Week 7 Video 7

Knowledge Inference: Other Structures

How do we get a skill-item mapping?

- Hand-development and refinement
- Automatic model discovery
- Hybrid approaches

Hybrid Approaches

- The most popular hybrid approach is called Learning Factors Analysis

- Cen, H., Koedinger, K., Junker, B. (2006) Learning Factors Analysis – A General Method for Cognitive Model Evaluation and Improvement. *Proceedings of the International Conference on Intelligent Tutoring Systems*, 164-175.

Learning Factors Analysis (LFA)

- Uses a mathematical model similar to Performance Factors Analysis
- Adds a student parameter, has only one learning parameter per skill

Learning Factors Analysis (LFA)

- Take an existing skill-item mapping
- Add a set of potential candidate “learning factors”

- Repeatedly tries to split skills based on learning factors
  - Using A* space search algorithm

- For Skill A, Learning Factor B
- Test new skills (A and B), (A and not B)

Three Ways to Improve Skill-Item Mappings

- Hand-development and refinement
- Automatic model discovery
- Hybrid approaches

Why is this important?

- A good skill-item mapping is a prerequisite to using algorithms like BKT, PFA
- If you consider irrelevant evidence (student performance at hockey when predicting math)
- You'll have ineffective prediction

A limitation of Q-Matrices

- Assumes no relationship between skills
- Except that a specific item can involve multiple skills

A definite limitation

- Several ways that skills can interconnect

Partial Order Knowledge Structures

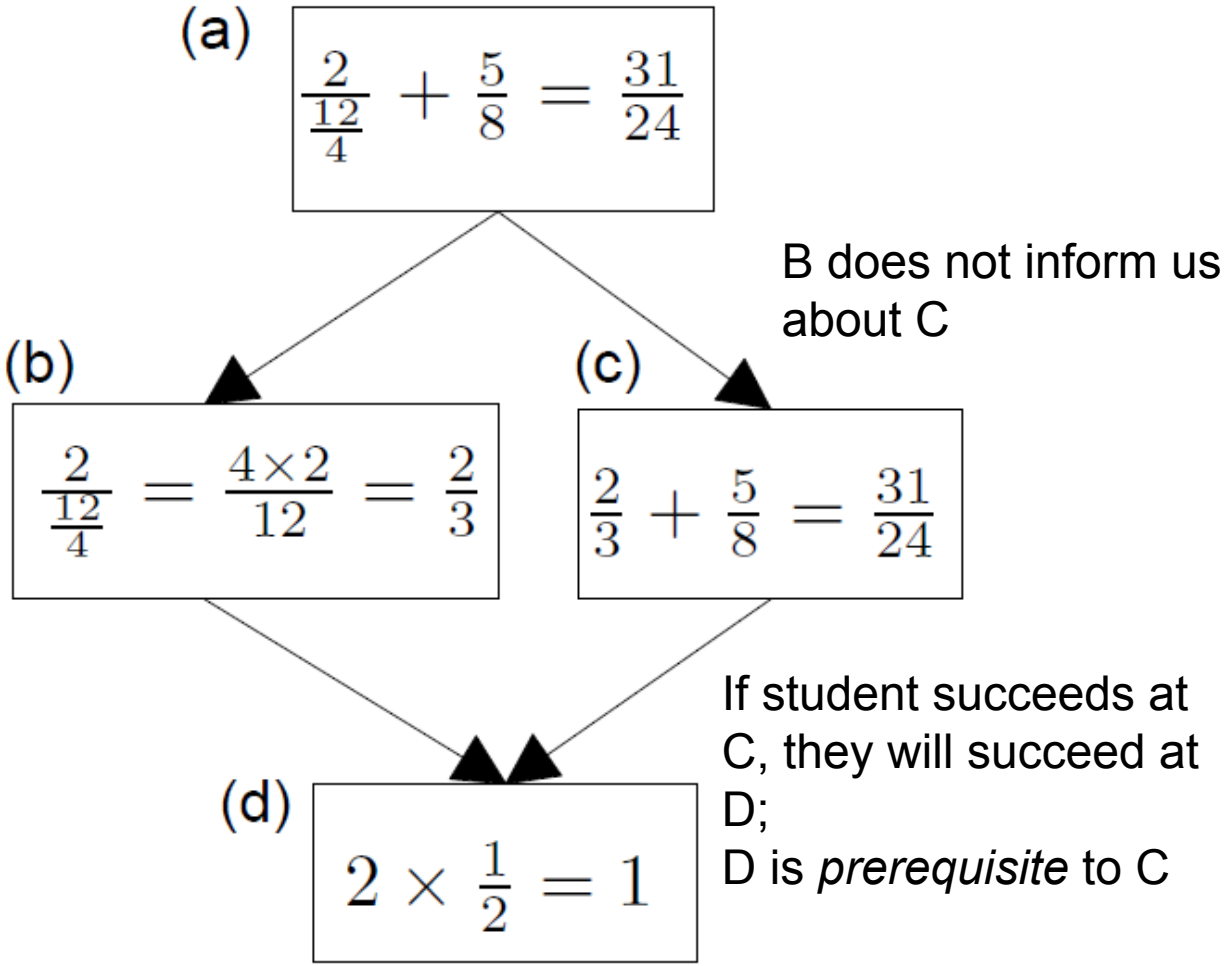
- Desmarais, M.C., Maluf, A., Liu, J. (1996) User-expertise modeling with empirically derived probabilistic implication networks. *User Modeling and User-Adapted Interaction,* 5(3–4), 283–315.
- Desmarais, M.C., Meshkinfam, P., Gagnon, M. (2006) Learned Student Models with Item to Item Knowledge Structures. *User Modeling and User-Adapted Interaction, 16,* 5, 403-434.

Partial Order Knowledge Structures

- Postulate relationships between items

- Mastery of one item
  is *prerequisite* to
  mastery of another item

Example (Desmarais et al., 2006)



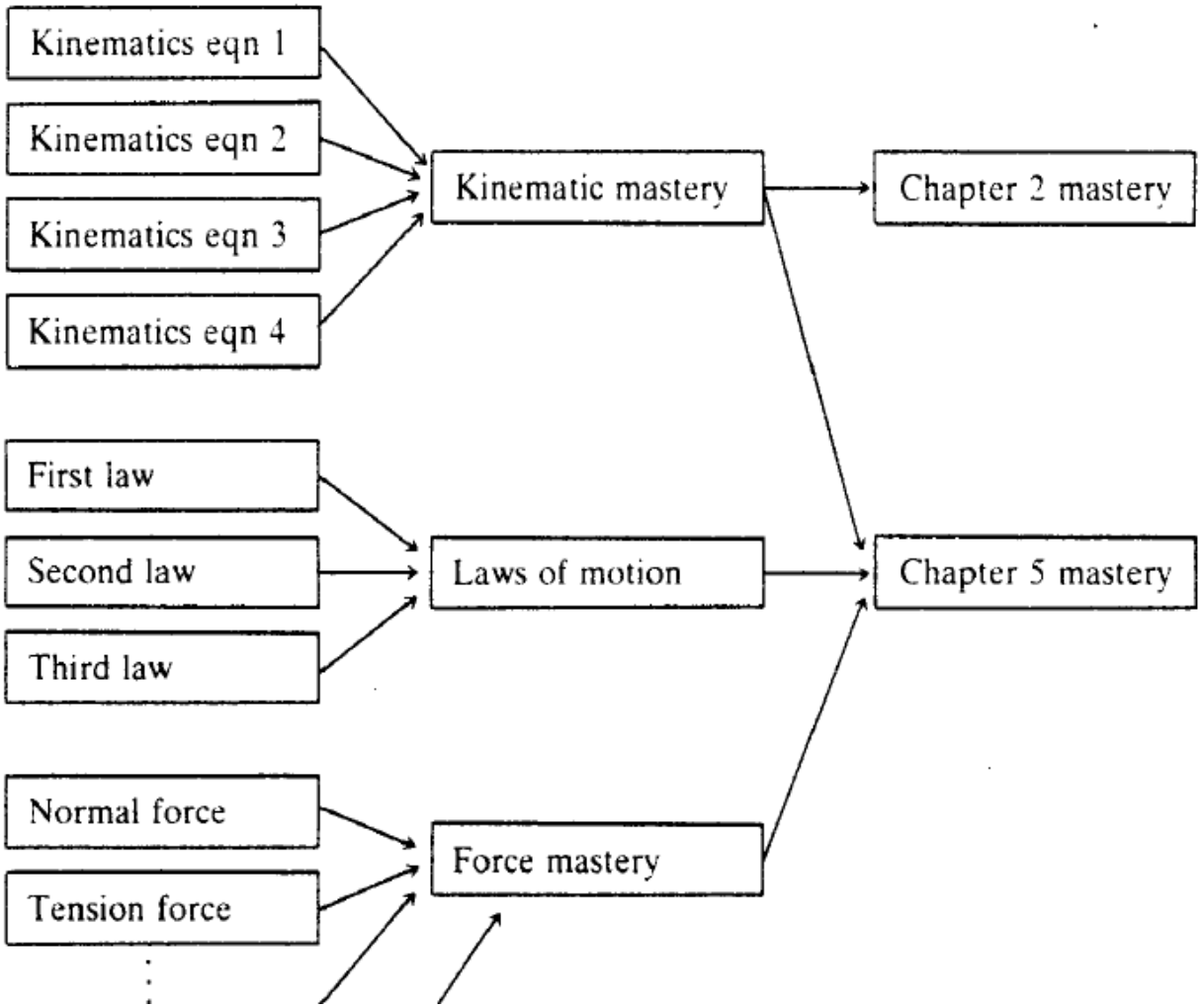
Extension to skills

- POKS can be extended rather easily to use skills (interchangeable items) rather than items

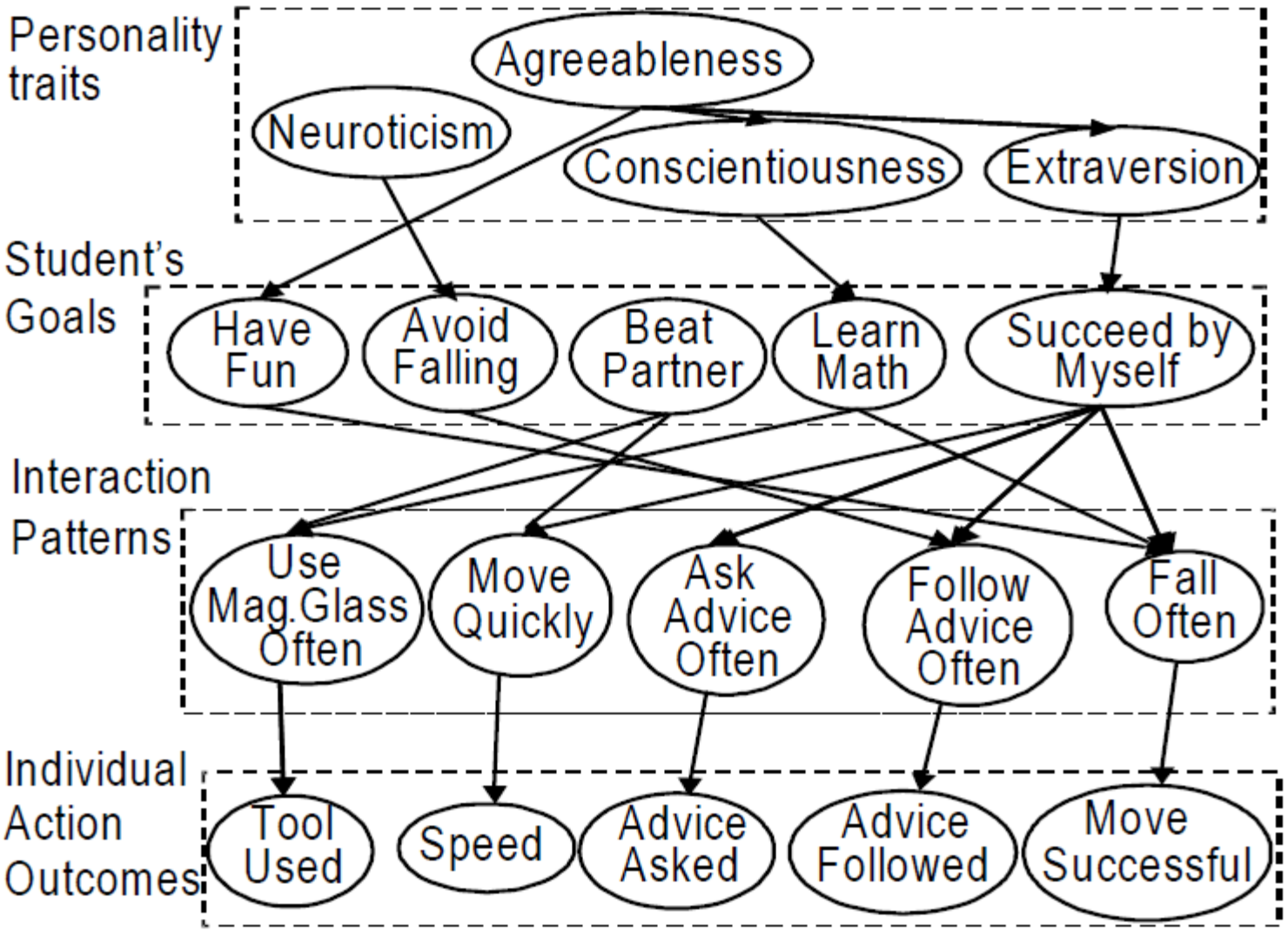
Bayesian Networks

- Less restricted set of models that also infer relationships between skills and items, and between skills
- Can infer more complicated relationships between material than the very restricted set of relationships modeled in POKS
  - Can infer {skill-skill, item-item, skill-item} relationships at the same time
  - Can model hierarchies of skills and meta-skills
  - Can integrate very diverse types of information
- That extra flexibility can lead to over-fitting (cf. Desmarais et al., 2006)

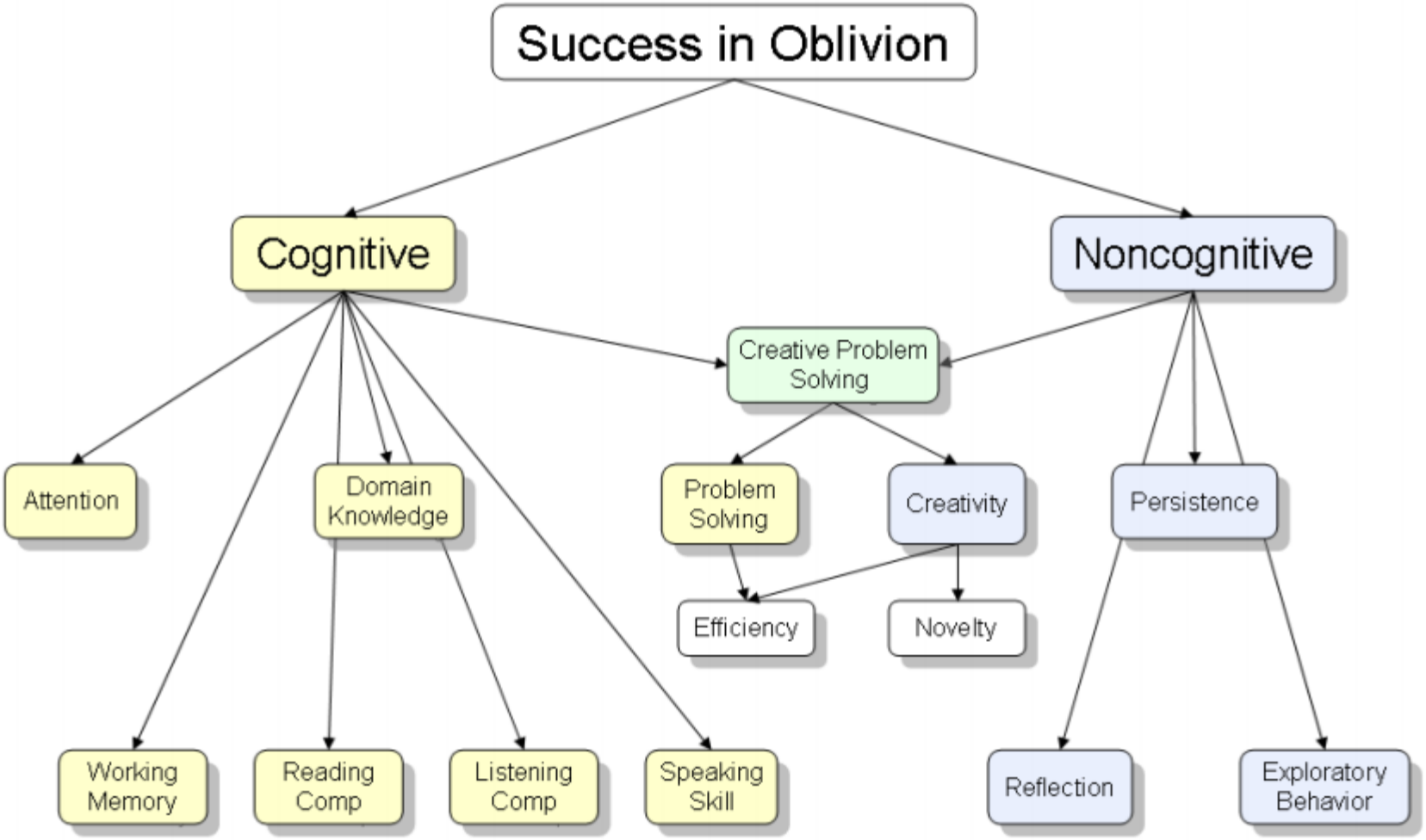
Martin & VanLehn (1995)



Conati et al., 2009



Shute et al., 2009



Propagation of Information

- Several algorithms are used for propagating information around a Bayes Net
- If we know that a student has skill A
- Then this provides us with information about all of that skill's prerequisite skills
- And some information for skills for which skill A is a prerequisite
- And some information about relevant meta-skills

Bayes Net or Simpler Model?

- How much do the interconnections between your skills matter in the context of your learning system?
- How much do you care about hierarchy in skills?
- The cost of a Bayes Net is complexity, over-fitting, and over-propagation of information

Tools for creating Bayes Nets

- Netica
  - http://www.norsys.com/netica.html
- SamIam
  - http://reasoning.cs.ucla.edu/samiam/

Next Up

- Week 8: Advanced Topics