Thinking part II
Problem Solving
Solve this maze at your leisure.

Start at phil’s house. At first, you can only make right turns through the maze. Each time you cross the red zigzag sign (under Carl’s auto repair), the direction in which you turn changes. So, after the first time you cross that sign, you can then only make left turns; after the second time, you switch back to right turns only, etc. How can Carl’s auto repair be reached?
Overview

- Well-defined problems
  - heuristics to search problem spaces

- Ill-defined problems
  - obstacles in problem-solving
  - mental set/functional fixedness

- Insight vs. trial & error

- Tests of Creativity
Views of Problem solving

• **Well-defined problems**
  – Much studied in AI
  – Requires search
  – Domain general heuristics for solving problems

• What about **ill-defined** problems?
  – No real mechanisms for dealing with these
  – The problem may be solved suddenly by ‘seeing’ the problem differently
  – Often requires developing a **suitable representation**
Problem solving as search

Play the game: [http://vornlocher.de/tower.html](http://vornlocher.de/tower.html)
Problem Solving is a search problem

Search Space

Initial state

Solution

Goal state
Search spaces can be large

<table>
<thead>
<tr>
<th>#DISCS</th>
<th>#STATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>$3^3 = 27$</td>
</tr>
<tr>
<td>4</td>
<td>$3^4 = 81$</td>
</tr>
<tr>
<td>5</td>
<td>$3^5 = 243$</td>
</tr>
<tr>
<td>6</td>
<td>$3^6 = 729$</td>
</tr>
</tbody>
</table>

FIGURE 3  A search space for the Tower of Hanoi.
What if the search space is too large?

- It is not possible to enumerate the entire search space for many well-defined problems.

- We must use **heuristics**
  - Not guaranteed to work but easy to implement
  - Example heuristics
    - **Trial and error**
    - **Hill climbing**
    - **Means-end analysis**
Trial and Error

- Edward L. Thorndike (1874-1949) found that many animals search by trial and error.

- Found that cats in a “puzzle box” (see left) initially behaved impulsively and apparently random.

- After many trials in puzzle box, solution time decreases.

In order to escape the animal has to perform three different actions: press a pedal, pull on a string, and push a bar up or down.
Hill Climbing

• Find some measure of the distance between your present state and the end state.
  – Take a step in the direction that most reduces that distance
Hill Climbing

- Might lead to suboptimal solutions: local maximum
Means-end analysis

• Set up a goal
• Look for a difference between current state and goal or subgoal state
• Find an operator to reduce this difference. One operator is the setting of a new subgoal
• Apply operator
• Repeat until final goal is achieved
Setting subgoals in means-end analysis

- Painting your house (GOAL 1)
- Apply paint (SUBGOAL 2)
- Need paint and brush (SUBGOAL 3)
- Go to hardware store (SUBGOAL 4)
  - Went to hardware store (SUBGOAL 4)
  - Got paint and brush (SUBGOAL 3)
- Apply paint (SUBGOAL 2)
- Paint the house (GOAL 1)
Starting in the square marked by the circle, draw a line through all the squares without picking up your pencil, without passing through a square more than once, without diagonal lines and without leaving the checkerboard.
What about ill-defined problems?

• No real mechanisms for dealing with these

• According to Gestalt psychologists, the problem may be solved suddenly by ‘seeing’ the problem differently

• Often requires developing a suitable representation
Six stick problem

With these six sticks:

Make four equilateral triangles:

Wrong solution:

Answer:
Functional Fixedness

Maier’s (1931) two-string problem
Only 39% of subjects were able to see solution within 10 minutes.
Why people get stuck solving problems

*Functional Fixedness:*

Subjects who utilize an object for a particular function will have more trouble in a problem-solving situation that requires a new and dissimilar function for the object.

*Mental set:*

A frame of mind involving a particular way of representing problem or solving a problem
Exercise: Assume that a steel pipe is imbedded in the concrete floor of a bare room as shown below. The inside diameter is .06" larger than the diameter of a ping-pong ball (1.50") that is resting gently at the bottom of the pipe. You are one of a group of six people in the room, along with the following objects:

100' of clothesline
A carpenter's hammer
A chisel
A box of Wheaties
A file
A wire coat hanger
A monkey wrench
A light bulb

List as many ways you can think of (in five minutes) to get the ball out of the pipe without damaging the ball, tube, or floor.

Insight

• Seemingly sudden understanding of a problem

• Often involves conceptualizing a problem in a totally different way (e.g. six stick problem, overcoming functional fixedness)

• How can we distinguish between problems requiring insight and problems requiring noninsightful problem solving?
Kohler (1945): monkey and banana problem.

Kohler claimed that chimpanzees appeared to have an insight into the problem before solving it; he claimed there was no process of trial-and-error.
Video: insight or trial and error/ hillclimbing? (1 min)

http://www.youtube.com/watch?v=mDntbGRPeEU&feature=related
Possible evidence for concept of insight: Metcalfe and Weibe (1987) experiment

1) Noninsight problem (algebra):
   - factor $16y^2 – 40yz + 25z^2$

2) Insight problem (nonroutine):
   • A prisoner was attempting escape from a tower. He found in his cell a rope which was half long enough to permit him to reach the ground safely. He divided the rope in half and tied the two parts together and escaped. How could he have done this?
Results (1)

• First result: subjects “feelings of knowing” (beforehand) only predicted eventual success of solving the problem for noninsight problems.

• At 15 seconds intervals, ss. rated how close they felt to solving the problem:

  1=cold (nowhere close to solution)
  ....
  7=hot (problem is virtually solved)
Number of times a particular warmth rating was given.
Creativity & Divergent Thinking

• Guilford (1967) hypothesized that creative individuals possess *divergent thinking abilities*

• Led to tests such as *alternative uses task*

• E.g. “think of as many uses as possible for a simple object, like a paperclip”
Example: uses for a paperclip

- Example responses:
  - Hold papers together
  - Cufflinks
  - Earrings
  - Imitation mini-trombone
  - Thing you use to push that emergency restart button on your router
  - Keeping headphones from getting tangled up
  - Bookmark

- Scoring bases on a number of dimensions:
  - **Fluency** – how many uses you can come up with
  - **Originality** – how uncommon those uses are (e.g. “router restarter” is more uncommon than “holding papers together”)
  - **Flexibility** – how many areas your answers cover (e.g. cufflinks and earrings are both accessories, aka one area)
  - **Elaboration** – level of detail in responses; “keeping headphones from getting tangled up” would be worth more than “bookmark”
Predicting Creative Ability

• Do divergent thinking test scores predict real-life creativity in a specific area of creativity such as art, math-science, drama, writing, music?

• Some researchers have found that divergent thinking tests can better predict creative achievement than IQ tests (e.g. Kim, 2008).

• However, correlations are often quite small
Divergent Thinking and Brain Functional Connectivity

• Takeuchi et al. (2011) related functional connectivity to divergent thinking
• Finding: higher creativity is associated with higher connectivity between medial prefrontal cortex (mPFC) and the posterior cingulate cortex (PCC)
• Creativity = better information transfer between distant brain regions?
• Similar brain connectivity result found for Schizotypy – people who experience psychotic symptoms