Problem solving and decision making
See mind tools on web
Contributors

• Some older psychologists
• Two recent Nobel prize winners
  – Herbert Simon
  – Dan Kahneman
• Many others including engineers, teachers, MDs…
Many practical books written
A GUIDE FOR
IMPROVING THINKING,
LEARNING, AND
CREATIVITY
THE IDEAL PROBLEM SOLVER
aha! Insight Martin Gardner
Problem Solving and Comprehension
A Short Course in Analytical Reasoning
Second Edition

Arthur Whimbey and Jack Lochhead
The Wright Brothers

- [http://wright.nasa.gov/overview.htm](http://wright.nasa.gov/overview.htm)
- I have always looked at the Wbinvention of the airplane as a model of problem solving. NASA has a webpage with some of the highlights.
Results

• Classic problems
  – Two string problem, water jar problem, radiation problem, Wason card problem
• Identification of common fallacies
• Useful generalizations that can be taught
For example -1

• 1. When in difficulty, examine problem statement to see if information has been previously extracted
• 2. When in difficulty, search for a new problem representation
  • Change point of view
  • Choose new sensory code, e.g., imagery
  • Work backwards
• Try hypothetical reasoning
• Try proof by contradiction
Thinking with a Pencil

With 692 illustrations of easy ways to make and use drawings in your work and in your hobbies.

Henning Nelms
study the relations between the people in a group. Each person is asked to give his first, second, and third choice among the other members of the group. The names are written down and enclosed in cartouches. The choices are then marked by lines with arrows.

A rough chart like Step 1 is not very revealing. However, when the names are rearranged to make the lines as short and straight as possible, the structure of the group becomes clear [Step 2].
For example-2

3. Be active in defining ill-defined problems by
   - Making gap filling decisions
   - Trying to solve the problem as a method for understanding it
4. Use external representations where possible
   - Use perspective drawing
   - Use matrices for keeping track of information
   - Use drawing to find implicit relations in the problem
5. Build working models, simulation, trial and error
Two modes of representing categorical syllogisms: English and circle diagrams

All cognitive psychologists are pianists.
All pianists are athletes.
Therefore, all cognitive psychologists are athletes.

Logicians often use circle diagrams to illustrate class membership and to make it easier to figure out whether a particular conclusion is logically sound. The conclusion for this syllogism does in fact follow logically from the premises, as shown in the circle diagram in Figure 12.1. However, the conclusion is false because the premises are
In decision making

- Modern mind tools -- statistics, probability theory -- are MUCH better than the naïve mind.
- Other techniques including
  - Satisficing
  - Cost-benefit analysis
Examples and applications
Cost-benefits in the Iraq war
Jaywalking

• National ignorance or selective sample? We have no base rate information on this.
• Notice how many of the silly answers might be due to priming -- semantic or phonological. Who worships cows? “Mooslims” Where are Parisians from? Peru!
Gambler’s fallacy

- Professor Limber has played poker for 20 monthly games. He has won in all of them. Is he doomed to lose a lot in the coming year?
Base rate fallacy
Representativeness heuristic
Unspoken constraints
Move the bucket?

- By moving only 1 bucket, can you line up these buckets so every other one is full and every other one is empty?
Move one bucket?

Pour the second into the fifth bucket!
Move one bucket?

Pour the second into the fifth bucket!
Causal inference

• Despite frequent warnings about inferring a causal relationship from just an association between events, humans often tend to see cause-effect in temporal associations.

• Children cannot help in engaging in what Piaget called “phenomenal causality” For example, a child is angry at its mother who then becomes ill and the child feels guilty.

• Common superstitions may reflect this tendency. While not always in error—and probably better than no intuition in some circumstances --, these intuitions can be refined and evaluated using statistics.
Science as mind tool

• Science is a culturally evolved “toolkit” that helps do this.
  • The logic of a causal inference
    » Verify a correlation exists
    » Verify the supposed cause preceded the effect
    » Rule out alternatives

• The various “experimental methods” are designed to help out in this process. Random assignment in an experiment helps “rule out” alternatives.
  » Limits on causal inferences?

• Hopeless in complex interacting situations? Maybe but no reason to give up! (build a model!)
Illusory correlations

- Selective attention, perception, memory for confirming events; failure to consider base rates, valuing the personal experience over the abstract assessments -- all can lead us to perceive a relationship between events when no real correlation exists.
Inference of a correlation between “silicon” and disease K

• This depends on either a correlation—a non-chance association between silicon implants and disease K; or an illusory correlation, e.g. due to failure to consider base rates of observation that many women with silicon implants have the disease anyway regardless of their implants.

• Consider there are 100 million women and 1/100 have disease K and 1/100 have implants. That means there are a million with disease K and a million with implants.
• If there is no connection between the two, we would expect about 10,000 women with implants to have the disease --EVEN IF THERE IS NO CAUSAL RELATIONSHIP THERE. Thus a packed field house with 8000 women with implants and disease K might give a jury an illusory correlation but it can't be taken as evidence in itself. The jury needs to take the baseline data into consideration.
## Data- implants and disease

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Pop</td>
<td>100,000,000</td>
<td></td>
</tr>
<tr>
<td>Disease K</td>
<td>1,000,000</td>
<td>0.01</td>
</tr>
<tr>
<td>implants</td>
<td>1,000,000</td>
<td>0.01</td>
</tr>
<tr>
<td>D &amp; I</td>
<td>10,000</td>
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</tbody>
</table>
Conjunction fallacies

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice and also participated in antinuclear demonstrations. (Tversky & Kahneman, 1983, p. 297)

Based on the preceding description, list the likelihood that the following statements about Linda are true:

(a) Linda is a teacher in elementary school.
(b) Linda works in a bookstore and takes yoga classes.
(c) Linda is active in the feminist movement.
(d) Linda is a psychiatric social worker.
(e) Linda is a member of the League of Women Voters.
(f) Linda is a bank teller.
(g) Linda is an insurance salesperson.
(h) Linda is a bank teller and is active in the feminist movement.

If you are like 85% of the people Tversky and Kahneman studied, you rated the likelihood of item (h) above as greater than the likelihood of item (f). Stop for a minute, however, and imagine a huge convention hall filled with the entire population of bank tellers, and now think about how many of them would be at a hypothetical booth for feminist bank tellers—a subset of the entire population of bank tellers. If Linda is at the booth for feminist bank tellers, she must, by definition, be in the convention hall of bank tellers. Hence, the likelihood that she is at the booth (i.e., she is a feminist bank teller) cannot logically be greater than the likelihood that she is in the convention hall (i.e., she is a bank teller). Nonetheless, given the description of Linda, we intuitively feel more likely to find her at the booth than in the convention hall. This intuitive feeling is an example of a fallacy in judgment and reasoning.
Induction
Abduction

- This neglected aspect of problem solving refers to the process of coming up with a hypothesis to evaluate in an inductive situation.
Leads to creativity - where do ideas come from?
Two complementary reasoning systems-1?

- William James (1890) and others have suggested there are two different reasoning systems.

  - 1. An associative system based on tendencies for things to occur together, etc.
  - 2. A rule-based system, which involves manipulations of relations among representations (symbols.)
Two complementary reasoning

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Associative system</th>
<th>Rule-based system</th>
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<tbody>
<tr>
<td>Principles of operation</td>
<td>Similarity and contiguity</td>
<td>Symbol manipulation</td>
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<tr>
<td>Source of knowledge</td>
<td>Personal experience</td>
<td>Language, culture, and formal systems</td>
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<tr>
<td>Nature of representation</td>
<td>Concrete and generic concepts, images, stereotypes, and feature sets</td>
<td>Concrete, generic, and abstract concepts; abstracted features; compositional symbols</td>
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<tr>
<td>Basic units</td>
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<tr>
<td>Relations</td>
<td>(a) Associations</td>
<td>(a) Causal, logical, and hierarchical</td>
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<tr>
<td></td>
<td>(b) Soft constraints</td>
<td>(b) Hard constraints</td>
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<tr>
<td>Nature of processing</td>
<td>(a) Reproductive but capable of similarity-based generalization</td>
<td>(a) Productive and systematic</td>
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<tr>
<td></td>
<td>(b) Overall feature computation and constraint satisfaction</td>
<td>(b) Abstraction of relevant features</td>
</tr>
<tr>
<td></td>
<td>(c) Automatic</td>
<td>(c) Strategic</td>
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<tr>
<td>Illustrative cognitive functions</td>
<td>Intuition</td>
<td>Deliberation</td>
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<td>Fantasy</td>
<td>Explanation</td>
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<td>Creativity</td>
<td>Formal analysis</td>
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<td>Imagination</td>
<td>Verification</td>
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<td></td>
<td>Visual recognition</td>
<td>Ascription of purpose</td>
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<td></td>
<td>Associative memory</td>
<td>Strategic memory</td>
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</table>
Two complementary reasoning systems-2?


• (also review the box on Steve Pinker’s research on verb endings)
Two complementary reasoning systems-3?

• Could this be partly behind the Jefferson penny phenomenon?

• “my mind raced ahead without thinking and said he was facing right.”

• “I read it and immediately knew Jefferson wasn’t on the penny>”
Thinking: Intelligence and cognition

• Cogitate (shake)
• Intelligence (select)
END