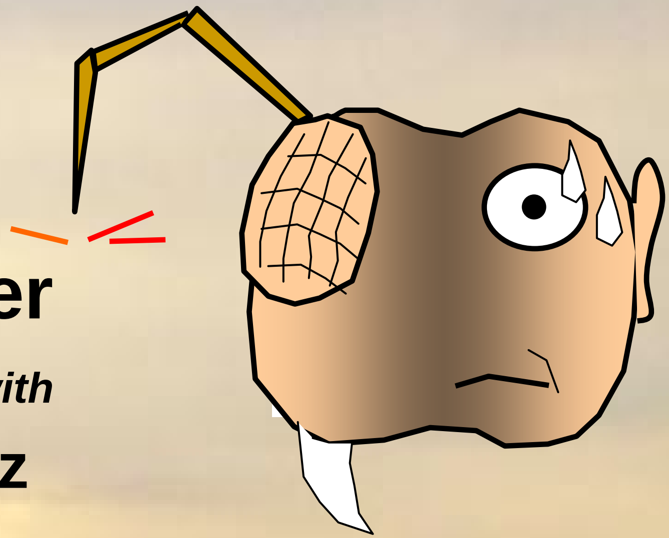
Symmetry breaking in escaping ants

and other experiments in self organization



E. Altshuler

In collaboration with

J. Fernández

Y. Núñez

O. Ramos

C. Noda

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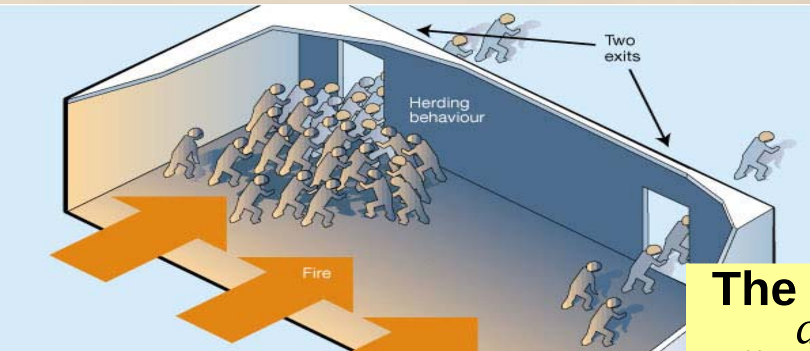
Self-propelled particles: Modeling emergent features of "escape panic"

Helbing, Farkas & Vicsek, Nature **407**, 487 (2000)



The model

$$m_i \frac{d\vec{v}_i}{dt} = m_i \frac{v^0{}_i(t)\vec{e}^{\,0}{}_i(t) - \vec{v}_i(t)}{\tau_i} + \sum_{j(\neq i)} \vec{f}_{ij} + \sum_w \vec{f}_{iw}$$

Individual movement
(includes the desire to "follow the crowd")

Person-person interaction
(may include repulsion, tangential interaction, etc.)

Wall-person interaction
(may include repulsion, Tangential friction, etc.)

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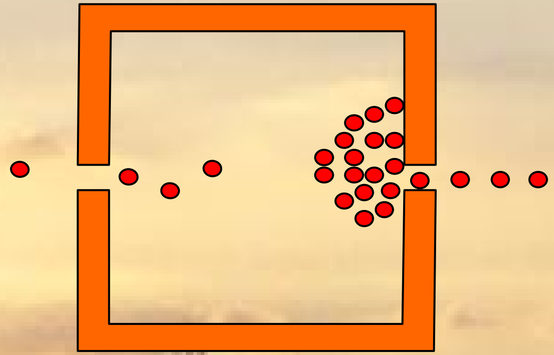
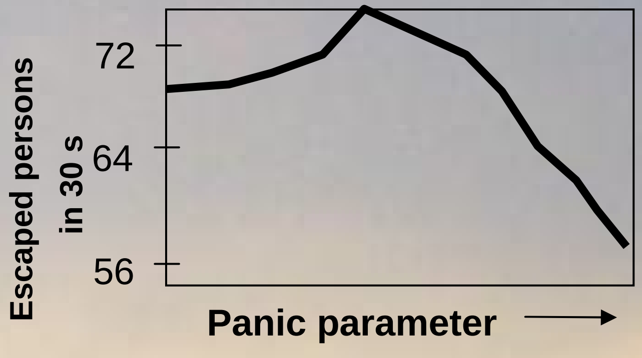
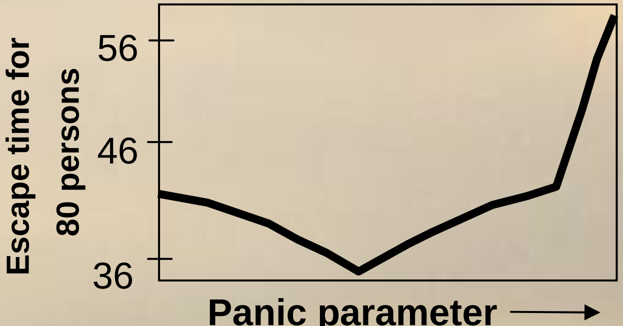
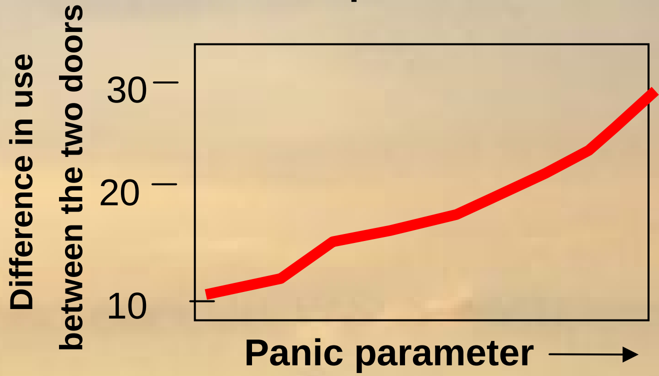
”People” escaping under panic:

Emergence of symmetry breaking as a theoretical prediction









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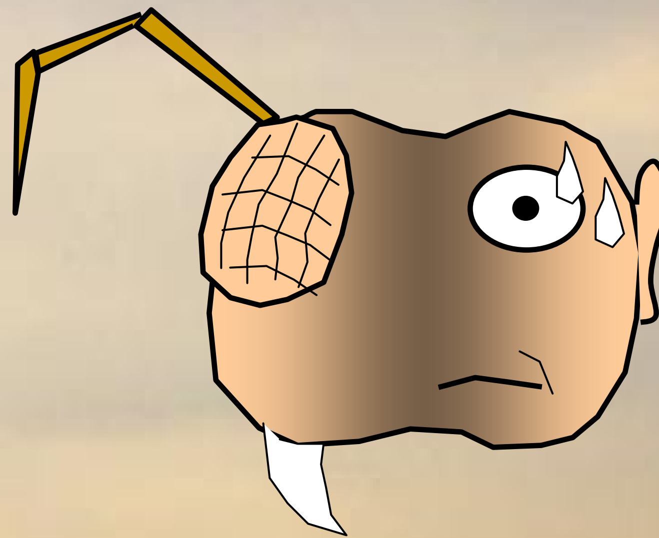
Our proposal: using ants as model pedestrians



***Atta insularis*:**
BIBIJAGUA

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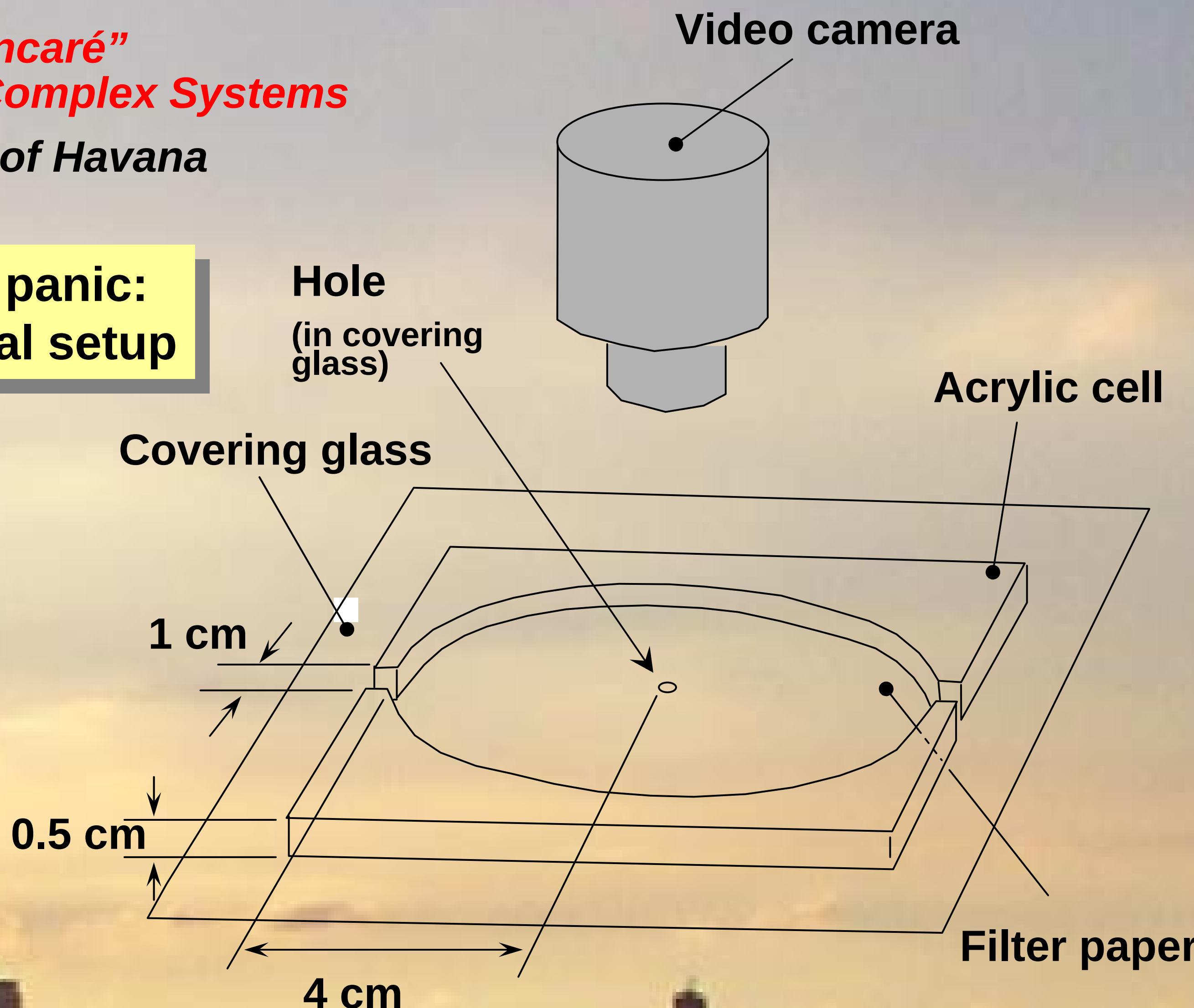
Ants escape under panic: a simple experimental setup



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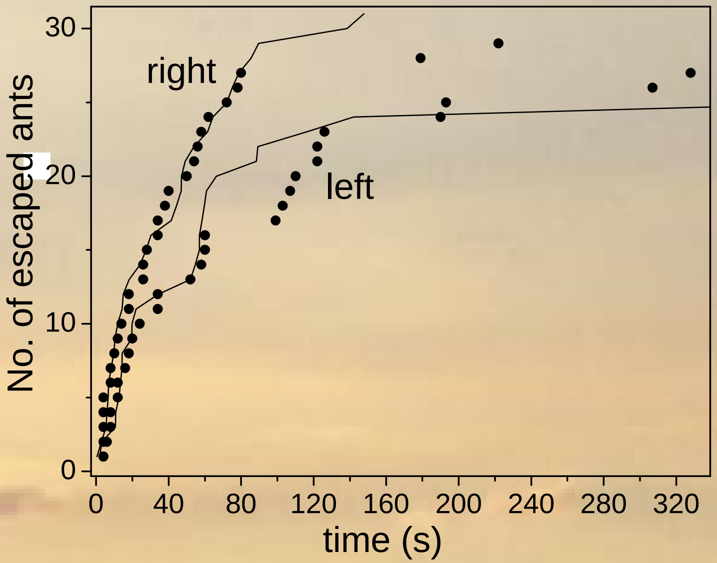
Ants in moderate panic:



Statistics for several experiments:

12 ± 3 % difference

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Ants in panic:
how to produce panic?

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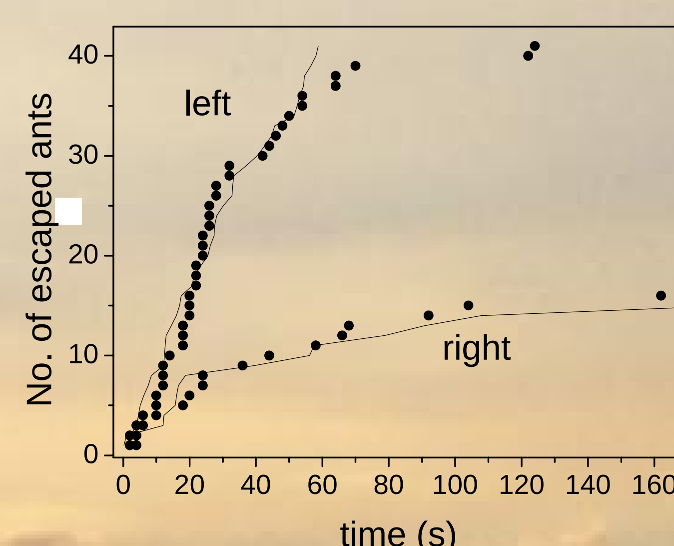
Ants in panic:
Using a repellent fluid



Statistics for several experiments:

51 ± 7 % difference

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Ants in moderate panic:
A simulation inspired in Helbin *et al.*’s

Cell shape: circular

Initial conditions:

1) Ants size distribution: Gaussian

2) Ants positions into the cell: random

3) Ants initial velocities: Gaussian distribution of speeds, random directions

Rules:

1) Ant-wall interaction: simple reflection

2) Ant-ant interaction: just delays the will to follow a given direction

3) Ant escape: ant within a distance $D < R_e$ from exit

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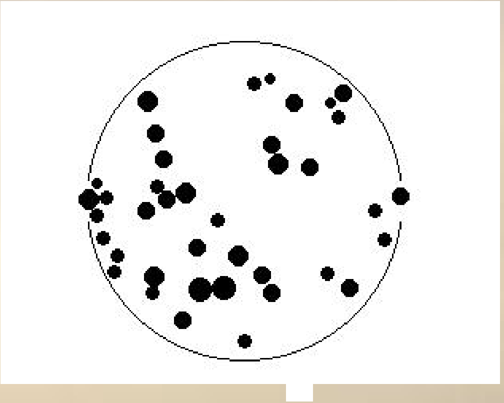
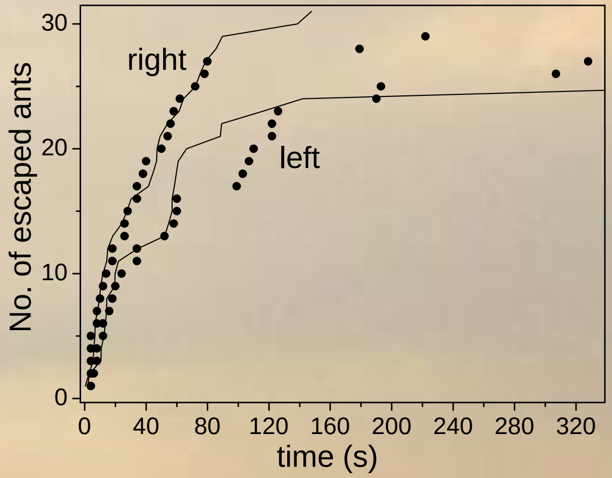
Simulations vs. experiments: moderate panic





Simulation parameters

$n = 60$

$R_{cell} = 4\ cm$

$d_{exit} = 1\ cm$

$v_0 = 0.5\ cm/s, \sigma_v = 0.25\ cm/s$

$\langle d_{ant} \rangle = 4.2\ mm, \sigma_d = 0.7\ mm$

$R_e = 5\ mm$

Statistics for several experiments: 12 ± 3 % difference
Statistics on 300 simulations 10.4 ± 0.09 %

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Ants in high panic:
A simulation inspired in Helbin *et al.*’s

<u>NEW Rules</u>:

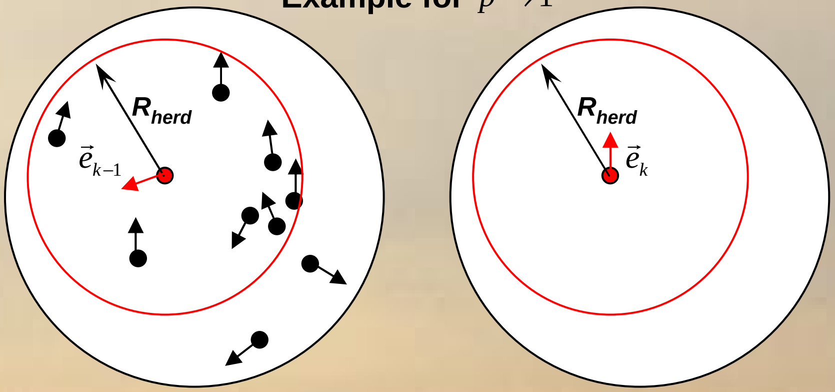
1) Ant-poison interaction: If direction points to poison area, it changes at random

2) Ant direction: given by [a]

$$\vec{e}_k = Norm\left[(1-p)\vec{e}_{k-1} + p\left\langle \vec{e}_{k-1}^{\,herdspeed} \right\rangle\right]$$

where p **is a panic parameter, and** $\vec{e}_{k-1}^{\,herdspeed}$ **has been calculated within R_{herd}**

Example for $p \to 1$



[a] Vicsek *et al*. PRL 75: 1226 (1995)

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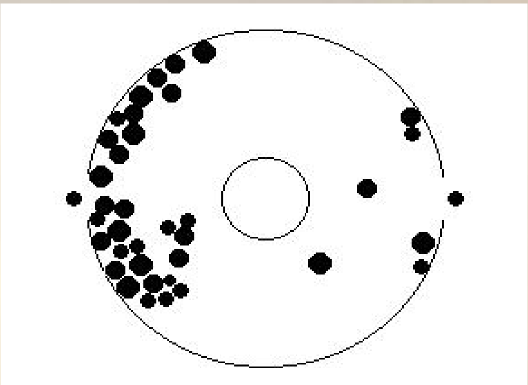
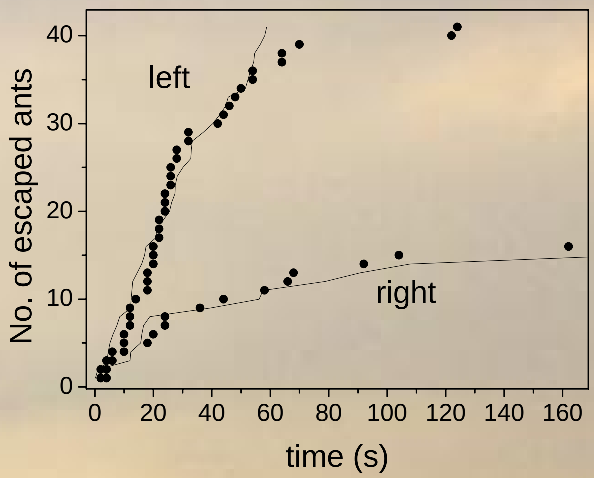
Simulations & experiments: ants in panic





Simulation parameters

$n = 60$

$R_{cell} = 4\ cm$

$d_{exit} = 1\ cm$

$v_0 = 1\ cm/s, \sigma_v = 0.5\ cm/s$

$\langle d_{ant} \rangle = 4.2\ mm, \sigma_d = 0.7\ mm$

$R_e = 5\ mm$

$R_{herd} = 3.75\ mm$

$p = 0.8$

Statistics for several experiments: 51 ± 7 % difference
Statistics on 300 simulations: 50 ± 4 %

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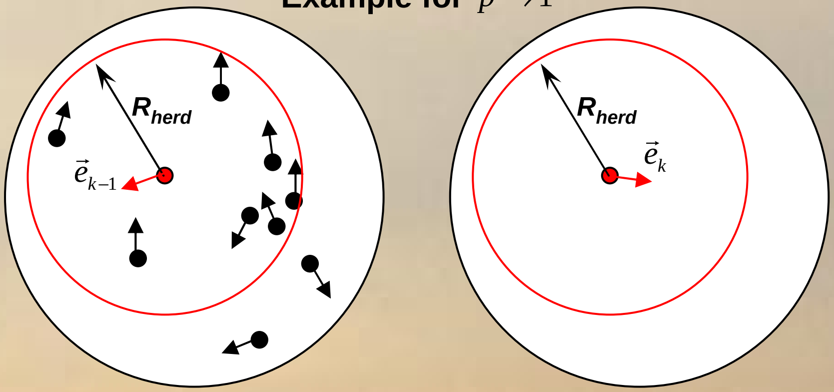
Ants in high panic:

A simulation less inspired in Helbin *et al.*’s

Modifying the herding rule:

Example for $p \to 1$



Ant direction: given by

$$\vec{e}_k = Norm\left[(1-p)\,\vec{e}_{k-1} + p\,\vec{e}_{k-1}^{\,herdCM}\right]$$

where p **is a panic parameter, and** $\vec{e}_{k-1}^{\,herdCM}$ **has been calculated within R_{herd}**

RESULTS

Statistics for several experiments: 51 ± 7 % difference

Statistics on 300 simulations, same parameters as Helbing’s inspired model: 49.5 ± 3 %

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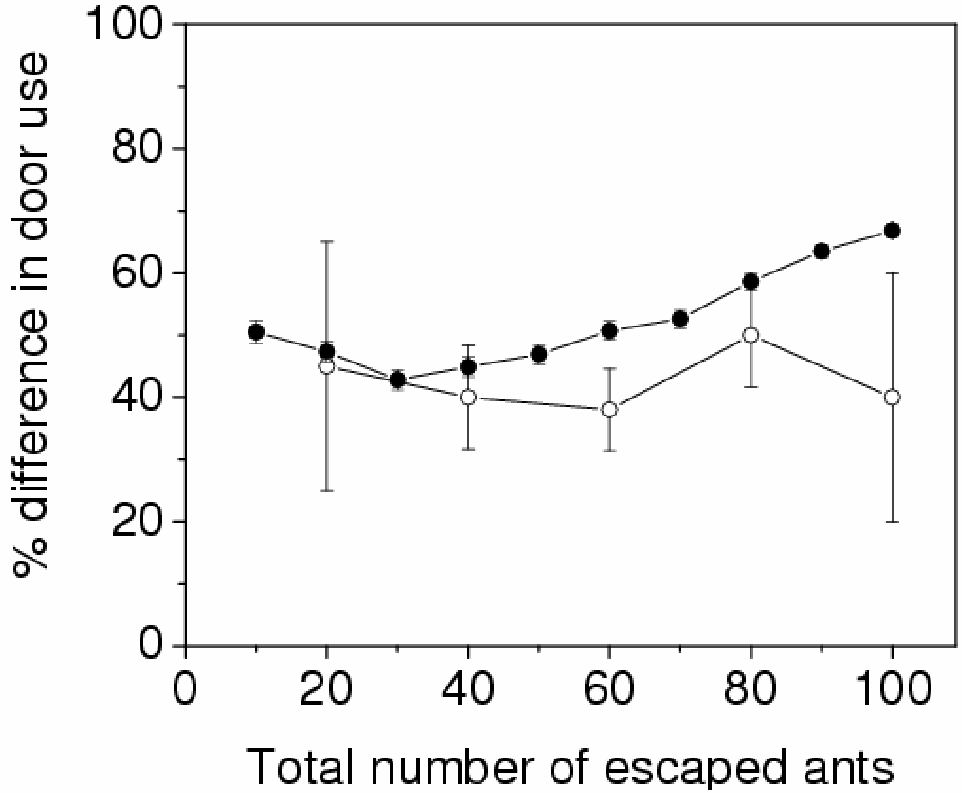
Authors in panic:
The effect of Biological Reviewers



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A few conclusions

We have demonstrated in a real experiment the possibility of the emergence of symmetry breaking when ants escape from a room under panic.

The phenomenon can be modelled in a simple fashion, if appropriate ”herd-following rules” are applied.

If Helbing *et al*.’s model really applies to humans, we are forced to conclude that, at least partially, people can behave like ants in a situation of escape induced by panic!

Symmetry breaking in escaping ants

and other experiments in self organization

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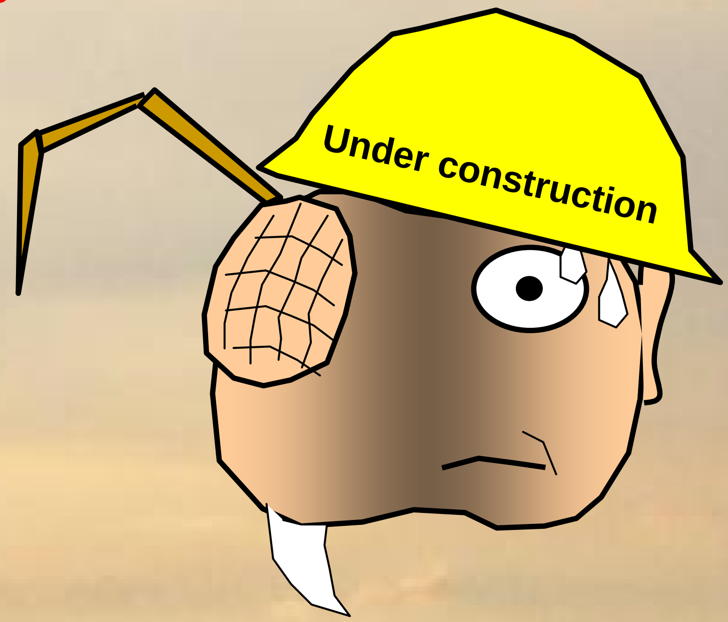

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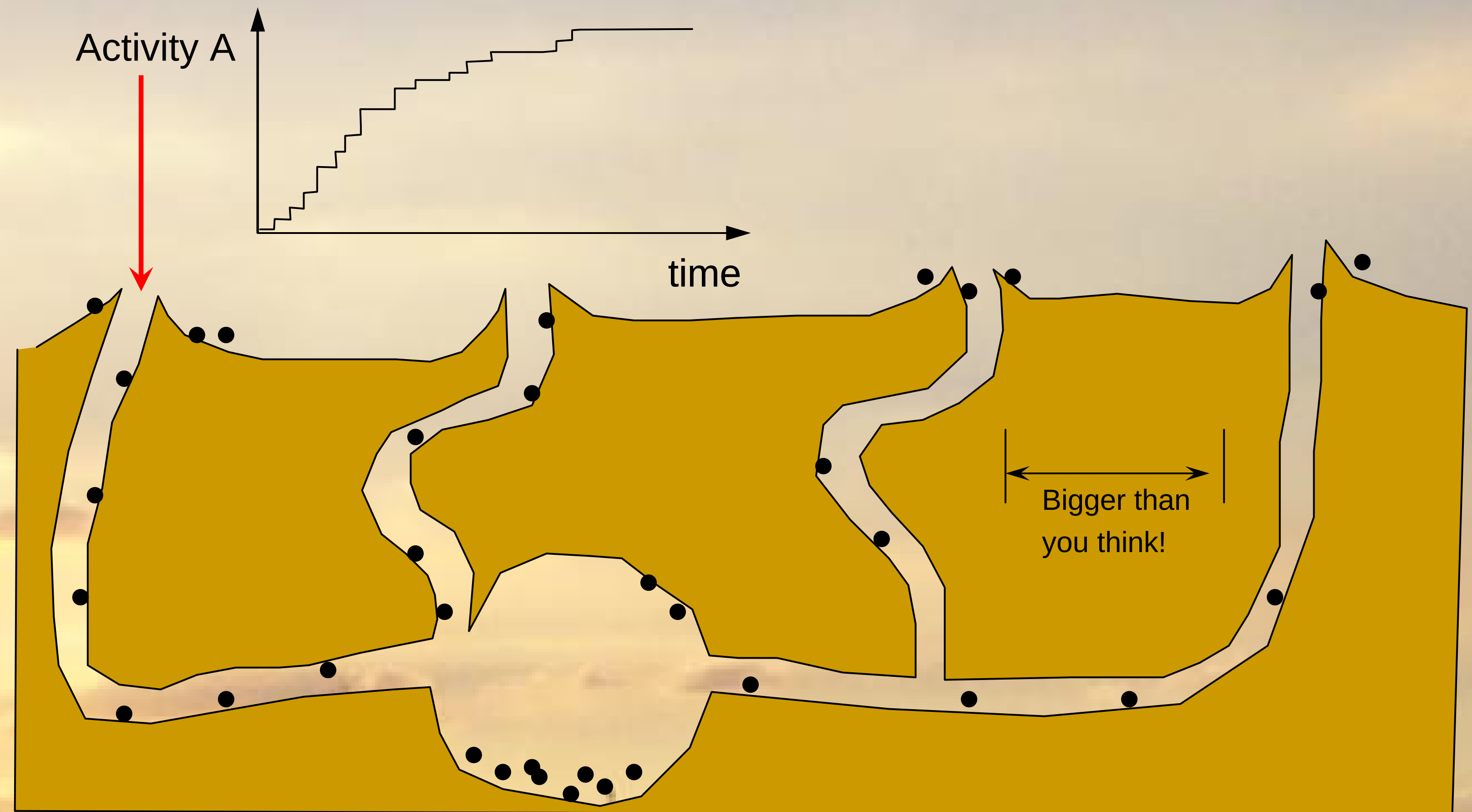
One experimental idea



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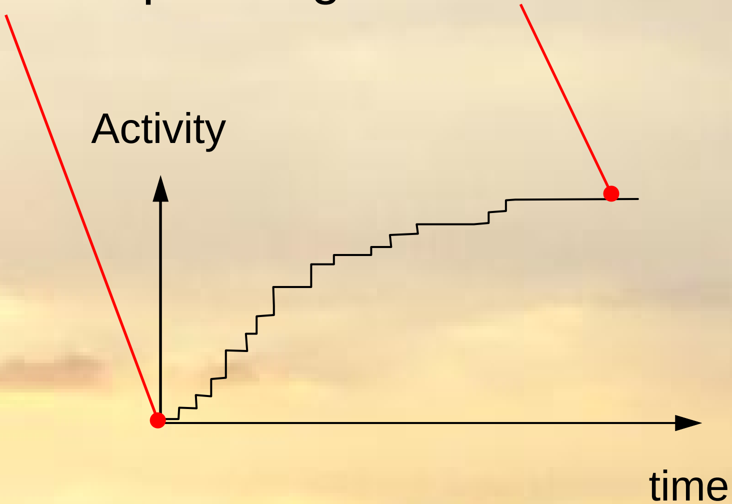
Available models
(to start from)

Around limits of the daily cycle: How the colony “wakes up”and “goes to bed”?



CA simulations

Solé *et al*. J. Theor. Biol. (1993) 161, 343-357

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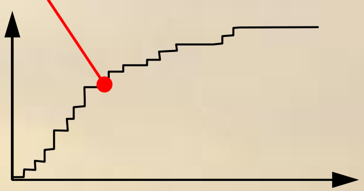
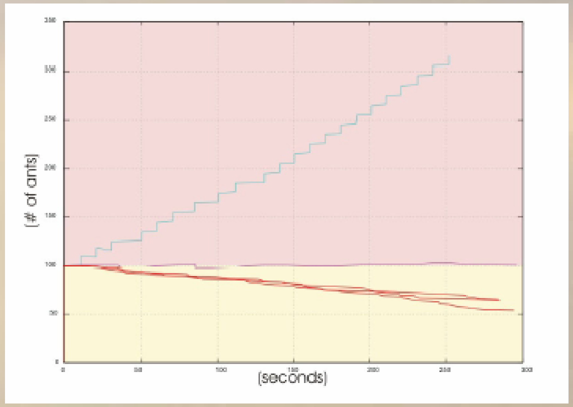
Available models
(to start from)

Dynamics during “work hours”

Pheromone trails:

http://www.melotti.com/EngHome/Computing/AntsSim/AntBoxSimulator.pdf



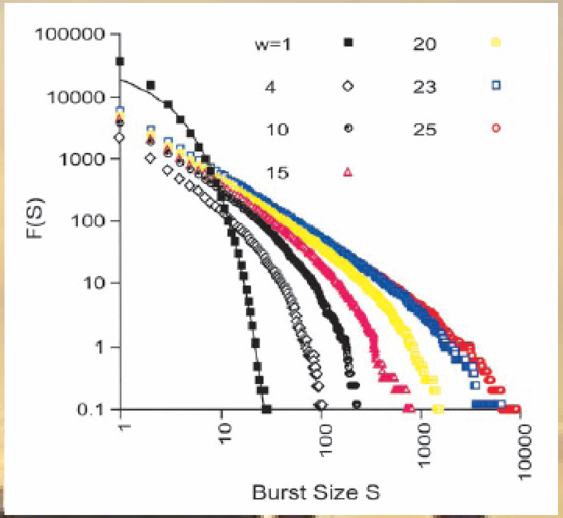


Panic simulations

Panic1 (MD-like): Helbing *et al*. Nature **407**:487 (2000)

Panic 2 (CA): Saloma *et al*. PNAS **100**: 11947 (2003)

Panic 3 (CA-like): Altshuler *et al*. Am. Nat. ?? (2005)



Contamination Dynamical Networks

Sospedra, Noda & Altshuler…somewhere...sometime

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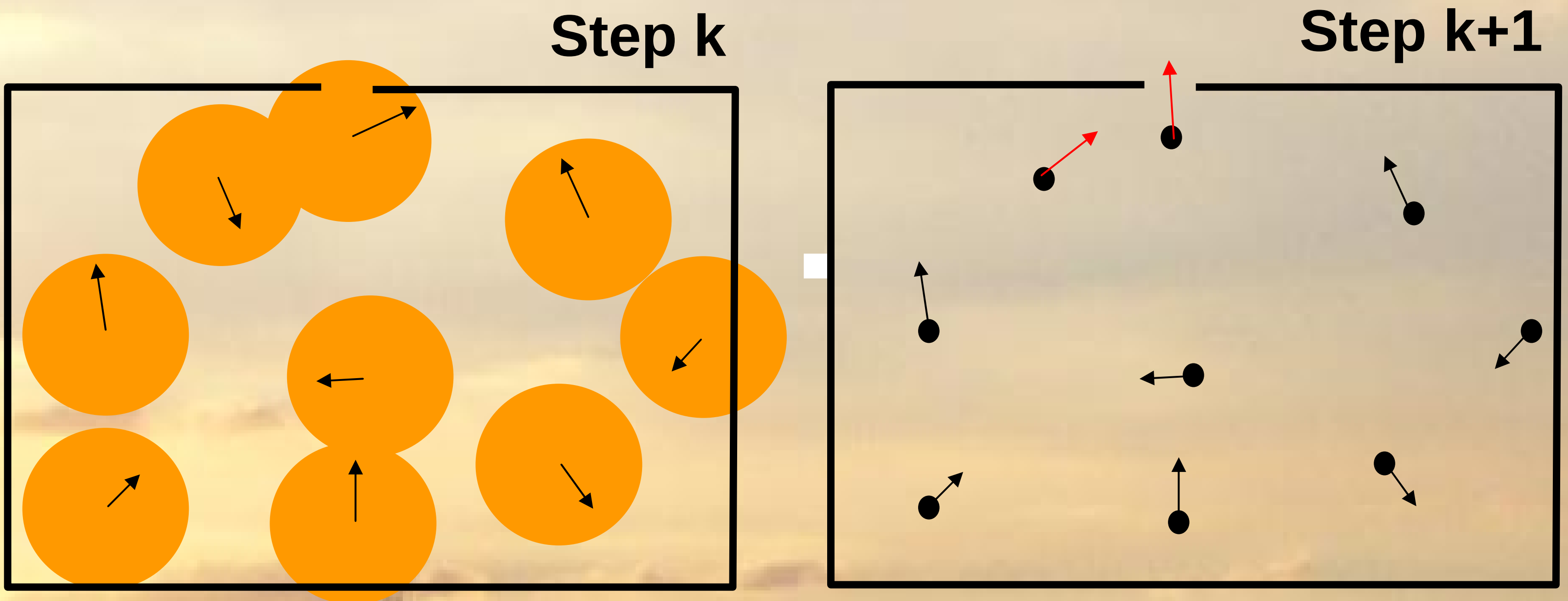
Contamination dynamical network

Door detection radius

Contamination radius



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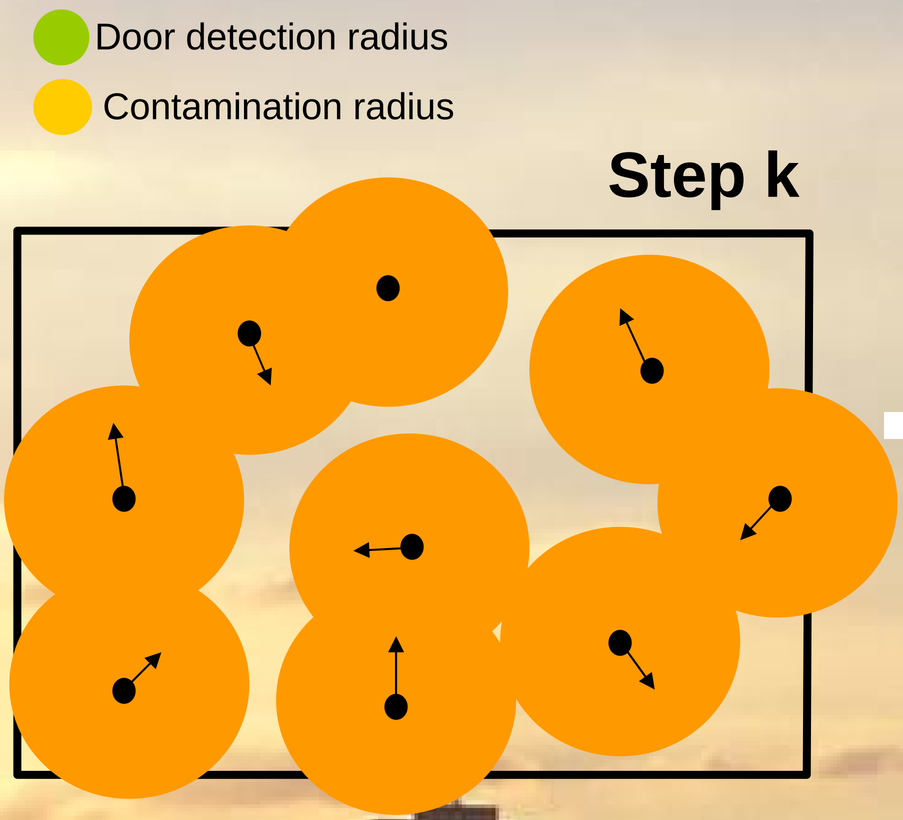
Contamination dynamical network



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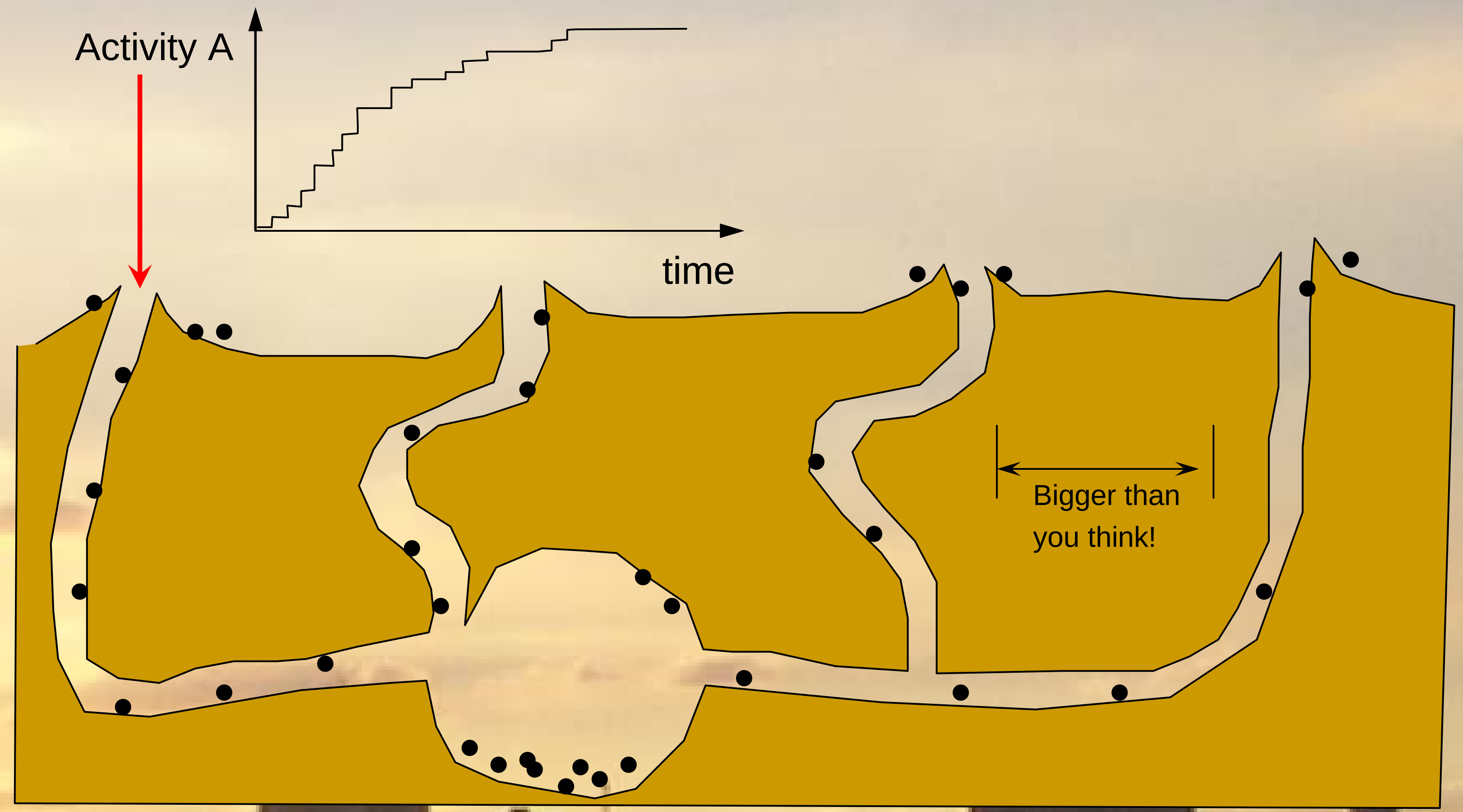
Further experimental ideas



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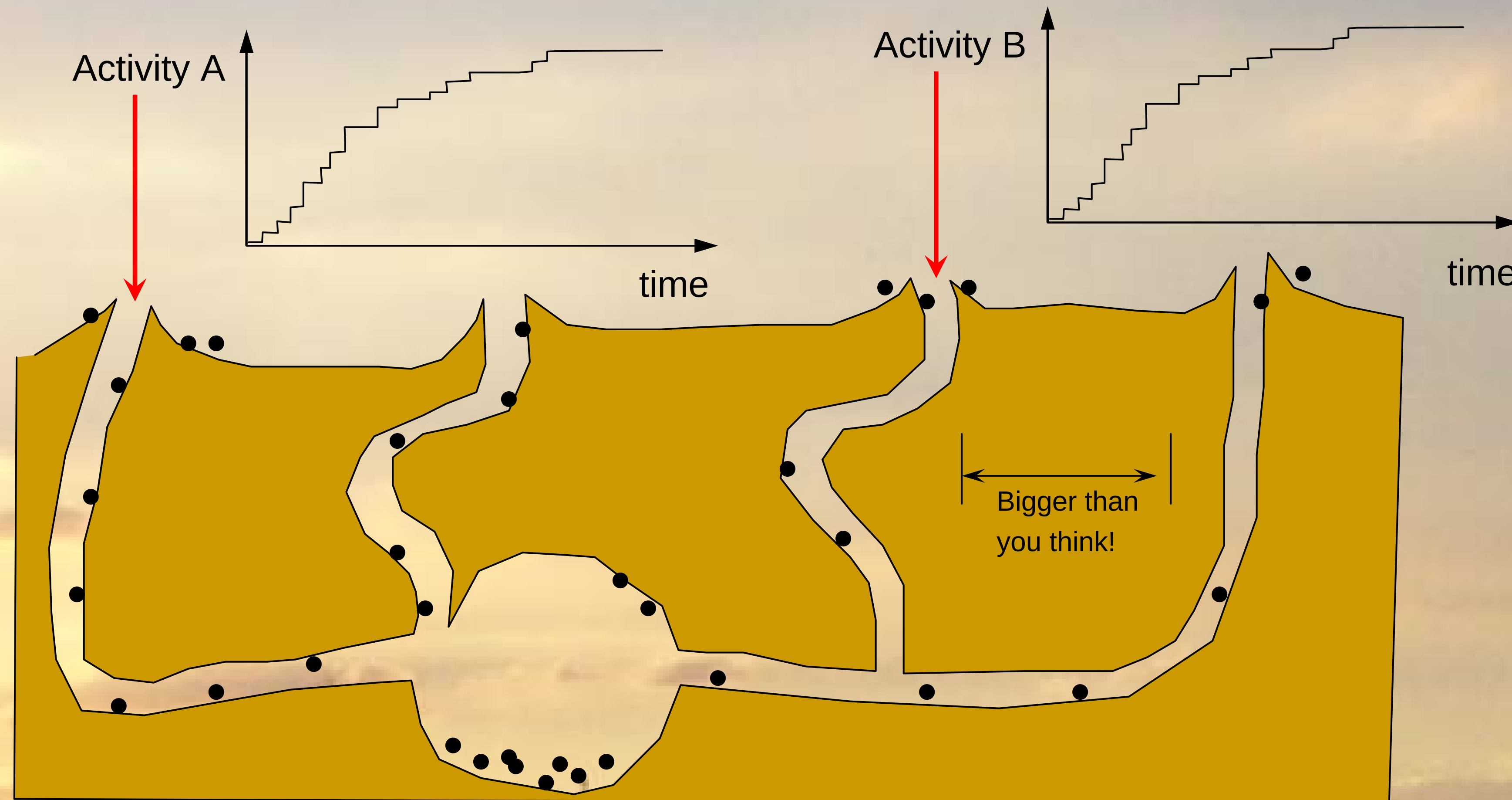
Further experimental ideas



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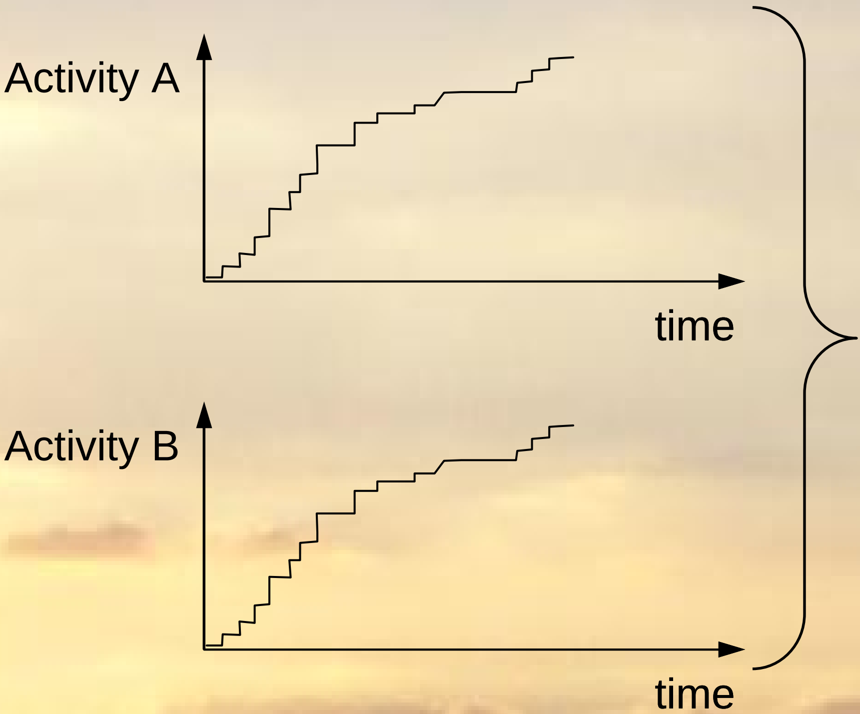
Further experimental ideas



Measuring correlations

$$C_{ab}(t') = k \frac{\langle A_a(t) A_b(t+t') \rangle - \langle A_a(t) \rangle \langle A_b(t) \rangle}{\sqrt{\sum \left[A_a(t) - \langle A_b(t) \rangle \right]^2 \sum \left[A_a(t) - \langle A_b(t) \rangle \right]^2}}$$

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But how such biologist’s dream would come true?