Complex Dynamics of Student Groups during Introductory Physics Tutorials

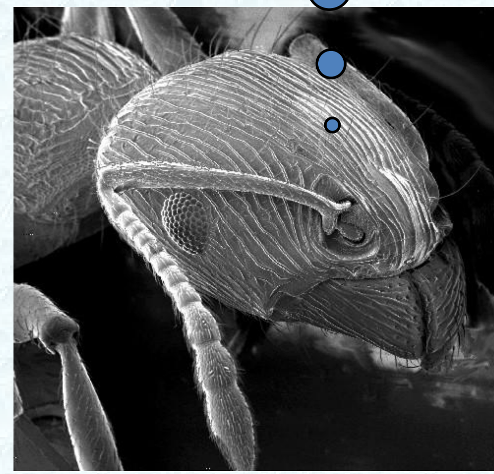
An exploration into how & why we might model tutorial groups this way

Complex Systems: An

mmm…pheromones

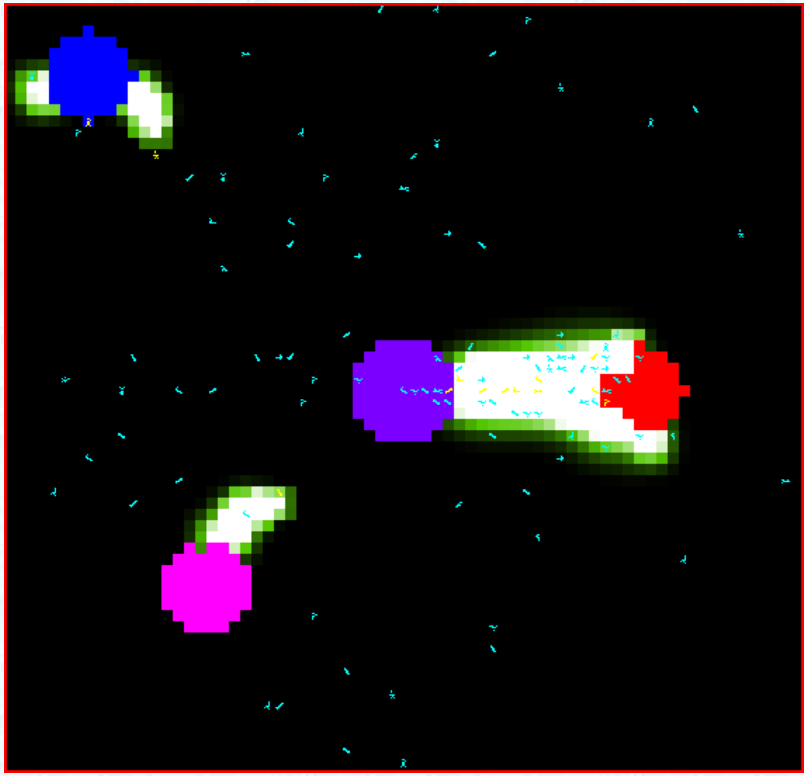
Ants are kinda dumb

- Ants have no sense of what is happening on a colony level
- Ants have no leaders among them
- Ants' behavior follows simple (and local) rules, based on pheromones
    - If an ant encounters a trail with x amount of pheromone, it has y probability of following the trail



Complex Systems: An Example

- Ant COLONIES are wicked smart
  - Colonies solve complicated problems
  - Colonies make important and difficult decisions
    - How to allocate colony's resources to defense, repair, foraging
    - How to find the quickest path to the best food
    - Which exit through which to escape



http://zool33.uni-graz.at/schmickl/models/ants_foraging_decision.html

Ant Colonies are Complex Systems

- Emergence
  - Patterns, properties, behaviors that cannot be reduced to those of the individual parts
- Self-organization
  - Leader-free creation of order
  - robustness & adaptability
  - Power law behavior
- Feedback
  - Nonlinear interactions that amplify or control

Are Tutorial Groups Complex Systems?

Which is *not* to say that the tutorial students are dumb as ants…

- There is a small literature on small groups as complex, self-organized systems
  - During 'turbulent' conditions, groups that self-organize are more effective (smith & comer 1994)
  - Student groups have been shown to exhibit power laws (warren, 2005)
- Motivation: by modeling the groups, we can more deeply understand their dynamics

Emergence

Patterns, properties, behaviors that cannot be reduced to those of the individual parts

- Behavior modes emerge out of the individual students' framing of behavior modes
  - Each student frames tutorials differently
  - Overall, through feedback (e.g. frame negotiation), the group settles on one of the same four modes at any time
  - All of the groups seem to exhibit the same four behavior modes (independent of membership)

Self-Organization

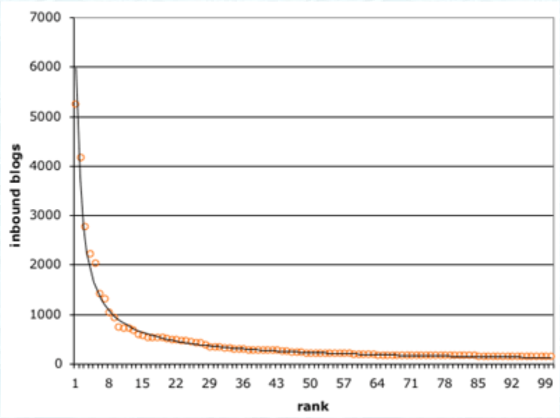
Robustness and adaptability in creating and maintaining order

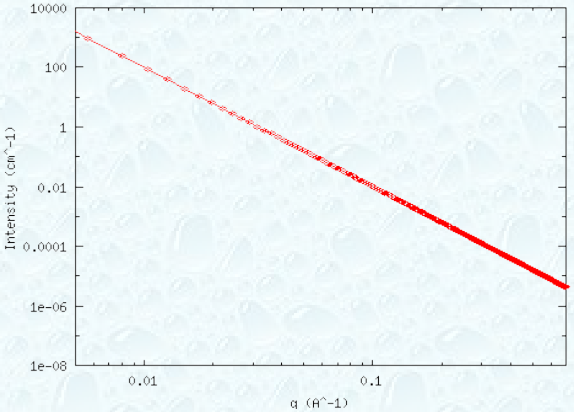
- The behavior modes are stable
  - lasting from seconds to minutes
- The behavior modes are robust
  - W.r.t changes in the environment
- The tutorials are "far-from equilibrium"
  - Fundamental assumptions (e.g. dependency) challenged
- The tutorials are leaderless

The Power Law

<u>Self-organized criticality</u>—When self-organized systems are on the brink of order and chaos (i.e. the turbulent regime)

Critical systems typically exhibit fractal outputs that can be characterized by a <u>power law</u>





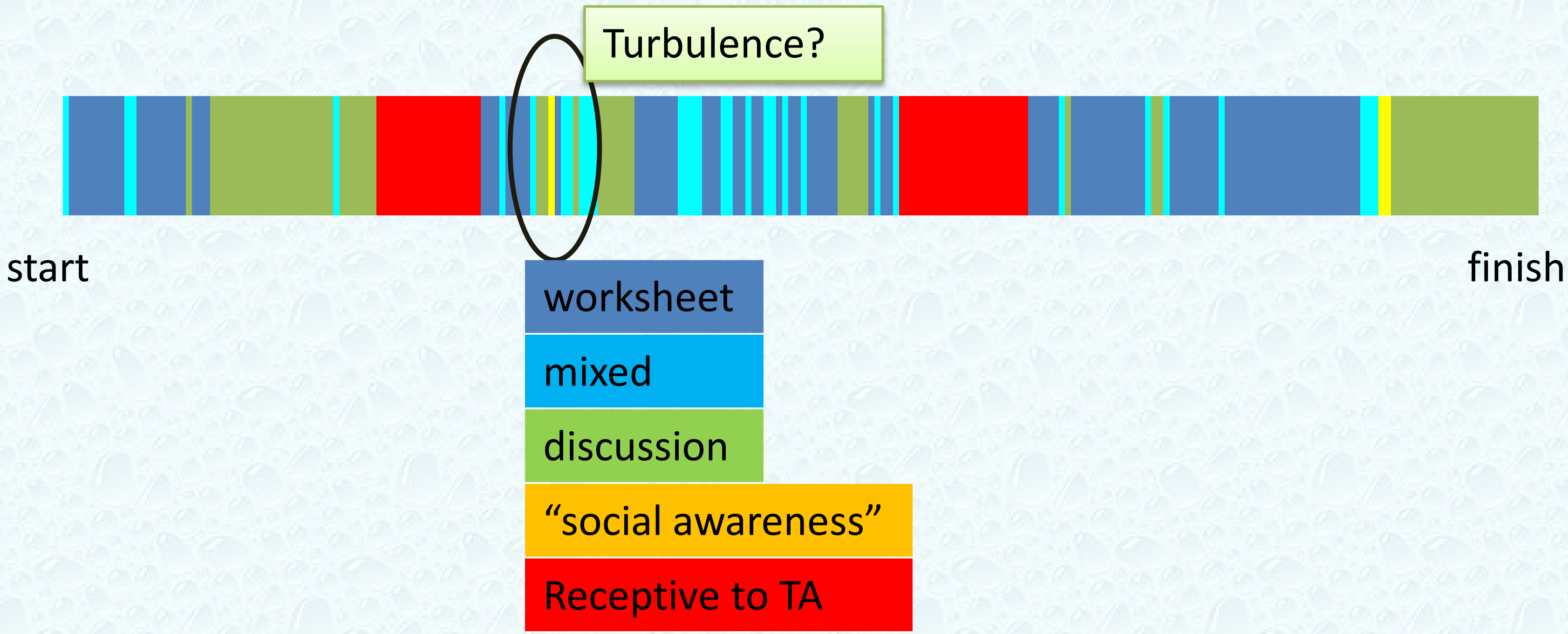
$$F \propto x^{-\alpha}$$

where $\alpha \approx 1$

Power Law for Tutorials?

It seemed that students during a ‘turbulent’ time make many teeny mode transitions…

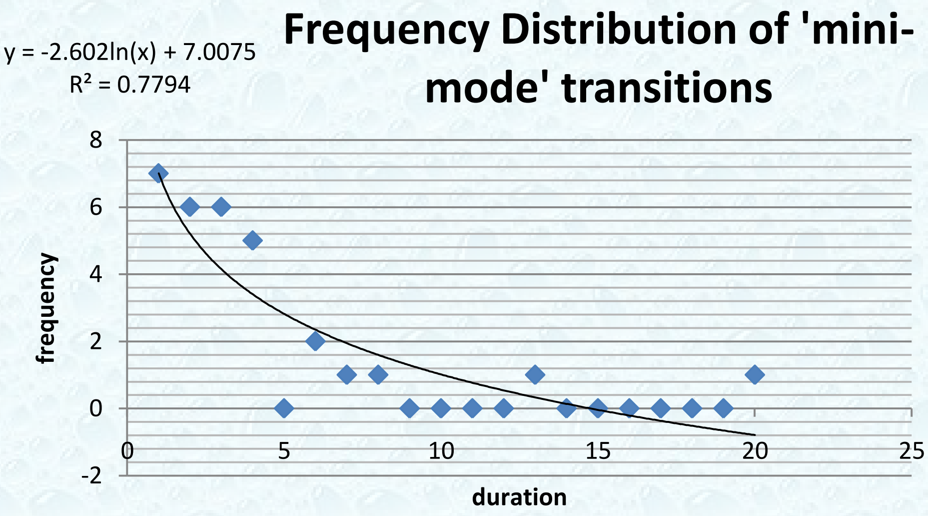
perhaps there are MANY small ones, and a few large ones?



Power Law for Tutorials?

Watching a single student for ‘mode-like’ behavior transitions on the order of a *second*.

Graph the frequency of ‘mini-modes’ of given lengths (1 second, 2 seconds…)



Complex Systems Literature

- Per Bak
- Stuart Kauffman
- Etc…