


### Self-organized pattern formation

Corpse aggregation in ants

Necrophoric behavior




Real duration : 36 hours

### Empirical investigation of corpse aggregation: Collective level

Initial conditions

100 corpses  
Ø: 25 cm

200 corpses  
Ø: 25 cm

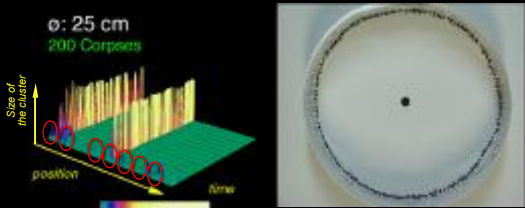


### Empirical investigation of corpse aggregation: Collective level

Corpse aggregation dynamics

- Corpse clustering is an auto-catalytic process

Ø: 25 cm  
200 Corpses



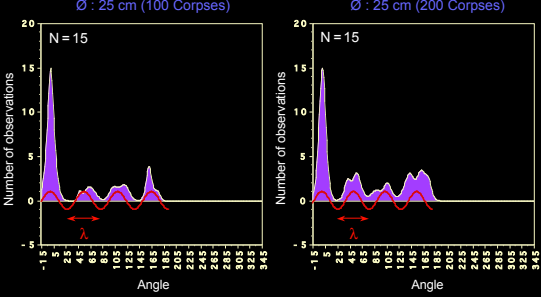
Real duration : 24 hours

### Empirical investigation of corpse aggregation: Collective level

Spatial distribution of clusters after 24 hours

Ø : 25 cm (100 Corpses)


Ø : 25 cm (200 Corpses)



### Empirical investigation of corpse aggregation: Individual level

Range of perception of an individual ant

- Probabilities to pick-up and drop a corpse on a cluster depend on the local density of corpses which is sensed by the ant
- Experimental measurements lead to a characteristic radius of perception  $\Delta \approx 5\text{mm}$

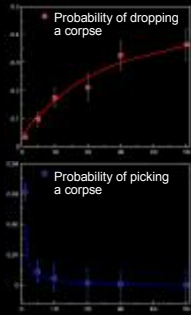


### Empirical investigation of corpse aggregation: Individual level

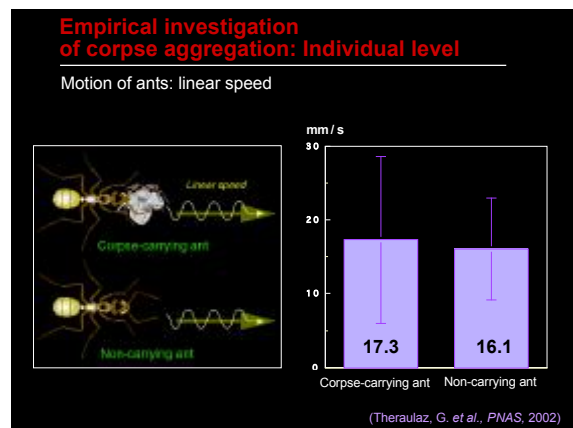
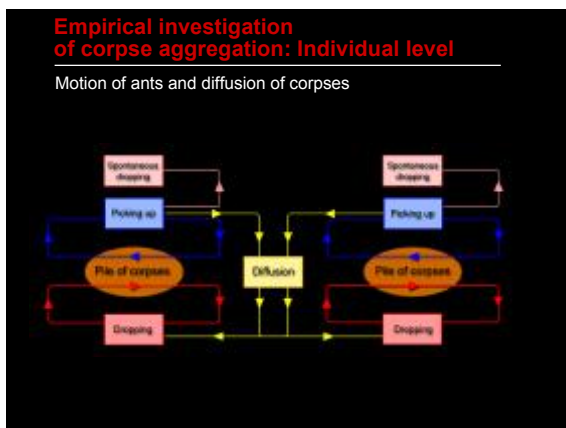
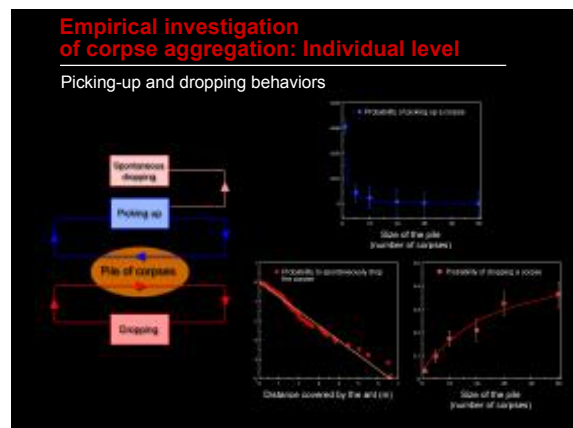
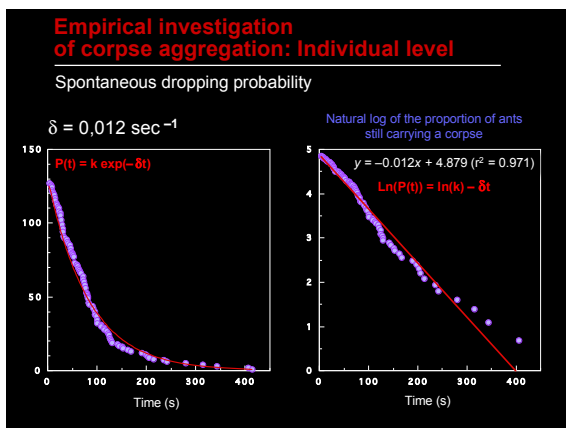
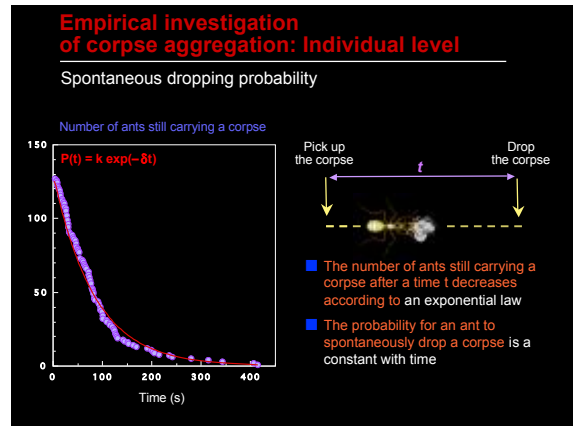
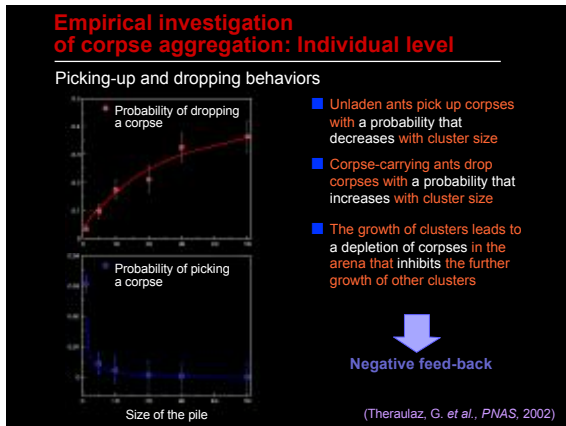
Picking-up and dropping behaviors

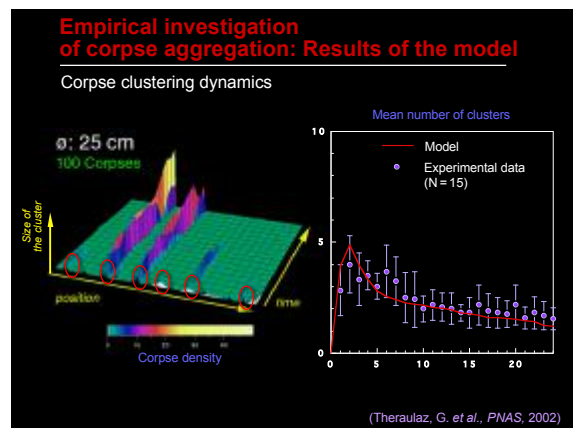
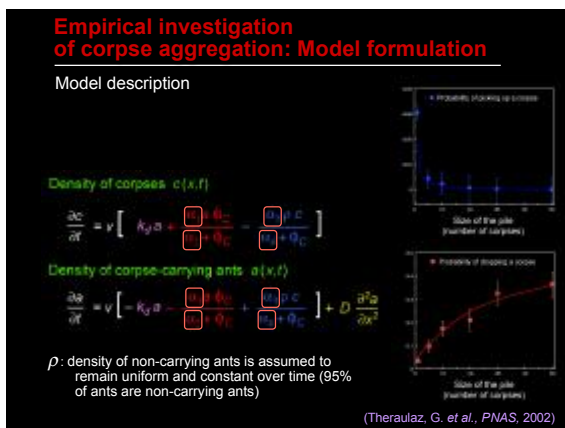
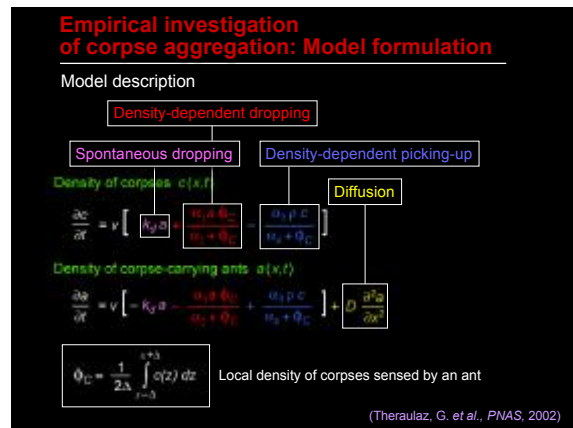
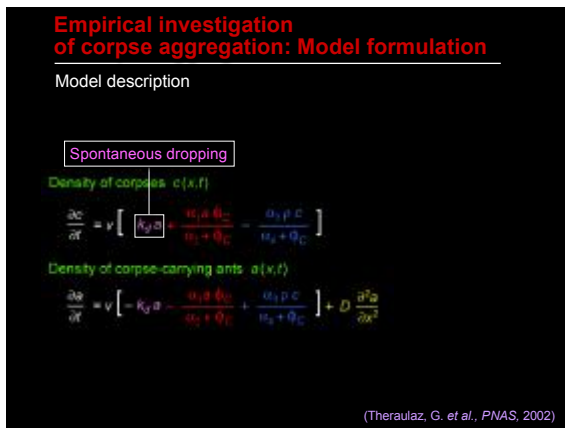
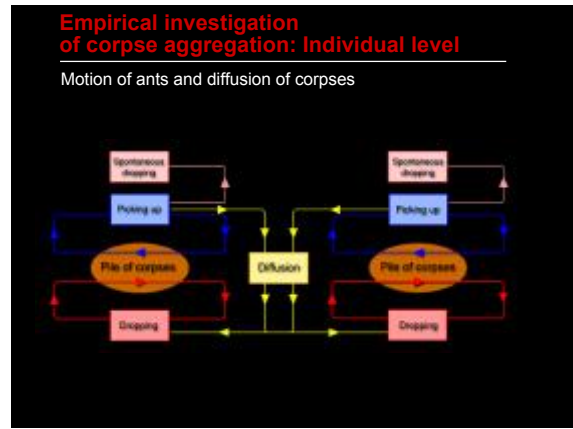
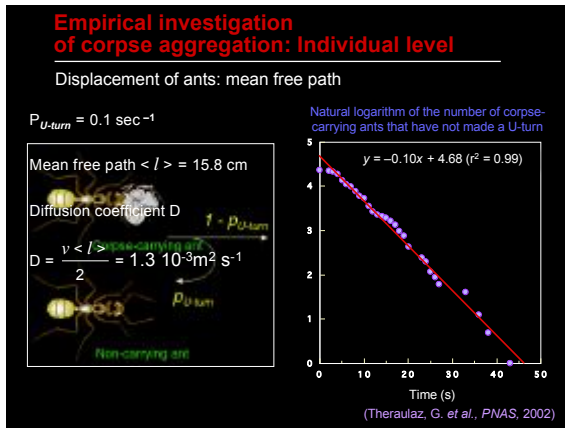
- Unladen ants pick up corpses with a probability that decreases with cluster size
- Corpse-carrying ants drop corpses with a probability that increases with cluster size

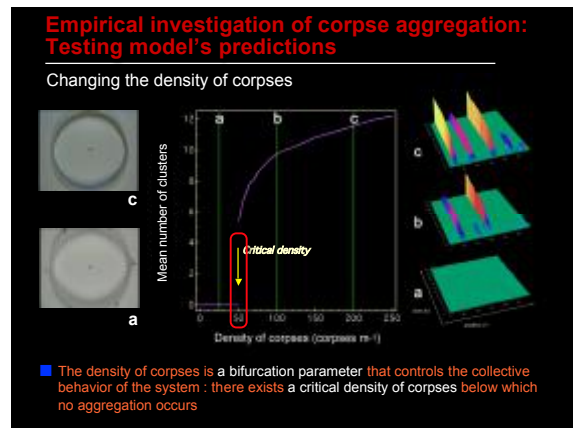
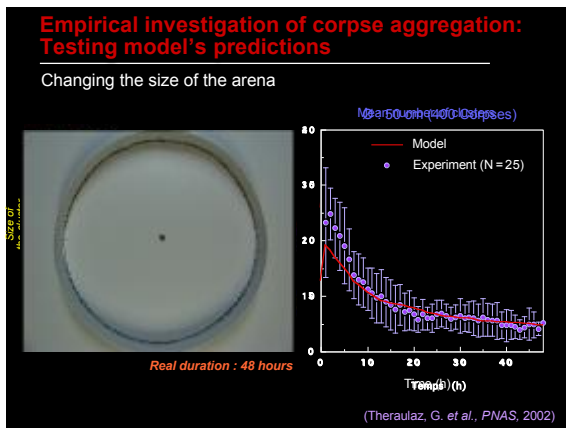
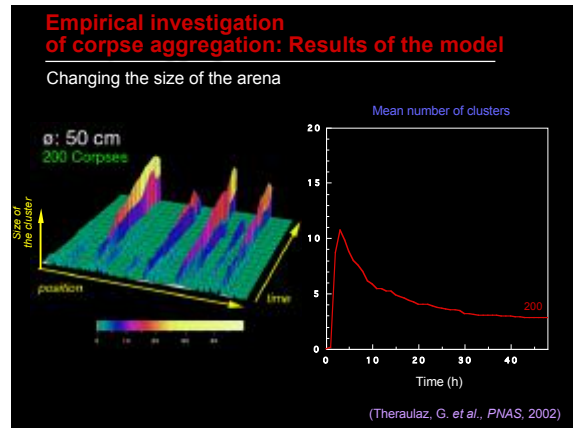
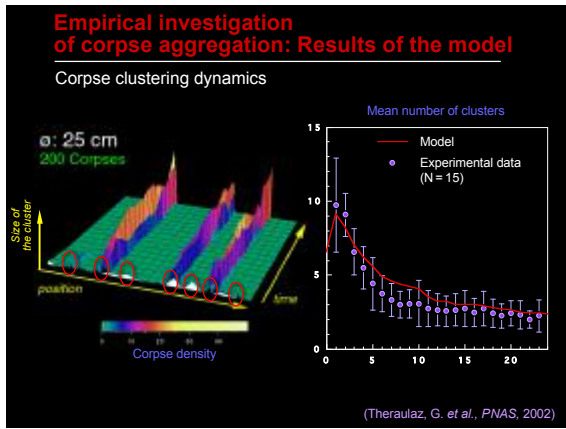
Positive feed-back



(Theraulaz, G. et al., PNAS, 2002)







### Self-organization

Definition

- Self-organization is a set of dynamical mechanisms whereby structures (nests, trail and galleries networks) emerge at the global level of a system from interactions among its lower-level components
- Collective structures are not explicitly coded at the individual level
- The rules specifying the interactions among insects are executed on the basis of local information, without any knowledge of the global pattern

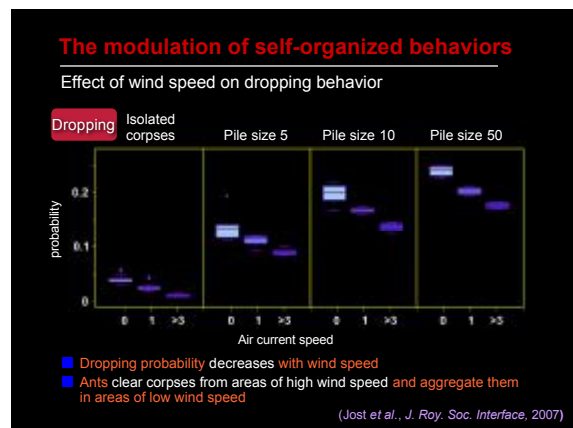
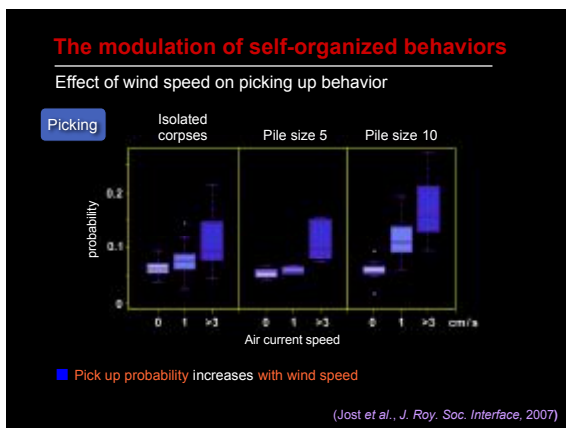
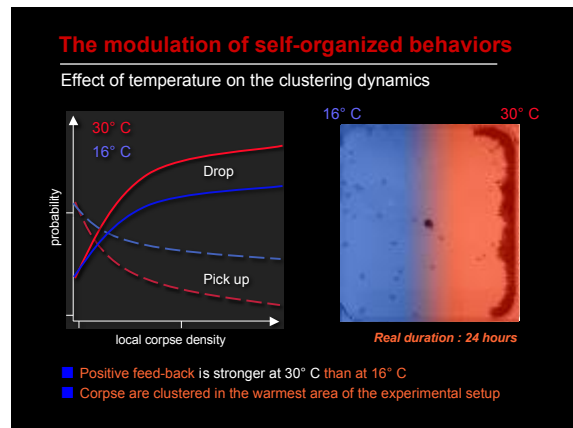
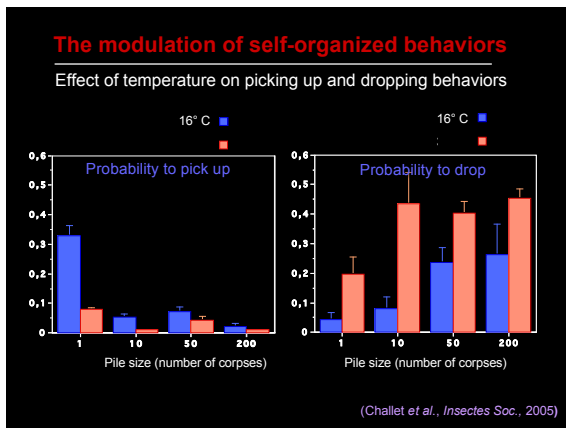
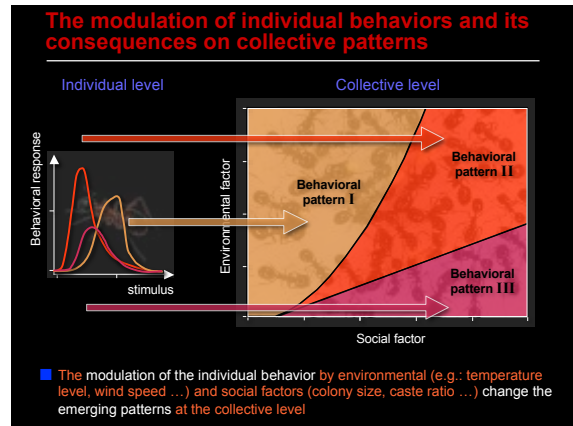
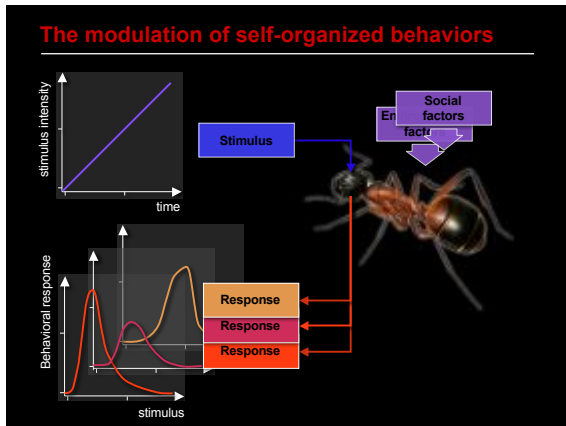
(Camazine et coll., Self-organization in biological systems, Princeton University Press, 2001)

### Self-organization

Basic ingredients

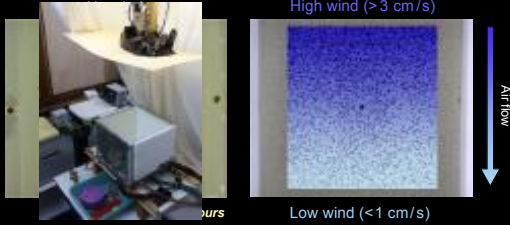
- Large number of interactions among individuals
- Positive feedback: they are simple behavioral 'rules of thumb' that promote the creation of structures
- Negative feedback: counterbalances positive feedback and helps to stabilize the collective pattern
- Amplification of fluctuations: fluctuations act as seeds from which structures nucleate and grow

(Bonabeau, E. et al., TREE, 1997)



### The modulation of self-organized behaviors

Effect of wind on clustering dynamics and the shape of clusters

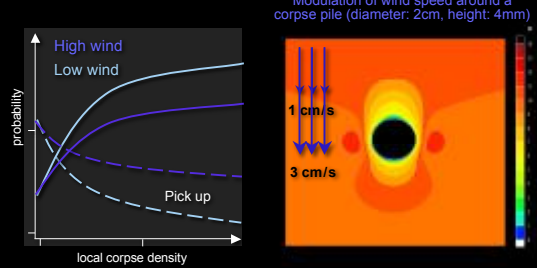


- Positive feed-back is stronger in low wind zones
- Clusters form in the low wind zone and are elongated in the direction of the air flow

(Jost et al., J. Roy. Soc. Interface, 2007)

### The modulation of self-organized behaviors

Effect of corpse piles on air flow and clustering behavior



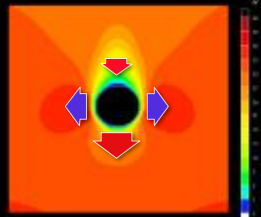
(Jost et al., J. Roy. Soc. Interface, 2007)

### The modulation of self-organized behaviors

Effect of corpse piles on air flow and clustering behavior

Modulation of wind speed around a corpse pile (diameter: 2cm, height: 4mm)

- Ants aggregate corpses in piles that locally modify air flow
- Individual probabilities to pick-up and drop corpses around the piles are modulated by the air flow speed
- The consequence of these interactions is the appearance of a new spatial structure



(Jost et al., J. Roy. Soc. Interface, 2007)

### Summary

- Coordination of building activities does not require complex behavioral or cognitive procedures
- Nest construction often involves the combination of different mechanisms (stigmergy, self-organization, templates)
- The signals involved in the coordination are simply activating or inhibiting
- Stigmergic behaviors in combination with environmental templates increases the flexibility and the variety of architectures

