Is More Less? How 3D visualization affects cognition

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Introduction

The use of 3D technologies in many applied areas is growing (Hirmas et al., 2014; Wilkening & Fabrikant, 2013). The specific type of 3D visualization may affect the way how people perceive and understand the depicted information (Špriňarová et al., 2015; Seipel, 2013). This study compares the Real and Pseudo 3D visualization of geographical data depiction with respect to the human perception, evaluation and interaction with the virtual geographical model.

Objectives

The Pseudo 3D visualization is displayed perspective-monoscopically on planar media and Real 3D uses both binocular and monocular depth cues secured by stereoscopy (Buchroithner & Kunst 2013). The virtual environments were generated in VRECKO software (see more details at http://vrecko.cz) and user interface consisted of passive 3D glasses, wide screen 3D projection and the combination of Wii RC and motion capture system.

Methods

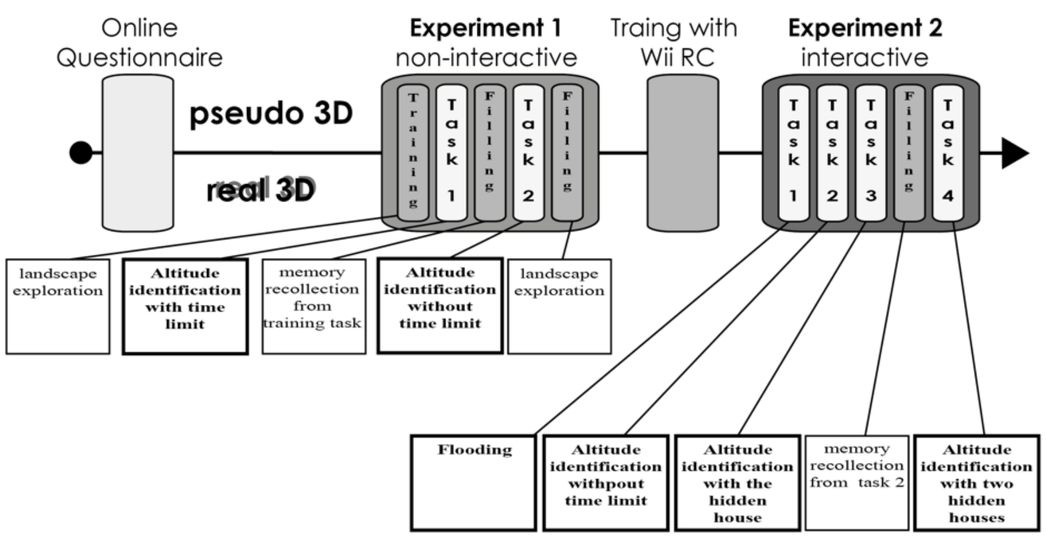
Participants

61 psychology students (42F-19M; age 19-31, m=23,24, sd=2,609)

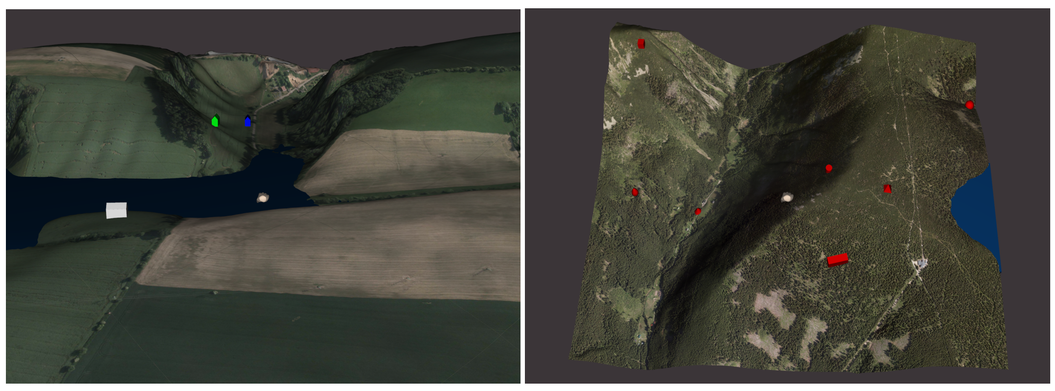
Procedure

Participants divided into two groups (Real/Pseudo 3D condition) were tested in two-phased computerized experiment regarding their ability to identify the altitude of the displayed landscape.

- Experiment 1 - non-interactive (non-manipulatable exposition)
- Experiment 2 - interactive (manipulatable exposition)



1) accuracy in the altitude identification (E1, E2)
2) time of responses (E1, E2)
3) participants' motor activity when searching for the solution (E2)
4) error rate - complete neglect of some objects in the scene (E2)



Task Examples (left – Exp. 1, Task1, right – Exp. 2, Task 2)

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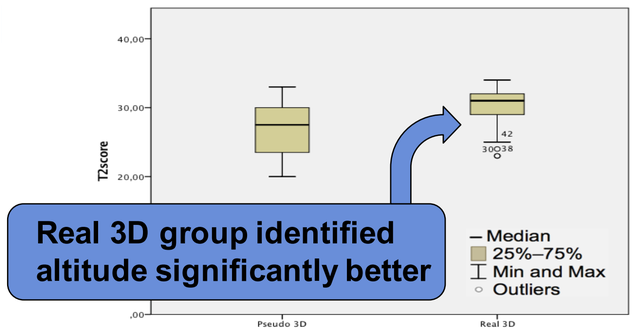
Results

Experiment 1 – Non-interactive part

Time According the Mann-Whitney U Test no significant differences were found in solving period (U= 391; p= ,304) between groups.

Accuracy The Real 3D participants were significantly better at identifying the altitude (U= 690,5, p = 0,001) than the Pseudo 3D group.

		P3D	R3D
Time	m	339,96	310,86
	med	327,97	306,05
	sd	113,90	88,70
Accuracy	m	27,11	30,54
	med	27,5	31,00
	sd	3,57	3,04



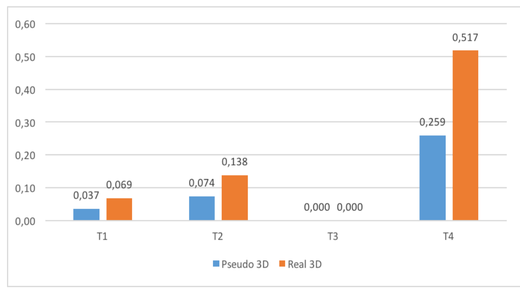
Experiment 2 – Interactive part

No significant differences (p>0,05) were found between groups in the matter of time, accuracy, motor activity or errors in all interactive tasks. Differences between groups in interactive Experiment 2 were flatten.

Exploratory Analysis

The number of participants, who completely neglected any target object in the interactive scene, was constantly higher in real 3D condition.

		Task 1		Task 2		Task 3		Task 4	
		Pseudo 3D	Real 3D	Pseudo 3D	Real 3D	Pseudo 3D	Real 3D	Pseudo 3D	Real 3D
Response time (s)	m	70	72,24	135,22	102,38	91,44	93,31	171,85	153,59
	med	68	60	92	95	78	81	142	150
	sd	35,28	38,62	92,97	52,03	52,83	46,97	102,26	79,86
Accuracy	m	4,33	3,83	3,48	3,76	2,63	2,69	3,85	3,93
	med	6	4	3	4	2	2	4	4
	sd	1,96	1,67	1,19	1,75	1,47	1,29	1,88	1,41
Error Rate	m	0,04	0,07	0,07	0,14	0	0	0,26	0,52
	med	0	0	0	0	0	0	0	0
	sd	0,19	0,258	0,267	0,351	0	0	0,526	0,79
Motor Activity	m	227,44	251,86	346,41	231,48	349,56	453,38	497,48	292,17
	med	139	248	220	119	200	279	263	201
	sd	256,34	180,26	391,69	250,15	365,11	515,043	567,94	264,32



Discussion

Real 3D visualization which includes binocular depth cues was supported as a promoter of a better spatial identification in the non-interactive 3D geographical visualizations on the perception level. On the interactive level, the missing binocular cues in Pseudo 3D visualization were compensated by other depth cues (e.g. motion parallax) and the differences were flatten. Despite the different number of visual cues in Real respectively Pseudo 3D visualization, the motor searching activity did not differ significantly. The highlight of the study is the observed increased number of neglected objects in the Real 3D condition in Experiment 2, which could imply the tendency of Real 3D users not to reach complex overview about displayed content.

Conclusion

The issue of the 3D visualization remains ambiguous. The Real 3D and Pseudo 3D visualization, although informationally equivalent, offers different message when interacting with them. The Real 3D vision can enhance the ability to detect the altitude distribution, but concurrently can also increase the risk of neglecting some important aspect of the exposition in interactive tasks. This should be considered as a crucial aspect of human-machine interaction, especially in applied areas of human factors.

References

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