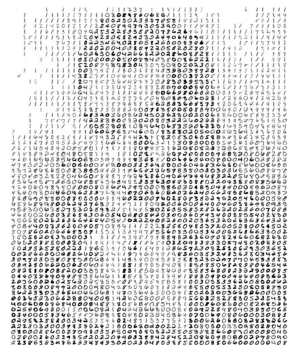

Mouselab-MDP: A new paradigm for tracing how people plan

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Contribution

Planning is a latent cognitive process that cannot be observed directly. To address this challenge, we propose a new paradigm that tracks participants' information gathering in a planning task. We show that this fine-grained data sheds new light on pruning strategies, and release the paradigm open-source as a jsPsych plugin [1].

Background

Many problems that people face require planning many steps into the future. Brute force search quickly becomes computationally intractable, thus people must rely on **approximate planning strategies**. Previous work has identified abstract planning strategies based on patterns of human errors [2]. However, a process model of human planning remains elusive.

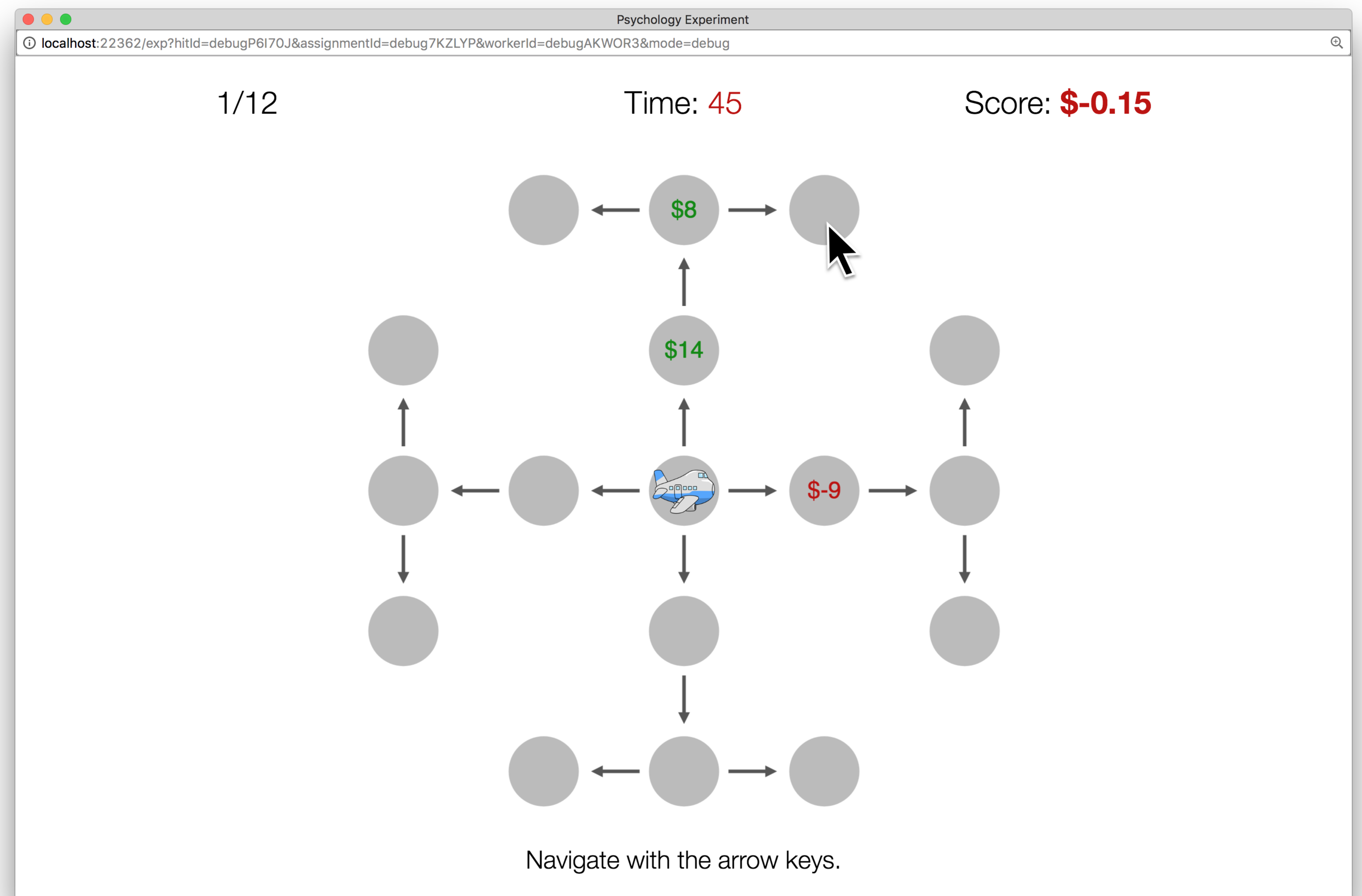
Process-tracing paradigms such as think-aloud protocols and eye tracking externalize some aspect of a cognitive process. In the "Mouselab" paradigm [3], a participant clicks on the cells of a matrix to inform a betting decision. By applying this idea to Markov decision processes (MDPs), we can gather fine-grained data that could inform process models of human planning.

Using Mouselab-MDP

A Mouselab-MDP experiment can be run online or in the lab. A JSON object specifies the MDP and its physical layout. Additional parameters control how information about the MDP is displayed. For example, the reward for traversing each edge could be visible only when the mouse is hovering over that edge (Fig. 1c).

This CofeeScript code generates Fig. 1a

```
trial =
  type: 'mouselab-mdp'  # use the jsPsych plugin
  graph:  # defines transition and reward functions
    B:
      up: [5, 'A']
      down: [-5, 'C']
    A: {}
    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'  # options: never, hover, click, always
```



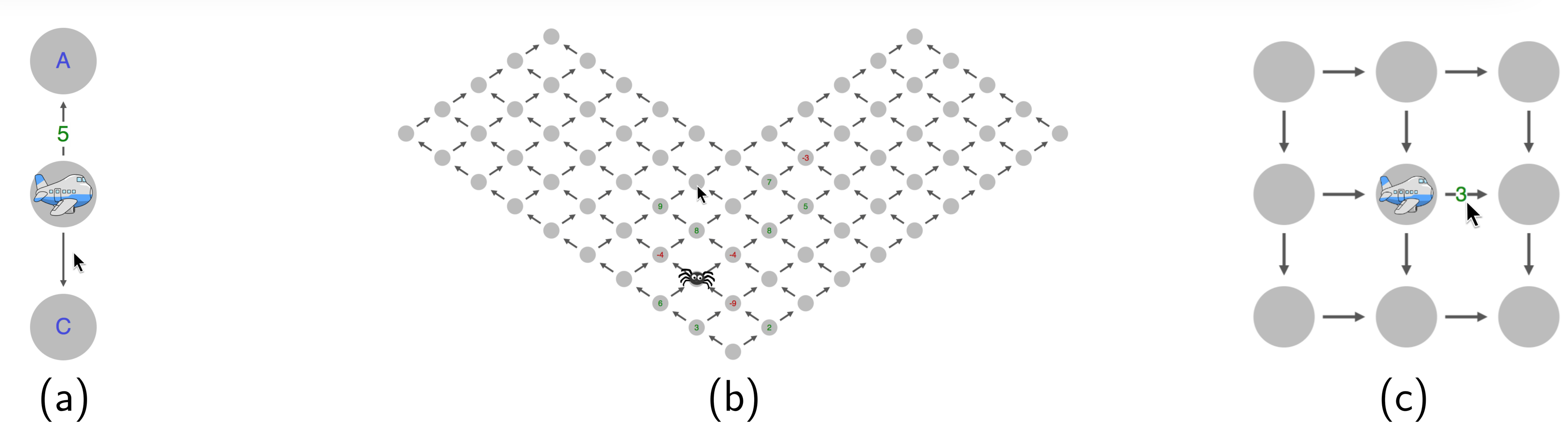


Figure 1: (a) example in **Usage**; (b) a programatically generated layout; (c) rewards displayed on hover.

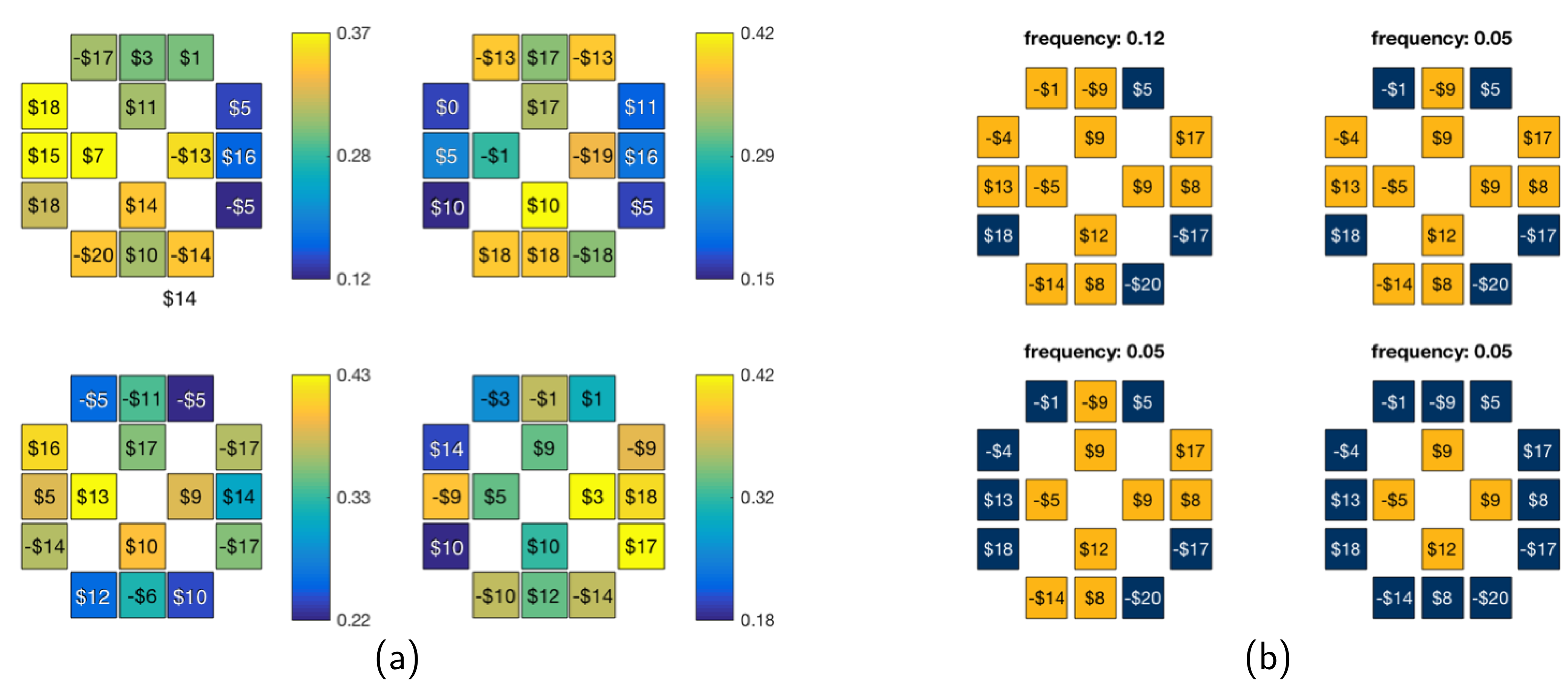


Figure 2: Human clicking patterns reveal pruning strategies. Each subplot shows the location and monetary value of each state. (a) Colors indicate how often each state was inspected before the first move, for four MDPs. (b) The four most common click sets for one MDP. Inspected states are gold.

Experiment

To demonstrate the paradigm in action, we designed a layout that encourages pruning (center image). 31 participants completed the online experiment. We set `stateLabels` to be the rewards associated with the edge leading to each state. We set `stateDisplay` to 'click' and `stateClickCost` to 0.10; thus participants could click on a state to reveal the reward for traveling to that state, at the price of $0.10. Participants were required to spend at least 45 seconds on every trial to prevent time cost from discouraging participants from clicking and planning.

Our results provide **direct evidence of pruning**: participants were less likely to click on states after large rewards (Fig. 2). This effect **varies smoothly with reward** (Fig. 3).

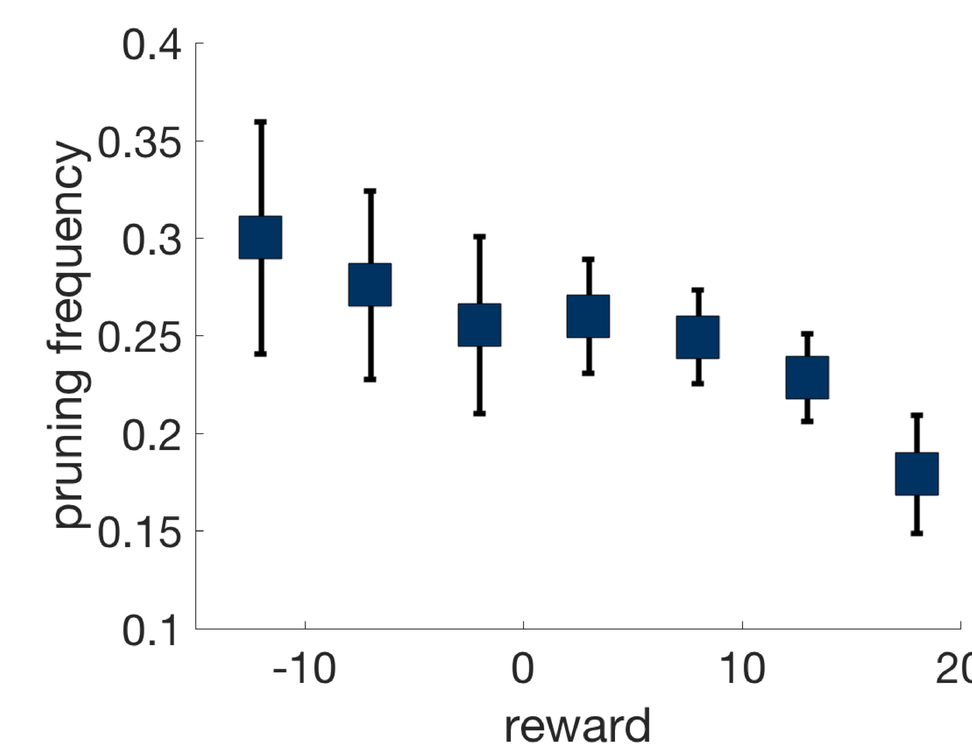


Figure 3: Frequency of pruning $\pm$1SEM given the reward at the stem of the branch. Pruning was defined as inspecting none of a branch's outer states (before the second move) after having inspected the reward at its stem (before the first move).

References

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