Towards real-world capable spatial memory in the LIDA cognitive architecture: Supplementary Information

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1. Comparison of hierarchical activation gradient-based route planning with human performance on the TSP task

In order to evaluate the plausibility of gradient-based multi-goal route planning, as described in the main text (see Figure 5), we have used data collected from participants recruited on Amazon Mechanical Turk, tasked with solving the travelling salesperson problem (TSP) in virtual reality environments. Data from 46 participants was analysed here. They were asked to mark all buildings in the 3D environment and then return to the building they started out with, using the shortest path possible (see (Madl et al., 2013) for details).

Each participant performed 5 trials in each of three types of environments: random (in which buildings were randomly distributed), clustered by looks (in which buildings of the same type, e.g. churches, were ensured to be grouped, close to each other), and clustered by distance (in which some buildings were placed close to build groups, regardless of their visual similarity).

Figure 1 shows participant performance, compared with a gradient-based route planner operating on a flat (single-level) representation. Interestingly, this non-hierarchical model seems to explain the human data well. As a caveat, it should be mentioned that participants were not checked for prior experience with 3D environments (an unknown percentage may have had trouble with the controls, falling back to the simplest strategy). Furthermore,

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this task is inherently more difficult in virtual reality, where cues important in real-world navigation are not available (e.g. depth information from stereo disparity, path integration / self movement information, etc.).

To avoid these caveats, we have replicated a real-world TSP experiment by (Wiener et al., 2009). This experiment was performed in a 6.0m x 8.4m room, with 25 different locations marked by boxes with symbols on them, as illustrated in Figure 2A. Subjects were given a 'shopping list' containing a number of different symbols, each of which denoted a location that they had to visit, and they subsequently had to plan the shortest route visiting all of these locations. Figure 2 shows subjects' performance at this task, and compares it with the simulated performance of an agent using the gradient climbing heuristic on two-level hierarchical cognitive map. The models performance closely accounts for human data, as can be seen from this figure, which substantiates the models cognitive plausibility.

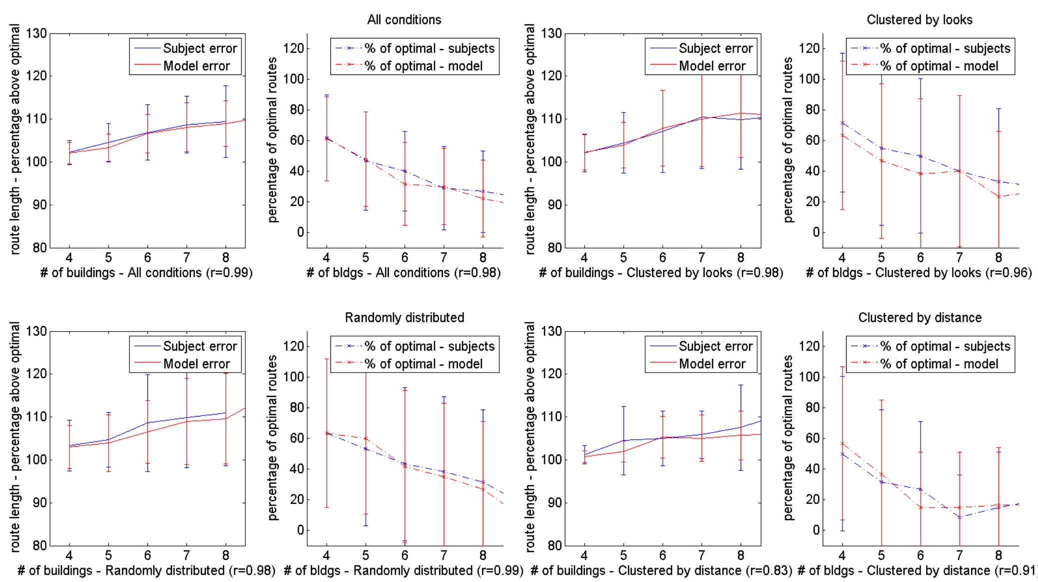

Figure 1: **Human performance in virtual reality, compared to gradient-based planning** on a flat grid of place nodes.

References

Madl, T., Franklin, S., Chen, K., Trappl, R., 2013. Spatial working memory in the lida cognitive architecture, in: Proc. international conference on

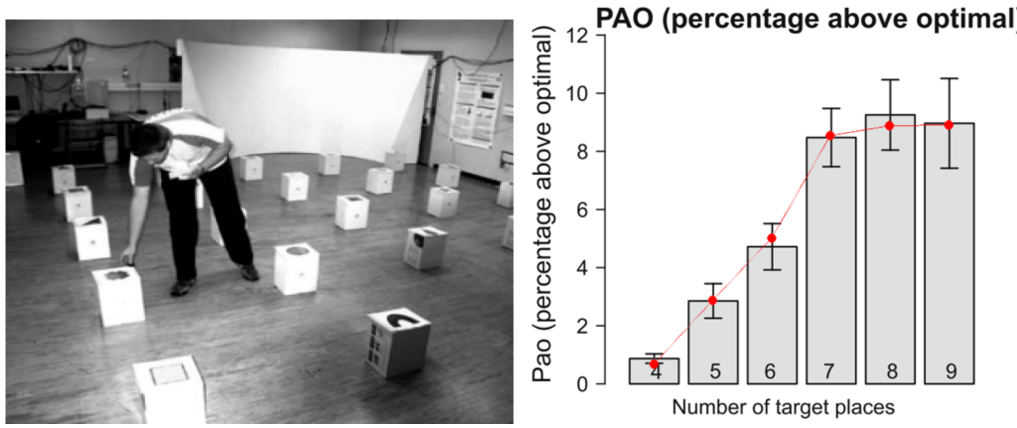

Figure 2: **Human performance in a real-world experiment (Wiener et al., 2009), compared to gradient-based planning,** on a hierarchical grid of place nodes. Figures modified from (Wiener et al., 2009) with permission.

cognitive modelling.

Wiener, J.M., Ehbauer, N.N., Mallot, H.a., 2009. Planning paths to multiple targets: memory involvement and planning heuristics in spatial problem solving. Psychological research 73, 644–58. URL: `http://www.ncbi.nlm.nih.gov/pubmed/18998160`, doi:10.1007/s00426-008-0181-3.