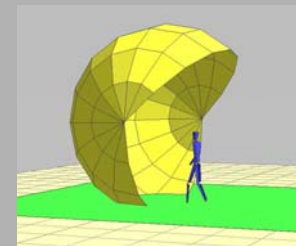




Quality and Barrier-Effects in Pointing in Reality and in VR of "Kindergarten" Childs

Michael M. Popp, Eva Neidhardt,
Melanie Lehmann
Human Factors Institute
Faculty of Aerospace Technologies
Federal Armed Forces University Munich
michael.popp@unibw.de

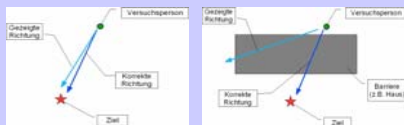


Introduction

Piaget and Inhelder (1975) and a later stage model offered by Siegel and White (1975) still represent the most popular ("classical") models describing ontogenetic development of orientation and navigation in large scale (urban) environments. Path integration as the process of collecting and inferring directional information during walking is not mentioned in these models as they emphasize more on explicit spatial knowledge. Siegel and White (1975) as well as Piaget and Inhelder (1948) would not expect Kindergarten children to be able to point to the starting point of a complex path they have just walked. As survey knowledge is postulated to precede this kind of pointing performance, the fact that adults perform well over chance level (Golledge, Dougherty & Bell, 1995; Popp, 1998) contradicts the "classical postulates".

Motivation

To learn more about the stages of orientation abilities we planned and performed an experiment with Kindergarten children at the age of 2 to 6 years. Spatial orientation was measured with a pointing task. The children were asked to walk through an unknown urban area and to stop and point to the piece of rock marking the starting point at several locations where the stone was not visible. Additionally, we were interested in the "barrier-effect" (Newcombe & Liben, 1982). Therefore some of the pointing locations were chosen close to visual barriers with respect to the correct pointing direction.



Experimental area

The experiment took place in the campus of our university in Neubiberg in the south east of Munich. The area consists of approximately 100 buildings, nested between dense vegetation with small paths and without any road names and other orientation aids. The area was new for our little experimental subjects.



Standardized measurement is difficult to obtain within this kind of study; hence we performed the experiment not only outdoors within the real university campus, but also in a VR environment.

The VR "NeuViberg" is a nearly perfect copy of the reality. It is shown to the subjects in form of an immersive 180° projection in our 5m VisionDome device.



Both birds-views show the experimental area with the starting point (red), the walking route and the different pointing locations (blue).

Subjects

34 children at the age of 4 to 6 (mean 5.1 years, 14 male, 20 female) participated in our experiment. They came from the university kindergarten and from an other kindergarten in a new built housing area near the university.



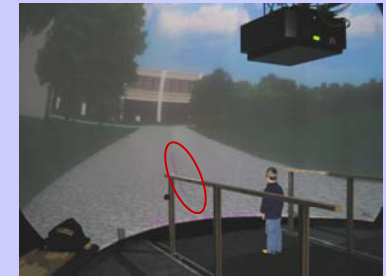
Task (reality):

Each child walked the same route through the terrain, guided by one experimenter. The whole walk takes 10 to 12 minutes. At the beginning of the route, the experimenter pointed to a nearby positioned piece of rock and told the child to remember this rock and its position well. After walking a few steps the rock was invisible for the rest of the whole route. From the starting point they walked to the 6 different pointing locations. At each place, first the pointing device was positioned. Then the child was asked to point by hand into the direction of the piece of rock and after that he was asked to use the pointer to mark the same direction. Both directions were recorded.



Task (VR):

Each child was positioned in the centre of the VisionDome, looking towards the starting point.



The experimenter demonstrated the appearance of the rotating scene and trained the use of the fixed pointer to indicate directions (see above) using the position of the piece of rock at the starting point. After that, each child walked virtually to the 6 pointing locations. At each point the scene started to rotate and the child was asked to say "stop" whenever the fixed pointer in the centre of the rotating scene pointed to the direction of the rock at the starting place. That direction was noted.

Interview:

After the walk and the VR experiment we asked the children and their parents if the children had experience with walking alone outdoors, if they walked to or from the kindergarten without their parents, and if they reach the kindergarten with their parents as pedestrians, by bicycle or by car. In addition we asked whether they used to play computer games.

Data:

Data analysis and statistical tests were performed with SPSS V13.0.

Results:

Interviews:

Parents and children differ in their answers to the question if the child walks outdoors alone. Only in 15 of 29 cases, the answer of the child was the same as the answer of the parents.

Anzahl	Eltern: Darfst Du alleine zu Freunden gehen?		Gesamt
	nein	ja	
Kinder: Gibt es Wege, wo du ganz allein hingehst?	nein	ja	
	6	13	19
	1	9	10
Gesamt	7	22	29

No child plays 3D computer games. 2/3 of them sometimes play 2D computer games.

Results (reality):

Quality of pointing:

In general the pointing quality of most of the subjects was not perfect.

Between the directions of pointing with the arm und using the pointing device at the same pointing place are differences. One fraction of these differences may result from the difficulties of the experimenters to measure the correct pointing direction observing only the direction of the arm of the children. Another source of differences was the difficulty of the children to understand the concept of rotating the pointer of the device in the direction they intended.

The statistical analysis of the observed differences show a significant correlation between the two pointing measures ($r=0.784$, $p=0.0$). The t-test of differences between the both measures (two-sided) was not significant ($p=0.368$).

We consider both methods of measuring the pointing direction to be equivalent.

Range of correct pointing:

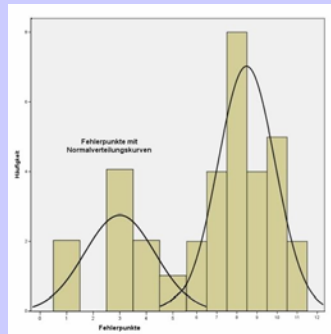
According to the work of Golledge, Dougherty & Bell, (1995) we consider pointing directions within the range of +/- 30° as correct.



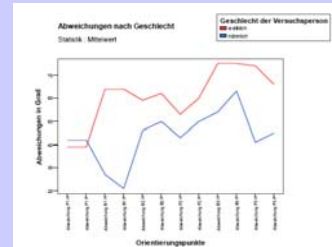
For all pointing places (with and without barriers) 41.3% of our subjects point correctly (+/- 30°), 58,7% failed to point to the starting point.

Two Groups:

Looking at the distribution of quality of pointing over all pointing places the histogram is twofold. One group performs significantly better than the other.



Dividing the quality of pointing results into male and female subjects showed a significant difference between the two groups. Boys performed significantly better than girls (t-test, two-sided, $p<0.005$).



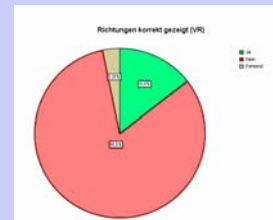
From the distribution of deviations from the correct pointing direction from pointing place to pointing place it can be shown that male subjects (with the exception of the first place) had always better results than the female subjects.

Results (barrier effect):

Looking at the pointing results at places without compared to places with barriers the results seem to show the effect, but the statistics fail to prove it. The pointing directions correlate significantly and the t-test (two-sided) was not significant ($p=0.11$).

Results (VR):

One of our assumptions was that the subjects behave similarly in the VR and outdoors. But the results show that the children behave significantly different (t-test, two-sided, $p<0,001$).



Our experimental subjects had great difficulties to understand the concept of adjusting their direction ideas in a virtual world, rotating around them. The comparison with the pointing results in the reality showed a significant deviation (t-test, two-sided, $p=0.000$).

Discussion

To sum up the results of the experiment: Children at the age of 4 to 6, hence in the "preoperational" stage of cognitive development, are able to point correctly to not visible goals even at a first contact to a formerly unknown area. This result is in contradiction with the model of Piaget & Inhelder and with the model of Siegel & White. The postulated barrier-effect of Newcombe & Liben is not supported by our results, yet our sample was small. Boys and girls differed significantly. The pointing performance in a VR was significantly worse, compared with the performance in reality. Experience with 2D computer games had no effect on the results. This differentiates the model of Piaget & Inhelder insofar as the ability to change the personal reference point develops indeed in later stages of cognitive development. Our experimental subjects had various problems and great difficulties to understand the concept of adjusting their direction ideas in a virtual world, rotating around them. The comparison with the pointing results in the reality showed a significant difference (t-test, two-sided, $p<0.001$).



Golledge, R. G., Dougherty, V. & Bell, S. (1995). „Acquiring spatial knowledge: Survey versus route-based knowledge in unfamiliar environments“. *Annals of the Association of American Geographers*, 85, 134-158.

Neidhardt, E. (2003). „Die ontogenetische Entwicklung von Raumkognition in Makroräumen – Pfadintegration bei Vorschul- und Grundschulkindern“. *Habilitation, Universität Marburg, Fachbereich Psychologie*.

Newcombe, N. & Liben, L. S. (1982). „Barriere Effekts in the cognitive maps of children and adults“. *Journal of Experimental Child Psychology*, 34, 1, 46-58.

Piaget, J. & Inhelder, B. (1975). „Die Entwicklung des räumlichen Denkens beim Kinde“. *Stuttgart: Ernst Klett Verlag*.

Popp M. M. (1998). „Zeigeverhalten, Landmarken und mentale Raumrepräsentationen“. In: Bülthoff H. H. et al. (Herausg.), *Beiträge zur 1. Tübinger Wahrnehmungskonferenz*, 27.02.-01.03.1998, Kirchentellinsfurt, Knirsch, S. 73.

Siegel, A. W. & White, S. H. (1975). „The development of spatial representations of large-scale environments“. In: Reese, H. W., „*Advances in Child Development and Behavior*“. USA, New York: Academic Press, Vol 10, 9-55.