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Modelling How and When Learning Happens in a Diagrammatic Reasoning Task

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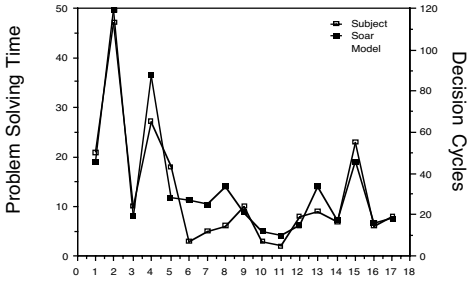

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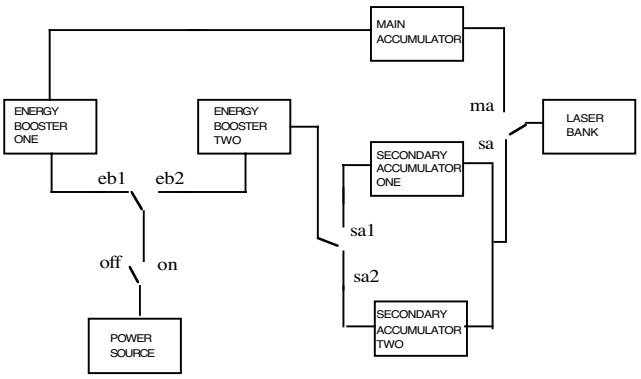
Diagrams, Interfaces, and Klingons

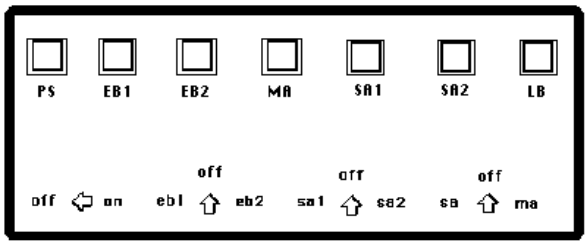
- Based on Kieras & Bovair's Starship+ (='Klingon') interface



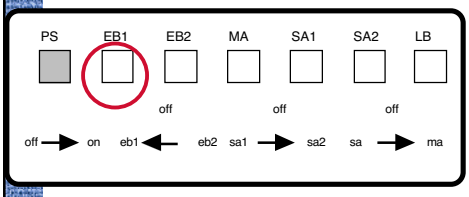
Device Schematic

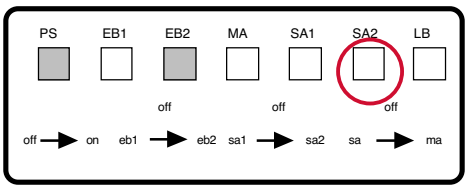
Task Details

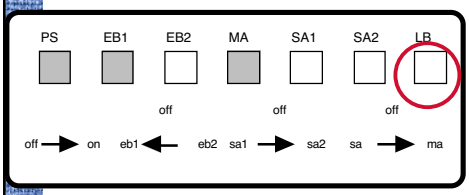
- Subjects are given:
  (i) a general intro. to the problem
  (ii) basic information on the interface
  (iii) a diagram of the underlying circuit
- Subjects are told that ONE component in the circuit is faulty, and are asked to indicate which one

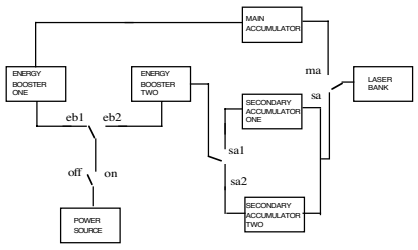


Some Example Faults









Device Schematic

Why pay attention?

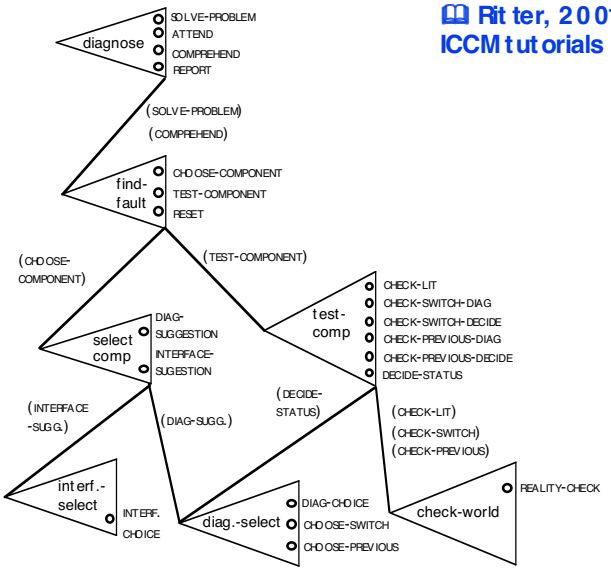
- How to learn with interaction
- Illustrates human-level learning
  - Forbus gold standard,
  - Langley notes "just on this task"
- Shows that Soar chunker models learning and transfer of learning
- Shows learning and/with reasoning
- There is no wireless network

Diag-Soar (v16)

(Ritter & Bibby, 2001)

- 173 rules + 220 chunks (new rules)
- Schematic knowledge represented as linked lists, organized as 'routes' through the circuit
- Visual interface information represented as declarative structures for lights & switches
- Status of interface diagram represented in top goal, accessed by *attend*

Diag-Soar's Problem Spaces



📖 Ritter, 2001. *Soar ICCM tutorials*

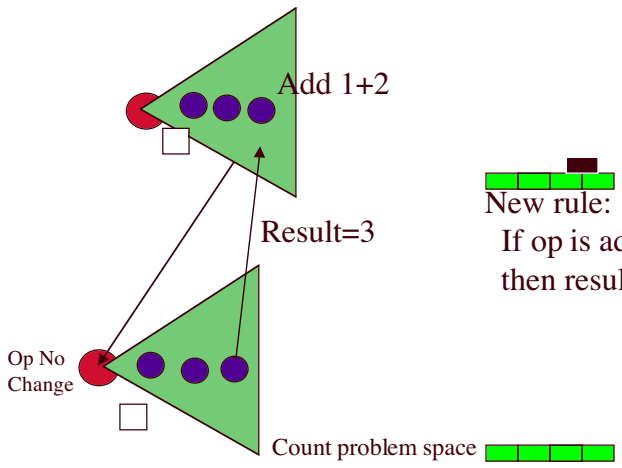
Diag-Soar (cont.)

- Organization of components on the interface diagram 'sequences' the checking of each component
- If a subgoal requires perceptual information, goal stack must be re-built
- *attend* and *comprehend* operators used to represent the perceptual components of the task

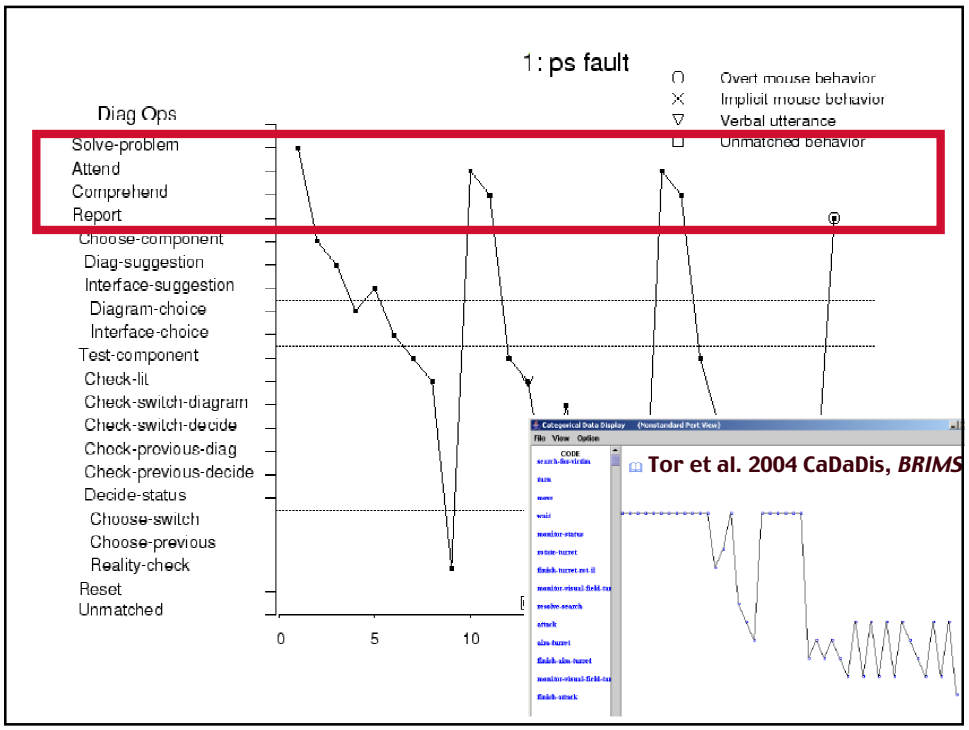
Representation?

- Experience and knowledge stored in Soar production rules
- Rules organized as implementing problem spaces, operators, and choices between them
- All learned knowledge is also represented in rules with these structures

Soar, Learning in Action



New rule:
If op is add 1+2
then result = 3



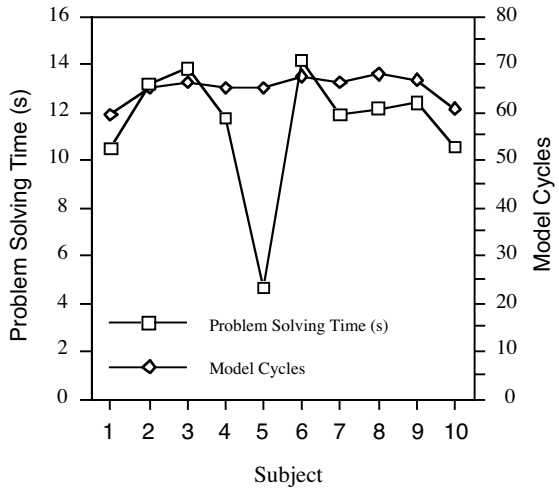
What is Learned?

- (All learning implemented as new rules)
- Where to look - implementation of Choose-component; and creation of Attend and additions to Attend
- What stimuli mean - implementation of Comprehend (and lower operations)
- Augmentations to the state from previous problem solving
- Huge amounts of transfer

General Results

- Does the task
- General Strategy — sequential components checking — emerges from the interface representation, consistent with Ss protocols
- Final ('fully chunked') behaviour reflects this strategy, behaving as if it were simply a recognition (immediate response) task

Average RTs by Subjects

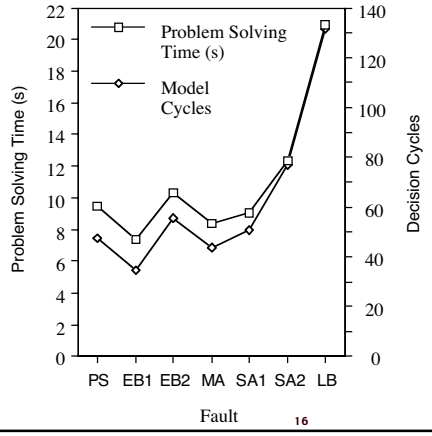


The data

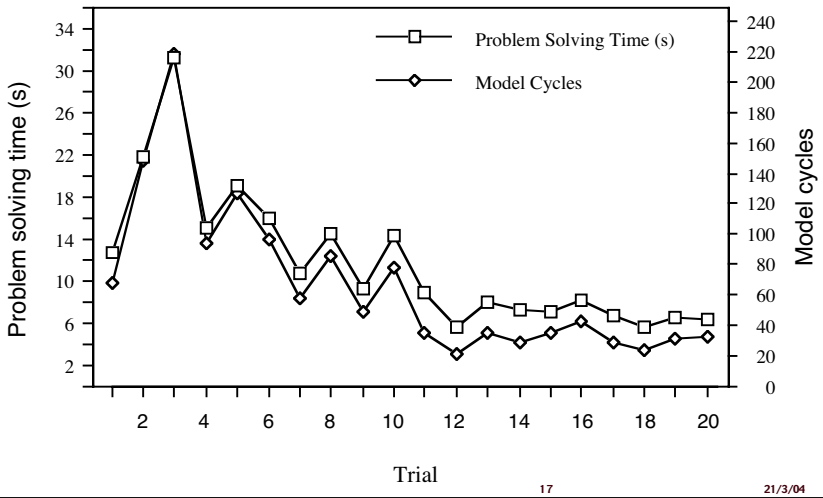
- 10 subjects solved
- 20 problems
- Each subject saw a different series of problems
- Problems sampled with replacement (nominally)
- RTs and answers recorded
- Incorrect trials discarded
- Some comments taken at end of trials

RTs by Fault Type

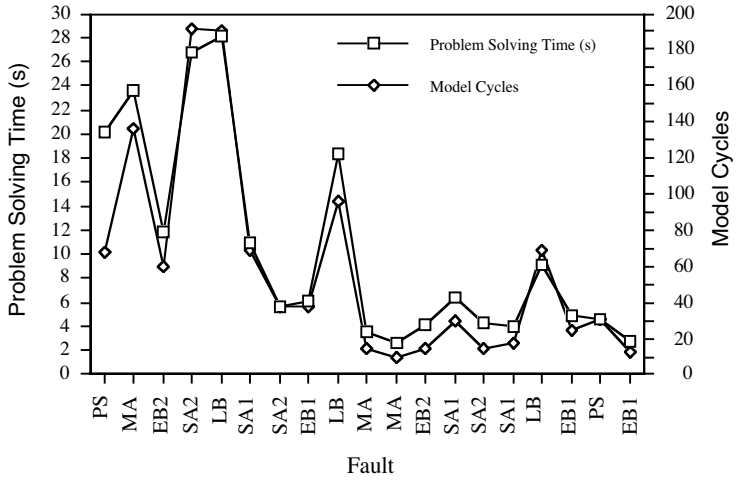
- Accounts for 90% of Ss' RT variability



RTs by Trial Number



Matches RT by Individual's Trials (s9)



Learns like No Other Model Tested with Data (!?)

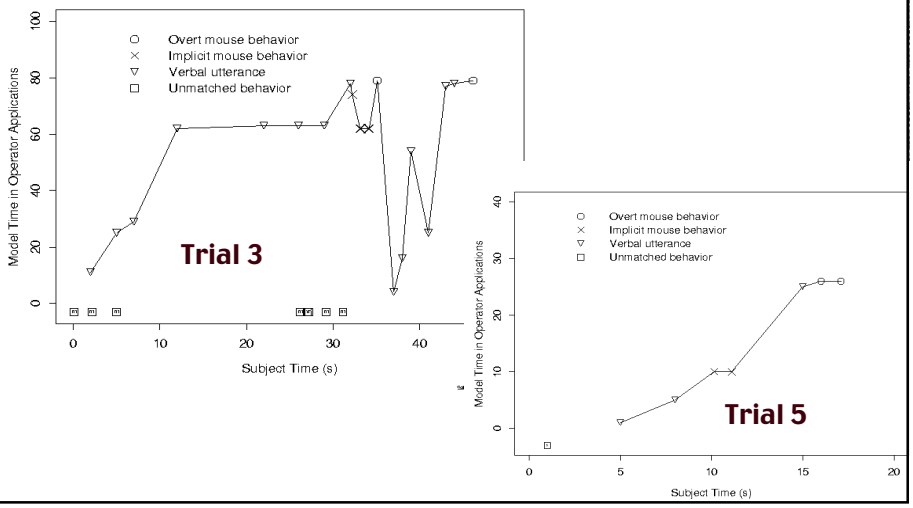
∴ No model with automatic learning, tested in detail across tasks while learning

- Able does not do transition on the fly
- Anderson's tutors just add rules
- VanLehn looked at new rule acquisition but added rules by hand
- Altmann ('99) programming model does this with recognition of objects

Data and Regularities Left Behind

- Modelling the perceptual improvements in motor skills omitted
- No account of *initial* learning of the task
- Model accounts for < 10% of the variability for some subjects (2 out of 10)
- 2nd trials on a problem are too fast in the model; Verbal protocols not reported here

Evidence for Reflection in Participants



What Can Diag-Soar Tell Us About Reasoning with Diagrams?

- Our subjects learn and **only** learn the diagram information that is relevant to the context of each stage of the problem-solving
- The model supports that subjects still use the diagram information in a cyclical, iterative fashion as an external resource to support the problem-solving sequence
- Result is recognition-driven problem solving, rather than model-driven behaviour arising out of problem solving
- Soar's chunking models transfer in this task

Where Next ?

- Model transfer on a fine level of detail
- Explaining where learning may have mismatched
- Apply to a more dynamic task such as dTank (a simple tank game)
- Modeling the type of reflection suggested in the protocols

Thank you

- Ritter, F. E., & Bibby, P. A. (accepted pending revisions). Modeling how and when learning happens in a diagrammatic reasoning task. To *Cognitive Science*.
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