Perception of 2D and 3D Terrain Visualization

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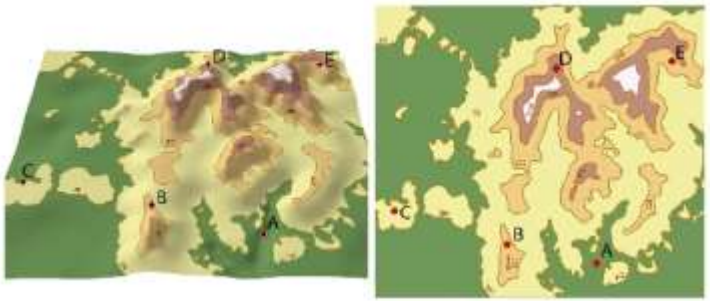
Ours Laboratory

- Department of Geoinformatics
- Palacký University in Olomouc, Czech Republic
- SMI RED 250
- Sample frequency 60/120 Hz

- SMI Experiment Suite 360°
- OGAMA
- eyePatterns

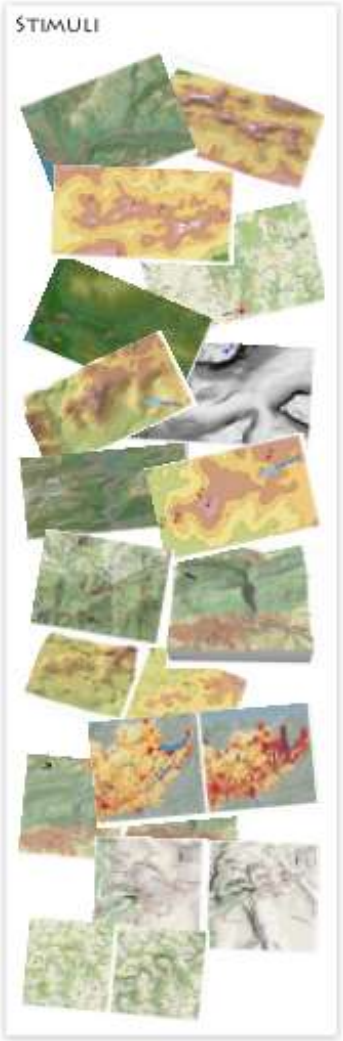
Evaluation of 2D and 3D terrain visualization

- DualMap experiment
- SingleMap experiment
- Questionnaire



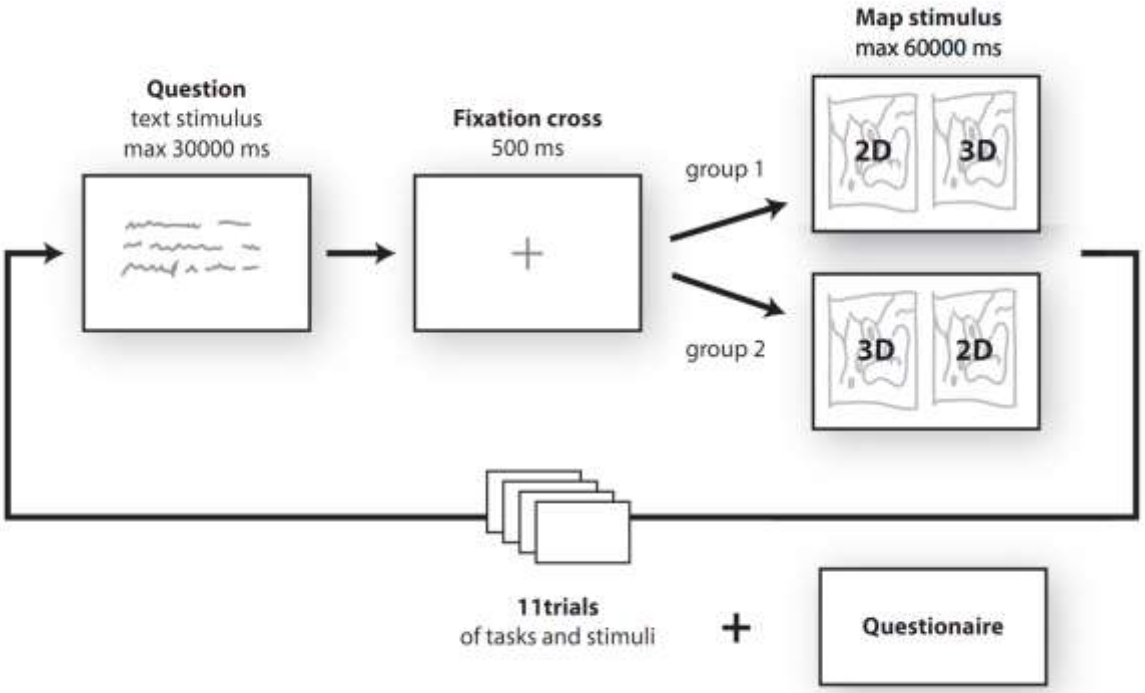
Který z červených bodů je nejvyšší?

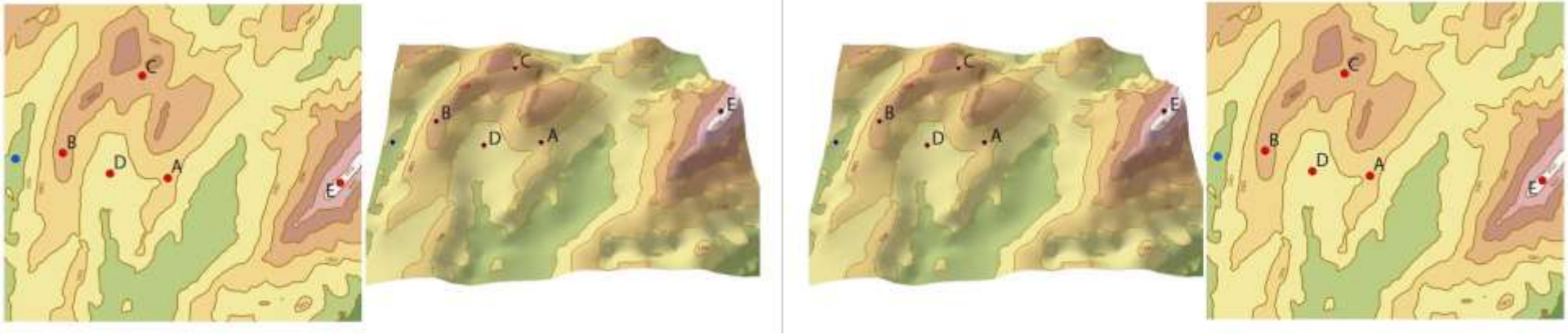
	ANO	NE
Byla 3D mapa (vlevo) přehledná?	○	○
Byla 2D mapa (vpravo) přehledná?	○	○
Byla 3D mapa vhodnější pro nalezení odpovědi?	○	○
Byla 3D mapa esteticčtější? Líbila se Vám víc než 2D?	○	○



DualMap experiment

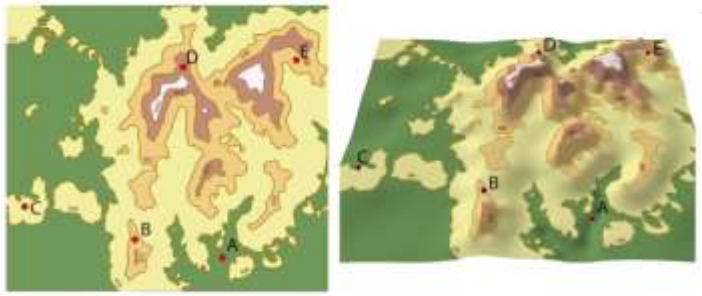
- 11 stimuli
- 40 participants (20 cartographers vs. 20 noncartographers)
- Stimuli were designed as a pair of maps in 2D and 3D side by side.
- **Task: Which kind of visualization will be prefered when searching for answer on spatial query?**
- We tried to avoid influence of the left-right location of the stimuli
- Two versions of stimuli - on the first one, 2D map was presented on the left side, 3D on the right. On the second version vice versa



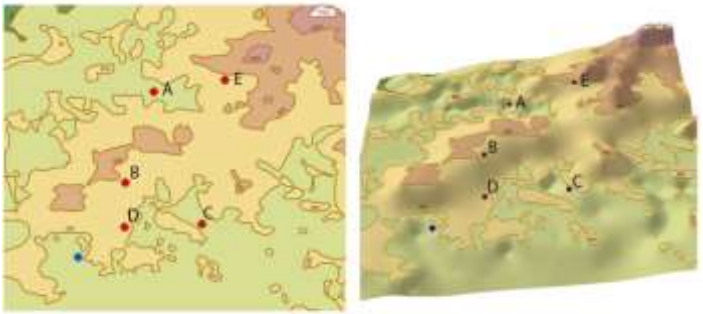


Task: From which red point, all other points are visible?

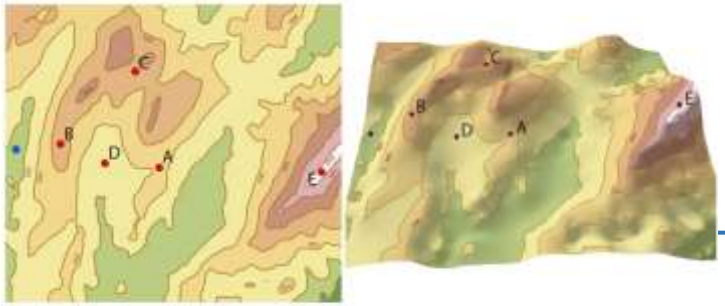
Examined stimuli



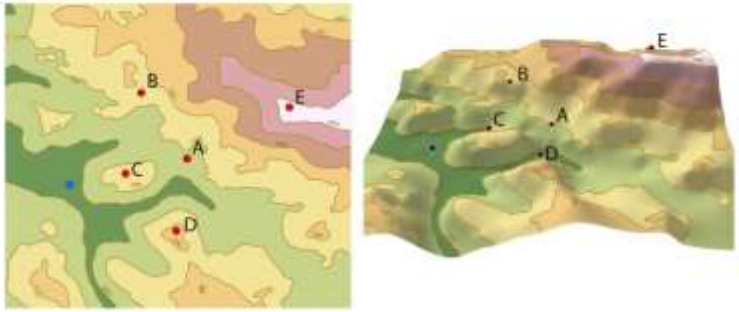
Q4 Which of the red points is the highest?



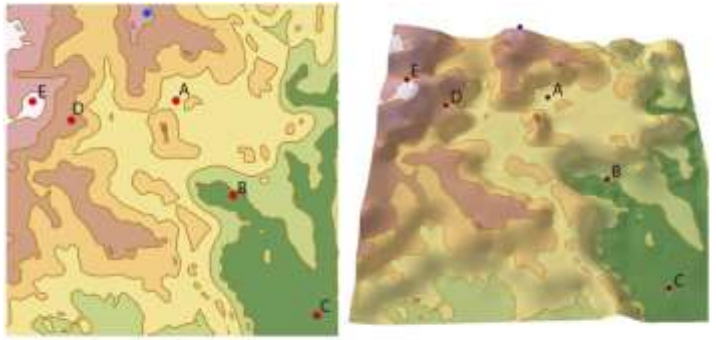
Q5 Which of the red points is the furthest from blue point?



Q6 From which of the red points, all other points are visible?

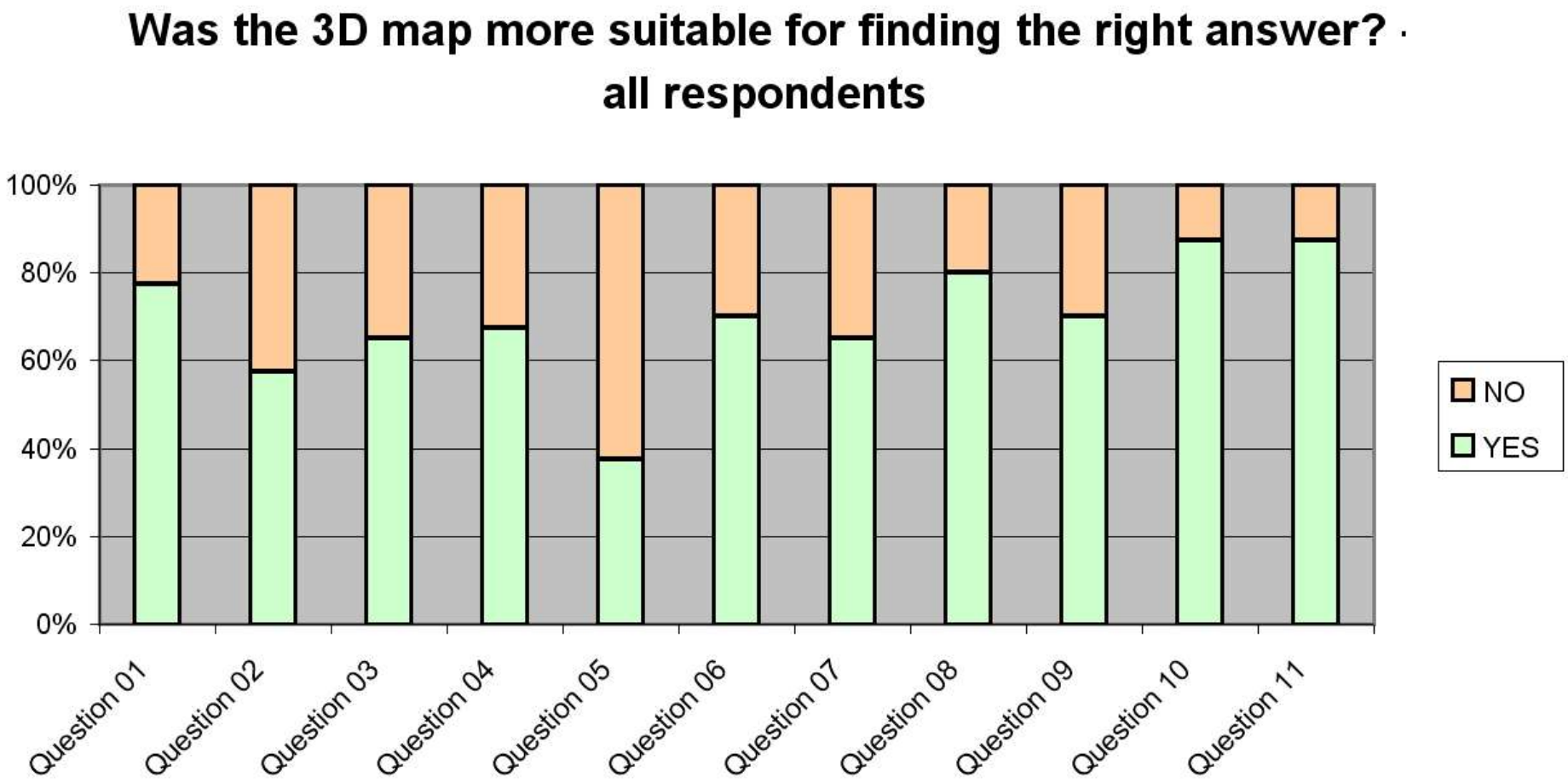


Q7 Which of the red point is not visible from the blue point?



Q8 If you drop the ball in the blue point, how far it rolls?

Analyses of questionnaire



Analyses of DualMap experiment

- Sample frequency 120 Hz
- Event detection with use of I-DT algorithm
- Within the stimuli, two AOI representing 2D and 3D map were marked
- “Dwell Time” metric was chosen

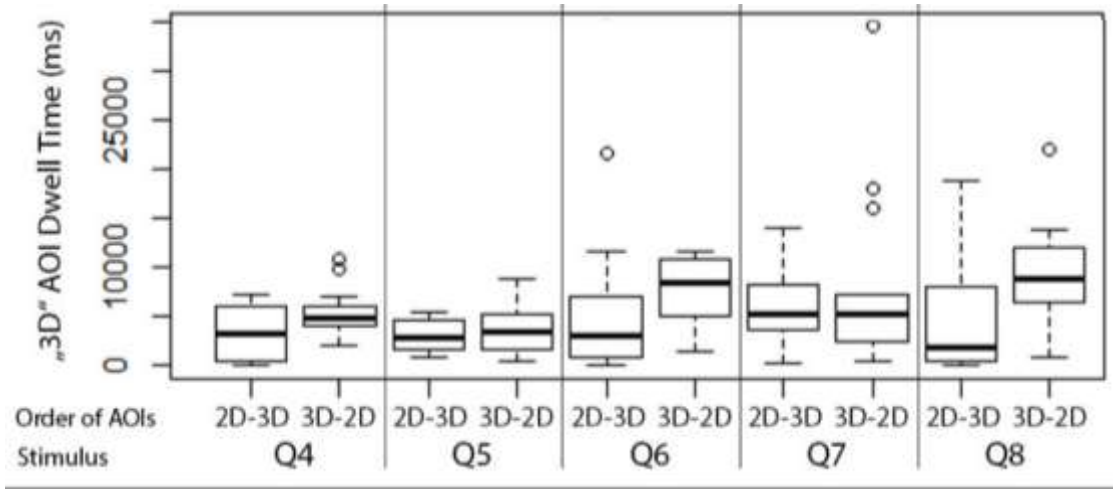
Analyses of DualMap experiment

- On the significance level $\alpha = 0.05$ **no statistically significant difference between** dwell time values in 2D and 3D map for any of the studied (5) stimuli was found
- Differences between dwell time values based on the **order of maps** in the stimuli were also tested with use of Wilcoxon rank sum test
- There was found a statistically significant difference in the half of observations

3D: 2D3D vs. 3D2D	Alpha	W	p-value	statement
Trial 004	0.05	52	0.03453	Rejecting H0
Trial 005	0.05	92	0.8036	Failed to reject
Trial 006	0.05	55	0.04974	Rejecting H0
Trial 007	0.05	97	0.982	Failed to reject
Trial 008	0.05	52	0.03504	Rejecting H0

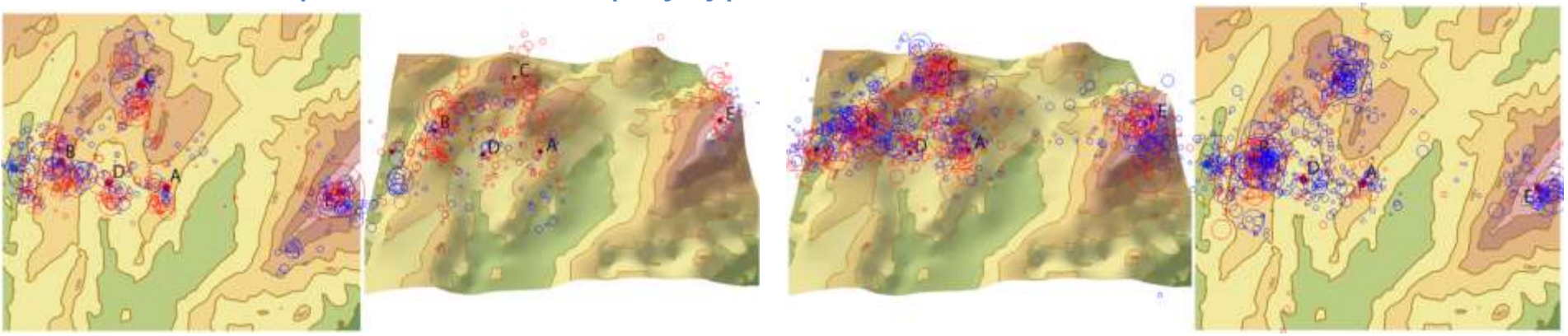
Analyses of DualMap experiment

- The boxplot shows dwell time values for 3D AOI for each stimuli
- The order of the AOI in the stimuli is described by “2D-3D” and “3D-2D” label
- Dwell time value is higher in all cases for the „3D-2D“ variant, where 3D map was on the left side of the stimuli

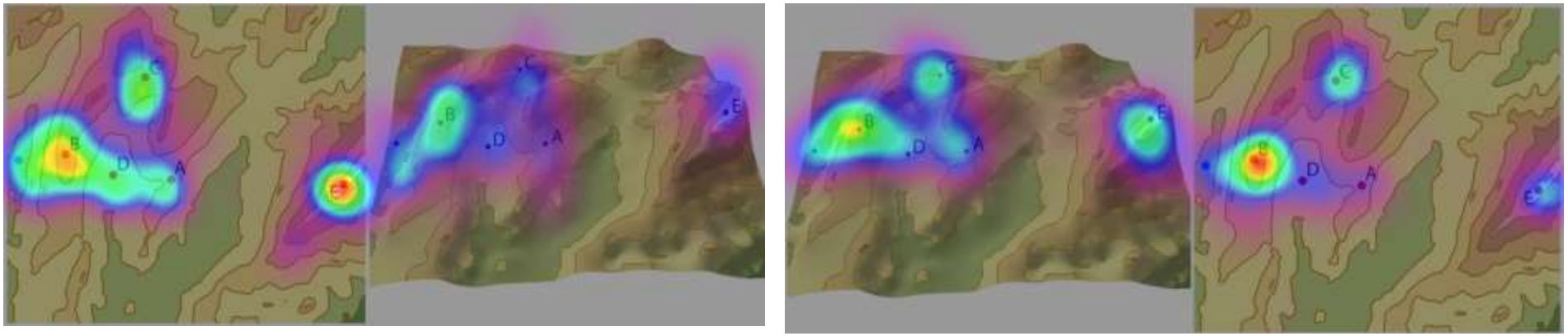


Data visualization in OGAMA

Scanpath module – display type Circle – radius 30 – no connections

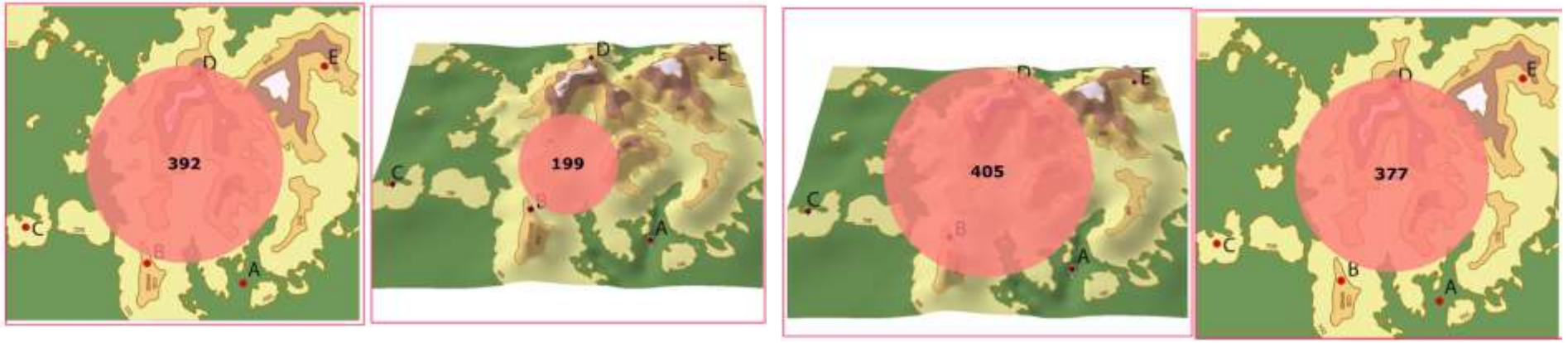


Attention map – weight fixations by length – Gaussian kernel 200

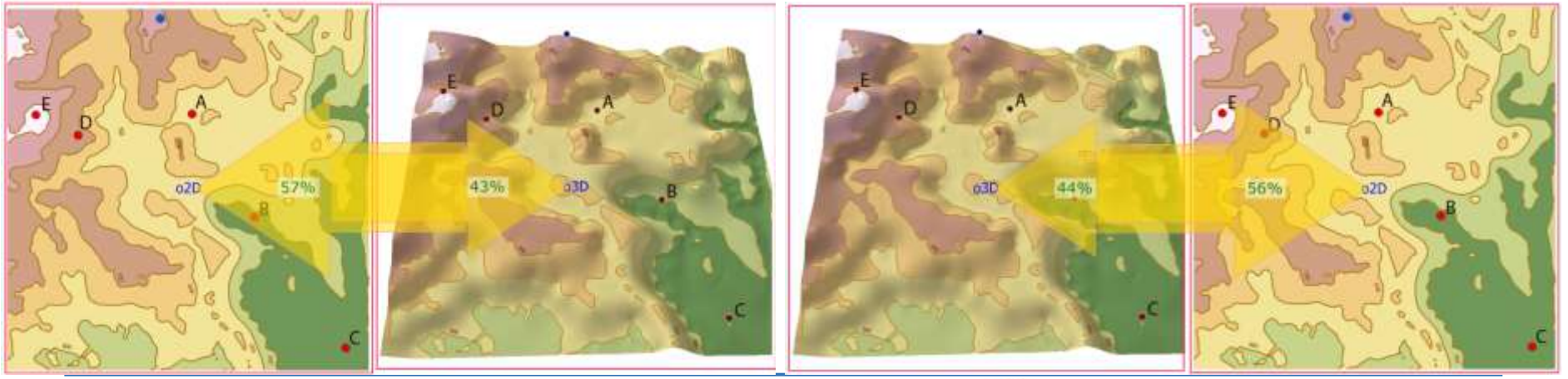


Data visualization in OGAMA

Areas of Interest – number of fixations in AOI



Areas of Interest – relative transitions values

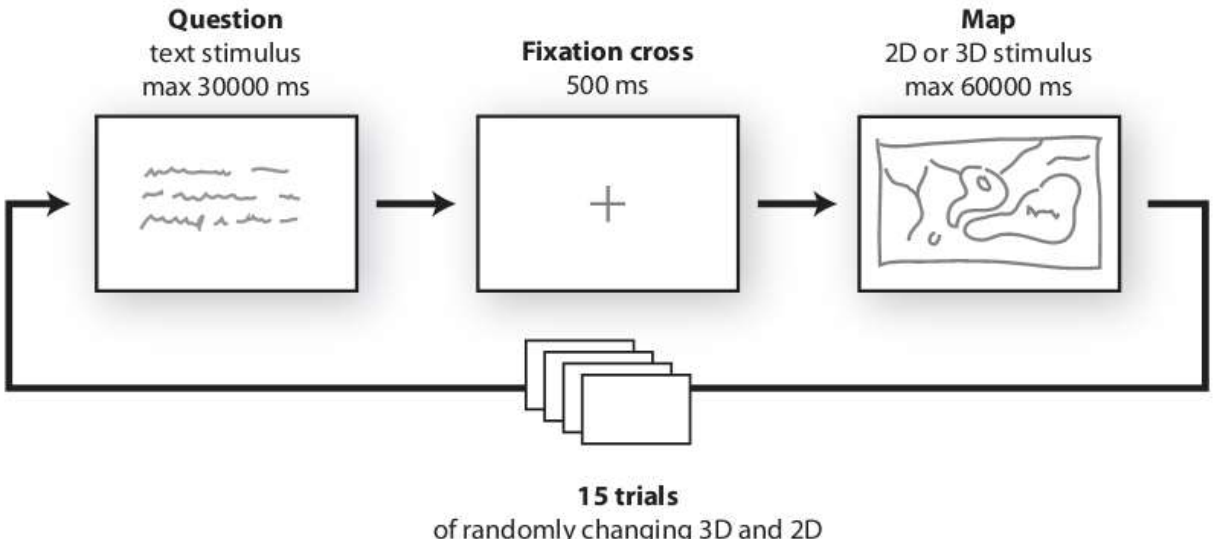


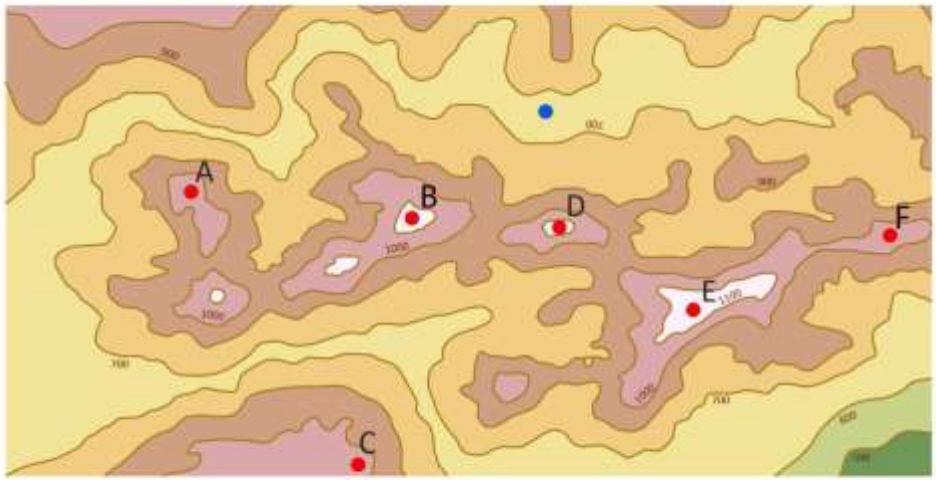
Analyses of DualMap experiment

- These results indicates, that DualMap experiment design was not suitable
- Respondents perception was influenced with the order of the maps in the stimuli more than with differences between 2D and 3D visualization
- For further analyses, use of SingleMap experiment should be more appropriate

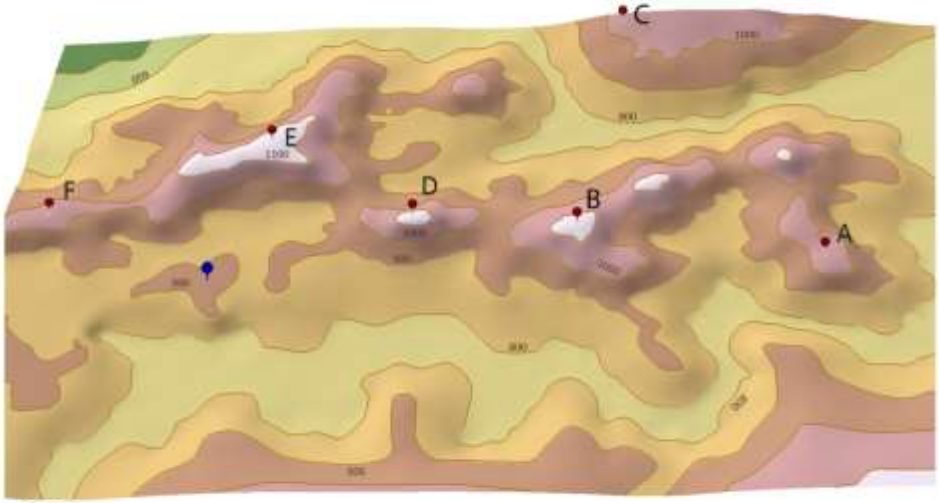
SingleMap experiment

- Total of 15 stimuli in the experiment
- 40 respondents (20 cartographers, 20 noncartographers)
- Stimuli were presented in the random order.
- Within subject study
- To avoid the learning effect, maps with 3D visualization were rotated or the question was modified a bit.





Q1 Mark all red points, from which the blue one is visible

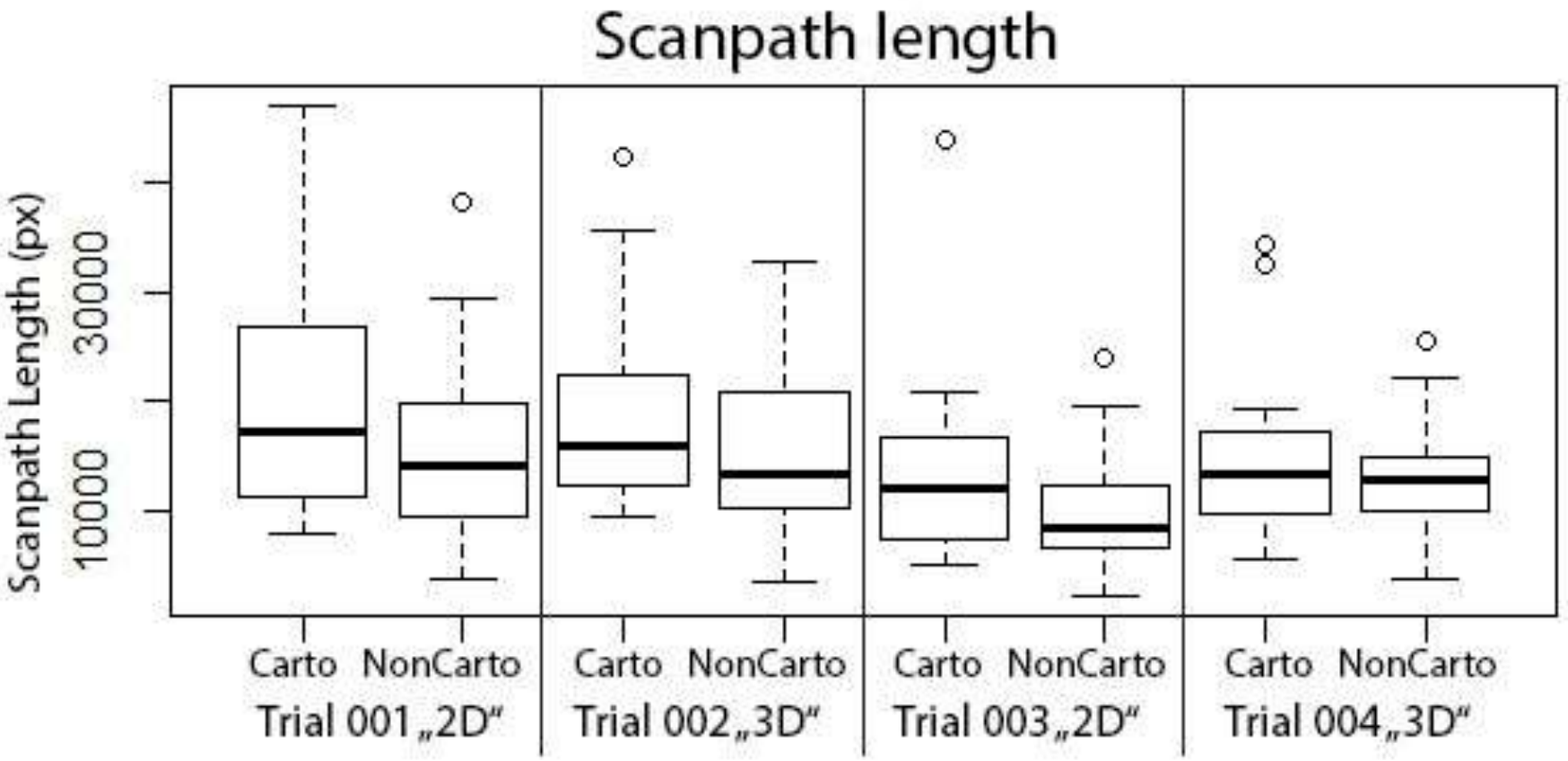


Q2 Mark all red points, from which the blue one is visible

Analyses of SingleMap experiment

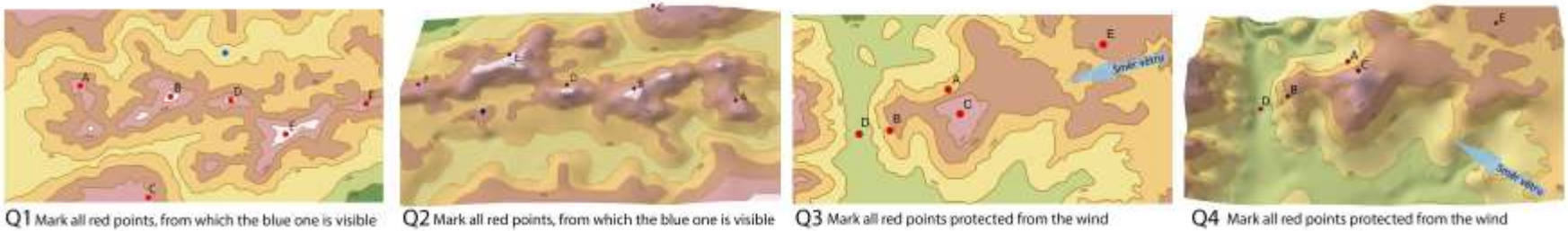
- Four stimuli were selected and analysed using “Scanpath length”
- According to Goldberg et al. (2002), a longer scanpath indicates less efficient searching
- Contrast to this assertion, group of cartography experts had longer scanpaths than novices in all cases

Analyses of SingleMap experiment



Analyses of SingleMap experiment

- Wilcoxon test was used again to investigate differences between scanpath lengths for “2D” and “3D” maps
- (always the pair of maps – T01-T02 and T03-T04)



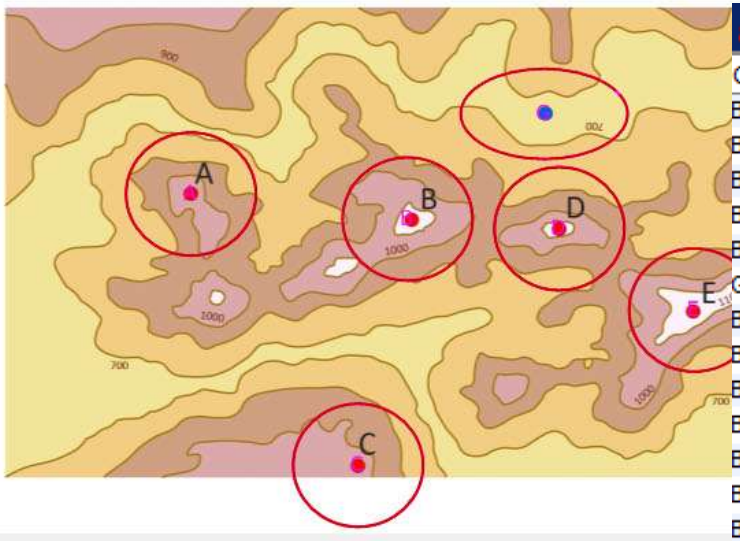
- Statistically significant difference was found between map 3 and 4 (in case of novices, and generally if neglecting groups).

Scanpath Similarity

- No statisticaly significant differences were found in case of using other eye-tracking metrics (fixation duration mean, fixation count, trial duration)
- It doesn’t mean that participants approach was the same for both stimuli
- We used the scanpath comparison based on string editing (introduced by Privitera and Stark, 2000)
- Fixations are replaced with characters standing for the AOI’s they hit and the ScanPath is represented as character string

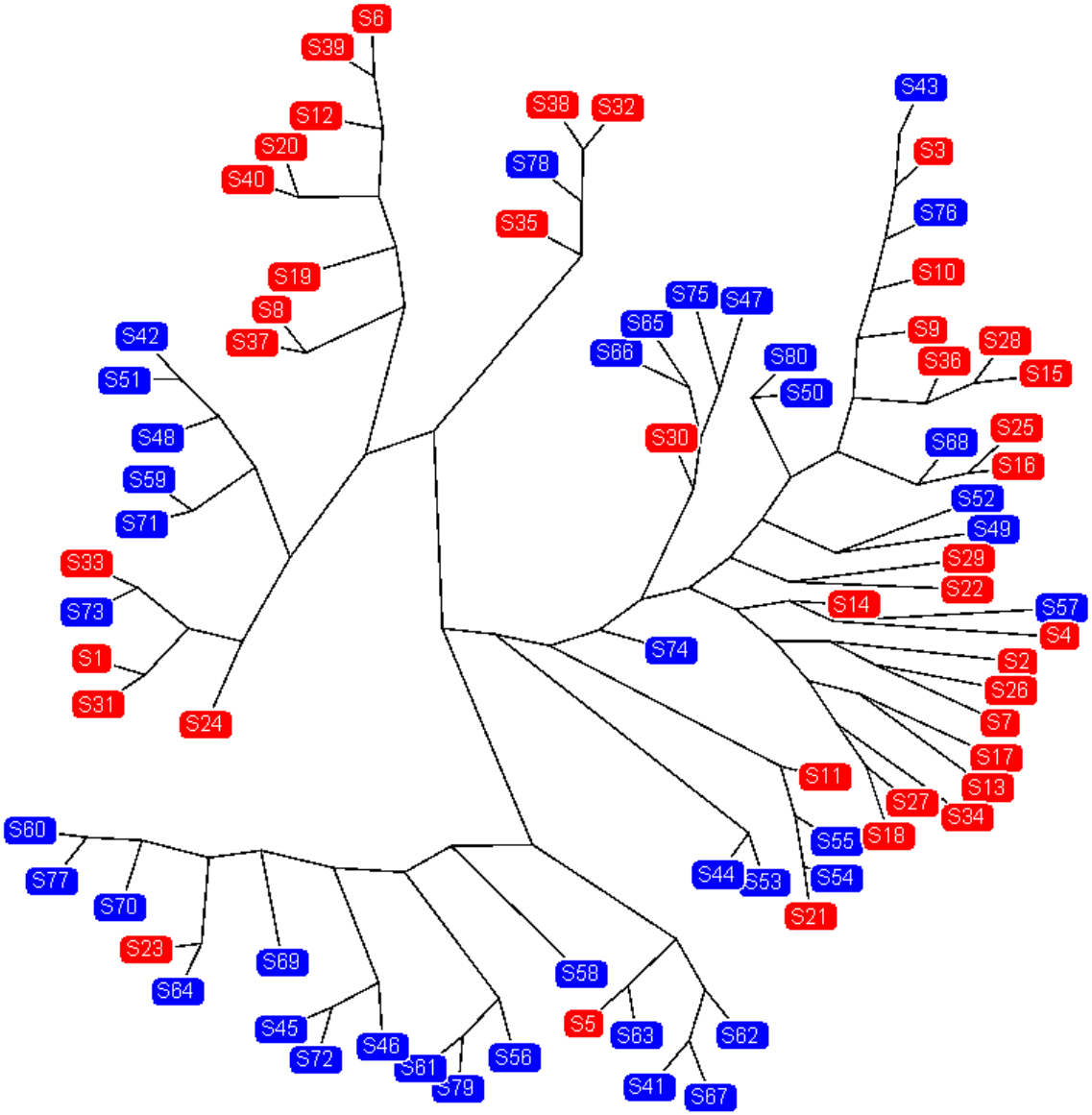
Scanpath Similarity

- Scanpath similarity analysis for 40 participants and two stimuli (T01 and T02).
- On both maps, the same AOI's were created. (AOI around point A was named as „A“ in both stimuli)



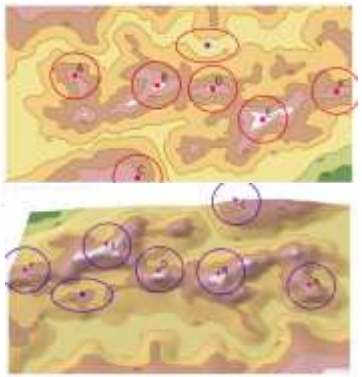
Sequences

Collapsed Sequence	Expanded Sequences
BAGBDBDEGFEABG	BBAGGBBBBDBBBDDEEEGG...
BGABABAGABGDBDEDGDEDCFDEDEDFDFEDGDGDCB	BBBGABAABAGGABBBBBB...
BGBGBABABDCEFDABGAGABABABADBABABGBABGBABDBDBDGDBDECEDEDGDEDG...	BBGBBGGBBABBABDCEFD...
BDGDBDGDGDGFGDGDBCDGABDEBGBDBGBDBDG	BDGDBDGGGDDGGDDGGF...
BGDEDEFEFBDBAGACDCDGABABG	BBGGGGDDDDEEEEEEEED...
GDBABCDCGDEFEFEGFG	GDBBAAABBCCDDCCGGG...
BGBAGBDBDGDEDACABADEGEFGBEFDFD	BGBBAGBDBBDDGDEDACA...
BGDBABDBDEFGFCBCBCDG	BBGGDDDBBAABBBBBDBBB...
BDGBCDGBGFEDEBDACGBCABABGABABGFBDEDGBGBCEDGEDGBDEBDG	BDGGGBCCCCDDGBBGGFE...
BGDBDBDBABABACEAEDEFEFCFEDBDFEDEFCBDBEDFEBFCFEFD	BGDBDBBBBBDDBABABBA...
BGDBGDEDEDBEDEDEFGEDBCDGDCDGCAG	BGGDBGGDEEDDDEDBEDE...
BABGBAGBDEFEDEGCDEGF	BBAABBGBAAAAGGBDDDE...
BGBCABEFCDBABGBCBCDGDBGEDGDFG	BGGBBCCAABBEEEFCCDB...
BAGBDFGBDGDGEDEDBDGADBABCBDBACEDBDFDFA	BAGGBDDDFGBDGGDDDGE...
BDGBACBABAGFEFDGBCBCBABGBGDEDEFDEFDGFBFABADGAGAG	BBDGGGBACCBABAGFFEE...
BGDBACEDGDBDBDECABGBEFEFEDBDBABAGABDCDEFCGBE	BBGGDBBACCEEEEDDDGG...
BGDBABGFEDABGABABDCBCBDCGDCDBDCDGCDEDEFA	BBGGGGGDDBABBGGGFED...
BGBGDFEGBABGABABGBDCDBADEBDBDFGDGEGE	BBBBBBGGGGGGGGBBBBG...



Tree graph of data from 40 participants and two stimuli

Colours are distinguished according to the belonging to the stimulus

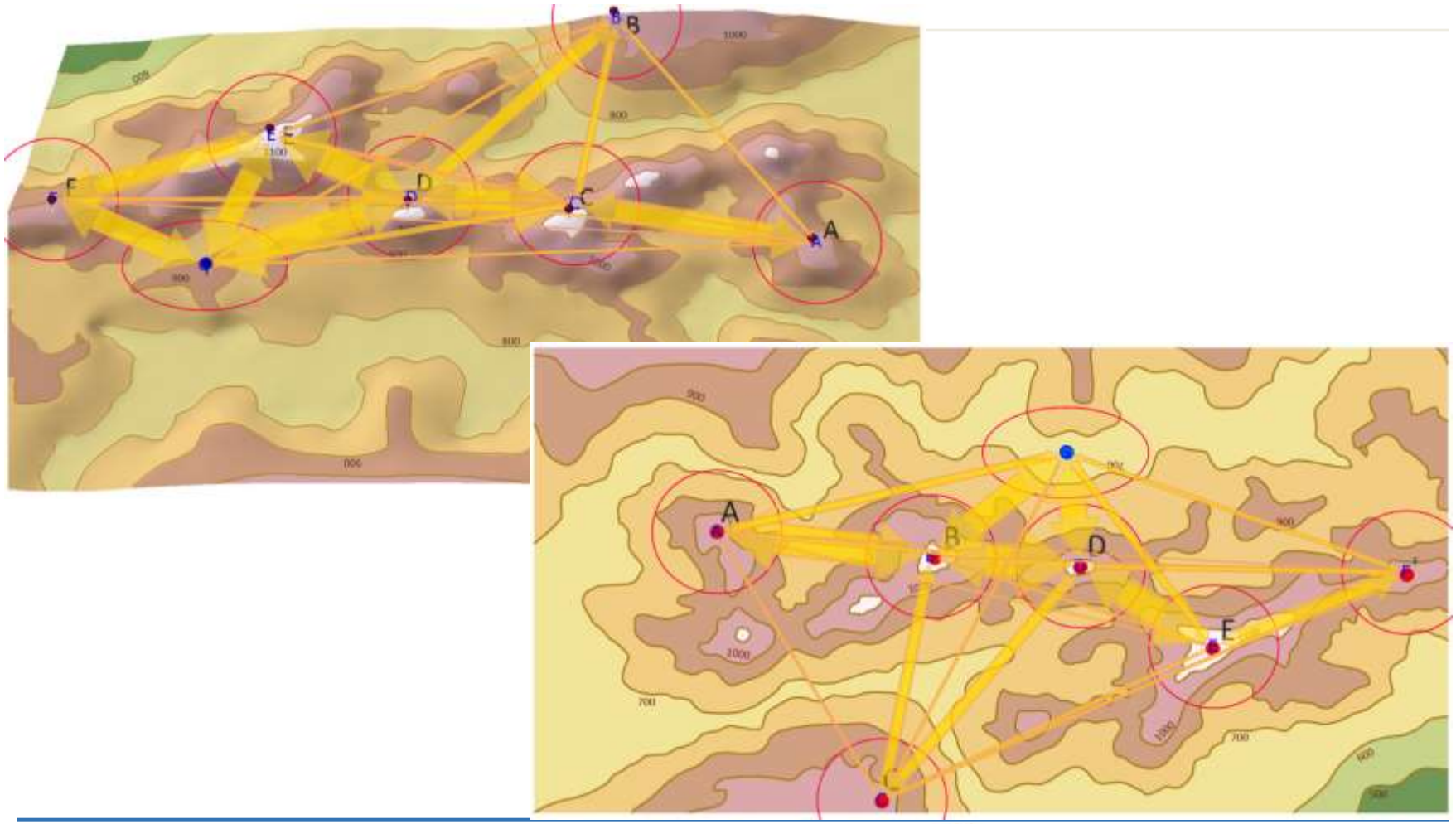


2D Red

3D Blue

From this result, the different participants strategy for two stimuli is visible

Data visualization in OGAMA



Thank you for your attention…

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