

Transitions in Human Expertise Development

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Complex Systems

- Study of emergent behaviours
- Fundamental theoretical tools:
 - networks
 - adaptive/intelligent processes
 - system level measures (e.g. entropy)
- Applications
 - understanding and prediction
 - software tool development
 - Games

Grand Challenges

To build human-friendly artificial creative thinking systems which scale to arbitrary size

To understand how social and organisational systems foster, or frustrate, human creativity and how organisations can become themselves adaptive and creative.

Themes

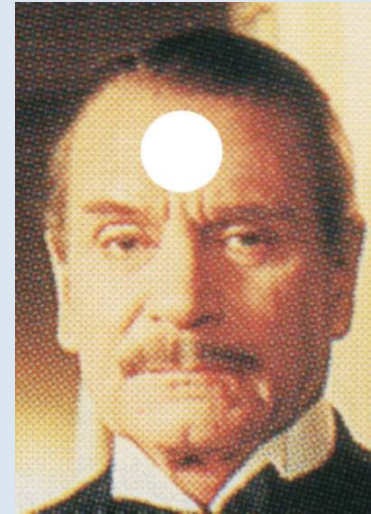
- Complexity theory & Emergence
 - Evolution; networks; learning; dynamics
- Complexity applications
 - Agent-based modelling
 - Pattern recognition
 - Computer usability
- Paradigm of social theory
 - Organisational; educational; health

Evolution and Learning

- Adaptability properties of entities (*agents*) in complex systems
- Evolutionary forces and strategies
- Phase transitions in systems and populations
- Complexity of agent intelligence and relationship to evolutionary dynamics

Tipping Points

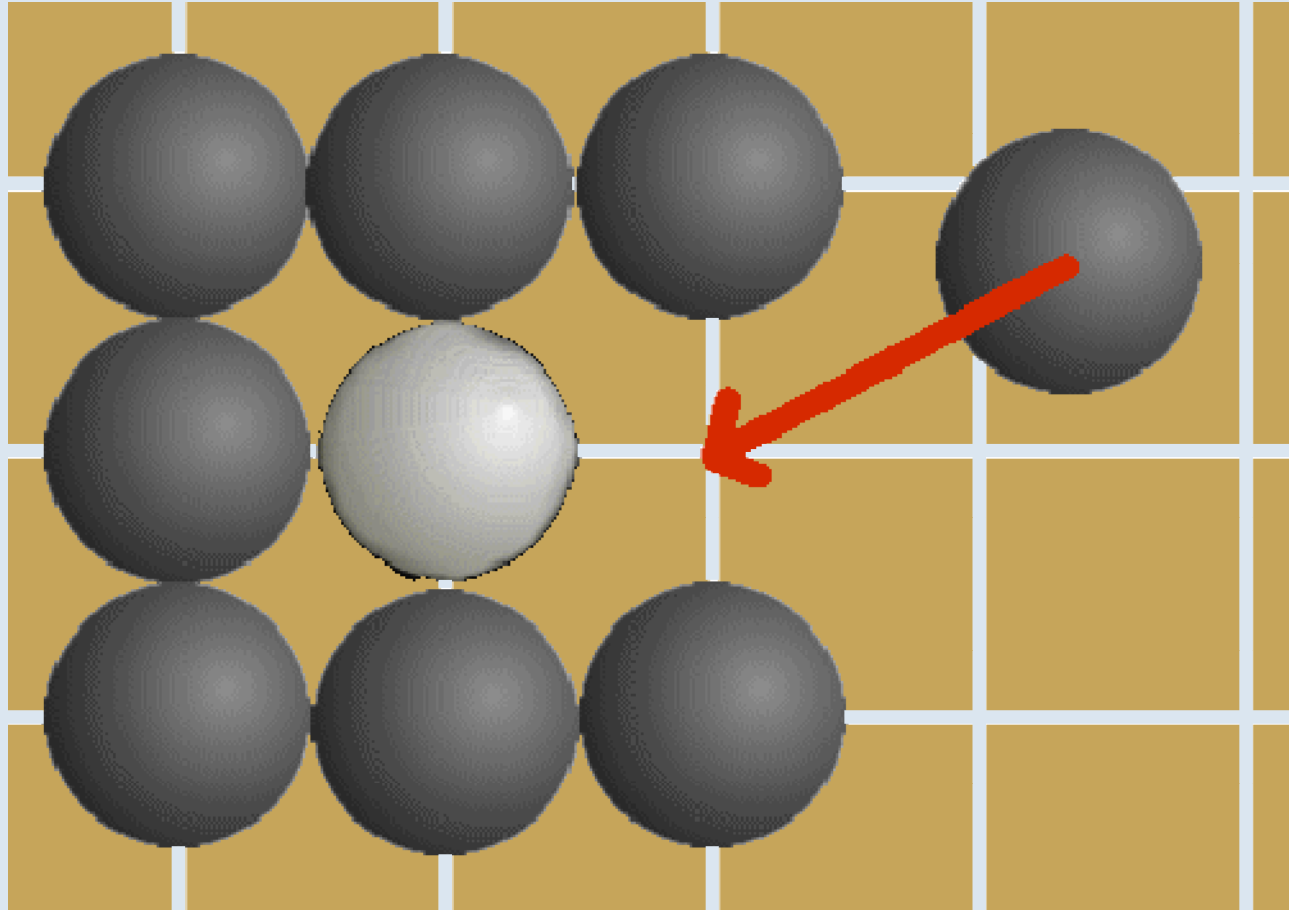
- Phase transitions and catastrophes
- Second order transitions
 - very long correlation lengths
 - critical slowing down
 - increased variance
- Mutual information peak
 - almost universal indicator



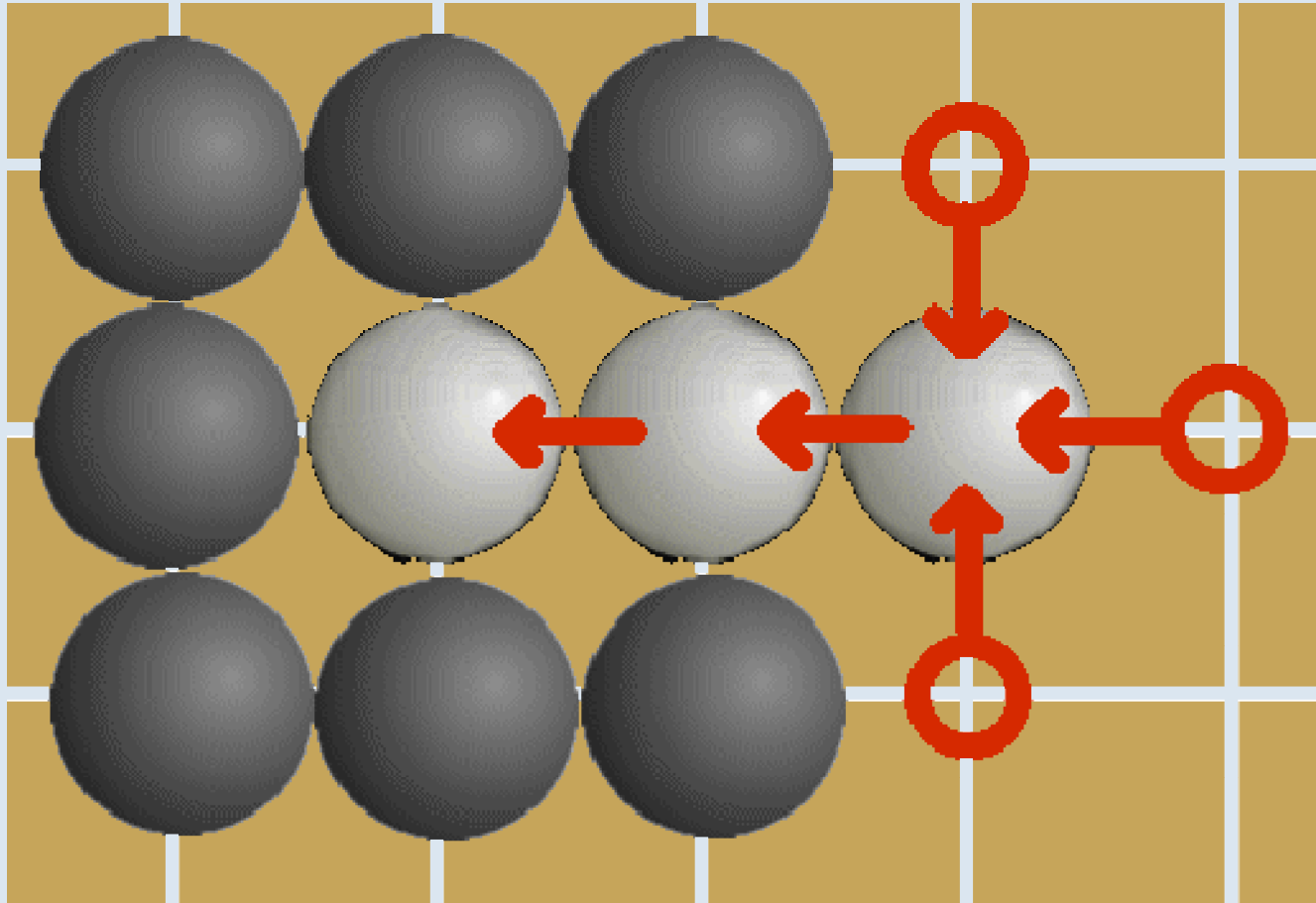
Go

- Most difficult known game for computers
- Interesting problems in local-global order
- Huge search space – intractable
- Human expertise different to computer
 - Strong use of pattern memory (we think)
 - Marvin Minsky conundrum
 - *People get better the more they know, machines get slower.*

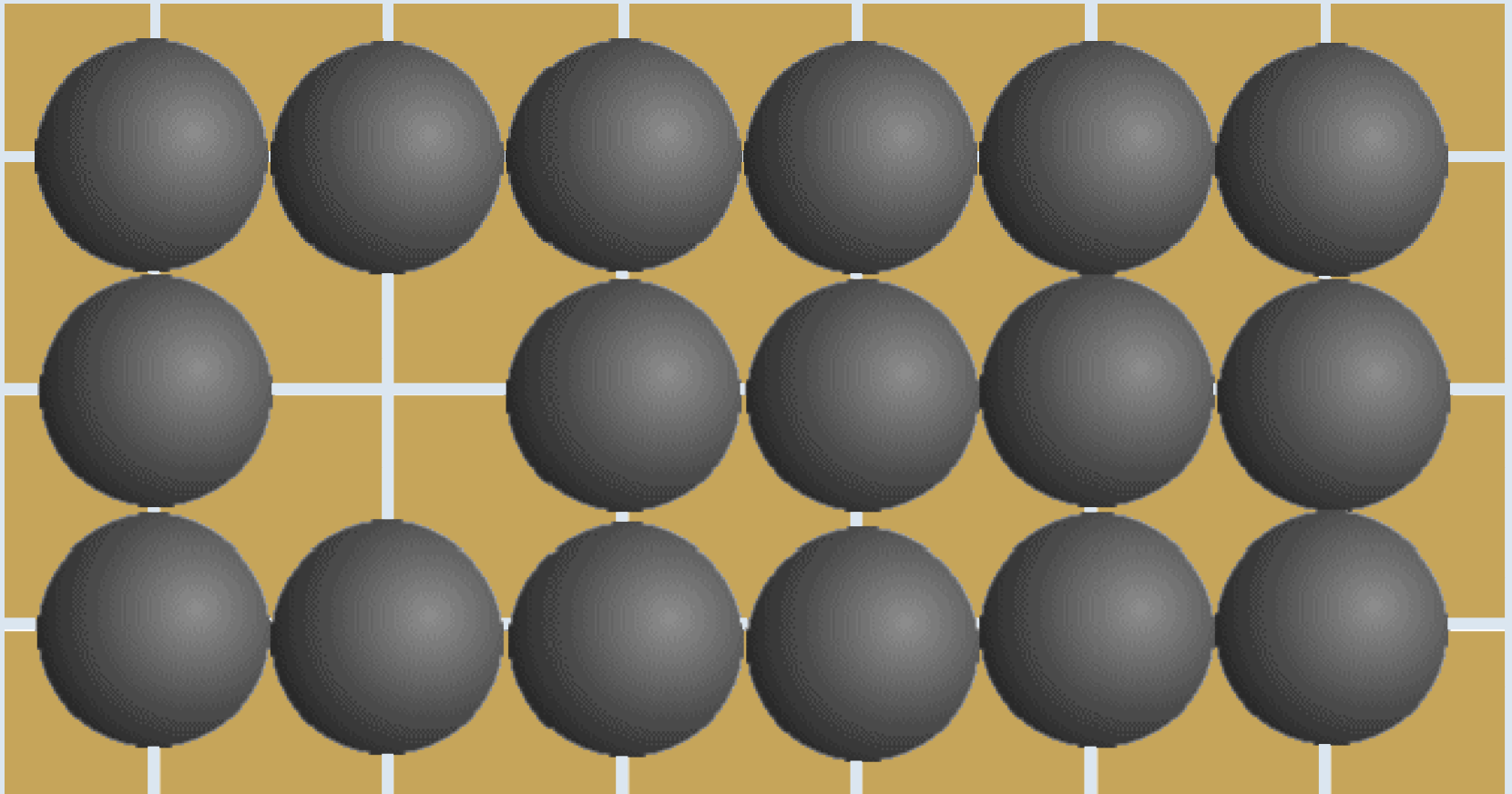
Capture



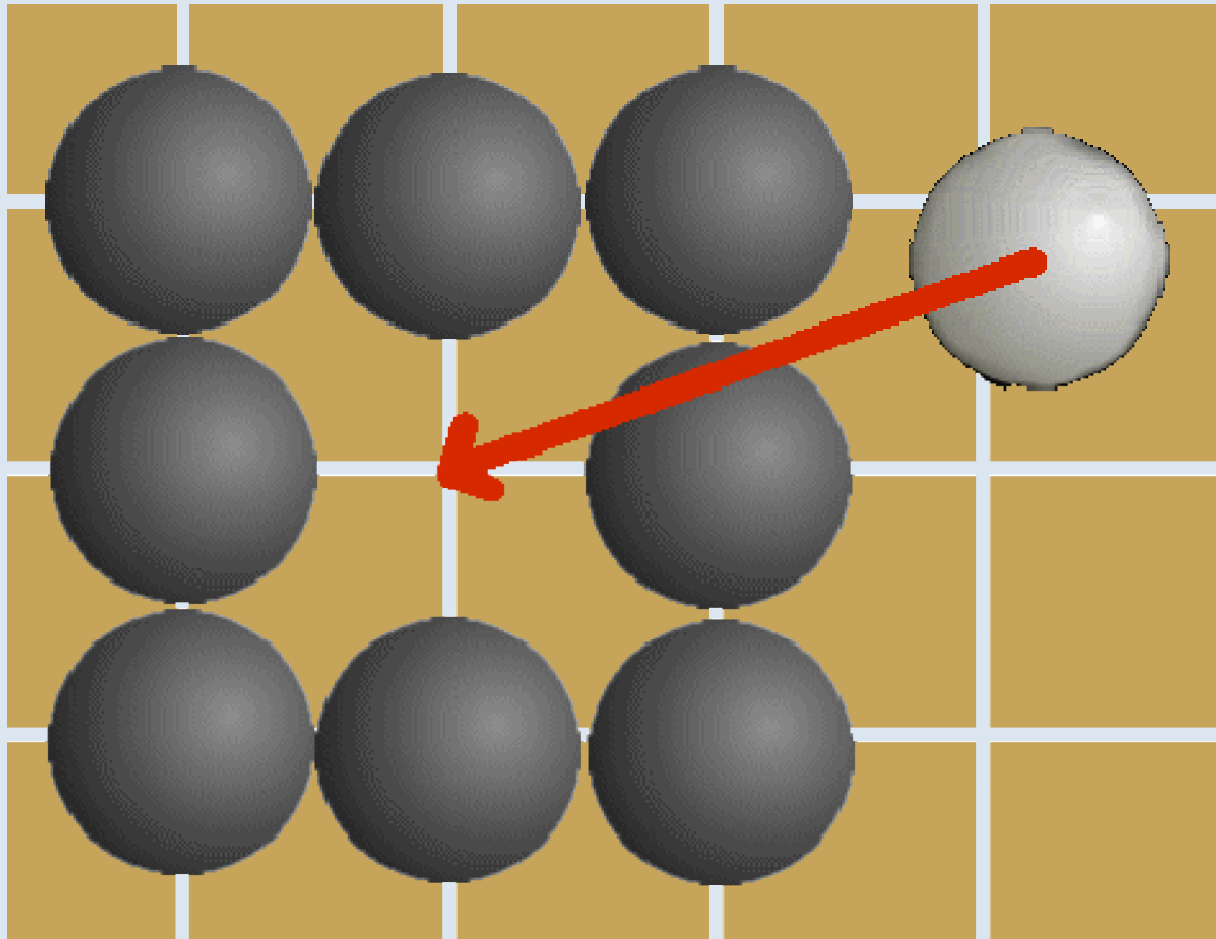
Liberties



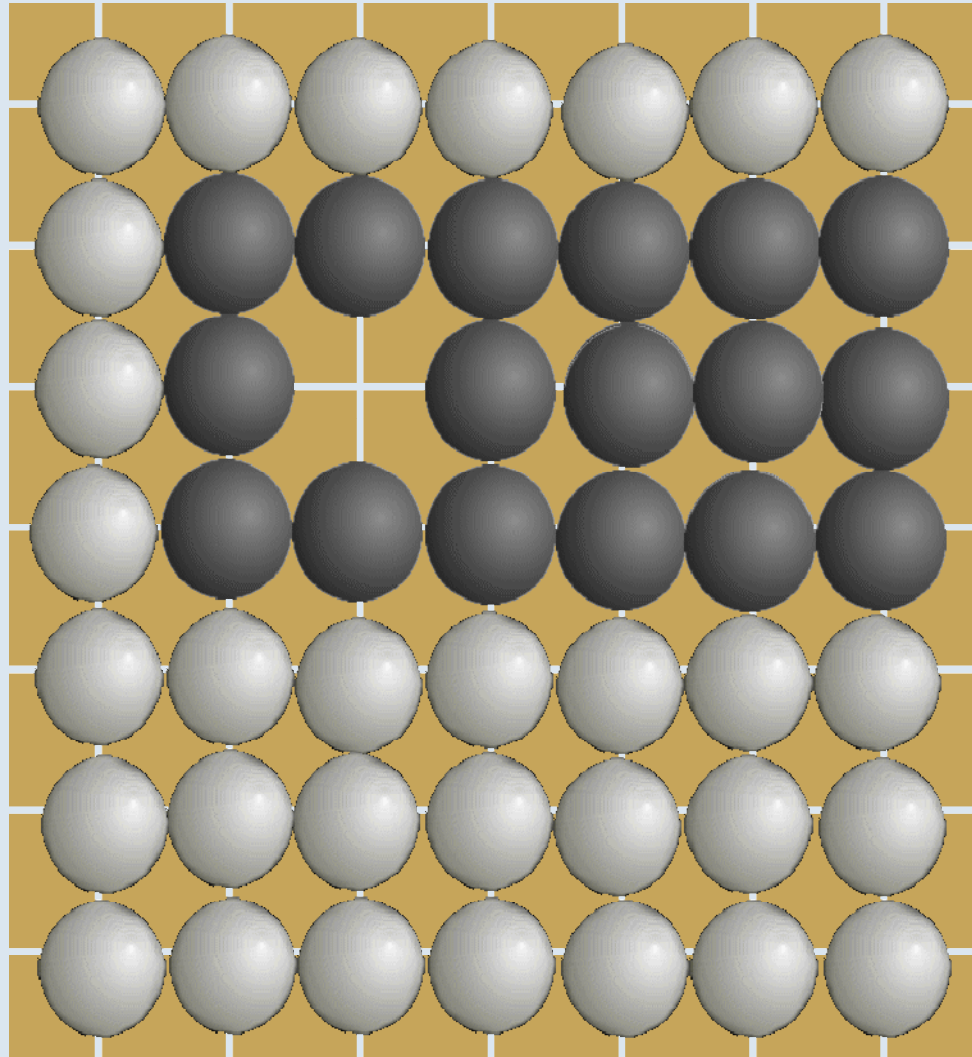
A Single Eye



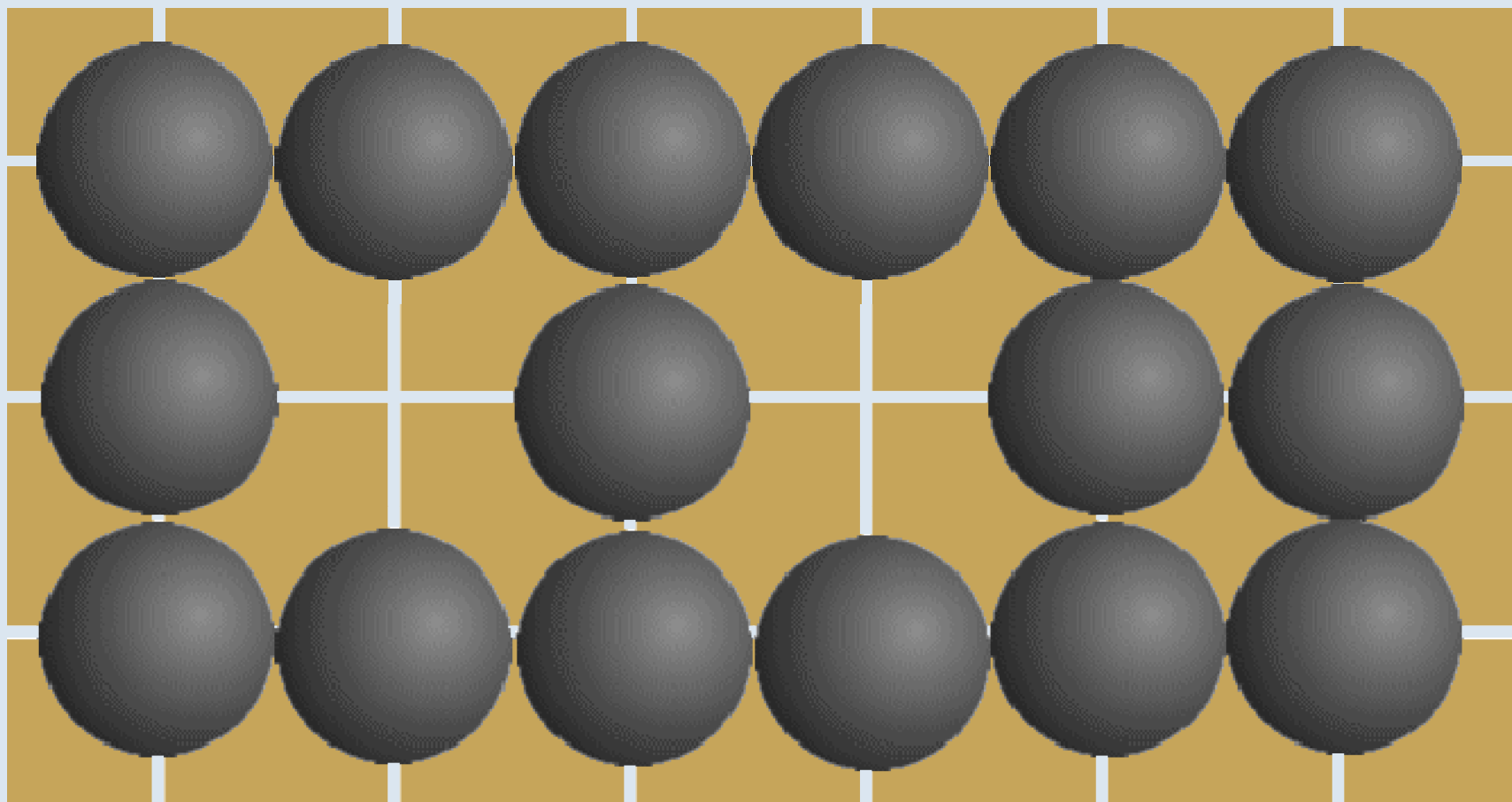
Suicide



Capture



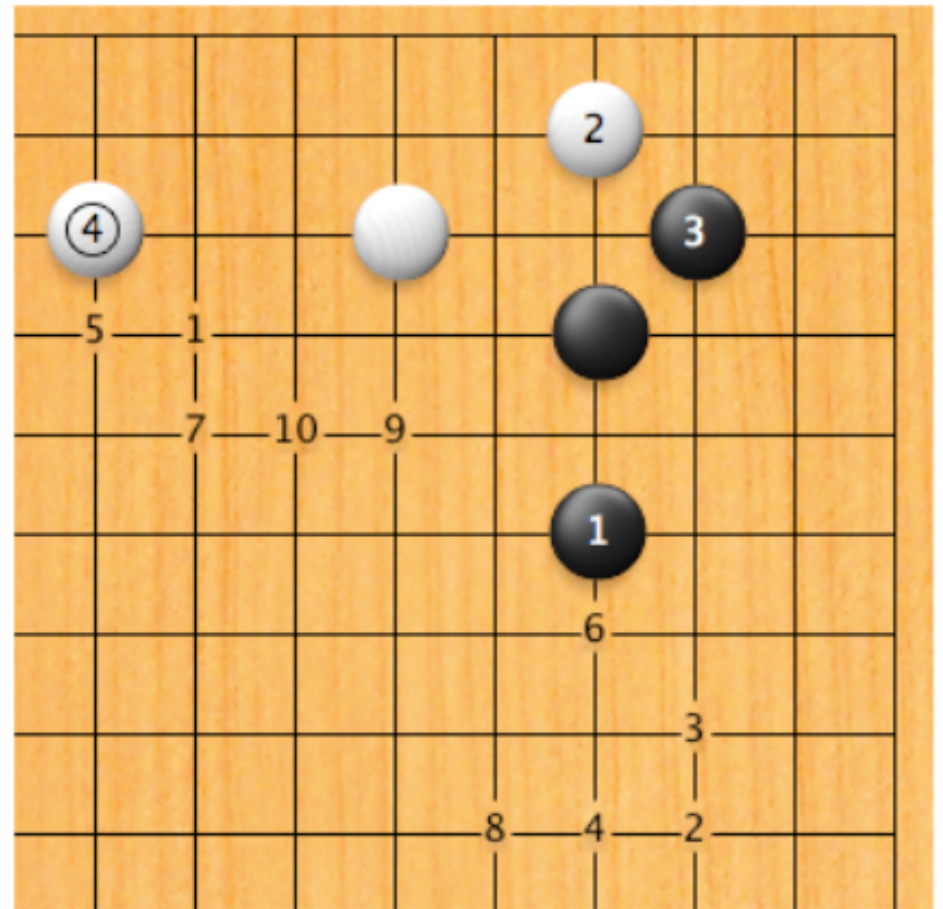
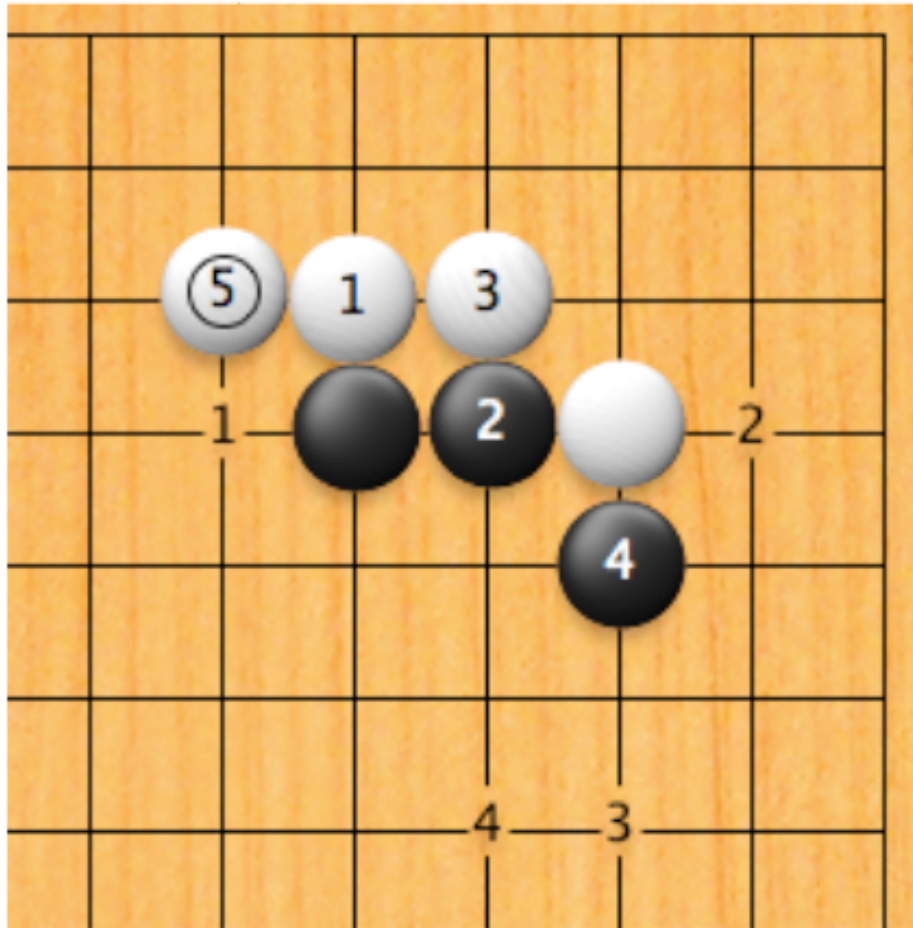
Two Eyes

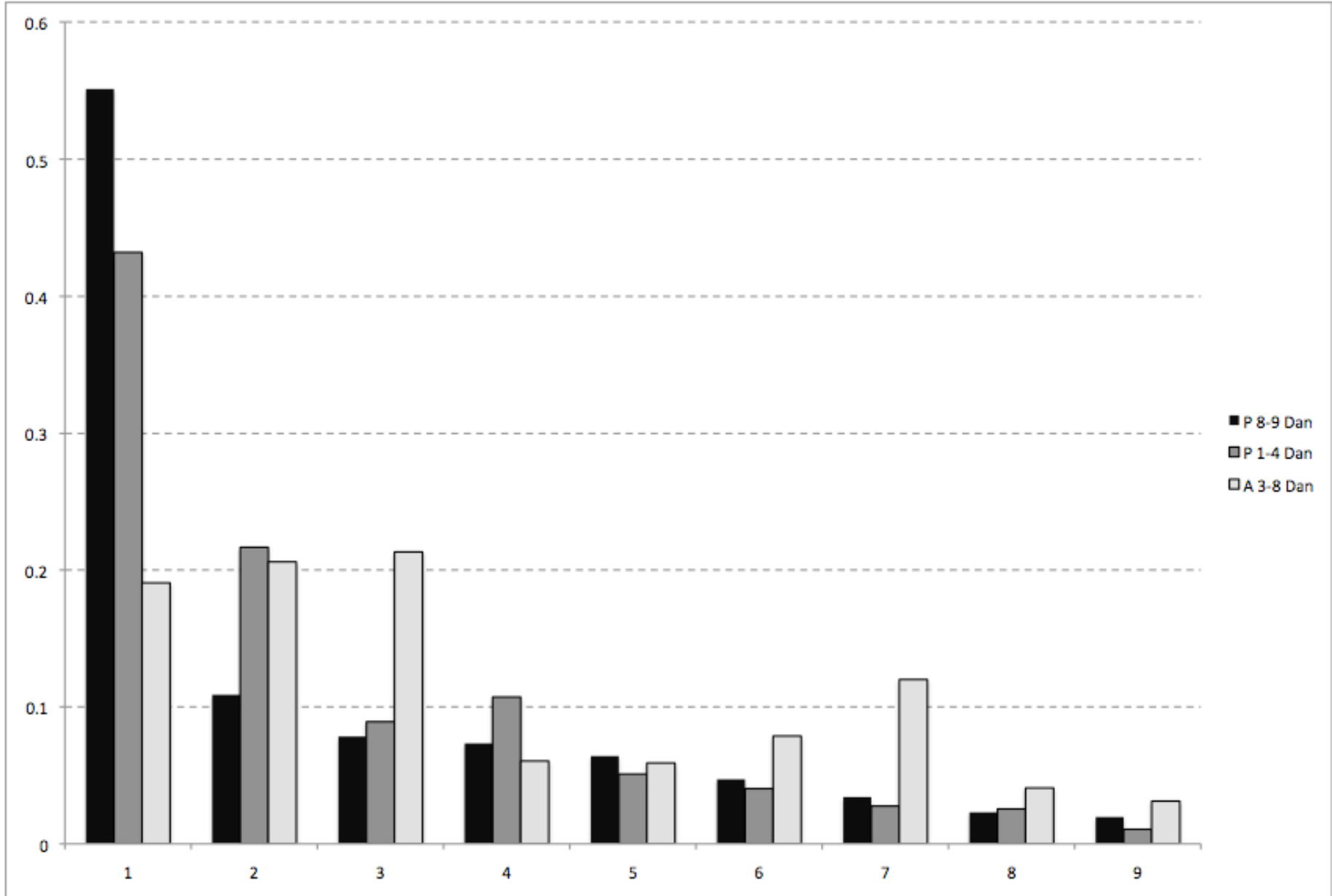


Studying Go Patterns

- Use Go knowledge to select key patterns
 - Joseki and fuseki
- Study variations from expertise
 - Two levels (amateur and professional)
 - Up to 9 dan levels in each
 - 9 Dan Professional, effectively grand master
- Find probability distributions on moves

Avalanche Joseki





Probability Distributions

- Measure for common moves frequencies made
 - Different distributions for different players ranks
- Compare distributions
 - measure expertise differences
 - determine how players differ in local/global skill

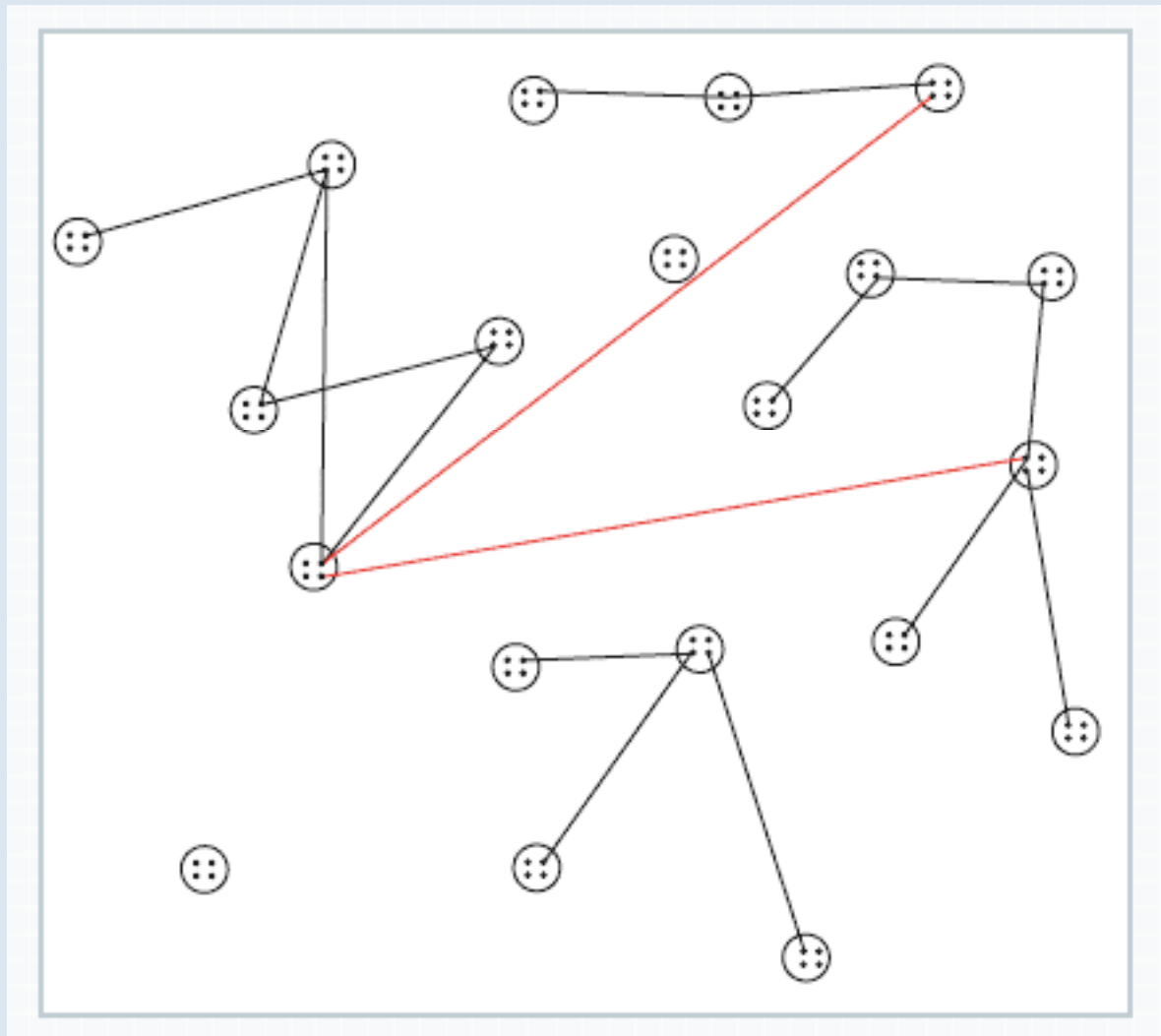
Rain Man's Expertise

- In the film Rain Man Dustin Hoffman shows extraordinary memory skills
- Are such skills inherent in all of us?
 - Snyder Centre for the Mind at Uni Sydney –YES
 - possible to release these skills with brain simulation
- Such skills dynamically inhibited by higher level concepts

Paradigm Shifts

- Idea made famous by Thomas Kuhn, in *Structure of Scientific Revolution*
- Individuals can create paradigm shifts
 - Darwin, Einstein, Planck...
- Do paradigm shifts occur gaining expertise
 - YES

Random Graphs



K-Directed Divergence

$$D_S(k) = \sum_j p^{(k)} \ln\left(\frac{p^{(k)}(\sigma_j)}{0.5 * (p^{(k)}(\sigma_j) + m(\sigma_j))}\right)$$

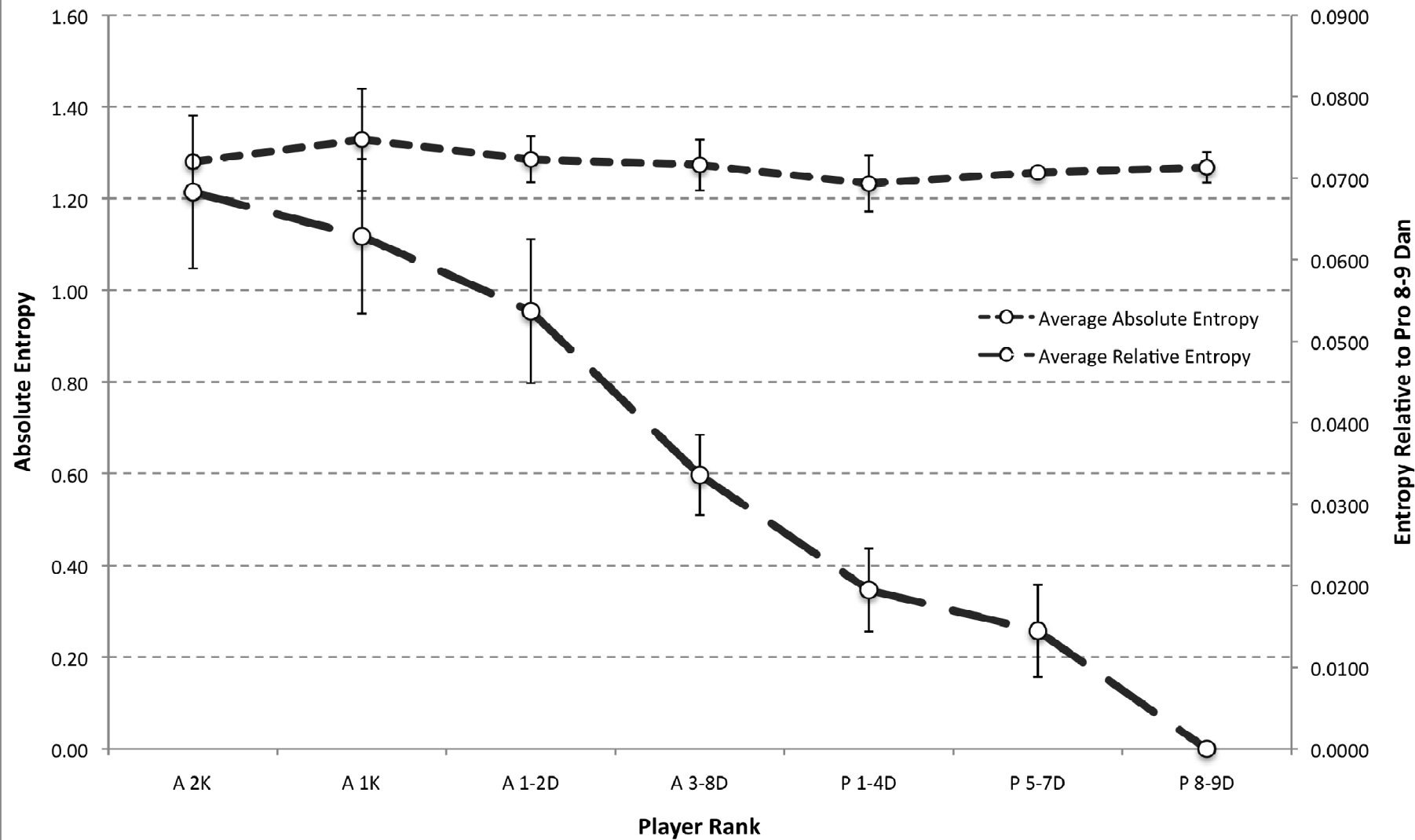
Differential Strategic Divergence

$$\Delta D_S(k) = \sum_j p^{(k)}(\sigma_j) \ln\left(\frac{p^{(k)}(\sigma_j)}{0.5 * (p^{(k)}(\sigma_j) + p^{(k-1)})}\right)$$

Error Terms

$$\sigma = \sqrt{\frac{1}{N} \sum_{k=1}^B (\ln q_k + H_{obs})^2 q_k (1 - q_k)}$$

Average of Absolute and Relative Entropies by Player Rank



KDD Variation with Skill

- KDD falls roughly linearly with rank
 - but for global problems stays flat until about 1 Dan amateur (very strong club player)
 - understanding global context takes longer to learn
- Big difference at 1 Dan professional
 - conceptual reorganisation at this level
- See Harré, Bossomaier and Snyder: *Minds and Machines*, **21**, 449-464 (2011)

Game Tree Analysis

- 8,500 starting corner positions
 - About 2,000 games
- Compute game trees 6 pli deep
- Compute entropies on
 - Ordered sequences of plays
 - Unordered (static positions)
- Compute Mutual Information
 - Real indicator of phase transitions

Results

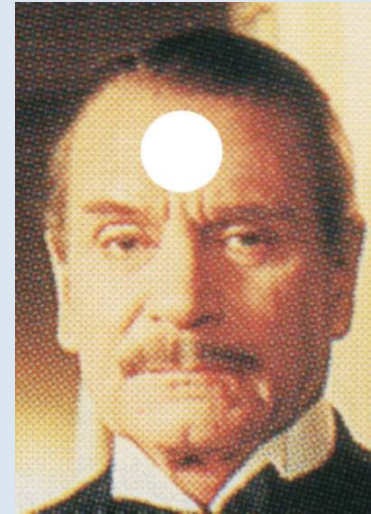
- Peak in Mutual Information around 1Dan professional
- Clear indication of a phase transition
- Open question as to whether this occurs in other forms of expertise
- See Harré, Bossomaier and Snyder: Eur Phys. J. B, **80**, 555—563 (2011)

Nature of Transition

- Kohonen maps used to determine perceptual templates from online game data
- Amateur and expert templates differ
- The paradigm shift occurs at a low perceptual level
- See Harré, Bossomaier, Snyder: *Nature SR*, **2**, 502 (2012)

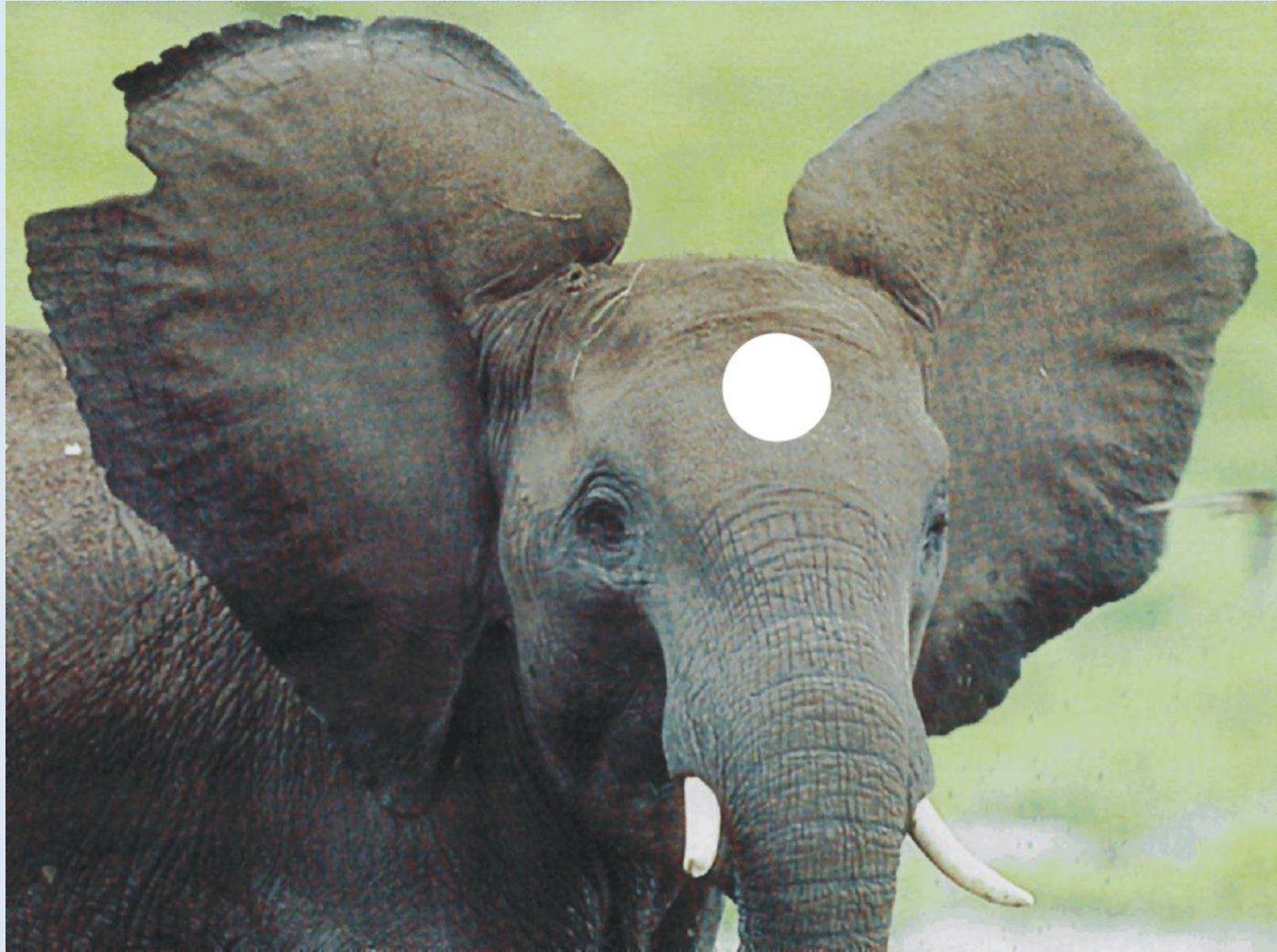
Serious Games

- Games for education and planning
 - Long used by military
 - Many projects, domains
- Stealth assessment
 - measuring performance in game
 - adaptive mechanisms
 - finding expertise transitions













Games with (more) ToM

- Bridge, Poker
 - A lot of online work in Poker (gambing driven)
- Video games (MMOGs?)
- Real life
 - Transitions in medicine
 - Financial trading