A model of planning in human complex problem solving

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The goal

1. Understand how people form plans when solving complex problems
2. By only looking at behavior (no introspection or verbal reporting)
3. Using a computational, psychologically plausible model

The task

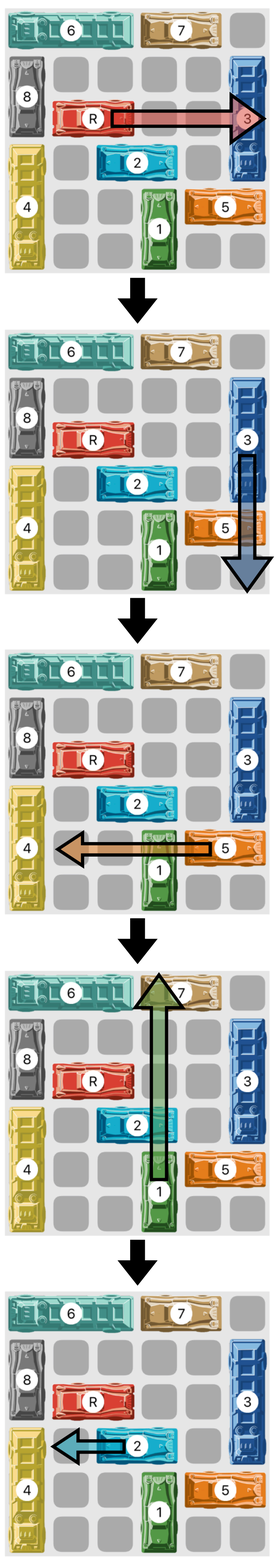
Requirements:

- Complex yet tractable
  - Need to plan multiple steps ahead
  - Tractable state space
  - Optimal solutions available
- Minimal perceptual effects
  - Minimal pattern detection [3]
- Minimal social component
  - Single player
  - No language
- Fun
  - Popular game

⬇

Rush Hour ([1-3])

The model



1. Find the move that solves the puzzle
→ this is the **goal**

2. Find which cars are blocking this move
→ unblocking the blue car is the next **subgoal**

3. Find a move that moves the blue car out of the way of the red car
→ moving blue 2 down unblocks the red car

4. Find which cars are blocking this move
→ unblocking the orange car is the next **subgoal**

5. Find a move that moves the orange car out of the way of the blue car
→ moving orange 3 left unblocks the blue car

6. Find which cars are blocking this move
→ unblocking the green car is the next **subgoal**

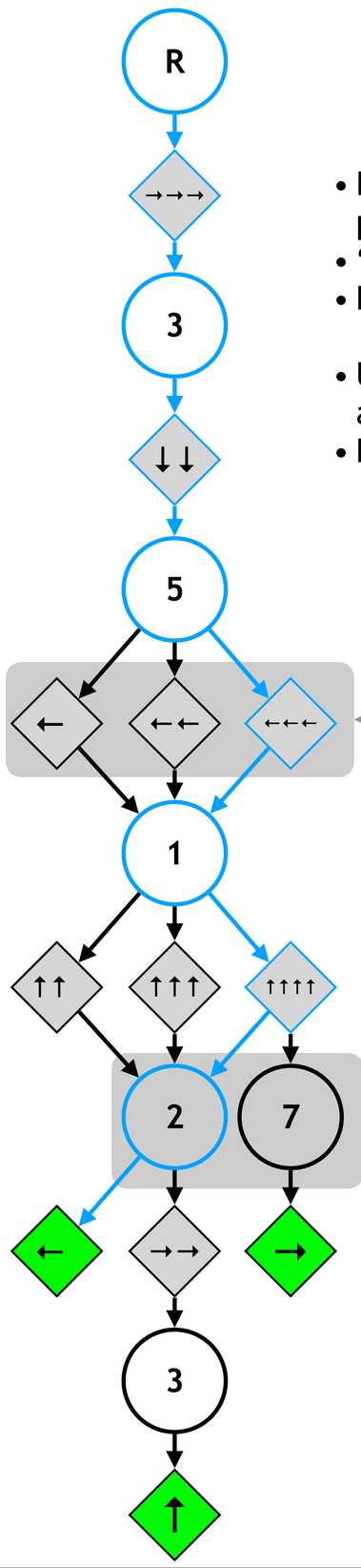
7. Find a move that moves the green car out of the way of the orange car
→ moving green 4 up unblocks the orange car

8. Find which cars are blocking this move
→ unblocking the green car is the next **subgoal**

9. Find a move that moves the cyan car out of the way of the orange car
→ moving cyan 1 left unblocks the green car

10. Find which cars are blocking this move
→ no cars block this move so we stop here

The representation



AND-OR tree

- Represents all possible plans the model could propose
- "Unravel" from bottom up to find plans
- By itself, not sufficient to guarantee a solution
  - Replanning is almost always necessary
- Used in early AI development to create automated problem solvers ([4-5])
- Has not seen any use in cognitive science

OR nodes

- Decisions
- Represent moves that unblock the parent car
- Either one unblocks the parent
- Subject plans along one of these

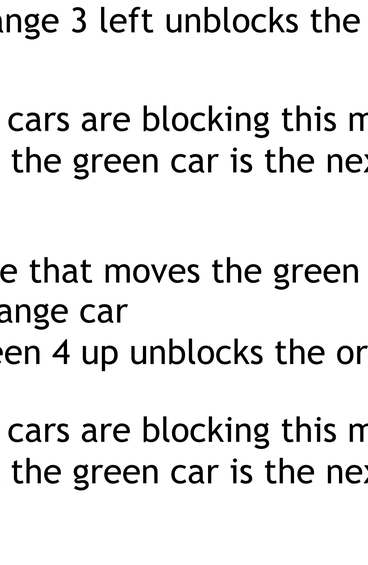
AND nodes

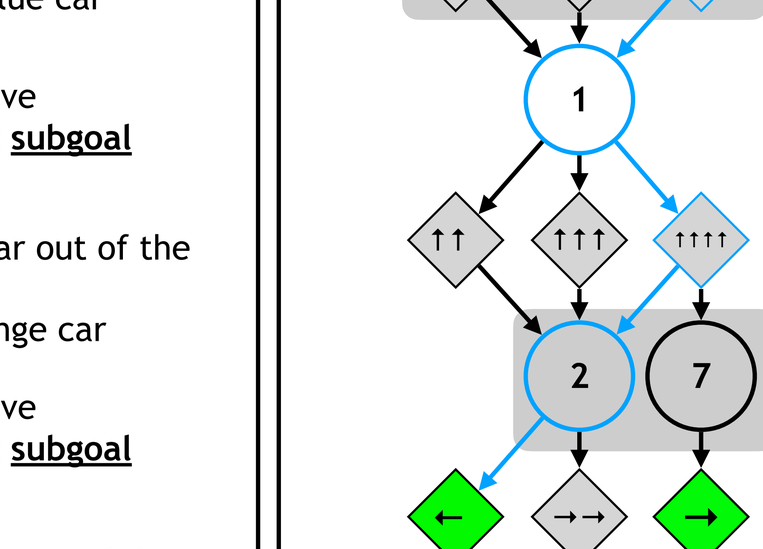
- Subgoals
- Represent cars that have to be unblocked
- All must be unblocked before parent move is possible
- One subgoal considered at a time
  - Exponential branching otherwise

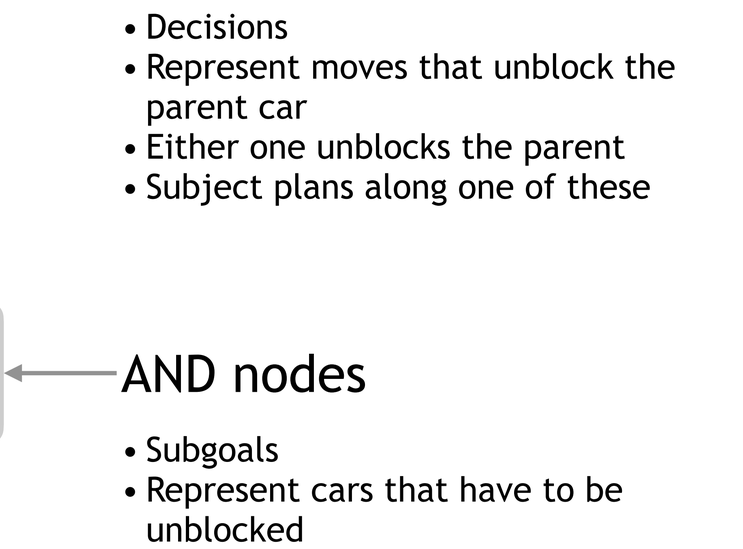
The results

Model fitting

1. Get AND/OR tree
2. Propagate probability according to parameters
   - γ : stopping probability
   - $\mathbf{h}$: heuristics to decide which AND/OR node to expand
3. Apply lapse rate λ
4. Find parameters that maximize log-likelihood sum of all moves a subject makes







The references

[1]:Bockholt, M., Peters, O., Narciss, S., & Zweig, K. A. (2018). Analysis of human problem solving drafts: a methodological approach on the example of Rush Hour. In CogSci.
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[3]:Bockholt, M., & Zweig, K. A. (2015). Why is this so hard? Insights from the state space of a simple board game. In Serious Games: First Joint International Conference, JCSG 2015, Huddersfield, UK, June 3-4, 2015, Proceedings 1 (pp. 147-157). Springer International Publishing.
[4]:Pearl, J. (1984). Heuristics: intelligent search strategies for computer problem solving. Addison-Wesley Longman Publishing Co., Inc..
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