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The complex tasks with 3D cartographic visualization – the role of immersion and interactivity

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Motivation

- The use of three-dimensional geovisualization is pushed by:
  - the technology development (Widescreen 3D projection, Active Shutter 3D Glasses, Virtual reality helmets),
  - users' demands in different areas of human activity.
- The usability and users issues of 3D are still ambiguous. (e.g. Livatino et al., 2015; Seipel, 2012; Beurden et al., 2010).

- Grant No. MUNI/M/0846/2015, "Influence of cartographic visualization methods on the success of solving practical and educational spatial tasks"
  - Funded by Masaryk University, Czech Republic.

Research questions

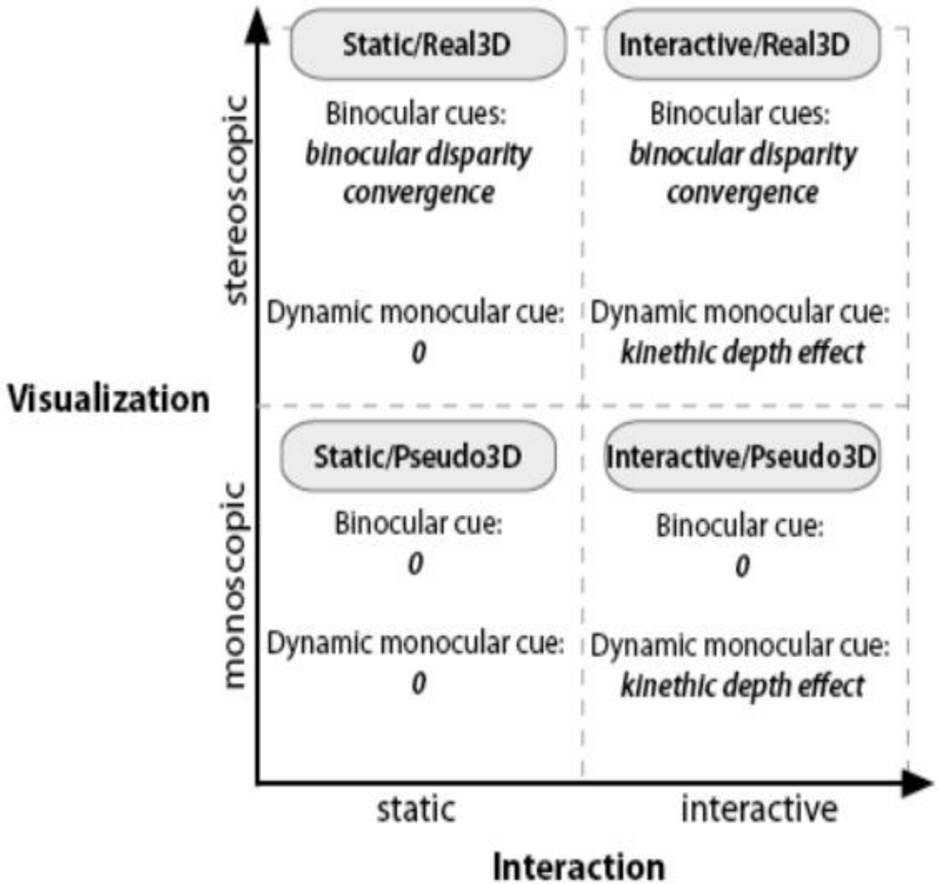
- Based on the realized studies (Juřík et al, 2017; Sprinarová et al., 2015; Herman and Stachoň, 2016; Klippel et al., 2011)
- Focus on the perception of the 3D terrain geovisualizations displayed in real (stereoscopic) 3D and pseudo (monoscopic) 3D visualizations and also regarding the static and interactive types of geovisualization.

    - **Can the type of 3D visualization (monoscopic/stereoscopic) influence the performance of the users?**
    - **Does the level of interactivity influence the usability of 3D visualization?**
    - **What is the role of personal spatial abilities in the process of solving 3D visualization tasks?**

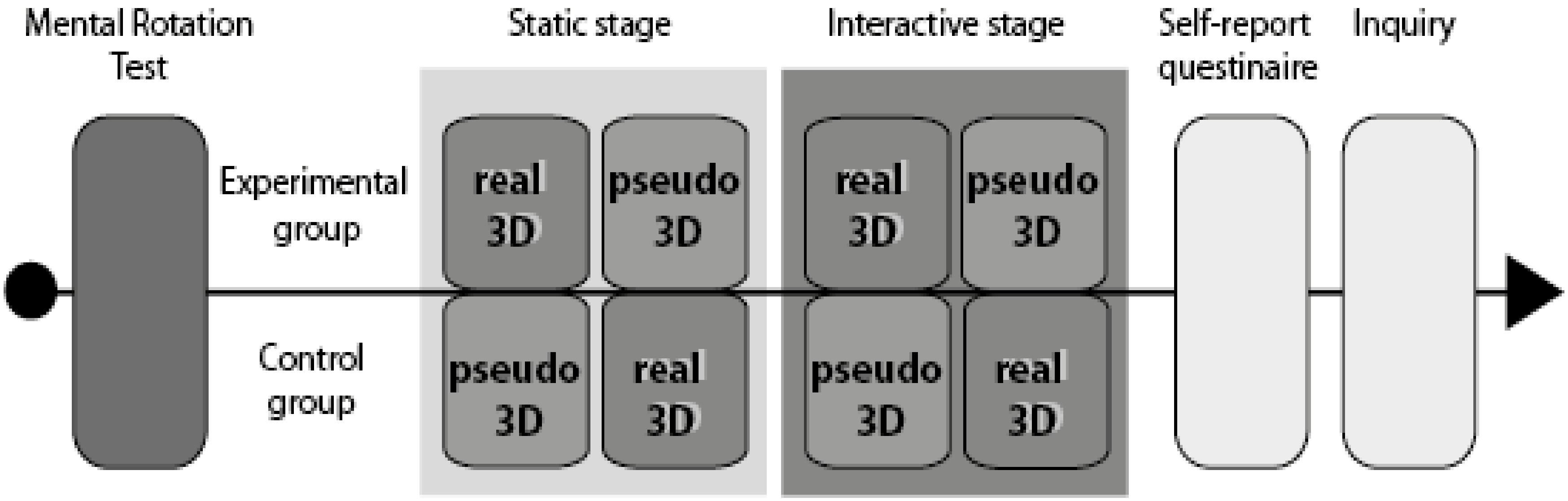
- Jurik, V., et al (2017) When the Display Matters: A Multifaceted Perspective on 3D Geovisualizations. Open Geosciences, Berlin: De Gruyter Open, 2017, roč. 9, č. 1, s. 89-100. ISSN 2391-5447. doi:10.1515/geo-2017-0007.
- Herman, L., Stachon, Z. (2016). Comparison of User Performance with Interactive and Static 3D Visualization – Pilot Study. In: Halounova, L., et al. (eds.) ISPRS Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XLI-B2. Prague, Czech Republic, pp. 655-661.
- Sprinarova, K. et al. (2015). Human-computer Interaction in Real 3D and Pseudo-3D Cartographic Visualization: A Comparative Study. In: C. R. Sluter et al. (eds.) Cartography - Maps Connecting the World: 27th ICC 2015, CH.. pp. 59-73.
- …

3D visualizations - visual cues

- 3D visualizations contain a number of visual cues
- The pseudo 3D (monoscopic) visualizations use only monocular cues.
- The real (stereoscopic) 3D visualization is ensured with the inclusion of both the binocular and monocular depth cues (Buchroithner and Knust, 2013).



Experimental design



Participants

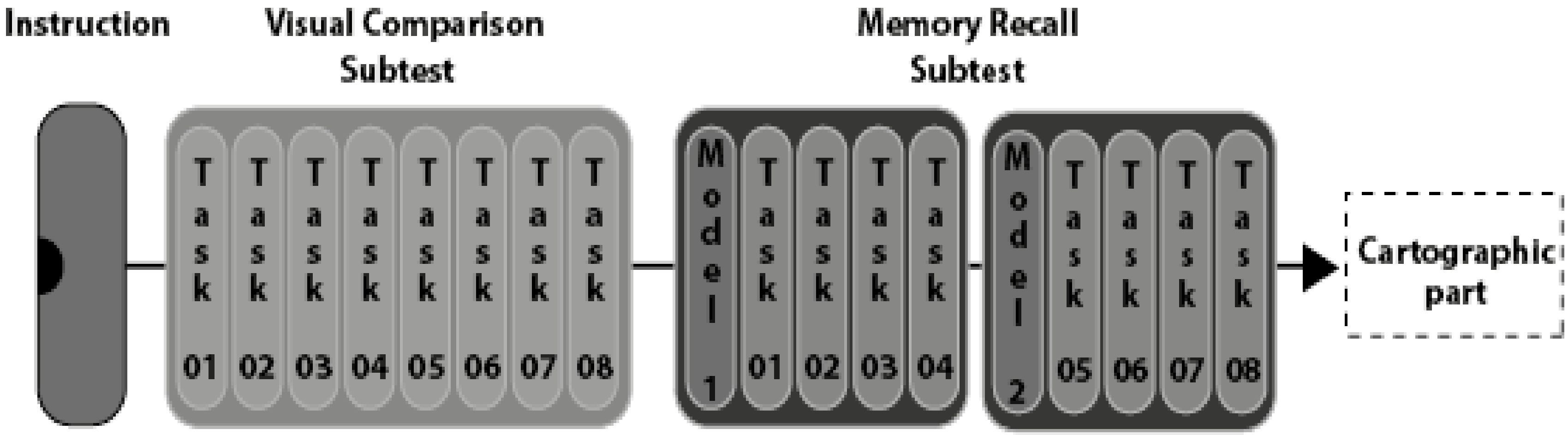
- 39 volunteers (18 females and 21 males; age 16-18) recruited from two high-schools in Brno (the Czech Republic).
- data collected during October and November 2016.
  - All participants had normal or corrected-to- normal vision and had no motor/movement limitations.
  - All the participants agreed with the experimental procedure and participated voluntarily, with the open opportunity to withdraw from the testing at any time.

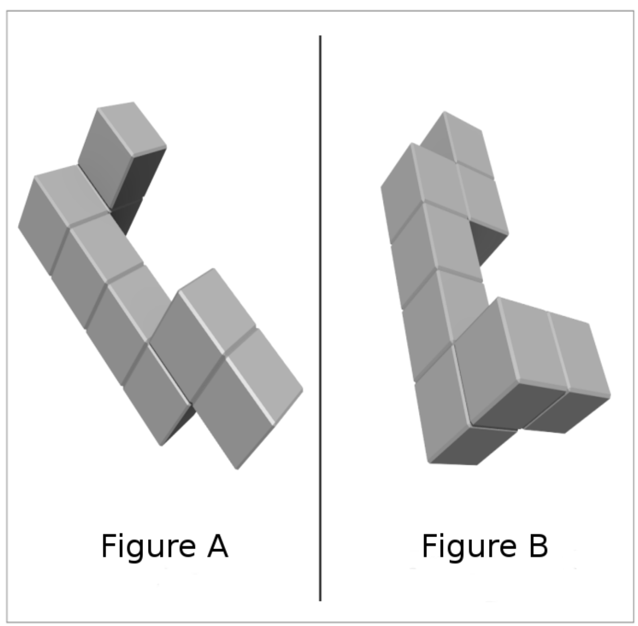
Technologies

- Testing platform Hypothesis (Štěrba et al., 2015, Popelka et al., 2016).
- For the main experiment, a new testing application was developed based on the Unity® game engine.
- Desktop PC and 27" display compatible with NVIDIA 3D Vision technology.
- Users were instructed to put on/off shutter glasses before each section of real 3D/pseudo 3D tasks.
- A common PC mouse was used as an input device.

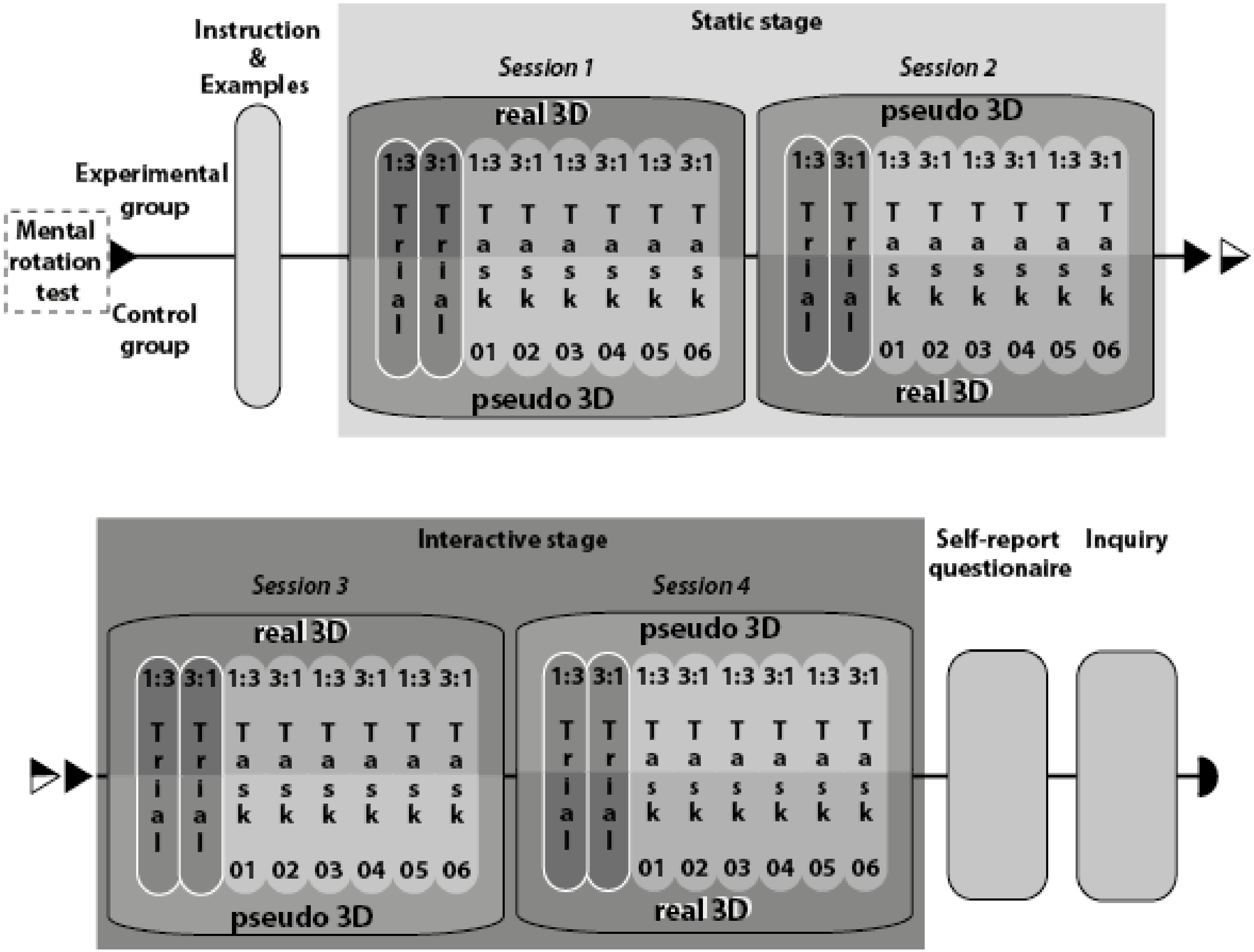
- Štěrba, Zbyněk, Čeněk Šašinka, Zdeněk Stachoň, Radim Štampach and Kamil Morong. Selected Issues of Experimental Testing in Cartography. first. Brno: Masaryk University, 2015. 107 s. ISBN 978-80-210-7909-0. doi:10.5817/CZ.MUNI.M210-7893-2015.
- Popelka, Stanislav, Zdeněk Stachoň, Čeněk Šašinka and Jitka Doležalová. Eyetribe Tracker Data Accuracy Evaluation and Its Interconnection with Hypothesis Software for Cartographic Purposes. Computational Intelligence and Neuroscience, 2016, February, ISSN 1687-5265. doi:10.1155/2016/9172506.

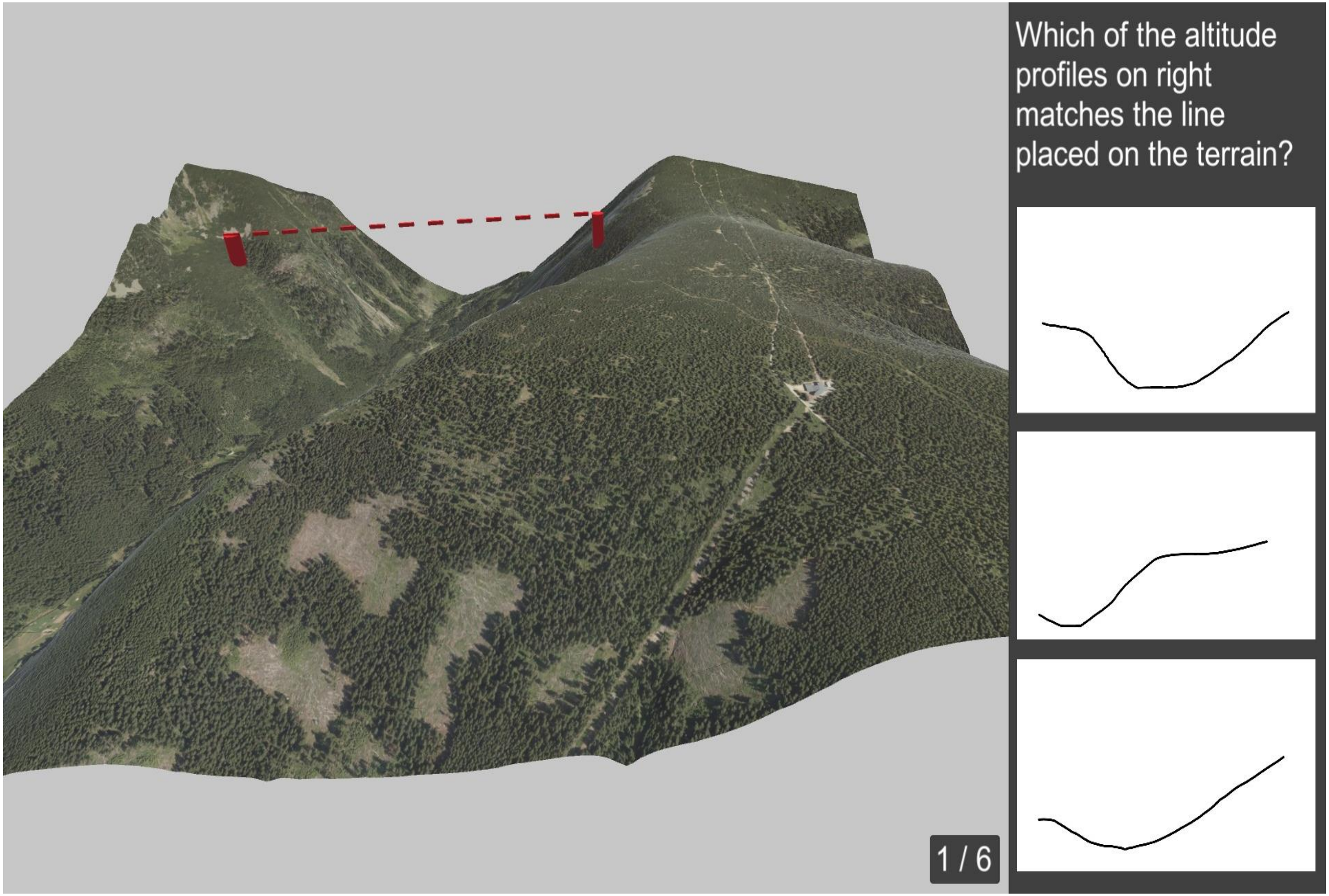
Tasks and stimuli - MRT

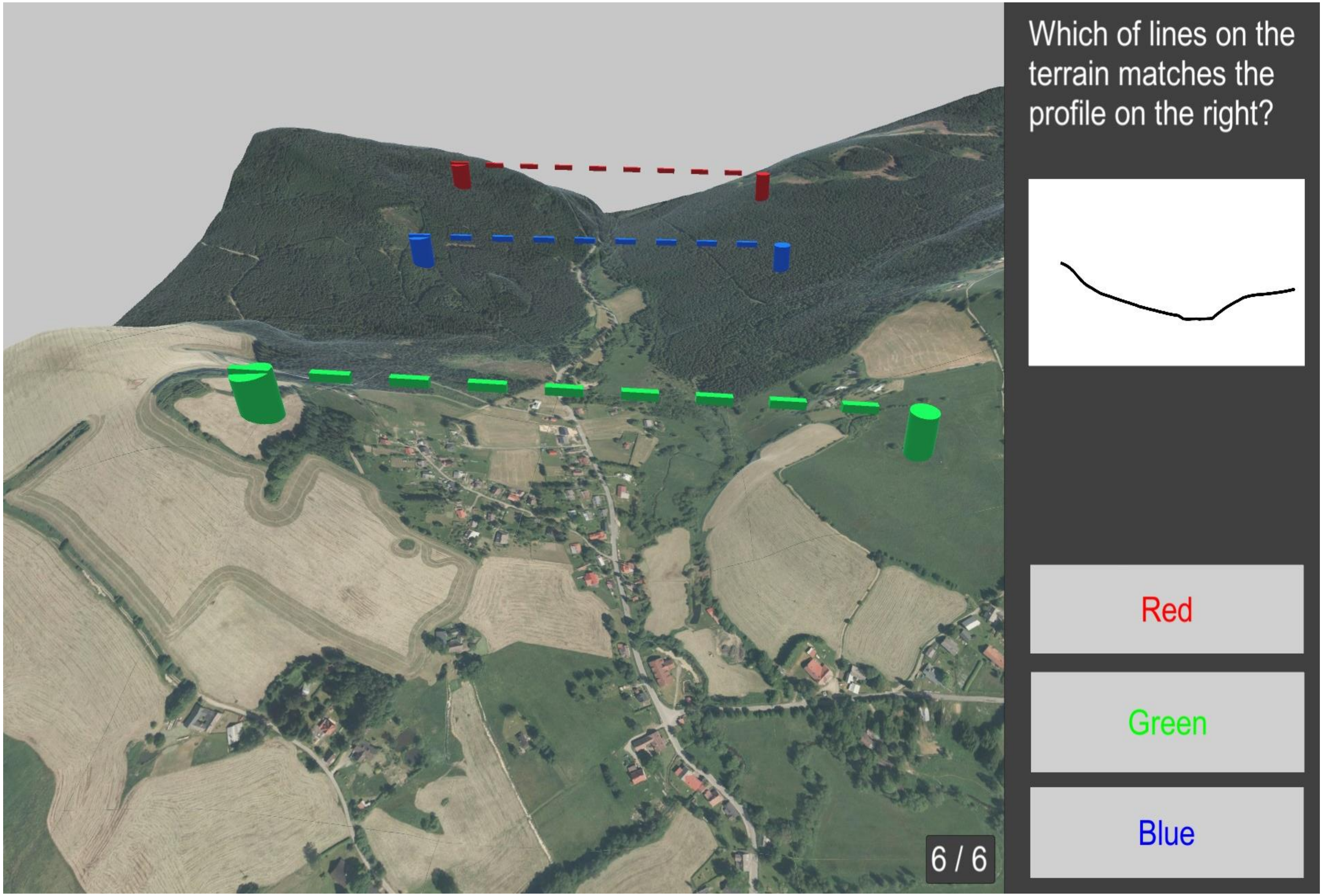




Tasks and stimuli – Cartographic part




Which of the altitude profiles on right matches the line placed on the terrain?
1 / 6


Which of lines on the terrain matches the profile on the right?
Red
Green
Blue
6 / 6

Results

Correct answers

	static	interactive
pseudo 3D	m=5.00; sd=1.34	m=5.74; sd=1.33
real 3D	m=5.15; sd=1.66	m=5.77; sd=1.39

Response times

	static	interactive
pseudo 3D	m=16.30; sd=5.86	m=20.85; sd=8.89
real 3D	m=16.72; sd=5.79	m=20.01; sd=8.94

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M/F differences

	m males	m females	sd males	sd females
pseudo 3D and static	5.33	4.61	1.24	1.38
real 3D and static	5.43	4.83	1.57	1.76
pseudo 3D and interactive	5.71	5.78	1.45	1.22
real 3D and Interactive	6.14	5.33	1.56	1.03

Subjective evaluation

Difficulty (likert scale - 1=very easy, 5=very difficult)

	Static		Interactive	
	mean	Median	mean	Median
Pseudo 3D	2.74	3	2.08	2
Real 3D	2.13	2	1.49	1

Task preference

Preference of	1:3 type of task	No preference	3:1 type of task
Frequency	17	10	12

Some participants experienced difficulties:
- with the manipulation (interaction) of the 3D geographical models,
- reported discomfort using the shutter glasses.

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Conclusions

- The influence of the type of 3D visualization (monoscopic/stereoscopic) on the performance of the users is still not clear.
  - the recorded differences in user performance within the test were not significant.
- The level of interaction strongly influences the usability of particular 3D visualization.
  - The evaluation of correct answers and the response times showed statistically significant differences only between the static and interactive stage.
- Influences of the spatial abilities on the performance of the user within the 3D environment were not identified.

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Future outlook

- The designed experiment the real 3D (stereoscopic) visualization did not provide any significant positive effect in either the static or interactive environment.
- Contrary to this finding the work of Juřík et al. (2017) provides evidence of positive influence of real 3D visualization to the relative point altitude evaluation.

- It appears that for certain types of tasks (as in our case work with terrain profiles) it is better to use an interactive visualization, no matter if it is real or pseudo 3D.

- *Future plans:*
  - *to focus on different user groups*
  - *to extend the complexity of tasks solved by the participants.*

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- Thank you for your attention!

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