PCS

COGSCI
THE ANNUAL MEETING OF THE COGNITIVE SCIENCE SOCIETY

Reviews of 1527 - *"A resource-rational analysis of human planning"*

Reviewer 4 (coordinator)

Type of Submission

Cognitive Science, Psychology

The Review

All three reviews are quite thorough and I won't repeat their points here. I simply encourage the authors to take seriously the questions, suggestions, and criticisms from this thoughtful group of well-qualified experts when revising this paper and in carrying the research forward. It is quite clear the research is original and technically sound, but I also resonate with the concern that this particular paradigm is so knowledge lean and abstract that it barely qualifies as "planning" at all, and this will serve to decrease the breadth of interest in this research within the cognitive science community.

Reviewer 1 (reviewer)

Type of Submission

Cognitive Science, Computer Science, Psychology

The Review

I liked this experiment and the meta-planning model and thought the paper was clear novel and well written. I would overall recommend the paper be accepted as a talk.

In general, I found comparison with extant proposals of how people plan was elegant and convincing for the most part but was less convinced by the framing that the task tests "cognitively" bounded planning, since the constraints here are imposed by the costs of revealing nodes rather than performing computations. I think there needs to a be a little more setup to link the optimisation over costs of revealing node information to optimisation of which computations to perform during a cognitive planning episode. There's a kind of implicit suggestion that the meta-planning algorithm in the head faces a situation like the spider - i.e., structure of the path tree is clear but the rewards can only

be revealed by performing computations. I'm struggling to map this to a real simple scenario. As a causal cognition researcher, I think a potentially more appropriate alternative (for the future) might be one where the structure rather than the rewards are initially concealed. Alternatively, the link to resource-rational cognition could be loosened, since this could be framed as an optimal active learning task, without bringing cognitive limitations in explicitly. The intro was a little wordy for what it did say, so space could be made to talk more about this conceptual linkage.

Results: I like to have seen a few basic descriptives of performance at the start of the results. What is the expected bonus for random responding and optimal behaviour? What did participants achieve? What was the spread?

Model comparison: I was confused about the use of aggregated data. In what way was it aggregated? One would expect node-revealing clicks to be strongly dependent on the preceding clicks and outcomes, so a count of all first choices, then all second choices etc, would seem to lose that structure in the data. It is not surprising that a flexible metastrategic model can fit counts of choices by people applying different strategies than any individual strategy model, since it presumably can distribute likelihood smoothly to mixed population data than the rigid strategy models. i.e., Do you also get a good fit if you use a weighted mixture of all the other strategies? That is, I'm not sure the aggregate comparison distinguishes between a population of people who each weakly optimise over planning strategies, or a population of people each rigidly apply a strategy, but where there are more people in the population who use better strategies. Why not do the fitting at the individual level, or at least to the long data with the appropriate trial context for each click? Also, I'd have liked a column for the number of parameters for each model and maybe a pseudo-R^2 column, this would help give a sense of the absolute adequacy of fit and relative flexibility of these models that might help convince readers who are not fans of AIC and BIC.

Minor:
"For all strategies, paths are explored in the order they would be traversed." - Why? A leaf-first final-destination-establishing strategy seems like a plausible competitor to me too. I have the intuition that in life we often pursue distal goals without fully accounting for all the intermediary steps they will entail. Getting a little off topic, this seems a little related to the paradox of happiness where we often end up enjoying the intermediary steps more than actually achieving the final target state we initially valued (perhaps it is boundedly rational to lump all rewards at the ends of paths even if the ground truth rewards come during the intermediate steps).

P1 - "discern between" - sounds a bit odd, maybe "distinguish between".

Reviewer 2 (reviewer)

Type of Submission

Artificial Intelligence, Cognitive Science

The Review

(1) the submission's originality and significance: very original work in an interesting area,
(2) technical soundness: as far as I can tell the modeling and experimentation is sound
(3) theoretical merit: helps to think about the strategies people use for planning (at least in terms of searching strategies--it does not tell us where the strategies for particular tasks come from)
(4) breadth of interest for the broad Cognitive Science audience: fits well in the conference, but may for some people be challenging to follow.
(5) clarity of writing: clearly written and reads well

summary
The authors of this article analyze the planning process by framing it in terms of a resource-rational process. They contrast different possible models and find that humans are quite optimal in their planning process in a virtual maze. They then test the predictions of this model by manipulating uncertainty in the environment, which should affect the amount of backward vs forward planning, and the data were consistent with these predictions.

main points
I think this is very good work, and the article is clearly written. The model comparison is elegant, and really helps to elucidate our understanding of when planning is optimal and when it is not.
I find it a bit difficult to evaluate the quality of the model fit because the predictive accuracy is relatively low. What exactly is being predicted?
The other thing I wonder about is how much differences in planning strategy actually lead to differences in payoff. Does it matter what strategy do you use for the amount of money you make? And is the strategy used correlated with the payoff people make? Could this explain when people do not rely on the optima strategy?
The model does not seem to take into account time, but the task has this interesting structure where the participant has to wait if s/he is too fast. Is this not a problem? Why not?

minor points
p.3 Why did you use 40 simulated trials? Why not more? And what is magical about this

particular number?

To what extent do these findings extend to other types of planning, e.g., the order in which to perform a sequence of actions or the solution of a puzzel?

Reviewer 3 (reviewer)

Type of Submission

Artificial Intelligence, Cognitive Science

The Review

This paper investigates the processes that people go through as they plan. It states that people perform planning by rationally allocating their cognitive resources to developing the plan. They ran an experiment where participants considered exploration vs. exploitation to maximize earned reward in a simple path-based environment. Their analysis supports the resource-rational analysis, with participants behavior most closely matching bounded-optimal planning as compared to breadth-first search, depth-first search, and a couple other alternates.

Overall, the paper addresses an important topic; however, there are some major flaws that, if addressed, would make the paper much stronger.

—writing
While the paper's prose was clearly written, there were still times when the paper is confusing. First, the descriptions and definitions of breadth-first, depth-first and progressive deepening searches were, at times, written in non-standard ways. The paper was also missing key things like definitions of all of the terms used in equation 4, etc.

—experiments
The experimental design decisions need to be more clearly explained and motivated.
(1) The paper should better explain why participants had to pay a fee to explore, instead of, say, introducing in some time pressure. It seems that the fee less directly maps to resource limitations than time pressure would have.
(2) The actual experimental results, not just the BIC measures, should be included in the manuscript.
(3) The domain is so simple as to, arguably, not really be a meaningful planning problem. It seems like it won't really get at people's resource-limited planning mechanisms since they can keep entire "plans" in this domain in working memory (and also visually see reminders of their planning state).
(4) Was the $1 cost to see a path reward taken from the participants' earnings? You should also include what their total "budget" was here.

—results
(1) In Figure 2a, the human graph doesn't match the two computational graphs. That should be fixed; it is misleading as is.
(2) For users to explain the results, the predictions of the competing computational approaches need to be better explained. Why does the bounded-optimal strategy skip ahead to a final destination, but the BFS doesn't? Why doesn't BFS terminate its search when the expected value of information drops below the cost of attaining that information? Can you give an example of this and how it differs from the bounded-optimal? Simple providing two equations for this algorithm (equations 5/6) isn't enough to give users the ability to understand those very important differences.
(3) Some version of means-end analysis should be considered as one of the competing approaches.

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