Geographic Slant Improves Navigation Performance in Virtual Environments

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1. Introduction

In our daily life we steadily have to solve navigation tasks in order to find our way in our environment. This requires a mental representation of our environment. This mental representation contains diverse information which can be used for different navigation strategies. Many cues are visual, like landmarks, optical flow (path-integration), or geographic slant.

In this experiment we examined whether geographic slant has an influence on the acquisition of a spatial memory and whether geographic slant as an additional source of information has an effect on the performance.

2. Experimental Environment

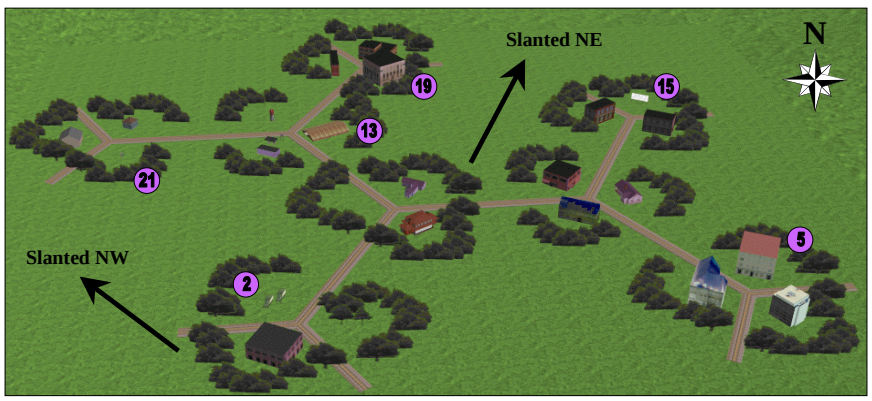
In this experiment we used a modified version of the virtual environment „Hexatown“ (*Gillner and Mallot 1998).* “Hexatown” has been put on a four degree (7%) slope.

The following versions are used as experimental conditions:
flat maze : No slant
slanted NW : 30 degree slant north-west
slanted NE : 30 degree slant north-east

The north direction was defined arbitrarily.

The virtual environment was presented on a large projection screen (a half-cylinder of 7 meter diameter and 3.15 meter height) (*van Veen et al. 1998*)

Pure rotations were simulated stepwise under mouse-control. Translations were simulated by pedaling an exercise bicycle with force-feedback.



Aerial view of “Hexatown” with goals

3. Experiment

• **Exploration task**
In this task the subjects learned 15 routes between 6 defined goals (marked by numbers in the aerial view). This ensures that the subjects had learned the virtual environment “Hexatown” and had built a spatial memory.

Aufgabe	Startpunkt	Ziel
1	15	5
2	15	2
3	15	13
4	15	19
5	15	21
6	5	15
7	21	2
8	2	15
9	13	19
10	13	15
11	5	2
12	19	15
13	2	13
14	21	15
15	19	5

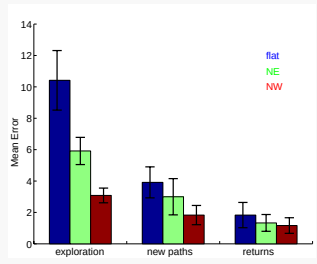
• **Pointing**
The subjects were released at a junction next to a goal. Their task was to point to another target. The subjects had to point from every junction at a given goal to all other goals, not presently visible. In all, 19 pointing tasks were performed.

• **The difference of altitude of the goals**
Pictures of two different goals were shown simultaneously on a computer monitor. In a 2 AFC-task, subjects had to decide which of the shown goals had a greater altitude in “Hexatown” (10 tasks).

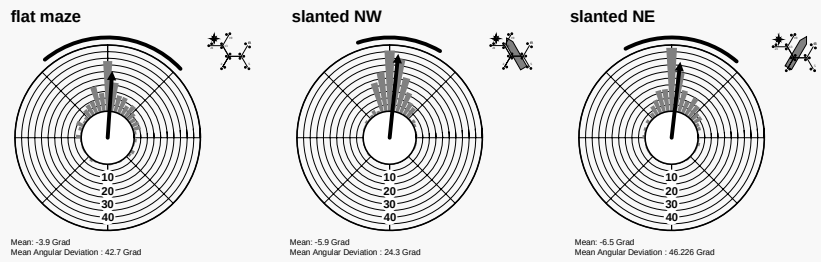
• **Drawing a map**
Finally the subjects were asked to draw a detailed map of “Hexatown”.

4. Results

• **Exploration task**
In the three different experimental conditions, the subjects showed different numbers of errors (flat maze 194 errors, slanted NW 73 errors, slanted NE 123 errors).
A three-way ANOVA (3 path types X 3 exp. conditions X 2 gender) showed a significant effect of
- way type ($F(2,60) = 27.69$, $p < 0.001$ ***)
- condition ($F(2,30) = 5.78$, $p = 0.008$ **).



• **Pointing from memory**
In the pointing tasks, we determined the errors in degrees.The plots show the distribution and mean circular errors from 19 trials and 12 subjects per condition.



The differences between the conditions are significant (circular F-Test):

flat maze / slanted NW	$p < 0.001$	***
flat maze / slanted NE	$p < 0.001$	***
slanted NW / slanted NE	$p < 0.001$	***

• **The difference of altitude of the targets**
Correct answers of the subjects in percent:
- slanted NW: 90,8 %
- slanted NE: 78,3 %

• **Drawing a map**

Orientation	NE	NW	SW	not determinable
Ebene	3	0	6	3
Nordost	6	0	2	4
Nordwest	2	5	1	4

5. Conclusions

• **geographical slant is used for spatial memory**

• **geographical slant supports learning of an unknown environment**

• **performance of the pointing task is better with a geographical slant**

6. References

1. **Sabine Gillner, Hanspeter A. Mallot** (1998) Navigation and Acquisition Spatial Knowledge in a Virtual Maze *Journal of Cognitive Neuroscience 10:445-463*

2. **Hendrick A.H.C. van Veen, Hartwig K. Distler, Stephan J. Braun, Heinrich H. Bülthoff** (1998) Navigation through a virtual city - Using virtual reality technology to study human action and perception *Future Generation Computer Systems 14:231-242*