1. **Problem-Solving**
   October 29, 2009

2. **The Problem with problem-solving research**
   “In field research, there is often too much [complexity] to allow for definitive conclusions, and in laboratory research, there is usually too little complexity to allow for any interesting conclusions”
   Brehmer & Dörner (1993)
   *Computers in Human Behavior, 9*, 171-183

3. **Salient differences between puzzle problems and real-world problems**
   - Puzzles
     - unfamiliar
     - involve no prior knowledge
     - all necessary info. is present in the problem statement
     - requirements are unambiguous
   - Real-world problems
     - familiar
     - require prior knowledge
     - necessary information often absent
     - solver must ask ‘what is the goal?’

4. **Problem Examples**
   - Water jug problem
   - Two-string problem
   - Nine-dot problem
   - Candle Box problem
   - Missionaries and cannibals
   - Tower of Hanoi

5. **Candle Box Problem (Duncker, 1945)**

6. **Gestalt Viewpoint**
   - Problem-solving is both reproductive and productive
   - Reproductive PS involves re-use of previous experience (can be beneficial or detrimental)
   - Productive problem-solving is characterized by restructuring and insight
   - Insight accompanied by subjective “ah-ha” experience

7. **Gestalt Contributions**
   - Perception more than just association – it involves conceptualization
   - *Functional Fixedness* can hinder problem-solving (candle box problem)
   - Problem restructuring: productive
   - Development of insight
   - Implication: importance of problem *representation*

8. **Information-Processing Approach to Problem-Solving**
   - Problem-Space Theory
     - solving a problem involves negotiating alternative paths to a solution
     - initial state is linked to goal state by a path
     - knowledge states are produced by the application of mental operators
     - algorithms vs. heuristics are used to move along the path
     - limited processing resources provide constraints on the degree to which multiple moves can be considered

9. **Ohlsson’s Insight Theory**
   - Gestalt findings can be reinterpreted within PST
     - multiple mental representations of the same problem
- specific knowledge operators needed are retrieved from memory
- current representation of the problem acts as a memory probe
- impasses in problem-solving are solved through ‘re-representation’
  • elaboration
  • constraint relaxation
  • restructuring or recategorization

Routine v. Insight Problems: A useful distinction?
• Key Concept: insight and trial-and-error (routine) problems involve subjectively different experiences
• Key Debate: “Special Process” vs. “Business as Usual”
• Routine: problem-solvers good at predicting their success; monitor accurately how close they are to solution
• Insight: problem-solvers poor at predicting success; can’t monitor closeness to solution
  – “What can move large logs but cannot move a small nail?”

Neurobiology of Insight
Problem Isomorphs
• Similar formal structure of two problems
• Reasoning by analogy
• Similarities often very difficult to detect if the problems do not have identical structure (an impediment to generalization)
• Military vs. radiation problem

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Important Ideas in Problem-Space Theory
• Problem-space refers to the abstract structure of a problem
• Operators are specific knowledge structures that transform data
• Algorithm: method or procedure
• Heuristics: strategies, “rules of thumb”
  – means-end analysis: calculate difference between current state and goal; create a subgoal to reduce that difference; select an operator that will solve this subgoal
  – Anti-looping heuristic: don’t go further from the goal than you currently are
• Subgoal structure – essentially are short- and long-term goals (interim v. final destinations)

Progress Monitoring Theory (MacGregor, Ormerod, and Chronicle, 2001)
• Two general problem-solving heuristics
  – Maximisation heuristic – making the most headway possible
  – Progress monitoring – assessing rate of progress toward goal
• Criterion failure (“wake up call”) causes problem solvers to seek an alternative strategy and can be important in obtaining a solution – problem solved better when wakeup is received

Four versions of the eight-coin problem. The dark shading indicates that one coin was on top of another coin. The figures on the right have valid two-dimensional moves, whereas those on the left do not. From Ormerod et al., (2002). Copyright © 2002 by the American Psychological Association. Reprinted with permission.

Evaluation
• Insight appears to be dependent on
  – Constraint relaxation
  – Combined with criterion failure
  – Problem solvers who realize that means–ends analysis is proving unsuccessful are more responsive to changing their strategy than are those for whom means–ends analysis is at least partially successful
• Jones (2003)
  – Previous experience with related problems is also important

Mental Models in Problem-Solving
• Developing an understanding of the formal structure of the problem
• Imagistic and propositional processing
• Fleshing out formal implications of problem by seeking examples and counterexamples, or by playing out real-world implications

Flagpole Problem
• Two flagpoles are standing, each 100 feet tall. A 150-foot rope is strung from the top of one of the flagpoles to the top of the other and hangs freely between them. The lowest point of the rope is 25 feet above the ground. How far apart are the flagpoles?

The Singles Bar
• While sitting in a club where all single men tell the truth and all married men lie, a woman is approached by three men. She asks the first guy if he is married, but the music is so loud that she can't hear his answer. So she turns to the second guy, who tells her, "The first guy said, 'I am married,' but he really is single." Then she turns to the third guy, who says, "The second guy is single." Determine the marital status of each of the three men.

Obstacles to Problem-Solving
• Mental sets, entrenchment, and fixation (viewing the problem from the “dominant paradigm)
• Negative transfer
• Memory load/interference – importance of incubation