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# Forgetting rate of topographical memory in a virtual environment

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## Background

It is well admitted that spatial knowledge of large-scale environments is organized into route or survey representations (Thorndyke and Hayes-Roth 1982; Montello 1998; Allen 1999). The route representation consists in the memory trace of the sequence of landmarks encountered along a specific route and of the turns associated with each landmark. The survey representation is considered as being map-like, allowing direct access to the global layout of an environment. While extensive research has been devoted to the retention of verbal knowledge, very little is known about the retention of spatial knowledge. The available data show no systematic decline of performance in topographical memory for a long-term period. However, these data were gathered through a limited set of tasks (mainly tapping survey-type memory) performed in real-world environments, which were not entirely controlled from a methodological point of view. For these reasons, in the present study the forgetting rate of route and survey memory was investigated in a virtual environment.

## Method

The present study involved 16 male and 16 female young participants matched for level of education and age, and used a complex town-like virtual environment presented using a desk-top (monitor) display. The experiment comprised a learning phase followed by four testing phases performed 5 min, 1 week, 1 month and 3 months later. During the learning phase the participants followed repeatedly a fixed well-learned route, from which they were required to build route then survey knowledge. Two route tasks (number of turns and travel time between two unseen landmarks along the route) and two survey tasks (pointing and Euclidean distance to unseen landmarks) were administered to the participants (see Fig. 1). The first testing phase evaluated the initial level of route and survey memory while the other three phases, which were performed without additional learning but with different series of items, evaluated the forgetting rate of route and survey knowledge.

In the Route Memory Task 1, the participants were placed at a location in the environment along the previously learned route from which they had to estimate, following the route, the number of turns to take from the current position of the observer to the target building. On the top of the screen an image of the front of the target building was presented. On the bottom of the screen a slider was shown, with the two numbers aside reminding the possible range of values in number of turns. The participants were asked to move the cursor to a position corresponding to the estimated value by clicking on it. They were free to rotate their point of view before giving their response, but no translation was possible. Following their response, the participants were dropped at a different location of the environment for a next trial.

In the Route Memory Task 2, the participants were placed at a location in the environment along the previously learned route from which they had to estimate, following the route, the route distance from the

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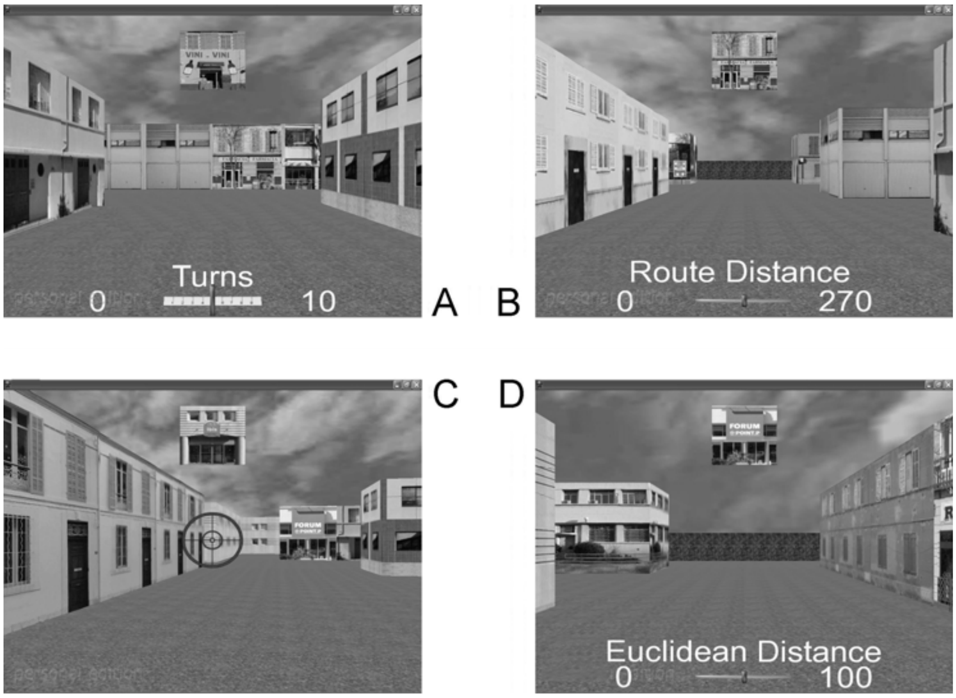


**Fig. 1** Sample of stimuli presented during the experiment:
a Route Memory Task 1;
b Route Memory Task 2;
c Survey memory Task 1;
d Survey memory Task 2

current position of the observer to the target building. On the top of the screen an image of the front of the target building was presented. On the bottom of the screen a slider was shown, with the two numbers aside reminding the possible range of values in virtual meters. The participants were asked to move the cursor to a position corresponding to the estimated value by clicking on it. They were free to rotate their point of view, but no translation was possible. Following their response, the participants were dropped at a different location of the environment for the next trial.

In the Survey Memory Task 1, the participants were placed at a location in the environment along the previously learned route, from which they had to point to the target building. On the top of the screen an image of the front of the target building was presented. In the center of the screen a sight was shown; the participants were free to rotate their point of view, but no translation was possible. They were required to move the cursor to a position corresponding to the estimated value by clicking on it. Following their response, the participants were dropped at a different location of the environment for a next trial.

In the Survey Memory Task 2, the participants were placed at a location in the environment along the previously learned route, from which they had to estimate the euclidean distance from the current position of the observer to the target building. On the top of the screen an image of the front of the target building was presented. On the bottom of the screen a slider was shown. The two numbers aside the slider remind the possible range of values in virtual meters. The participants were asked to move the cursor to a position corresponding to the estimated value by clicking on it. They were free to rotate their point of view before responding, but no translation was possible. Following their response, the participants were dropped at a different location of the environment for a next trial.

## Results

For each kind of task, the amount of remembered knowledge was computed as a correlation index between the participants' estimates and the actual values. An ANOVA with gender as a between-participant factor, and task and session as within-participant factors, revealed a significant effect of task and of session. Although performance was worse for the survey than for the route tasks, it slightly declined with time for both kinds of knowledge. The interaction task x session was not significant, as there was no effect of gender.

## Conclusions

The analysis of remembered knowledge as a function of time revealed only a light decrease of both route and survey memories. Current experiments are investigating to what extent these kinds of memories are differentially affected by time if the participants are not given the possibility to reactivate their knowledge along the testing phases (i.e., in the absence of repeated testing). As a matter of fact, when the participants are tested only after learning and after three months, there is no possibility of "reconsolidation" of topographical memory (Nadel and Moscovitch 1997).

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