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PRESENTATION
FROM THE

ICA JOINT WORKSHOP



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Czech Republic
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Atlases & Cognition & Usability





Palacký University
Olomouc



Intuitiveness of uncertainty visualizations: an user study

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Presentation overview

problem
statement

motto

main aims

questionnaire

ET testing

results

future



Motivation

- people both **reason** and **make decisions** with uncertain geospatial data every day
- in case of **scientific work** uncertainty is often hidden
- crucial in **spatial ecology datasets** and studies targeted **wider audience**
- when you communicate with these kind of data it is important to understand **the complexity of uncertainty!**
- You should know how it propagates through each dataset, and how to best **visualize uncertainty** to support reasoning and decision-making for your audience



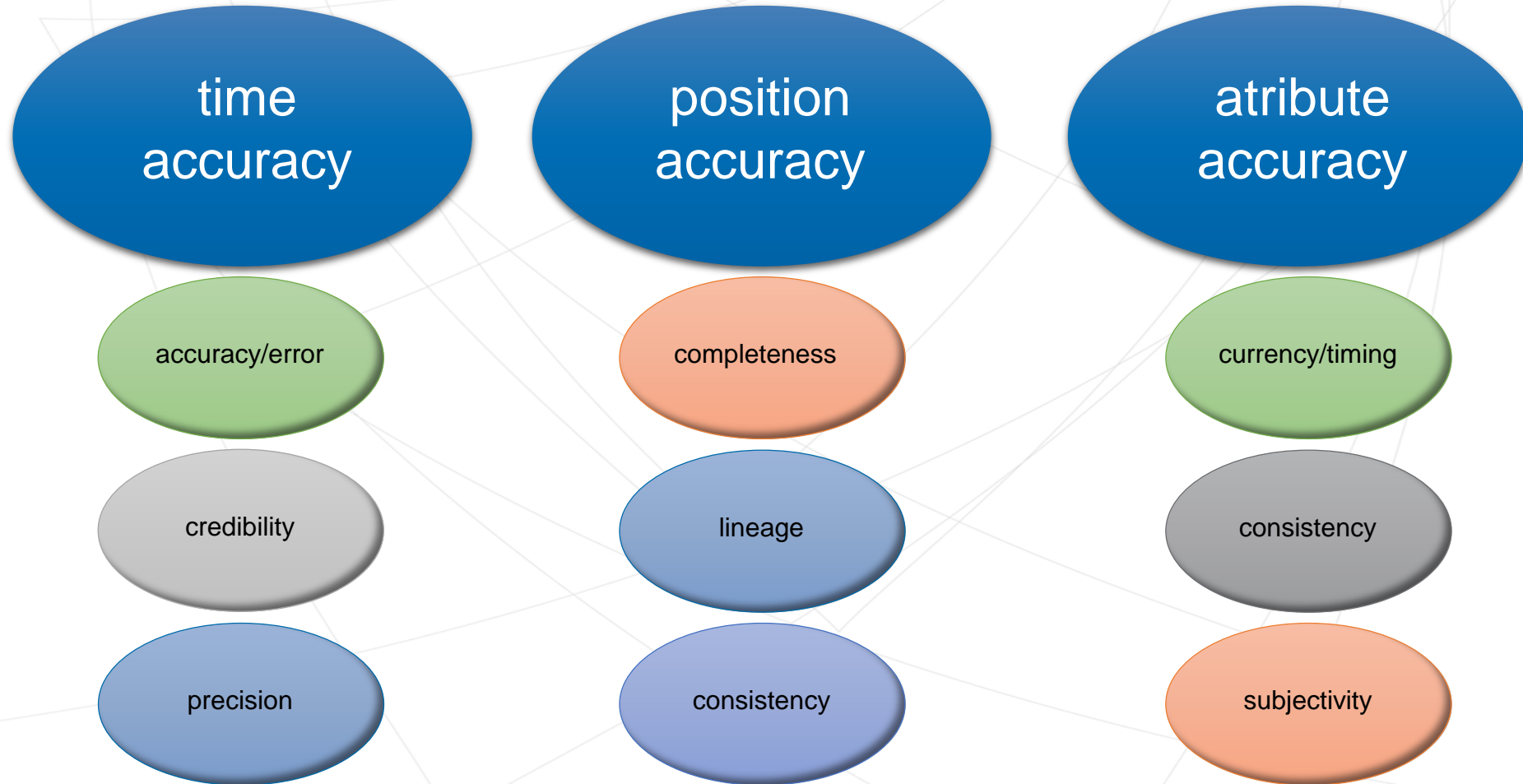
We are not only geographers ...

- botanist, ecologist and general public
- no geographical background
- some people may not have spatial thinking developed
- some of them do not even utilise maps
- Often they do not care about “geospatial” uncertainty
- **We have bias in “our” spatial data. How to tell them?**
 - via visualizations?





Uncertainty?



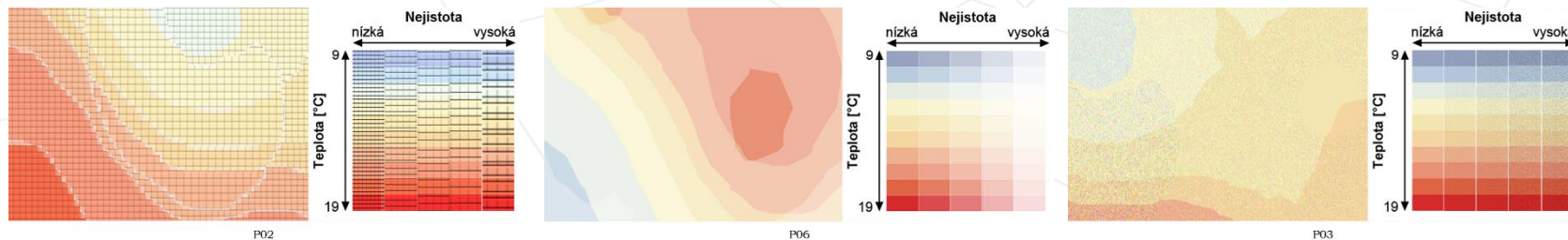
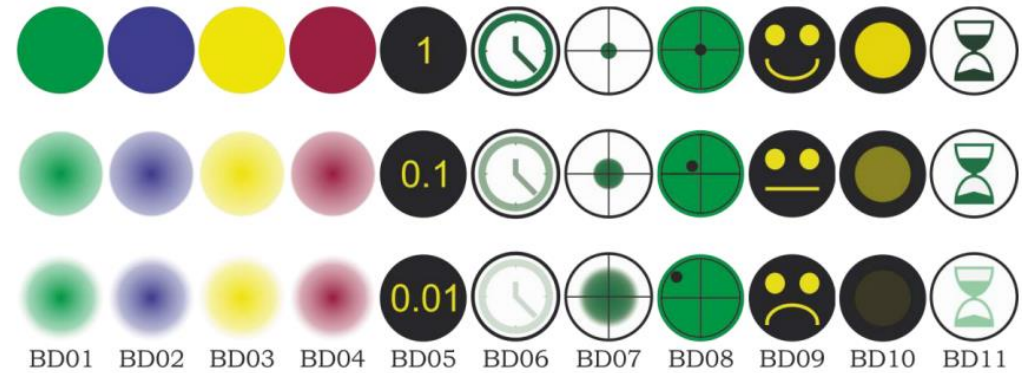


Main aims

- creating **custom symbol sets** for representing uncertainty
- **prove** designed symbols
- analysis of reading symbol sets with **eye-tracking**
- **evaluating** the created characters with an emphasis on intuitiveness
- optimizing character sets and legends **to express uncertainty**

Symbol design

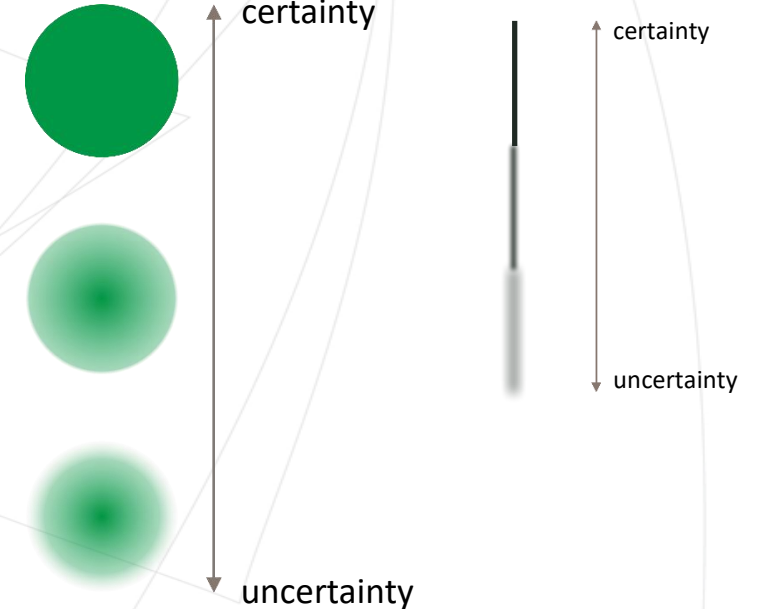
- we designed **37 symbol sets** for visualization of uncertainty – points, lines and areas
- following **MacEachren et al., 2012**: Visual semiotics & uncertainty visualization: an empirical study
- we updated my **dissertation findings**





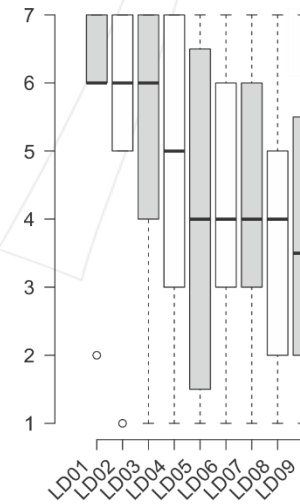
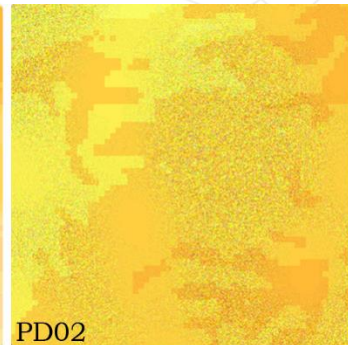
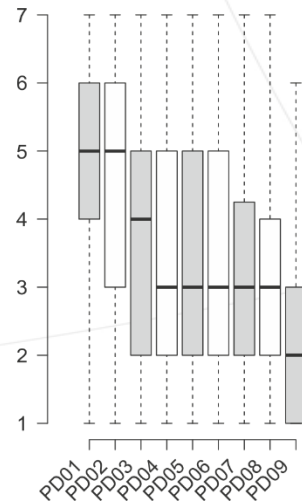
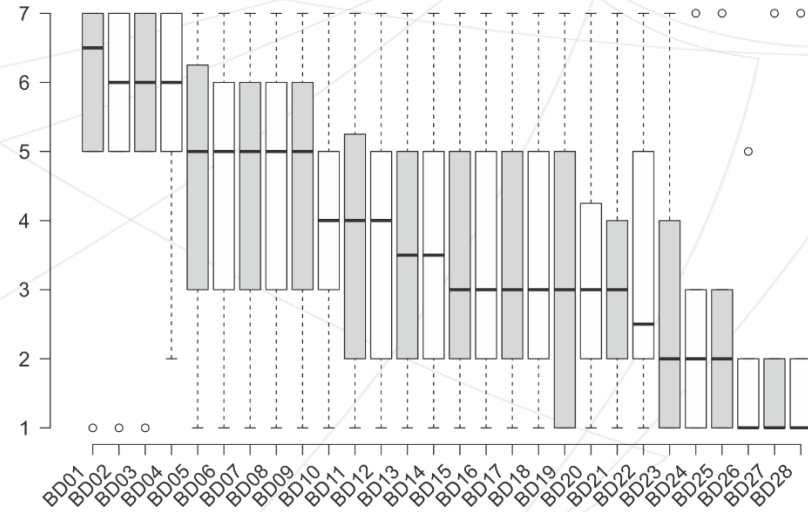
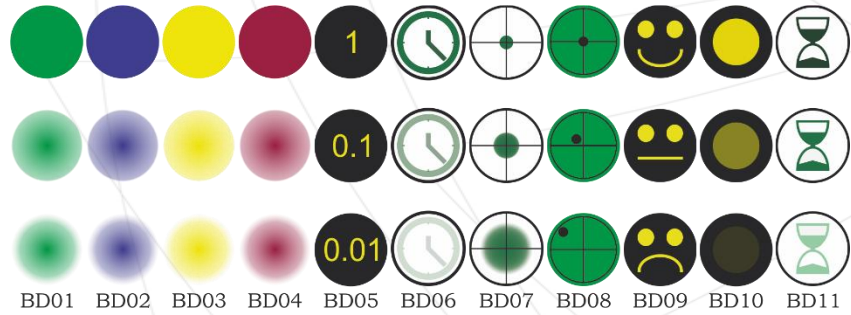
Questionnaire

- we evaluated designed symbols
- **100** respondents and **87** respondents with cartographic knowledge
- they rated **logical** level of symbol sets (7 – logical, 1 – nonlogical)
- choosing selected symbol sets for further use



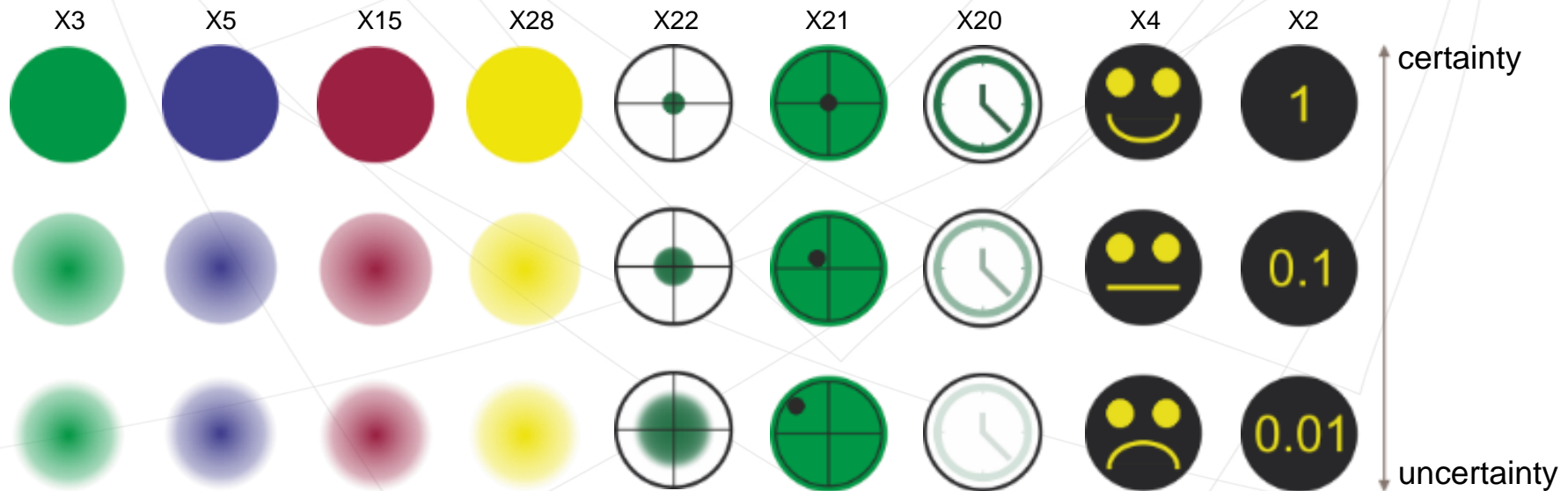
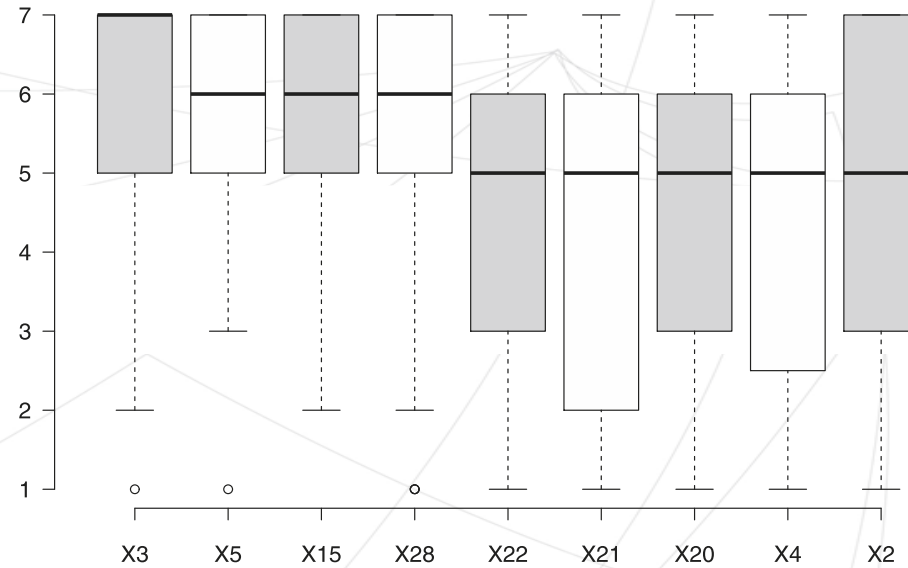


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Best point symbol sets





Paradox

X13

0.01

certainty

0.1

1

uncertainty

X2

1

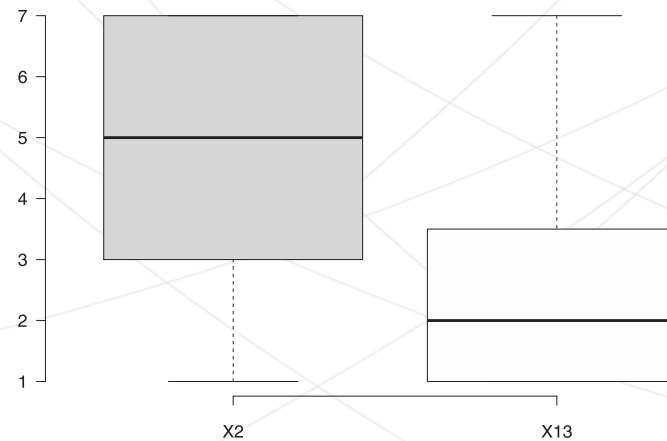
certainty

0.1

0.01

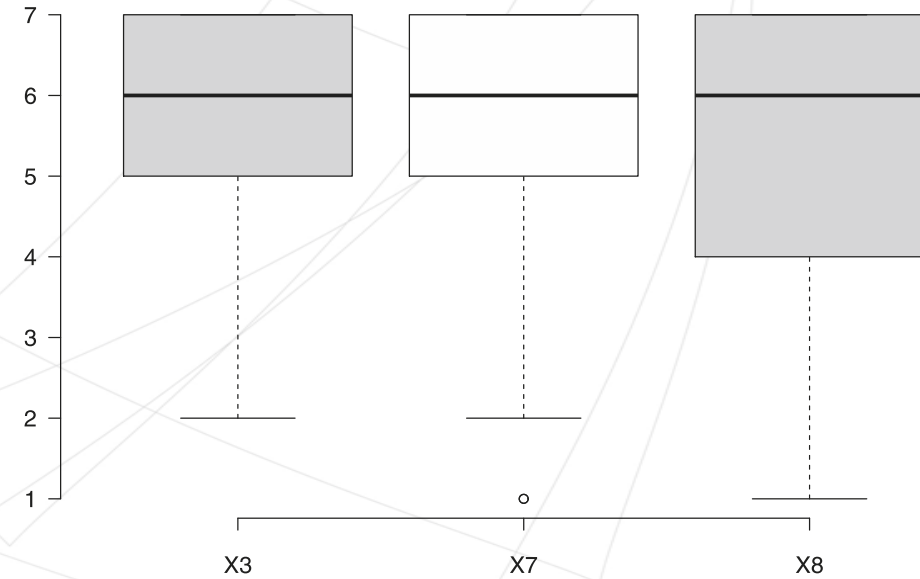
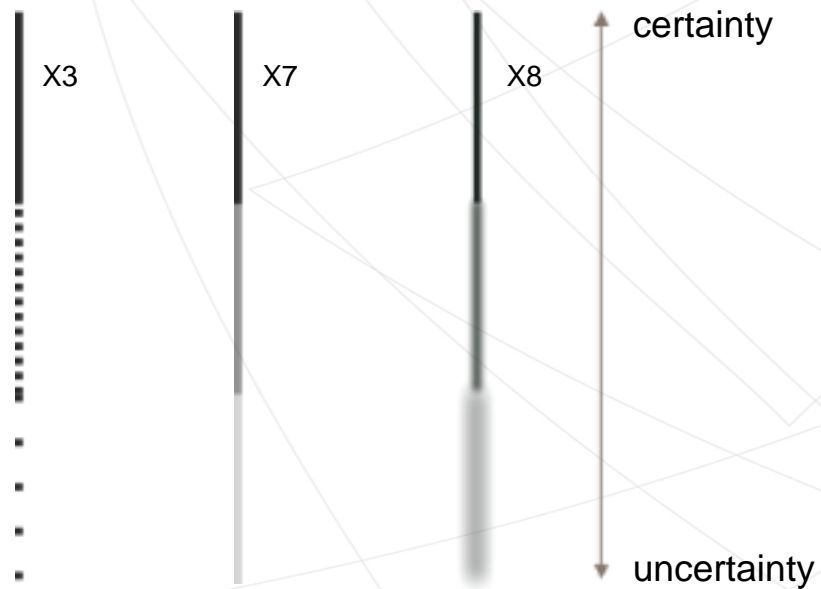
uncertainty

- 0.01 is more accurate than 1
- idea was that 0.01 is ideal symbol for certainty and 1 for uncertainty
- respondents conversely think otherwise...



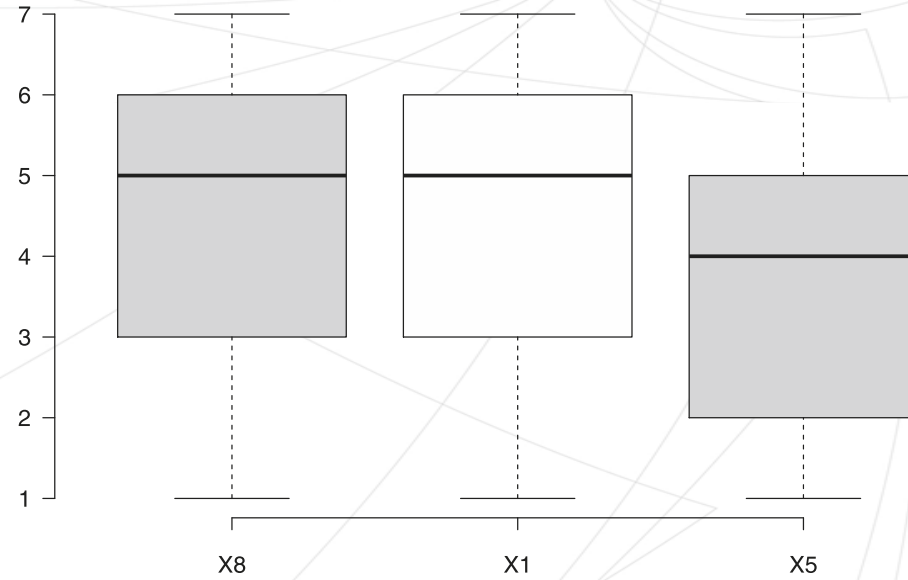


Best line symbols

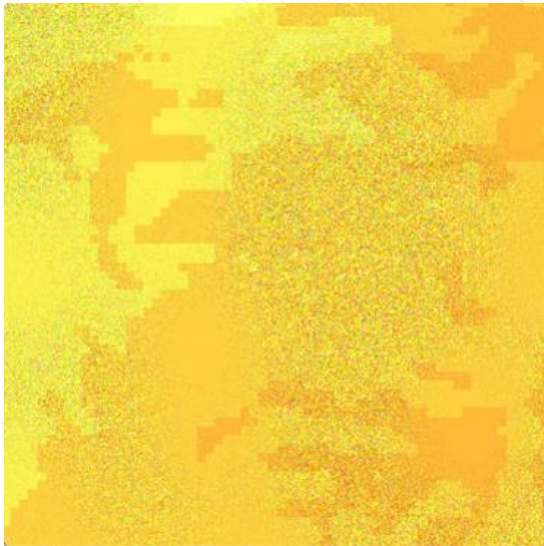




Best areal symbols



X8



X1



X5





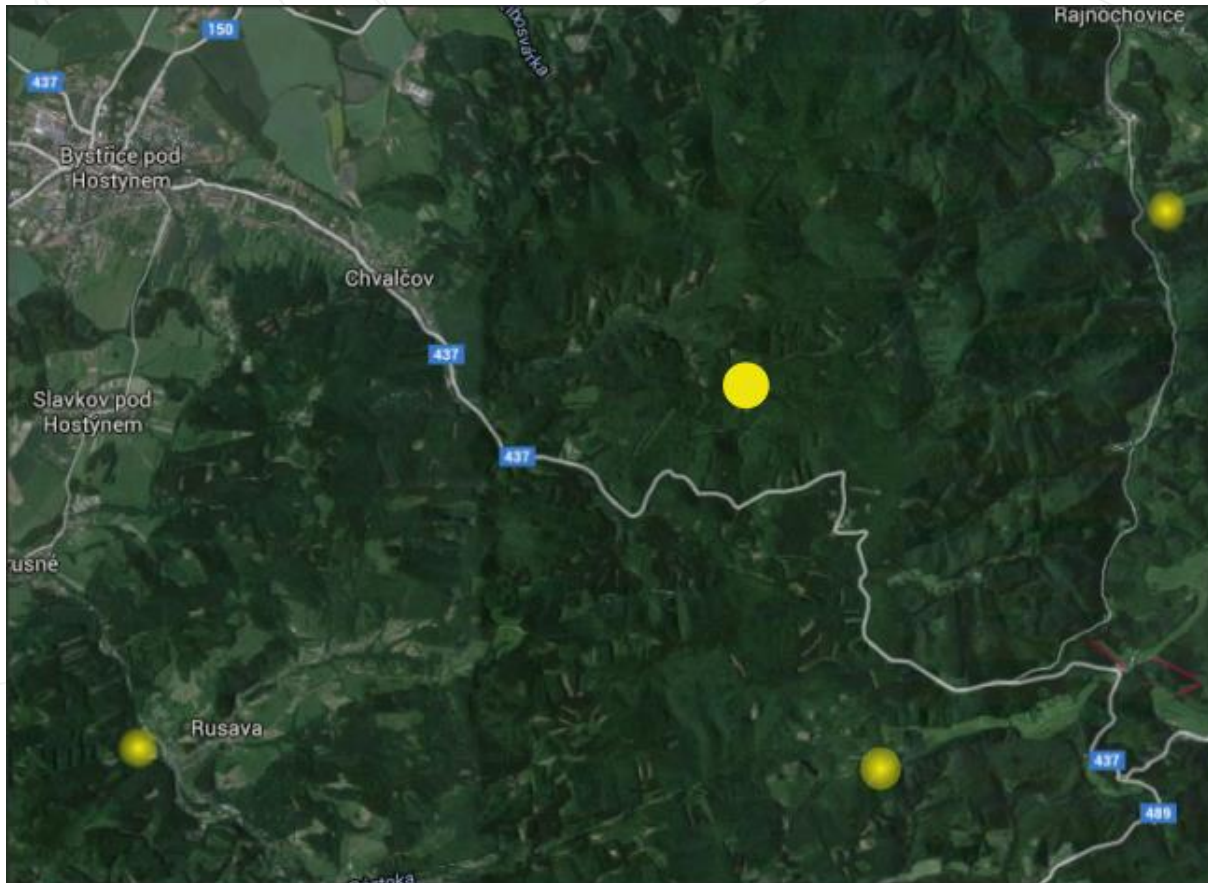
Eye-tracking experiment

- **selected symbols** placed in the map field
- supplemented by **questions** with an indirectly worded query on data uncertainty
- verifying that the **proposed characters** are able to bear primary information and also the **degree of uncertainty**
- are users able to **understand** and use it?
- **40** respondents (20 cartographers and **20 laics**)



Experiments

- Incorporating the symbols into decision making tasks
- *Eg.: Select location where you can spot the fox?*



● Fox occurrence

● ↑ certainty



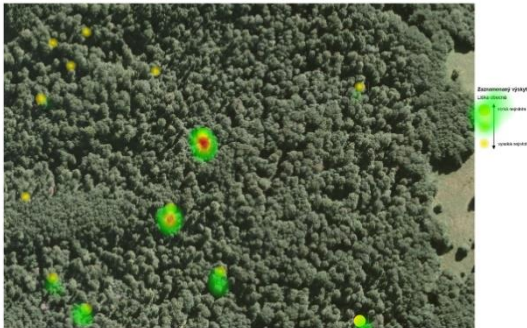
● ↓ uncertainty



Experiments structure

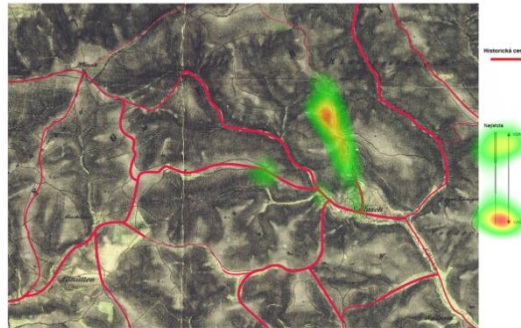
13x

Point symbols with 1 phenomenon



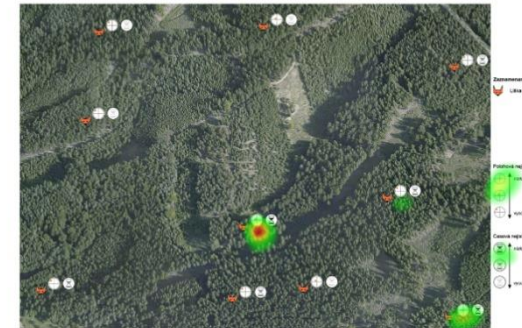
14x

Line symbols with 1 phenomenon



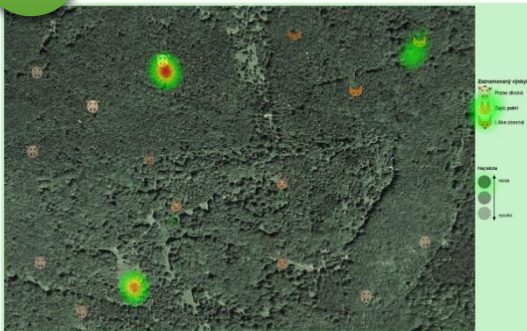
6x

Symbol sets for time and positional accuracy



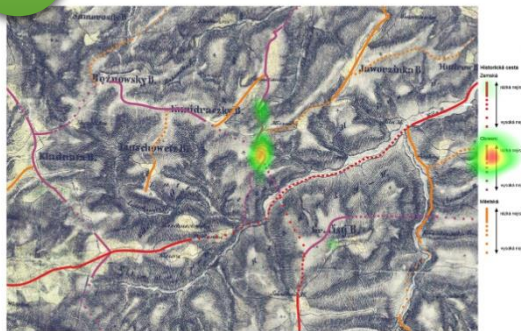
8x

PS with more phenomena



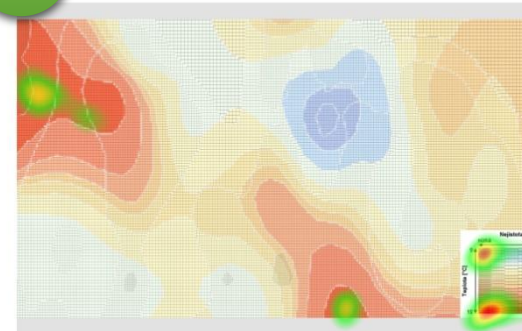
9x

LS with 1 phenomenon



12x

Areal symbols





Map content

- **noticeable** information overflow
- demand for **same number of symbols** and their complexity
- for **accurate** results need to **decrease** number of symbols



- Zaznamenaný výskyt
- Liška obecná
 - Zajíc polní
 - Prase divoké
- Polohová nejistota
- nizká
 - vysoká
- Časová nejistota
- nizká
 - vysoká





2nd questionnaire

- after eye-tracking testing
- gaining information about perceived suitability after practical usage of symbol sets
- 40 respondents
- 62 questions

eye-tracking
experiment

questionnaire

Varianta 2 - A:

Zaznamenaný výskyt

 Prase divoké

 Zajíc polní

 Liška obecná

Nejistota

 nízká



 vysoká



*

1

2

3

4

5

6

7

nelogické



logické

unlogical

logical



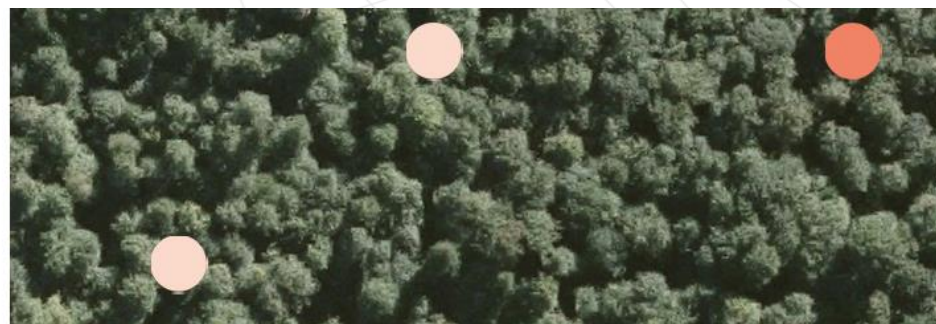
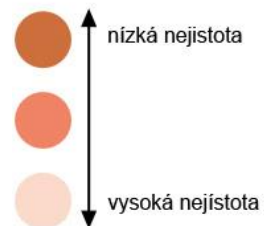
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Point symbols

nízká = low
vysoká = high
nejistota = uncertainty

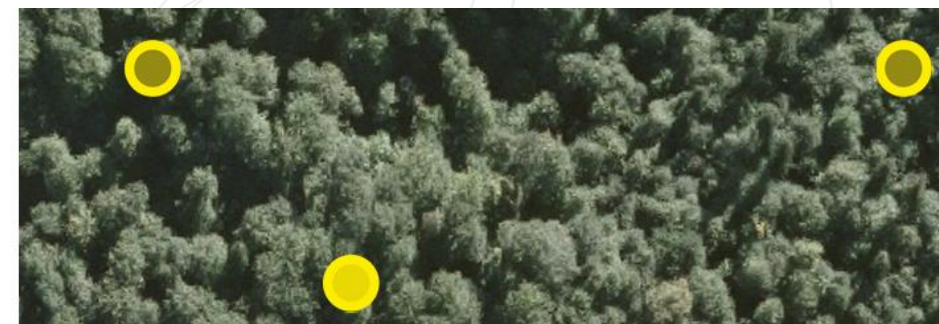
Point set	Corect answers	Trial duration	Gaze lenght	Perceived appropriateness	Final score
B13_B	1	1	3	2	1
B08_B	4	4	2	3	2-3
B10_B	7	3	1	4	2-3

Zaznamenaný výskyt
Liška obecná



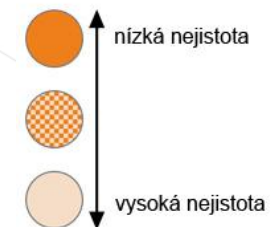
B13_B

Zaznamenaný výskyt
Liška obecná



B08_B

Zaznamenaný výskyt
Liška obecná



B10_B





Point symbols

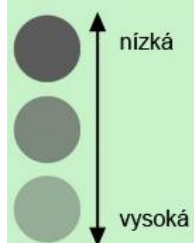
nízká = low
vysoká = high
nejistota = uncertainty

Point set	Corect answers	Trial duration	Gaze lenght	Perceived appropriateness	Final score
BK08_A	1	2	2	2	1
BK01_B	2	1	1	8	2
B07_B	8	4	3	1	3

Zaznamenaný výskyt



Nejistota



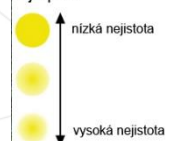
BK08_A

Zaznamenaný výskyt

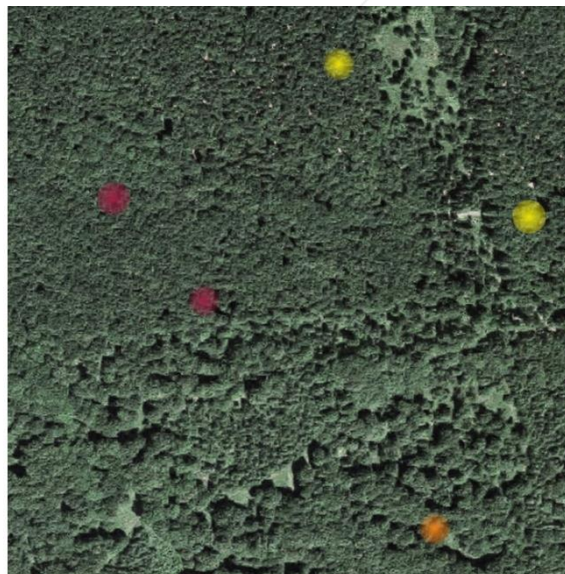
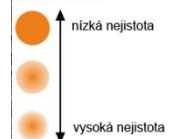
Prase divoké



Zajíc polní



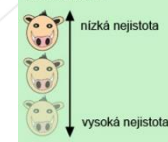
Liška obecná



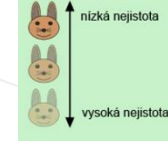
BK01_B

Zaznamenaný výskyt

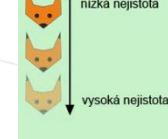
Prase divoké



Zajíc polní



Liška obecná



B07_B



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Line symbols

Point set	Corect answers	Trial duration	Gaze length	Perceived appropriateness	Final score
BK08_A	1	2	2	2	1
BK01_B	2	1	1	8	2
B07_B	8	4	3	1	3



Historická cesta



Nejistota

↑ nízka

↓ vysoká



Historická cesta



Nejistota

↑ nízka

↓ vysoká

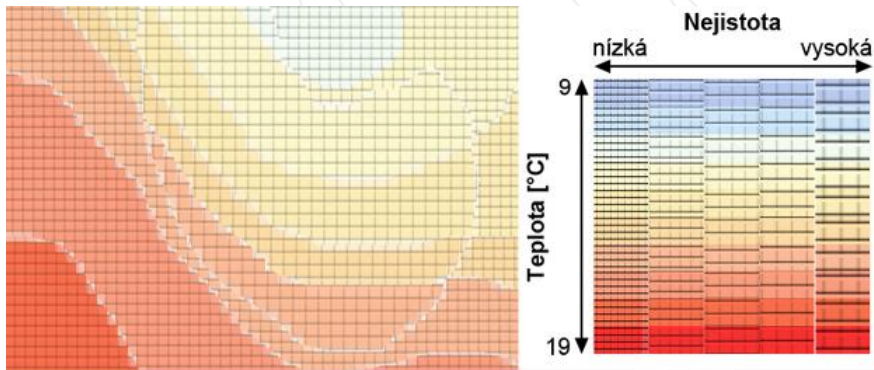




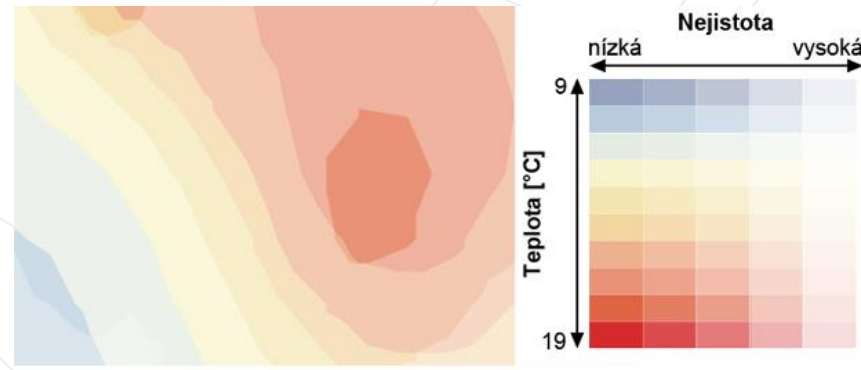
Areal symbols

nízká = low
vysoká = high
nejistota = uncertainty

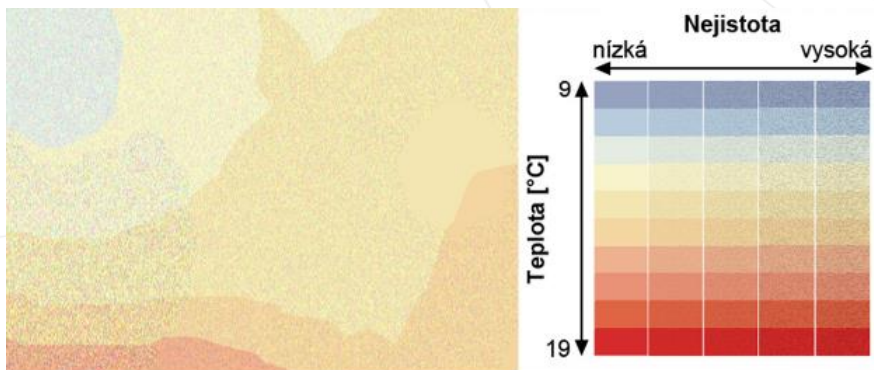
Point set	Corect answers	Trial duration	Gaze length	Perceived appropriateness	Final score
P2L, P2H	6 and 5	1 and 6	1 and 3	6	1
P6L, P6H	1 and 10	2 and 7	2 and 10	3	2
P3L, P3H	6 and 5	4 and 8	6 and 5	5	3



P02



P06



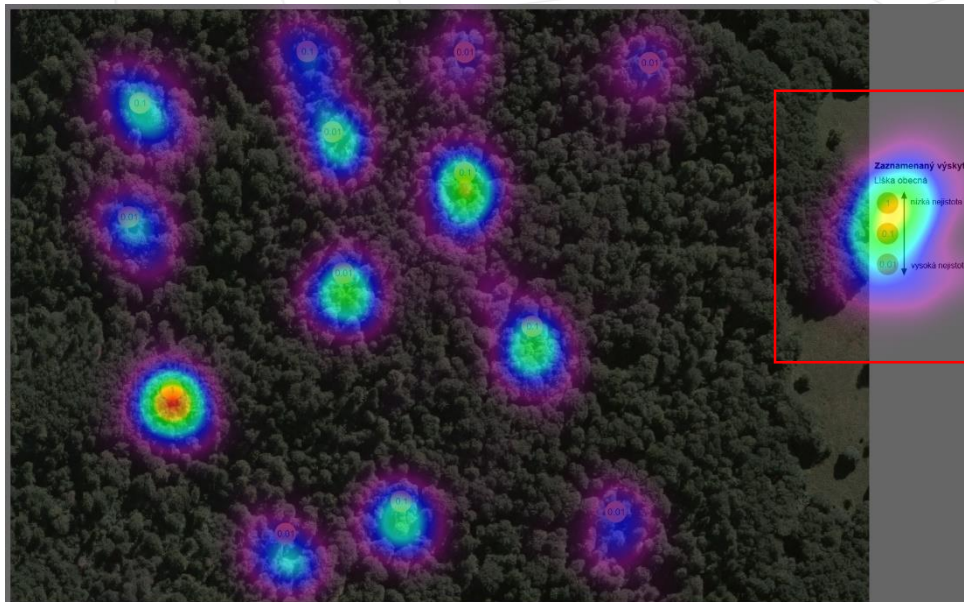
P03



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The level of intuitivness

Fixation duration = 75 s

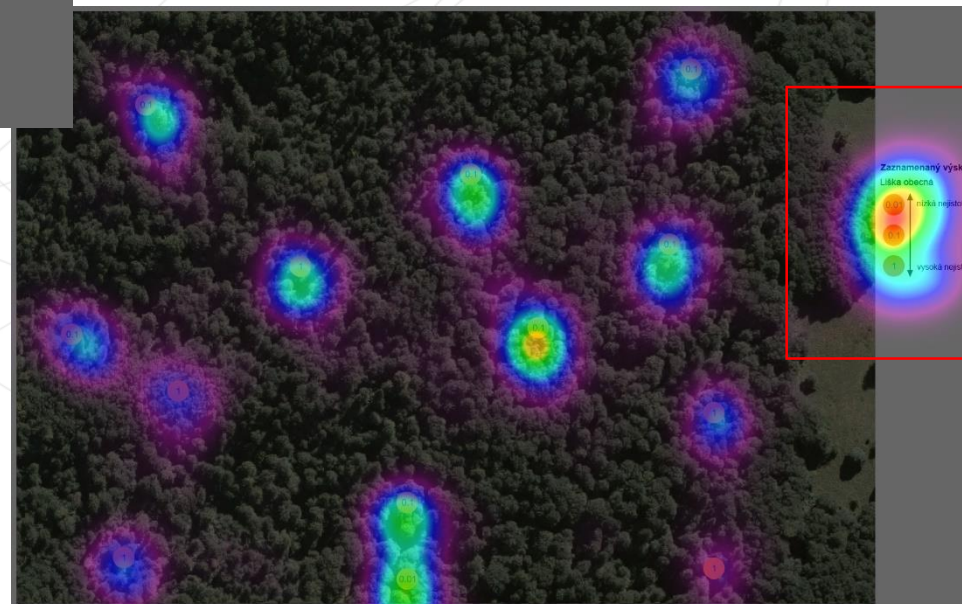


Zaznamenaný výskyt

Liška obecná



Fixation duration = 95 s



Zaznamenaný výskyt

Liška obecná





Legend comparison

- evaluation based on time spent in legend area and map field

Zaznamenaný výskyt



Liška obecná

Nejistota



nizká



vysoká

varianta A

Zaznamenaný výskyt

Liška obecná



nizká nejistota



vysoká nejistota

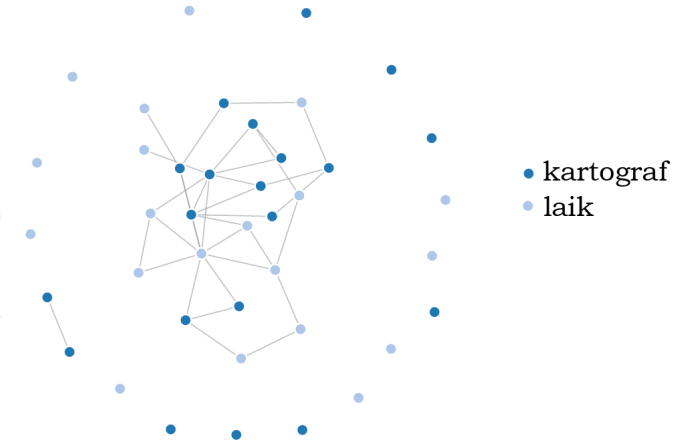
varianta B

	Share of total fixation time [%]			
	Variant A		Variant B	
	Legend	Map field	Legend	Map field
Linear expression of more phenomena	29,18	69,60	29,96	68,14
	25,51	72,43	30,81	67,16
	35,27	63,49	30,75	68,13
Point expression of one phenomenon	18,70	77,14	18,04	78,63
	18,40	77,50	14,68	82,73
	20,16	75,39	14,46	82,76
	18,61	76,86	16,25	81,41
	14,84	81,80	15,66	82,38
Point expression of multiple phenomena	15,30	83,91	25,33	73,39
	21,53	77,63	23,53	74,54
	19,85	78,86	20,19	78,23
	18,76	80,35	19,04	79,59



Difference laic / cartographer

- methods used for evaluation
 - *Loci a Sequence similarity*
 - *two-sample Wilcoxon test*
- applied to cognitive metrics
(*Trial duration, Fixation count, Gaze length*)



statistically significant difference

- detected
- not detected

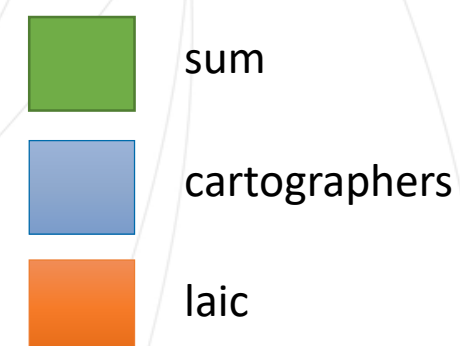
Trial group	p-value		
	Trial duration	Gaze length	Fixations count
Point symbols (one phenomenon)	0,0027	0,0437	0,1589
Point symbols (multiple phenomenon)	0,0144	0,2967	0,1642
Line symbols (one phenomenon)	0,1498	0,0020	0,0018
Line symbols (multiple phenomenon)	0,8697	0,0001	0,0120
Symbols for time and positional accuracy	0,0064	0,0641	0,0954
Areal symbols	<0,0001	0,0443	0,0004



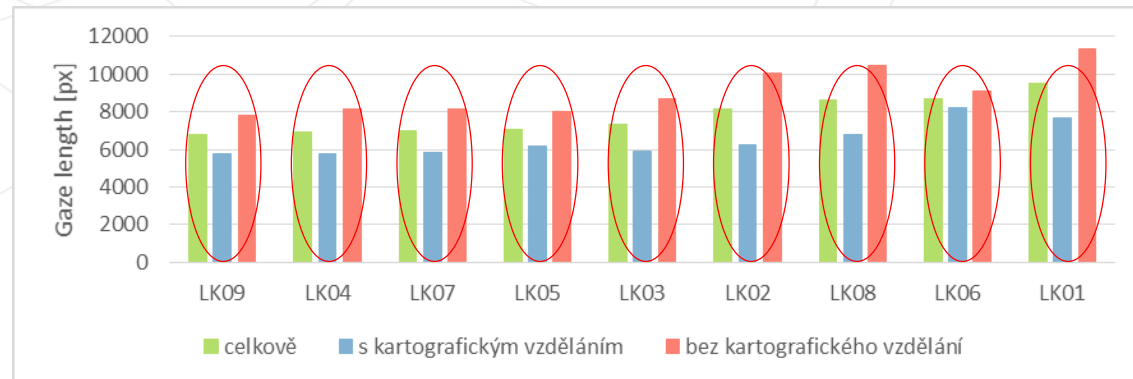
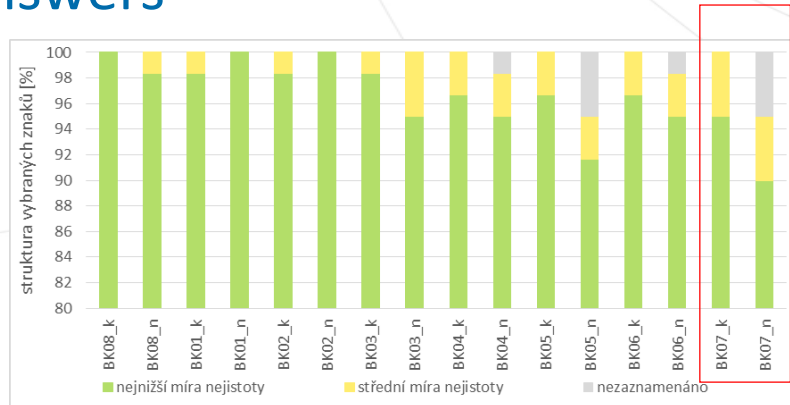
Difference laic / cartographer

- low eye trajectory differences when reading a map

Trial group	Similarity of the cognition of the respondents groups [%]		
	cartographers	laics	between groups
Point symbols (one phenomenon)	62,86	60,98	62,36
Point symbols (multiple phenomenon)	61,50	59,72	60,96
Symbols for time and positional accuracy	75,68	70,14	71,20



- however, the difference is recorded in the cognitive parameters and the selected answers





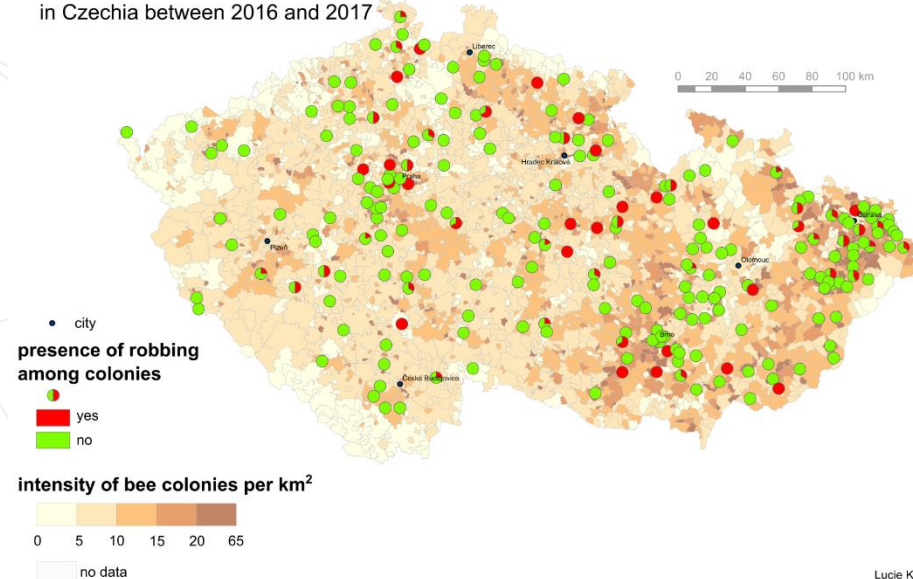
Conclusion

- information about the **perception** of symbols
 - (before and after the practical use)
- **parameters of practical character deployment** (complexity and accuracy of information interpretation)
- the **most appropriate** form of legend for visualizing uncertainty
- recorded **differences** between **cartographers and laics**



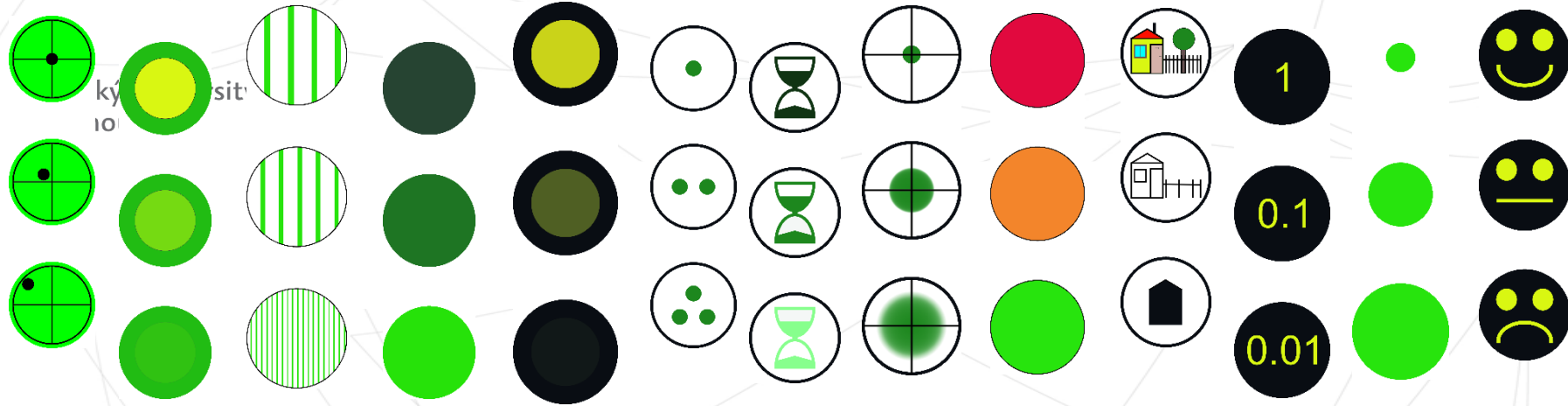
- **Implementation** of results in project
Prevention of honey bee COLony LOSSes
- An international association that monitors the success of wintering bee colonies and associated bee colony losses

PRESENCE OF ROBBING AMONG COLONIES
in Czechia between 2016 and 2017



CITIZEN SCIENCE





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