

Grounded yet Transportable Understandings of Scientific Systems

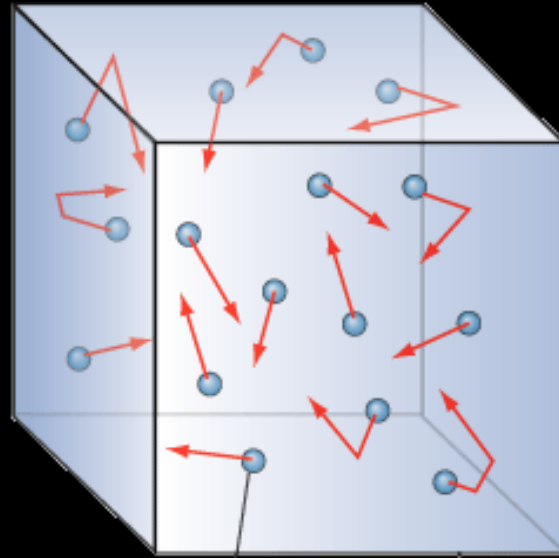
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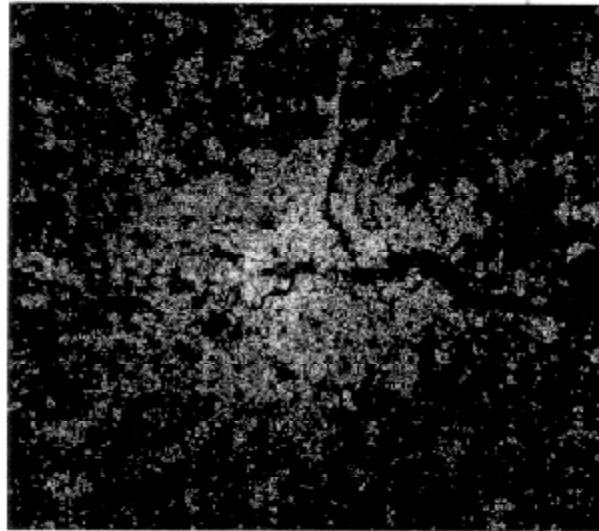
What good can games do?

- We want students to develop grounded understandings of particular scenarios
 - Games often foster embodied, perception-action learning
 - We want students to generalize and transfer what they have learned to new situations
 - Systems that look different may instantiate the same deep principle
 - Unifications in science are important (Darwin, Einstein, Shepard)
- If performance is tied to perceiving and interacting with particular scenarios, then how can we hope to have transfer from one scenario to another scenario that looks quite different?

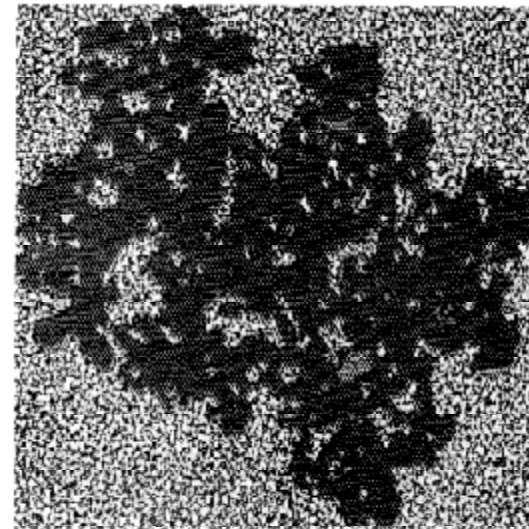
Different systems, same Boltzmann-Gibbs distribution



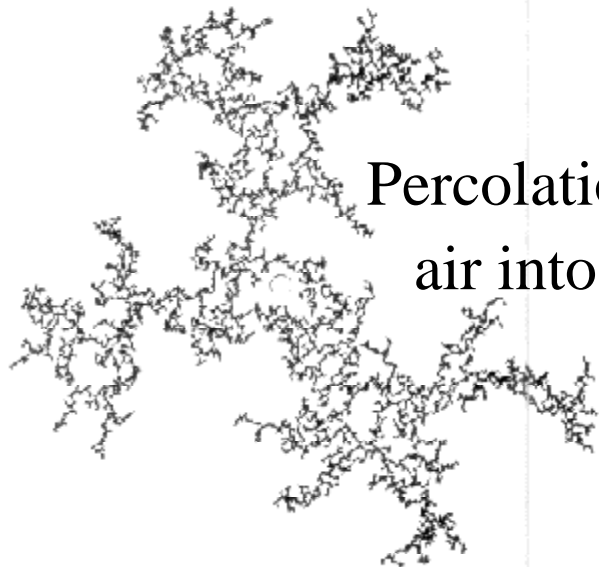
Different systems, same diffusion-limited aggregation



a London



b Polymer spheres
in solution

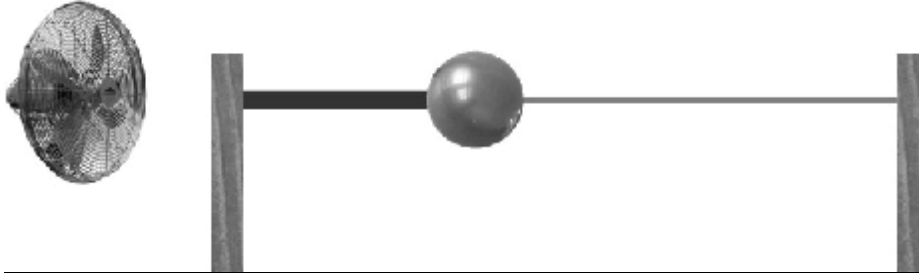


c Percolation of
air into oil

Fig. 9.19 The shape of the city of London, as represented by this map of employment density, is an irregular cluster of small units (a). Rather similar shapes can be seen in the aggregation of polymer spheres in solution (b), and the slow percolation of air into very viscous oil (c). (Images: (a) Michael Batty, University College, London; (b) Arne Skjeltorp, Institute for Energy Technology, Koller; (c) Roland Lenormand, Institut Français du Pétrole, Rueil-Malmaison.)

A case study of grounded transfer (Day & Goldstone, 2009)

- Applying forces that reinforce or oppose a system's natural resonance
- Initial scenario
 - Oscillating ball with fan
 - Goals to stabilize or extremitize balls
 - Real-time interaction based on perception and action
- Transfer scenario
 - Controlling a city's population with media
 - Goals to stabilize or extremitize population
 - Turn-based text interface



Year 0:
Population: 400000
Appeal: 0
Change in appeal: 0

Year 1:
Population: 442500
Appeal: 42500
Change in appeal: 42500

Year 2:
Population: 511563
Appeal: 69063
Change in appeal: 26563

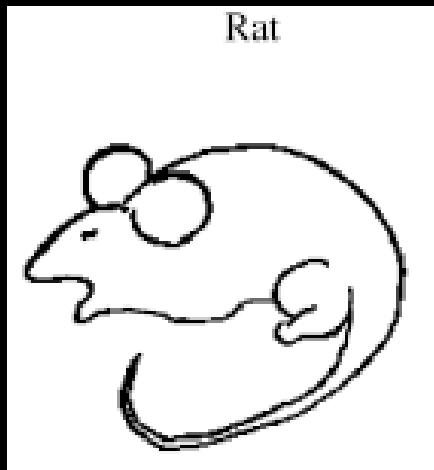
Media

No Media

- Results

- Better performance with “population” when it is preceded by the congruent, rather than incongruent, version of “ball”
- Transfer was found even if students didn’t explicitly see the relation between the simulations, and couldn’t draw correspondences
- Transfer is still concretely grounded – switching side of fan matters
- Relying only on explicit measures of knowledge may underestimate the transferrable benefits of interactive simulations

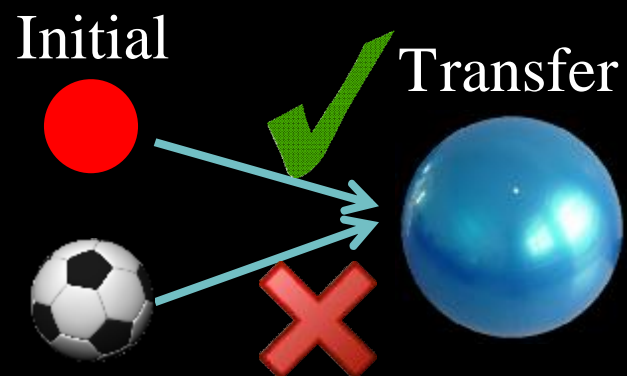
Spontaneous adaptation of perception based on previous experience



Leeper (1935)

Transfer by “Rigging Up Perception-Action Systems”

- Formalism-based transfer is powerful, but formalisms are also often cognitively inert (Ross, 1987, 1989) and their final form belies their visuo-spatial inspiration (Hadamard, 1949; Lakoff & Nuñez, 2000)
- Perceptual Learning - Perceptual interpretation is led by tracks laid by previous simulation (Goldstone, 1994, 1998, 2003; Green & Bavelier, 2003; Livingston, Andrews, & Harnad, 1998; Özgen, 2004)
- Perception-action training can lead to generalized learning (within limits), particularly if strategic idealization is employed (Goldstone & Sakamoto, 2003; Goldstone & Son, 2005; Schwartz & Black, 1996)



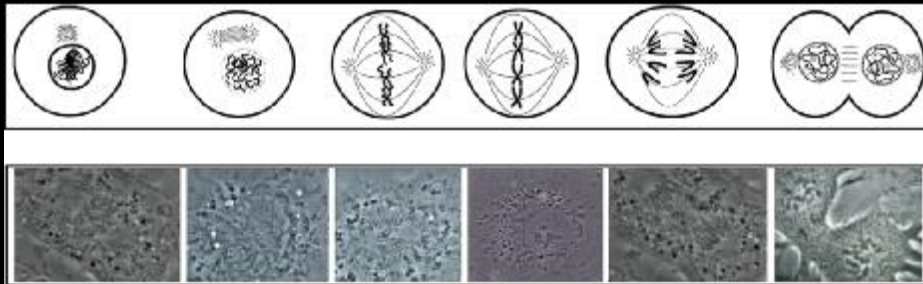
Concrete Idealized



Son, Smith, & Goldstone (2008)

Concrete Idealized

Kaminsky, Sloutsky, & Heckler (2008)



Scheiter et al., (2009)



Uttal, Liu, & DeLoache (2006)

Grounding, Generalization, and Games

- Abstraction as the deployment of trained and strategic perceptual-motor processes
- Future questions for understanding the pedagogical good that games can do
 - How long-lasting and far-reaching is perception-action priming?
 - What are the implicit, grounded models that people build and apply? How are space, dynamics, and forces represented?
 - What kinds of grounding help/hurt?
 - Can even formal understandings be grounded in perception and action?
 - How are grounded and formal understandings interrelated? (Schwartz, Martin, & Pfaffman, 2005)

