Mental models

Psy 20
Prof Colin Camerer

MMs are: intuitive understanding of a causal system
            incomplete, unstable, perhaps incoherent
            unscientific, can have `superstitions'
            (feng shui, athlete superstitions, astrology, boy/girl conception)
            often propositional

examples:
    i. intuitive hydraulics:
            What happens to contents of a tilted glass?
    Many people mistakenly take an object-centered view (liquid
    level perpendicular to the glass, not parallel to the ground)

    ii. intuitive physics (McCloskey reading)
            Where do moving objects go?

    Correct theory:
    have same velocity as carrier (Jet Li jumping from moving train)
    centrifugal force for twirled objects

    Impetus theory (c. 14th century):
            Objects get `**impetus**' from previous movement
            impetus gradually dissipated
    evidence: Intuitive missile trajectories, dropped balls while moving,
                    push pucks through curved tunnels

    iii. intuitive economics
            e.g., "wage-push" theory of inflation
            vs. monetarism (Milton Friedman)   (key: hyperinflation!)
            "concrete veil" in analysis of taxation (incidence of luxury tax)

    critiques: Performance better in familiar contexts?
            (<u>not</u> true of bartenders, waitresses in liquid-level problem)
      Ss recognize flaws in simulations based on predictions

    Qs: Why doesn't everyday life correct mistakes in mental models?
    A: (evolutionary) would if survival depended on it...
       ...but many mistakes are "new" processes (missile trajectories)
            or causally ambiguous ones (birth-- Abaji twins)
            or truth may be suppressed (Galileo)
            also: confirmation bias (remember successes), poor record
    keeping of errors

Problem Solving & Expertise

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Procedural knowledge: How do people solve problems?

Newell-Simon comp'l approach:

Problem space (states of system)
operators change state
initial state--> **goal** state

Great contribution:
  Defines structure which is a language for human PS
  <u>and</u> gives normative (optimal) answer

Operators (steps)

How learned?
  by instruction (words, imitation)
  by examples (induction)

  e.g. Reed-Bolstad 13% answers w/ abstract instr'ns
          28% w/ one example
          40% with both

Analogy
  (radiation problem)
  solar system/atom analogy
  prison/university

Production rules
  Operators expressed as
  If…(application test)...then rules (productions)
  Useful for measuring cognitive complexity (number of rules)

Selection of Operators

Use **heuristics:**
      wide range of application
      no guaranteed optimal solution

e.g. **repeat-state avoidance** (don't go back)
    difference-reduction (hill-climbing)

problem: can get stuck at obstacle (fence)

      means-ends analysis
         create subgoals

Examples: Missionaries-cannibals (a/k/a hobbits/orcs)

      --difficulty w/ repeat-state avoidance

      Tower of Hanoi

      --usefulness of subgoals

fMRI & damage patients: Prefrontal cortex implicated in "planning"

Problem Representation

mutilated checkerboard problem
      Can arrange 31 dominoes on 62-square board?

wormy apple problem
      apples packed 3x3x3. Worm in center one.
      Can eat way through adjacent apples w/o
      repeating?

Problem Representation (cont'd)

key is to create "problem isomorph" where
      solution is more transparent

e.g. alternate selecting integers 1-9 to add to 15
      what game is this? who wins? (1st player or 2nd?)

Set effects (Einstellung):
      Can "overlearn" a heuristic

      Luchins water jugs

"insight problems"

insight problems solved by single "insight" (Aha)

obstacle: <u>functional fixedness</u>
      (candle-box problem, two-string problem)
      finding: "hint" helps, but unconsciously

insight vs. noninsight
      insight problems:
            no "feeling of knowing" near sol'n
            breaks help ("incubation")
             cheap-necklace:55% in 30 mins,
                         64% w/ 30 min break
                         85% w/ 4 hr break
            like daydreaming-- "reverses" wrong paths,
                activates other promising paths

            verbalizing interferes (reinforces "set")

Expertise

Chase's rules: 10 yrs or 10,000 hrs to become expert
                           expert-novice gap grows w/ difficulty

three stages:
      declarative
      associative (eliminate errors, combine steps)
      autonomous stage (automatic, fast)

      e.g. driving a car, cooking, typing...

      --> power law of speed, error frequency (cigars)
         cost of making products

      break --> start again on lower learning curve (Fig 9.4)

development of expertise:

proceduralization (learn procedures)

tactical (local?) learning-- specific rules, not generalized
                             (memorize recipes)

strategic (global?) learning-- learn class of solutions,
                                    customized tricks

      e.g. physics problems

novice: start w/ unknown, work backward
expert: start w/ knowns, work forward using laws...

      (cf. differential equations)

      e.g. cooking

novice: buy ingredients, cook from recipe
expert: see what's available, cook from memory

      e.g. programming, writing, painting

novice: problem "depth" first
expert: problem "breadth" first

      e.g. college admissions

novices: read carefully, weigh cues equally
experts: look for unusual features, categorize
      into types, use world knowledge (specific HSs)

Memory and expertise

Chess experts much better at "known" boards, not random
Expert "vocabulary" of 50,000 positions?
Experts-- no loss over 30 sec interval
Can such memory be trained?
      Yes...Carnegie runner subject SF (Fig 9.13)

Zintacteco shaman shown fuzzy pictures
      more images, faster, never say "I don't know"
      (Macroeconomic/Wall St analysts??)

Transfer of skill

What "transfers"?

Aristotle et al: general "faculties" (like muscles)
      observation, attention, discrim'n, reasoning
      level of exertion is key-- Latin, geometry, music

Seems to be false:
      Idiot savants; no corr'n across memories, skills
      Brazilian street kids making change
        98% correct on street, 37% in lab, 74% word probs

Thorndike "theory of identical elements":
      similar stimulus-response relations transfer
      add--> multiply,   Latin--> French

      not quite:
          transfers if abstract knowledge structures similar
          e.g. calculus in physics and in economics,
          word processing packages, programming lang's

            not much "negative" transfer-- set effects (Luchins)