Mouselab-MDP: A new paradigm for tracing how people plan

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Key points

- Planning is an unobservable cognitive process.
- Studying unobservable things is hard.
- Our novel paradigm tracks participants' information gathering in a planning task.
- This data sheds new light on pruning.
- We release the paradigm open-source as a jsPsych plugin [1].

Background

- Many problems require planning into the distant future. Brute force search is intractable, thus people must rely on **approximate planning strategies**. Previous work has identified abstract planning strategies based on patterns of human errors [2].
- **Process-tracing paradigms** externalize cognitive processes. In the "Mouselab" paradigm [3], a participant clicks on the cells of a matrix to inform a betting decision. We apply this idea to MDPs.

Example code

This CofeeScript code generates Fig. 1a.

```
trial =  # a trial is defined by a JS object
  type: 'mouselab-mdp'  # use the jsPsych plugin
  graph:  # defines transition and reward functions
    B:
      up: [5, 'A']  # action: [reward, next_state]
      down: [-5, 'C']
    A: {}  # terminal states have no actions
    C: {}
  layout:  # defines position of states
    A: [1, 1]
    B: [1, 2]
    C: [1, 3]
  initial: 'B'  # initial state of player
  stateLabels: {A: 'A', B: 'B', C: 'C'}
  stateDisplay: 'always'  # never, hover, click, always
  edgeLabels: 'reward'  # can be an arbitrary mapping
  edgeDisplay: 'click'  # never, hover, click, always
  edgeClickCost: 1  # subtracted from score whenever
                    # an edge is clicked
```

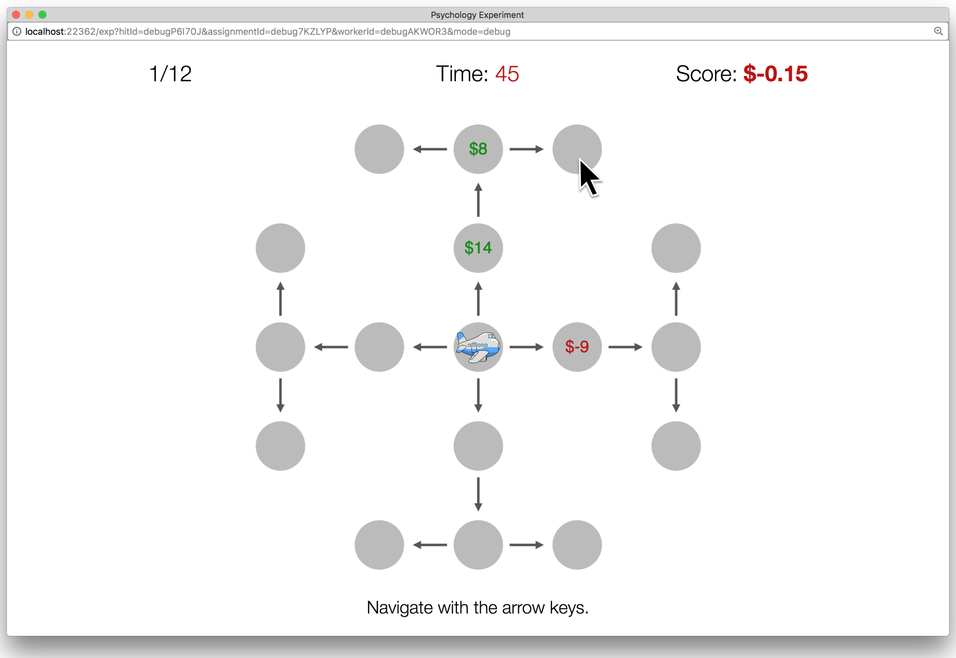

Figure 1: (a) See **Example code**; (b) a programatically generated layout; (c) rewards displayed on hover.

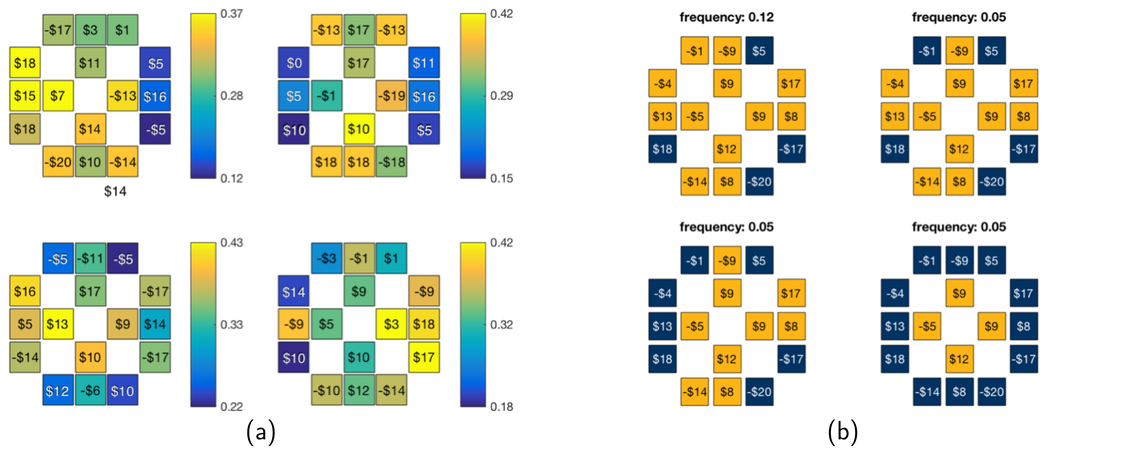

Figure 2: Human clicking patterns reveal pruning strategies. Each subplot shows the location and monetary value of each state. (a) Colors indicate how often each state was inspected before the first move, for four MDPs. (b) The four most common click sets for one MDP. Inspected states are gold.

Experiment

- Proof-of-concept experiment run online ($N = 31$)
- Layout encourages pruning (center image)
- Reward at each state revealed upon click
- \$0.10 penalty for each click
- Minimum of 45 seconds per trial
- Clicking patterns provide **direct evidence of pruning**

Results

- Fewer clicks on states after large costs (Fig. 2)
- Effect varies smoothly with reward (Fig. 3)

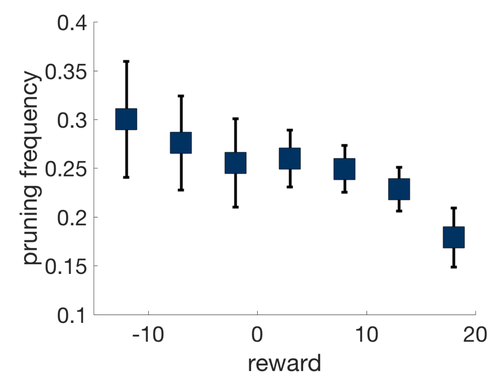

Figure 3: Frequency of pruning $\pm$1SEM given the reward at the stem of the branch. Pruning was defined as inspecting none of a branch's outer states (before the second move) after having inspected the reward at its stem (before the first move).

References

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[3] John W. Payne, James R. Bettman, and Eric J. Johnson. Adaptive strategy selection in decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14(3):534, 1988.

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