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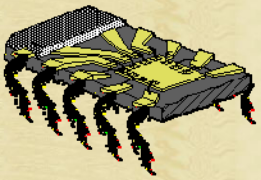
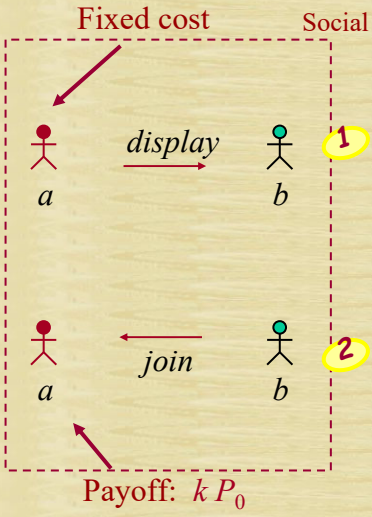


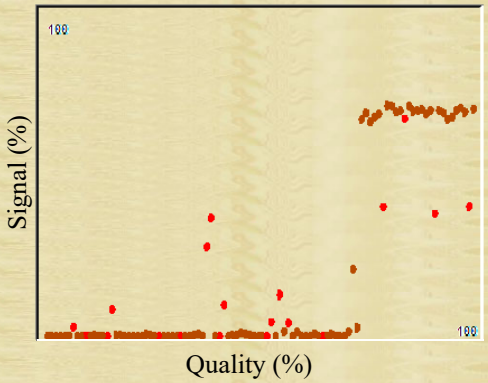
Social Emergence in complex systems

Jean-Louis Dessalles
Telecom Paris
www.dessalles.fr

Evolutionary stability of social signals

Asymmetrical bonds (Twitter-like network, one quality)





Asymmetrical bonds (Twitter-like network, one quality)

turdoides squamiceps

Signal $s(q) = g(q)\, q$

Cost: $Cg(q)$

Profit: $k\, P_0$

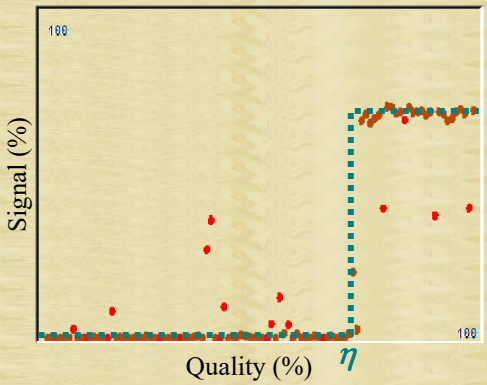
$s(q) = 0$ for $q < \eta$

For $q > \eta$:

Benefit: $B(q) = kP_0 - Cs_0/q$

$s_0 = \eta = 1 - 1/k$

→ $1 - 2/k \leq s_0 \leq 1 - 1/k$



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Dessalles (2014). Optimal investment in social signals. *Evolution, 68 (6), 1640-1650.*

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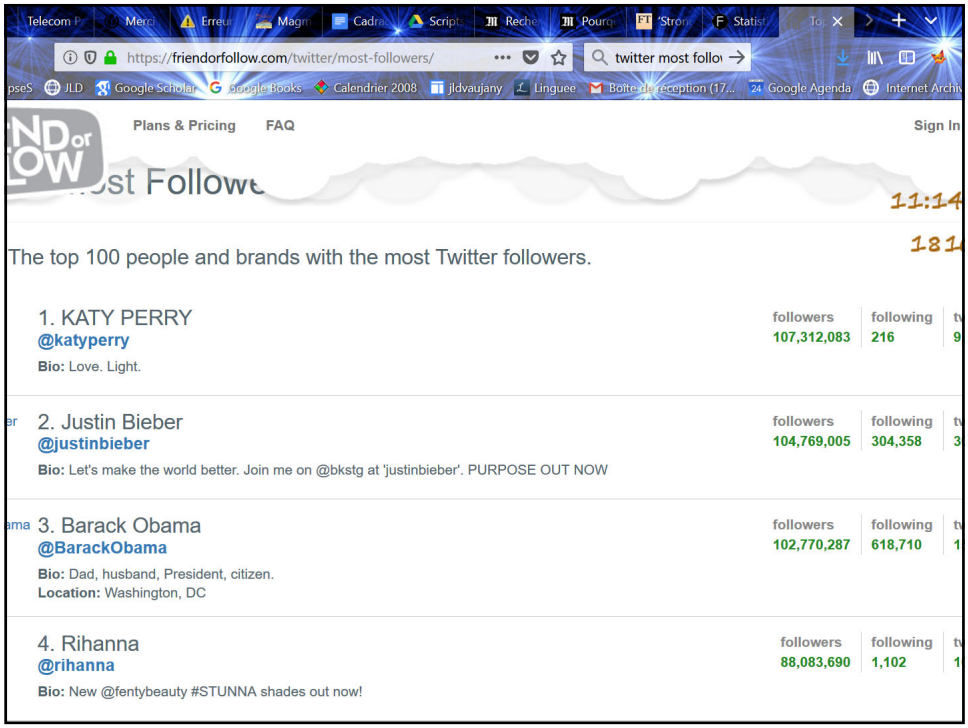

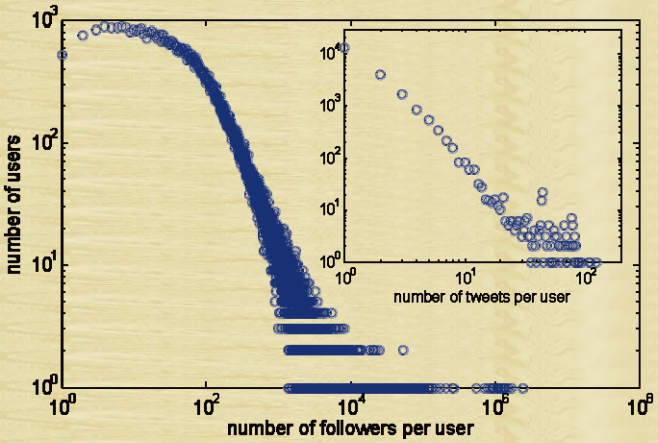

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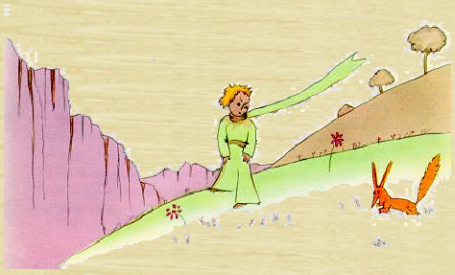
C'est le temps que tu as perdu pour ta rose
qui fait ta rose si importante.



It is the time you have wasted for your rose
that makes your rose so important.

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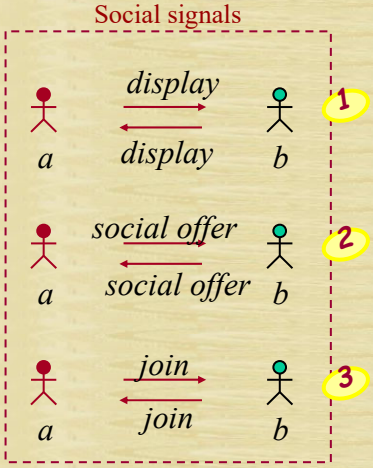
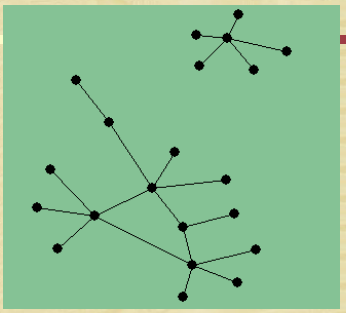
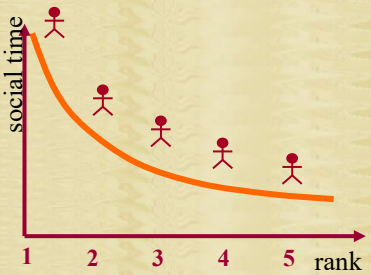
The time sharing (TS) model

Social signals







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The time sharing (TS) model

profit

$P(q) = 1 - \Pi_i (1 - K\, r^i\, q)$

assortativeness

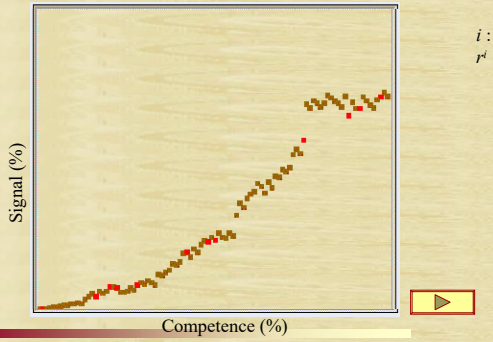
Social offer :

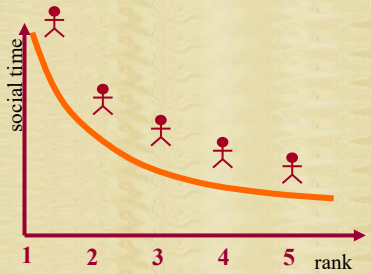
Competence × Time

$s(q)$ r^i

i : B's potential rank in A's contact list

r^i : amount of time offered by A to B ($0 \leq r \leq 1$).





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Homophily in Twitter | Homophily in networks | Homophily in humans

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Competitive signalling

profit

$P(q) = 1 - \Pi_i (1 - K r^i q)$

Signal $s(q) = g(q)\, q$

Cost: $Cg(q)$

assortativeness

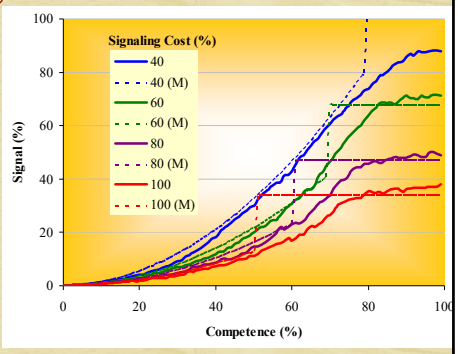
Benefit: $B_c(q) = P(q) - C\, s(q)/q$

Suppose a mutant with competence q sends the signal normally sent with competence $q+dq$.
The recruitment of a better partner provides $P(q+dq)$
by dint of an augmented cost $C\, s(q+dq)/q$.

Benefit variation
$dB_c = P'(q)\, dq - C\, s'(q)\, dq\, /q$
must be zero for the equilibrium to be stable:

$s'(q) = q\, P'(q) / C$

$s(q) = [\, qP(q) - \int P(q)\, dq\,] /C$



$n = 1, K = 1, L_0 = 0.05$

Dessalles, J.-L. (2014).
Optimal Investment in Social Signals.
Evolution, *68* (6), 1640-1650.

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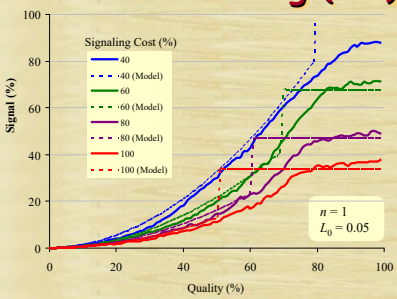
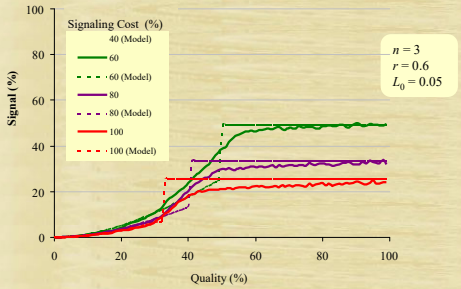
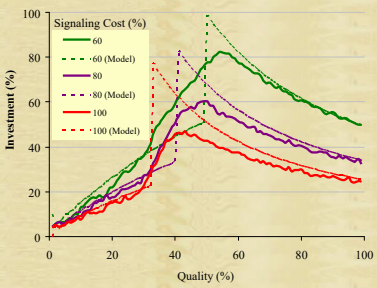
The time sharing (TS) model







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Dessalles (2014). Optimal investment in social signals. *Evolution, 68 (6), 1640-1650.*

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The bankers' suit paradox

profit

$$P(q) = 1 - \Pi_i (1 - K r^i q)$$

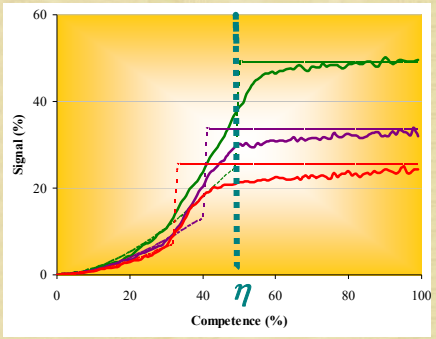
Signal $s(q) = g(q)\, q$

Cost: $Cg(q)$

Above η, all individuals send s_o

$$B_u = P(\tau) - C\, s_o / q$$

$$\tau = (1+\eta)/2$$



$n = 3$, $r = 0.6$, $K = 1$, $L_0 = 0.05$

What controls uniform level?

Dessalles (2014). Optimal investment in social signals. *Evolution, 68 (6), 1640-1650.*

Noise explains uniform level

Learning

Noise = $\alpha L_0 q$, where L_0 *is the maximum variation of* $g(q)$

An agent in the $[\eta, 1]$ range emits $(s_u + \rho\alpha L_0 q)$, where $\rho \in [-1, 1]$

Its probability of getting acquainted with another agent of the elite club, and thus of getting social profit $P(\tau)$, varies between 0 for $\rho = -1$ and 1 for $\rho = 1$.

$$B_u(\rho) = (1+\rho)\, P(\tau)/2 + (1-\rho)\, P(\eta)/2 - C\,(s_u + \rho\alpha L_0 q)/\, q$$

$$dB_u/d\rho = P(\tau)/2 - P(\eta)/2 - C\alpha L_0$$

$dB_u/d\rho$ must be zero, otherwise s_u would not be stable.

$$P(\tau) - P(\eta) = 2C\alpha L_0$$

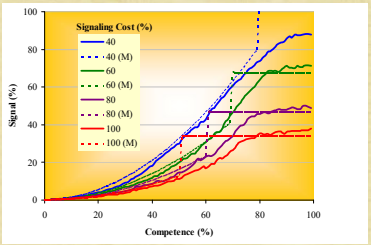
This relation defines η.
The threshold η corresponds to the limit between the competitive mode and the uniform mode.

$$s_u = [\ \eta P(\eta) - \int_0^{\eta} P(q)\, dq\ ]\ /C$$

This relation defines s_u.

$$B_u = P(\tau) - C\, s_o / q$$

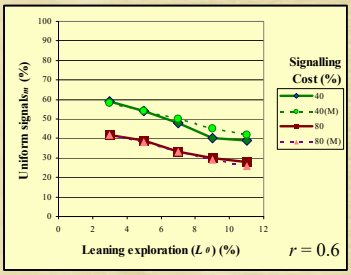
$$\tau = (1+\eta)/2$$

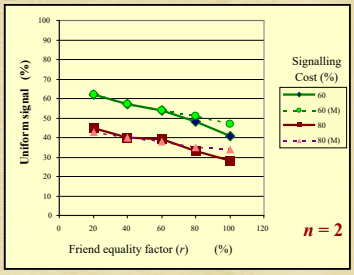


$n = 1$, $K = 1$, $L_0 = 0.05$
$\alpha = 1.2$

Dessalles (2014). Optimal investment in social signals. *Evolution, 68 (6), 1640-1650.*

Noise explains uniform level





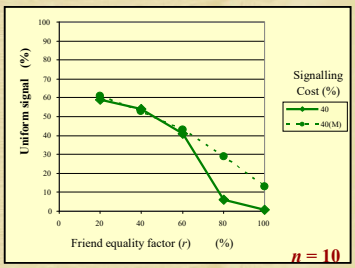
$\alpha = 1.2$
$K = 1$
$L_0 = 0.05$

$P(\tau) - P(\eta) = 2C\alpha L_0$

This relation defines η.

$s_u = [\ \eta P(\eta) - \int^{\eta} P(q)\, dq\ ] / C$

This relation defines s_u.



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Dessalles (2014). Optimal investment in social signals. *Evolution, 68 (6), 1640-1650.*

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Learning

One agent learns at each step, after the tournament has been played.
The new value of $g(q)$ realizes a compromise between:

- $g(q')$ for neighboring abilities q'.
- past values of $g(q)$ that provided highest value of B (memory span is typically limited to 10 learning episodes).
- an additive perturbation of $g(q)$ of amplitude L.
  L decreases until the agent reaches 'adulthood', where it reaches a bottom value $L0$.

Agents 'die' when they reach a maximum age.
They are replaced by another agent with same ability q but a random value for $g(q)$.
After a definite number of steps, the overall shape of function g is supposedly reached.
All new agents are then born adult, as a way to lower the temperature of the learning system.

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Dessalles (2014). Optimal investment in social signals. *Evolution, 68 (6), 1640-1650.*

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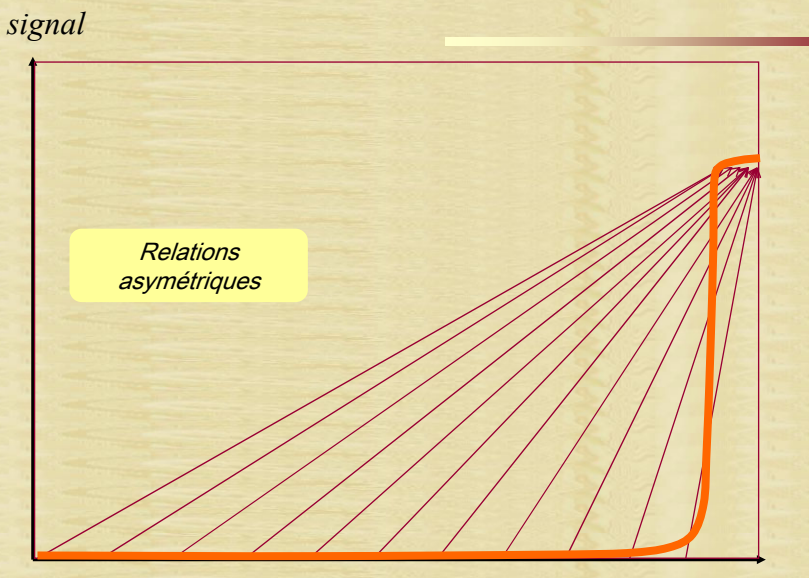

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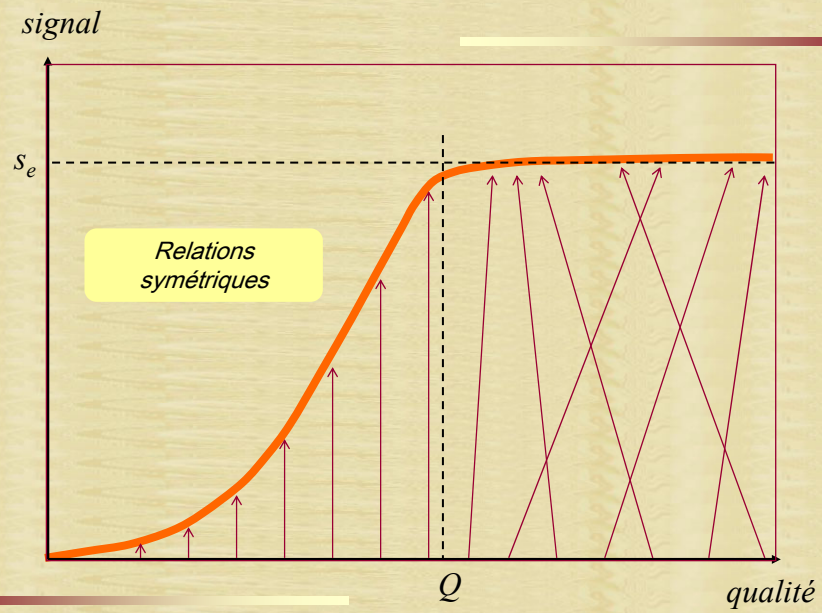

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Assortative bonding through signalling

$$B_c(q) = P(q) - C\,s(q)/q$$

$$B_u = P(\tau) - C\,s_m / S(q)$$

$$\boldsymbol{P(q) = 1 - \Pi_i\,(1 - K\,r^i\,q)}$$

This expression means that the presence of the i^{th} friend during a fraction r^i of the time contributes by $K\,r^i\,q$ to reducing the probability of getting killed.

Social offer

Time × Competence

r^i q

O1. 15 000 words a day.
O2. Talkative individuals.
O3. Futile matters.
O4. No discrimination.
O5. Unexpected events (*8–10*).
O6. Huge lexicon.
O7. Correlation with social bonding.
O8. No sex difference.
O9. Uniqueness.

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