Reasoning and Decision Making

Comparisons to "Gold Standards"

not general models of reasoning, such as problem solving etc.

general finding: people don't meet gold standards

Background issues:

1. Common sense reasoning:

Anderson: formal vs. human reasoning is architecture issue
symbolic (formal) reasoning vs. neural models

But it is not an architecture issue
1. it is a question of fullness of knowlege representation
2. in limited domains expert systems are fine
3. neural systems have analogous problems or worse
scaling is impossible w/o precision

2. Kinds of Logic:

propositional logic
p's and q's are variables that refer to entire (unanalized propositions)

first order predicate logic
similar to propositional notation seen earlier:
proposition consists of predicate (relation) + arguments

Fast(John)
□ x Likes(John x)
□ x Person(x) => Likes(John x)

rules in predicate logic

□ x Bird(x) => Flies(x)
Bird(Tweety)
Flies(Tweety) ?how

Unify Bird(x) & Bird(Tweety) by binding variable x to constant Tweety
So...

Bird(Tweety) => Flies(Tweety)
Bird(Tweety)
Flies(Tweety)

3. Some definitions

deductive reasoning

a -> b
a
———
b

"inductive reasoning" (two versions)

abductive reasoning

a -> b
b
———
a

inductive reasoning as concept formation

bird1 flies
bird2 flies
bird3 flies
....
....
———
all birds fly

4. Reasoning & Logic

psychological question-
relationship to logic
Boole 1854 "An investigation into the laws of thought"

(a deeper take on this)

Deductive Reasoning and Problems with Conditional Reasoning

rules of inference:
(permit valid deductions)

p -> q p q	modus ponens
p -> q ~q ~p	modus tollens

Rips & Marcus 1977

e.g., p -> q ~q ________ ~p	57% always 39% sometimes 4% never
p -> q q ________ p	23% always 77% sometimes 0% never

failure to apply modus tollens

Wason selection task:

each card: letter + number:
rule: vowel -> even number ?

example: E K 4 7
what to do to verify rule?

permission interpretation of conditional

Griggs & Cox 1982

if person is drinking beer -> person is over 19
each card: age + drinking beer/coke

Cheng & Holyoak 1985
each card transit/entering + vaccinations (?cholera)
if entering -> cholera

better with rationale

probabilistic interpretations

Oaksford & Chater 1994

p -> q means q is likely when p occurs
and both are typically rare events

broken headlight -> broken tailight

broken headlight:	check tailight (correct)
not broken headlight:	don't check (correct)
broken tailight:	people check (incorrect logically but is confirming evidence)
not broken tailight:	people ignore (incorrect logically but not worth trouble)

<u>Reasoning about Quantifiers</u>

Categorical Syllogisms

2 premises -> conclusion
each has categorical subject and predicate
quantifiers: *all, no, some, some not*

e.g.,

all A's are B('s)	some A's are B('s)
<u>all B's are C('s)</u>	<u>some B's are C('s)</u>
all A's are C('s	some A's are C('s)

findings: people too willing to accept false syllogisms
but there are patterns to people's responses

Explanations:

the atmosphere effect: Woodworth & Sells 1935

positive conclusion from positive positive premises
negative conclusion from negative or mixed premises
negative conclusion from mixed premises

no A's are B's
<u>all B's are C's</u>
no A's are C's

universal conclusion from universal premises
particular conclusion from particular or mixed premises

all A's are B's
<u>some B's are C's</u>
some A's are C's

problems with hypothesis:

not functional (what or why)
doesn't explain effect of validity
doesn't explain effect of form

some A's are B's
some B's are C's
some A's are C's

some B's are A's
some C's are B's
some A's are C's

Other Explanations:

* content effect (believability)

  but people are accurate on valid syllogisms

* failure to accept logical task

*cultural and developmental differences

* failure to discriminate information in premises and information retrieved from memory

* forgetting premises

Johnson-Laird: Mental Models

1. construct model of first premise

2. add info in second to model of first, taking into account various ways it can be done

3. frame a conclusion, if any, that holds in all the models

Predictions of Theory-

1. difficulty depends on number of models

2. figural effects
   fifo working memory
      easier to state conclusion in same order
   A-B B-C easiest
   B-A C-B hold second, reprocess first

   A-B C-B harder-
   B-A B-C need to convert premise

Reasoning about Probabilities

"gold standard" Bayes's Theorem:

$$\text{Prob}(H|E) = \frac{\text{Prob}(E|H)*\text{Prob}(H)}{\text{Prob}(E|H)*\text{Prob}(H) + \text{Prob}(E|\sim H)*\text{Prob}(\sim H)}$$

prior probability	P(H)	overlooked, often low
conditional probability	P(E|H)	can be high and still
posterior probability	P(H|E)	produce low posterior P

derivation of Bayes's Theorum

H: hypothesis is true, ~H: hypothesis is false
E: evidence is true/present, ~E: evidence is false/not present

	H	~H
E	A	B
~E	C	D

Prob(E) = A + B

Prob(H|E) = A/A+B

so what are A, B, (and C, D) ?

does A = Prob(E)*Prob(H) ?? what would that assume?

A = Prob(H)*Prob(E|H) = Prob(E)*Prob(H|E)

B = Prob(~H)*Prob(E|~H) = Prob(E)*Prob(~H|E)

So:
Prob(H|E) = A/A+B

$$= \frac{\text{Prob}(E|H)*\text{Prob}(H)}{\text{Prob}(E|H)*\text{Prob}(H) + \text{Prob}(E|\sim H)*\text{Prob}(\sim H)}$$

Explanations for discrepancies:

- Base Rate Neglect
  - Kahneman & Traversky 1973
    - (30 engineers 70 lawyers)

- Conservatism
  - (too little attention to evidence)
  - Edwards 1968
    - choosing chips from bags

- Correspondance to BT with Experience
  - Gluck & Bower 1988
    - patients w 4 symptoms
  - *what is wrong with this*?

Heuristics

- Tversky & Kahneman, 1974
  - availability
  - representativeness

- gambler's fallacy
  - vs regression to the mean <=

Decision Making

- subjective utility

- framing effects