Grouping of places to regions does influence human route planning

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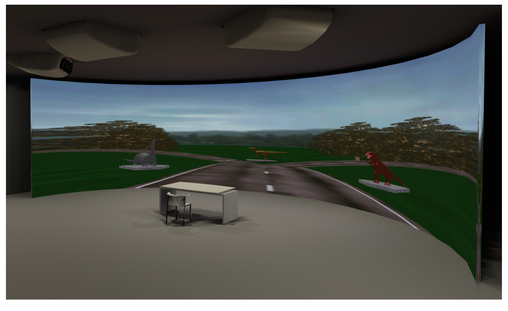
Introduction

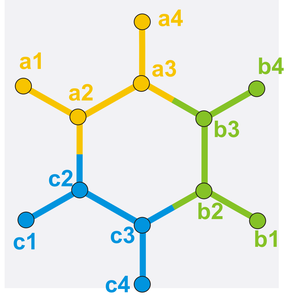
Hierarchal encoding of space influences distance estimations, directional estimations, spatial priming and recall of landmarks (e.g., Allen, 1981, Stevens & Coupe, 1978, McNamara, 1986, Hirtle & Jonides, 1985).
However, the ultimate purpose of an internal representation of space is to allow navigation, route planning, and directed movements. To our knowledge it is still an open question whether or not hierarchical representations of space do influence navigation.
By employing a navigation task in a virtual environment we provide additional evidence for the hierarchical structure of spatial representations, and their role in route planning.

Material & Methods

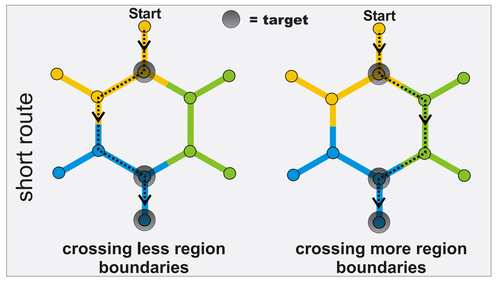


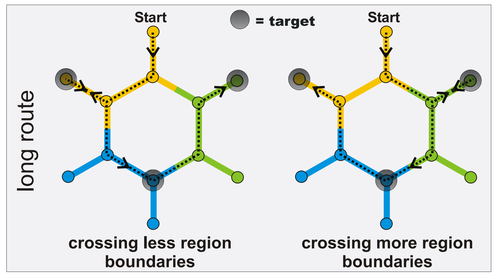
The setup:
Subjects were seated in front of a half-cylindric projection screen (7 m diameter, 3.14 m height) and navigated through a virtual environment (see figure below).

The experimental environment:
Six places were arranged in a hexagonal ring, the other six places could be reached by dead-end roads starting from the corners of the hexagonal ring. While each place could be identified by an associated object (a1 - c4), the places were grouped into three different semantic regions according to the object category of the single landmarks (animals, buildings and cars; see colors in the figure to the right). For an earlier version of this environment see: Gillner & Mallot, 1998.



The experimental procedure:
After an exploration- and training-phase subjects were asked to find the shortest route connecting three places (targets) within the environment. The test routes featured two optimal solutions of equal length that only differed in the number of region boundaries they passed by (see figure below).



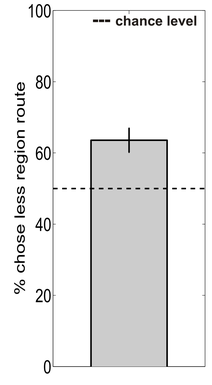


Depicted in the figures are the alternative optimal solutions for both types of test routes (short route, long route). In both route types one of the solutions crosses more region boundaries than the alternative (colors represent regions). There were six rotationally symmetric variants for each route type.
Subjects navigated all variants once for each of two blocks.

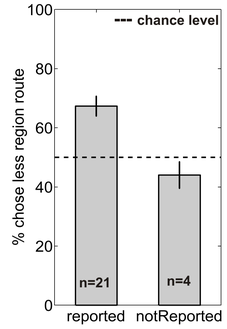
Results

Variable of interest:
In the test routes subjects could choose one of two equally long routes. Here we evaluated whether or not subjects preferred the route that crosses fewer region boundaries.

Results:
An ANOVA did not reveal any main effect on the route-type, experimental block or variant, nor interaction. We therefore collapsed data across route-types, blocks and variants. Subjects preferred the route that led through fewer regions in 63.6% of the trials (t-test against chance level (50%): $t(24) = 4.0$; $p = 0.001$).



21 out of 25 subjects reported after the experiment that they had detected the regions. If the performance of those subjects was evaluated separately, the effect of regions became even stronger (see reported-group): they chose the route through fewer regions in 67.3% of the trials (t-test against chance level (50%): $t(20) = 5.1$; $p < 0.001$). Although performance of the reported-group was not significantly different from the not-reported-group the trend is obvious.



Conclusions

We demonstrated the influence of regions within an environment on human route-planning behavior in an active navigation experiment.

- we therefore conclude that this grouping of spatial relations to regions is present in the internal representation of space.
- route planning is based on region-connectivity, not place-connectivity alone.
- although not statistically ensured, subjects have to consciously perceive regions to establish a hierarchical representation of space.

This work provides additional evidence for the concept of hierarchical representations of space.

We suggest that planning routes from the current location to a goal uses coarse space information (regions) for the goal but fine space information for the starting point.

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