

# Cognitive Psychology



Solving a problem is a function of your previous experience

*Have you encountered a problem like this before?*

**Yes, frequently** Use skill-based expertise

**Yes, sort of...** Use rules (heuristics) learned from similar experiences

**No, never** Identify problem space & goals, plan & hypothesise, try various heuristics, build a mental model

## Problem Solving Heuristics

Working backward: start at the goal state and work towards initial state

Difference reduction (*hill climbing*) method: working forward

Means-ends analysis (goal reduction): creation of sub-goals (that are solvable)

Analogy heuristic: mapping the solutions from one problem onto another

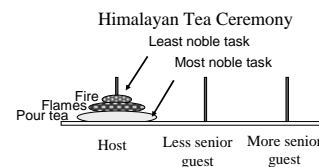
*Re-representing the problem*

The greatest difference between experts and novices is in how they represent the problem

Some representations make the problem much easier to solve

Analogy heuristic (mapping the solutions from one problem onto another) is powerful

Works best for *problem isomorphs* problems with the same structure (solution path) but different content (surface representations)



## Representing the Problem

Superficial similarities and differences have a large effect on the likelihood of drawing an analogy

### Positive transfer

Experience with a 3-disc tower of Hanoi problem will make the tea ceremony problem easier to solve if you can make the connection

Selection of an inappropriate representation can lead to negative transfer..

Mental Set Effects

Problem-solving: trial-and-error or otherwise?



## Gestalt Viewpoint

Perception more than just association

Problem solving is both reproductive and productive  
Reproductive problem solving 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"

## Gestalt Viewpoint

*Functional Fixedness* (a result of reproductive strategy can hinder problem-solving (candle problem))

Problem *restructuring*: a productive strategy

Development of *insight*

Implication: importance of problem *representation*

## Mental Set

Without lifting your pencil, connect all nine dots with four straight lines

Previous heuristics applied even when inappropriate (incorrect assumptions about the rules)

## Mental Set Effects

People may become biased by experience to prefer certain approaches to a problem  
*einstellung* (mechanization of thought)

Edith Luchins' water-jug experiments  
(Luchin 1942, 1959)

Participants given a set of jugs of various stated capacities, and is asked to measure out a desired quantity of water



## Insight & Problem Solving

Insight is a sudden "*aha!*" experience

All-or-none solution, not gradual progress

According to *Gestalt* psychologists problem-solving requires insight and "restructuring" (overcoming prior experience and reproductive strategies)

A new perception of the problem space

Progress towards solution is difficult to foresee  
(Metcalf, 1986) "*how close you are to the end?*"  
People cannot guess

A problem with the Gestalt approach to problem solving is that concepts involved are rather vague and ill-defined.

*What is "restructuring", for example?*

Also, are not very compatible with the information processing accounts of cognition

## Neo-Gestalt View (Metcalf)

Insightful vs. noninsightful (routine) problem-solving

Routine: problem-solvers good at predicting their success; monitor how close they are to solution

Insight: problem-solvers poor at predicting success; can't monitor closeness to solution

## Neo-Gestalt View

### Representational Change Theory

Problem solving involves accessing semantic memory

How a problem is currently represented determines what information is to be retrieved from semantic memory (i.e. the problem representation is the probe that directs activation in semantic memory)

The retrieval of information from semantic memory involves spreading activation among related concepts

If the representation does not probe the information required to then the problem cannot be solved (i.e. there is an impasse)

### Representational Change Theory

Insight occurs when an impasse is broken.

An impasse is broken when the problem solver changes their representation of the problem, producing a new memory probe that can quickly access the relevant information

3 processes leading to insight

Elaboration: adding new information to the problem representation

Constraint relaxation: assumed constraints on the problem representation are removed (lines problem)

Re-coding: a part of the problem is reinterpreted in a different way (e.g. a pliers reinterpreted as a weight in the two strings problem)

### Insight & Problem Solving

Gauss: mathematics of prime numbers, working on proof that any number can be represented as a product of primes in one and only one way. Tried for 4 years.

*"Finally two days ago, I succeeded, but not on account of my painful efforts. Like a sudden flash of lightning, the riddle happened to be solved... For my part I am unable to name the nature of the thread which connected what I previously knew with that which made my success possible"*



### Insight & Problem Solving

Why insightful problem solving is experienced as sudden

(Gick & Lockhart 1995)

Lack of access to the problem representation (mental block)

difficult, slow, may be implicit

Construction of new representation  
difficult, slow, may be implicit

The use of representation (old or new)  
easy, always explicit

### Insight & Problem Solving

There is a stick 2 m long  
200 ants are walking along this stick in either left or right direction, with the speed of 1 cm/sec  
If a ant meets another one, both change the direction to the opposite

If an ant comes to the edge, it falls down  
How much time will it take before all ants are on the ground (and the stick is "antless")?

### Insight & Incubation

Putting the problem aside for a while seems to help for difficult problems

M. Calvin: frustrated with laboratory results that were incompatible with his understanding of photosynthesis.

While waiting for his wife in a parking lot, a flash of insight revealed the missing piece of the process.

*"It occurred just like that - quite suddenly - and suddenly, also in a matter of seconds, the cyclic character of the path of carbon became apparent to me... the original recognition of phosphoglyceric acid, and how it got there, and how the acceptor might be regenerated, all occurred in a matter of 30 seconds."*

Calvin was awarded the Nobel prize in 1961 for his insight

### Insight & Incubation

Tesla: invention of alternating current, sudden insight while walking in park with a friend began reciting Goethe's *Faust* "*The sun shudders and shimmers, having survived the day, and moves on to stir new life*"

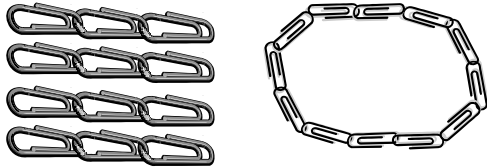
*"...the idea came like a flash of lightning and the solution to the problem of alternating current motors appeared before him as a revelation. He stood as a man in trance, trying to explain his vision to his friend... the image which appeared before Tesla seemed as sharp and clear and as solid as metal or stone. The principle of rotating magnetic field was clear to him."*

All Tesla had to do was to run back to his cottage and make a sketch of his vision, the Tesla coil



### The cheap necklace problem (Silveira 1971)

You are given four separate pieces of chain that are each three links in length.  
It costs 2¢ to open a link and 3¢ to close a link.  
All links are closed at the beginning of the problem.  
Your goal is to join all 12 links of chain into a single circle at a cost of no more than 15¢.



### The cheap-necklace problem (Silveira 1971)

Control group: Worked on the problem for half an hour  
55% solved the problem

Experimental group 1: Worked for half an hour,  
interrupted by a half-hour break (other activities performed)

64% solved the problem

Experimental group 2: same as Ex1, but with a 4 hour break

85% solved the problem

Participants were asked to think aloud as they worked  
They came back to the problem where they left off, and did not have preformed solutions

### Insight & Incubation

Kekulé: working on chemical structure of benzene (previously all chemical compounds were thought to be linear chains)



*"I turned my chair toward the fire place and sank into a doze. Again the atoms were flitting before my eyes. Smaller groups now kept modestly in the background. My mind's eye sharpened by repeated visions of a similar sort, now distinguished larger structures of varying forms. Long rows frequently rose together, all in movement, winding and turning like serpents; and see! what was that? One of the serpents seized its own tail and the form whirled mockingly before my eyes. I came awake like a flash of lightning. This time also I spent the remainder of the night working out the consequences of the hypothesis."*

### Insight & Incubation

Leowi: realised that certain drugs mimic stimulation of nerves, thought nerves contain chemicals that transmit the nervous impulse. Could not think of a way to test it and forgot about it.

*"The night before Easter Sunday of that year, I awoke, turned on the light, and jotted down a few notes on a tiny slip of thin paper. Then I fell asleep again. It occurred to me at six o'clock in the morning that during that during the night I had written down something important, but I was unable to decipher the scrawl. The next night, at three o'clock the idea returned. It was the design of an experiment to determine whether or not the hypothesis of chemical transmission that I had uttered seventeen years ago was correct. I got up immediately, went to the laboratory, and performed a simple experiment on a frog heart according to the nocturnal design.... If I had carefully considered it (the design) in daytime, I would undoubtedly have rejected the kind of experiment I performed.... It was good fortune that at the time of the hunch I did not think but acted."*

### Insight & Incubation

Putting the problem aside for a while seems to help for difficult problems

#### *What happens during incubation?*

May reduce negative transfer because unimportant & irrelevant details will be forgotten (removal of mental blocks)

May be result from consolidation in LTM or new perspectives due to changed contexts (new representations)

### Insight & Creativity

Insightful solutions are often called creative

#### Creativity

Creative solutions show:

Fluency - the production of many ideas  
Originality - the uniqueness of ideas  
Flexibility - the modifiability of ideas  
Elaboration - the extension of ideas



Torrance Tests of Creative Thinking  
TTCT-V & TTCT-F  
(E. Paul Torrance, 1963, 1993)

**Wallach-Kogan Creativity Battery  
(1965)**

**Fluency** - the production of many ideas

**Originality** - the uniqueness of ideas

**Instances**

*name all of the round things you can think of*  
*name all of the things you can think of that will make a noise*  
*name all of the square things you can think of*

**Alternate uses**

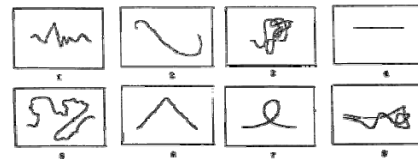
*tell me all the different ways you could use a newspaper*  
*tell me all the different ways you could use a knife*  
*tell me all the different ways you could use a cork*

**Similarities**

*tell me all the ways in which a carrot and a potato are alike*  
*tell me all the ways in which a cat and a mouse are alike*  
*tell me all the ways in which a desk and a table are alike*

**Line Meanings:**

*tell me all the things you can about it*



**Creativity and Semantic Knowledge  
(Rychlicka, 1990)**

**Pairs of words**

frog – grass (20 close relationship)  
 frog – airplane (20 remote relationship)

*Do these words associate?"*

For close associate pairs both creative & high  
 IQ participants answered YES quickly

**For remote associates**

Creative people: answered slowly YES  
 High IQ people: answered quickly NO

**Creative Problem Solvers**

**Cognitive explanation:** Creative persons' knowledge representations are more complex, more susceptible to general, nonspecific activation, and activation persists longer

**Motivational explanation:** Spreading activation will eventually reach any node in the network  
 Creative persons show longer reaction time,  
 Perhaps creative people more easily tolerate temporary lack of success & wait for a longer period of time

**Positive aspects of high creativity  
(Colangelo & Davis, 1997)**

Aware of creativeness

Original

Independent

Risk-taking

Energetic

Curious

Sense of humour

Attracted to complexity

Artistic

Open-minded

Need time alone

Intuitive

**Negative aspects of high creativity  
(Colangelo & Davis, 1997)**

Indifferent to conventions and courtesies

Challenge rules and authority

Rebellious, uncooperative

Capricious, careless, disorderly

Absentminded, forgetful

Argumentative, cynical, sarcastic

Sloppy with details and unimportant matters

Egocentric, tolerant, tactless

Temperamental, emotional

Overactive physically and mentally