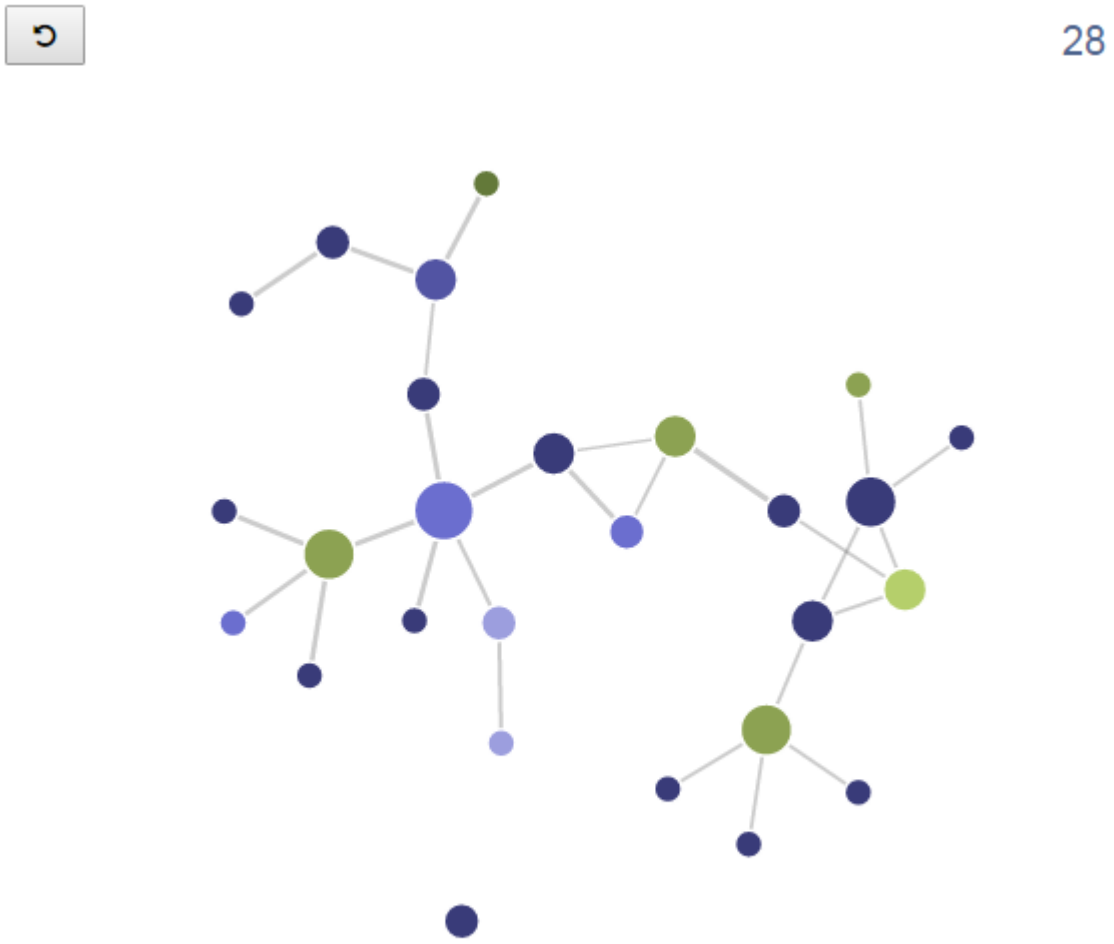
Animated



Made with SONIA

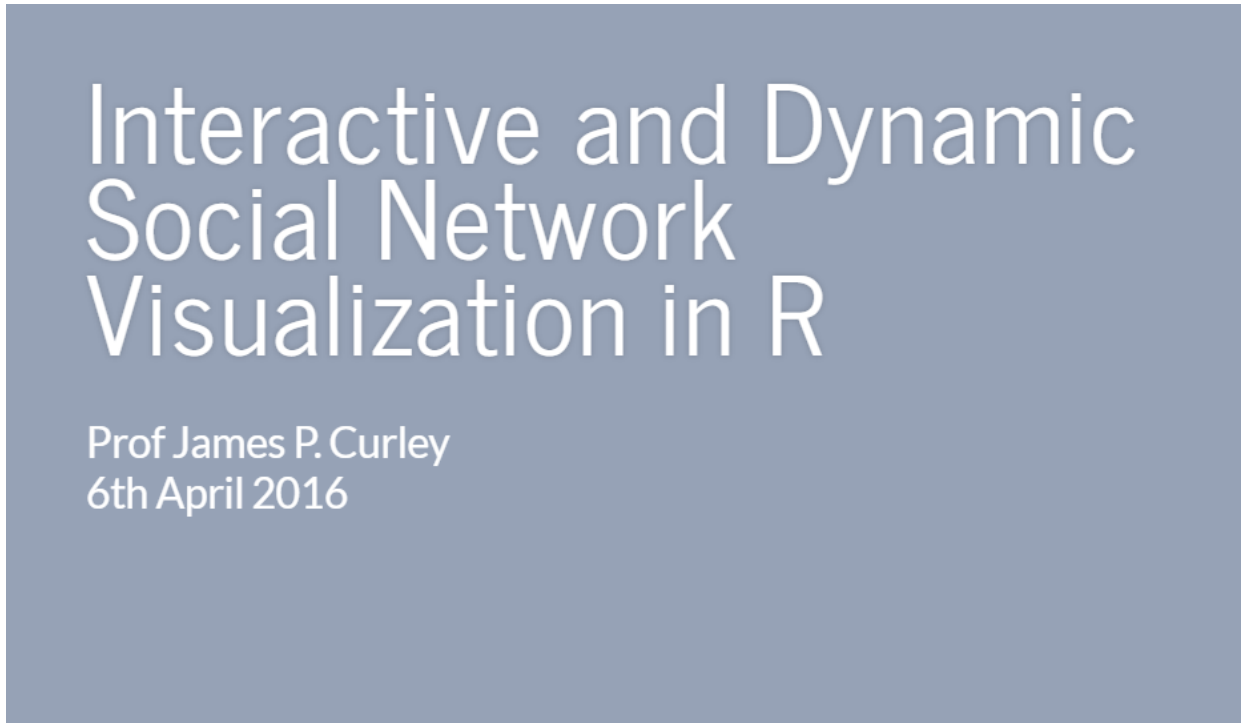
Christakis & Fowler 2010 PlosOne

Animated D3.js



e.g. See this example

Animated Networks using R

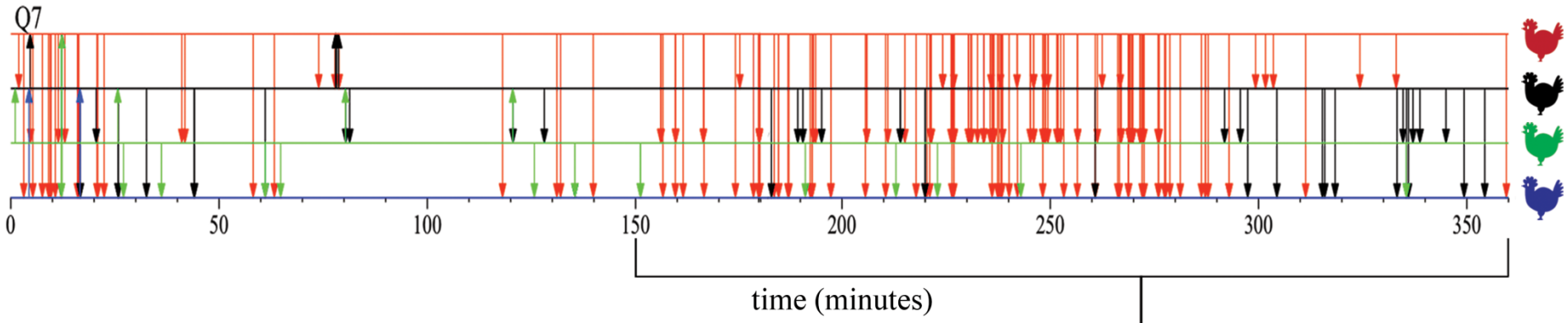


SEE my ONLINE TUTORIAL … http://curleylab.psych.columbia.edu/netviz/netviz5.html

SEE recent animations in rthreejs - http://bwlewis.github.io/rthreejs/animation/animation.html

Timelines

(A) Music Notation Representation of Agressive Interactions in a Group of Hens



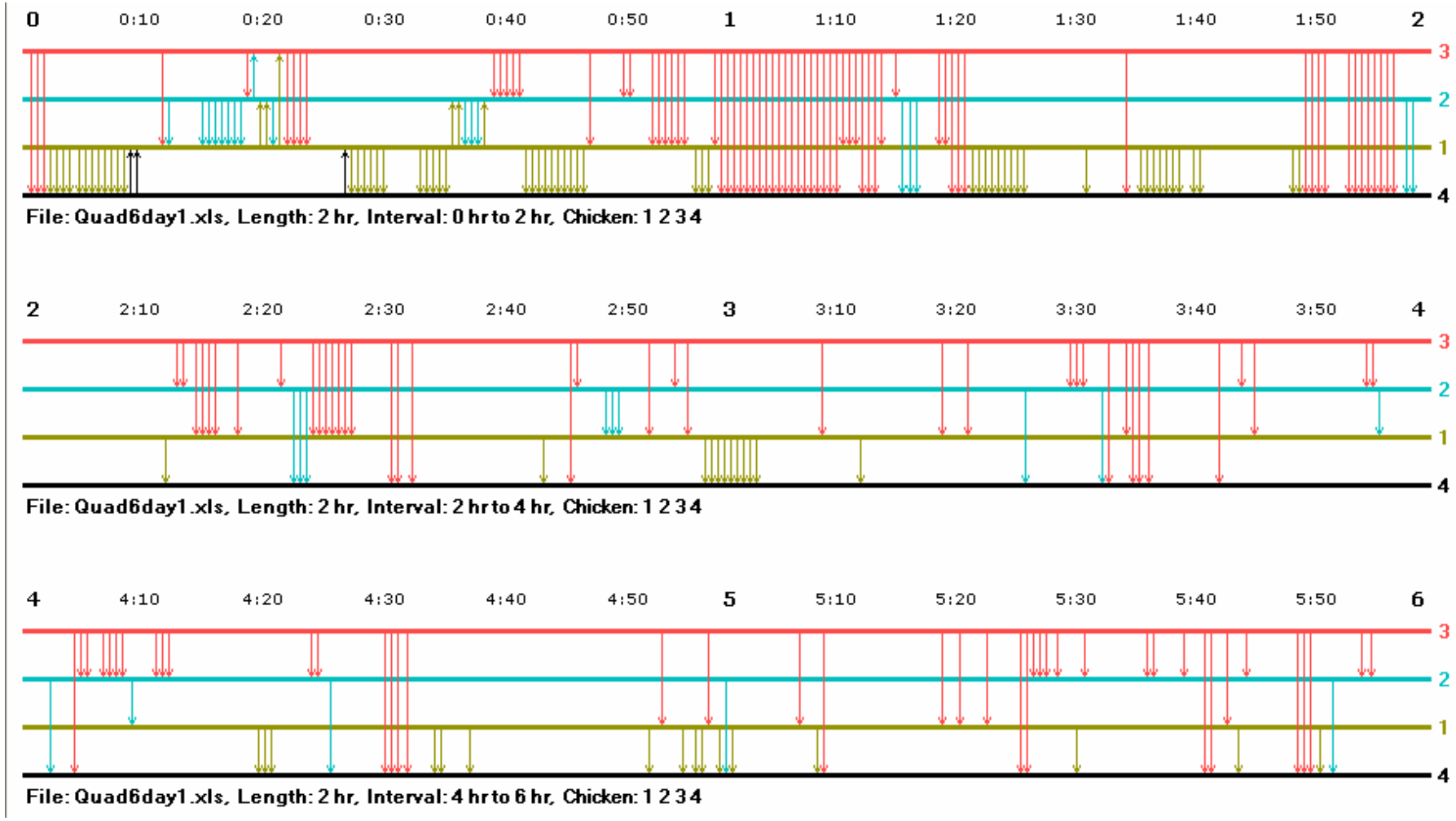
(B) Interaction Matrix

-	17	92	59
0	-	7	8
0	0	-	6
0	0	0	-

(C) Linear Hierarchy

(Ivan Chase)

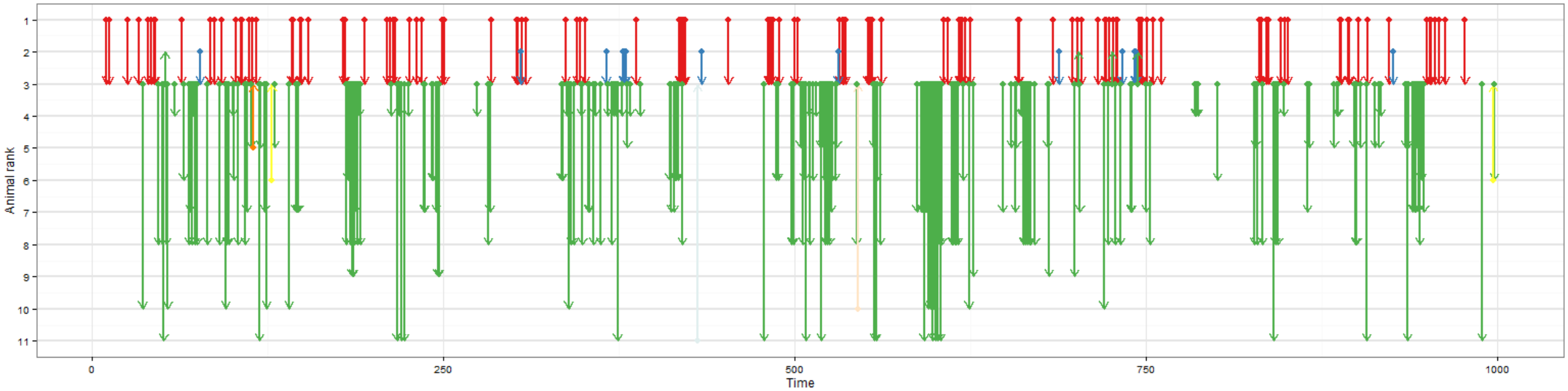
Timelines



Curley 2016 – “musicnotationR” R package

Timelines

Shiny App: https://jalapic.shinyapps.io/music/



Filter all aggressive interactions (incoming & outing) for animal Rank #3 - high directional consistency of behavior

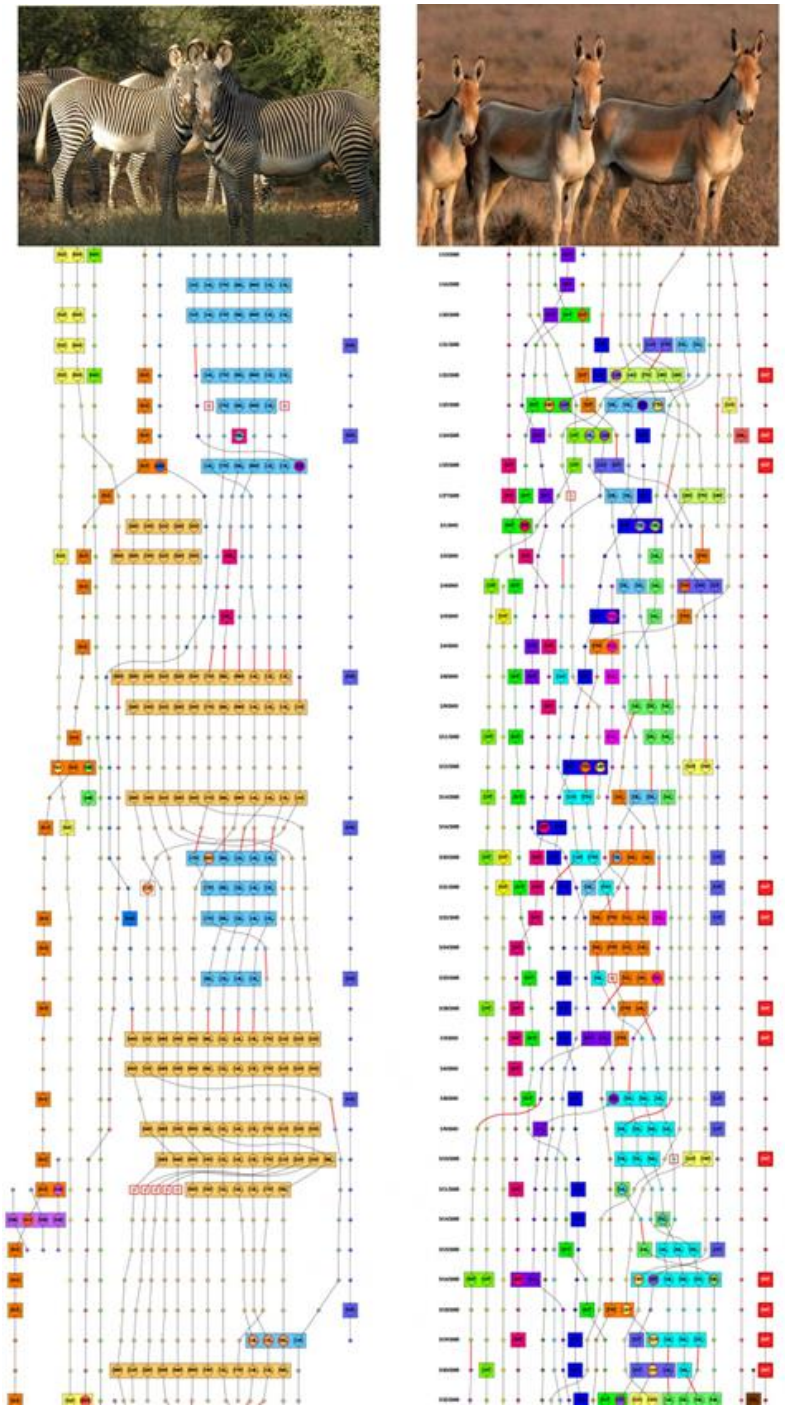
Colors represent unique individuals

Curley 2016 – “musicnotationR” R package

Timelines

Dan Rubenstein- Princeton
PlosOne 2015

Community membership over time in zebras vs onagers



Conclusions

- Lots of tools exist to visualize networks
- It’s easy to make really attractive network visualizations
- It’s also easy to make really bad network visualizations

- **What question do you want to explore or communicate to an audience?**
- **What’s the most effect way of achieving that?**
- **Learn the programming language / software that will facilitate this !**

Links to examples in talk

Katya Ognyanova tutorials - http://kateto.net/

Martin Grandjean work - http://www.martingrandjean.ch/social-network-analysis-visualization-morenos-sociograms-revisited/

My friendship visualization - http://curleylab.psych.columbia.edu/friendship.html

My friendship visualization 2 - http://curleylab.psych.columbia.edu/friends.html

Identifying neighbors in D3js - http://blockbuilder.org/jalapic/0020bebb012760de0d54

Identifying triads in D3js - http://blockbuilder.org/jalapic/aeb4b1085f800d31b4be

Identifying geodesic distance in D3js - http://blockbuilder.org/jalapic/0eba1241acdf67c62f5b87357864d662

rthreejs example by Bryan Lewis - http://jalapic.github.io/facebook

Linked Matrices in D3js - http://curleylab.psych.columbia.edu/socdom1.html

D3js animated network example - http://blockbuilder.org/jalapic/cf1454d62c7efa48d96ee4d803856dfa