

General Comments in Response to Reviewers:

[Please see pg. 2 for point-by-point responses]

We very much thank the editor and all three reviewers for their careful consideration of our revised submission, and for their thoughtful comments. We have made some small changes to our preregistration in response to this feedback (detailed below). In addition to these changes, we have also updated our reference to Cen et al. (formerly cited as a preprint; now published in *Communications Psychology*).

We again thank the reviewers and the editor for their consideration of our manuscript, and we hope these changes satisfy any outstanding concerns.

Sincerely,
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O'Donoghue et al.

Revision: Disentangling the influences of curiosity and active exploration on cognitive map formation

The manuscript is substantially improved. The clarity of the question makes more sense, as does the relationship between active learning and curiosity. Most of the comments and concerns brought up by the reviewers have been addressed.

The question is very interesting and understanding more about how curiosity drives learning will add richness to our understanding of learning processes. On the other hand, my enthusiasm is still rather tepid. There is nothing seriously wrong with the methods, so on that front it can pass the registered report, but I'm not sure that these are the best methods to answer the question. I just don't feel confident that this paradigm would really give us a definitive resolution to the question.

Thank you very much for your feedback on our submission. We appreciate the concerns that you have raised, and we hope you will find that our attending to them has strengthened our report.

To me, asking people about how curious they are about an office or lounge doesn't really get at how curious they are about finding out about a specific thing in that environment, but more their general interest in offices and lounges. Perhaps this is more of a critique on the field of curiosity research – it is fairly new and the paradigms do not quite fit right – rather than this particular study, although it does suffer from the same shortcomings.

Thank you for raising this point. We agree that our curiosity measures are quite general, in that we will ask participants to rate their curiosity based solely on the room labels, and before seeing the rooms themselves (i.e., we do aim to index curiosity for particular types of environments, such as offices or lounges). We selected this particular measure (1) in effort to replicate Cen et al. (2024), who found that even such general, anticipatory curiosity states have a strong influence on exploration and on subsequent memory, as well as (2) because of its parallels to other commonly-used paradigms in curiosity research – such as the trivia paradigm (Gruber, Gelman, & Ranganath, 2014 *Neuron*) – which likewise investigate the effects of anticipatory curiosity on subsequent performance.

However, we do agree that more specific curiosity measures would be very useful to explore. In future research, we hope to extend the proposed paradigm to examine whether moment-to-moment fluctuations in curiosity (i.e., curiosity re: specific objects in the environment) are predictive of learning and cognitive map formation, as indexed by measures such as self-report (e.g., asking participants to think aloud as they explore) and neural activation (indexed by fMRI). We have not implemented these methodologies here,

because our present aims are to replicate Cen et al. (2024), and to determine whether anticipatory curiosity has a direct influence on memory; however, if we replicate Cen et al.'s findings, we do intend to explore them in upcoming projects.

To then rely solely on drawings also is very limited. The navigation field has moved on from only using drawings because they have substantial shortcomings, which I pointed out in my previous review. The scoring is only based on reviewer 1-5 ratings rather than objective measurements of locations of objects. The removal of the other tests makes the reliance on drawings even more central to the study.

This is certainly a valid consideration. We agree that sketch map drawings have limitations, and that the quality of participants' drawings is not necessarily reflective of their navigational ability. However, in the planned project, we are more interested in spatial memory (e.g., memory for which objects were in the room, and where they were positioned) than in navigation itself.

In future research, we do plan to extend the proposed paradigm to more fully examine whether & how curiosity influences navigational strategies & the flexible deployment of cognitive maps. To do so, we eventually plan to (1) expand the virtual environments themselves (so that they comprise complex multi-room structures rather than single rooms), and (2) employ more established measures of cognitive mapping ability (e.g., detour and shortcut navigation; note that these measures are not suitable for the present project because our virtual environments are single rooms without occlusion). We also plan to be transparent about these future directions and the limitations of our room drawing measure in the discussion of our Stage 2 submission.

However, we do also agree that a more objective measure of memory performance would be quite beneficial. With this consideration in mind, we now also plan to score participants' drawings according to their hit rate (calculated as $[\# \text{ correct objects} / \# \text{ correct objects} + \# \text{ objects missed}]$). Importantly, this measure is independent of drawing ability and depends solely on an objective facet of participants' memory (i.e., how many objects were actually in each room vs. how many objects participants correctly remembered). We do still plan to include subjective rater judgements for consistency with Cen et al. (2024); however, we will re-run our critical analysis twice (once with hit rate as the DV; once with subjective drawing accuracy as the DV) in order to determine whether rater subjectivity influences our results.

The authors say that people spend more time in rooms that they are curious about, and that later spatial memory is also better. One question is whether it is the curiosity that is leading to the better memory or whether it is an indirect effect of the amount of time spent and amount they looked around. I think the authors are making this conjecture. I would suggest some kind of mediation analysis to understand the nature of this relationship more carefully.

Thank you for raising this point. Here (as in Cen et al., 2024), we plan to statistically control for exploration duration because we want to rule out the possibility that any effects of curiosity on memory simply reflect the amount of time spent in high-curiosity rooms. Rather than exploration time, we are theoretically interested in exploration patterns: that is, whether curiosity energizes particular kinds of exploration that are conducive to learning about virtual environments.

These patterns might be at least partially reflected by variables such as path roaming entropy (Path RE). Indeed, in Cen et al. (2024), we conducted a mediation analysis which suggested that the effect of curiosity on memory may be at least partially mediated by Path RE; however, because the posterior mean and HDPI were quite close to zero, any mediation effect (if reliable) is likely to be modest.

Importantly, however, mediation analyses cannot fully address our critical research question (does curiosity directly benefit memory, or do the benefits of curiosity depend on the ability to actively engage in curiosity-driven exploration?) because curiosity-driven exploration is likely to be highly idiosyncratic, such that individuals choose to explore their environments according to their own hypotheses about those environments and/or their experiences of curiosity surrounding those environments (which are likely to depend on highly individualized factors such as personality, interests and exploration history, among others; see Markant & Gureckis, 2014 *JEP:General*, for related findings in the context of category learning). Variables such as Path RE could certainly reflect facets of these patterns, but cannot fully capture the influence of curiosity on participants' exploration trajectories. As such, beyond mediation analyses, our between-group active/passive manipulation is critical to explore our research question.