Structure and Function of Social Networks

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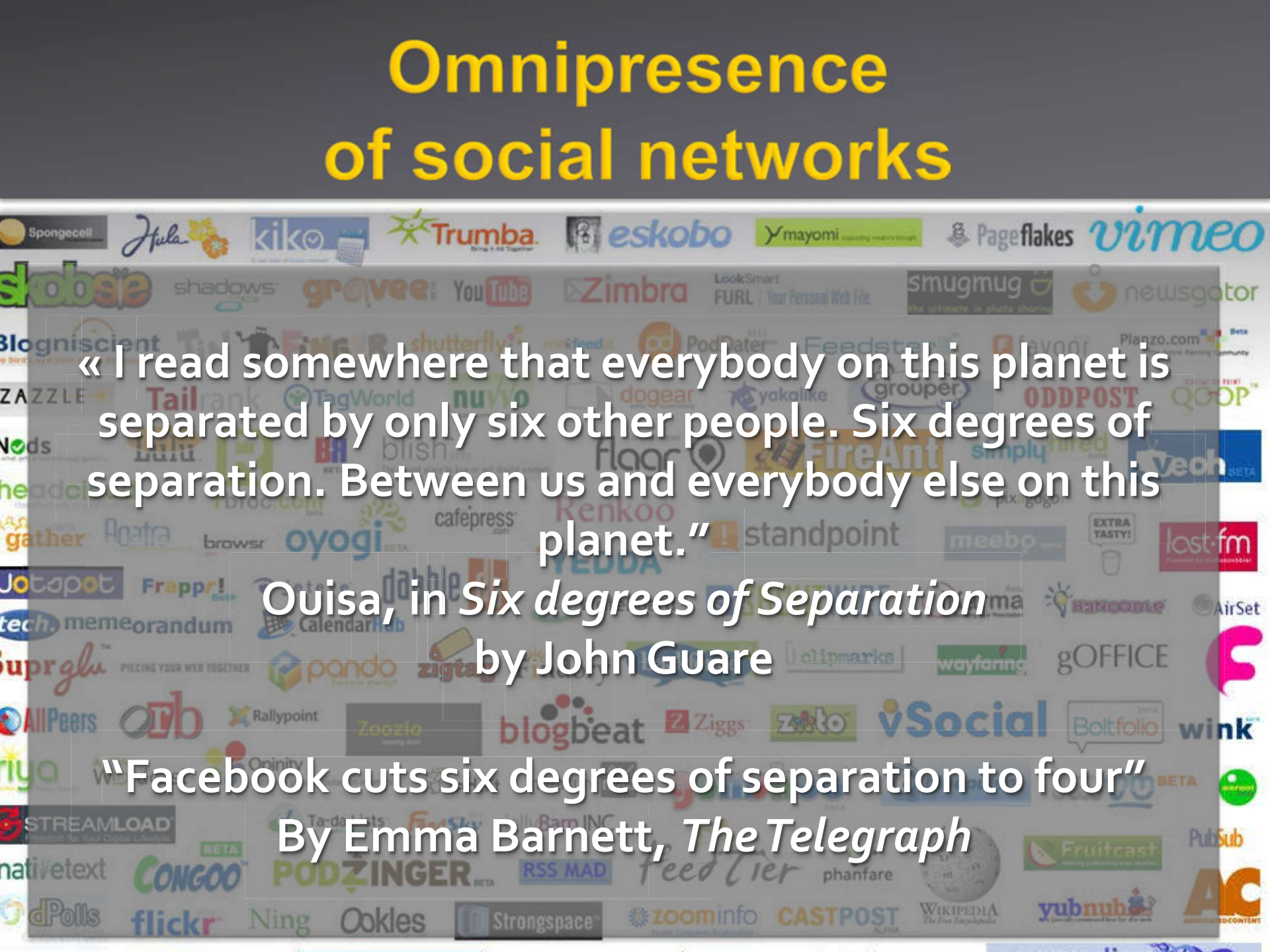
Omnipresence of social networks



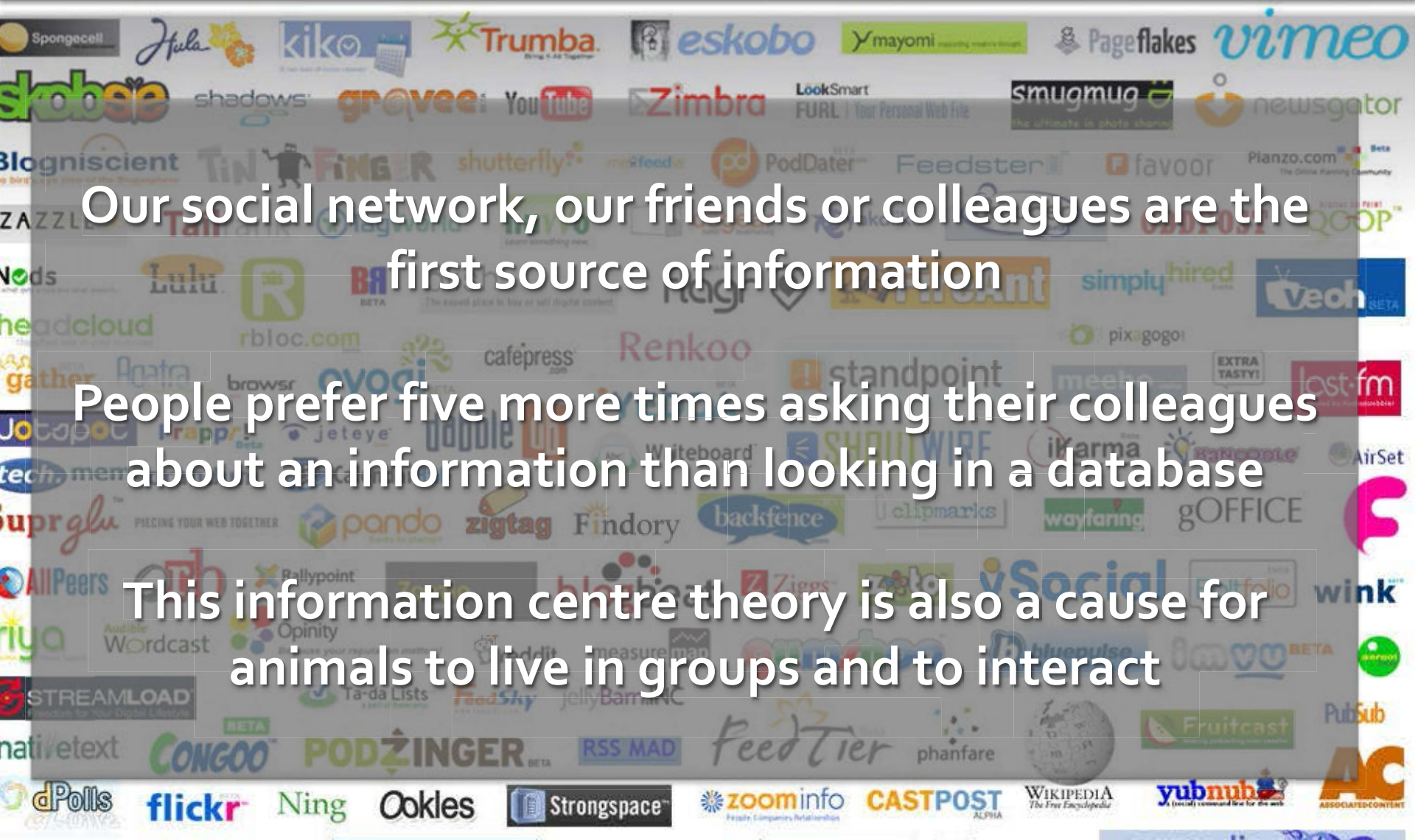
« I read somewhere that everybody on this planet is separated by only six other people. Six degrees of separation. Between us and everybody else on this planet.”

Ouisa, in *Six degrees of Separation*
by John Guare

“Facebook cuts six degrees of separation to four”

By Emma Barnett, *The Telegraph*

Omnipresence of social networks

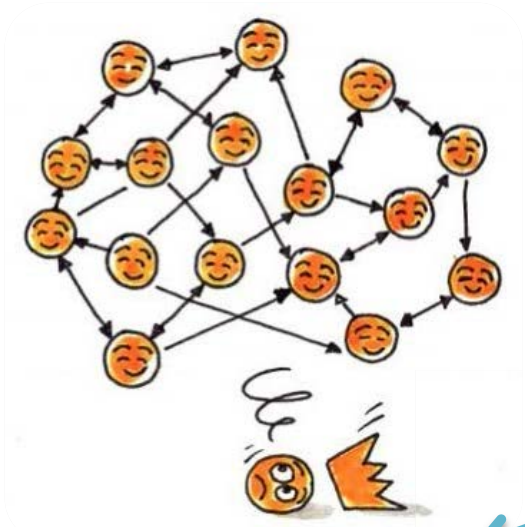


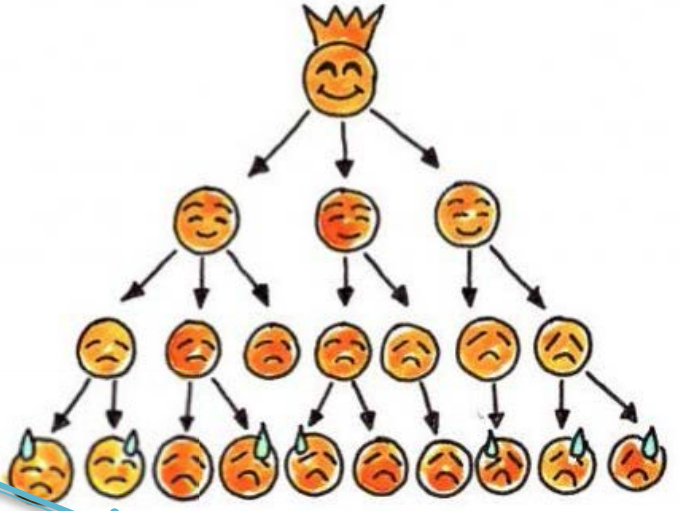
Our social network, our friends or colleagues are the first source of information

People prefer five more times asking their colleagues about an information than looking in a database

This information centre theory is also a cause for animals to live in groups and to interact

Decision efficiency according to social network





Firm

Employees wellbeing

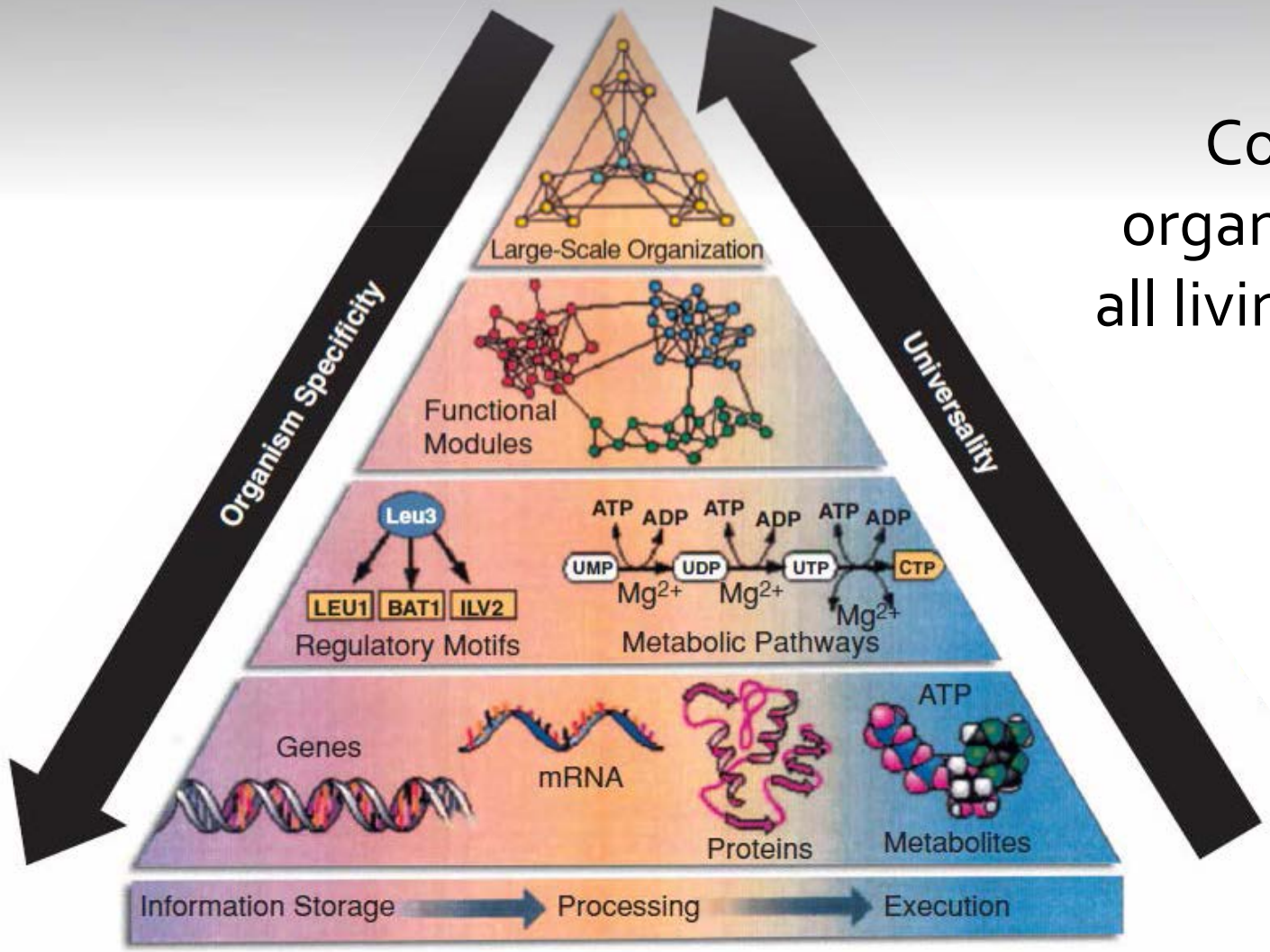
Quality

Speed

Egalitary system

Leadership

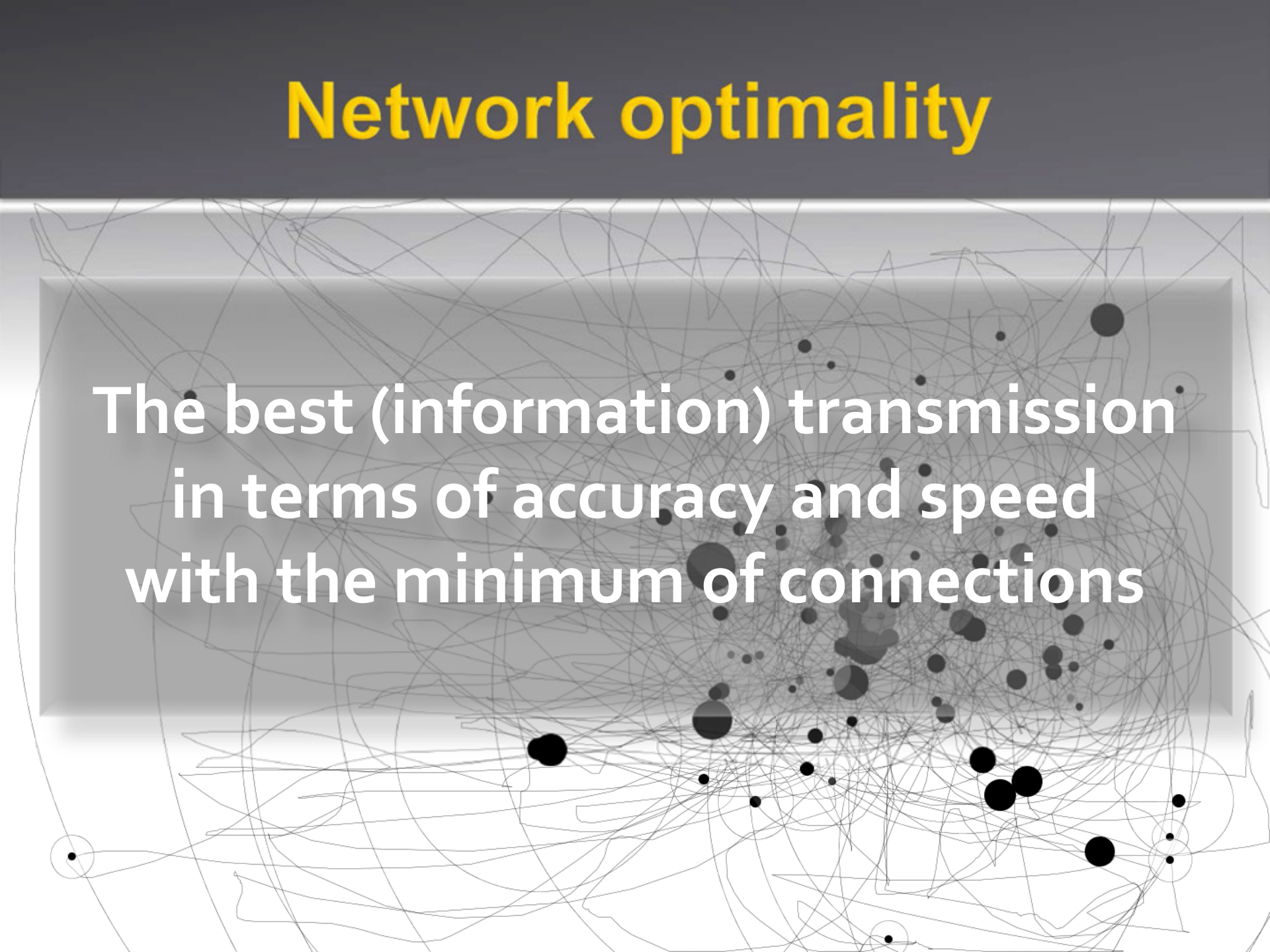
From Molecules to Ecosystems



Complex organisation in all living systems

Network optimality

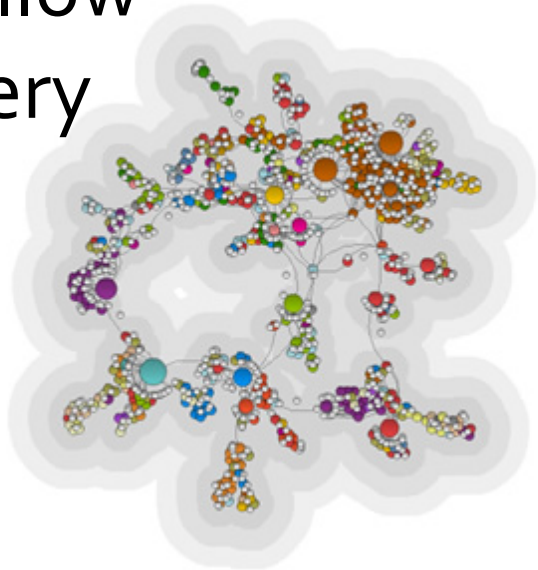
The best (information) transmission in terms of accuracy and speed with the minimum of connections



Networks optimality in genes or proteins

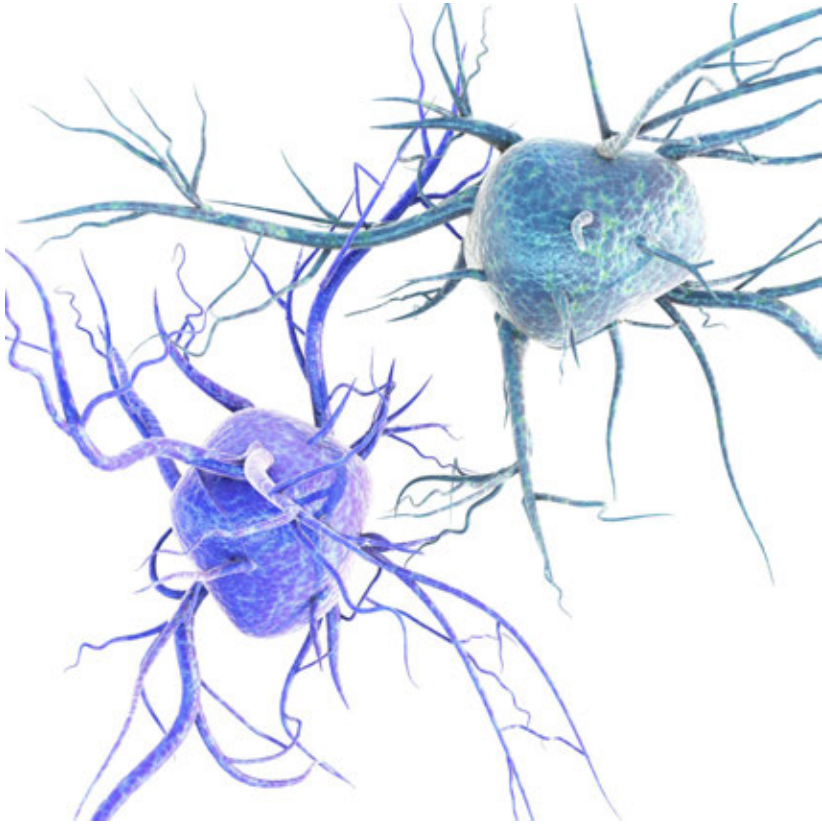
- Gene networks appear to be dynamically robust to mutation and changes in the environment

- Regulatory protein networks allow bacteria to adapt to almost every environment



Neural Networks

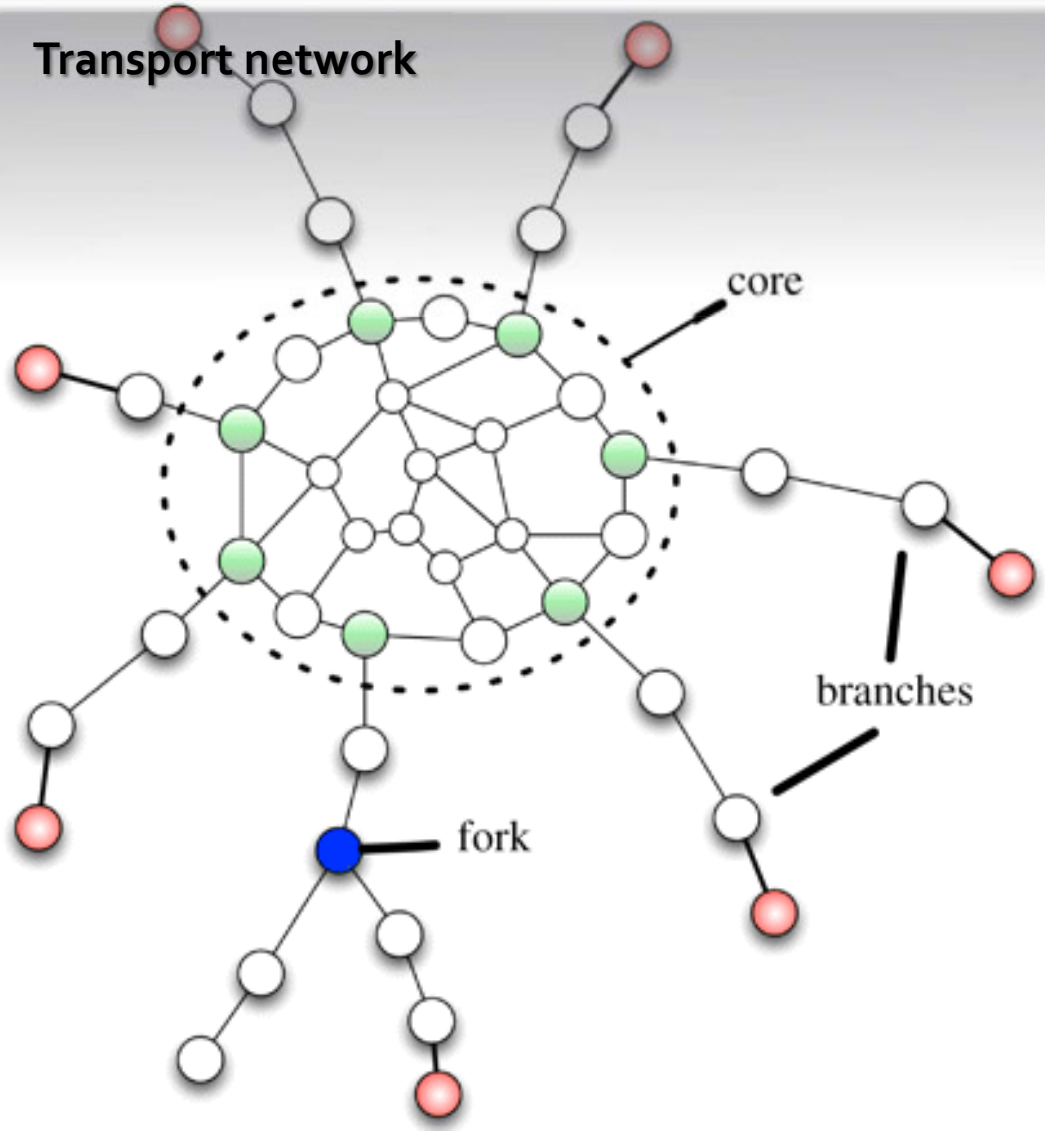
- Neural networks are efficient and behave like optimal statistical tests
- Evolutionary processes implied in the network structure



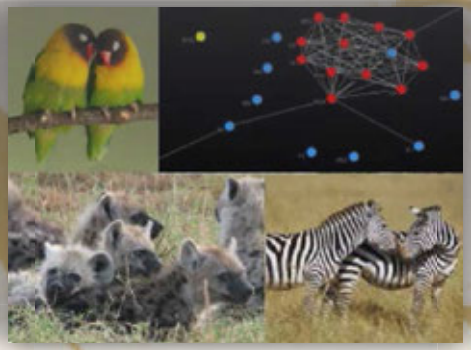
Optimality of other networks

Language network

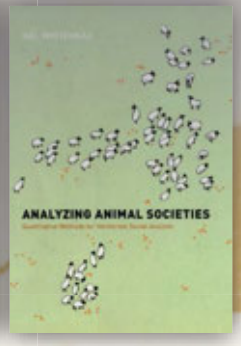
Transport network



Animal social networks

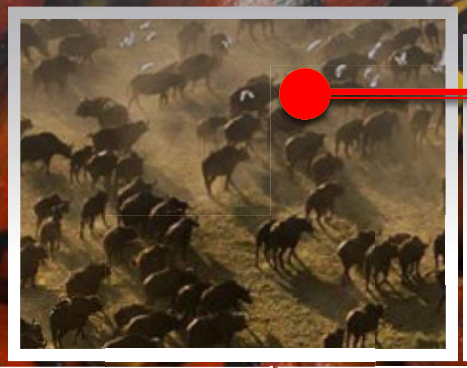


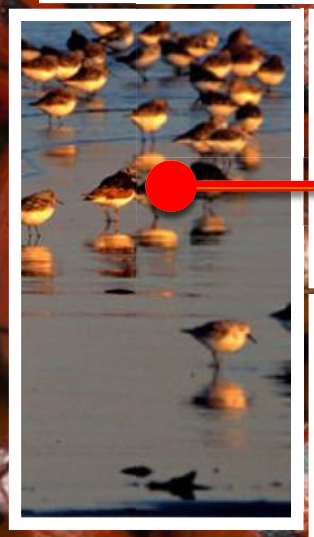


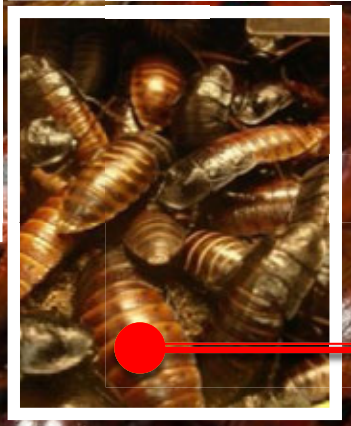


Is social network somewhere somehow selected to optimize advantages to live together?

Living in groups







Advantages

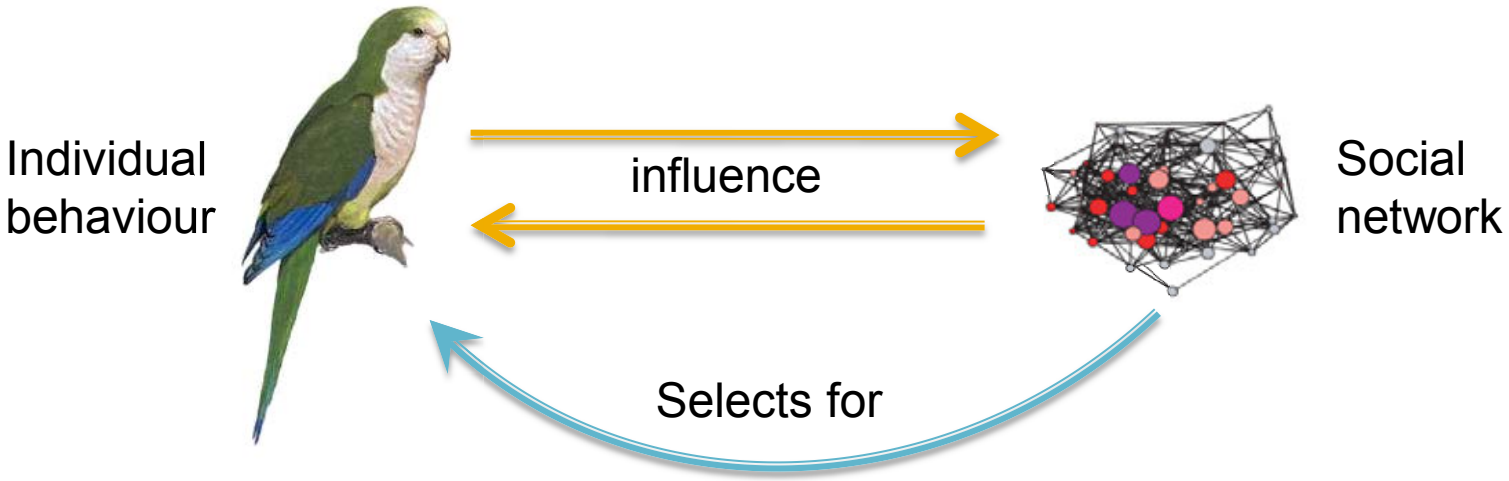
- Predation risk
- Food searching
- Reproduction

Inconveniences

- Competition, temperature
- Diseases
- Different needs

Interactions between individuals

- Animals have to maintain group cohesion and interactions to balance advantages and inconveniences of sociality
- Assortativity of associations in most social animals
- Why? Relationship between structure and functioning of networks



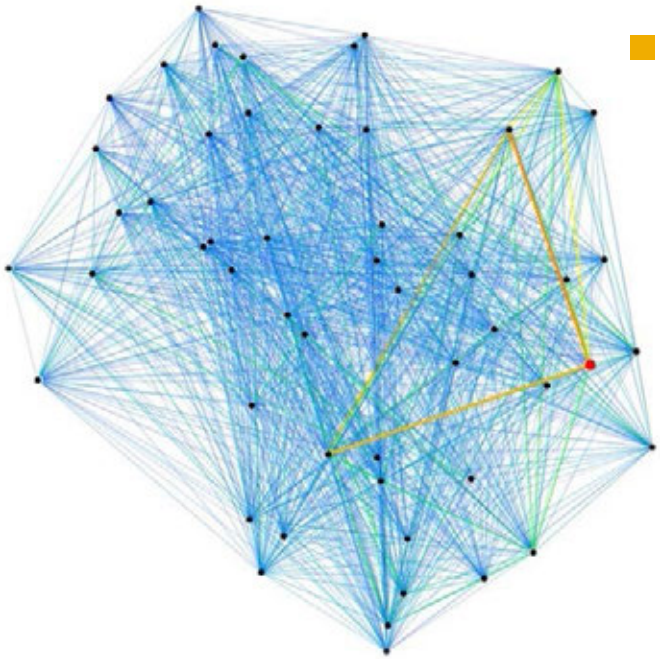
Influence of social network

Central individuals have a higher fitness

- Silk et al. 2009: juveniles with central mothers live better
- Formica et al. 2012: central males have higher reproductive success
- Stanton and Mann 2012: central males live longer

Information Processing in Social Insect Networks

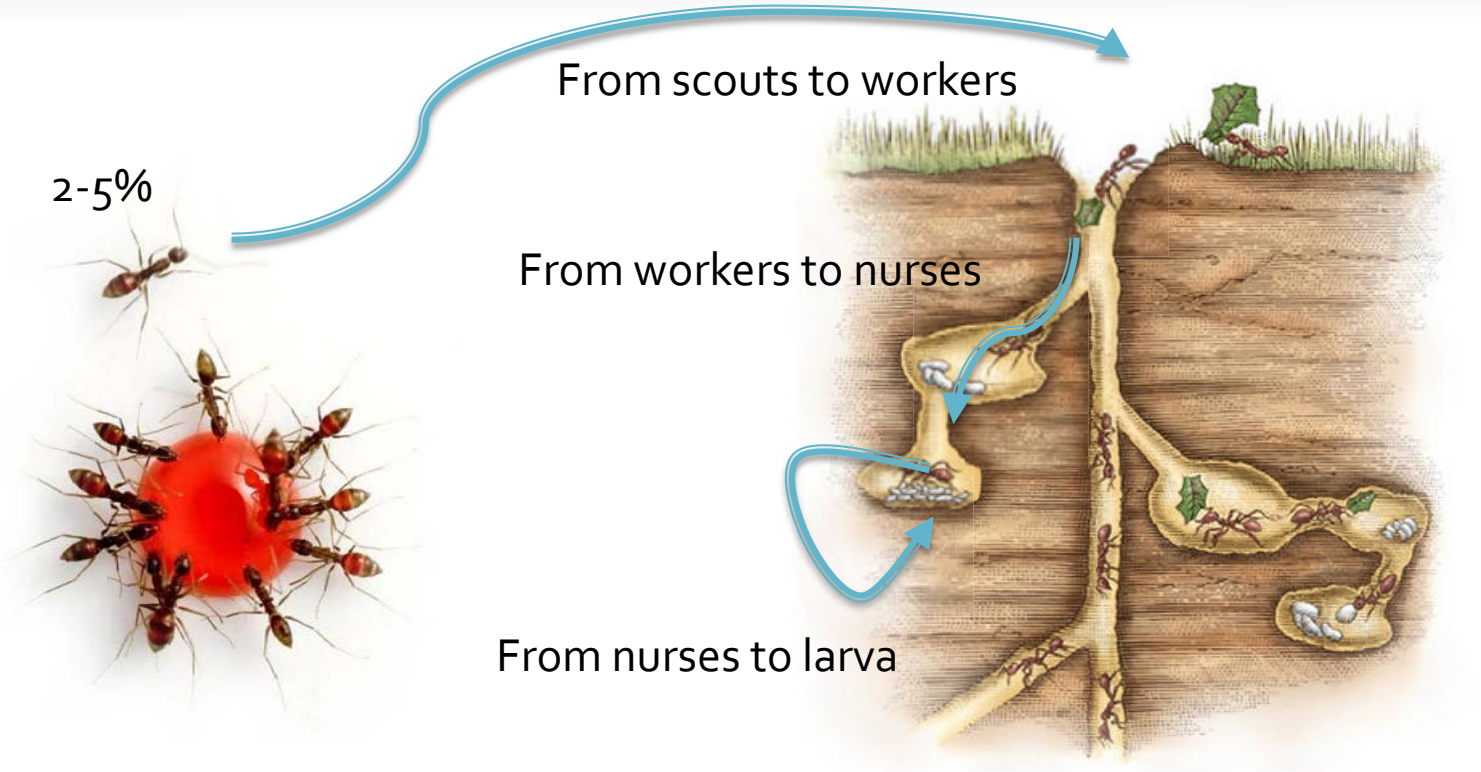
- Waters and Fewell, 2012: "the network structure has been selected to maximize colony-level function rather than individual success"



- Peter-Wollman et al. 2011: "Individual variation in connectivity creates interaction centres, which may expedite information flow and food transfer"

PhD project ULB + UDS

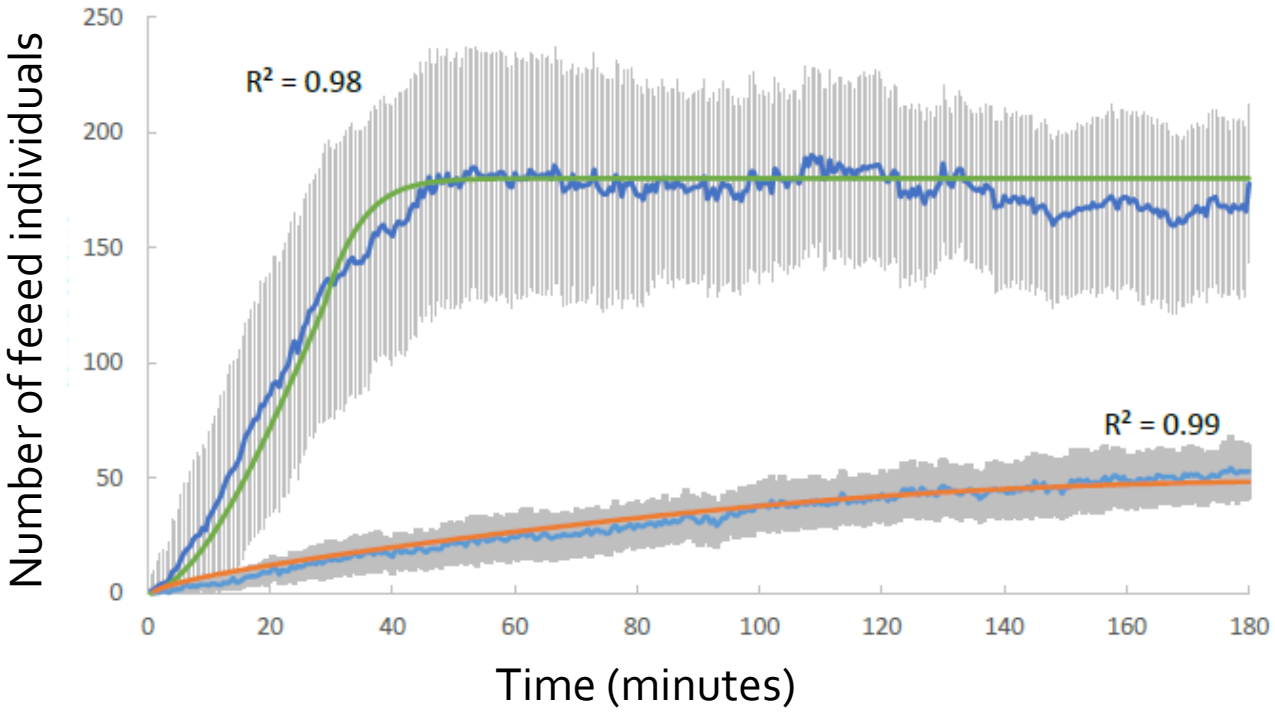
- Dynamics of food transfer in ants: a theoretical approach. Olivier Bles



Bles et al. in prep

PhD project ULB + UDS

- Dynamics of food transfer in ants: a theoretical approach. Olivier Bles



Up: 4 days of starving
Down: 1 day of straving

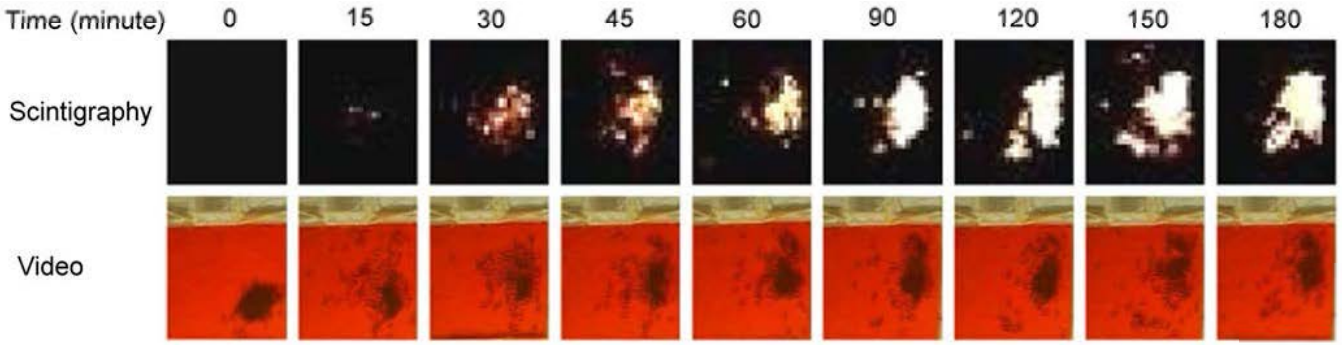
Only two parameters:

- Time to find trophallaxy partner
- Time to go outside from the nest

Bles et al. in prep

PhD project ULB + UDS

- Combination of different approaches to study interactions networks



RFID

Colour

Interaction networks of *Physarum polycephalum* in a foraging context

David Vogel & Audrey Dussutour

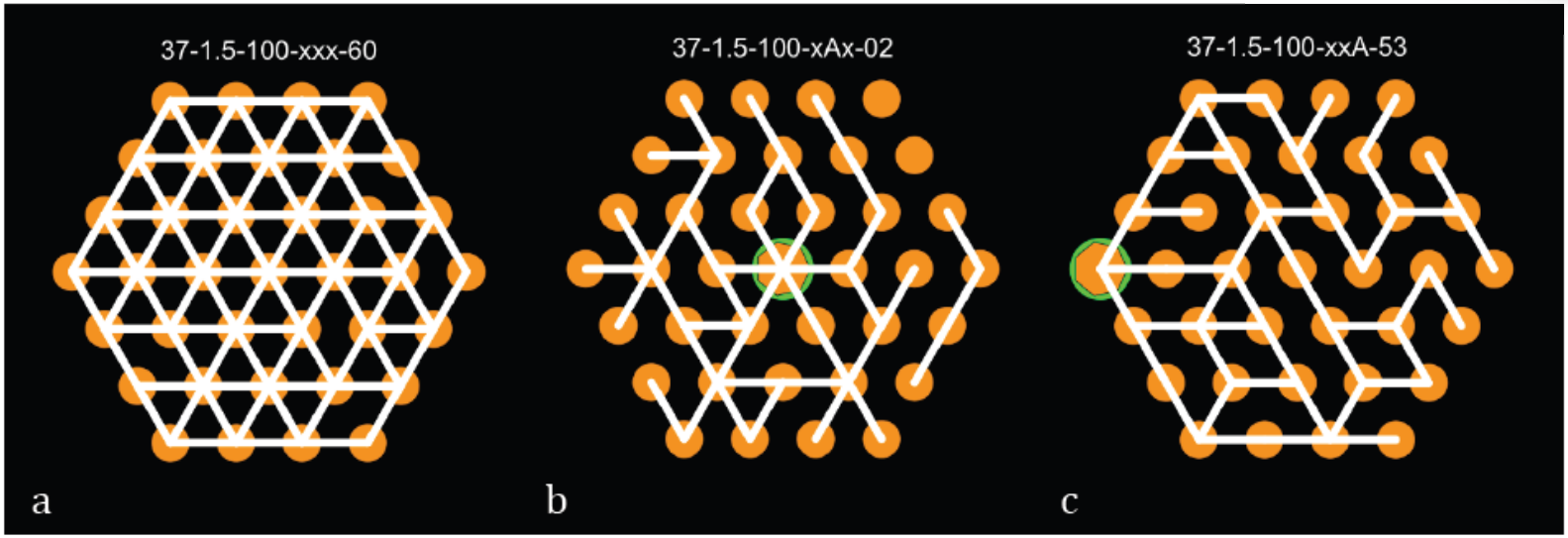


Fig.4: Exemples of network topology at the end of the experiment without food source for a short distance between slime molds (1.5R) (a), with a food source in the centre (b) and with a food source at the periphery (green =oat). The orange spots represent patches of slime molds and the white lines represent the link between slime molds (edges).

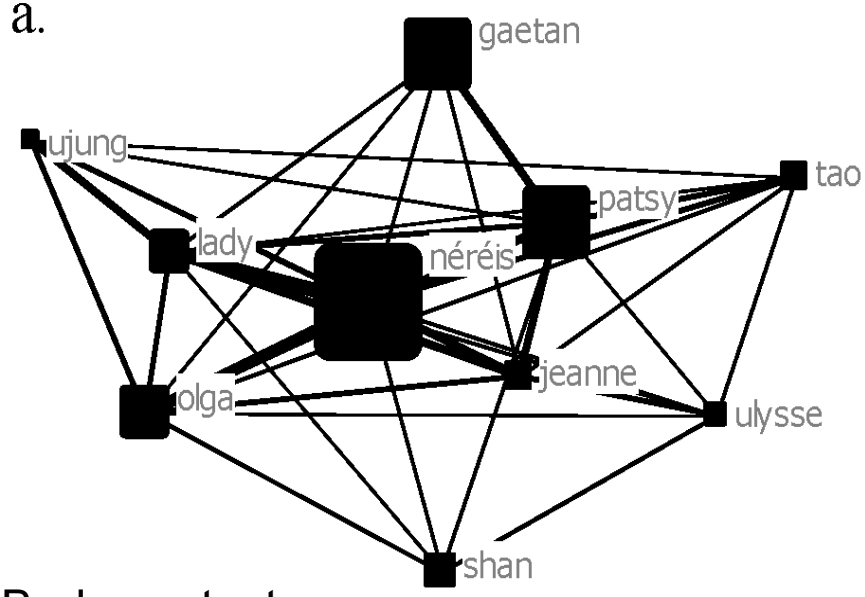
Interaction networks of *Physarum polycephalum* in a foraging context

Eigenvector centrality vs. Group leadership in primates

- Size of nodes = leadership probability
- Leaders are central group members

Macaca tonkeana

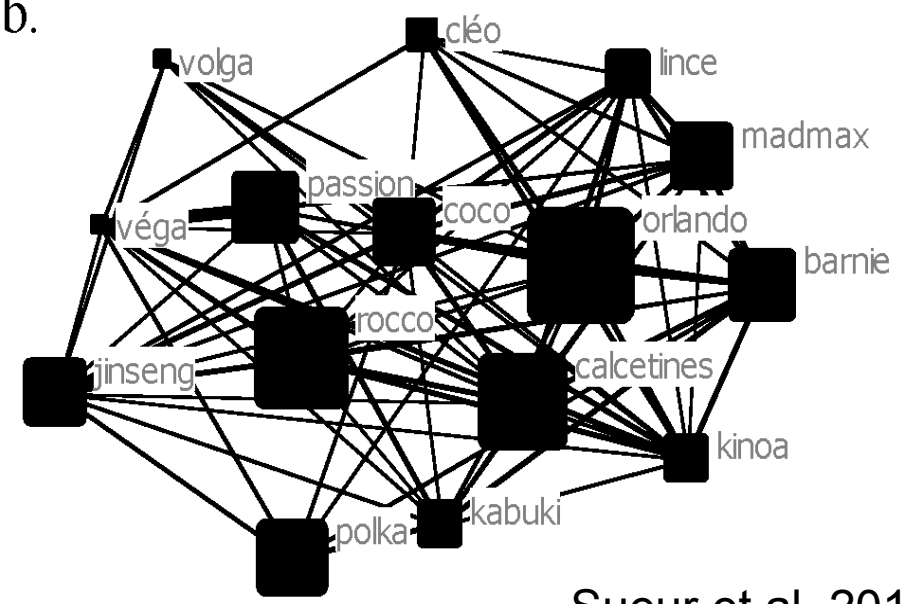
a.



Body contacts

Macaca mulatta

b.

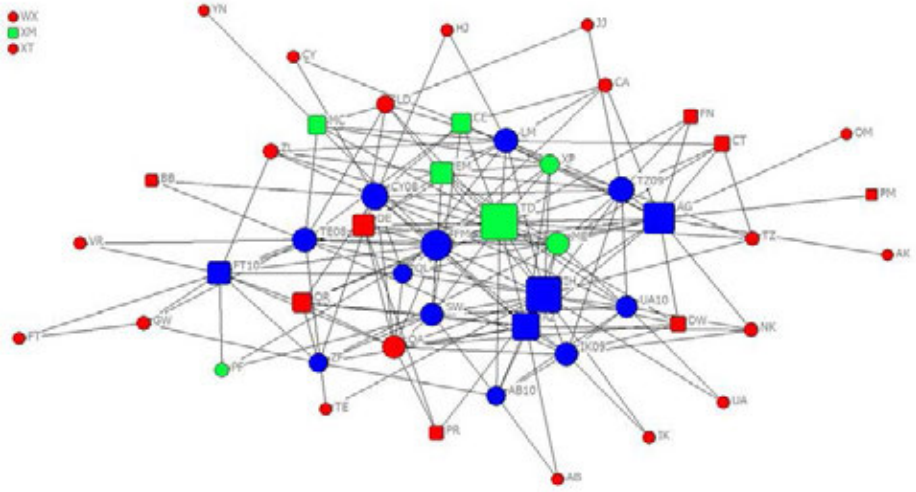


Sueur et al. 2014

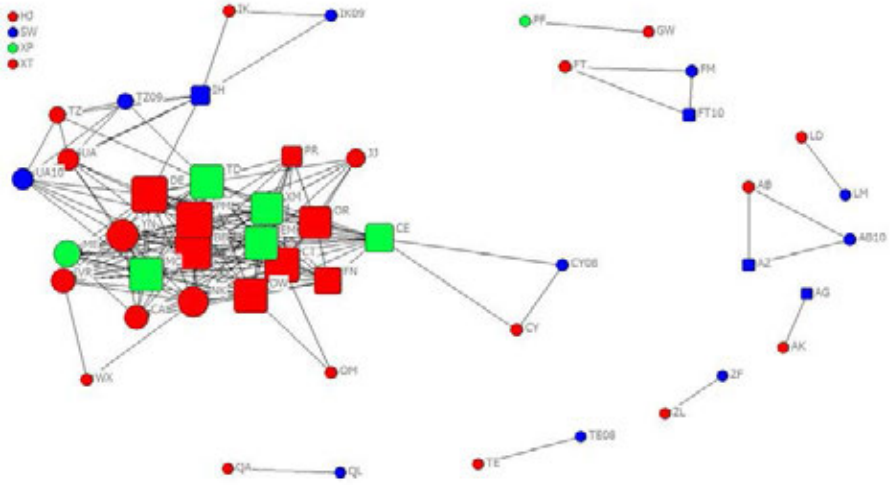
Importance of social play network for wild chimpanzees

- The social play network may allow individuals to develop the social techniques necessary to acquire a central position in a society

Social play network



Grooming network

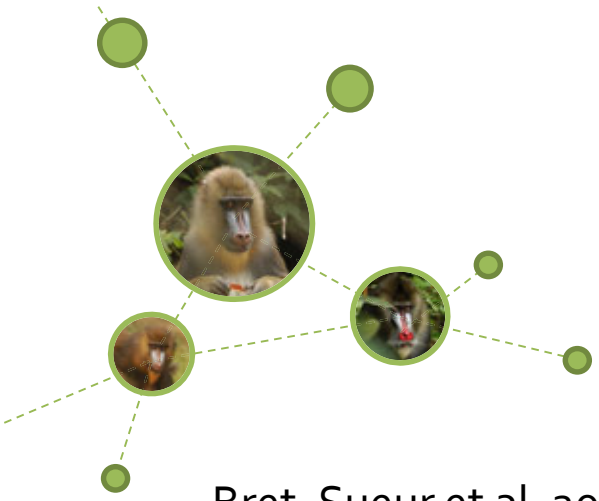


Red: adults, green: subadults, blue: juveniles

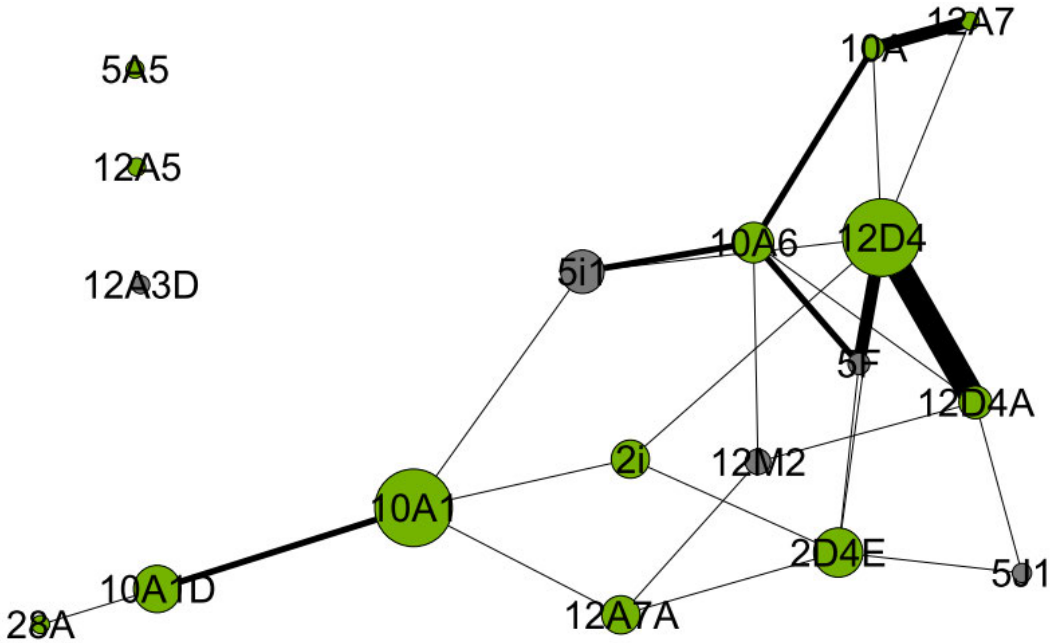
Shimada and Sueur, 2014

Social structure in mandrills
Central individuals, who are you?

- Two central females (dominant one and oldest one) allowing group cohesion and fast information transmission

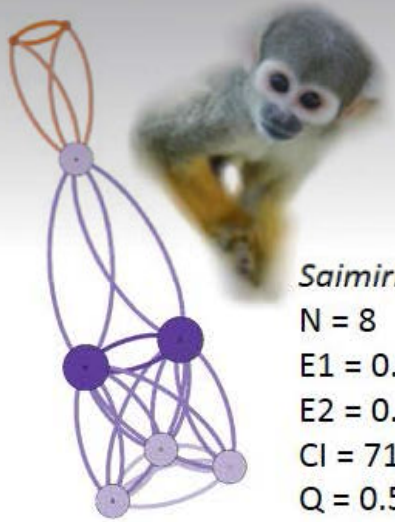


Bret, Sueur et al. 2013



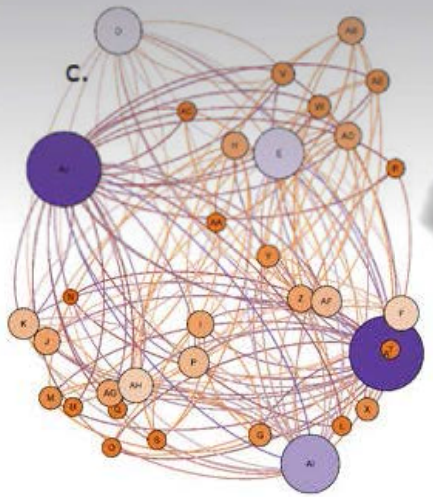
Social network in primates: smart and tolerant species have more efficient networks

a.



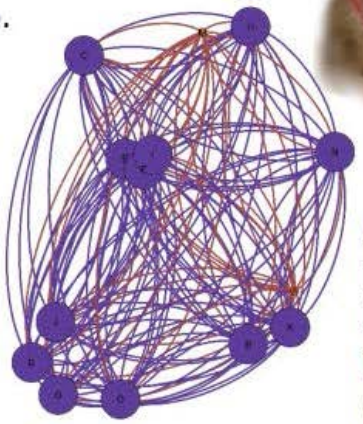
Saimiri sciureus
N = 8
E1 = 0.17
E2 = 0.46
CI = 71.13
Q = 0.50

c.



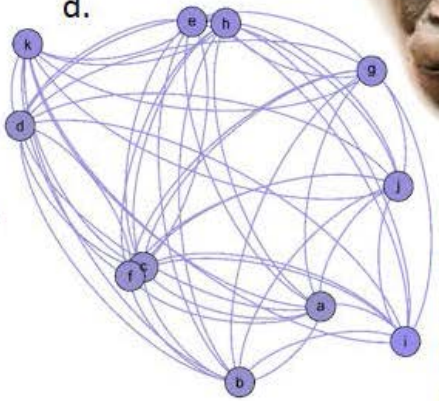
Homo sapiens
N = 34
E1 = 0.12
E2 = 0.49
CI = 38.94
Q = 0.44

b.



Macaca arctoides
N = 14
E1 = 0.08
E2 = 0.99
CI = 47.64
Q = 0.22

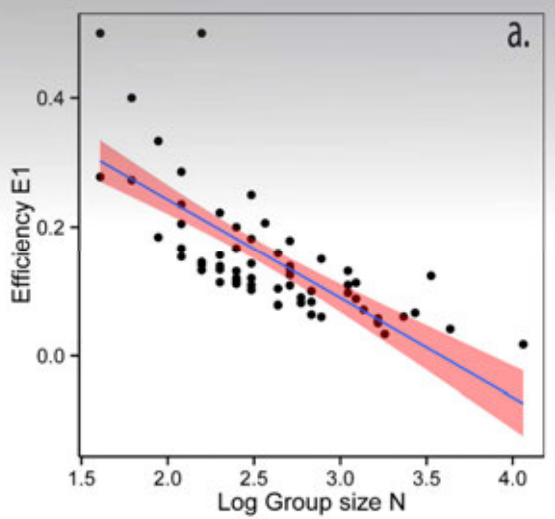
d.

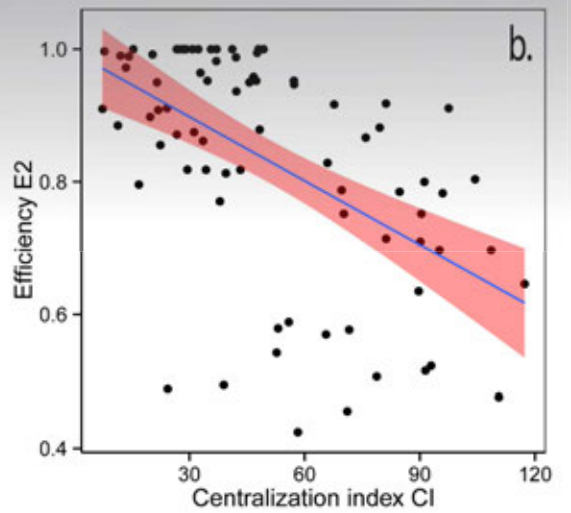


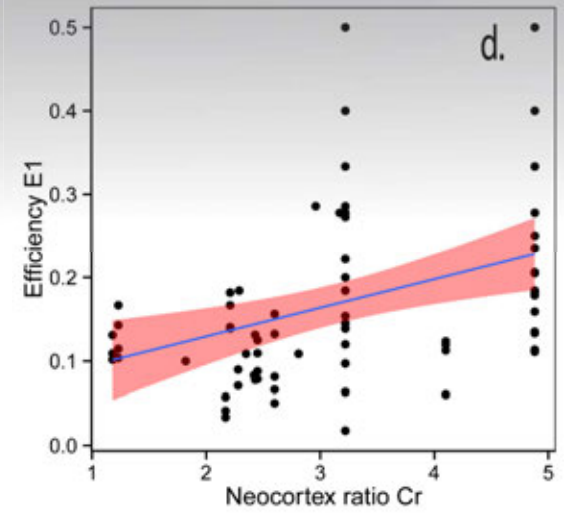
Pan troglodytes
N = 11
E1 = 0.2
E2 = 1
CI = 28.59
Q = 0.13

Pasquaretta,..., Sueur. Submitted

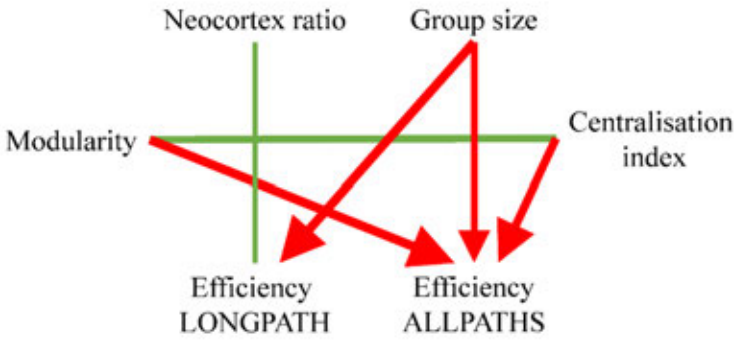
Social network in primates: smart and tolerant species have more efficient networks







Evolutionary processes implied in social network optimality



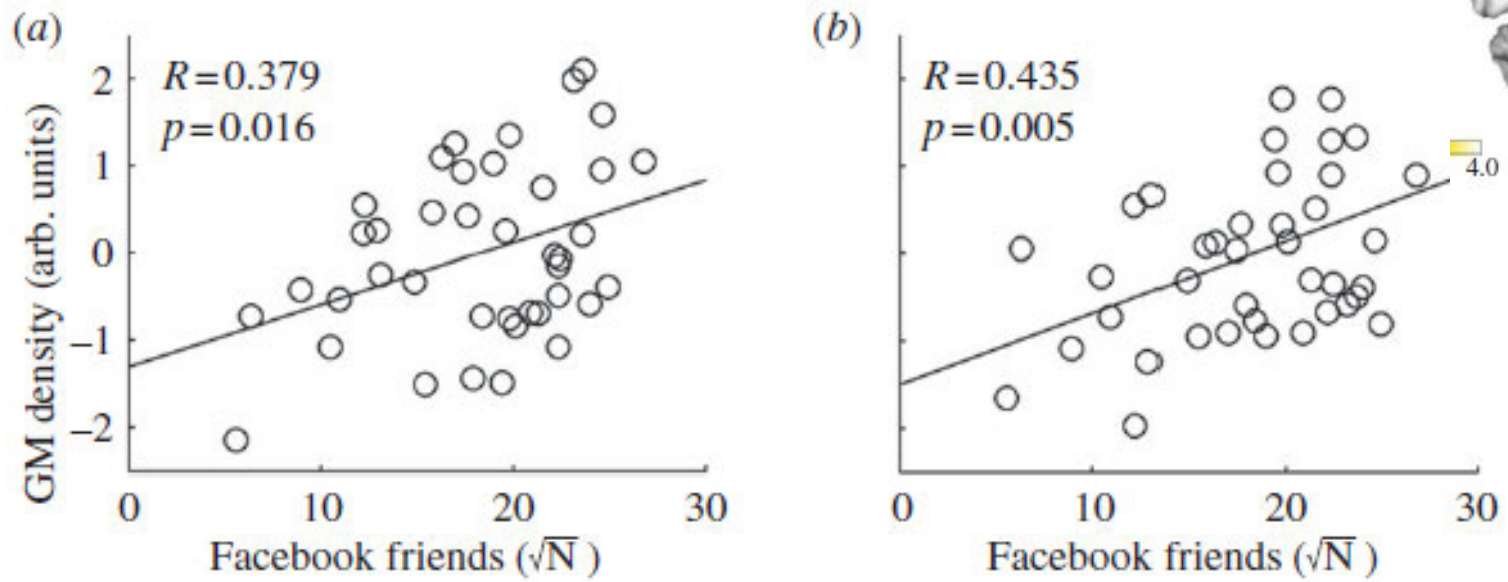
PROCEEDINGS OF THE ROYAL SOCIETY B

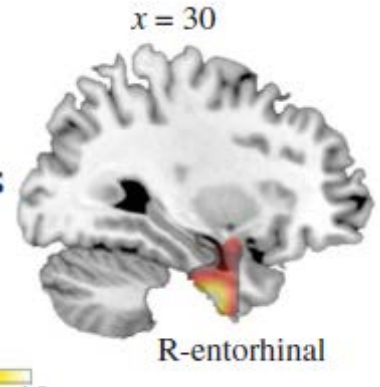
Proc. R. Soc. B (2012) 279, 1327–1334
doi:10.1098/rspb.2011.1959
Published online 19 October 2011

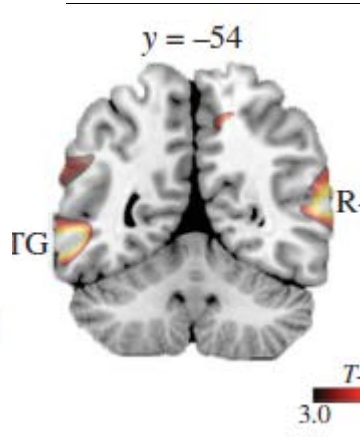
Online social network size is reflected in human brain structure

R. Kanai[1,*], B. Bahrami[1,2,3,4], R. Roylance[5] and G. Rees[1,2]

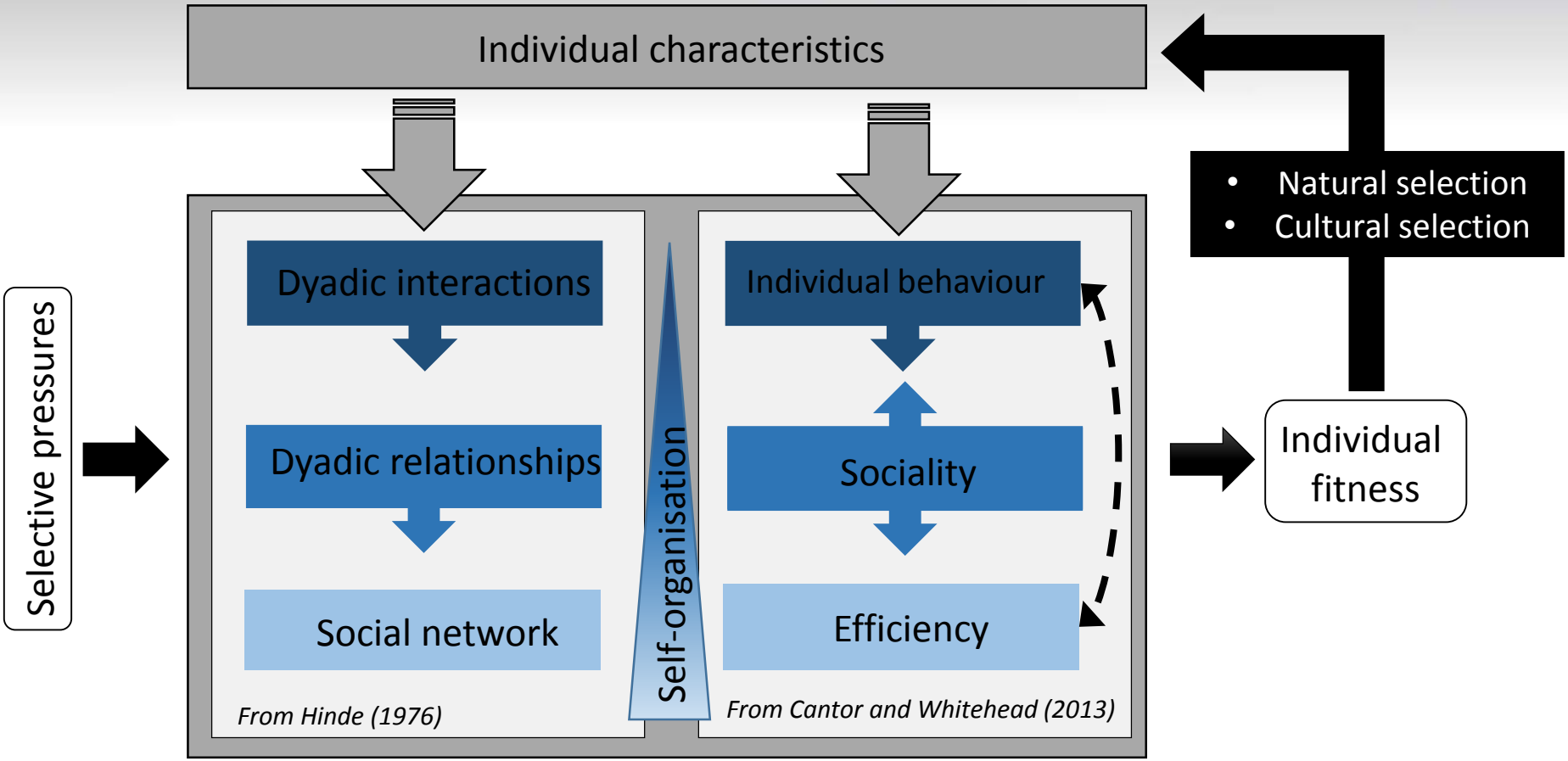
[1]*UCL Institute of Cognitive Neuroscience, 17 Queen Square, London WC1N 3AR, UK*
[2]*Wellcome Trust Centre for Neuroimaging, University College London, 12 Queen Square, London WC1N 3BG, UK*
[3]*Interacting Minds Project, Institute of Anthropology, Archaeology, Linguistic Aarhus University and* [4]*Centre of Functionally Integrative Neuroscience, Aarhus Univer Norrebrogade 44, Building 10 G, 8000 Aarhus, Denmark*
[5]*Institute of Cancer, Barts and The London School of Medicine and Dentistry, Charterh London EC1M 6BQ, UK*





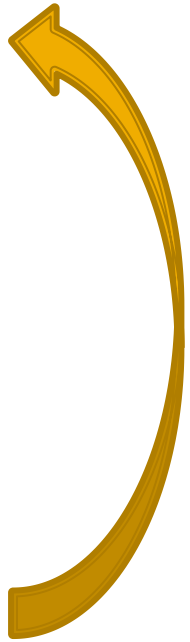


Evolution and Selection of social networks



Evolution and Selection of social networks

- By a combined effect of self-organisation and cultural selection, social networks may evolve to increase all group members' fitness
- However, inside the group, individuals having higher cognitive abilities through genetic advantages have higher fitness
- This leads to increase network efficiency



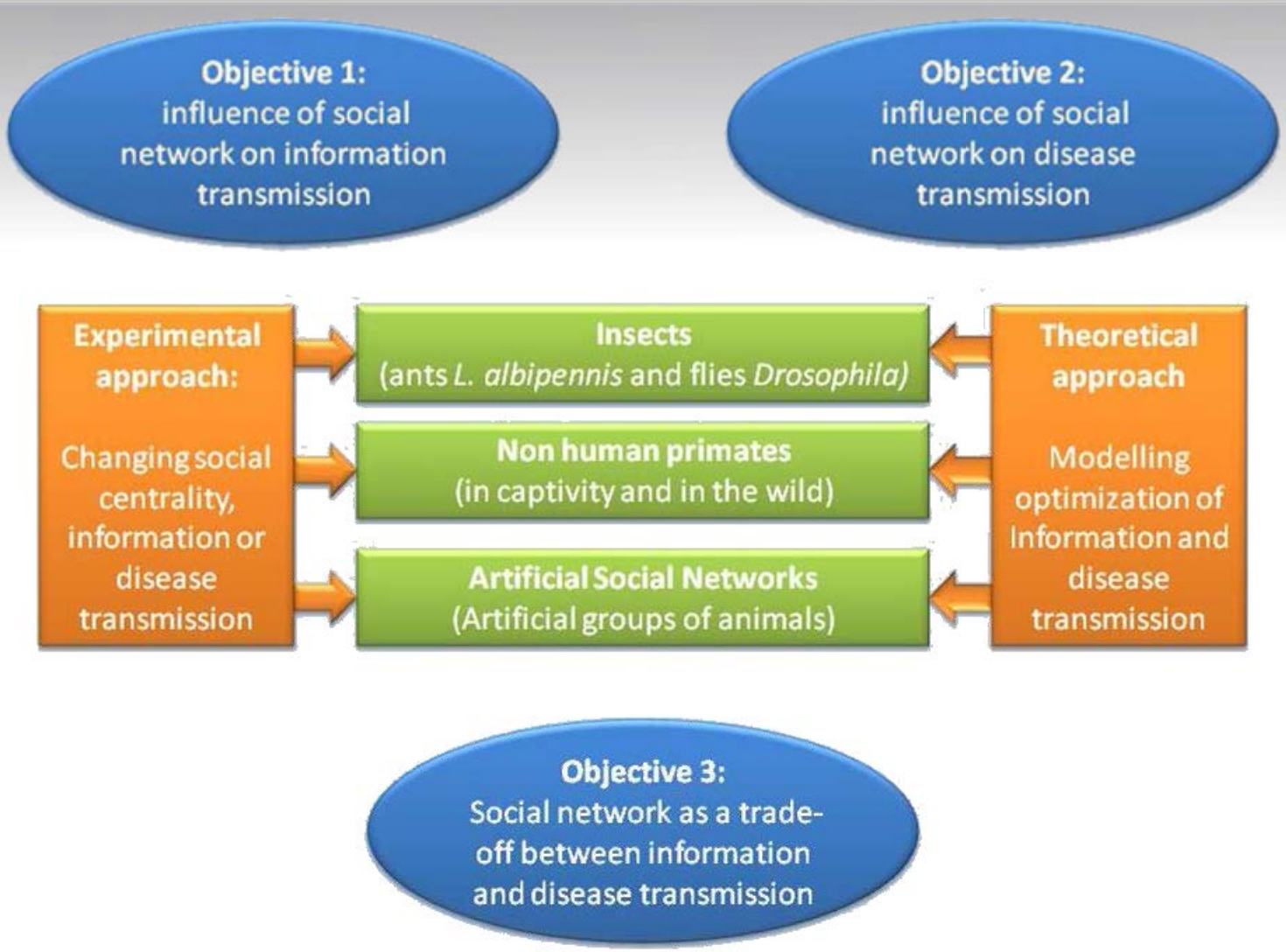
Perspectives

- Does social network influence positively or negatively other social phenomena?

In Japanese macaques, females central to the grooming network exhibit higher species richness and intensity of infection by parasites. *MacIntosh A. et al 2012*

- How is this social network a trade-off between different variables?

Research plan

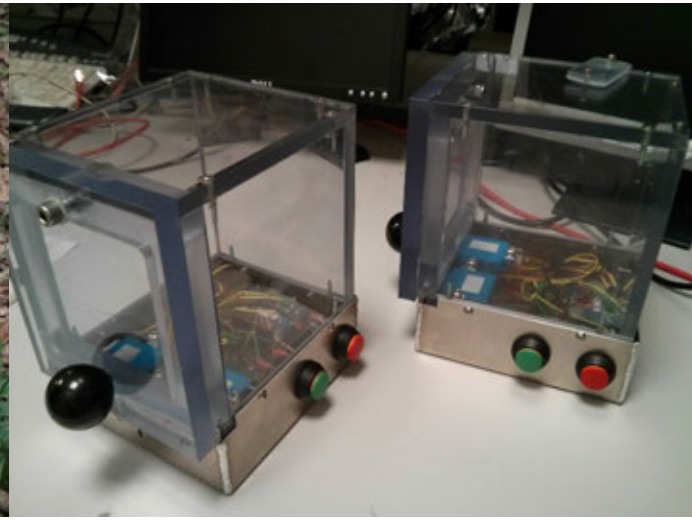


Social network as information and health trade-off in primates

Simultaneous experiments on individual network centrality

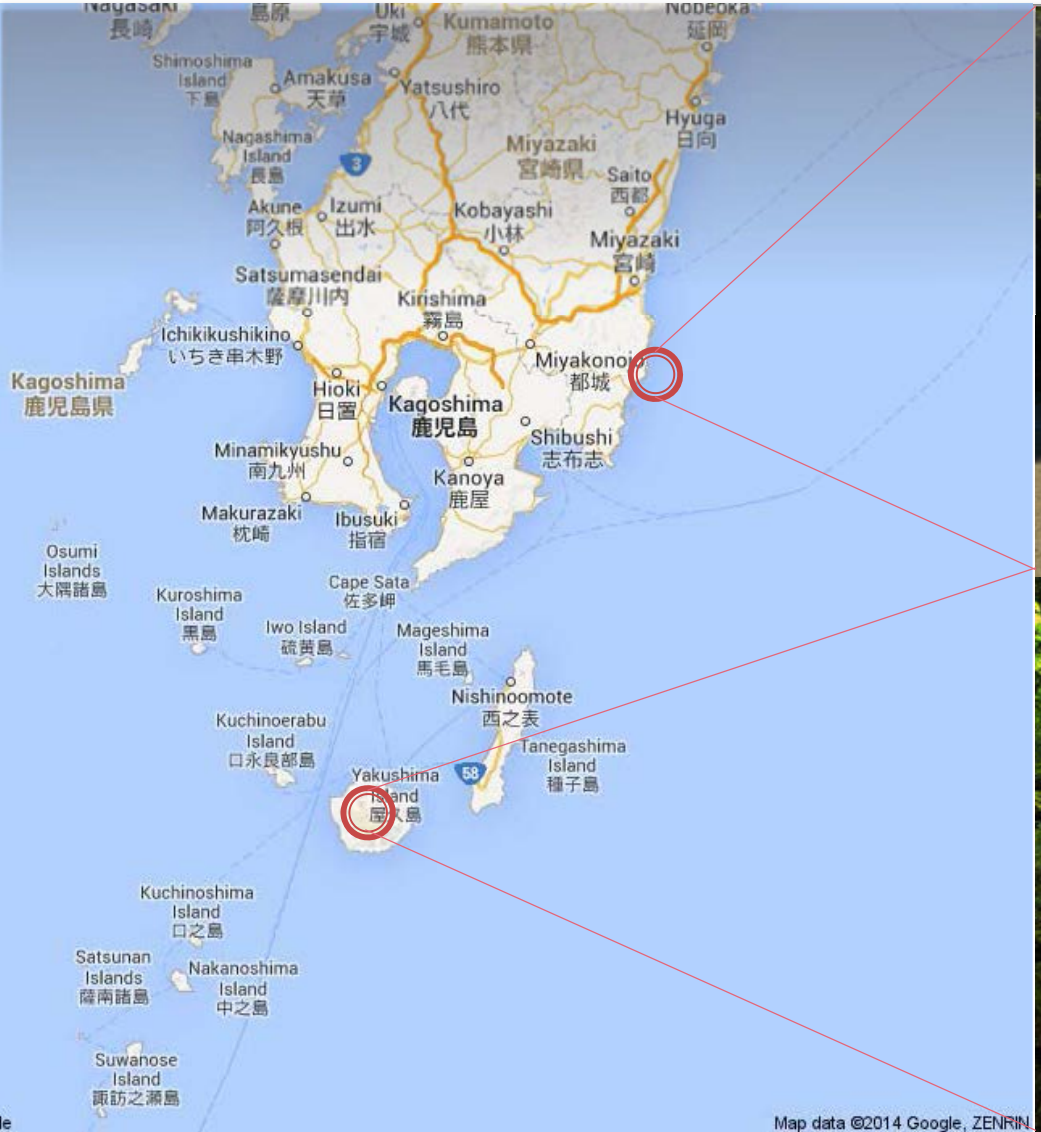
Parasite transmission
- **Feces**
- **PEPS (pseudoectoparasites)**

Information transmission
- **Social learning through new foraging techniques boxes**

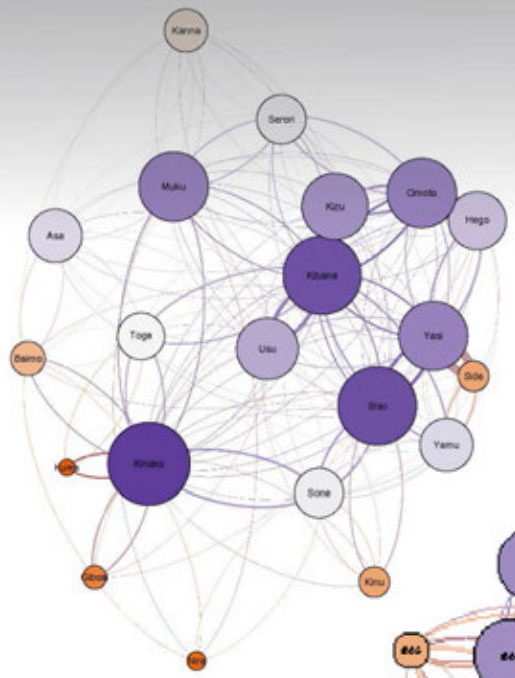


Social network as information and health trade-off

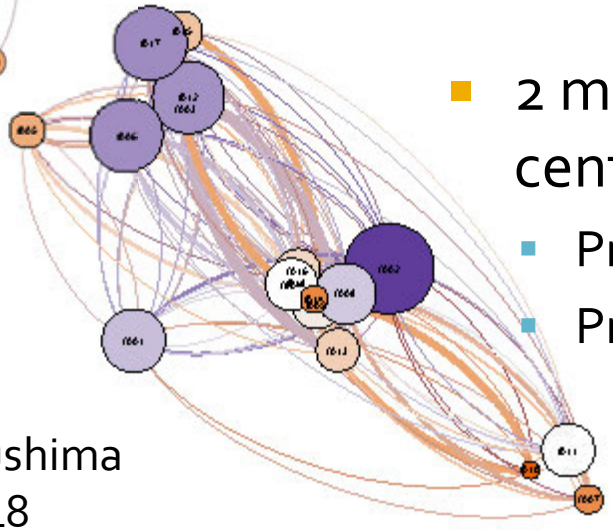
Simulations of transmission



Simulations of transmission



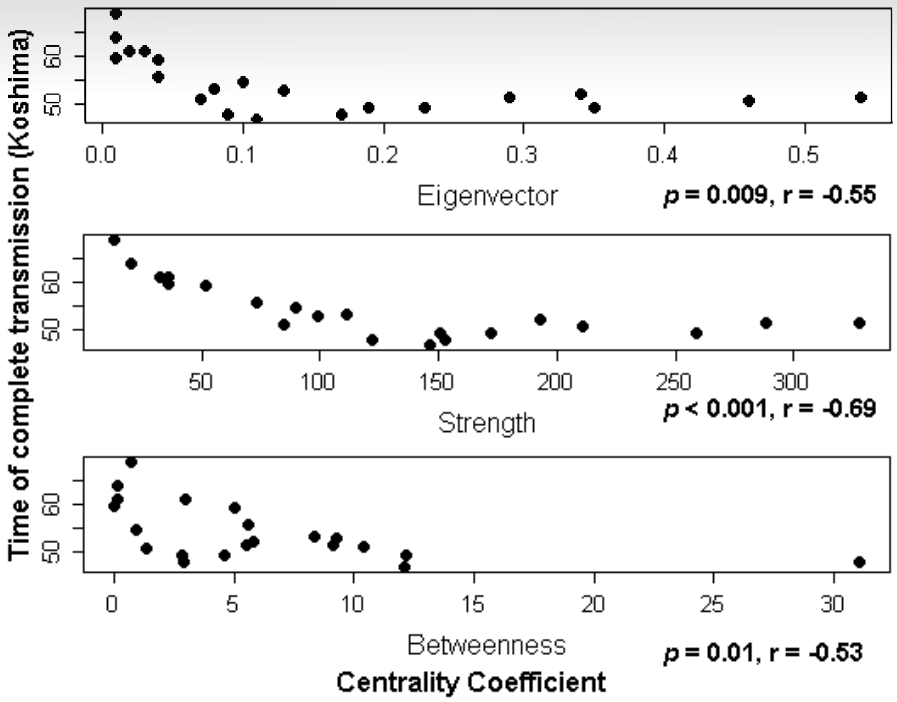
Koshima
N = 21

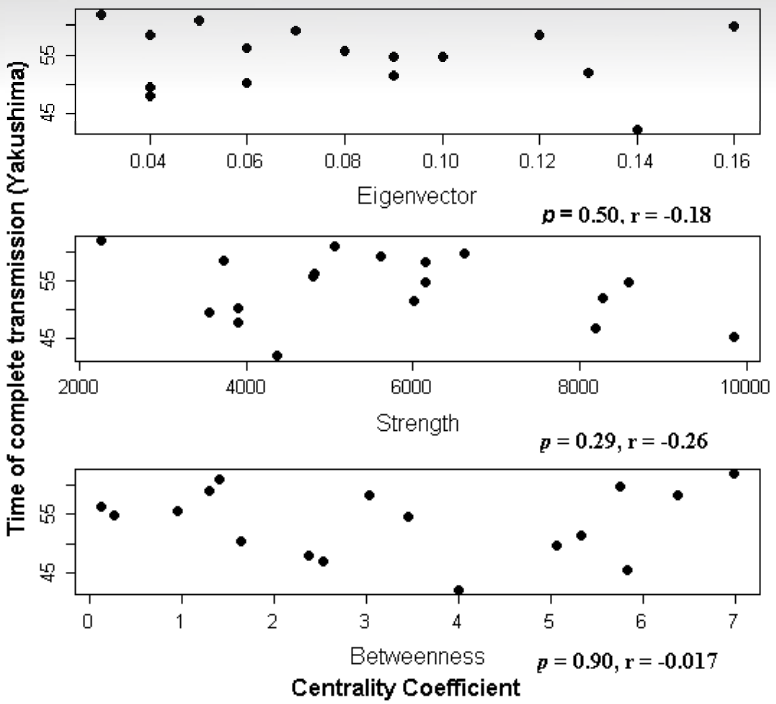


Yakushima
N = 18

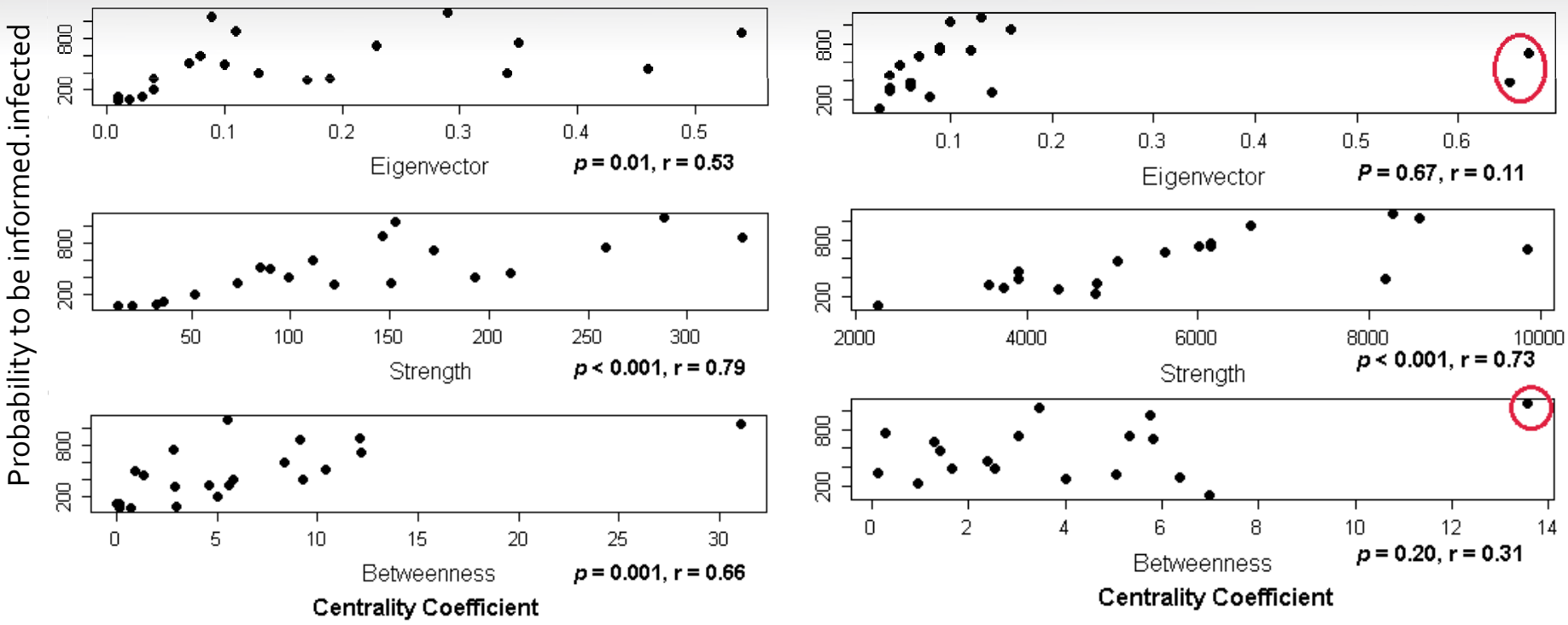
- Grooming data implemented in a model of information/disease transmission
- Probability of diffusion depends on social networks (graph-based simulation approach)
- 2 measures according to network centralities
  - Probability to transmit info/disease
  - Probability to be informed/infected

Probability to transmit info/disease

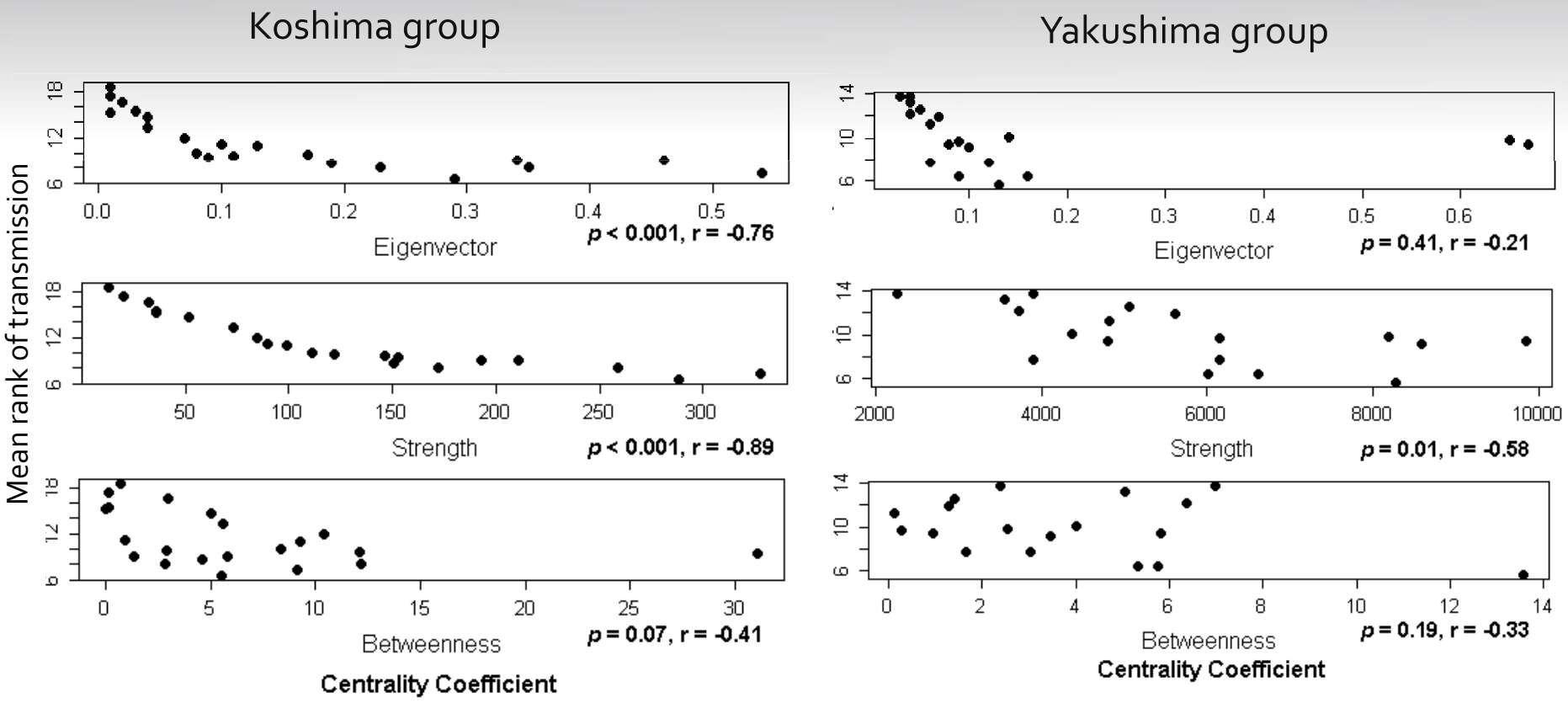




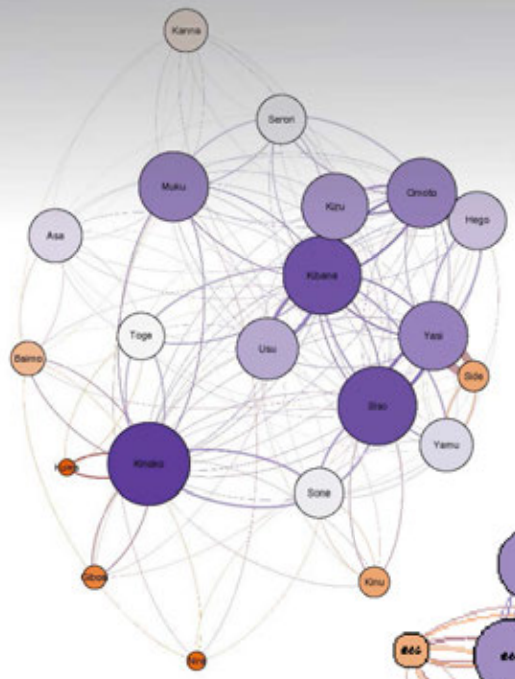
Probability to be informed/infected



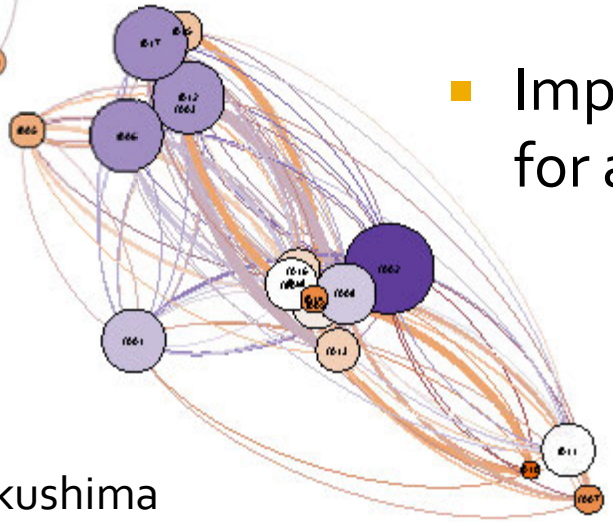
Probability to be informed/infected



Conclusion on the two groups



Koshima

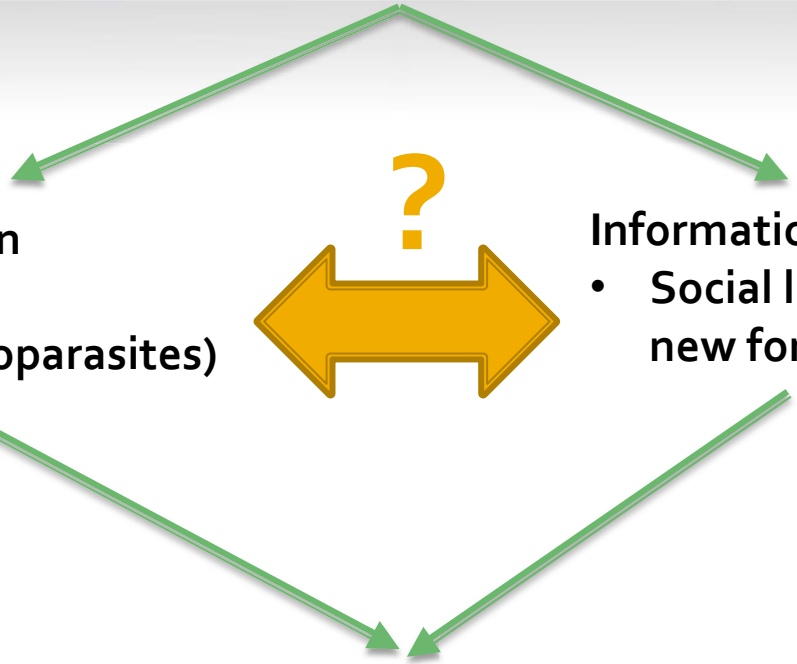


Yakushima

- Same group size (18 vs.21)
- Different social network (density and distribution of centralities)
- Different transmission at the individual and at the group level
- Importance of network efficiency for all group members' fitness

Social network as information and health trade-off

Simultaneous experiments
on individual network centrality



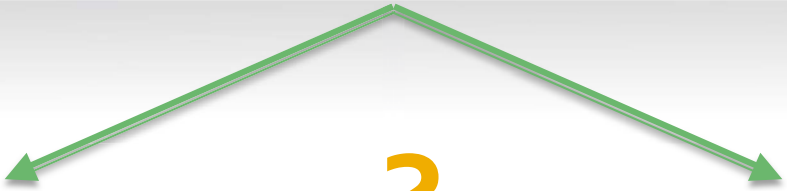
Parasite transmission
- Feces
- PEPS (pseudoectoparasites)

Information transmission
- Social learning through new foraging techniques boxes

Social network as a trade-off

In ants and fruitflies?

Simultaneous experiments
on individual network centrality



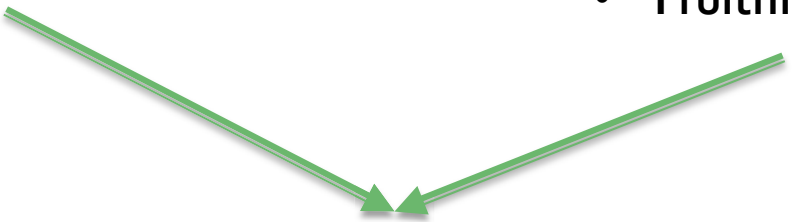
Disease transmission

- Ants: poison and antidote
- Fruitflies: N/A

?

Information transmission

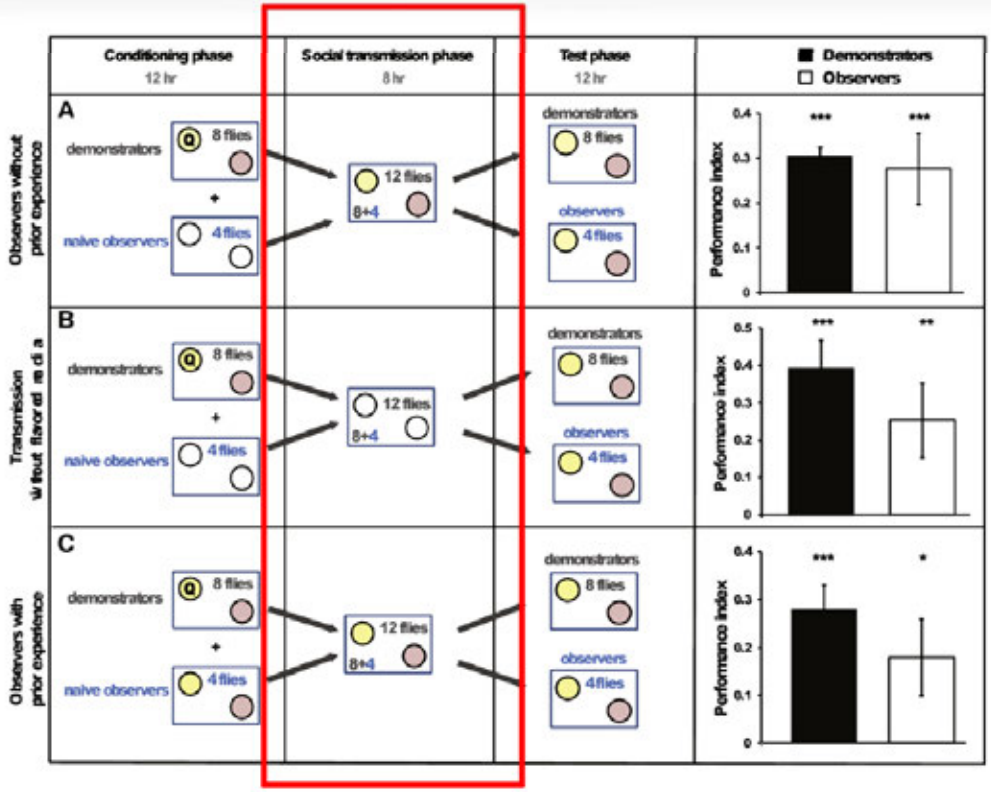
- Tests of preferences
- manipulating supports of communication
- Ants: via glue on the abdomen or inhibitors to avoid pheromone transmission
- Fruitflies: hydrocarbon profile



Social network as a trade-off

Social network analysis of information transmission in *Drosophila*

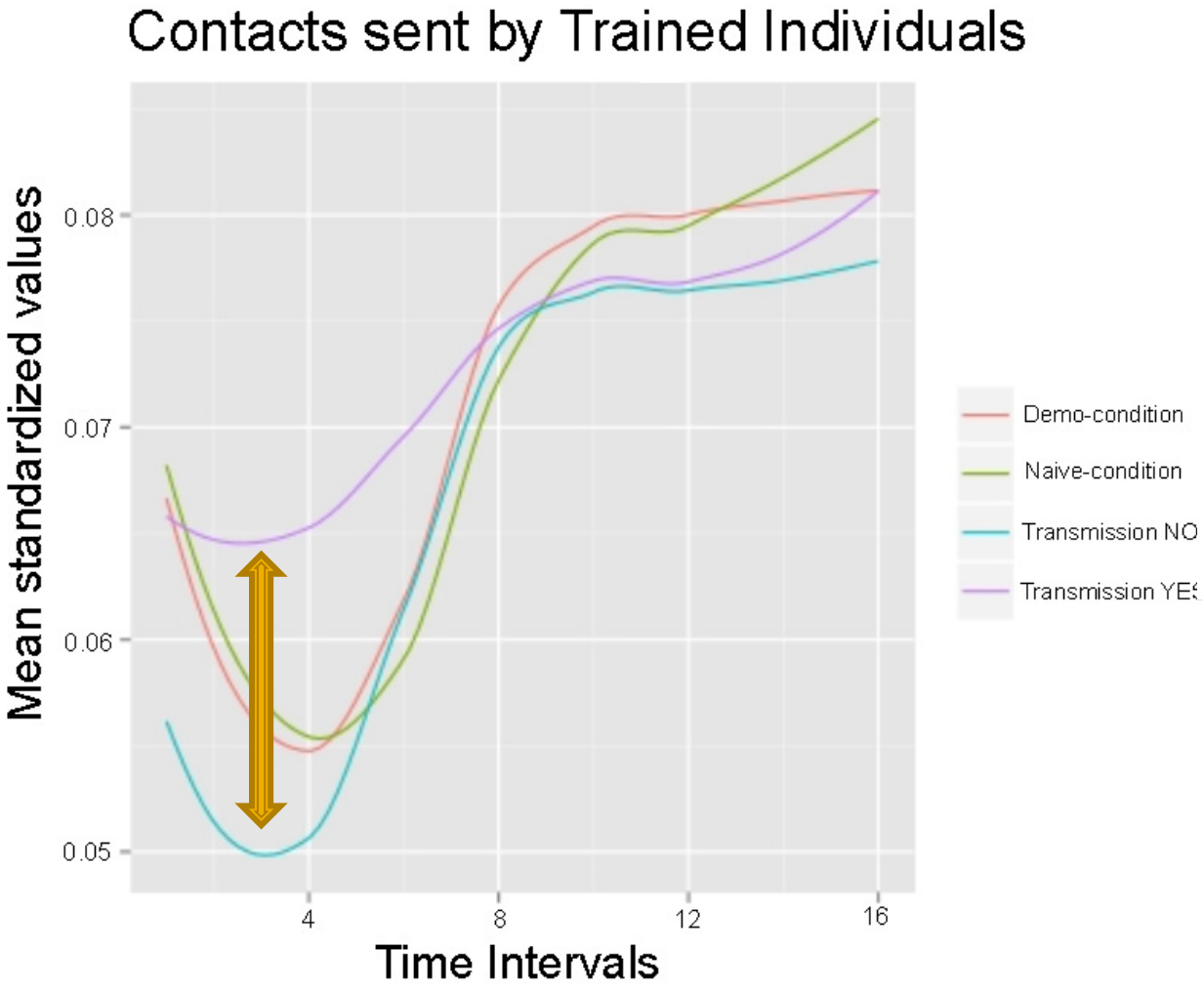
- Ovoposition site choice of Naive individuals is influenced by interactions with previous trained individuals



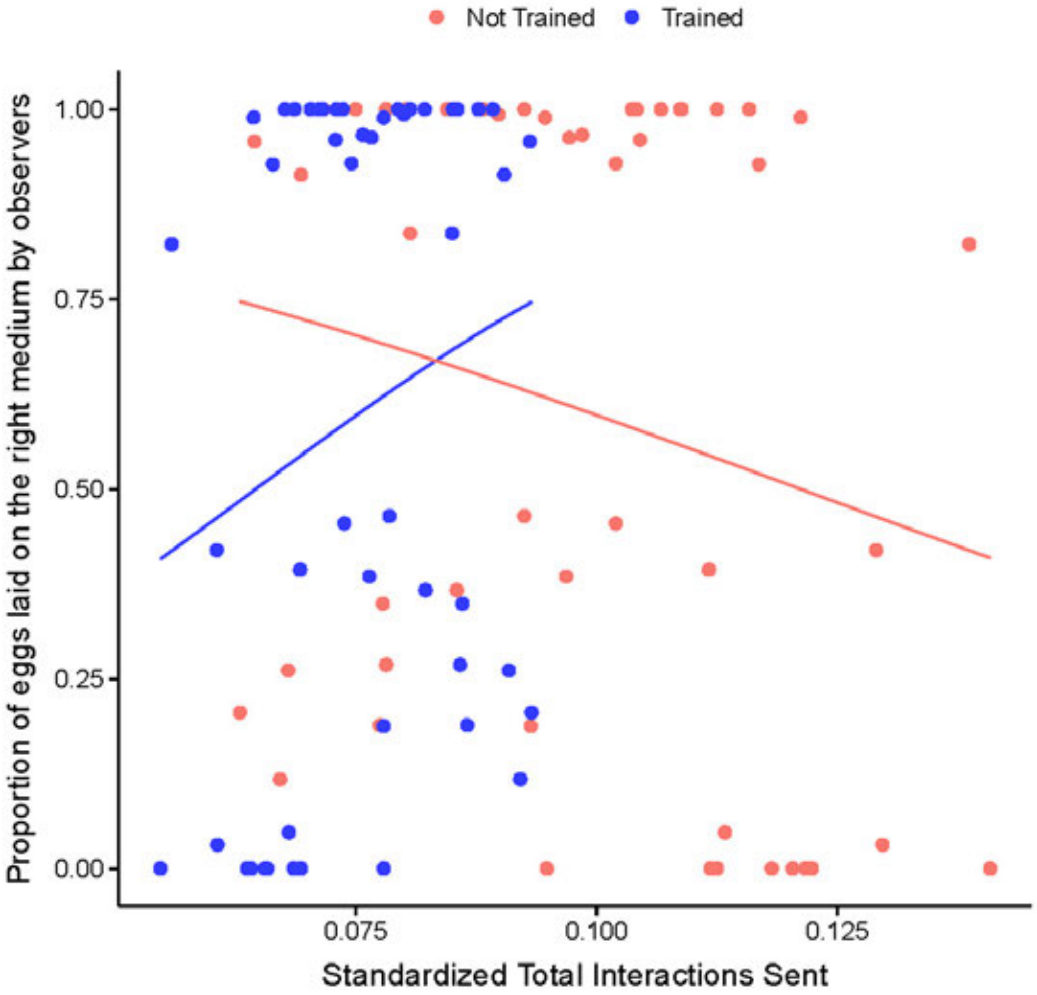
Battesti et al. 2012

NO previous personal INFO

Previous personal INFO



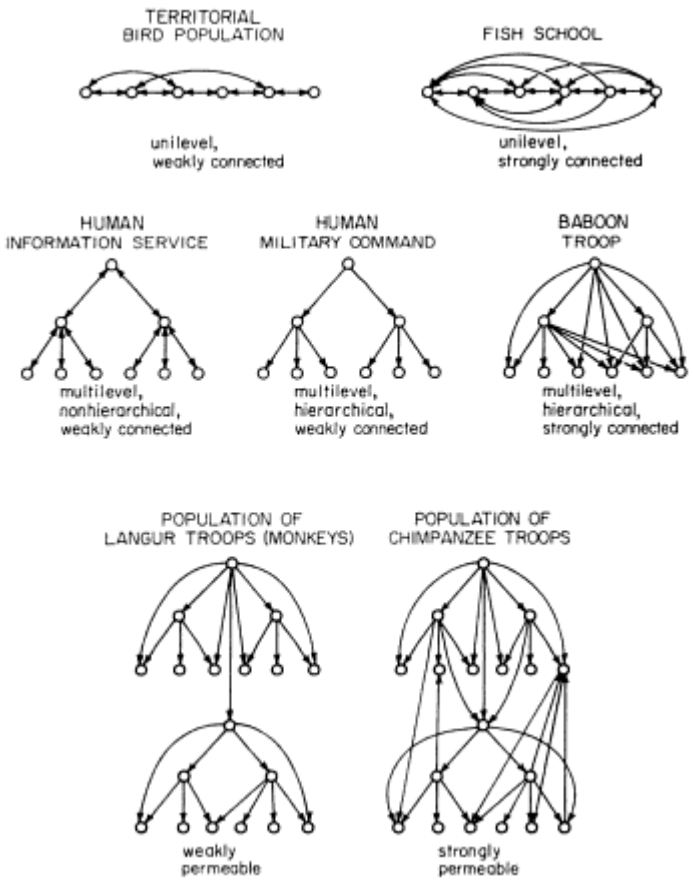
Demonstrators (trained individuals) need to be active and to contact naïve individuals in order to observe an information transmission



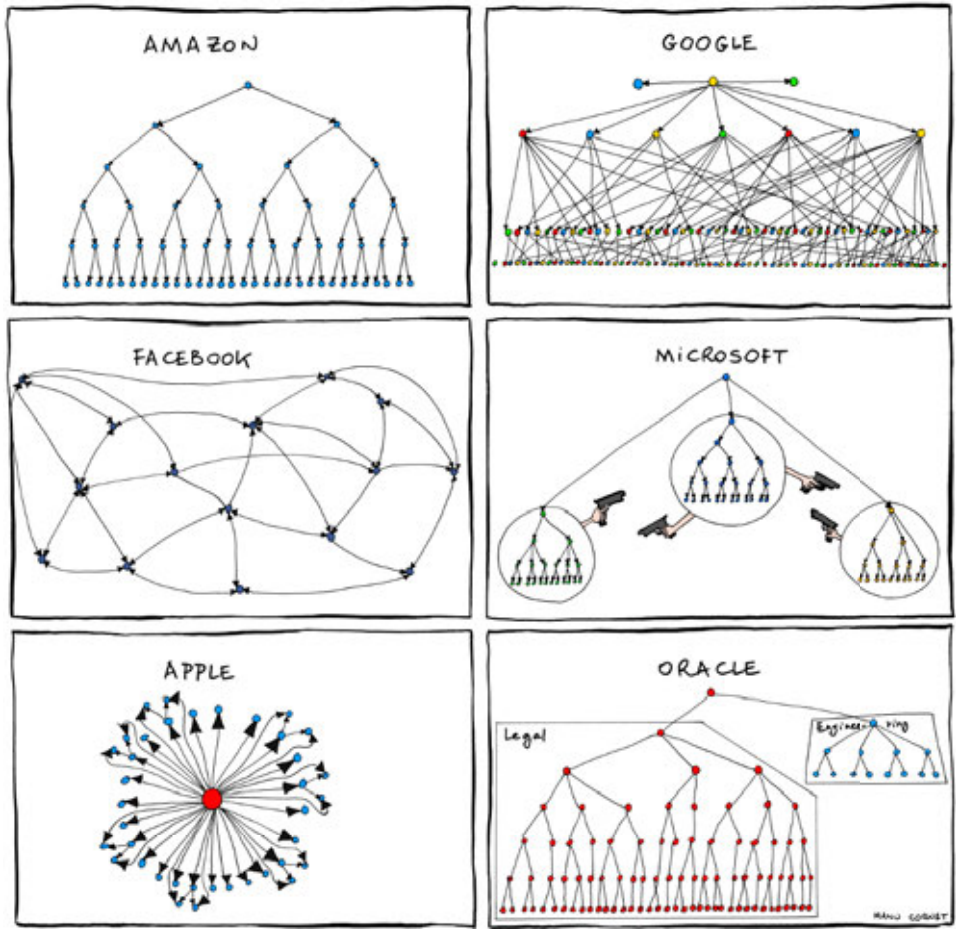
Whilst naïve indivisuals gain information (more eggs with more contacts), demonstrators (trained individuals) loose information (less eggs with more contacts)

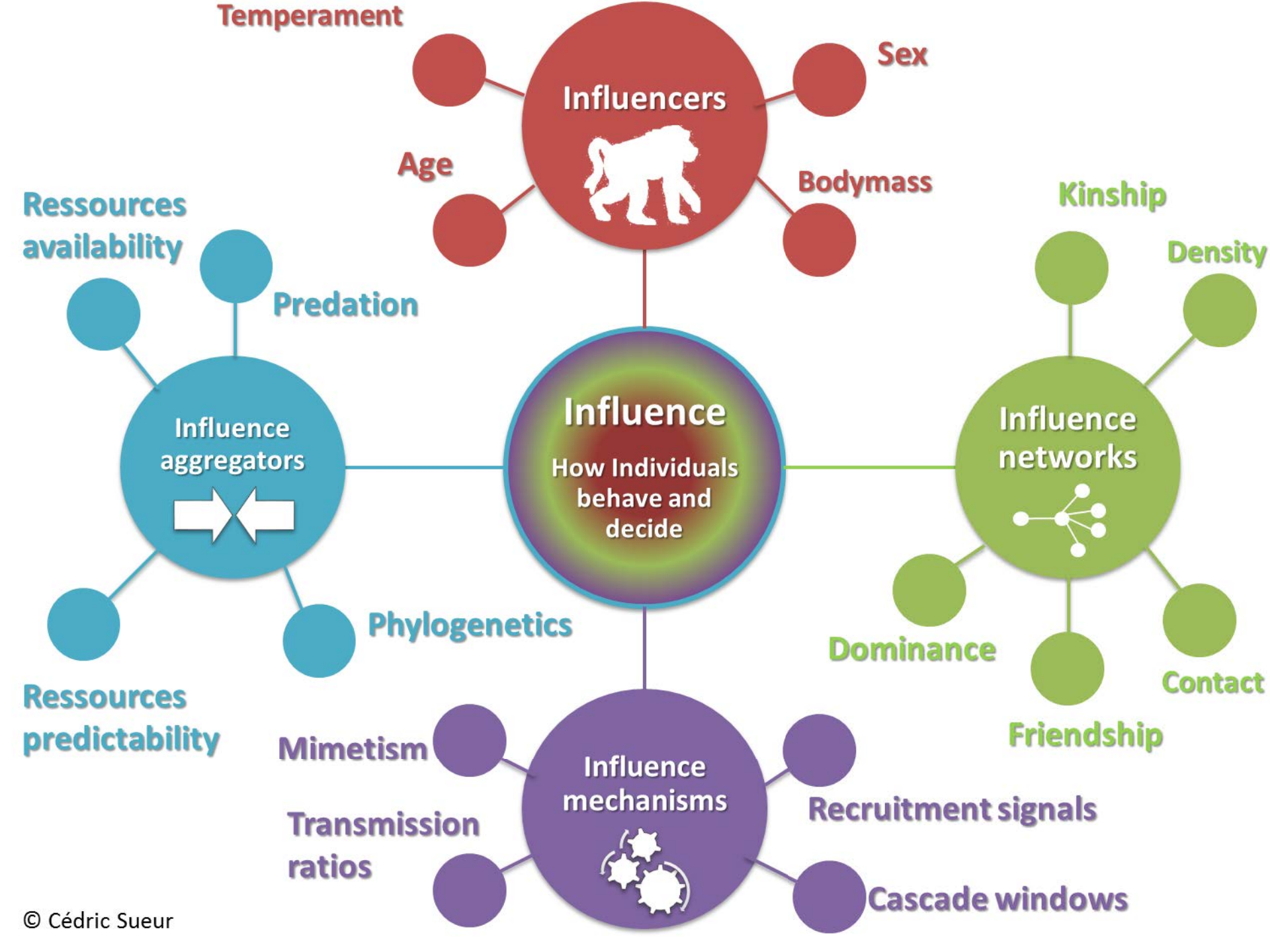
Applications to human beings?

Animals (Wislon, 1975)



Human beings
(New York Times, 2013)




Temperament
Influencers
Sex
Age
Bodymass
Ressources availability
Predation
Influence aggregators
Influence
How Individuals behave and decide
Kinship
Density
Influence networks
Dominance
Contact
Friendship
Phylogenetics
Ressources predictability
Mimetism
Influence mechanisms
Recruitment signals
Transmission ratios
Cascade windows
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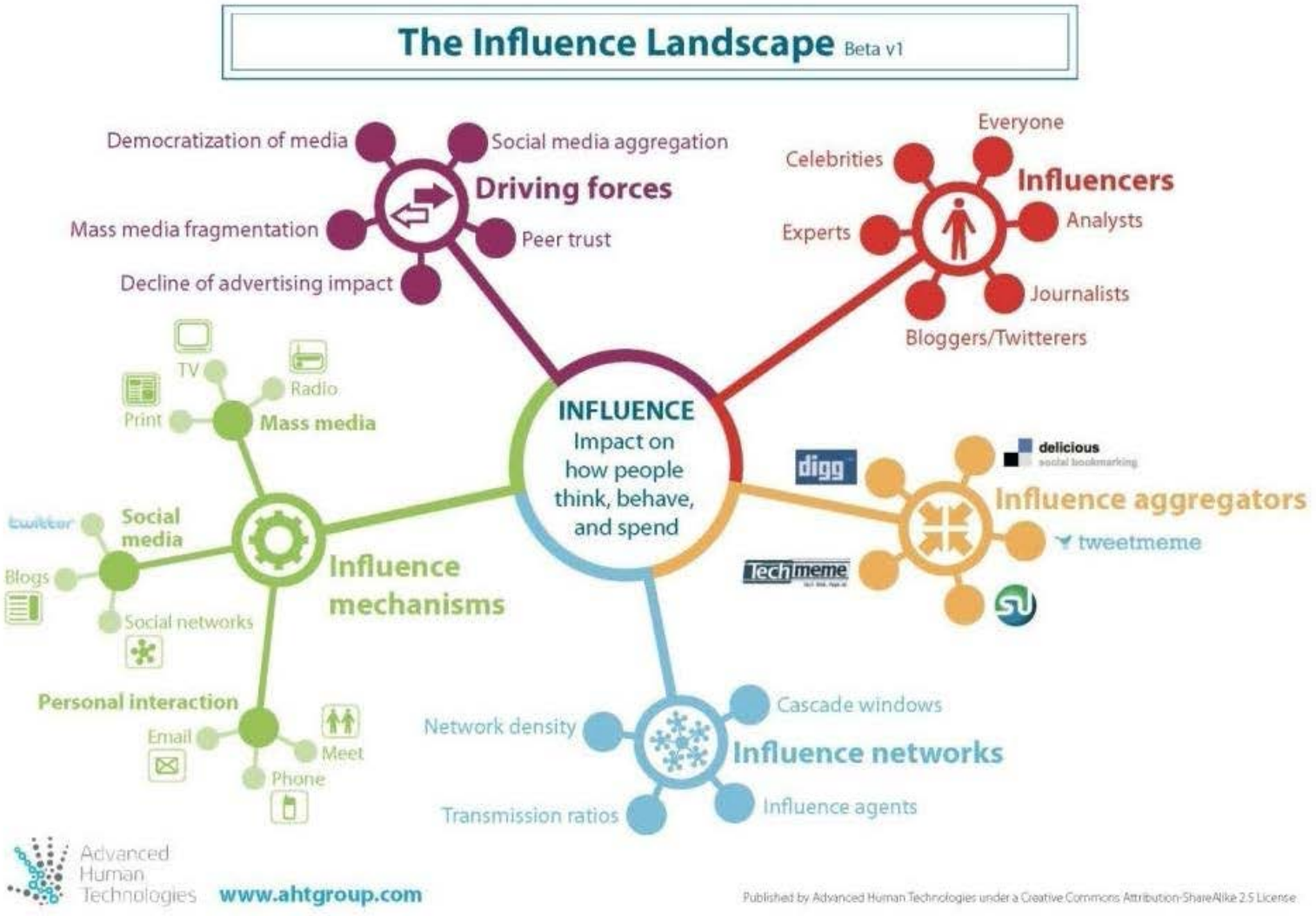
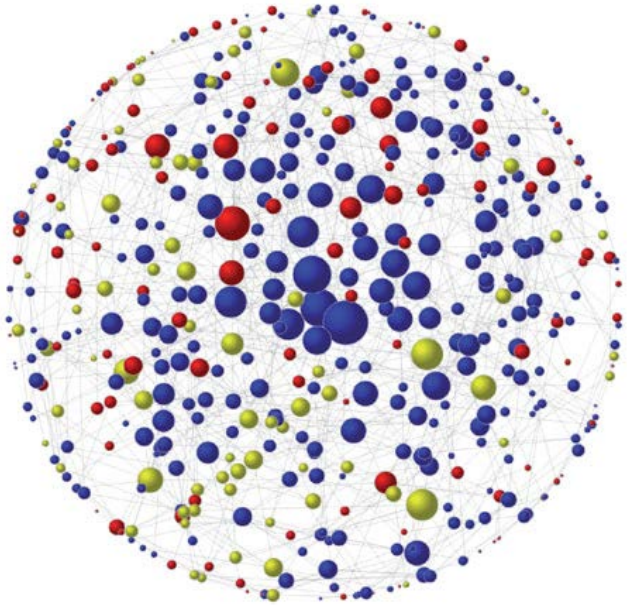
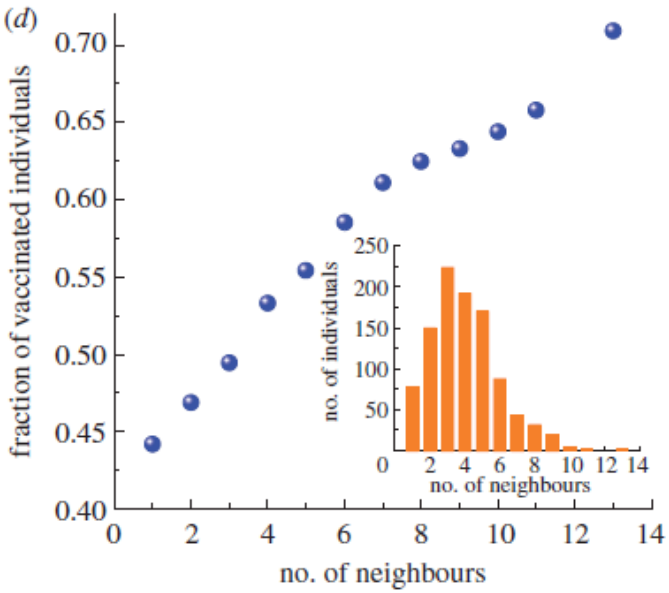
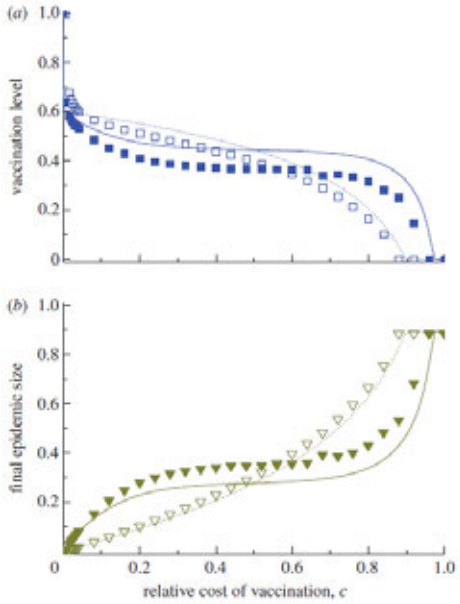
Management, productivity and well-being in human beings (firms)

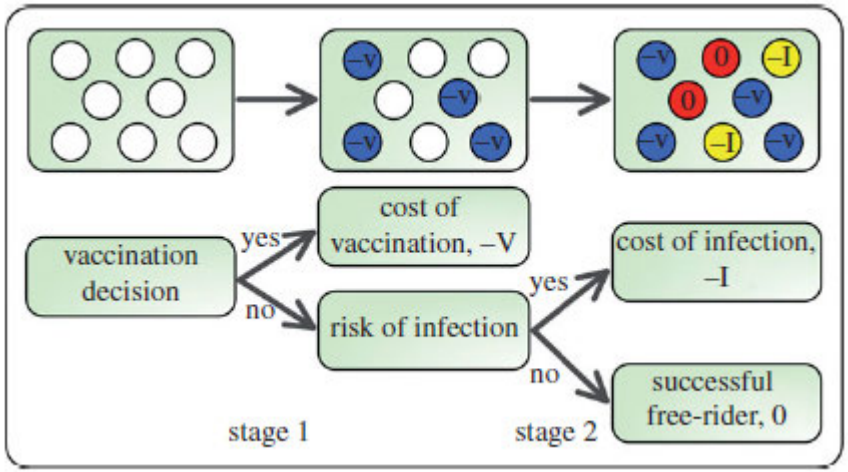


Imitation dynamics of vaccination behaviour on social networks. Fu et al 2010









Vaccination threshold decreases when taking into account individual centralities

Network-Based vaccination in chimpanzees. Rushmore Julie et al.

- Threshold required to stop contagion:
  - 35% of individuals based on greatest centrality
  - 17% based on core-ranging individuals

Thank you for your attention!

And my colleagues, Marie Pelé, Odile Petit, Jean-Louis Deneubourg, Andrew J King, Andrew JJ MacIntosh

SNAAS network